DECEMBER 4, 1959

electronics

A McGRAW-HILL PUBLICATION VOL. 32, No. 49 PRICE SE[illegible] CENTS

Special

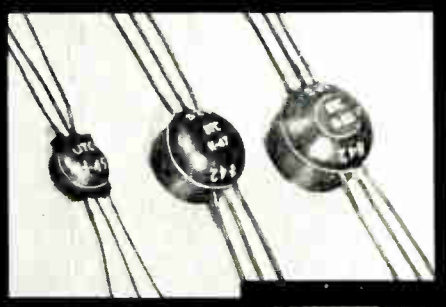
MATERIALS for Environmental Extremes

PULSE TRANSFORMERS

FROM STOCK

MINIATURE STABLE WOUND CORE — HERMETIC MIL-T-27A TYPE TF5SX36ZZ

UTC miniature, wound core, pulse transformers are precision (individually adjusted under test conditions), high reliability units, hermetically sealed by vacuum molding and suited for service from —70° C. to +130° C. Wound core structure provides excellent temperature stability (unlike ferrite). Designs are high inductance type to provide minimum of droop and assure true pulse width, as indicated on chart below. If used for coupling circuit where minimum rise time is important, use next lowest type number. Rise time will be that listed for this lower type number . . . droop will be that listed multiplied by ratio of actual pulse width to value listed for this type number. Blocking oscillator data listed is obtained in standard test circuits shown. Coupling data was obtained with H. P. 212A generator (correlated where necessary) and source/load impedance shown. 1:1:1 ratio.



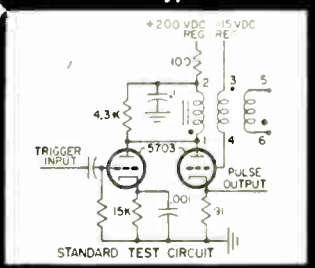
DEFINITIONS

Amplitude: Intersection of leading pulse edge with smooth curve approximating top of pulse.
Pulse width: Microseconds between 50% amplitude points on leading and trailing pulse edges.
Rise Time: Microseconds required to increase from 10% to 90% amplitude.
Overshoot: Percentage by which first excursion of pulse exceeds 100% amplitude.
Droop: Percentage reduction from 100% amplitude a specified time after 100% amplitude point.
Backswing: Negative swing after trailing edge as percentage of 100% amplitude.

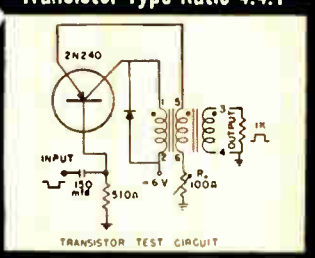
Type No.	APPROX. DCR, OHMS 1-2	3-4	5-6	BLOCKING OSCILLATOR PULSE Width μ Sec.	Rise Time	% Over Shoot	Droop %	% Back Swing	P Width μ Sec.	COUPLING CIRCUIT CHARACTERISTICS Volts Out	Rise Time	% Over Shoot	Droop %	% Back Swing	Imp. in, out, ohms
H-45	3	3.5	4	.05	.022	0	20	10	.05	17	.01	20	0	35	250
H-46	5.5	6.5	7	.10	.024	0	25	10	.10	19	.01	30	10	50	250
H-47	3.7	4.0	4	.20	.026	0	25	8	.20	18	.01	30	15	65	500
H-48	5.5	5.8	6	.50	.03	0	20	5	.50	20	.01	30	20	65	500
H-49	8	8.5	9	1	.04	0	20	10	1	24	.02	15	15	65	500
H-50	20	21	22	2	.05	0	20	10	2	27	.05	10	15	35	500
H-51	28	31	33	3	.10	1	20	8	3	26	.07	10	10	35	500
H-52	36	41	44	5	.13	1	25	8	5	23	.15	10	10	45	1000
H-53	37	44	49	7	.28	0	25	8	7	24	.20	10	10	50	1000
H-54	50	58	67	10	.30	0	20	8	10	24	.25	10	10	50	1000
H-55	78	96	112	16	.75	0	20	10	16	23	.40	5	15	20	1000
H-56	93	116	138	20	1.25	0	25	10	20	23	.6	5	10	10	1000
H-57	104	135	165	25	2.0	0	30	10	25	24	1.5	5	10	10	1000
H-60	.124	.14	.05	.05	.016	0	0	30	.05	9.3	.012	0	0	20	50
H-61	.41	.48	.19	.1	.016	0	0	30	.1	8.2	.021	0	0	15	50
H-62	.78	.94	.33	.2	.022	0	0	18	.2	7.4	.034	0	5	12	100
H-63	1.86	2.26	.70	.5	.027	2	10	20	.5	7.5	.045	0	20	25	100
H-64	3.73	4.4	1.33	1	.033	0	12	25	1	7	.078	0	15	23	100
H-65	6.2	7.3	2.22	2	.066	0	15	25	2	6.6	.14	0	10	20	100
H-66	10.2	12	3.6	3	.087	0	18	30	3	6.8	.17	0	10	20	100
H-67	14.5	17.5	5.14	5	.097	0	23	28	5	7.9	.2	0	18	28	200
H-68	42.3	52.1	14.8	10	.14	0	15	28	10	6.5	.4	0	15	30	200

Note: 0 = Negligible

Vacuum Tube Type Ratio 1:1:1



Transistor Type Ratio 4:4:1



H-45 46, 60 thru 68 are 3/8 cube, 1 gram — **H-47 thru 52, 9/16 cube 4 grams** — **H-53 thru 57, 5/8 cube 6 grams**

AND SPECIAL UNITS TO YOUR SPECS

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Engineering

Departments

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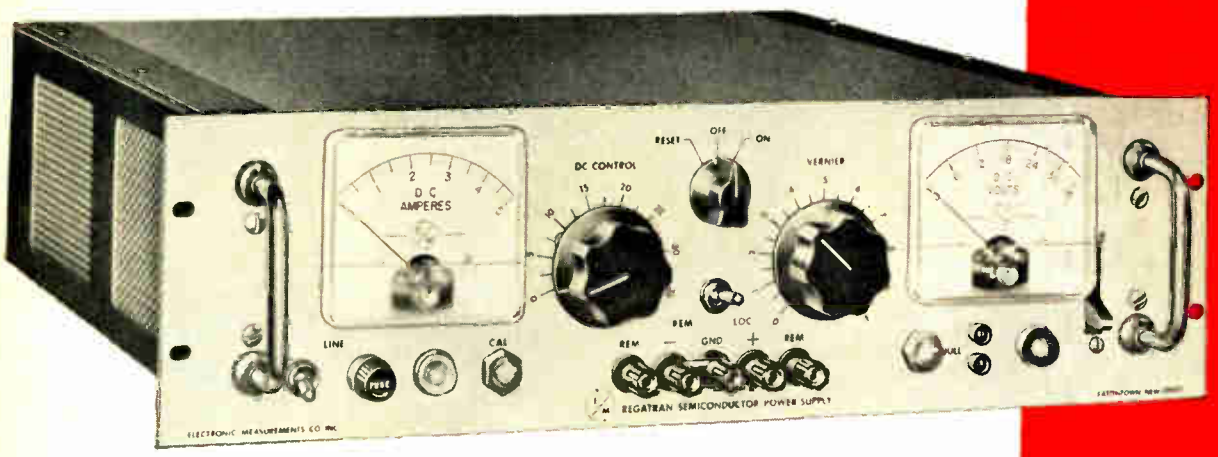

- sensing terminations
- front panel calibration
- any grounding arrangement
- small size, light weight

Regatran Semiconductor Power Supplies are available in various ratings up to 0 to 60 V dc and 0 to 30 amperes, depending on model. Write for Bulletin 721.

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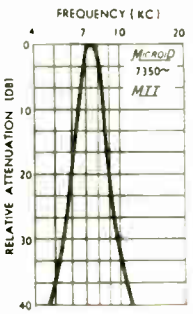
SPACE SHRINKERS

MICROIDS AND MONKEYS -- Burnell & Co. welcomes the assistance of their simian friends in the task of gathering data vital to space shrinking. By shrinking toroids, filters and related networks for guidance and communication systems, Burnell helps space vehicles carry bigger payloads -- more instrumentation, animals -- eventually man. Typical of our accomplishments is the MTT MICROID® telemetering band pass filter. Significantly, the combined weight of 23 MICROIDS -- plus the monkey -- is less than the single non-miniaturized telemetering band pass filter pictured here. MICROID band width is 15% at 3 db -- 60% -- 40% at 40 db. Frequency coverage is from .4 kcs to 70 kcs.

Sizes	
Channels 1-6	2x27/32x1/2
Channels 7-10	1-5/16x11/16x11/16
Channels 11-18	15/16x19/32x1/2
Alternates A-E	15/16x19/32x1/2

Write for Filter Bulletin MTT 23.



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SHOPTALK . . . editorial

SILENT DEATH. The U. S. is spending billions for defense against manned bombers, ballistic missiles and submarines but little for defense against chemical and biological warfare.

CW and BW are silent but deadly. They can turn the air we breathe, the food we eat, the water we drink against us. They can be spread by wind, water current or saboteurs. Areas can even be seeded with deadly disease germs that are dormant until irradiated.

Modern chemical agents can't be detected by the keenest nose. Colorless and odorless, they defy detection and can at least destroy judgment when judgment is needed most. The culture, slide and microscope technique doesn't work fast enough in identifying germs. Not when trigger-quick action is required to head off planted epidemics.

There are electronic instruments to detect gas. Some rely on infrared spectroscopy. There are television-like instruments to warn against unusual concentrations of airborne germs.

The Army Chemical Corps has some of this equipment. Civil Defense none. More is needed to insure against attack today. Much more research is needed to develop new instruments for use tomorrow.

W W MacDonald

EDITOR

Coming In Our December 11 Issue . . .

MICROMINIATURIZATION. Some of the most intensive research effort in our industry lies in the field of microminiaturization. Various techniques are being tried in an attempt to cram as many electronic components into a cubic inch as possible.

Some researchers stress the design of integrated circuits (ELECTRONICS, p 35, June 26), while others concentrate on developing micromodules (p 51, May 22).

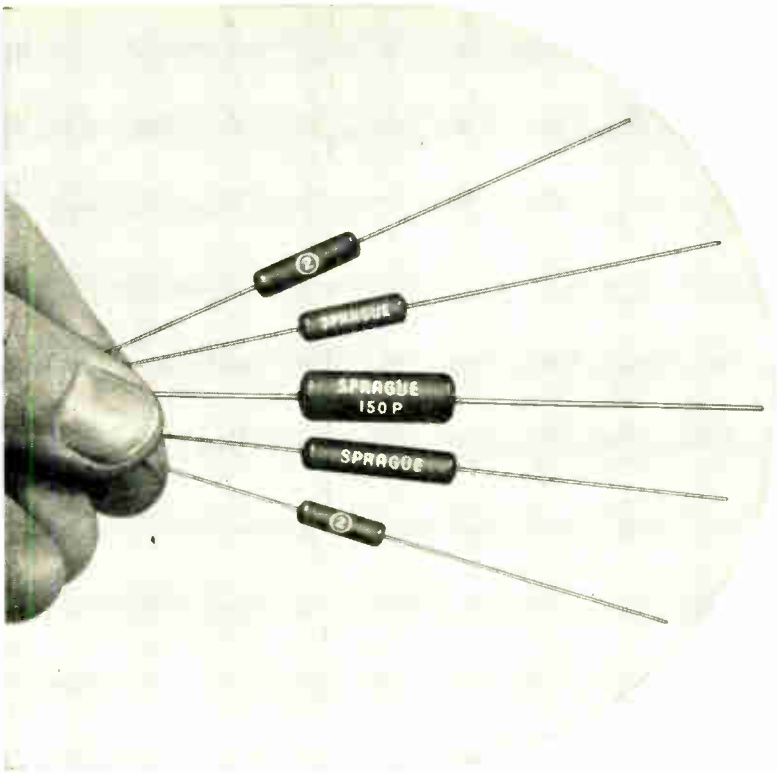
Next week, R. Langford of Weston Instruments in Newark, N. J., describes the limitations and possible future applications of three approaches to microminiaturization.

From one of these approaches—the concept of the integrated or solid circuit—packing densities of 500 million parts per cubic inch are foreseen.

NOISE. Communication system designers are continually seeking out new ways to improve signal to noise ratio. A radio system for high noise paths has been developed at N. V. Philips' Gloielampenfabrieken in Eindhoven, Netherlands. J. A. Greefkes and F. de Jager claim their new system works at times when noise causes other radio links to fail.

Basic idea of the system is to split voice sounds into frequency and amplitude components, then transmit the two types of information on separate channels and, finally, recombine the separate components into the original sounds.

MIXER DESIGN. When two frequencies are heterodyned in a nonlinear device, a great number of spurious responses is obtained in addition to the desired sum or difference frequency. R. F. Baum of W. L. Maxson Corp. in New York City presents some nomographs that will help circuit designers find which unwanted harmonics of the two signals will cause interference.



Miniature

PROKAR® 'D' Molded Capacitors

--with improved moisture resistance and a new dual dielectric for 125 C operation without voltage derating

Sprague's new and improved PROKAR 'D' Molded Tubular Capacitors meet the need for *ever smaller* molded capacitors capable of withstanding 125 C operation in military, commercial, and industrial electronics.

Key to the new design is an improved processing technique which greatly increases moisture resistance. The new dual dielectric used in Type 150P Capacitors combines the dielectric strength of the highest grade capacitor tissue with the effective moisture resistance of plastic film, giving these miniature units high insulation resistance plus extended life at 125 C. The impregnant used is still the same exclusive high temperature organic material which marked a milestone in molded capacitor development for the original Prokar series.

The improved performance of PROKAR 'D' Capacitors is worth investigating—greater resistance to humidity, high insulation resistance (minimum of 10 megohm-microfarads at 125 C), moderate capacitance change with temperature, longer life, and improved reliability.

For complete specifications on Type 150P PROKAR 'D' Molded Tubular Capacitors, write for Engineering Bulletin 2300 to Technical Literature Section, Sprague Electric Company, 35 Marshall St., North Adams, Mass.

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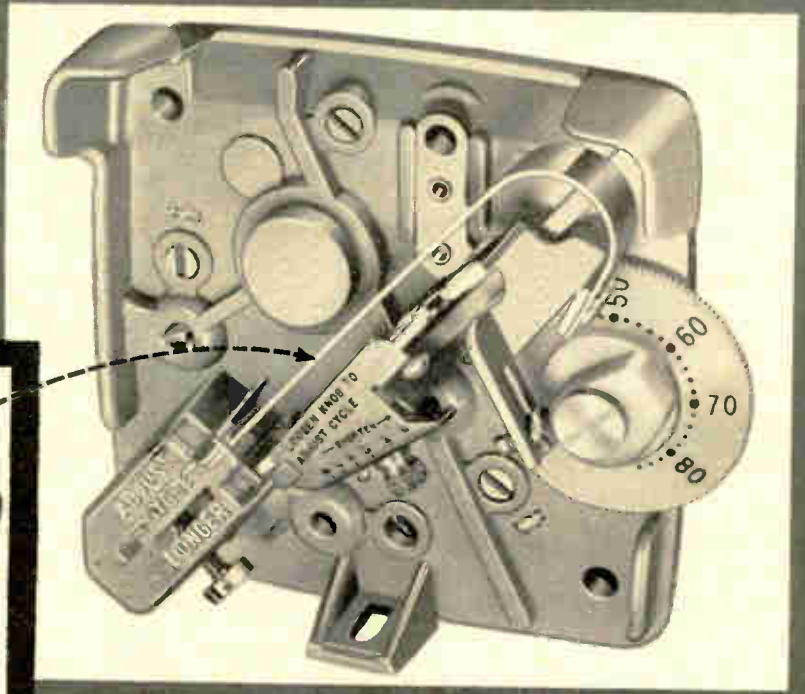

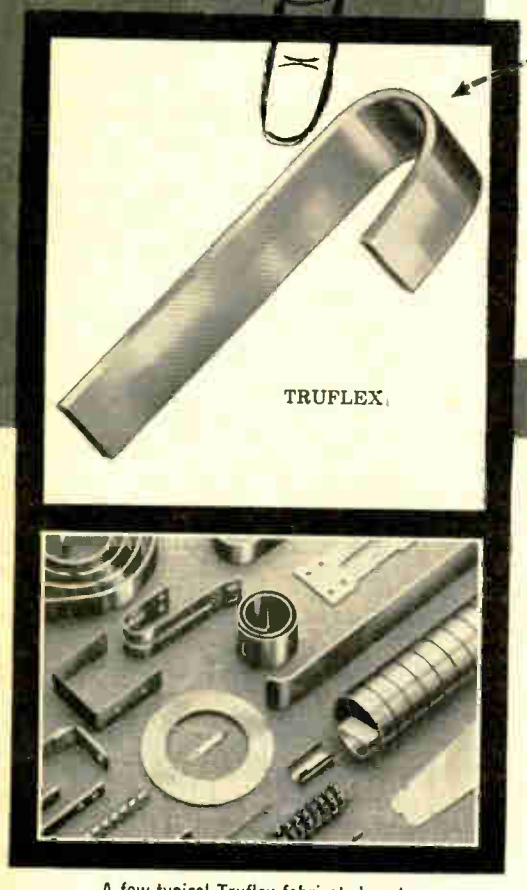

A few typical Truflex fabricated parts

In designing its new attractive thermostat Signet Controls turned to General Plate for Truflex Thermostat Metal. Here's how Mr. W. D. Gibson, Manager of Signet Controls, puts it:

"The heart of a thermostat is the temperature-responsive element. In designing our new Model T500 we were careful to select a thermostatic material which would be consistently sensitive and accurate. Our previous experience assured us that we would obtain these vital characteristics with Truflex Thermostat material."

When you buy General Plate Truflex Thermostat Metal you can be sure that the first lot meets specifications 100% and every succeeding lot is a duplicate . . . has identical characteristics to the original . . . whether it be manufactured days, months or years later.

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Truflex Thermostat Metals are available as fabricated elements, assemblies and extra long coils or flat strip. Write for information.

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with these convenient, precision

NEW AMPLIFIER!

Just clamp on probe and read current instantly!

hp 154A Voltage/Current Dual Channel Amplifier

SPECIFICATIONS

(When plugged into -hp- 150A/AR Oscilloscope)

CURRENT CHANNEL

Band Pass:	50 cps to 8 MC.
Sensitivity:	10 calibrated ranges, 1 to 1,000 ma/cm, 1, 2, 5, 10 sequence. Accuracy ± 5%. Vernier between steps (extends 1,000 ma/cm range to at least 2,500 ma/cm).
Max ac Current:	10 amperes rms 20 KC and above. Below 20 KC core saturation reduces current capability proportional to frequency.
Max dc Current:	Direct current to ½ amp has no appreciable effect.
Input Impedance:	Approx. 0.01 ohm shunted by 0.8 uh.

VOLTAGE CHANNEL

Band Pass:	dc coupled: dc to 10 MC, 0.035 μsec rise time. ac coupled: 2 cps to 10 MC, 0.035 μsec rise time.
Sensitivity:	9 calibrated ranges, 0.05 to 20 v/cm; 1, 2, 5, 10 sequence. Accuracy ± 5%. Vernier between steps.
Input Impedance:	1 megohm (nominal), 30 uuf shunt.

GENERAL

Vertical Presentation:	(1) Either voltage or current signal continuously or (2) voltage and current signals sampled at 100 KC or on alternate traces.
Vertical Position:	Each channel individually adjustable.
Price:	$430.00 (includes current probe).

The new hp 154A's exclusive "clamp-around" probe permits fast, direct measurement of current from 50 cps to 8 MC, 1 ma to 15 amperes (peak-to-peak) *without breaking into the circuit, loading, or voltage drop due to resistor insertion.* Here is a time-saving convenience feature of real significance in the investigation of transistors, logic circuits and other measurements where current information is of prime importance.

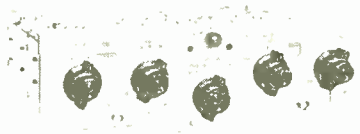
In addition, the 154A — actually two instruments in one—makes possible swift, simple and direct comparison between voltage and current waveforms. In this comparison service, one section of the 154A reads current while the other reads voltage in a manner identical with other hp voltage indicating instruments. Comparison is achieved by electronic channel switching—through alternate sweeps or 100 KC chopping. Either of the 154A's dual channels may also be used individually.

hp now offers better-than-ever service

EN

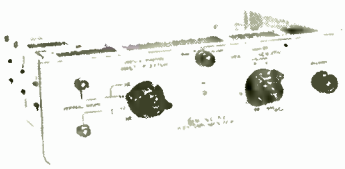
the utility of your 150 A/AR oscilloscopes

amplifiers and accessories



152B Dual Trace Differential Amplifier. New plug-in amplifier providing differential input and dual traces electronically switched between A and B channels at either 100 KC or on alternate sweeps. Sensitivity range 0.05 v/cm to 50 v/cm, input attenuator with 9 calibrated ranges in 1, 2, 5, 10 sequence and vernier. $250.00.

153A Very High Gain Amplifier. New plug-in permitting 150A to be used for many direct measurements from transducer without *preamplification.* Pass band dc to 500 KC, sensitivity 1 mv/cm to 125 v/cm, balanced input on all ranges. 15 calibrated ranges in 1, 2, 5, 10 sequence, 1 mv/cm to 50 v/cm; plus vernier. $125.00.



151B High Gain Amplifier. For 150A high gain unit with 5.0 mv/cm sensitivity, frequency response dc to 10 MC. 12 calibrated ranges on 1, 2, 5, 10 sequence, 5 mv/cm to 20 v/cm; accuracy ± 5%. Vernier adjustment. 1 megohm input impedance with 31 uuf shunt. Pass band rise time 0.035 μsec. Has 2 BNC terminals. $200.00.

196A Oscilloscope Camera. All new, most useful scope camera ever. Full-size, distortion free pictures; full picture area may be scaled. Simple multiple exposures; with one hand move lens through 11 detented positions. Pictures sharp, clear, compare to CRT resolution. Professional bellows prevents light leaks; easy tab pulling; set f-stop and shutter without removing camera from scope; mount on scope with one hand. Employs Polaroid® Land Camera back, new *flat* Wollensak 3" f/1.9 lens. Wt. 9 lbs. $425.00.

AC-115A Oscilloscope Testmobile. For 150 series oscilloscopes but fits others. 4" rubber tired wheels, heavy chrome tube construction, tilts 'scope to 30° in 7½° increments, folds for storage, shipping. $80.00 AC-116A Storage Unit fastens to AC-115A, holds 150A plug-ins or AC-117A Accessory Drawers. AC-116A, $22.50. AC-117A, $10.00.

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

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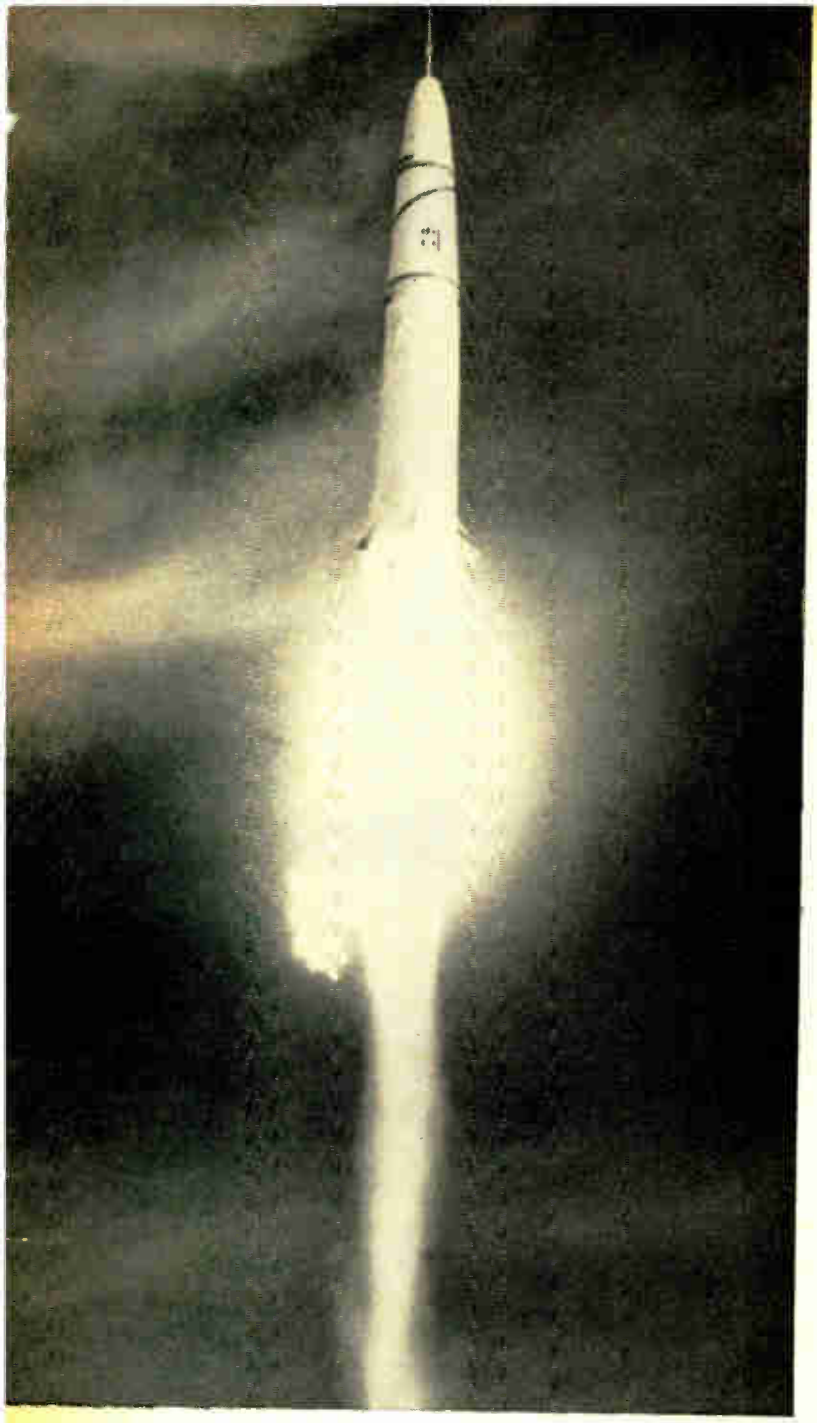
NOW! IN EUROPE!

In 1959, Hewlett-Packard S.A. was established in Geneva and a branch opened in Frankfurt am Main offering technical sales and engineering help and information. Previously established relationships with representatives in other parts of Europe of course continue. In addition, there is now an warehouse in Basel stocking instruments and parts, and an factory near Stuttgart producing instruments for customers throughout Europe.

to our customers in Europe!



EIMAC CERAMIC-METAL REFLEX KLYSTRONS FOR SEVERE ENVIRONMENT APPLICATIONS

In modern airborne and missile systems, reflex klystrons must be capable of maintaining exceptional frequency stability under conditions of severe shock, vibration and acceleration. Eimac's new ruggedized X- and K-Band reflex klystrons achieve this stability through an advanced system of stacked-ceramic construction and integral brazed 'dual-cavity' design.

Ceramic construction permits internal electrodes to be supported on rigid concentric cones and allows the entire vacuum assembly to be furnace-brazed into a single rugged structure. The resonant cavity design consists of a fixed-tuned (and hence rugged) inner cavity closely coupled through a ceramic window to a secondary tunable cavity outside the vacuum envelope. The external cavity is tuned by means of a capacitive slug over a minimum range of 700 megacycles per tube.

This advanced design has resulted in a series of four exceptionally stable reflex klystrons covering the 8500 to 11,500 megacycle range at a typical output power level of 75 milliwatts. At vibration levels of 15 to 20G the peak-to-peak deviation of these tubes is less than 50 kilocycles for any vibrating frequency from 20 to 2000 cycles per second, with the force applied in any plane of the tube. The advantage of this low FM noise level in local oscillator service is obvious. Ceramic construction and the superior tube manufacturing techniques it makes possible permit tube or seal temperatures of 250°C without impairment of operation.

For severe environment microwave applications investigate the advantages of Eimac ceramic-metal reflex klystrons.

Eimac

EITEL-McCULLOUGH, INC.
San Carlos, California

ELECTRONICS NEWSLETTER

ORBITING COMMERCIAL NAVIGATION SYSTEM for use by mariners is proposed by Bendix Aviation. A. C. Gilbert, director of the company's Space Long Range Planning division, suggests that a transmitter could be included among the instruments aboard a NASA satellite without impairing the satellite's scientific objectives. Commercial ship owners could then buy receivers at from $1,000 to $2,000 each. Apparently the Bendix system would not use the "radiotelescope" principle on which the planned Navy navigation satellite *Transit* is based. To use *Transit*, the satellite's precise position must be known and predictable long in advance at all times. Azimuth and elevation of the radio beam from *Transit* will be measured by surface ships and aircraft as if the man-made satellite were a star; lines of position will be calculated by prepared tables. Though Bendix does not disclose how its system will operate, Gilbert says a stable predictable orbit is not required.

Pinhead-sized electronic gear for space vehicles was predicted by scientists at last month's American Rocket Society meeting. Gene Strull of Westinghouse's Semiconductor division, Baltimore, described a light telemetry system which, besides power supply and load, consists of a single semiconductor wafer 1/1,000 of a cubic inch.

ATLAS ICBM SIGNAL FAILURE when the vehicle's speed reaches about 6,800 mph, at altitudes under 55 miles, was also reported at the American Rocket Society meeting. Edward Niemann, Jr. of GE's Missile and Space Vehicle department, reported the failure was almost instantaneous, with transmission resuming after several seconds. Max Lowy of Data Control Systems, Inc., Danbury, Conn., said the phenomenon might be a problem in Project Mercury, which is expected to use the Atlas as a booster for a manned space satellite. Data on thrust chamber pressure was among signals that faded.

Radio-controlled winged booster, half aircraft and half missile, is proposed as a means of recovering costly rocket boosters by Rudi P. Buschmann of Lockheed's Advanced Design division. He said present boosters cost from $1,000 to $10,000 per pound of payload, added that a vehicle brought back to earth would almost halve booster costs.

NEW OCEANOGRAPHIC VESSEL for Woods Hole Oceanographic Institution will be provided by a $3-million National Science Foundation grant. NSF Director Alan T. Waterman called the grant a "first step" in meeting the need for adequate research vessels. (On the need, see ELECTRONICS, p 40, Nov. 20). The new ship, a "distinctive" research vessel which evolved from design studies previously supported by NSF, will replace the 28-year-old *R/V Atlantis* of WHOI's fleet. Another sign of new civilian oceanographic effort is NSF's announcement of the appointment of John Lyman as Associate Program Director (Oceanography) for Earth Sciences. He was formerly director of the division of oceanography of the U. S. Navy Hydrographic Office.

Analog-to-digital conversion system that will simultaneously sample as many as 15 sonar or other analog inputs at rates up to 17,000 per second is being developed for the U. S. Navy Electronics Laboratory, San Diego, by Packard Bell Electronics.

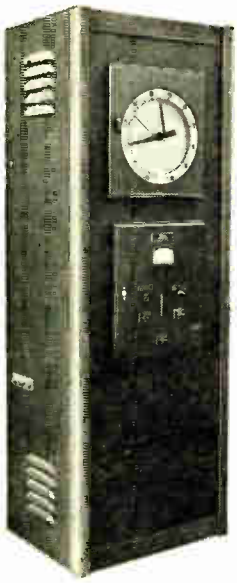
INFORMATION HANDLING at a 30-million-word-a-second rate is possible with several devices reportedly created at Sperry Gyroscope, Great Neck, N. Y., a Sperry Rand division. The devices were created, says the company, "for the purpose of developing computers and communications systems capable of handling large amounts of information at speeds at least 1,000 times faster than large electronic computers currently in use." One device is a microwave diode which switches 700 million bits of information a second; another is a microwave amplifier tube which performs logic operations at the rate of 1 billion times a second.

SATELLITE POSSIBILITIES which the Strategic Air Command feels should be explored include satellites with reconnaissance capability, communications satellites and those with built-in know-how needed to launch, if necessary, a warhead from orbit. Some may be used to intercept others and put them out of operation, or for electronic surveillance of the increasing orbital traffic. "If the occasion demands," says SAC, "satellites will one day be able to jam enemy radars or toss a high-frequency monkey wrench into enemy communications networks." SAC adds that contracts for much of this "hardware" have already been let.

Bendix is readying production plans for a new general-purpose computer in the medium-to-large range. System will be designated the G-20, is due on the market next year.

SEAWARD EXTENSION OF SAGE will be accomplished under a new contract for Airborne Long Range Input (ALRI), which will amount to about $35 million in its first stages and has just been awarded to Burroughs by the Air Materiel Command, Dayton, Ohio. Burroughs' system management contract runs for 42 months, with some 50 to 60 percent of the work to be placed with subcontractors.

CANADIAN MICROWAVE SYSTEM running 142 miles from Rimouski, Quebec, to New Carlisle, N. B. is expected to be completed in June, 1960. System, which is being built by Canadian Pacific Communications, will carry French-language tv, may be expanded later.



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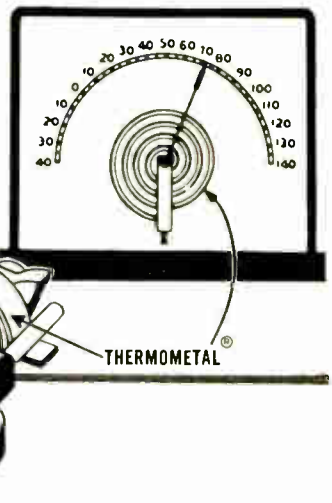

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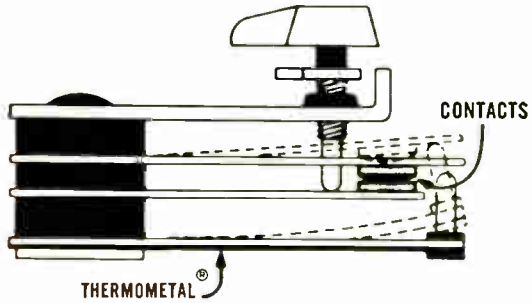

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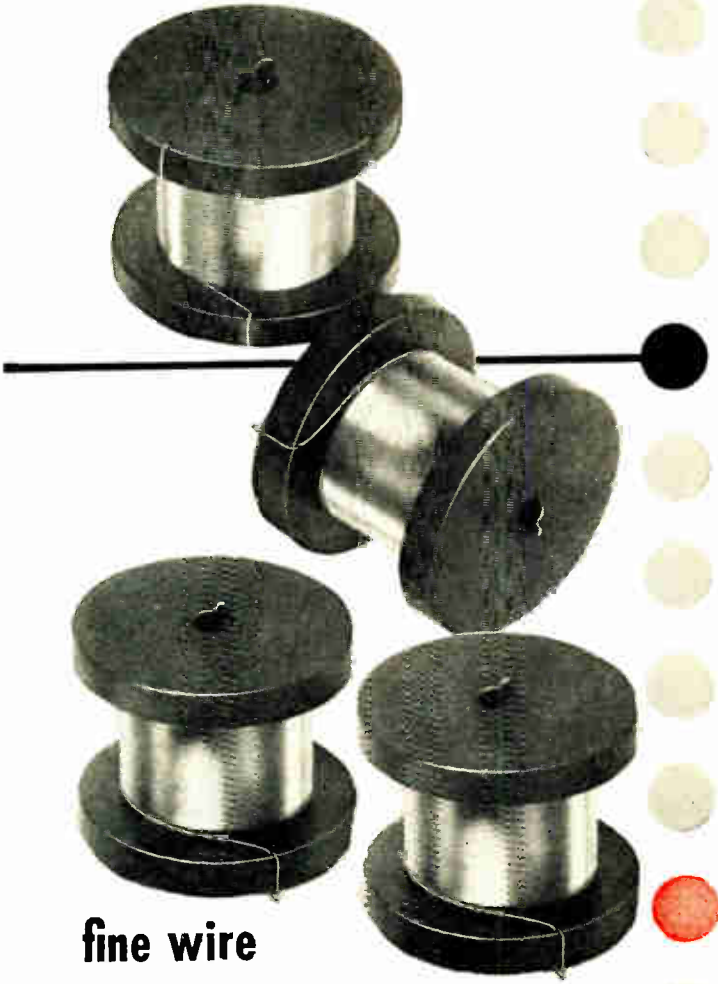

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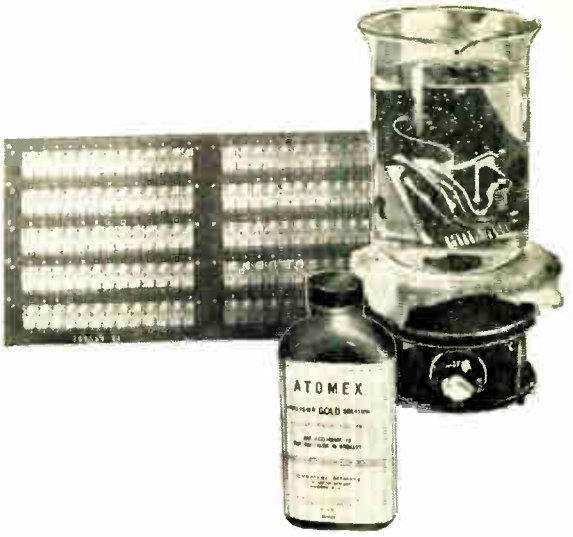

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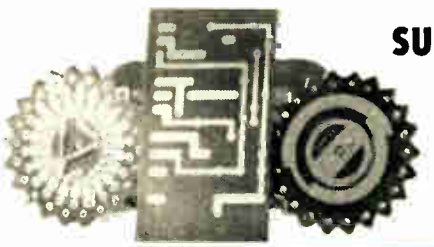

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EXECUTIVE OFFICES:

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WASHINGTON OUTLOOK

DEFENSE DEPARTMENT continues to enforce its go-slow policy in Army countermissile development. For fiscal 1961, the Army requested $300-million for continued research and development on the Nike-Zeus anti-ICBM and at least $700 million to begin production of subsystems and components. The Pentagon approved the R&D request but turned down the production plans.

Defense Department officials say they want to wait until the Zeus can be tested as an entire system—which isn't likely to occur before 1962. They also express doubts about the feasibility of meeting the threat of salvos of ballistic missiles with the Zeus system. Consensus of high Pentagon officials—faced with serious budgetary pressures—seems to be that the $300 million for continued R&D is a reasonable hedge bet, but that production is unlikely.

Meanwhile, the ballistic-missile early-warning system is proceeding on schedule. If all goes well, ELECTRONICS learns, the three stations of the BMEWS network will be in at least partial operation sometime next year—long before an effective countermissile could possibly be developed to throw up against an attack.

- **Turmoil over government patent policies** is due to be revived. In recent months, industry has plumped for liberalization of the patent policy of National Aeronautics & Space Administration. NASA policy reserves to the government all patent rights on inventions developed under the agency's contracts. This differs from the Pentagon's policy: defense contractors can patent inventions and exploit developments on the commercial market. The only obligation the defense contractor has is to allow the military services royalty-free licenses to produce.

  Counter-pressure is developing now from congressional quarters to make the Pentagon follow the same policy as NASA, and restrict commercial exploitation of inventions made under military contract. The pressure comes from the Senate small-business committee, which begins a full-blown investigation into patent policies next Tuesday.

  Informed Washington sources told ELECTRONICS that the source of the pressure is the small businessman's complaint: that it's unfair to allow the big firms to commercially exploit developments the government has paid for.

- **Army has invited** some 100 aircraft and electronics companies to a special meeting this week to hear about the Army's long-range interests in aviation. One of the Army's interests: surveillance planes heavily instrumented with electronic detectors. The companies were asked to submit "voluntary" design concepts "on a no-pay basis" to meet the Army's aviation requirements.

- **Toolmakers, squeezed by growing competition** from low-cost foreign manufacturers, have taken a different tack from semiconductor manufacturers in asking help from the Office of Civil & Defense Mobilization.

  Machine-tool industry made a formal presentation to OCDM outlining the industry's problems: danger to national security represented by increasing dependence on foreign suppliers, decline of the export market, and related industry conditions. Then they said the government should determine whether or not the machine-tool industry is essential to national defense and devise its own scheme to "preserve" the industry.

  Semiconductor manufacturers, working through Electronic Industries Association, asked for import restrictions on the grounds of defense essentiality.

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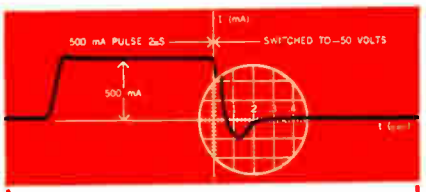

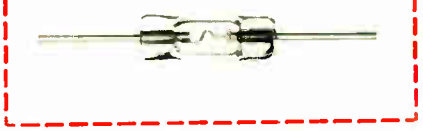

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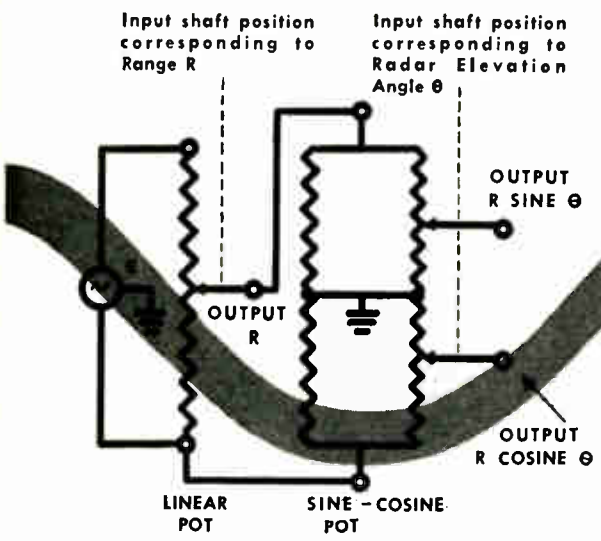

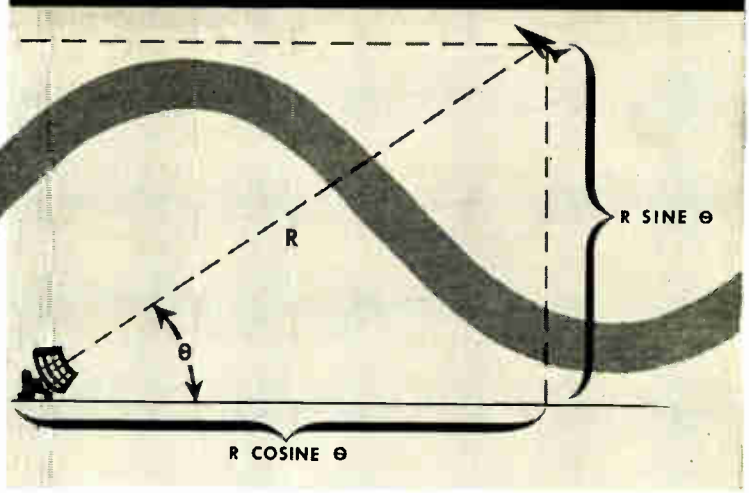

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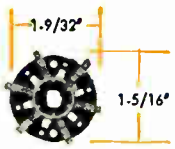
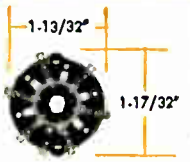
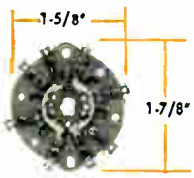


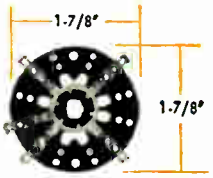
THROW: 30°, 45°, 60°, 90°
INSULATION: phenolic, Mycalex, ceramic



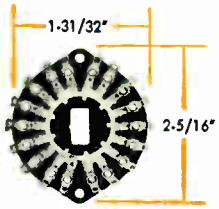
THROW: 25.7°, 30°, 36°, 45°, 60°
INSULATION: phenolic, ceramic



THROW: 18°, 20°, 30°, 36°, 45°, 60°, 90°
INSULATION: phenolic, Mycalex, ceramic

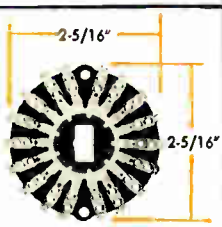


THROW: 30°, 36°, 45°, 60°, 90°
INSULATION: phenolic, Mycalex, ceramic

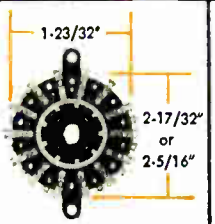


THROW: 20°, 40°
INSULATION: phenolic

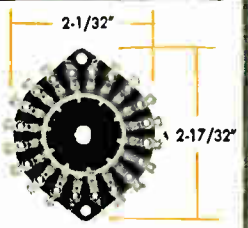
THROW: 15°, 30°
INSULATION: phenolic



THROW: 20°, 40°
INSULATION: phenolic, Mycalex



THROW: 12.85°, 25.7°
INSULATION: phenolic



THROW: 12.85°, 18°, 25.7°, 36°
INSULATION: phenolic

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STANDARD COMMERCIAL—Punched steel parts are lead-coated, cold-rolled steel. Parts such as nuts, lockwashers, etc., are cadmium-plated steel. Shafts may be cadmium-plated steel, brass, or aluminum. Brass parts are unplated.

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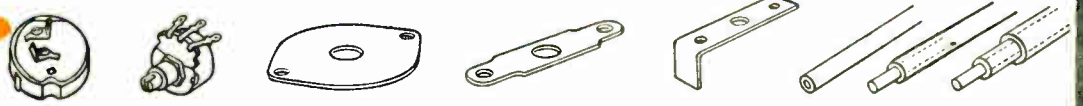

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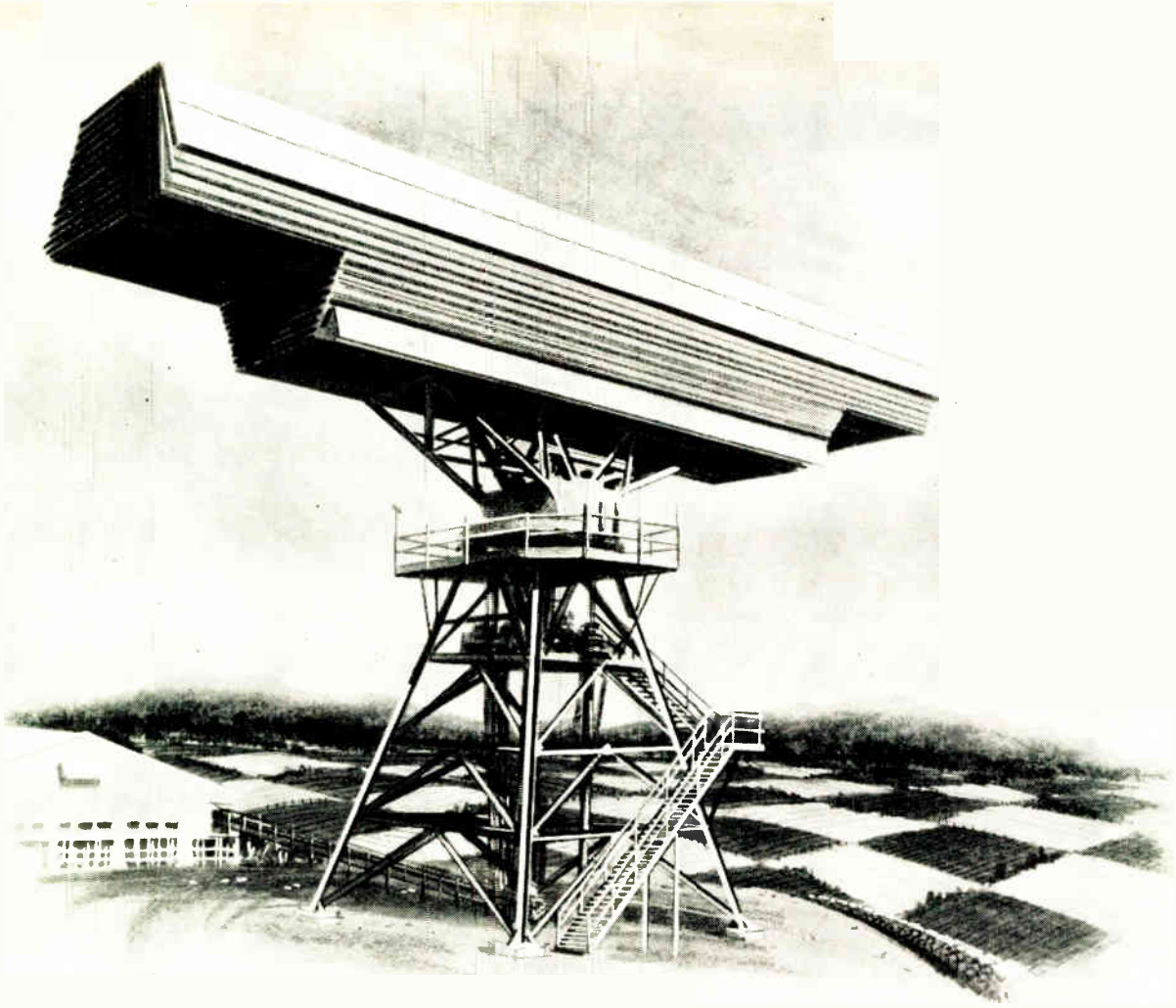
When your design calls for a low-power rotary switch, you want a unit that matches job requirements exactly—not an "almost" fit. But in the process you don't want the switch to involve a lot of extra tooling and delay either. At Oak, the above options, plus numerous other alternatives in construction, are *pretooled* for economy, service, and convenience.

Specify your low-power switches the easy way—from the most diversified, the most "ready-to-go" line available.



CHESSMAN . . . 1960

New orders of power through Amplitron transmitter application. New frequency areas. Ferrite mechanisms. Sophistication in receiving and data processing techniques. This is advance technology at Raytheon Heavy Electronics.

Developments in such areas are already incorporated in these Heavy Electronic long range radars, ordnance and communications systems:

AN/FPS-28 800-ton warning system for SAGE network.
96-voice channel pulse-code-modulation equipment.
Two-gun MEMRAD Bright Display.
AN/SPG-51 radar for Tartar Missile fire control system.

Each development evolved from imagination . . . technical command . . . experience — the qualities we always seek.

Select positions may be investigated by writing: Mr. Donald H. Sweet, Executive & Engineering Placement, Raytheon, 624W Worcester Road, Framingham, Mass. (suburban Boston).

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GOVERNMENT EQUIPMENT DIVISION

RAYTHEON
EXCELLENCE IN ELECTRONICS

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Earnings Keep Going Up

EARNINGS REPORTS continue to reflect the upward profit trend most electronics companies are enjoying this year. Among these are:

• **Sonotone Corp.,** Elmsford, N. Y.—reports for the nine months ended Sept. 30—the highest sales and earnings for any comparable period in company history. Net sales in this interval amounted to $18,271,000, an increase of 14 percent over 1958's $15,980,000. Net earnings for the 1959 period were $829,201, a 54-percent rise over net earnings of $539,424 in 1958.

• **Avnet Electronics,** Westbury, L. I., announces sales for its first fiscal quarter ended Sept. 30 were $2,132,091 and profits were $255,713. This is equivalent to 34 cents a share. For the same period last year, sales were $1,345,246, profits $161,002. Since Avnet was not publicly owned last year, earnings per share are not reflected for 1958.

• **Hallicrafters Co.,** Chicago, ended an eight-month fiscal period this year with sales up 21 percent from the same period in 1958. Net sales for the first eight months of 1959 were $15,904,952 as against $13,093,550 in 1958. Earnings this year rose 113 percent from 1958's $225,152 to $480,602. W. J. Halligan, Hallicrafters' president, said earnings for the first eight months of 1959 approach total 1958 figures.

• **Astron Corp.,** East Newark, N. J., reports net sales for the nine-month period ended Sept. 30 were $3,512,292, as compared with $2,944,750 in the same period in 1958. Earnings were down this year to $14,108, as compared with $19,329 in 1958. This is due to capital expenditures made in late 1958 and early this year to expand production and research facilities, says Joseph Frank, Avnet's president.

• **Clevite Corporation,** Cleveland, terms third-quarter results for this year "outstanding". Sales reached $19,651,000, and net profits were 73 cents per share. In 1958, comparable figures were $15,048,000 and 49 cents, respectively. Total sales for the first nine months of 1958 were $46,922,000, and $62,448,000 for this year. Nine-month profits for 1959 were $9,833,000, as against $3,914,000 for 1958.

• **Litton Industries,** Beverly Hills, Calif., reports first fiscal quarter sales of $36,400,000, up from $27,080,000 for the same period in the previous year. The 34-percent increase in sales was matched by a 35-percent increase in earnings. Earnings totals were $1,537,000 for the new quarter, as compared with $1,136,000 last year. Earnings per share on the 1,835,000 shares outstanding amounted to 82 cents, as compared with 64 cents a year ago.

25 MOST ACTIVE STOCKS

WEEK ENDING NOVEMBER 20

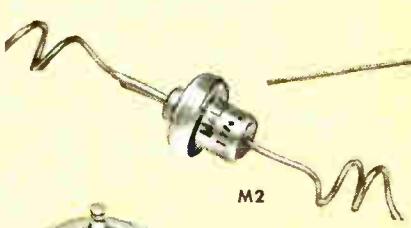
	SHARES (IN 100's)	HIGH	LOW	CLOSE
Elec & Mus Ind	5,768	12¼	10⅞	11½
Avco Corp	2,956	15⅜	13½	14¾
Univ Control	2,782	20¾	17½	20¾
Clarostat Mfg	1,556	15¼	12⅛	14⅜
Int'l Tel & Tel	1,157	42½	40⅛	40½
Philco Corp	1,057	28¾	26¾	27½
Siegler Corp	1,016	34⅝	29⅜	34½
Sperry Rand	900	23⅝	22¼	23¼
Lear	839	20¼	18¼	18½
Int'l Resistance	801	19⅞	16	19½
Reeves Sndcrft	706	10¼	8¾	10
Varian Assoc	691	48¼	42⅞	48¼
Gen Dynamics	689	45¾	43⅝	44⅝
Gen Instrument	675	31⅞	28⅛	29⅛
Gen Electric	661	84	81¼	83¾
Ampex	638	134⅞	113½	134⅞
Barnes Eng	632	32¼	27½	32
Sonotone	624	16⅜	14⅜	15
Beckman Inst	572	67	63	65
Skiatron	572	6⅞	6	6
Magnavox	567	39½	34½	36½
Raytheon	502	52⅞	50⅛	51
RCA	498	66½	64⅝	66
Burroughs Corp	471	33¾	32¼	33⅝
Hoffman Electncs	453	31⅞	28½	31⅛

The above figures represent sales of electronics stocks on the New York and American Stock Exchanges. Listings are prepared exclusively for ELECTRONICS by Ira Haupt & Co., investment bankers.

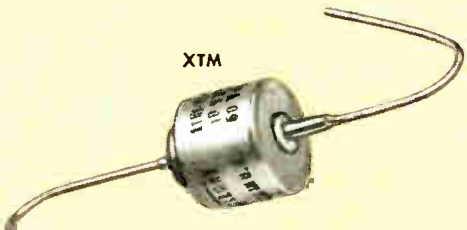
DIVIDEND ANNOUNCEMENTS

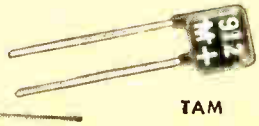
	Amount per Share	Date Payable
Amer Bosch Arma	$.30	Dec. 31
Hoffman Electrncs	.15	Dec. 11
Lockheed Aircraft	.30	Dec. 11
Standard Coil Prods	3%	Dec. 31

18,000-Hour Life



Type	Description	Capacity Range	W. Volts DC Rating at 85°C	Temperature Range	Case Style	Body Length	Body Diameter
HAT	Pellet Anode—Liquid Electrolyte	1-10 mfd.	16-1V.	—20 to +85 C	Metal Case—Axial Leads—Insulated Case	.210" max.	.075" max.
TAS	Pellet Anode—Solid Electrolyte	.33-330 mfd.	35-6V.	—80 to +85 C	Metal Case—Axial Leads	.250" to .750"	.125" to .341"
TAM	Pellet Anode—Solid Electrolyte	6.8-56 mfd.	25-6V.	—55 to +85 C	Dip Coated Resin—Upright Mounting	.175" thick	.313" square
TAF	Foil Anode—Semi-Liquid Electrolyte	.25-440 mfd.	150-3V.	—55 to +85 C	Metal Case—Axial Leads	.688" to 2.750"	.188" to .375"
STNT	Pellet Anode—Liquid Electrolyte	2-40 mfd.	50-3V.	—55 to +85 C	Metal Case—Axial Leads	.350"	.155"
TNT	Pellet Anode—Liquid Electrolyte	4-80 mfd.	50-3V.	—55 to +85 C	Metal Case—Axial Leads	.500"	.155"
TAP	Pellet Anode—Liquid Electrolyte	2-30 mfd.	90-6V.	—55 to +85 C	Metal Case—Axial Leads	.500"	.238"
TAP2	Pellet Anode—Liquid Electrolyte	11-140 mfd.	90-6V.	—55 to +85 C	Metal Case—Axial Leads	.660"	.238"
M2	Pellet Anode—Liquid Electrolyte	11-140 mfd.	90-6V.	—55 to +150 C	Metal Case—Axial Leads	.500"	.290" (Body) .484" (Flange)
XTK	Pellet Anode—Liquid Electrolyte	2-70 mfd.	340-8V.	—55 to +175°C	Metal Case—Axial Leads or Terminal	.438" to 1.313"	.650"
XTM	Pellet Anode—Liquid Electrolyte	4-140 mfd.	340-8V.	—55 to +175°C	Metal Case—Axial Leads or Terminal	.563" to 1.781"	.650"
XTL	Pellet Anode—Liquid Electrolyte	3.5-120 mfd.	630-18V.	—55 to +200°C	Metal Case—Axial Terminal	.500" to 2.595"	.875"
XTH	Pellet Anode—Liquid Electrolyte	7-240 mfd.	630-18V.	—55 to +200°C	Metal Case—Axial Terminal	.688" to 4.063	.875"
XTV	Pellet Anode—Liquid Electrolyte	18-1300 mfd.	630-30V.	—55 to +175°C	Metal Case—Axial Terminal	.563" to 2.750"	1.125"
XTO	Pellet Anode—Liquid Electrolyte	7-240 mfd.	630-18V.	—55 to +200°C	Metal Case—Axial Terminal	.563" to 2.750"	1.125"





Tests Prove Reliability

of Mallory Tantalum Capacitors

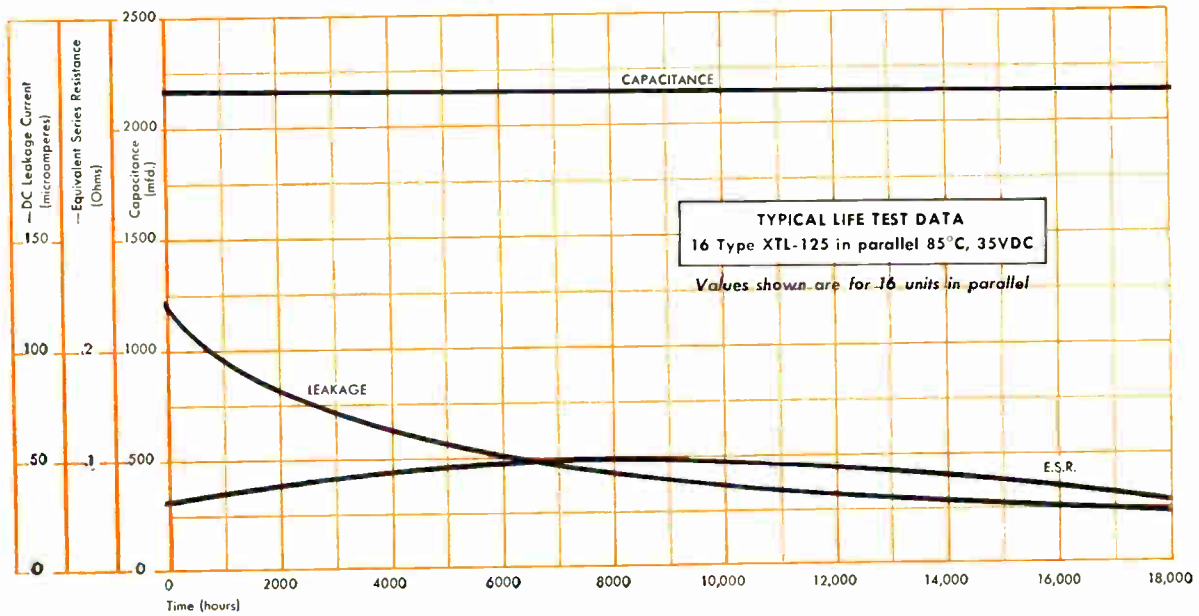
The real measure of reliability is the proved ability to "take it." And that's what you get with Mallory tantalum capacitors. Latest proof of Mallory performance is a series of life tests recently completed. Longest of the tests, made on 16 production samples of XTL-125 capacitors, ran for 18,000 hours at 85°C with rated voltage applied to parallel connected capacitors.

Not a single capacitor failed. At the end of the test, capacitance and equivalent series resistance measured essentially the same as the day the test began. DC leakage current decreased from 125 to 25 microamperes.

In the laboratory, Mallory tantalum capacitors are further checked by 100% inspection tests, and by electrical tests under MIL-C-3965B and 2000-hour life tests at elevated temperatures made on random samples from production lots. In the field, Mallory tantalum capacitors have built a reputation for trouble-free service during the ten years that we have been manufacturing them.

Pioneer in tantalum technology, Mallory makes 15 different tantalum types to match your requirements . . . ranging from micro-miniature to high capacity units. Many are available in 200°C ratings, introduced commercially by Mallory a decade ago.

Write for complete data, and for a consultation on your specific circuit requirements.



Mallory Capacitor Company
Indianapolis 6, Indiana
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Serving industry with these products:

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- Capacitors
- Batteries
- Resistors

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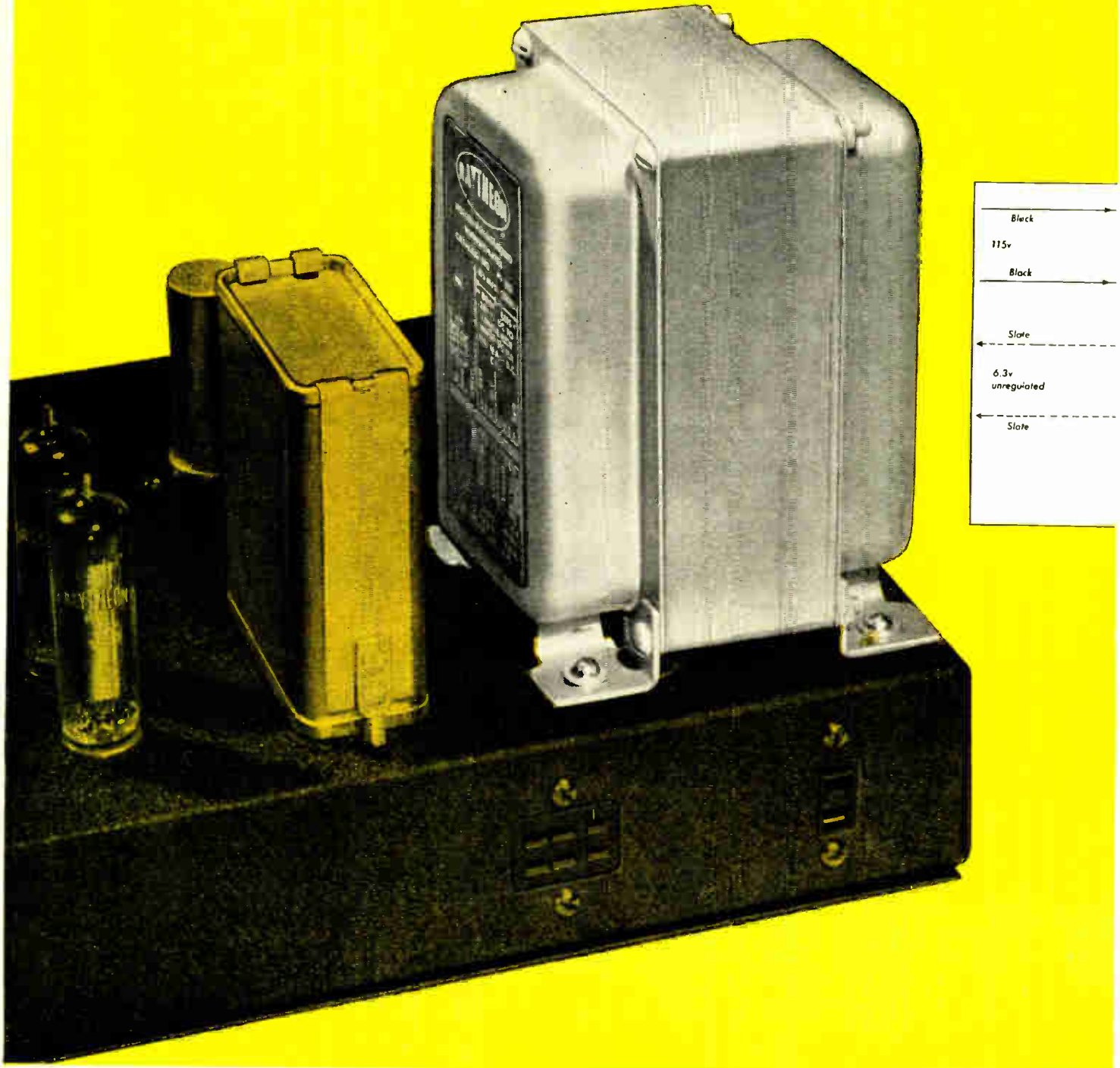
Electromagnetic
- Vibrators
- Relays
- Choppers

Electronic Assemblies
- Power Supplies
- Tuning Systems

Metallurgical
- Contacts
- Powder Metallurgy Materials
- Welding Materials
- High Density Metals

Semiconductor
- Silicon Rectifiers

Raytheon Voltage Regulating PLATE-FILAMENT



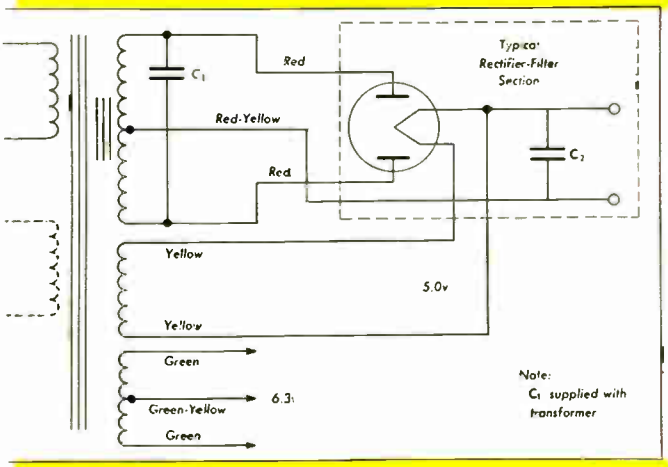
TRANSFORMERS . . . . . .

Transformers that regulate voltage to within ± 3%

This versatile Raytheon unit looks like a transformer, but does the combined job of transformer plus voltage regulator.

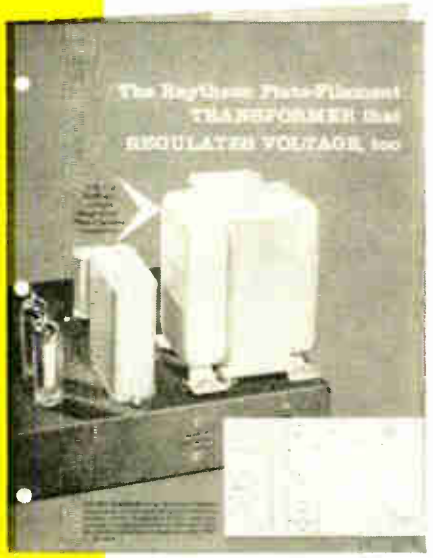
In a conventional power supply circuit, the voltage regulating transformer maintains a dc output voltage within ±3% with line variations of ±15%.

For custom requirements, please write our Applications Engineering Group for an answer to your particular need. Raytheon Company, Manchester, New Hampshire.



CIRCUIT DIAGRAM shows Raytheon Voltage Regulating Transformer in typical full-wave rectifier circuit. Three standard models with ratings up to 380 VDC @ 250 MA are immediately available from stock.

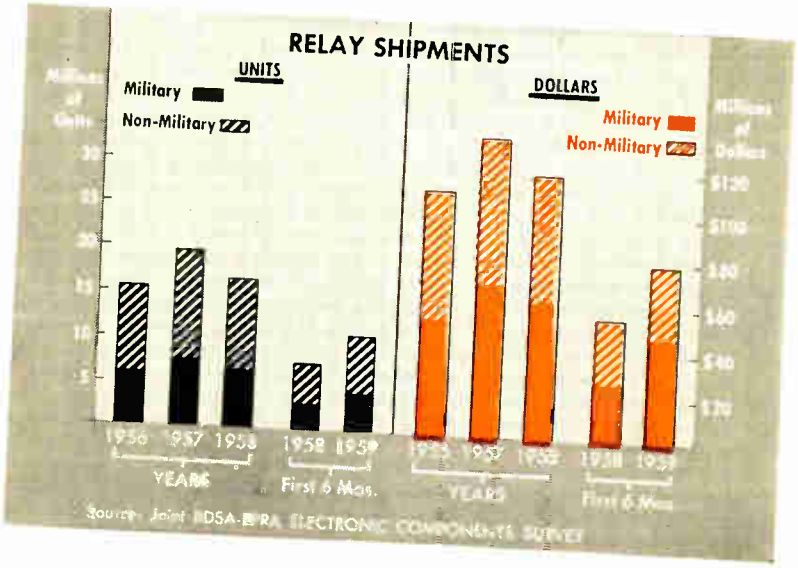
THIS BOOKLET GIVES YOU COMPLETE SPECIFICATIONS. For your copy plus a companion data booklet, write Raytheon, Manchester, N. H.



RAYTHEON COMPANY
Industrial Apparatus Division

RAYTHEON

Excellence in Electronics



Relay Market Shows Strength

RELAYS for electronic applications shipped during the first six months of 1959 were way ahead of the first half of 1958, according to the latest joint survey by Electronic Production Resources Agency and Business and Defense Services Administration.

Survey returns are of special significance at this time because they confirm previously reported opinions of manufacturers and others that the market for relays has suffered little from the development of solid-state switches.

Shipments of 11,071,000 relays worth $79,365,000 were made in the first half of 1959, the survey reports. In the first half of 1958, about 7,621,000 relays worth $54,384,000 were shipped.

Comparison of the figures shows a first half 1959 gain of about 45 percent in both dollars and units over the 1958 first half.

• **One Japanese transistor** is imported today for every 3.6 transistors produced in the United States, although imports began only three years ago, reports David R. Hull, president of the Electronic Industries Association.

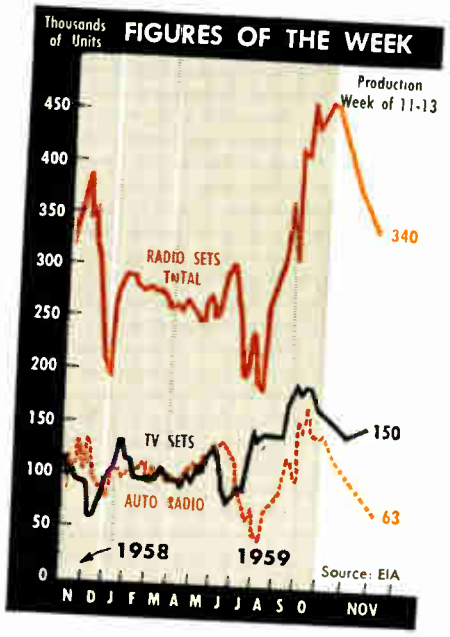
Within two years, Japanese penetration of the transistor radio market has increased five-fold and now equals 25 percent of domestic output, Hull adds.

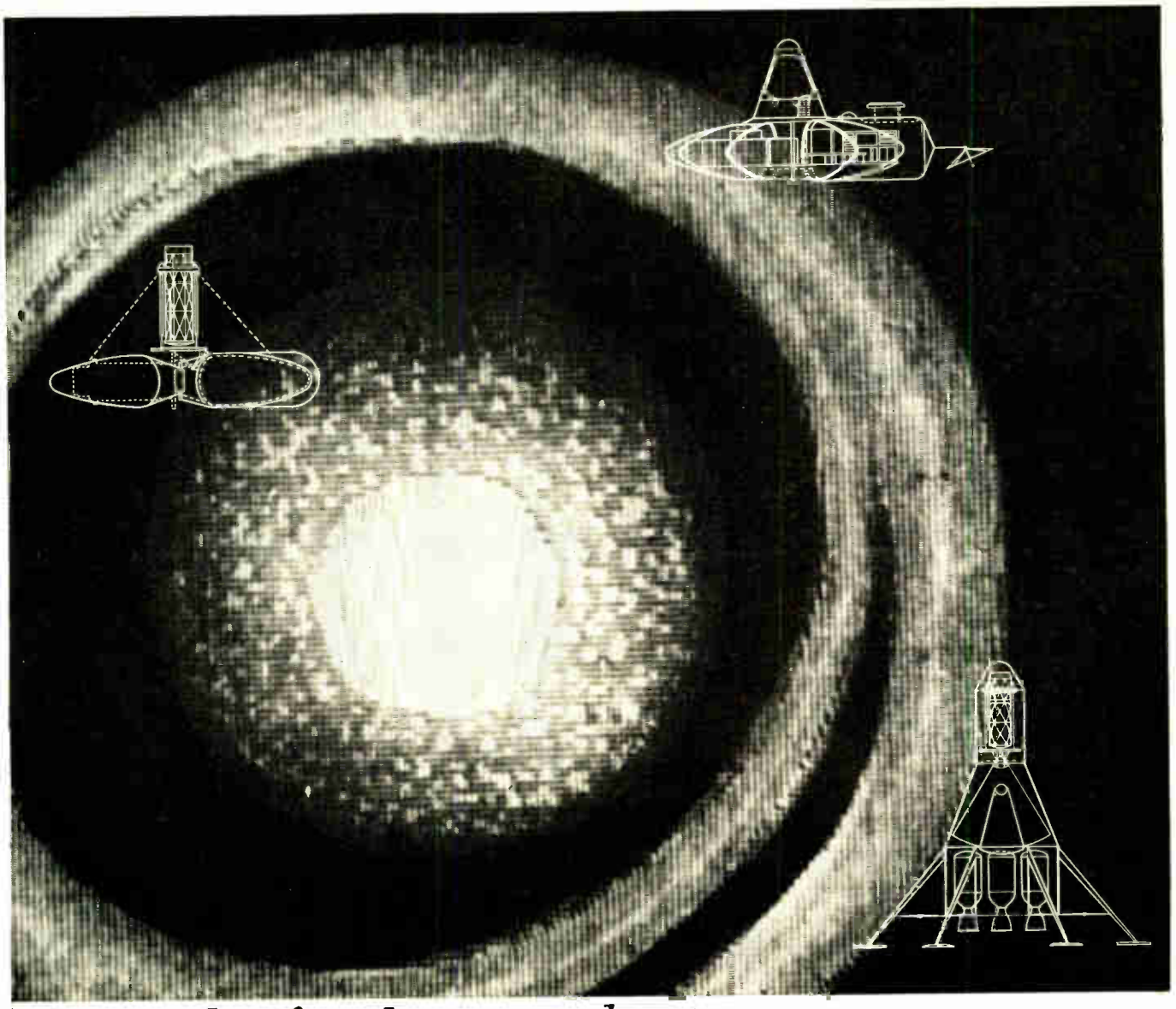
Speaking before a conference of the Joint Electron Devices Engineering Council, he said: "We regard transistor imports as merely the beginning of a general deployment of the Japanese electronics industry on the territory and into the defense potential of the United States."

LATEST MONTHLY SALES TOTALS

(Add 000)

(Source: EIA)	September 1959	August 1959	Change From One Year Ago
Rec. Tubes, Value	$34,594	$29,974	+ 1.9 %
Rec. Tubes, Units	41,989	35,435	+ 4.81%
Pic. Tubes, Value	18,066	15,494	−13.2 %
Pic. Tubes, Units	914	823	−14.7 %
Transistors, Value	20,851	18,054	+92.8 %
Transistors, Units	8,653	7,130	+70.5 %





New styles for the man-about-space

Every time a space traveler leaves home (earth), he has to wrap himself in the complete environment necessary to his physiological and psychological well-being. Styling sealed space capsules to suit man's every requirement has been a major project at Douglas for more than ten years. Forty basic human factors areas were explored in these studies. Now Douglas engineers have evolved plans for practical space ships, space stations and moon stations in which men can live and work with security thousands of miles from their home planet. We are seeking qualified engineers and scientists who can aid us in furthering these and other out-of-this-world but very down-to-earth projects. Some of our immediate needs are listed on the facing page.

Dr. Eugene Konecci, Head, Life Sciences Section, reviews a new concept in space cabin design with Arthur E. Raymond, Senior Engineering Vice President of **DOUGLAS**

MISSILE AND SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ DC-8 JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB ■ GROUND SUPPORT EQUIPMENT

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SYNCHROS · SERVO MOTORS · MOTOR TACH GENERATORS

400 Cycle: Many for 125°C operation . . . Higher for special applications

Many Immediately Available From Stock in Small Quantities

SIZE 8 SYNCHROS

Highly Stable. Minimum Error Variation from −55°C to +125°C

OSTER TYPE	CLASS	INPUT VOLTAGE	INPUT CURRENT AMPS	INPUT WATTS	OUTPUT VOLTAGE	PHASE SHIFT (° LEAD)	ROTOR RESISTANCE (OHM)	STATOR RESISTANCE OHMS	Z_{ro} OHMS	Z_{so} OHMS	Z_{rss} OHMS	NULL VOLTAGE (MV)	MAX. ERROR FROM E.Z. (MIN.)
4253-01*	LZ-CT	11.8	.087	.21	23.5	9.0	157.0	24.0	212+j722	28+j119	263+j69	30	±7
4269-01*	Diff	11.8	.087	.21	11.8	9.0	35.0	24.0	37+j139	28+j124	47+j13	30	±7
4273-01**	XMTR	26.0	.100	.54	11.8	8.5	34.0	12.0	48+j255	12+j45	82+j31	30	±7
4277-01*	HZ-CT	11.8	.030	.073	22.5	8.5	316.0	67.0	500+j1937	79+j350	594+j182	30	±7
4261-01**	Resolver	26.0	.043	.39	11.8	15.0	162.0	22.0	208+j612	34+j159	243+j77	30	±7

*Stator as Primary **Rotor as Primary

SIZE 8 SERVO MOTORS

OSTER TYPE	RATED VOLTAGES	Z = R + jX	IN. OZ. STALL TORQUE	RPM NO LOAD SPEED	WATTS PER PHASE	GM. CM. ROTOR INERTIA	LENGTH IN. MAX.	WEIGHT OZ.	T/I RATIO RAD/SEC²
5004-01	26V 26V	288 = 226 + j 176 294 = 238 + j 174	.15	6200	2.0	.47	0.863	1.2	22,500
5004-02	26V 36V	288 = 226 + j 176 526 = 409 + j 332	.15	6200	2.0	.47	0.863	1.2	22,500
5004-03	26V 40V	288 = 226 + j 176 715 = 582 + j 415	.15	6200	2.0	.47	0.863	1.2	22,500
5004-09	26V 40V	230 = 190 + j 131 519 = 399 + j 332	.20	6200	2.5	.47	0.863	1.2	30,000

SIZE 8 MOTOR TACH-GENERATORS

OSTER TYPE	RATED VOLTAGES	Z = R + jX	IN. OZ. STALL TORQUE	RPM NO LOAD SPEED	WATTS PER PHASE	GM. CM. ROTOR INERTIA	LENGTH IN. MAX.	WEIGHT OZ.	T/I RATIO RAD/SEC²	GENERATOR VOLTAGE	INPUT WATTS	OUTPUT VOLTS PER 1000/RPM
6204-01	26V 40V	230 = 190 + j 131 519 = 399 + j 332	.20	6000	2.5	.65	1.728	2.5	21,800	26	2.5	.25
6204-03	26V 26V	230 = 190 + j 131 230 = 190 + j 131	.20	6000	2.5	.65	1.728	2.5	21,800	26	2.5	.25

Oster®

The Size 8 400 Cycle Servo Motor Tach Generators listed above have 150° max. cont. frame temperature, 110 MA input current, ±5° phase shift and Null Voltage (Total R. M. S.) of 15 millivolts.

OTHER PRODUCTS INCLUDE:

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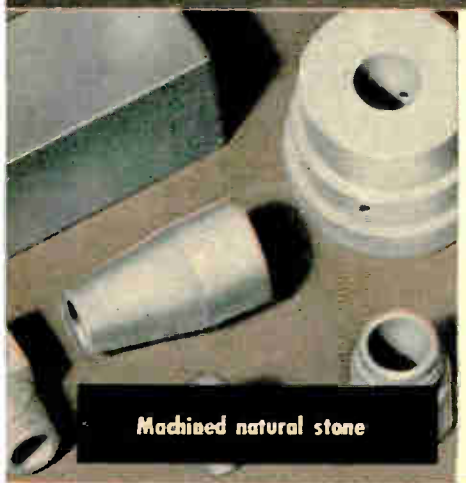
Engineers For Advanced Projects: Interesting, varied work on designing transistor circuits and servo mechanisms.
Contact Mr. Robert Burns, Personnel Manager, in confidence.



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the widest variety of technical ceramics from any single source

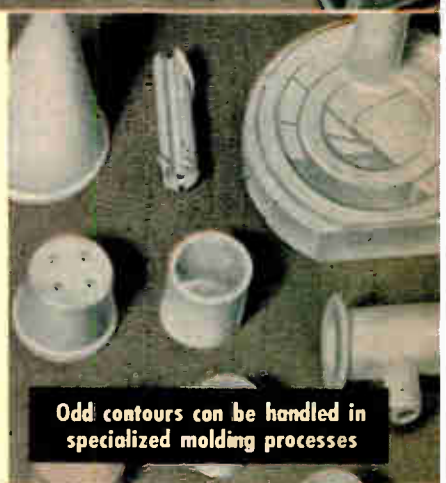
Specialized engineering talent in depth • The quantity you need . . . deliveries and quality as agreed • Special speedy service on prototypes • Specialized equipment for smaller quantity production • Unequaled facilities for volume production when you really need volume.

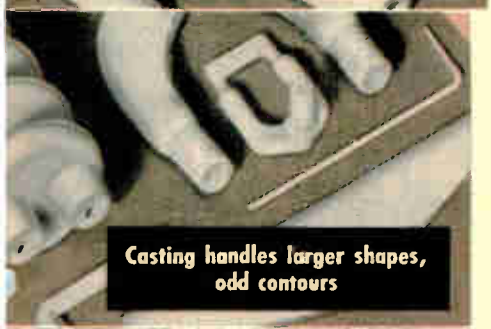
from one source . . .

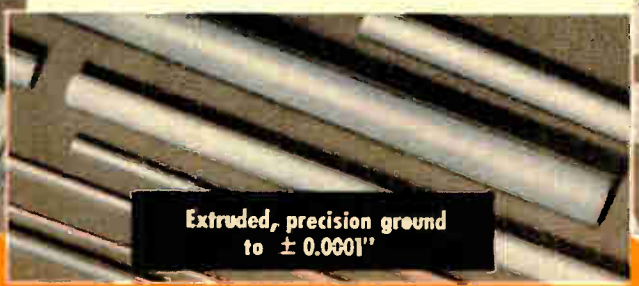
These are typical samples picked up in our Inspection Department over a week end. They illustrate the great variety of technical ceramics constantly flowi g through our ultra-modern plants.

Parts are shown approximately ½ size.

Property Chart Sent on Request.







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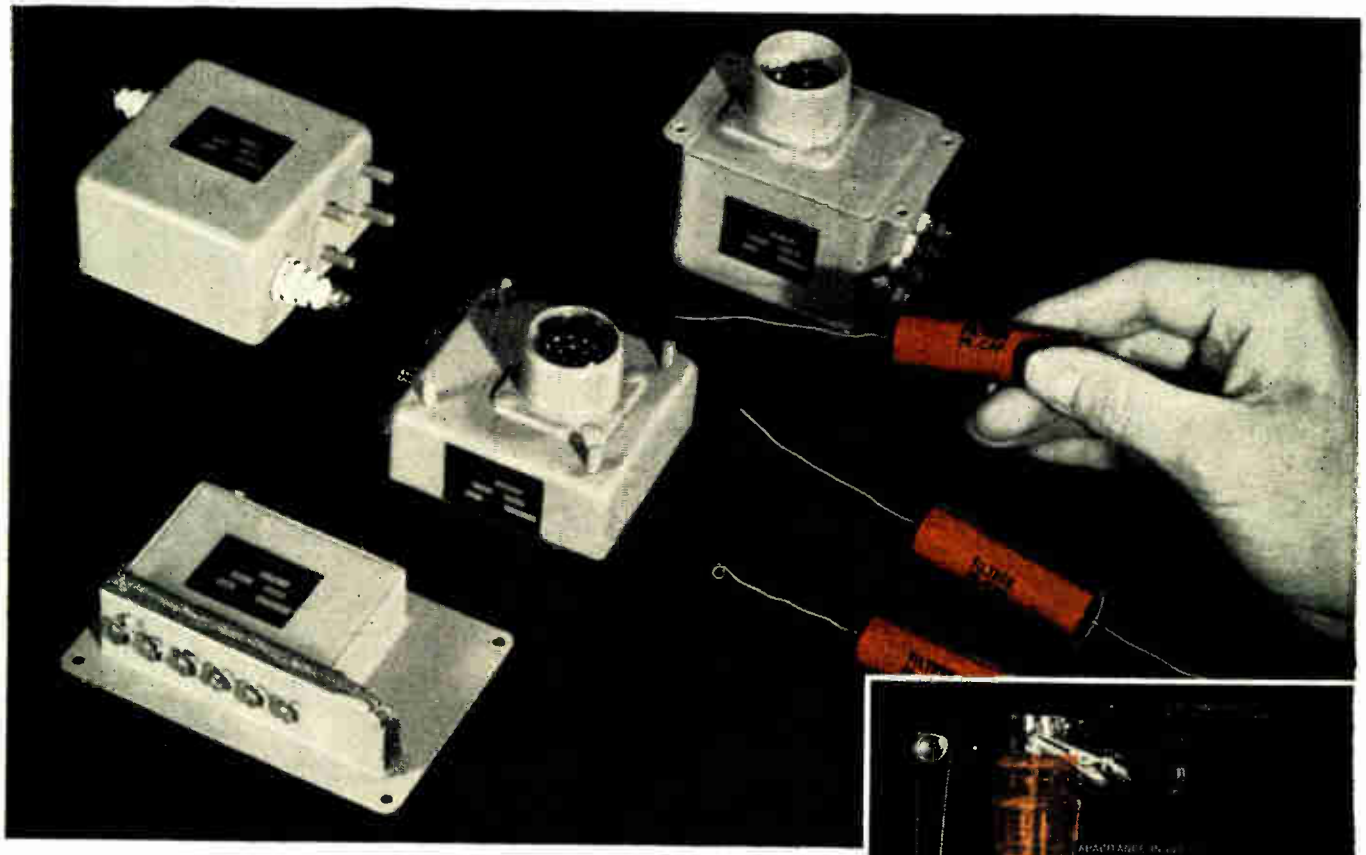
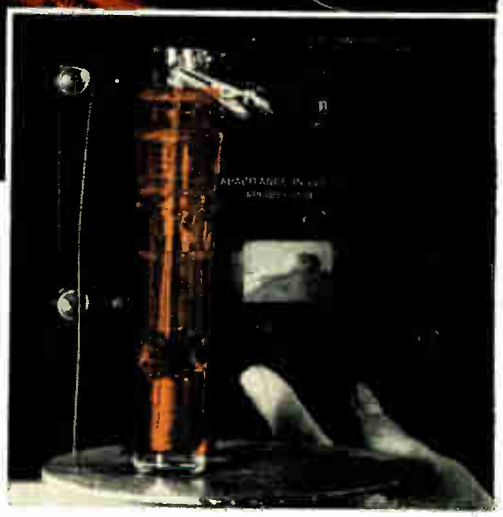
All other export: Minnesota Mining & Manufacturing Co., International Division, 99 Park Ave., New York, N. Y.

Plan For Uniform Performance





Low Power Factor and Constant Capacity Assured by Dow Corning Silicone Fluids

Here's an example of value engineering with silicone fluids:

The Filtron Co., Inc., of Flushing, N. Y., manufactures RF interference filters and capacitors for both military and commercial use. To assure an almost constant capacitance vs temperature relationship for their specialty capacitors . . . and the lowest possible power factor for their RF interference filters . . . Filtron engineers impregnate them with Dow Corning silicone fluids.

Silicone fluids are, in themselves, excellent dielectrics. In capacitors and RF filters such as these, silicone fluids boost the performance of the paper dielectric . . . substantially increase permissible operating temperatures, decrease electrical losses. Highly stable to changing environments, silicones show little drift in electrical or physical properties over a broad range of temperature and frequency conditions. They add greatly to reliability . . . often eliminate costly compensating circuits.

Dielectric-Coolants . . . Silicone fluids also make highly effective heat transfer media. Because of their relatively constant viscosity, their pumping rate does not vary appreciably at differing temperatures. They're nonoxidizing, nongumming . . . can be sealed in for the life of the equipment. Electric grade fluids may be cycled directly over operating assemblies.

Typical Dielectric Properties of 200 Fluid, 100 CSTK.

Property	Temperature —55 C	23 C	200 C
Dielectric Constant,			
1.0 kcs.	3.1	2.7	2.3
0.1 mcs.	3.1	2.7	2.3
Dissipation Factor,			
1.0 kcs.	0.0005	0.00004	0.001
0.1 mcs.	0.0002	0.00001	0.0003
Resistivity, ohm-cm	$10x10^{14}$	$2.0x10^{14}$	$1.0x10^{13}$
Electric Strength, dc, 20 mil gap v/mil	700	650	550

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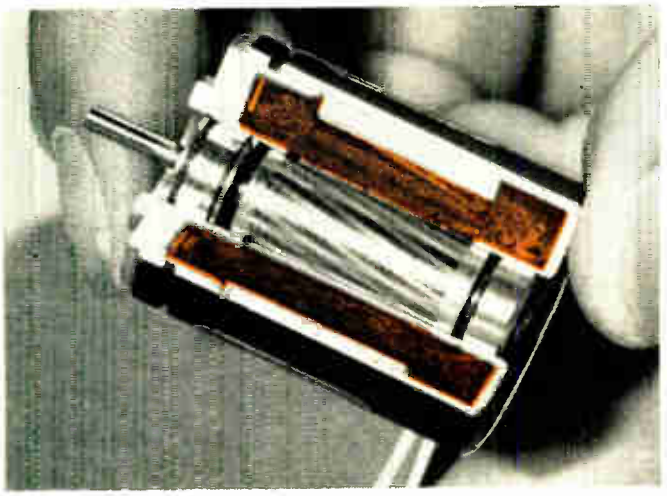

Solventless Resin Fills A Void

This servo motor, made by G-M Laboratories, Inc., Chicago, must withstand high humidity and high temperatures in operation. On analyzing the requirements of size, weight and reliability, engineers at G-M Laboratories concluded that a silicone insulation system would permit the best design, so they impregnated the stator under vacuum with Dow Corning solventless silicone resin. This moisture-proof, heat-resistant material fills the coil interstices and sets up to a solid, bubble-free mass. It protects against vibration, oxidation, corona and moisture . . . provides good heat transfer.

Investigate Dow Corning solventless silicone resins for use as rigid potting, filling, impregnating or encapsulating materials. They're radiation resistant . . . can be used with inorganic fillers.

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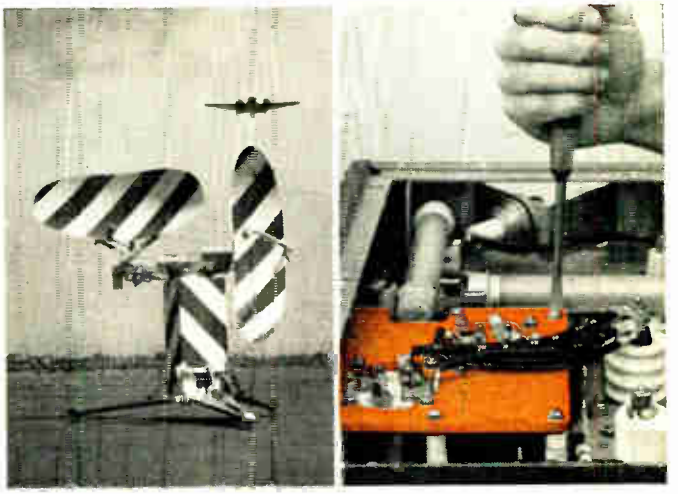

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Ground approach radar must provide the ultimate in reliability. That's why Gilfillan Brothers, Inc., of Los Angeles, use silicone-glass laminates in their Quadradar sets which are designed to provide vital flight information that facilitates ground controlled approach and landing of high speed aircraft.

Silicone laminates are specified because they have uniform dielectric properties under climatic and atmospheric conditions. Little affected by moisture, silicone-glass terminal boards prevent recurrent arcing even at high voltage and high humidity . . . provide low loss factor and low attenuation at RF frequencies. In addition, silicone laminates are strong and resist creep under pressure of fasteners; and, when needed, their heat resistance is exceptional . . . up to 250 C continuous for years on end.

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This transistorized oscillator, produced by Delta-f, Inc., Geneva, Illinois, is designed for use in airborne and transportable communications equipment. To protect against shock, Delta-f engineers use a flowed-on blanket of Silastic® RTV. It supplies needed cushioning, and is unaffected by the built-in heating element. Silastic RTV can withstand temperatures up to 260 C, down to —70 on the cold side. In addition, it resists moisture, oxidation, and other adverse conditions.

Silastic RTV is the Dow Corning fluid silicone rubber that vulcanizes at room temperature. Easy to use, it can be applied by dipping, pouring or with a caulking gun. When used as a potting material, it flows into place, filling all voids . . . sets up to form silicone rubber with excellent dielectric properties.

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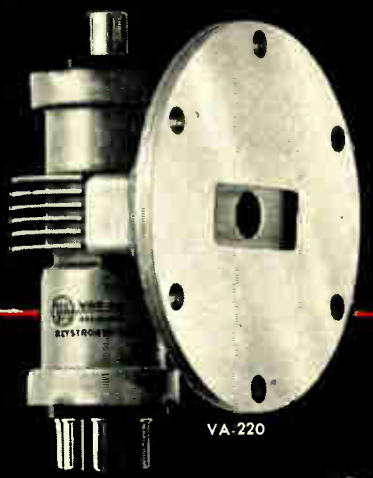

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VA-220C and VA-222C	6875-7125 Mc
VA-220D and VA-222D	6575-6875 Mc
VA-220E and VA-222E	6125-6425 Mc
VA-220F and VA-222F	5925-6225 Mc
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Germ-Gas Electronic Detectors

Civil Defense has no warning system against attack by chemical or biological agents. Soviets say they will use these in any full-scale war

By JOHN F. MASON, Associate Editor

THE COLD FRONT that brought snows to Montana and chills to most of the eastern U. S. last month could have put millions of Americans to bed with influenza or killed them with psitticosis.

Accomplishing this would have been easy.

One or two aircraft could have seeded with pathogenic organisms the warm air that precedes the cold front. This could have been done far up in the Arctic.

Nerve gas that kills in minutes is not as easy to deliver. The source must be closer to the victims. Nevertheless, it too is a threat.

Soviet leaders have stated publicly that in the next war they will use thermonuclear, chemical and biological weapons. Russian writer Raymond Gorthoff says in his book *Soviet Strategy in the Nuclear Age:* "Such weapons can be released from suboceanic containers in the Pacific to 'ride' the prevailing winds covering the U. S."

The National Security Council has recommended that CBR (Chemical - Biological - Radiological Warfare be restricted to use only in retaliation. Some groups want this decision reversed and CBR elevated to membership in the accepted family of combat weapons systems.

What Chemical Warfare Means

The U. S. and the Soviets both possess psychochemicals that can convert agressive extroverts into cowering, useless neurotics. Other chemicals might cause defenders of a city to welcome the enemy with ludicrous hospitality or incapacitating fits of giggles.

These chemicals—derivatives of lysergic acid—attack nerve centers.

Both sides have lethal nerve gases—organic phosphorus fluorine compounds—producible in up to 20 combinations. Acting as an anticholinesterase, one nerve gas attacks the nerves around the heart, constricting and stopping it in a matter of four minutes.

Pellets of radioactive material can be released above the clouds to float down to an unsuspecting population below. This approach is unlikely, however, due to cost.

Chemical and biological agents can be delivered in many ways. A low-flying Snark-type missile could dump almost any of the agents over an airfield, town or cornfield ready for harvest.

Saboteurs could do the job with a thermos bottle emptied into a city's water supply, germs dusted into the ventilation system of an office building, or a few trucks armed with gas dispensers surrounding a Strategic Air Command base or a Bomarc air defense site.

Investigations by Army Chemical Corps and by university researchers have established that reproductive rates of microorganisms can be influenced by r-f energy. In the microwave spectrum, this effect can be negative; in the h-f spectrum, it is not only positive but highly frequency-specific. X-band energy, for example, inhibits yeast reproduction, but h-f energy in the 1-to-20-meter band stimulates growth of many microorganisms.

The reaction apparently is not a function of heat, but seems to be due to electrical fields acting on the microorganism.

Researchers have proved that ultrasonic energy also effects reproductive rates of microorganisms. This effect too seems to be frequency specific.

Short-wave r-f and ultrasonic energy also change the reaction times of many enzymes. Uhf energy can denaturate proteins.

Electronics: Vital for Detection

At present the Chemical Corps has prototypes of warning devices for biological warfare and chemical warfare agents. Civil Defense has no warning devices for either.

The BW warning system consists of three components: an air sampling device developed by the Chemical Corps and the Armour Research Foundation called the aerosoloscope; a particrome analyzer; and an automatic colony counter and microculture counter, developed by

Field tests of chemical, biological and radiological warfare agents require elaborate electronic instrumentation

Needed

DuMont. The entire complex fills a large room. The Corps would like a transportable trailer system.

The aerosoloscope electronically measures and counts airborne particles—including radioactive fallout—ranging in size from one micron to 64 microns at the rate of 100 per second. Here's how it works:

The dust particles seen in a shaft of light are only reflections of the particles themselves. The reflection caused by the light is detected by a multiplier phototube that determines the size of each particle. Electrical impulses are amplified and transmitted to 12 dials. The first dial records the number of particles one to 1.4 microns in diameter. Each succeeding dial records slightly larger particles.

The next step is to identify whether the particles are dust, pollen or germs. The output of the aerosoloscope is fed into the partichrome analyzer. The particles are stained with a blue dye. When viewed under ultraviolet light, BW germs fluoresce blue while dust and pollen fluoresce green. A tv camera using sensitive color filters automatically counts the blue and green particles. A sudden increase in blue particles reveals the presence of a large concentration of germs.

Particles are fed into an automatic colony counter for electronic counting in one second.

The counter uses rectangular plastic strips, each perforated with 994 holes. The strip is photographed and the film examined by a tv scanner which counts the number of holes containing bacteria.

Probe 10-Micron Area

For long-range detection of chemical agents, the Corps is looking for efficient and sensitive infrared detectors that will operate in the 10-micron area. Eastman Kodak is studying use of zinc gold-doped germanium phototransistors.

Prototype of a ¼-mi to 5-mi-range infrared device has been developed by the Corps and Farrand Optical Co. for use by troops in the field.

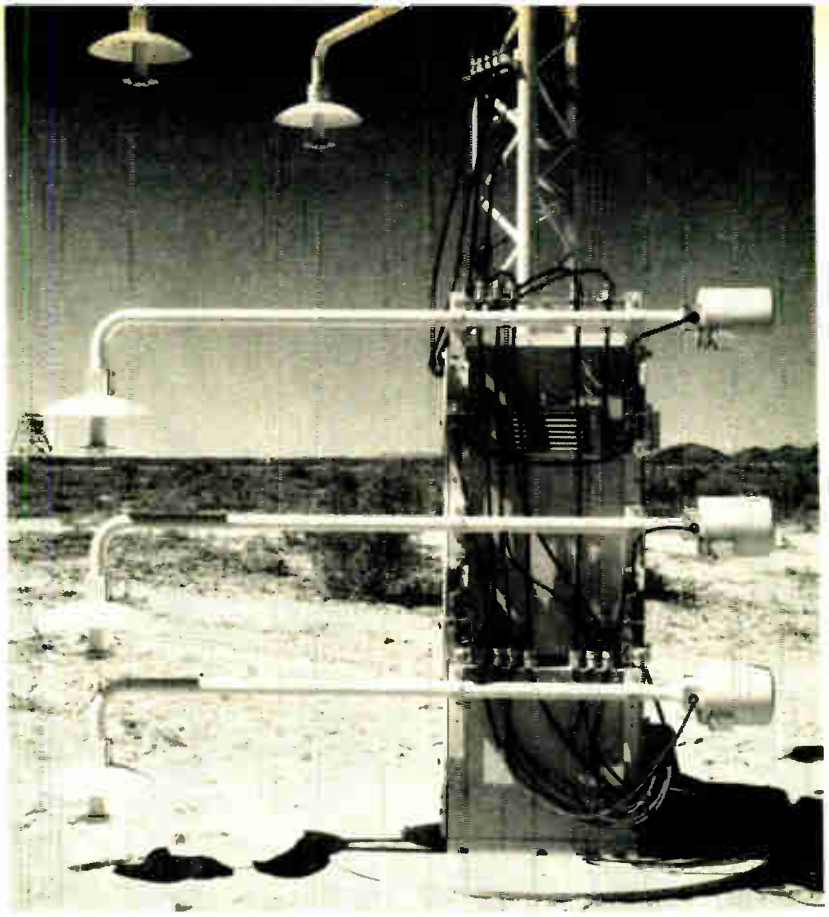
Called LOPAIR (for long-path infrared), the equipment is based on the i-r spectrometer. When a tiny amount of contaminant in the air crosses an i-r beam, a warning light flashes and a horn sounds. Contaminants are detected even if they are colorless and invisible to the naked eye, as nerve gas is.

The system can detect and measure almost any substance by its i-r spectrum. Once the alarm has been set to detect one specific substance, however, it will normally not be set off by other materials present.

The equipment will not sound the alarm if a person, animal or vehicle breaks the i-r beam.

The present system uses mirrors to set up a beam pattern.

The Army would like to circumvent using the mirrors. The setup requires precision and, in a tactical area, might be dangerous. With a more sensitive i-r detector, radiation could be reflected by natural objects, such as large rocks. An even more sensitive detector could receive natural i-f radiation emitted by the rock itself.



Precise meteorological data is automatically obtained on weather towers at the Chemical Corps Proving Ground and telemetered back to the master control center for analysis

Developing Dosimeter

The Corps is studying radiological warfare, investigating gamma and neutron shielding, and developing a tactical gamma-neutron dosimeter for use in field operations.

Research center for both CW and RW is the Chemical Warfare Laboratories, Army Chemical Center, near Edgewood, Md.

Main test work for BW, CW and RW is carried out at the U. S. Army Chemical Corps Proving Ground, Dugway, Utah. The proving ground includes meteorological towers, CW and BW samplers arranged in a grid pattern, telemetry network and central control center.

The weather towers continuously record temperature, barometric pressure, humidity and wind data. This information is telemetered to the control center every hour.

Samplers are glass bottles with small battery-run motors for taking in air and sealing the bottle; they are controlled remotely by radio.

The control center directs all sites by a master radio transmitter. Telemetered data from the weather towers and test sites are automatically translated to punched cards and fed into a computer.

A radioactive test facility is under construction at Dugway which will use a radio-controlled rail system for sending instruments into contaminated areas.

New Biological Effects of R-F

Research programs demonstrate that all biological effects of r-f are not traceable to heat. Studies aim now at causes

NEW RESEARCH in biological effects of r-f energy is beginning to demonstrate the possibility that living organisms present significant nonthermal reactions to various portions of the radio spectrum.

(Up until the beginning of this year—as ELECTRONICS reported in "Researching Microwave Health Hazards," p 49, Feb. 20—the most significant effects reported were thermal in character and thus directly related to average power level. One clearly nonthermal phenomenon was the formation of pearl chains in certain types of cells in suspension, under the influence of high-frequency power at low levels. But other nonthermal effects were extremely hard to trace, and many researchers hesitated to accept early and highly tentative findings.

(Research this year, however, has not only demonstrated nonthermal behavior, but also begun to educe theoretical explanations for it.)

The Marching Protozoa

Dramatic evidence of electrical influence on living matter has been presented by John H. Heller of the New England Institute for Medical Research. In his work, he has influenced the migratory behavior of unicellular organisms, produced chromosomal aberrations resulting in subsequent mutation, and produced a kind of split personality in large protozoa—amoebae and paramecia—in which their internal structure was oriented one way and their whole-body structure in another. In one repeatable experiment, he used this to sunder an amoeba violently, of course destroying it.

Heller's experiments were performed using a 1-to-100-mc variable-frequency oscillator. Voltage was continuously variable from zero to 20 kv. Pulse techniques were used, with pulses varying in width from 1 to 20 microseconds and rep rates varying from 30 to 10,000 per second.

Energy from the r-f source was coupled to two flat electrodes placed several millimeters apart. Specimens of particulate matter, bacteria or protozoa were placed between two cover slips, sealed with a silicone gasket, and the test chamber laid across the electrodes. Experiments were conducted at low average values of power, insufficient to heat the suspensions. Tests in the frequency range from 5 to 25 mc were most generally effective.

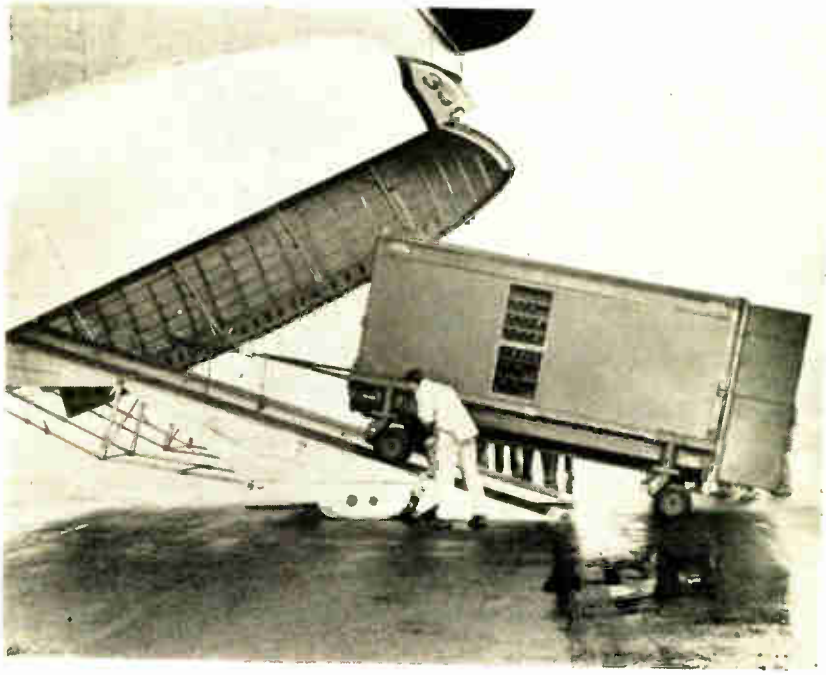
At lower frequencies, Heller reports, motile protozoa migrated parallel with the electrodes; at higher frequencies they switched and marched back and forth between the electrodes. Effective frequencies were quite specific for various organisms, so that at a given frequency, one species may march one way, another across the path of the first, and a third may be unmoved by the whole proceeding.

Mutant Garlic

Squashed garlic tips exposed to five minutes of r-f (about 6 mc) began, some 10 hours later, to exhibit aberrations in reproductive behavior, with the peak aberrancy occurring 24 hours later. Many cells could not properly reproduce: in some cases the nucleus divided—or almost divided—but the cell would not; in others the chromosomes scattered instead of remaining in a neat central nucleus; still other cells split but a chromatic bridge remained between nuclei, or the nucleus did not divide equally.

These chromosomal aberrations, Heller reports, appear to be frequency-specific. They also subsequently confirmed themselves as

Missile Control Center Goes Aloft



Battery control center for the Hawk missile system, Army's surface-to-air, semiactive radar homing missile, is loaded into a C-124 aircraft. Raytheon is prime contractor for the system; aluminum shelter is manufactured by Craig Systems, Inc.

Energy

permanent mutations.

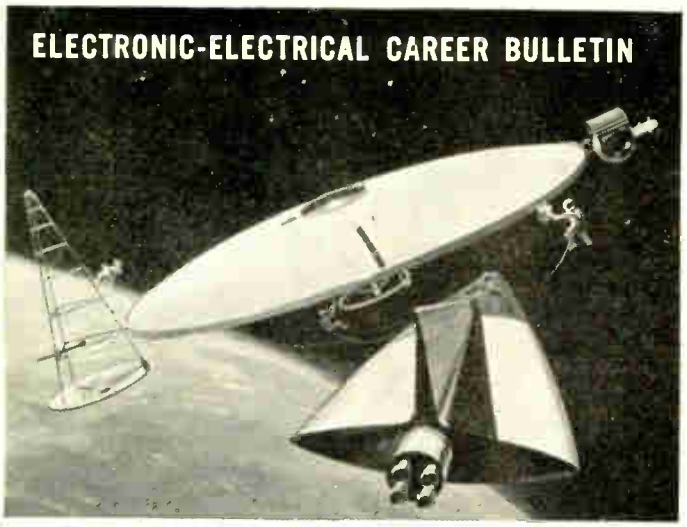
H. P. Schwan and D. W. C. Shen of the University of Pennsylvania's Moore School have evolved a theory that may eventually explain the marching protozoa. Certain advanced analytical investigations at the University of California at Berkeley may unriddle the mutation phenomena.

Schwan and Shen, continuing earlier investigations into the behavior of spherical particles in suspension, have applied the Maxwell-Wagner theory of inhomogeneous dielectrics to ellipsoidal particles in suspension. Their work demonstrates the frequency-dependence of the dielectric constant and conductivity of a suspension of membrane-covered ellipsoids. Dielectric constant falls irregularly with increasing frequency, and conductivity rises; the crossover point may be the point in the frequency spectrum at which the particles cease moving parallel to Heller's electrodes and begin moving across them.

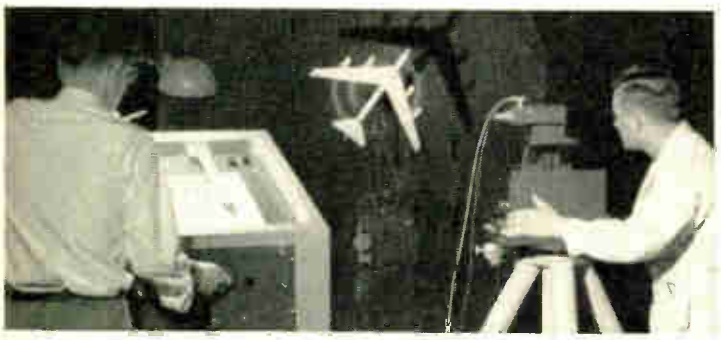
Investigations at Berkeley have established that the growth of microorganisms is stimulated by r-f irradiation. Other investigations show that X-band irradiation inhibits the reproductive and survival abilities of yeasts. Statistical evaluation of mutations has not yet been undertaken.

One investigator postulates that deoxyribonucleic acid, the memory constituent of individual cell nuclei, acts as a signal generator; that ribonucleic acid, another component of the nucleus, acts as an amplifier; and that enzymes or proteins act as effectors, obeying signals from the two acids. Signals are coded pulses in various regions of the spectrum, highly redundant to ensure data transfer, and recoupled by feedback loops. Cell membranes act as noise filters.

If this circuit analogy does exist, then r-f energy at frequencies high enough to bypass the cell-membrane capacitance can heterodyne the signals in the cells and affect the transfer of information.



MARS VEHICLE. Drawing, based on Boeing study, of space vehicle designed for launching from orbiting platform for reconnaissance flight to Mars and return. Lunar, orbital and interplanetary system studies, and expanding programs such as the advanced Minuteman solid-propellant ICBM, are typical of challenging, long-range assignments Boeing offers electronic-electrical engineers.



DARK TUNNEL. View in 100-foot dark tunnel, part of extensive Boeing infrared research and development facilities. Boeing investigations include use of infrared, visible and ultra-violet techniques for use in communication, navigation, detection and guidance at altitudes above tropopause. IR systems, inertial navigation, electrical power systems for satellites, shockwave radiation and refraction and irdome heating are other areas of assignments open at Boeing.

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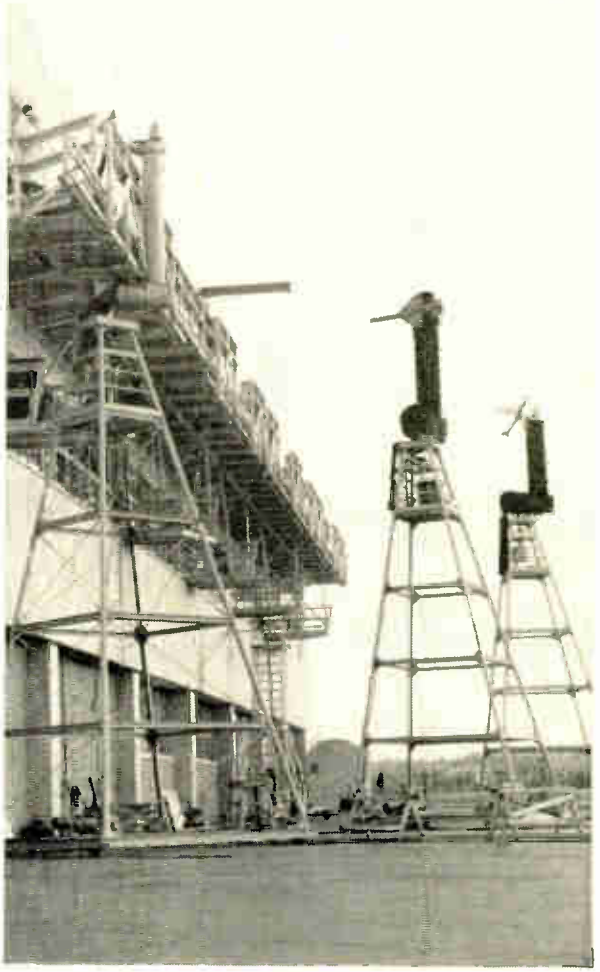

ANTENNA PATTERN RANGE, with movable towers capable of handling models up to 1000 pounds. Boeing has openings in ECM antenna development, and in gas, solid and liquid dielectric research, as well as large-aperture antennas for ASMs, orbital vehicles and airborne warning systems. Other openings are available in instrumentation, missile guidance and control.

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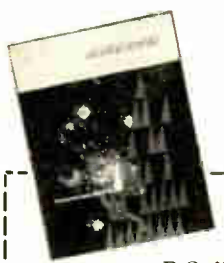

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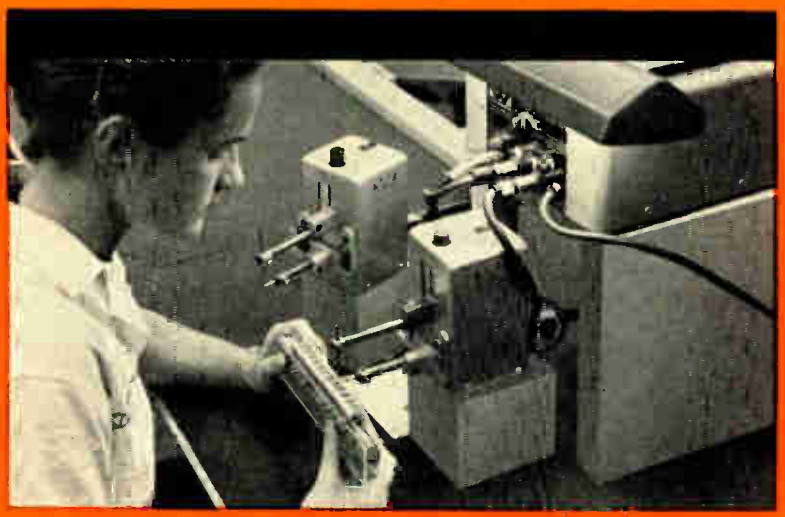

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IMAGINE reliability of only one reject in one million welds . . . no cold joints...no flux contamination...greater mechanical strength. FIND OUT how Weldmatic welding can help *you* with difficult metal-joining production problems.

(Above) Sippican assembler uses two Model 1032 Welding Heads and companion Weldmatic Power Supply in performing two separate welding operations on a "Weld-Pack" without changing electrodes or fixtures. (Right) Following wiring diagram on Mylar insulation sheet, operator welds nickel ribbon buss to both tinned copper resistor and dumet semiconductor leads in this computer logic stick.

WELDMATIC

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DIVISION OF UNITEK CORPORATION

New Russian computer, BESM-2, performs 8,000 mathematical operations per second while operating at calculating center of Moscow's USSR Academy of Sciences

USSR Improves Computers

Eight U. S. experts report that Soviet computer technology is moving up apace, still lags Western developments

BOSTON—SOVIET COMPUTER technology is advancing rapidly but appears still to lag the free world. That is the consensus of the members of an eight-man team of American experts who visited the Soviet Union last May. Report on team observations was disclosed here this week by Willis Ware of RAND Corp., speaking at the Eastern Joint Computer Conference.

The eight experts went to Russia as part of an exchange which saw eight Russians visit this country. The trip was sponsored by the Institute of Radio Engineers, Association for Computing Machinery, and the American Institute of Electrical Engineers.

Members of Team

The team was made up of Morton Astrahan, IBM; S. N. Alexander, Bureau of Standards; Lipman Bers, New York University; Morris Rubinoff, then with Philco, but now with University of Pennsylvania; Harry Goode, then of Bendix, now with University of Michigan; Paul Armer and Willis Ware, both of RAND Corp.; and Harry Huskey, University of California.

Several of the group, reporting their observations earlier to the Office of Naval Research, speculated that the Rusians may not have disclosed all of their latest computer developments and techniques.

Here are some of the team's observations:

Soviets lag in use of high-speed magnetic tape transports for input and output. Several Russian computers use punched movie-type film with eight data storage tracks, which provides 75 words per second. This is faster than punched paper tape, but substantially slower than magnetic tape input-output equipment.

Magnetic drums used as memory devices achieve storage density of about 100 bits per inch. Russians use a one-mil spacing between drum and read-write head. Heads are preheated before rotor is started to maintain a clearance between the drum and head when the drum expands.

Deposited-carbon resistors are used universally. One explanation is that fabrication of deposited-carbon resistors is a more easily mastered art than that of producing cheaper composition resistors.

Trouble With Transistors

Diffused-base transistors capable of operating at frequencies up to 120 mc were shown to the visitors. Russians, however, appear to be having trouble fabricating transistors with uniform characteristics.

Deposited thin magnetic films are being actively investigated by the Soviets. Best results have been obtained using an 80/20 permalloy with film thicknesses of about 2,000 angstroms.

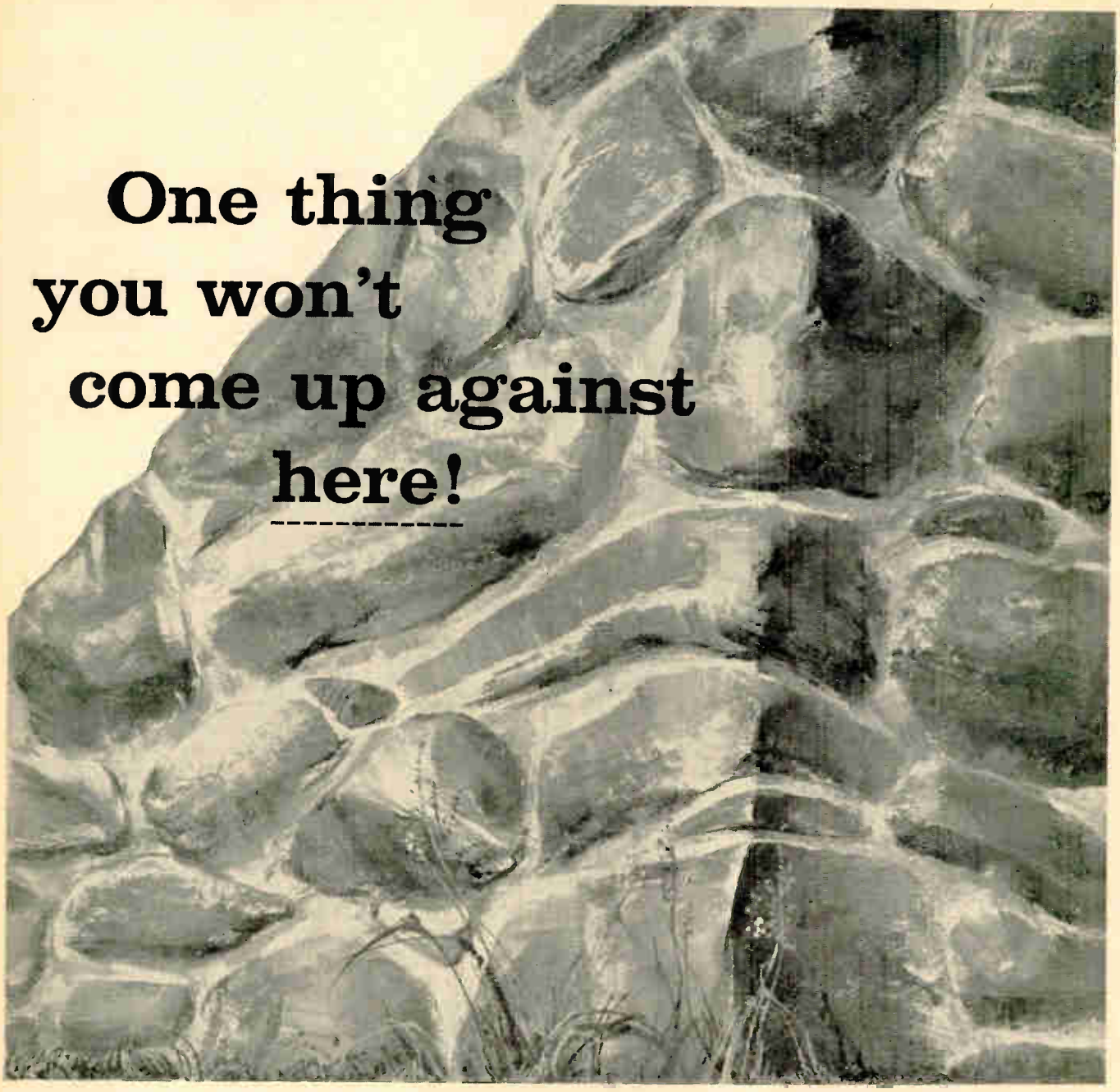
A high-speed printer capable of printing 50 lines per second is now under development. The machine is limited to numbers and does not print letters. Machine stores up to 10 lines at a time, prints them simultaneously.

Computer manufacturing techniques appear to be about on par with those in use in this country. No etched circuit boards were seen, but the Russians do make wide use of plug-in circuit modules.

One of the first large Russian digital computers is a machine that originally had an acoustic memory, later was changed to cathode-ray-tube storage and, still more recently, to ferrite-core memory. This computer can perform an average of 8,000 operations per second. An improved version of the earlier model is in the prototype stage.

A small digital computer operating at about 100 operations per second is in widespread use and has been exported in small numbers. More than 150 have been manufactured.

Small desk-size analog computers were much used in laboratories visited by the U. S. team.



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Packaging Engineers . . . with a knowledge of packaging and production techniques in sheet metal and electronic equipment. Will design electronic portions of guided missiles, radars, computers, test equipment. Should have thorough knowledge of circuitry.

Electromechanical Designers . . . will design electromechanical equipment and electronic portions of guided missiles, including coordination of effort through the shop. Will work closely with Design Engineers in developing electronic packaging philosophies. Knowledge of electronics, electronic components, and ability to read schematics required. Should have experience in sheet metal equipment design and knowledge of current "state of the art" in electronic equipment.

RAYTHEON MISSILE SYSTEMS DIVISION

New "METALLIZED" MYLAR Subminiatures

PROBLEM-SOLVING CAPACITORS for High density packaging

Good-All CAPACITORS

SPACE SAVING. Significant size reduction over film-foil and paper-foil designs can save vital space. The net volume saved increases with capacity value.

WEIGHT SAVING. The quantity of metal required for plates in these metallized Mylar* designs is less than 5% of that for an equivalent foil design. Weight saving increases rapidly as capacity value increases.

"EDGE MOUNTING". Because its cross-section is rectangular, Type X663F permits mounting with either the side or edge in contact with the chassis. Type X663FR is designed for edge mounting only.

SUPERIOR IR Insulation resistance of these rugged Mylar dielectric types far exceeds the IR obtainable from paper designs. (See curve below for actual performance.)

* DuPont's trademark for polyester film

X663F
AXIAL LEADS

X663FR
RADIAL LEADS

① TOUGH MYLAR CASE
② EPOXY END SEAL

INSULATION RESISTANCE. Greater than 30,000 megohm-microfarads at 25°C, but need not exceed 30,000 megohms
DISSIPATION FACTOR. Less than 1% when measured at or referred to 1000 CPS — temperature of 25°C
VOLTAGE RANGE. Available in 100, 200, 400 and 600 VDC

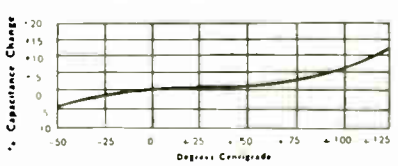
ACCELERATED LIFE TEST. 250 hours at +100°C and 125% of rated voltage
CAPACITANCE TOLERANCES. Standard tolerance ±20%, also available in ±10%, and ±5%
TEMPERATURE RANGE. Full rated voltage from −55 C to +100 C, to +125 C with 50% derating

TYPICAL SIZES-SHOWING THICKNESS • WIDTH • LENGTH

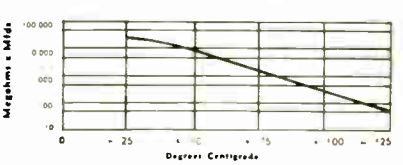
CAP IN MFDS	100 VOLTS T	W	L	200 VOLTS T	W	L
.01	.156	.203	3/4	.156	.281	3/4
.1	.250	.359	3/4	.250	.359	3/4
.33	.296	.484	1 1/16	.328	.500	1 3/16
.47	.359	.546	1 1/16	.343	.625	1 3/16
.68	.343	.515	1 1/16	.421	.750	1 3/16

CAP IN MFDS	100 VOLTS T	W	L	200 VOLTS T	W	L
1.00	.421	.593	1 3/16	.453	.687	1 3/16
2.00	.406	.718	1 1/4	.453	.734	1 3/16
3.00	.453	.765	1 1/4	.546	.903	1 3/16
4.00	.500	.890	1 1/4	.656	1.015	1 3/16
5.00	.484	.843	1 1/4	.625	1.250	1 3/16

Capacitance Change vs. Temperature



Insulation Resistance vs. Temperature



Write for literature on these NEW, "space-saving" types

GOOD-ALL ELECTRIC MFG. CO. OGALLALA, NEBR.

A LEADING MANUFACTURER OF TUBULAR, CERAMIC DISC AND ELECTROLYTIC CAPACITORS

What's Next for

Engineers at Radio Fall Meeting see transistors soon going in tv and f-m receiver front ends

SYRACUSE, N. Y. — Transistors soon in tv and f-m receiver front ends. That was the big news at last month's Radio Fall Meeting here. Interest in semiconductor trends brought more than 350 engineers to the meeting.

The three-day affair was sponsored by the Electronic Industries Association engineering department, with participation by Institute of Radio Engineers professional groups on reliability and quality control, electron devices, and broadcast and television receivers.

A highlight of the program was the transistorized tv tuner session: Victor Mukai, General Instrument Corp., presented design notes on a transistorized vhf tv tuner; Karl Whittig, Standard Coil Products Co., described transistorized tv and f-m tuners; and H. F. Cooke, Texas Instruments, Inc., discussed developmental work he and colleague R. R. Webster had done with mesa transistors and tv tuners.

Cite Performance, Cost

Improvement in performance of both microalloy diffused and mesa transistors, and continuing reduction of cost, were cited by panel members as reasons for their use soon in front ends of tv and f-m receivers.

Whittig said Standard Coil was pleased at the high rate of interchangeability it was having with transistors and that the devices had brought tuner costs down. Cooke noted good uniformity in mesa transistor production and predicted

Busy Communications 'Turrets'

Army Combat Development Experimentation Center, Ft. Ord, Calif., uses high frequency radiotelephones to collect real-time tactical data from experimental areas. Field messages are sent to a retransmission station. From there, 30 channels are combined by multiplex equipment and transmitted by microwave to the control center

Transistors

a 3-kmc limit for the device because of the small size in which it can be mass-produced. Also anticipated by the panel were 2-transistor f-m tuners.

Statements from the audience indicated the belief that tunnel diodes were still too early in the development stage to be considered in tuner design.

"Tunnel diodes now cost like diamonds—we're trying to get them down to gold," observed one engineer.

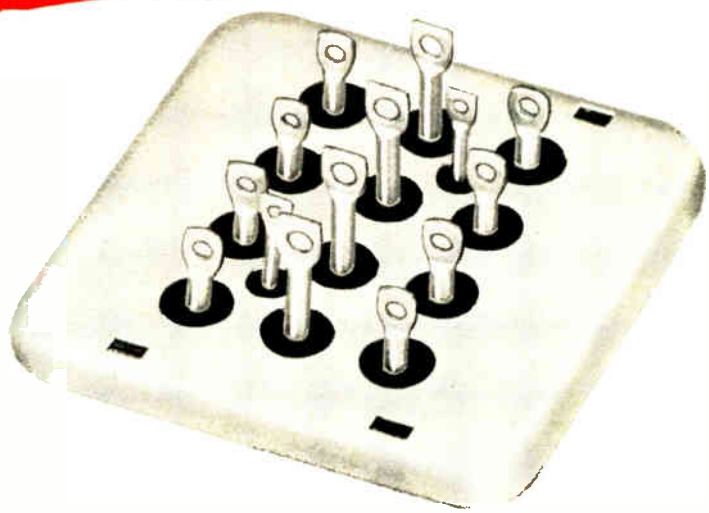
At the transistorized tv receiver session R. B. Ashley, GE, described a transistorized linear vertical deflection system; L. J. Mattingly, Motorola, discussed a receiver sound section using transistors; J. G. Humphrey, GE, presented a transistorized i-f amplifier; and C. D. Simmons and C. R. Gray, Lansdale division of Philco, described the video processing circuits of an all-transistor receiver. A. R. Curll, Philco, displayed a working model of a 21-transistor battery-operated receiver.

Applications, Trends

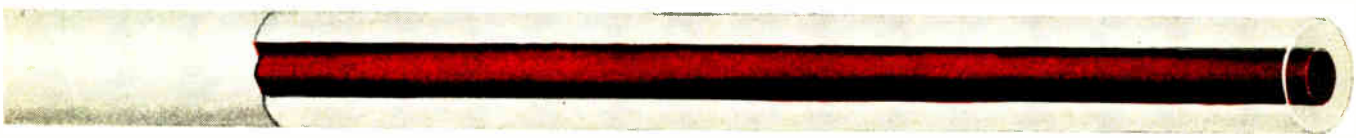
Transistorized a-m/f-m and auto radios were assigned a special session: H. Van Abbe, Amperex, described an integrated a-m/f-m portable; R. A. Santilli and H. Thanos, RCA, presented an a-m/f-m receiver using drift transistors; J. Hammerslag, Hughes Products, discussed application of semiconductor capacitors to auto radios; J. Kalman, Hoffman Electronics, described solar power supplies for transistorized radios; and R. A. Santilli and C. F. Wheatly, RCA, discussed us of drift transistors in car radios.

The electron tube meeting featured: new oscillator-mixer circuits for tv and f-m tuners, E. H. Hugenholtz, Amperex; composite base metal for oxide-coated cathodes, W. T. Millis, GE; sarong cathode, D. R. Kerstetter, Sylvania; new 6EV5 vhf tetrode, R. Pear, Westinghouse; and Nuvistor triodes as r-f amplifiers in tv receivers, L. Barr, RCA.

Need Better Electrical and Thermal Conductivity in a Glass-to-Steel Hermetic Terminal?



For most applications, solid 446 stainless alloy electrodes are best suited to our users needs. They are ideally suited to the perfect mating between our V24M glass and the pin. This fusion of glass and metal together with compression accounts for the rugged leak-proof character of Fusite Terminals under rough production handling and makes for easy solderability.



CONSIDER THE PLUS OF COPPER CORED ELECTRODES

When your application indicates the need for greatly improved electrical or thermal conductivity, you still need not sacrifice these inherent Fusite advantages. At slight additional cost, any of our terminals can be ordered with electrodes that have a copper core of as much as 25% of the total electrode area. Copper cored wire has up to 10 times increased current carrying capacity, yet, you maintain nearly all the advantages of solid 446 stainless.

INSULATE ELECTRICALLY
GLASS TO METAL
FUSITE
TERMINALS
PROTECT PRODUCT PERFORMANCE
SEAL HERMETICALLY

Would you like to make tests?
Write Department M-6

THE FUSITE CORPORATION
6000 FERNVIEW AVE., CINCINNATI 13, OHIO

Woodford Mfg. Co., Versailles, Kentucky.
In Europe: FUSITE N. V. Königsweg 16, Almelo, Holland

Jupiter IRBM Missile in final test and checkout area where actual flight conditions are simulated, at the Chrysler operated U.S. Army Michigan Ordnance Missile Plant near Detroit.

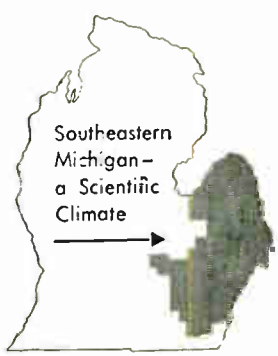
IN SOUTHEASTERN MICHIGAN:

A SCIENTIFIC CLIMATE FOR THE ELECTRONICS INDUSTRY

An important aspect of Southeastern Michigan's scientific climate is the steady growth of electronics research and production activity. Here electronics firms can benefit because of the area's world-wide reputation for know-how in production technology. Here components for improved missile controls, communications systems, data processing and miniaturization are produced profitably, for economical distribution throughout the United States.

The men that manage and man this new industry have found that Southeastern Michigan is a great place in which to live and work. And it has dozens of modern communities which have provided wisely for future expansion. Many have retained professional city planners to assure optimum land use. We would welcome the opportunity to discuss communities and plant sites with you on a completely confidential basis.

Typical of Southeastern Michigan's electronics activity are: (*Left*) Burroughs Corporation—assembly of test equipment for checkout of Atlas ICBM guidance system. (*Center*) Scientist observes formation of a vanadium crystal in Ford Motor Company Scientific Laboratory. (*Right*) Technician at Performance Measurements Company finishing a digital torque indicator.



Write Plant Location Service, Area Development Division

DETROIT EDISON

The Silicon Controlled Rectifier

how will it affect your business?

General Electric's revolutionary Silicon Controlled Rectifier was introduced just two short years ago. The SCR has already proved it lowers costs, improves performance and solves old problems in radically new ways. It can replace thyratrons, magnetic amplifiers, power tubes and transistors, relays, switches, and many other devices. These are a few of the changes the SCR is now bringing about:

Vastly superior motor control systems for industry. Faster, more precise, smaller, more versatile, non-mechanical.

AC current for vehicles and aircraft. The SCR is the first really practical means of getting high power AC from variable DC. Static inverters with ratings of several kilowatts are possible.

Simple temperature controls accurate to 1/10th degree or better. Practical for all types of industrial furnaces.

Superior DC motor operation from an AC source. Extends the use of DC where desirable. Eliminates motor generator sets or magnetic amplifiers. Replaces mechanical speed and direction changers.

Stage lighting dimmer controls. Small, precise, reduces cost of installation for the entire system.

Current-limiting circuit breaker. Opens in less than twelve micro-seconds, long before a fault current can reach its peak.

More efficient lighting systems. Much more light per bulb through small, efficient SCR frequency converters that result in higher frequency and smaller ballasts.

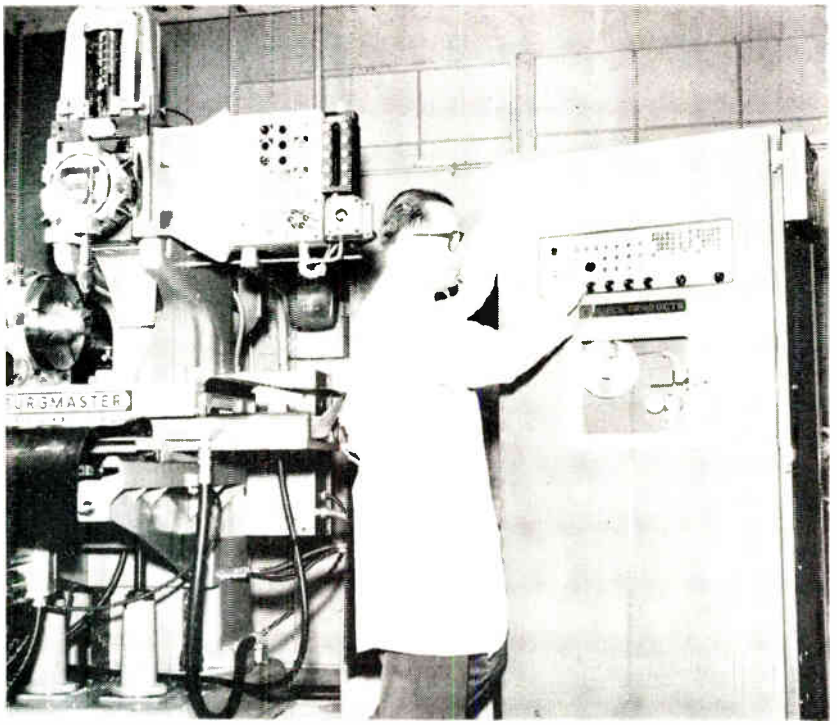
How will it affect your business?

You'll be better able to judge after you have read our informative new folder. Write today to General Electric Company, Semiconductor Products Department, Section S25129, Electronics Park, Syracuse, New York.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Semiconductor Products Department



Operator demonstrates ease of starting and stopping Hughes machine control equipment. Discrete positioning is possible at 180 inches per minute

New Controls for Machines

Transistorized system comes in modular units for easy maintenance, increased reliability

LOS ANGELES—A new numerical control positioning system, recently unveiled here by Hughes Aircraft, features repeatable accuracy to 0.0002 inch and adaptability to drilling, punching, riveting, spot welding, and turning operations.

Completely transistorized, the compact unit can be adapted to any of a number of new machines, or retrofitted to older models. William C. Leone, manager of the company's industrial systems division, reports the system "features highly advanced diode and transistor circuits, designed in modular units for easy maintenance and great reliability."

High Reading Speed

Standard punched tape, one inch 8-channel, is utilized. Extremely fast reading speed is made possible by electronic photocell positioning transducers. Reportedly, highly accurate positioning is obtainable using positioning speeds of 180 inches per minute.

Low power requirements of the transistorized circuits permit simple power needs—110 volt, single phase. Drive motors plus control equipment require less than 7 amps. The control device does not make use of any closed-loop type of servo, making it adaptable for numerical control of many existing machine tools. The system permits two-axis numerical control.

Control cabinet contains ample space for later additions of third-axis control equipment.

To allow for initial checkout of machining runs, the control can be set to operate manually or semi-automatically, as well as fully automatically.

When the machine tool is performing one operation, the tape unit is reading the next instructions, thus speeding up the process.

A single compact cabinet houses the photocell tape reader, operator control, and electronic circuits.

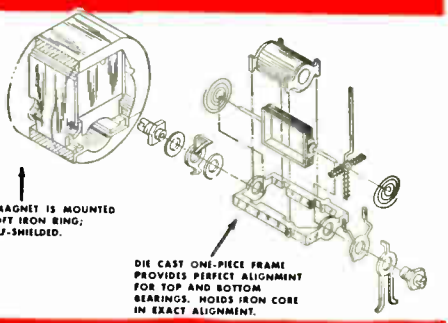
TRIPLETT

Quality... First to last

COMPLETE PANEL METER

BAR-RING TYPE MOVEMENTS (Exclusively Triplett)

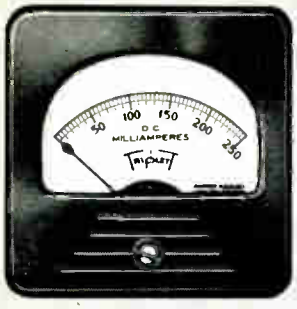
- Self Shielded
- Not affected by magnetic panels or substantially by stray magnetic fields.
- More Torque
- Lower Terminal Resistance
- Faster Response
- Exceedingly Rugged and Accurate
- All Case Sizes



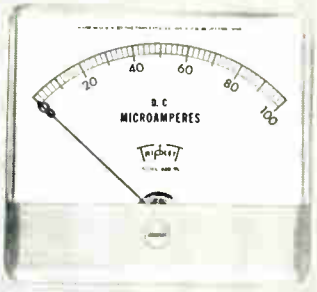
Round Flush Mounting (3½")
Model DC 221-T, AC 231-S, RF 241-T

Rectangular Flush Mounting (3½")
Model: DC 227-PL, AC 237-PL, RF 247-PL

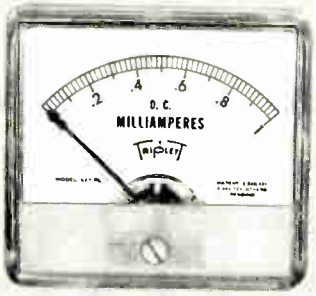
Round Flush Mounting (3½")
Model: DC 221-T, AC 231-S, RF 241-T, Dyn. 241



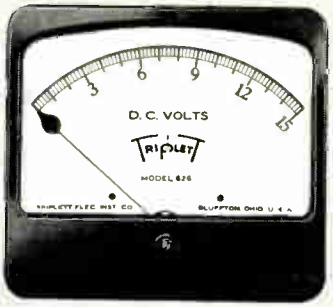
Rectangular Flush Mounting (2⅝")
Model DC 227-T, AC 237-S, RF 247-T



Rectangular Flush Mounting (4⅛")
Model: DC 420-PL, AC 430-PL, RF 440-PL

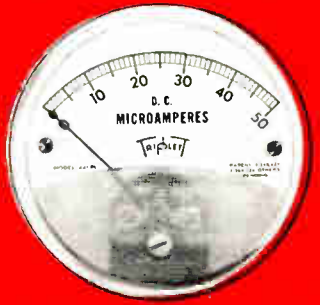


Rectangular Flush Mounting (2⅞")
Model: DC 227-PL, AC 237-PL, RF 247-PL

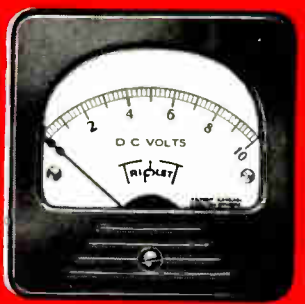


Rectangular Flush Mounting (6")
Model: DC 626, AC 636, RF 646

Suggested Instruments — 1½", 2½" and 3½"
In addition to the popular commercial line of panel instruments, Triplett supplies a complete line of ruggedized and sealed instruments designed to meet government specification MIL-M-10304A.



Round Flush Mounting (3½")
Model: DC 221-PL, AC 231-PL, RF 241-PL



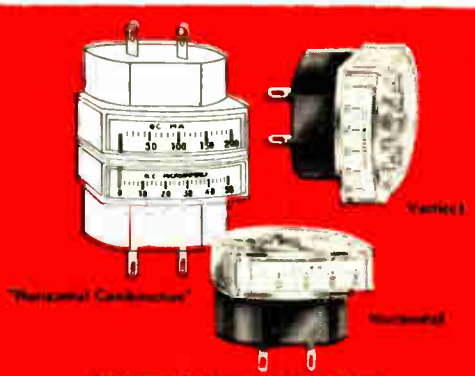
Rectangular Flush Mounting (3")
Model: DC 227-T, AC 237-S, RF 247-T, Dyn. 247-A

For complete details see your Electronic Parts Distributor, or write

LINE FULLY MEETS YOUR NEEDS

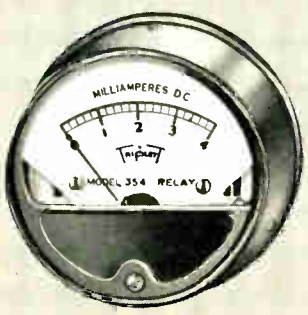
The name TRIPLETT has been on instruments of our manufacture for more than 55 years, and is regarded as a symbol of customer satisfaction to industrials and distributors in all parts of the world. Our instruments can be built to customer specifications or provided from our large stocks of standard ranges in hundreds of sizes and types. We also carry in stock many semi-finished movements which can be converted readily to special customer needs.

Rectangular Flush Mounting (4½")
Model: DC 430, AC 430, RF 440



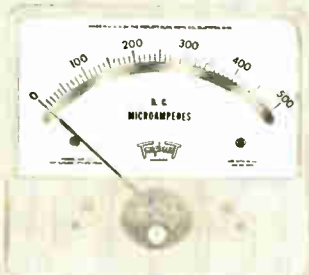
Miniature Edgewise Panel Meters
—Model 130

Model 327-U Unimeter 3½"
Assembled

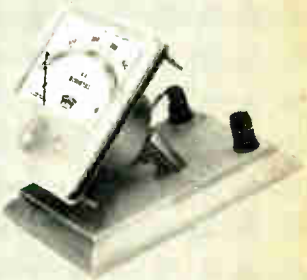


Model 354 Relay

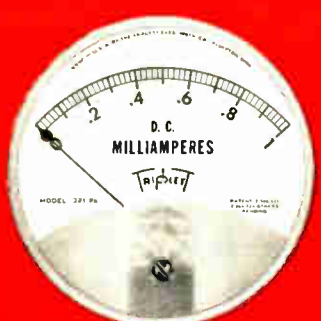
Tilting Case Portable
Model: 325 (DC), 335 (AC)



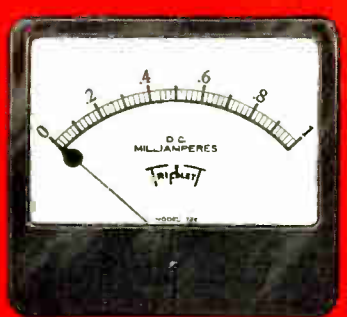
Model 420-U Unimeter 4½"
with mirror scale



Model 234 Unimeter Stand



Round Flush Mounting (3½")
Model: DC 331-PL, AC 331-PL
RF 341-PL



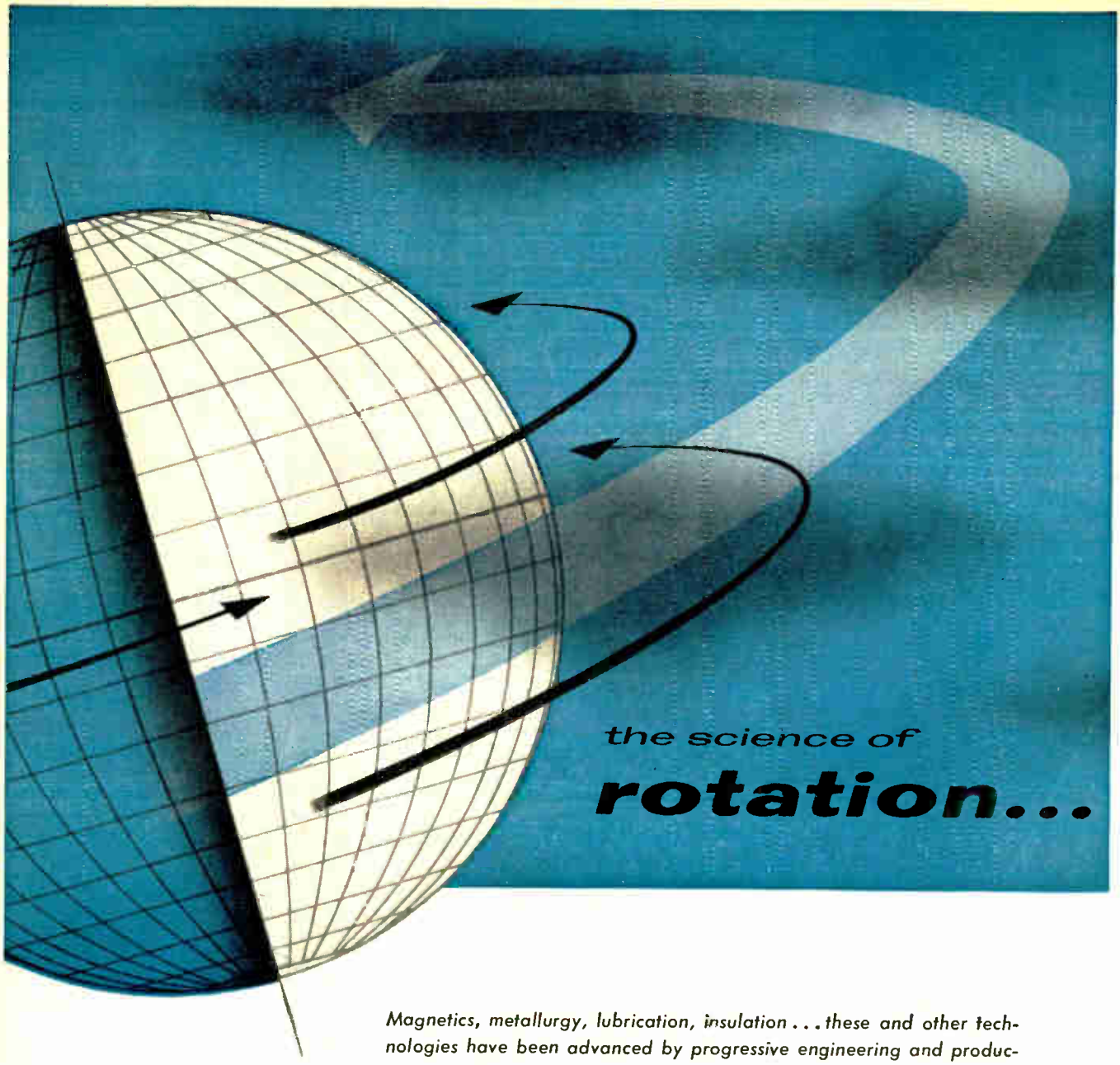
Rectangular Flush Mounting
Model: DC 736, AC 736, RF 746

Model 420 VU Meter
Type of Scale

6" Molded Case 6.7" Scale Portables
Model: 322 (DC), 633 (AC)

TRIPLETT
Quality... First to last

TRIPLETT ELECTRICAL INSTRUMENT COMPANY
BLUFFTON, OHIO



TYPE V1HJ-G8

Miniature Vane Axial Blower

Maximum air delivery in the smallest package

Combining a unique mechanical and aerodynamic design with EAD's standard, reliable 1" diameter motor has resulted in this extremely compact and efficient fan. In addition to the 2 pole characteristics listed below, EAD can supply 4 and 6 pole designs and models for operation from 1600-cycle and variable frequency power sources. Here is another development in the growing family of EAD V-Line vane axial blowers.

TYPICAL CHARACTERISTICS

115 Volt • 400 cycles single or three phase

19,000 RPM nominal

65 CFM at 0" SP

35 CFM at 2.3" SP

Life in excess of 1000 hours at 125°C.

1.5" total length

1.990" housing diameter

Available with:

1. Leads
2. Terminals on mounting flange
3. Terminals on housing

Write for complete technical data. Dept 397.

Magnetics, metallurgy, lubrication, insulation . . . these and other technologies have been advanced by progressive engineering and production personnel at Eastern Air Devices to make a science of "the act of turning." Since 1942, this scientific approach to the improvement and development of precision rotating devices has resulted in higher output efficiencies, reliable operation in higher ambients and superior performance characteristics under the most severe environmental conditions. In addition to continued product improvement, the application of this science has developed a number of firsts, including variable frequency motors, pure sine wave alternators and thermistor compensation of integrating tachometers. Combine this technical ability with high volume production, unsurpassed quality control, parts standardization for lower cost, and you can see why EAD has been specified by leading systems manufacturers for nearly two decades.

EASTERN AIR DEVICES, INC. EAD

Subsidiary of Norbute Corporation • Dover, New Hampshire

INDUCTION MOTORS • SERVO MOTORS • HYSTERESIS MOTORS
INTEGRATING TACHOMETERS AND MOTOR TACHOMETERS • BLOWERS
INERTIALLY DAMPED SERVO MOTORS • TORQUE MOTORS • FANS
DAMPING MOTOR TACHOMETERS • GEAR MOTORS • ALTERNATORS

←CIRCLE 53 ON READER SERVICE CARD

CIRCLE 54 ON READER SERVICE CARD

Engineers prepare reinforcing rod for strain gage installation atop The Old Man of the Mountains in New Hampshire

Gages Guard Great Stone Face

World-famous Old Man of the Mountains is being checked electronically for disintegration signs

THE OLD MAN OF THE MOUNTAINS in Franconia Notch, N. H.—the natural wonder immortalized in Hawthorne's "The Great Stone Face" and viewed by thousands of tourists each year—is being protected from disintegration by electronic monitoring techniques.

The Old Man, official symbol of the State of New Hampshire and proclaimed the most perfect natural stone face in the world, developed a cranial crevice hundreds of years ago, and state engineers estimate the crack has been expanding one inch per century.

Install Strain Gages

In addition to covering the top of the crevice and constructing a system of gutters to decrease water seepage, engineers clamped the two sides of the fissure together by steel rods. The rods bridge the gap diagonally and are fastened to each side of the crevice by steel hairpins imbedded 30 inches in the rock face. Large turnbuckles adjust the tension on each rod to eliminate further expansion of the crevice.

It was decided that observations using bonded filament strain gage techniques would provide the most reliable, repeatable and sensitive method of monitoring rod strain induced by shifting of the overhanging ledge and of determining the load distribution.

Engineers Take Readings

Electronics engineers from Yewell Associates of Burlington, Mass., and Baldwin-Lima-Hamilton of Waltham, Mass., several times climbed over the rugged pathways at the top of Cannon Mountain, 1,200 feet above Lake Profile, to prepare the rods, install the etched foil strain gages and take test readings with a battery-powered strain indicator.

A four-arm Wheatstone bridge configuration was installed on each rod, with gages arranged to provide maximum sensitivity to axial rod strain, a cancellation of bending strains and compensation for temperature effects on the strain gages. A jacking jig designed and built by the state engineers was used to jack the strain out of one link of each tie rod. This was done in order to reach a zero stress level as a reference for strain measurement.

Released load readings will be repeated in the spring to observe changes in rod strain resulting from shifting of the rock formation caused by frost, and to adjust the turnbuckles.

MEETINGS AHEAD

Dec. 3-4: Vehicular Communications, Annual Meeting, PGVC of IRE, Colonial Inn & Desert Ranch, St. Petersburg, Fla.

Dec. 8-10: Electrical Insulation, Applications, Nat. Conf., AIEE, NEMA, Shoreham Hotel, Cleveland.

Jan. 11-13: Reliability & Quality Control, National Symposium, ASQC, IRE, EIA, AIEE, Statler Hotel, Washington, D. C.

Jan. 31-Feb. 5: Comparison of Control Computers, Winter General Meeting, AIEE, New York City.

Feb. 3-5: Military Electronics, Winter Convention, Biltmore Hotel, Los Angeles.

Feb. 10-12: Solid-State Circuits Conf., AIEE, IRE, Univ. of Penn., Philadelphia.

Feb. 11-13: Electronic Representatives Asoc., Annual Convention, Drake Hotel, Chicago.

Feb. 20-29: Component Parts and Electronic Tubes, International Exhibition, Porte de Versailles, Place Ballard, Paris.

Mar. 21-24: Institute of Radio Engineers, National Conv., Coliseum & Waldorf-Astoria Hotel, N. Y. C.

Apr. 4-7: Nuclear Congress, EJC, PGNS of IRE, New York Coliseum, New York City.

Apr. 11-13: Protective Relay Engineers, Annual, A&M College of Texas, College Station, Texas.

Apr. 11-14: Weather Radar Conference, American Meteorological Society and Stanford Research Institute, San Francisco.

Apr. 18-19: Automatic Techniques, Annual Conf., ASME, IRE, AIEE, Cleveland-Sheraton Hotel, Cleveland.

Apr. 19-21: Active Networks & Feedback Systems, International Symposium, Dept. of Defense Research Agencies, IRE, Engineering Societies Bldg., New York City.

Aug. 23-26: Western Electronics Show and Convention, WESCON, Ambassador Hotel & Memorial Sports Arena, Los Angeles.

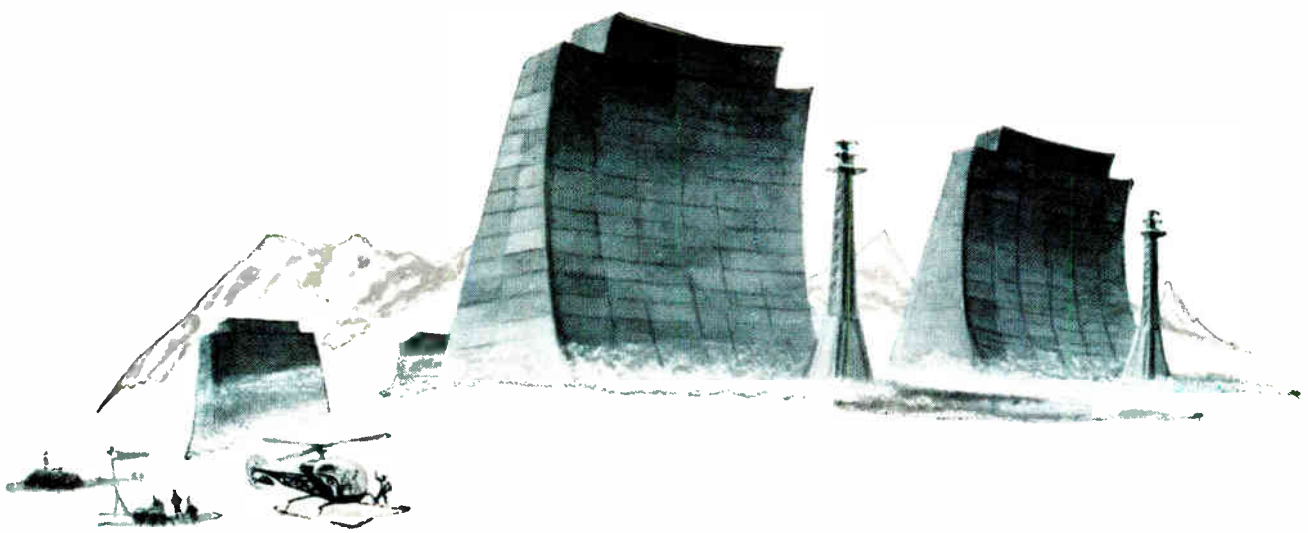
There's more news in ON the MARKET, PLANTS and PEOPLE and other departments beginning on p 132.

THE 'DO' LINE THAT TELLS AGGRESSORS, 'DON'T!'

Because the tropo scatter radio equipment of Radio Engineering Laboratories, Inc., has proved its worth in installations around the world, it is also specified for the U.S. Air Force's DEW-East—the vital DEW Line extension from the present terminal on Baffin Island 1,200 miles east to Iceland. Once again, Western Electric Co., Inc., has chosen REL apparatus for this "can do" communications system to bridge the gap of ice and open water, and overcome the plagues of atmospheric and electromagnetic disturbances.

It's the unequalled reliability of REL equipment which has made it the choice for eight of the nine major networks in operation or on order. In fact, more kilowatt miles of REL tropo apparatus are in use or on order than those of all other companies combined.

The hazards of snow, ice and weather that make construction of DEW-East stations so formidable for the men who build them, call for equipment with the same sturdiness, the background of experience, the same quality of "can do". That's REL. And that's why you'll want REL's help in solving your specialized radio problems.



Radio Engineering Laboratories · Inc

A subsidiary of Dynamics Corporation of America

Dept. E · 29-01 Borden Ave · Long Island City 1, NY

REL

Creative careers at REL await a few exceptional engineers. Address résumés to James W. Kelly, Personnel Director.

NOW 9 STANDARD TYPE TIME DELAY TIMERS

IN AN EXTENDED RANGE OF TIME CYCLES

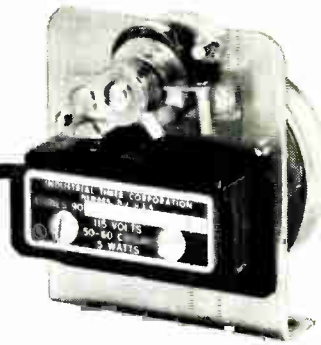
1/60th of a second to 24 hours

For bigger savings in OEM design and installation now, choose a standard time delay timer from Industrial Timer's expanding line to satisfy almost *every* mounting requirement . . . back, side, flush, through-the-panel, totally enclosed or explosion proof. Industrial Timer's bigger-than-ever selection gives you greater design latitude in both function and appearance . . . eliminates the need for costly custom-made controls in your specifications.

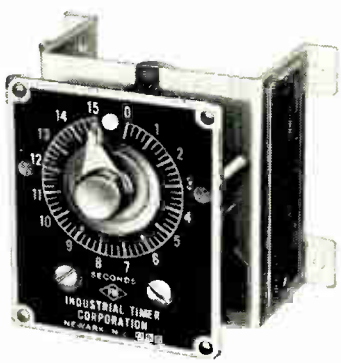
All 9 types have these special features:

1. Actuated by momentary *or* sustained pulse
2. Automatic reset
3. Heavy duty load switches rated at 10 and 15 amps
4. Easy, positive adjustment of time cycles

By specifying Industrial Timer you are assured of accurate and dependable controls for applications requiring a specific time delay between circuit operations. Full details in Bulletins 300, 800 and 900.

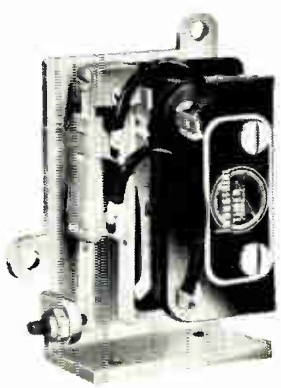


Series 90
Back-mounted, for applications where time cycle is infrequently changed or permanently fixed (½ sec. to 5 min.)

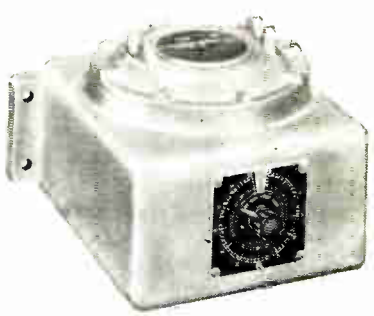


Series SF
Back-mounted (1/10 sec. to 5 min.)

Series TDAB
Flush-, back-mounted or totally enclosed (1/60 sec. to 3 hrs.)



Series TH
Back or bottom-mounted. Thermal time delay switch. (15 sec. to 2 min.)



Series TDXP
Bottom or back-mounted. Explosion proof. External adjustments (1/60 sec. to 3 hrs.)

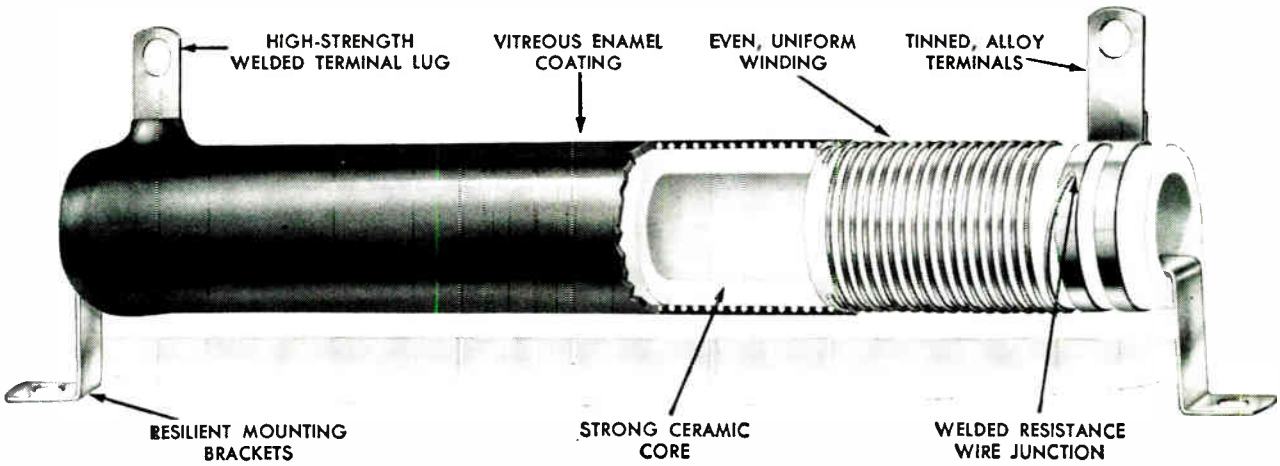
Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

INDUSTRIAL TIMER CORPORATION
1407 McCARTER HIGHWAY, NEWARK 4, N. J.

Industrial Timer's complete line also includes: Interval Timers, Running Time Meters, Cam Timers, Explosion Proof Timers, and Programmers. Our 40-page catalog describing these is available on request.

Quality Features of OHMITE® VITREOUS ENAMELED RESISTORS



Balanced Thermal Expansion
prevents crazing and moisture entrance

In Ohmite resistors, spot welding replaces soldering, brazing, and mechanical fastening. Spot welding produces strong connections that are not affected by vibration or high temperatures. Ohmite welded construction also produces an almost flush connection between the resistance wire and terminal. This prevents thin spots or bulges in the vitreous enamel coating which might cause future trouble and failure. Many different types of terminals are available besides the lug illustrated.

Ohmite can supply all of your resistor needs

some of the many types available

- Axial Lead
- Brown Devil® Wire Lead
- Fixed, Lug Type
- Dividohm® Adjustable
- Thin Type
- Noninductive
- Powr-Rib®, High Current, Round or Ribbon Wire, Open Wound
- Corrib®, High Current, Corrugated, Edgewound Ribbon
- Resistors with Heat Conducting Studs
- Ferrule Mounting Resistors
- Live Bracket Mounting Resistors
- Edison Screw Base Mounting Resistors
- Riteohm® Wire-Wound Precision Resistors, Encapsulated; Vitreous Enameled; Molded Jocket; Hermetically Gloss Sealed
- Riteohm® Metol Film Resistors
- Resistors to meet MIL Specifications
- High-Shock Resistors

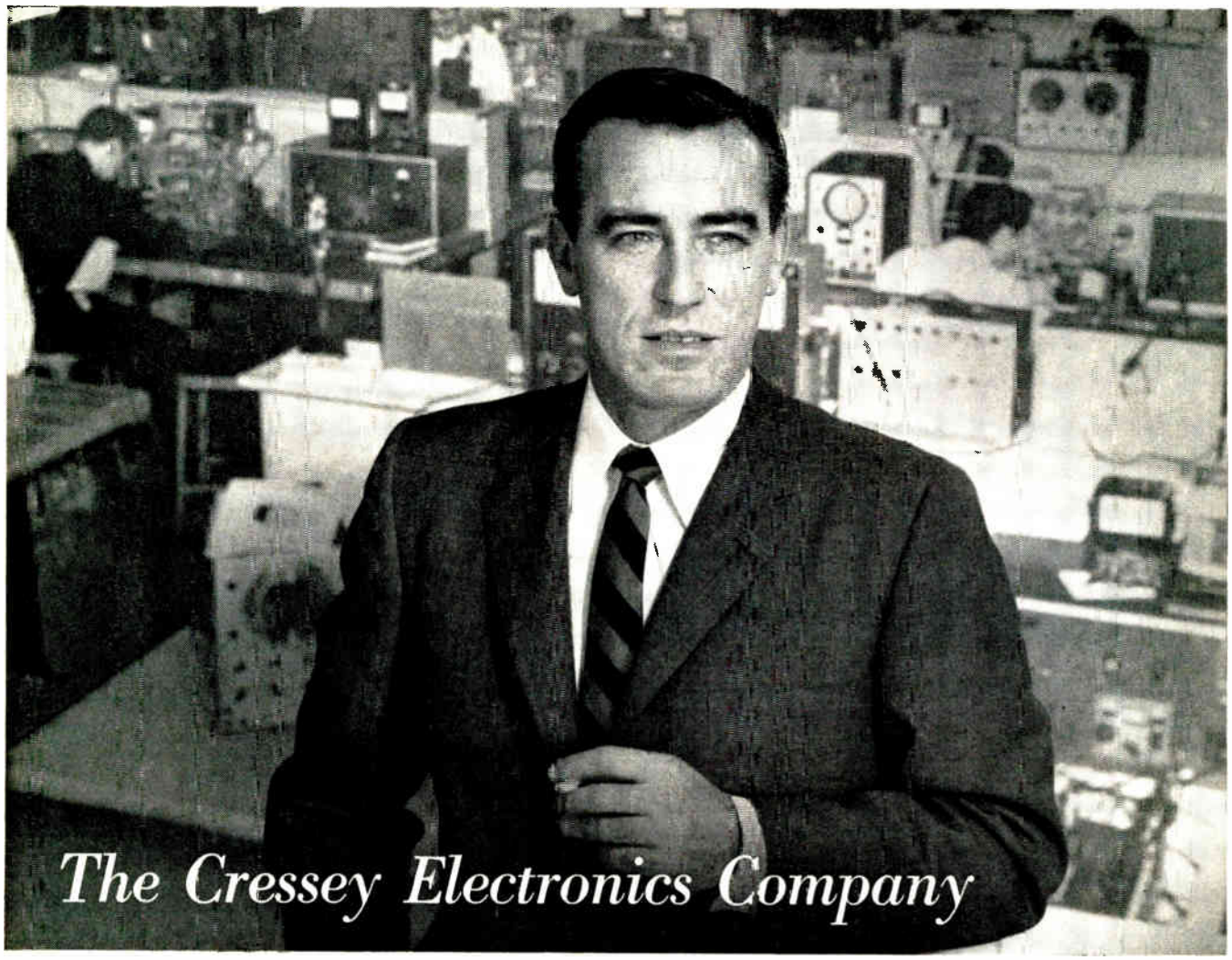
Write on company letterhead for Catalog 58

The almost endless variety of Ohmite resistors in many sizes and types—in a wide range of wattages and resistances—makes it possible to meet each individual need. Many of these can be supplied from the world's largest factory stock. Whatever your resistor requirements may be, chances are you will find exactly the type you need in industry's most complete line of high-quality resistors.

Be Right with OHMITE® Quality Components

Ohmite Manufacturing Company
3610 Howard Street
Skokie, Illinois

RHEOSTATS RESISTORS RELAYS
TANTALUM CAPACITORS TAP SWITCHES
VARIABLE TRANSFORMERS DIODES R.F. CHOKES



carries on into the future

. . . with the help of the Ætna Life's Business Planning Department

Stanley B. Cressey owns a small, but thriving electronics business. He built this business to a steady year-round volume and looks to the day his son can take it over.

A representative of Ætna Life's Business Planning Department explained what can happen to such a business when its owner-manager dies. With him goes not only the value of his own experience but also the "good will" he has created — leaving more of a problem than a legacy to the heirs!

So Stan's Ætna Life representative, attorney and accountant, worked out a plan to safeguard his family's interest. It will provide money to get them over the rough spots, to maintain profits and stabilize credit until Stan Jr., can take over.

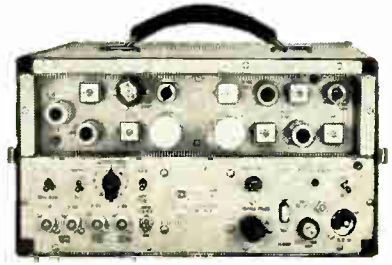
If you own or operate any kind of business, it will pay you to investigate the vital need for a business continuation plan — and no one is better equipped to serve your interests than the Business Planning Department of your local Ætna Life General Agency.

ÆTNA LIFE
INSURANCE COMPANY

Affiliates: Ætna Casualty & Surety Co. • Standard Fire Insurance Co. • Hartford, Conn.

1003-C VIDEO TRANSMISSION TEST SIGNAL GENERATOR

Produces multi-frequency burst, stairstep, modulated stairstep, white window, composite sync. Variable duty cycle. Regulated power supply.



1004-B VIDEO TRANSMISSION TEST SIGNAL RECEIVER

Very rapid and accurate measurements of differential phase and differential gain characteristics of video facilities. Responds to standard stairstep test signal modulated with 3.58mc, or any differential phase or gain test signal.

VIDEO TRANSMISSION TEST EQUIPMENT

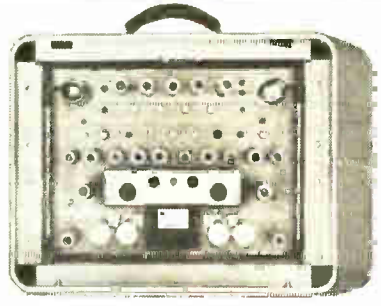
In Daily Use by All Major Networks, Stations and Telephone Co. Coaxial Cable, Microwave, and Intercity Facilities.

ALL CARRYING CASE UNITS IMMEDIATELY ADAPTABLE TO STANDARD RACK MOUNTING

1005-A VIDEO TRANSMISSION TEST SET

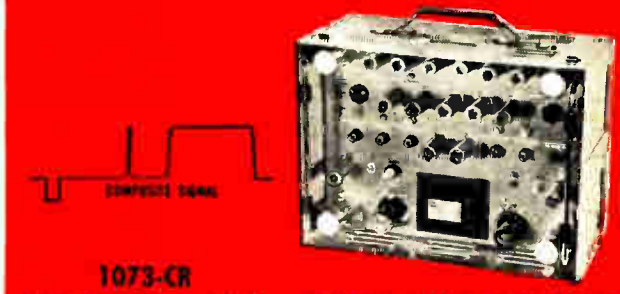
1005-A1 — Produces composite television waveforms suitable for measuring amplitude vs. frequency; differential gain vs. amplitude; dynamic linearity; differential phase vs. amplitude; high frequency transient response; low frequency transient response; low frequency phase or streaking; smears, mismatches, and other video characteristics.

1005-A2 — Supplies composite EIA Sync, blanking, horizontal and vertical drive signals and regulated B +, power for itself and 1005-A1. Features magnetic core binary counters.



1008-A VERTICAL INTERVAL KEYER

Permits test and control signals to be transmitted simultaneously with program material, between frames of TV picture. Any test signal (multiburst, stairstep, color bar, etc.) may be added to the composite program signal. Test signals are always present for checking transmission conditions without impairing picture quality. The home viewer is not aware of their presence.



1073-CR

SINE SQUARED (SIN^2)—SQUARE WAVE GENERATOR

Produces new waveform for testing TV or other pulse unit or system for amplitude and phase characteristics. Sin^2—Square Wave pulse is equivalent to TV camera signal and is more sensitive than a Square Wave in indicating ringing. Video test signal adjustable for 1.0 volts or 1.4 volts peak to peak. Now in use by major TV networks and telephone companies.

AT THE FRONTIERS OF ELECTRONICS
COLOR TV · INDUSTRIAL INSTRUMENTATION · TELEMETRY

TELECHROME MANUFACTURING CORP.

Full Specifications & Details Available on Request

TELECHROME MANUFACTURING CORP.

28 RANICK DRIVE AMITYVILLE, N.Y. LIncoln 1-3600 Cable Address: COLORTV TWX: AMITYVILLE NY2314

Midwest Engineering Division—106 W. St. Charles Rd., Lombard, Ill., MAyfair 7-6026 Western Engineering Division—13635 Victory Blvd., Van Nuys, Calif., State 2-7479

Largest selection

Trimpot®

the original leadscrew-actuated potentiometer

More engineers specify Trimpot because:

Trimpot line is complete

Bourns offers you the largest selection of leadscrew actuated potentiometers... 20 basic models—4 terminal types—three mounting methods.

Trimpot is small

Space saving size and rectangular shape permit the installation of 12 to 17 units in one square inch of panel area.

Trimpot is accurate

Multi-turn screwdriver adjustment provides 9000° of rotation...you can make and repeat the finest adjustments.

Trimpot is stable

Adjustment shaft is self-locking...settings are virtually immune to severe acceleration, vibration and shock.

Trimpot is fully tested

All instruments are 100% inspected before shipment to assure you of reliable performance.

Trimpot is proved

It is used in more military and commercial equipment than any other leadscrew actuated potentiometer.

Only Bourns Trimpot potentiometers give you these outstanding features

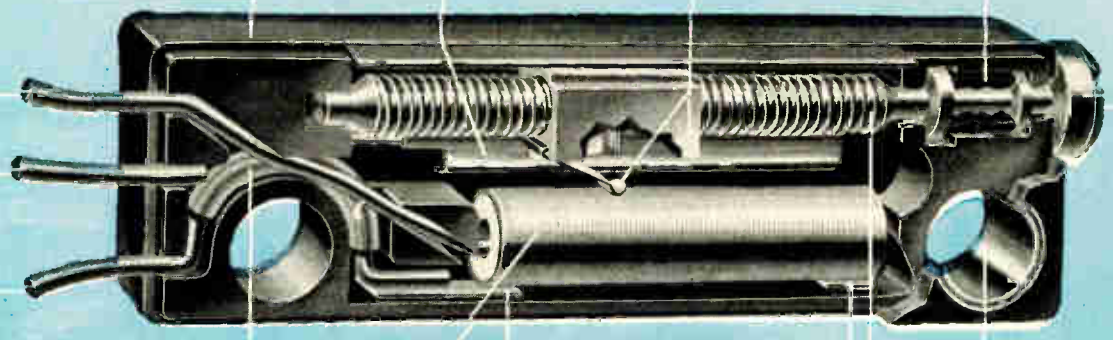
BODY—High-temperature, thermosetting plastic body is sealed, enabling potentiometer to meet Mil-Specs for humidity, sand, dust, fungus, salt spray, etc.

COLLECTOR BAR—Precious metal collector bar provides positive electrical contact, improves potentiometer performance and reliability.

WIPER CARRIAGE—Special high-temperature plastic carriage with precious metal contact spring permits exact settings and stability under severe environmental conditions.

SHAFT HEAD—Stainless steel with machined slot for screwdriver adjustment. Meets military salt spray requirements.

O-RING—Silicon rubber O-ring seals potentiometer against humidity, withstands high temperature.



TUBING INSULATION—Tubing around terminal eliminates possible short or electrical cross-over.

SILVERWELD* TERMINATION—This exclusive Bourns feature is unequalled in ruggedness. There is a metal-to-metal bond from the terminal to the resistance wire.

EYELETS—Stainless steel eyelets are set on ¾" centers and provide easy mounting with 2-56 screws.

TERMINALS—Three terminals are gold-plated copperweld wire or Teflon-insulated leads.

ELEMENT—Special ceramic mandrel is precision wound with low temperature coefficient resistance wire.

LEADSCREW—Stainless steel leadscrew is corrosion resistant, withstands salt spray.

*TRADEMARK

This cutaway of Model 220 is typical of the design of all Bourns Trimpot potentiometers though some features may vary from model to model.

Longest record of reliability

High-Temperature, Humidity-Proof Wirewound Trimpot—Model 224. Operates at 175°C / L,S,P terminals / 1 watt / 100 ohms to 100K. Meets Mil-Specs for humidity.

General Purpose Wirewound Trimpot—Model 200. Operates at 105 C / L,S,P terminals / 1/4 watt / 10 ohms to 100K. Available as rheostat, Model 201.

Humidity-Proof Wirewound Trimpot—Model 236. Operates at 135°C / L,S,P terminals / 0.8 watt / 10 ohms to 100K. Meets Mil-Specs for humidity.

High-Resistance Wirewound Hi-R® Trimpot—Model 207. Operates at 175 C / L terminal / 2 watts / 100 ohms to 100K. Available as rheostat, Model 208 Hi-R Trim R®.

High-Temperature Wirewound Trimpot—Model 260. Operates at 175°C / L,S,P terminals / 1 watt / 10 ohms to 100K.

Dual-Element Wirewound Twinpot® —Model 209. Operates at 105 C / L terminal / 1/4 watt / 10 ohms to 20K. Two potentiometer outputs with one adjustment shaft.

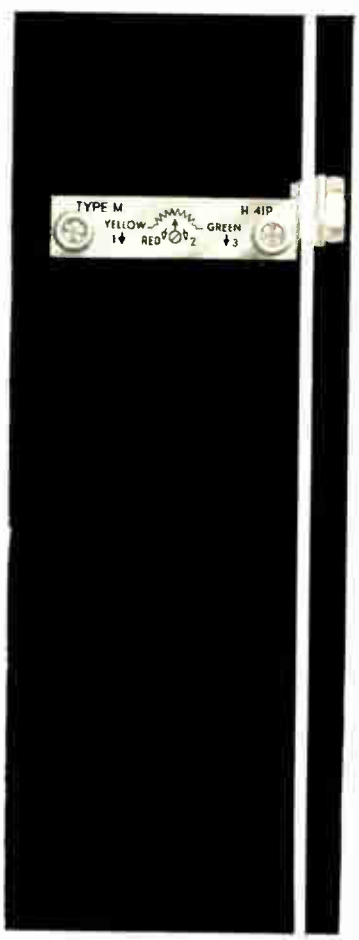
High-Quality Commercial Wirewound Trimit®—Models 271, 273, 275. Operates at 85°C / L,S,P terminals / 1/4 watt / 100 ohms to 10K.

General-Purpose Carbon Trimpot—Model 215. Operates at 125 C / L,S,P terminals / 1/4 watt / 20K to 1 Meg. Available as Mil-Spec humidity-proof unit, Model 235 (1K to 10 Meg).

High-Quality Commercial Carbon Trimit—Models 272, 274, 276. Operates at 85°C / L,S,P terminals / 0.2 watt / 20K to 1 Meg.

Subminiature Wirewound Trimpot—Model 220. Operates at 175°C / L & W terminals / 1 watt / 100 ohms to 20K. Meets Mil-Specs for humidity.

Low Cost Commercial Wirewound E-Z Trim®—Model 277. Subminiature—1" x 17/64" x 5/16". Tapered all-purpose lug terminals / 1/2 watt / 100 ohms to 10K. For computers, test equipment, industrial control systems, etc.



Panel-Mount Trimpot

All models are now available with the added convenience of panel mounting. Unique design permits quick factory attachment of rugged panel-mount assembly to standard "on-the-shelf" Trimpot potentiometers. The Panel Mount Trimpot takes as little as 1/12 sq. inch of panel space, meets Mil-Specs for vibration, shock, salt spray, etc. Recessed head prevents accidental changes of setting. Silicon rubber O-ring and Teflon washer provide moisture barrier.

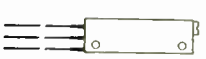
Key to terminals

L — insulated stranded Leads

S — Solder lugs

S — Solder lugs (Model 224 only)

P — Printed circuit Pins



W — uninsulated Wires

Standard resistances (ohms)

10	50	200	1K	5K	20K	100K	500K
20	100	500	2K	10K	50K	200K	1Meg

other Resistances Available

Write for detailed specifications and list of stocking distributors.

BOURNS Inc.

P.O. Box 2112, Riverside, California

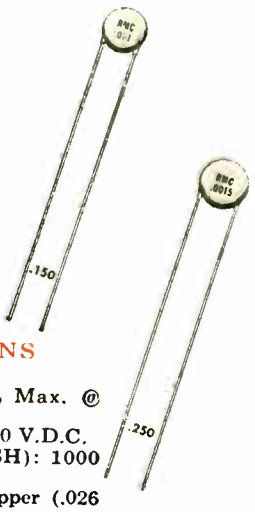
Plants: Riverside, California and Ames, Iowa

In Canada: Douglas Randall (Canada), Ltd., licensee

Exclusive manufacturers of TRIMPOT®, TRIMIT®. Pioneers in potentiometer transducers for position, pressure and acceleration.

Is inner-space your problem?

RMC Subminiature TYPE SM Discaps



If your designs continually shrink allowable space for components RMC's Type SM DISCAPS are the answer for capacitors. These subminiature DISCAPS can be specified with assurance of the quality, dependability and performance inherent in all DISCAPS.

Type SM meet the specifications of EIA-RS-198 for Z5U capacitors and are available in values of 800, .001, .0015 GMV; .005 + 80% — 20% ± 20%; .01 + 80% — 20% ± 20% and .02 + 80% — 20%. Capacity change between + 10°C and + 65°C is a minimum.

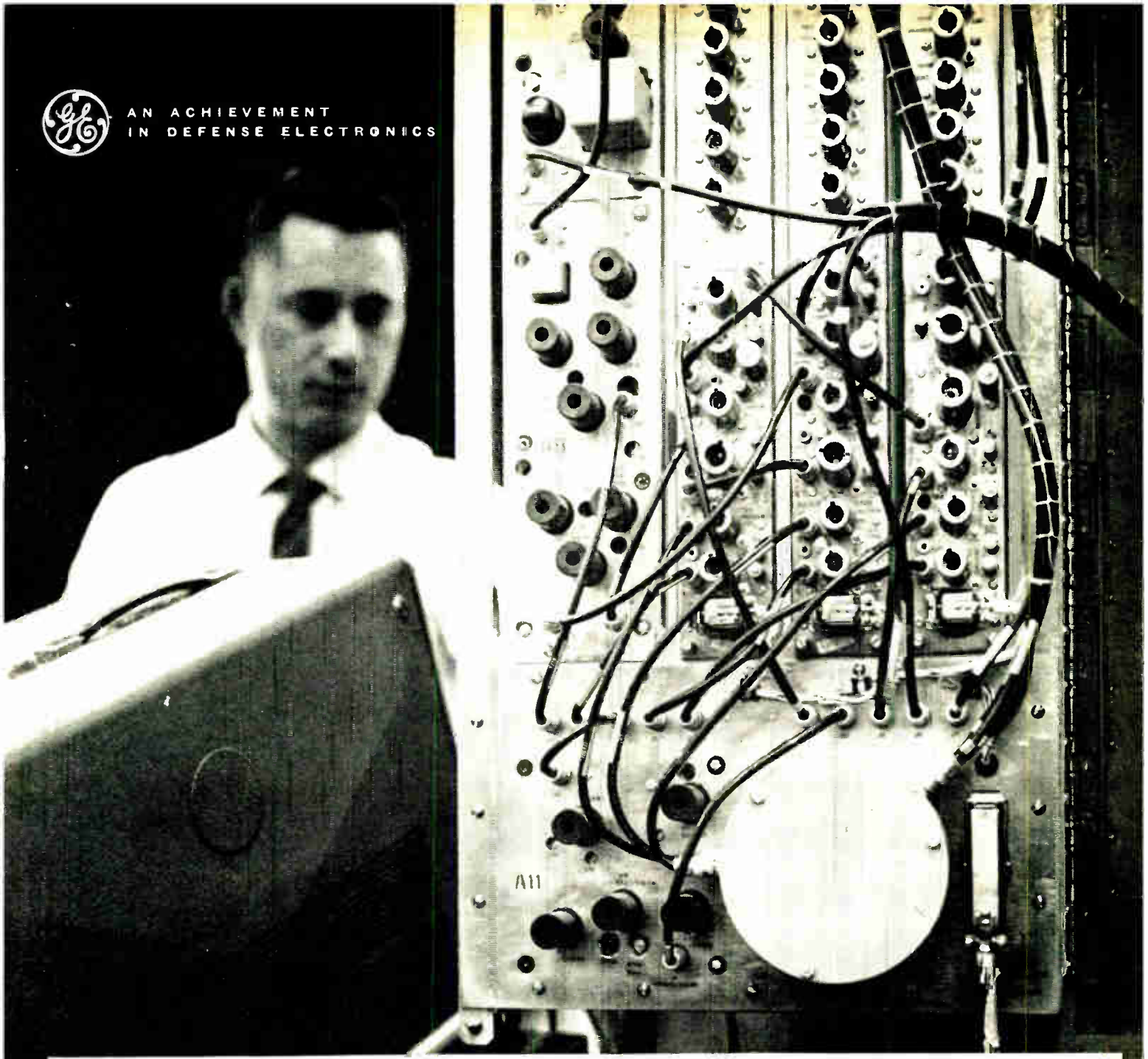
SPECIFICATIONS

POWER FACTOR: 1.5% Max. @ 1 KC (initial)
WORKING VOLTAGE: 500 V.D.C.
TEST VOLTAGE (FLASH): 1000 V.D.C.
LEADS: No. 22 tinned copper (.026 dia.)
INSULATION: Durez phenolic (⅛" max. on leads)—vacuum waxed
STAMPING: RMC—Capacity—Z5U
INITIAL LEAKAGE RESISTANCE: Guaranteed higher than 7500 megohms
AFTER HUMIDITY LEAKAGE RESISTANCE: Guaranteed higher than 1000 megohms

DISCAP CERAMIC CAPACITORS

RMC

RADIO MATERIALS COMPANY
A DIVISION OF P. R. MALLORY & CO., INC.
GENERAL OFFICE: 3325 N. California Ave., Chicago 18, Ill.
Two RMC Plants Devoted Exclusively to Ceramic Capacitors
FACTORIES AT CHICAGO, ILL. AND ATTICA, IND.



NEW SONAR SIGNAL PROCESSOR DOES WORK OF 1,000 UNITS

The first sonar signal processors to utilize time compression are being produced by General Electric. These new processors were developed in cooperation with the United States Navy. Extracting only critical bits of transmitted and received signals in series, one unit can perform as many correlating operations on a continuous signal—in the same time—as a parallel processor with thousands of units.

Excellent improvement in signal-to-noise ratio also makes these new processors effective against background levels which have formerly made certain signals undetectable by any other practical means. The new equipment is also designed to handle signals from more than one transducer.

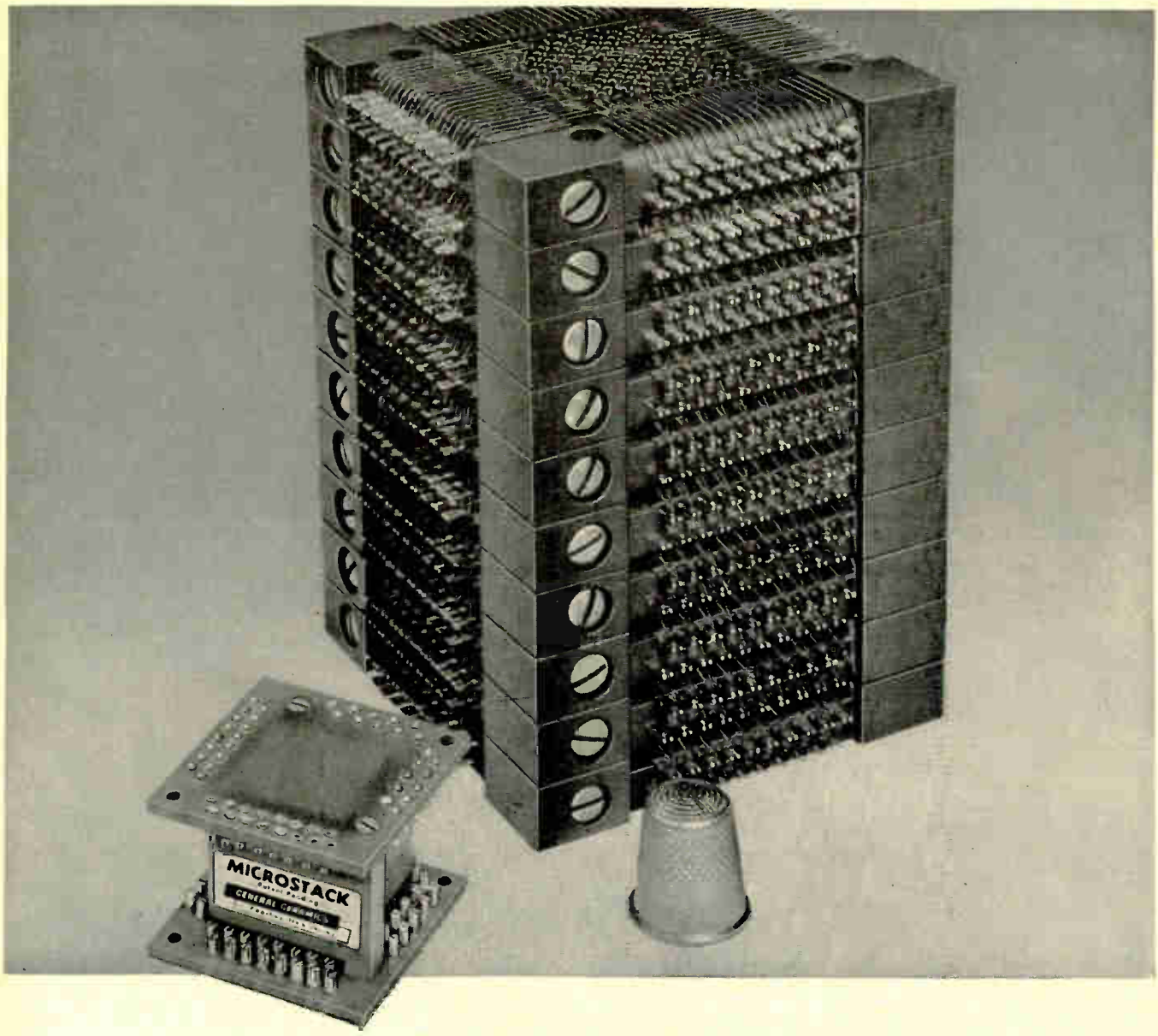
This advance in sonar signal processing is typical of General Electric's many achievements in defense electronics. 227-3

Progress Is Our Most Important Product

GENERAL ELECTRIC

DEFENSE ELECTRONICS DIVISION • HEAVY MILITARY ELECTRONICS DEPT. • SYRACUSE, N. Y.

Designing in miniature?
Here's how to save space—



...90% of it!

New G-C MICROSTACK* for coincident current memory systems has a physical volume just 10% that of conventional stack. MICROSTACK shown with 2560 cores measures only 1.125″ x 1.4″ x 1.4″, a reduction in size from 3½″ x 3½″ x 5″.

This miniature stack consists of an array of 16 x 16 x 10. Solder connections are greatly reduced (from 1192 to 104), thereby substantially increasing reliability.

Noise level in the new MICROSTACK is as low as that of conventional types. The new MICROSTACK is available with all standard memory cores. Standard packages are available with coincident current wiring in 10 x 10 x 8, 16 x 16 x 8 and 32 x 32 x 8 arrays.

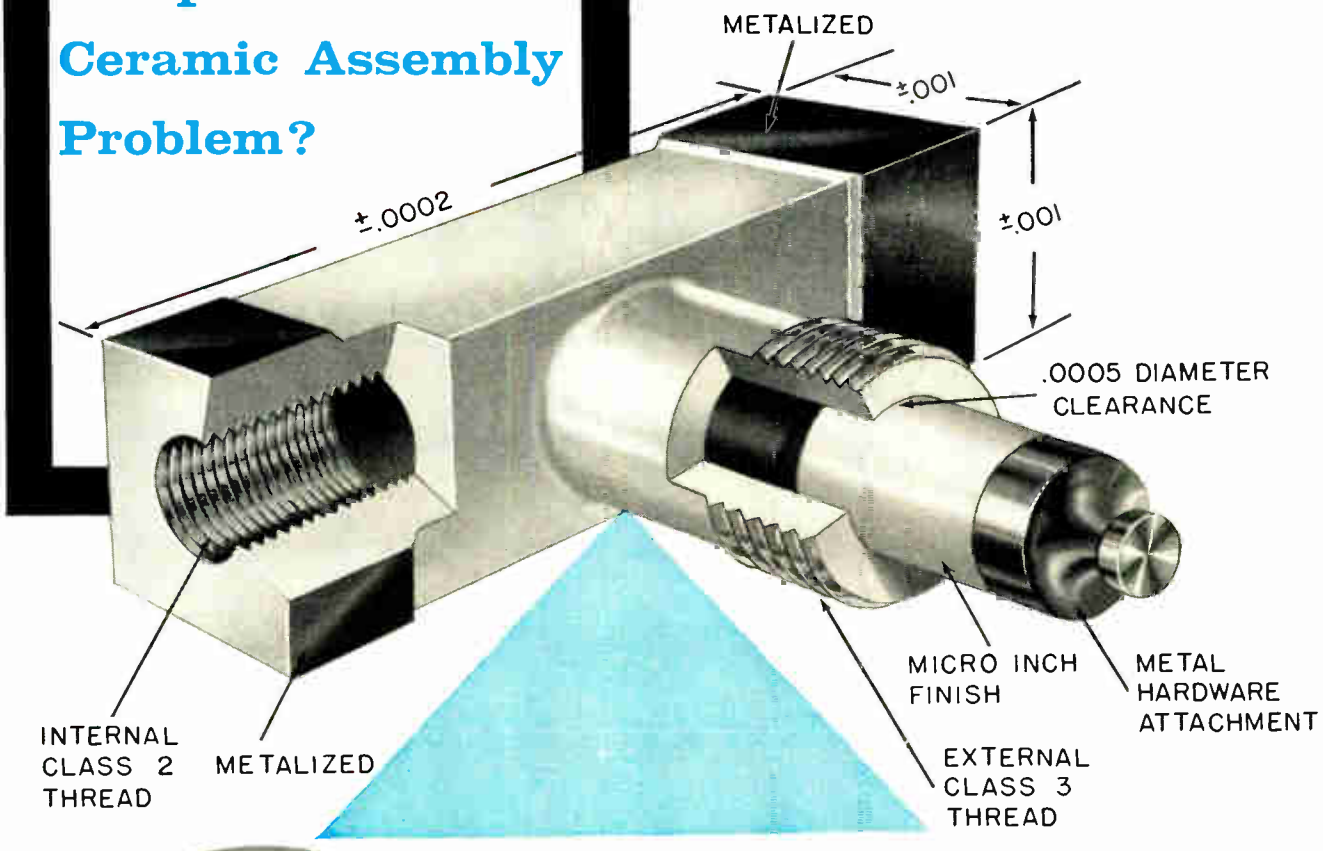
For further information, please write on company letterhead—address inquiries to Dept. E.

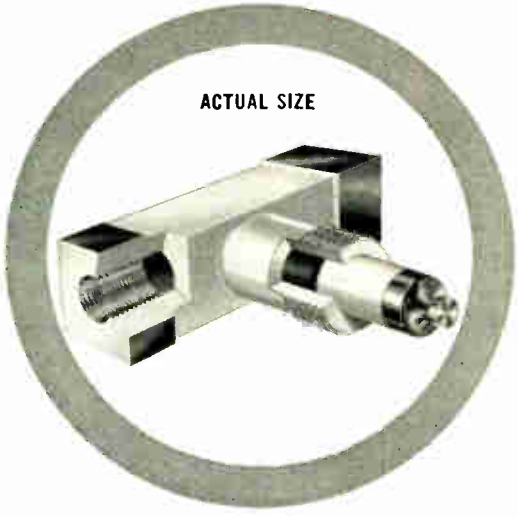
*Trademark

GENERAL CERAMICS
ORIGINATOR OF THE SQUARE LOOP FERRITE

General Ceramics Corporation
KEASBEY, NEW JERSEY, U.S.A.

Complex Ceramic Assembly Problem?





Centralab solves them daily

The pictured unit shows how CENTRALAB can control the manufacturing of precision ceramic-to-metal assemblies to extremely close tolerances, no matter how complex the shape, how intricate the machining. Let CENTRALAB design and production engineering help you take full advantage of the superior electrical and physical properties of High Alumina and Steatite ceramics.

You can achieve improved performance *and* eliminate production assembly problems by utilizing CENTRALAB's know-how in the specialized techniques of close tolerance ceramic-to-metal fabrication. CENTRALAB can handle complex, precision assemblies involving machining of ceramics or metals to ±.0002", metalizing of ceramics, cementing, riveting, soldering, plating, and stamping.

For detailed information on how High Alumina and Steatite ceramics can solve your electromechanical problems, write for free copy of CENTRALAB's new Ceramic Design Handbook (Bulletin No. 42-554), or consult Sweet's Product Design File (folio 4a/ce).

Centralab
X-5970

A DIVISION OF GLOBE-UNION INC.
914L E. KEEFE AVE. • MILWAUKEE 1, WISCONSIN
In Canada: 669 Bayview Ave., Toronto 17, Ontario

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

They got rid of the dobbin . .

We got rid of the bobbin!

Why should precision wire wound resistors continue to be wound on bobbins and encapsulated in epoxy resin . . . when we know the life of the resistor is shortened and its stability lowered by the varying expansion rates of the wire, bobbin, and resin.

Let's face it: Bobbin's ready for the pasture! General Transistor has developed a precision wire wound **bobbinless** resistor that floats in a special viscous fluid. Result: a strain-free resistor with tolerances as low as 0.05% and Temperature Coefficients of Resistance as low as 2PPM/°C.

These facts alone are proof that it's time to learn more about GT Precision Wire Wound Bobbinless Resistors.

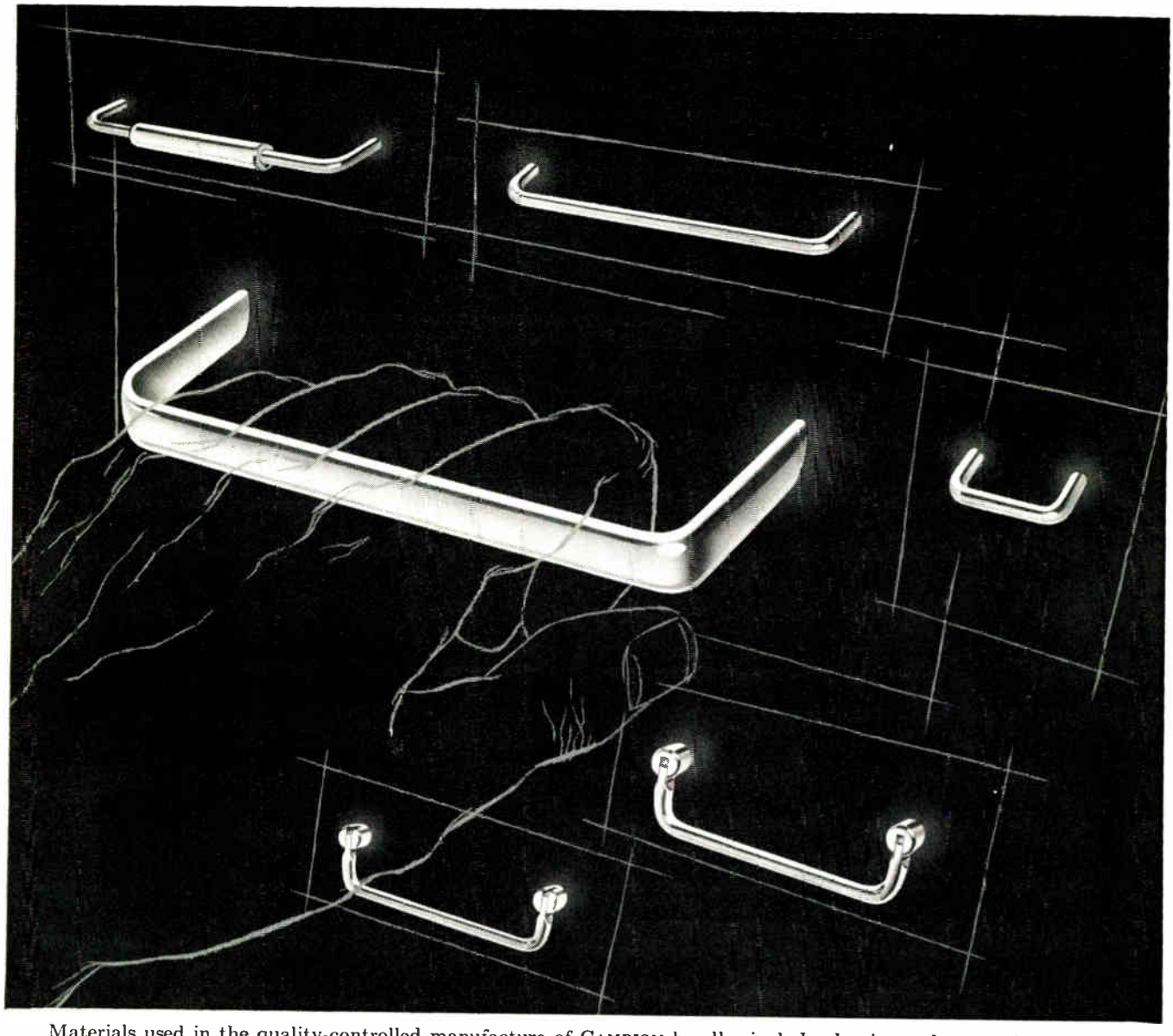
Actual size

Get the full details! Write today for brochure GR-30.

GENERAL TRANSISTOR CORPORATION

91-27 138th Place • Jamaica 35, New York • Phone: HIckory 1-1000

FOR IMMEDIATE DELIVERY FROM STOCK, CONTACT YOUR NEAREST AUTHORIZED GENERAL TRANSISTOR DISTRIBUTOR OR GENERAL TRANSISTOR DISTRIBUTING CORP., 91-27 138TH PLACE, JAMAICA 35, NEW YORK. FOR EXPORT: GENERAL TRANSISTOR INTERNATIONAL CORP., 91-27 138TH PLACE, JAMAICA 35, NEW YORK. PRECISION MAGNETIC RECORDING HEADS AVAILABLE FROM GENERAL TRANSISTOR WESTERN CORP., 6110 VENICE BLVD., LOS ANGELES, CALIF.



Materials used in the quality-controlled manufacture of CAMBION handles include aluminum, brass and stainless steel. Finishes are of polished nickel, black oxide, and black alumilite. Types available are rigid, adjustable and folding. Folding types are in two different models — designed to fold against the panel in either one or two directions.

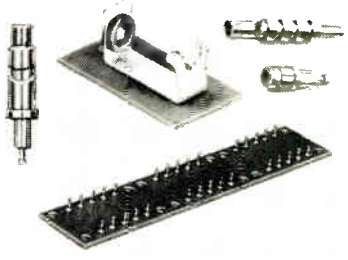
How to handle things better — 28 ways

Made in 28 different standard combinations, CAMBION® panel handles are also custom-made to any specifications, in any quantity. All are of quality materials which meet or better government specifications. In addition to a firm grip, all have an attractive appearance. Polishing before plating removes all surface imperfection, and color buffing after plating adds lasting luster.

Expert engineering and manufacturing skill control production of the complete CAMBION line — terminal boards, solder terminals, insulated terminals, coils, coil forms, capacitors, swagers and hardware. In any quantity of CAMBION components you order you get top quality — with every component guaranteed.

Available locally through Authorized CAMBION Distributors. Or write to Cambridge Thermionic Corporation, 437 Concord Avenue, Cambridge 38, Massachusetts. On the West Coast: E. V. Roberts and Associates, Inc., 5068 West Washington Blvd., Los Angeles, California. In Canada: Cambridge Thermionic of Canada, Limited, Montreal, P.Q.

The CAMBION line of panel and chassis hardware is recognized as the best looking, best behaving, most polished family in its field. Besides handles, other popular members are terminal boards, diode clips, battery clips, miniature plugs and jacks. CAMBION custom hardware can be designed and manufactured on request.

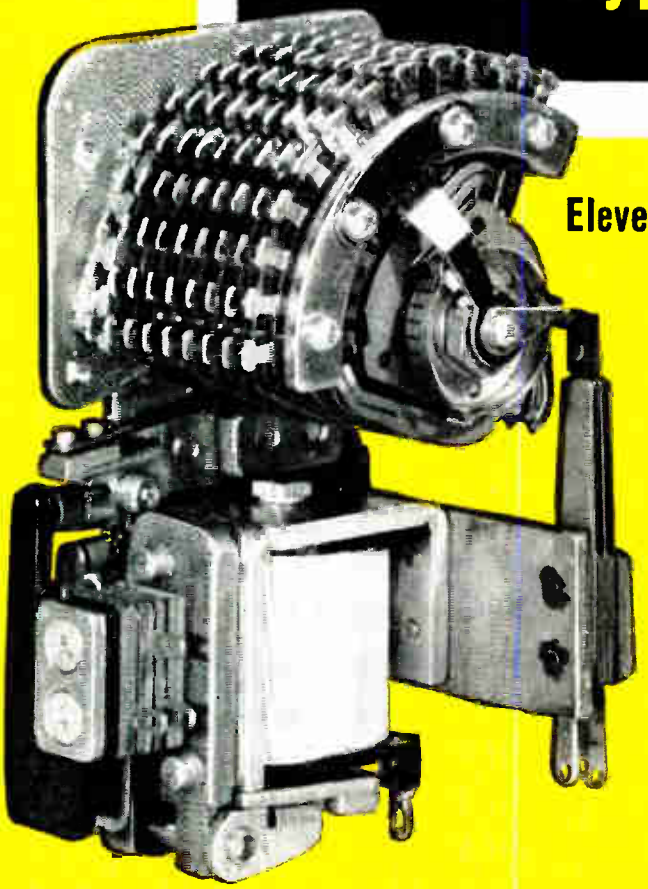


CAMBRIDGE THERMIONIC CORPORATION

CAMBION®

The guaranteed electronic components

CLARE ANNOUNCES THE
Type 211 Stepping Switch



Eleven-point stepping switch has 12-level capacity, 100,000,000-step* life

Many new, improved features give this Clare Type 211 springdriven stepping switch longer service life, greater capacity and a freedom from maintenance hitherto unknown in an 11-point switch. Rugged, compactly built, the 211 is available with a variety of enclosures and mounting assemblies to meet a wide range of design applications.

LONGER LIFE EXPECTANCY—This new switch has a life expectancy of from 100 million steps at twelve levels to 300 million steps at three levels with proper relubrication and readjustment.

GREATER STEP CAPACITY—Up to twelve 11-point levels or four 33-point levels enable it to handle complex switching, counting, totalizing, selecting, and sequence control operations.

SIMPLIFIED MAINTENANCE—Fewer moving parts, due to the elimination of pawl bearings, and a more rigid armature arm simplify maintenance and increase service life.

TYPE 211 SWITCH—ELECTRICAL DATA

OPERATING SPEEDS—Self-interrupt speed: 60 SPS at 25°C on nominal voltage. Remote impulse speed: 30 SPS at 25°C on nominal voltage with 66% make impulse.

OPERATE & RELEASE TIME—Operate time: 20 ms at 25°C on nominal voltage. Release time: 10 ms at 25°C on nominal voltage.

OPERATE & RELEASE VOLTAGE—Maximum pull-in at 25°C is 66% of nominal voltage. Minimum dropout at 25°C is 5% of nominal voltage.

BREAKDOWN TEST—1000 v, rms, 60 cps, is standard.

COILS—Coil resistances for typical voltages are shown below:

Voltage Vdc	1-8 Levels Ohms	9-12 Levels Ohms
6	1.5	1.5
12	6	6
24	24	20
48	100	70
60	150	100
110	600	400

TYPE 211 SWITCH—MECHANICAL DATA

OVERALL DIMENSIONS—Length (maximum)—4-5/16 in. Height (1C interrupter, 1C O.N.S.)—2¾ in. Width—from 1-5/16 in. for 3 levels to 2-13/16 in. for 12 levels.

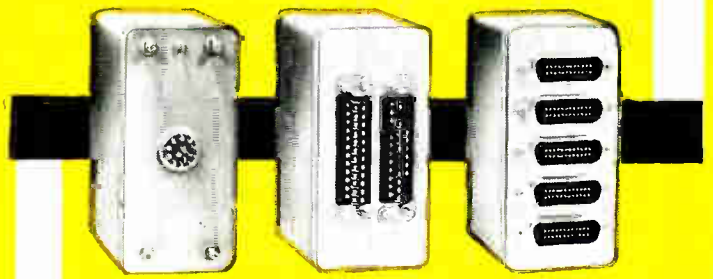
NET WEIGHT—From one pound for 3 levels to 1½ pounds for 12 levels.

BANK CONTACT—Standard is phosphor bronze. Also available are coin silver or gold plated phosphor bronze.

MAXIMUM BANK LEVELS & PILEUPS

Type of operation (points)	11	33
Bank levels maximum (electrical)	12	4
Interrupter springs	6	6
Off-normal springs	6	6
Number of ratchet teeth	33	33

WIPERS—Standard wipers are non-bridging phosphor bronze with coin silver and gold plated phosphor bronze available in either non-bridging or bridging models.

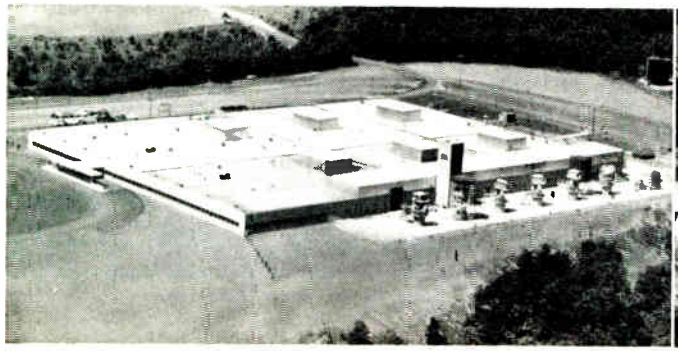


VARIETY OF ENCLOSURES—Hermetically sealed enclosures, filled with nitrogen or oil, are available with hook-type solder terminals. Dust cover enclosures are available with miniature or standard Amphenol Blue Ribbon connectors.

Write for bulletin CPC-3 to C. P. Clare & Co., 3101 Pratt Blvd , Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., P. O. Box 134, Downsview, Ontario. Cable Address: CLARELAY.

CLARE RELAYS

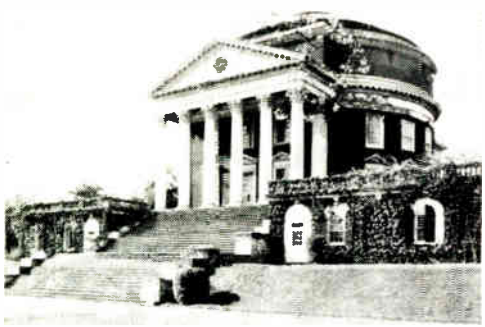
FIRST in the Industrial Field



MODERN PLANT of Sperry Piedmont Co. at Charlottesville, Virginia, started with 75,000 sq. ft. of floor space in 1956, now covers 175,000 sq. ft. Over 900 people are employed . . . 83-acre tract gives ample expansion room.

COMPLETE FACILITIES include dust-free rooms for precision production . . . environmental testing equipment . . . compass-testing devices that simulate ship's pitch, yaw and roll. Plant is fully air-conditioned.

COMPLEX INSTRUMENTS for submarines, warships, cargo vessels and small craft are made by skilled Virginians. In conjunction with state government, Sperry sponsored night school programs to advance employees' knowledge in electronics and mathematics.



UNIVERSITY OF VIRGINIA at Charlottesville is a source of engineers, and its facilities are available for employees' post-graduate courses or for research projects. Virginia Polytechnic Institute and other excellent colleges and universities also supply Sperry Piedmont with recruits.

Sperry Piedmont Finds Academic Atmosphere, Adaptable Labor, and Plenty of Elbow Room in VIRGINIA

In today's competition for engineering talent, good living conditions are important. And that's one major reason why Sperry Piedmont Company built its plant at Charlottesville, Virginia. Home of the University of Virginia, this historic town provided unsurpassed recreational and cultural background . . . traditionally good living . . . plus the academic atmosphere that's so attractive to technical men and so prevalent in Virginia's numerous university towns.

Other factors influencing Sperry's choice of location were excellent transportation facilities, nearness to Washington, no shortage of housing, good hospitals and medical care, dependable, conscientious manpower.

If you're planning a new plant, let us tell you why so many companies are locating in Virginia. Phone, wire, write, or visit in complete confidence . . .

***Let These Outstanding Industries Tell You Why They Have Located in* VIRGINIA**

- General Electric Company
- ITT Corporation
- The Babcock & Wilcox Company
- Reynolds Metals Company
- The Dow Chemical Company
- Allied Chemical Corporation

C. M. Nicholson, Jr., Commissioner
Division of Industrial Development
Virginia Dept. of Conservation and Economic Development
State Office Bldg., Richmond, Va.
Phone MIlton 4-4111 Ext. 2255

***You, too, can find these... and many other great competitive advantages in* VIRGINIA**

Virginia's a wonderful place to play or work. Send for Free Vacation Guide Book.

←CIRCLE 71 ON READER SERVICE CARD

CIRCLE 72 ON READER SERVICE CARD

BASIC BUILDING BLOCKS FROM KEARFOTT

FLOATED RATE INTEGRATING GYROS

Specifically designed for missile applications, these Kearfott miniature gyros operate efficiently at unlimited altitudes. Their outstanding accuracy and performance make them superior to any comparably-sized units on the market. Hermetically sealed within a thermal jacket, these gyros are ruggedly designed and completely adaptable to production methods. Performance characteristics that are even more precise can be provided within the same dimensions.

TYPICAL CHARACTERISTICS

Mass Unbalance:
Along Input Axis: 1.0°/ hr maximum untrimmed

Standard Deviation (short term):
Azimuth Position: 0.05°/hr
Vertical Position: 0.03°/hr

Drift Rate Due to Anisoelasticity
Steady Acceleration:
.015°/hr./g² maximum

Vibratory Acceleration:
.008°/hr./g² maximum

Damping:
Ratio of input angle to output angle is 0.2

Characteristic Time:
.0035 seconds or less

Weight: 0.7 lbs.

Warm-Up Time:
10 minutes from —60°F

Life: 1000 hours minimum

Write for complete data.

BASIC BUILDING BLOCKS FROM KEARFOTT

20 SECOND SYNCHRO

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

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

Write for complete data.

BASIC BUILDING BLOCKS FROM KEARFOTT

MINIATURE VERTICAL GYRO

Provides accurate vertical reference in the form of two 400 cps synchro signals proportional to sine of gimbals' displacement about pitch and roll axes. Gravity-sensitive vertical reference device provides electrical signals directly to torque motors which maintain gyro spin axis perpendicular to earth's surface. Hermetically sealed and impervious to sand, dust, sun, rain, salt, spray, humidity or fungus as specified in MIL-E-5272A.

TYPICAL CHARACTERISTICS

Free Drift Rate:
Within 0.5° in one minute time.

Shock:
The gyro operates satisfactorily without damage after 60g shock of .015 seconds duration.

Hermetically Sealed:
These instruments are hermetically sealed and are not affected by sand, dust, sunshine, rain, humidity or fungus conditions.

Operating Temperature Range:
Gyros operate in ambient temperatures below —20°C to +100°C. A maximum of 3 minutes of operation at 400°F will not damage these gyros nor impair their accuracy.

Weight:
5.5 lbs. approximately.

Write for complete data.

Time Index Digitalizer

Precise Angle Indicator

Size 8 Integrating Motor Generator

Engineers: Kearfott offers challenging opportunities in advanced component and system development.

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Will tomorrow be a challenge ...or a bore?

If you feel that your present job is not fully tapping your potential, here are 4 new career opportunities for Electronics Engineers that have every bit of the challenge you may be looking for . . .

1 *Site Systems Reliability Engineer:* This position calls for a seasoned engineer capable of integrating and directing on-site reliability assurance activities necessary to secure customer acceptance of the detection system. Unusual combination of technical ability, relations and communications (written and spoken) is required. Desirable experience includes approximately ten years in design and field installation of transmitters on electronic systems with ability in both electronic and mechanical fields. Ability to motivate technicians for optimum performance is necessary. Salary structure is equal to the challenge.

2 *Radar Equipment Systems Specialist:* This position calls for a creative engineer capable of conceiving and directing the design of long-range radar systems. Desirable experience includes around ten years in at least one of the following: radar systems design, antenna systems, R.F. components, radar receiver systems or radar data processing systems. Salary structure is equal to the challenge.

3 *Advanced Systems Engineer:* This position calls for a creative engineer capable of defining future defense and space detection problems as well as the ability to conceive and establish the feasibility of optimum systems solutions to these problems—making use of the most advanced techniques and understanding. He must recognize the need for and coordinate the development of new techniques and the exploration of new phenomena in the area of detection systems. Background desired: Bachelor degree plus a combination of advanced training and several years experience in both the theoretical and practical aspects of detection systems engineering. A desire to work in the conceptual phase of system design with the analytical ability required to evaluate and demonstrate the effectiveness of proposed systems.

4 *Advanced Radar Systems Analysis and Development Engineer:* Engineers are needed who are able to visualize and define future defense and space problems—conceive advanced radar systems to solve them. An advanced degree and/or strong background in system analysis and design is essential. Assignments open include: analyze and define requirements for advance detection systems and determine broader parameters for such systems, establish their feasibility; analyze long range missile detection systems and specify optimum configuration on the basis of utility, performance, cost and delivery. 228-9

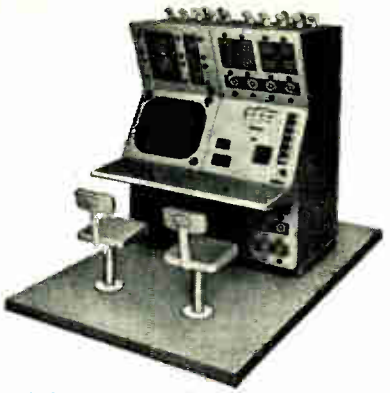
All of these openings are on General Electric missile and satellite detection projects and will be filled with engineers having the capability and desire to make creative contributions.

Write in confidence to T. M. George, Supervisor—Personnel Administration

Missile Detection Systems Section
HEAVY MILITARY ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

SYRACUSE, NEW YORK

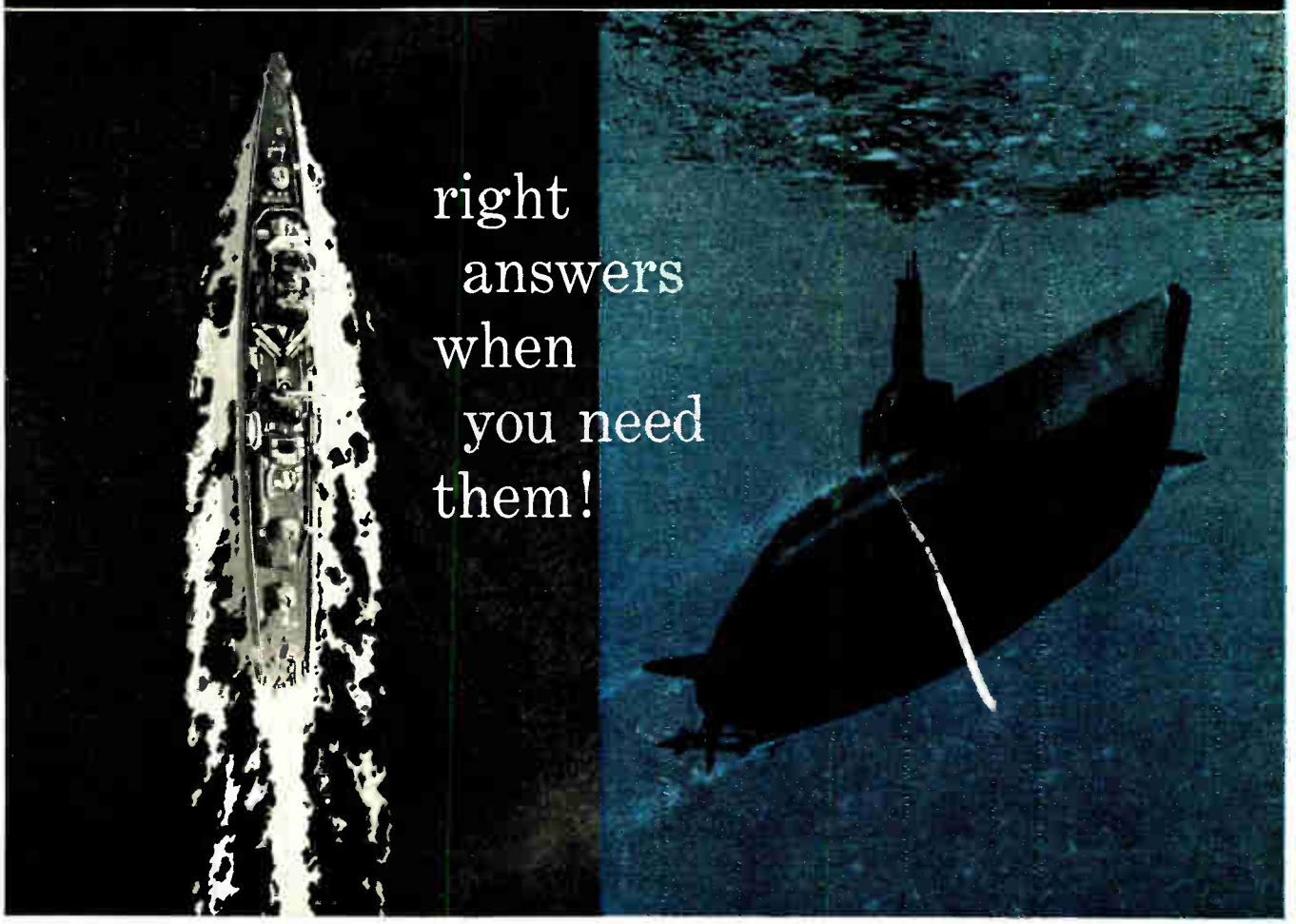


TODAY'S ANTISUBMARINE WEAPONS CONTROL COMPUTER

THE TIME: *Early 1940.* **THE ACHIEVEMENT:** *A small, compact ballistic computer for the U.S. Navy.* **THE RESULT:** *The beginning of Librascope's leadership in the design, development, and production of weapons and navigation control systems and components.*

Today, Librascope-designed and manufactured electronic and mechanical equipment for the MK 113, MK 111, MK 110, MK 107, and MK 105 underwater fire control systems include computers, attack directors, torpedo and missile angle solvers, attack plotters, depth plotters, position keepers, target motion analyzers, stabilization computers, roll and pitch computers, and various indicators and control instruments. ■ Librascope's simulation laboratories provide the Navy with a means for testing and analyzing the performance of equipment under "real attack" conditions. In the field, our engineers assist in the maintenance and improvement of Librascope systems.

SHIPBOARD COMPUTERS



COURTESY NBC-TV FILMS' "THE SILENT SERVICE"

For information on career opportunities at Librascope, write Glen Seltzer, Employment Manager.

Librascope's experience creating new concepts in computer—control systems for both military and industrial use can be accurately applied to your specific needs. ■ For detailed information and solutions to your computer problems, write...

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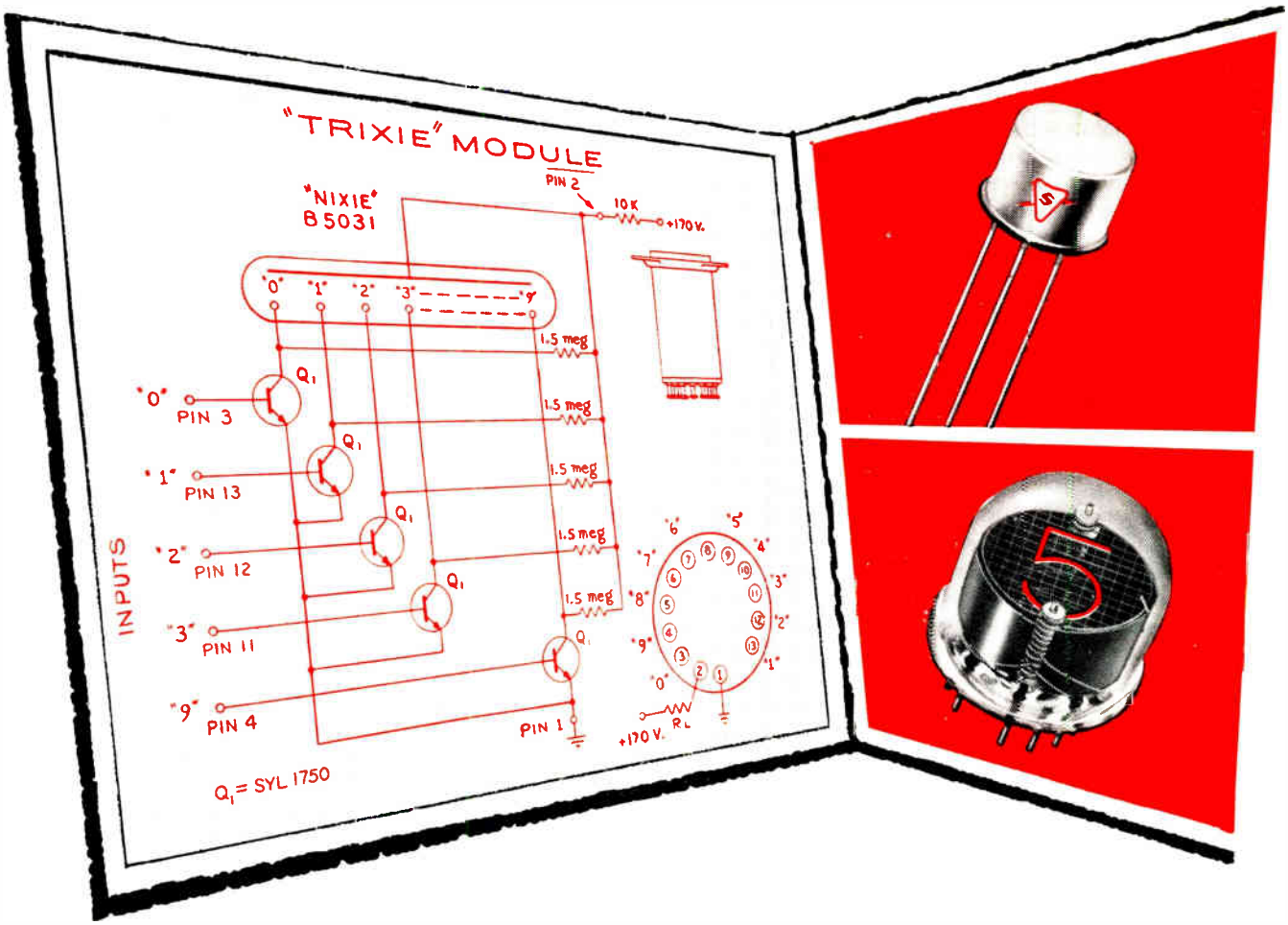

...NEW LOW-COST

Transistorized Readout

"Trixie", new computer readout circuit design, utilizes Sylvania's new NPN transistor, Syl 1750, and the Nixie® indicator tube

Now, designers can meet direct readout requirements for computers, instrumentation and data display with new economy and efficiency. Sylvania, pioneer manufacturer of NPN transistors, has developed new parameters in the Syl 1750 to meet the need for a low voltage input driving circuit for the Nixie indicator tube.

"Trixie" (Transistors + Nixie tube) comprises ten Sylvania NPN medium voltage switching transistors, Syl 1750, in a common emitter configuration. Each transistor drives one of the tube's ten cathodes. The result is the lowest power visual readout available. It can be designed in plug-in module form around a standard Nixie tube socket with terminals provided for electrical connections. A typical module, especially adaptable for direct panel mounting, has an over-all length of two inches and a nominal one-inch diameter.

The new Syl 1750, specially designed for "Trixie," is a 40 v (minimum) NPN germanium alloy junction transistor. Its low cost is a product of Sylvania's production know-how in NPN transistor manufacture and long experience in NPN design. Syl 1750 meets the reliability and performance criteria of other Sylvania switching transistors and matches their high-quality standards. It is encased in a JEDEC TO-5 package with the Sylvania welded hermetic seal for full protection against humidity and other environmental conditions.

Call your Sylvania representative now for full details of the new low-cost transistorized readout components.

"Trixie" & "Nixie" are trade marks owned by Burroughs Corporation.

SYLVANIA GENERAL SYSTEM

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

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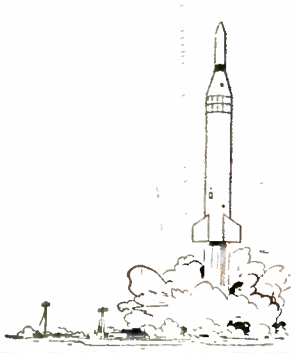
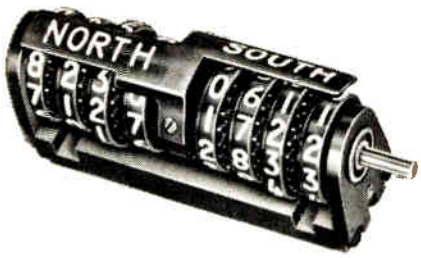


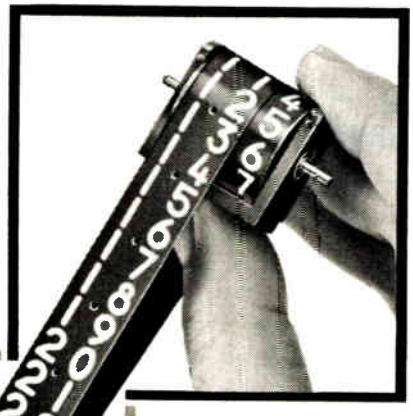


Precision Readout Counters for navigational and control systems include Tandem counters (left), concentric drums, and multi-bonk types. "Application Engineered" as complete packages.

PRECISION readout (DIGITAL IN-LINE) COUNTERS

High Speed Counter works at 1000 rpm with low torque and miniature size. For aircraft fuel-flow meter and similar applications.

New Concepts in Fast, Accurate Data Presentation



Precision Counter has completely internal supporting structure for instrument applications requiring extreme compactness, light weight and ruggedness. Three or five wheels, numerals in enamels or fluorescent points.

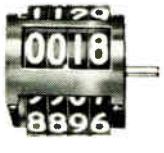
New 360° Tape-Type Bearing Counter recently developed for digital readout of angular relationship. Tape greatly reduces size and weight over conventional devices. "Application Engineered" as required.

Now you can use modern digital readout whenever extreme accuracy and precision indication are required. Veeder-Root Instrument-type Counters have "Application Engineered" tolerances, meet severe environmental specifications, operate accurately at high speeds, and offer wide selections of gearing and package designs.

Here are just a few of the ways Veeder-Root Precision Readout can improve and simplify product operation and performance . . .

- Figures and letters are positive, and easily comprehended
- In-line presentation more *quickly* read
- Replaces micrometer and vernier devices
- Maximum readability in miniature sizes
- Fractions, degrees are positively displayed

Take full advantage of digital readout with Veeder-Root Precision Counters — for military, aircraft, missile and industrial instrumentation. Standard types and special designs for all types of application, and design assistance is available from Veeder-Root Counting Engineers. Write or call.



High speed miniature counter suitable for applications requiring small size and weight, low torque and low cost. External pinion, ½" wheels, ⅛" characters.

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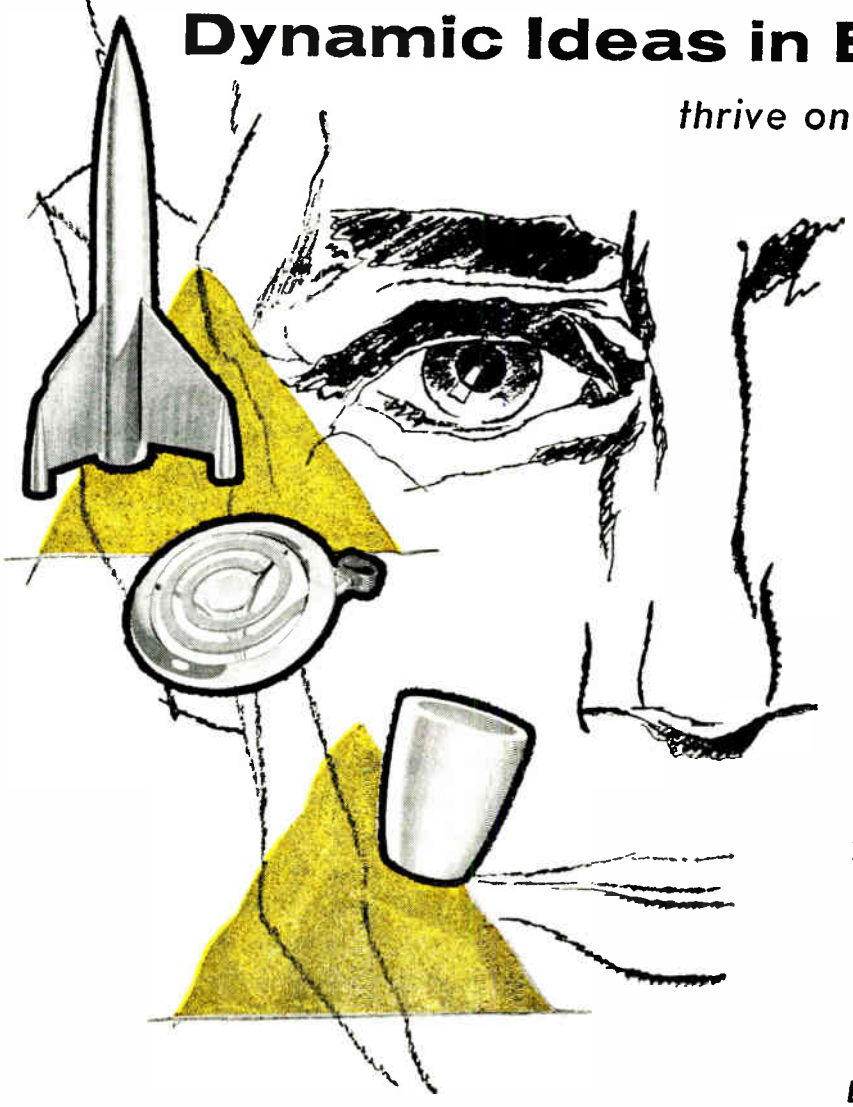
Here are the "basic ingredients" in some of today's most advanced design concepts . . . Norton Ceramic Materials. Exceptionally versatile, these exciting materials are meeting operating requirements of products and processes across industry.

Norton Ceramic Materials offer design engineers a wide range of outstanding physical, chemical, thermal, and electrical properties. What's more, they provide interesting *combinations* of these properties. For example: CRYSTOLON* silicon carbide provides high thermal conductivity as well as exceptional thermal strength; ALUNDUM* aluminum oxide has excellent chemical stability in addition to good abrasion resistance; MAGNORITE* magnesium oxide offers high purity, thermal and electrical resistance; fused

Dynamic Ideas in Engineering . . .

thrive on Norton ceramic materials



zirconium oxide is today's highest melting point material available in tonnage quantities and it's immune to both reducing and oxidizing atmospheres. And each product has *many* other invaluable properties.

Think of Norton Ceramic Compositions as essential components in equipment for metal and chemical processing, electrical, electronic, ceramic and nuclear applications . . . as "the answer" to literally hundreds of design problems. They're manufactured to meet highly exacting standards of purity, density, shape, size and wear resistance . . . available in granular and in fabricated form to meet *your* requirements efficiently and economically. For complete details, write for "Norton REFRACTORY GRAIN". NORTON COMPANY, Refractories Division, 941 New Bond Street, Worcester 6, Mass.

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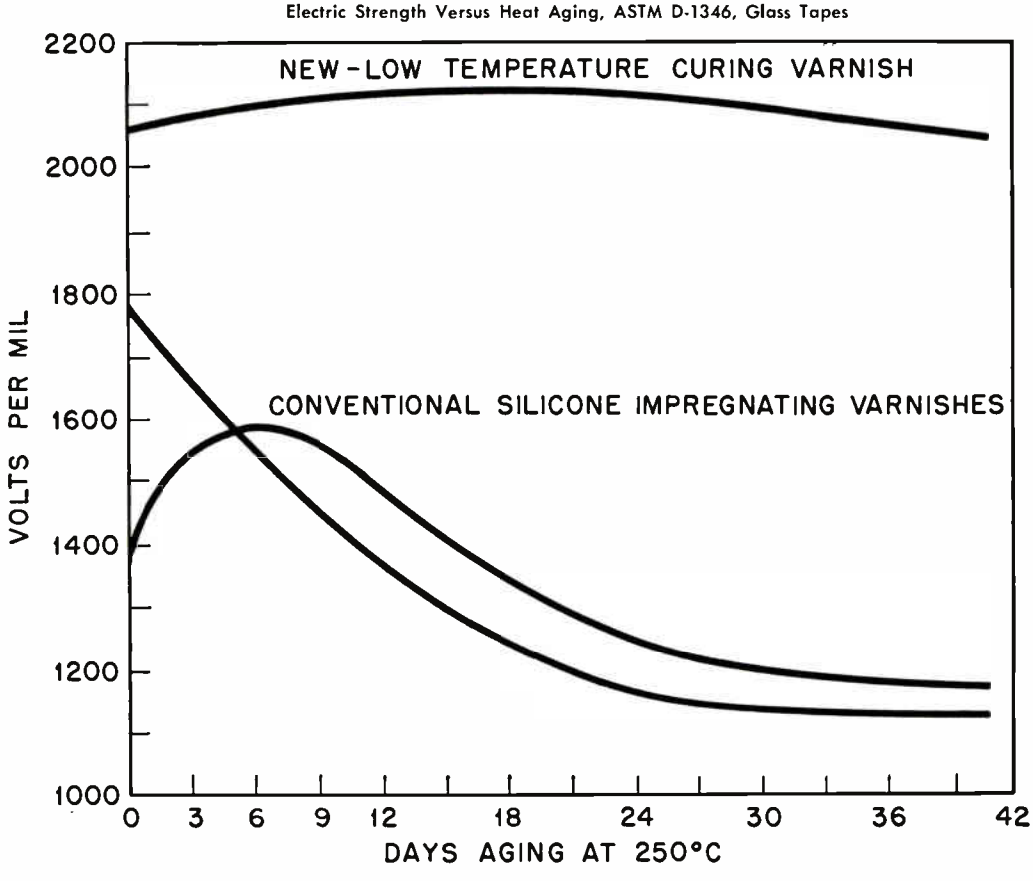
NORTON PRODUCTS Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electrochemicals — BEHR-MANNING DIVISION Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

SR-220 New Silicone Varnish cures at low (150°C) temperature

HEAT RESISTANCE SUPERIOR TO CONVENTIONAL SILICONE VARNISHES

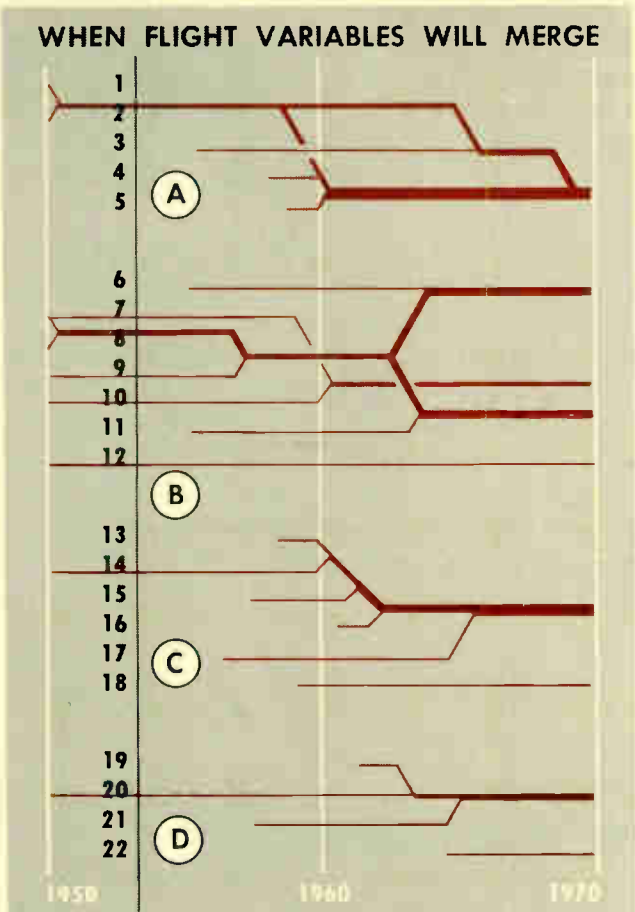


SR-220 is a new silicone impregnating varnish by General Electric that cures in the same ovens used for organic varnishes. The customary advantages of silicone insulation are improved, too. For instance, thermal stability at elevated temperatures is far better than conventional silicone varnishes. Shelf life and tank stability are excellent.

With G-E SR-220 you have a new opportunity to improve the temperature resistance of insulation systems in all temperature classes. Silicone insulation means longer equipment life, high temperature resistance, extra overload capacity and smaller equipment size. With SR-220 you can have these features without investing in high temperature ovens. Call your G-E Silicone Sales Representative for further details, or write Section N1216, Silicone Products Department, General Electric Company, Waterford, N. Y.

GENERAL ELECTRIC

Silicone Products Department



FLIGHT VARIABLES

A—Thermal Environment

1 Atmospheric Pressure
2 Atmospheric Temperature
3 Aerodynamic Heating
4 Solar Irradiation
5 Vehicle Radiation

B—Kinematic Environment

6 Acoustic Vibration
7 Mechanical Vibration
8 Atmospheric Temperature
9 Atmospheric Pressure
10 Steady-State Acceleration
11 Aerodynamic Heating
12 Transient Acceleration

C—Corrosive Environment

13 Ozone
14 Atmospheric Pressure
15 Solar Radiation
16 Ionized and Dissociated Gas
17 Aerodynamic Heating
18 Meteoritic Dust

D—Electromagnetic Environment

19 Solar Radiation
20 Atmospheric Pressure
21 Nuclear Radiation
22 Geomagnetic Field

FIG. 1

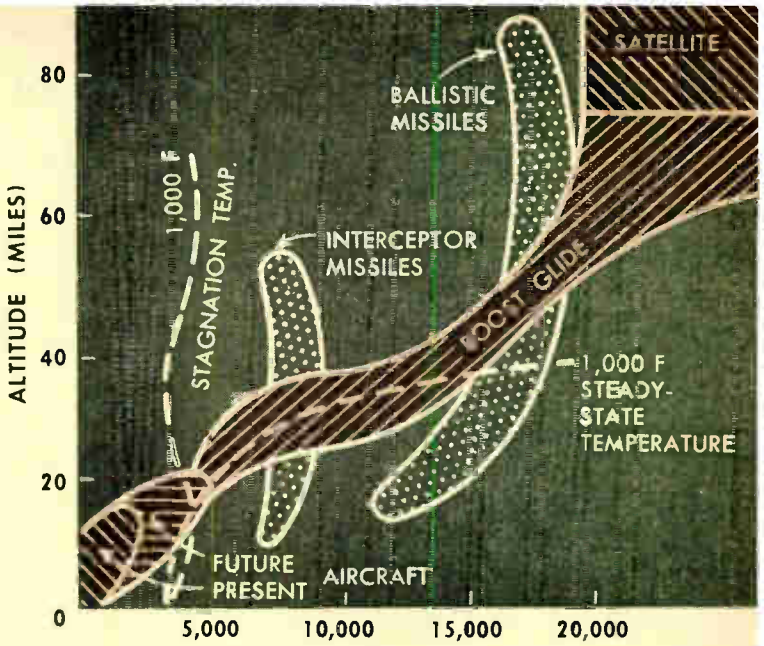


FIG 2

MATERIALS for Environmental Extremes

By GEORGE SIDERIS
Buyers' Guide Editor, ELECTRONICS

1. Tomorrow's Environmental Extremes
2. Environmental Limits of Materials
3. Compatibility of Materials
4. Materials Development Needs

MATERIALS—OUR MOST PRESSING PROBLEM

In his talk before the 1959 IRE National Convention, Allan M. Hadley, Deputy Secretary of the Advisory Group on Electronic Parts, ventured that the most pressing probem facing 75 percent of electronic designers was better materials. He said:

"The Jet Age (and the) Nuclear Age . . . both burst upon us almost simultaneously, bringing with them requirements which at first seemed so fantastic as to defy the imagination. Just at the time when operating temperatures of electronic devices had been pushed upward from 65 C to 125 C . . . the Air Force suddenly advanced requirements calling for operation at 350 C and 500 C.

". . . The impossibility of upgrading electronic parts made from conventional materials . . . was obvious almost at first glance . . . Cooling was a compromise which added to the complexity of the installations as well as to their weight and size . . .

Organic materials—at least as we now know them—have little or no possibility of use above 260 C . . . most magnetic materials undergo drastic changes at less than 500 C . . . the changes in the electrical properties of materials that might operate at 500 C would be intolerable . . . High on the list (of military needs) are materials possessing improved heat resistance, greatly improved dimensional stability over wide temperature ranges, and having uniform electrical properties under all conditions . . ."

1. Tomorrow's Environmental Extremes

Use of electronic equipment in high-speed aircraft, space vehicles and nuclear environments is bringing about serious problems of heat, radiation and stress

A MAJOR TASK of electronics materials developers is to cope with environments anticipated for special nuclear weapons, nuclear aircraft and missiles, and high-speed aircraft operating within the atmosphere (Table I).[1]

An estimate of when the environmental hazards will merge is shown in Fig. 1.[2] Conventional definitions of environmental extremes presuppose protection of electronic gear by cooling, heating, and by encasement in sealed housings or behind radiation shielding.

But space and weight considerations oppose use of heavy protective structures in some airborne equipment. Each extra pound of equipment weight in a missile raises its takeoff weight by about 30 pounds. In addition, it is difficult to cool equipment which must also be shock-mounted, or sealed. The objective is equipment which can be thrust almost naked into hostile environments.

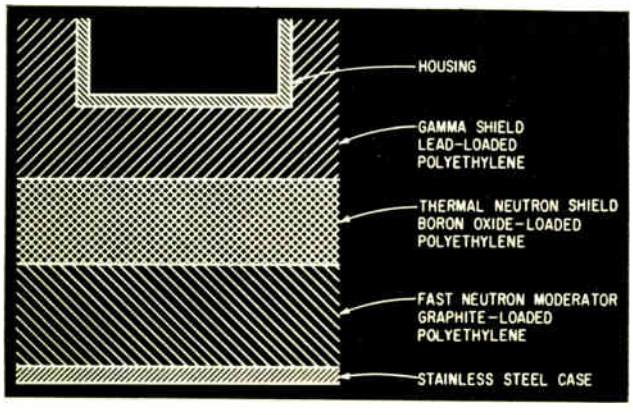


FIG. 3—Shielding which will protect electronic equipment from a near miss by an atom bomb (2 mev gamma energy and 1 mev neutron energy)

CIVILIAN ELECTRONICS—Military developments will probably, as in the past, affect civilian electronics. Temperature-stable materials can mean simplified circuits, new industrial markets, greater freedom in miniaturization, packaging and production techniques. Shock, moisture, humidity, corrosion and biological attack are problems common to military and civilian equipment.

SPACE FLIGHT—Successful performance of satellites has allayed some of the pre-Sputnik concern about the effects of ozone, low pressure, radiation,

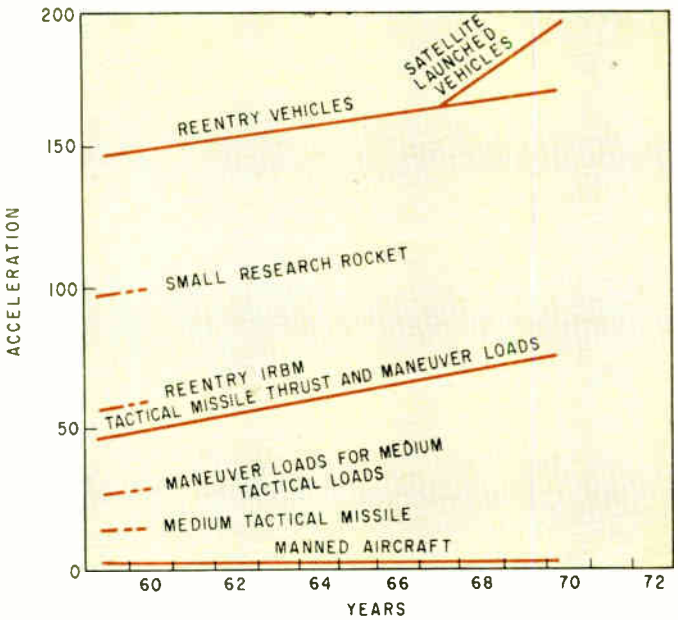


FIG. 4—Anticipated accelerations for aircraft, missiles and spacecraft

Table I—Military Environment Goals

Characteristic	1957	1959	Equipment[a]
Operating Temp	−65 to 1,000 C	−65 to 500 C	nuclear weapons
Storage Temp	−65 to 71 C	−65 to 85 C	all
Thermal Shock	.....	−65 to 500 C	nuclear weapons
Moisture 100% RH	10 cycles	10 cycles	all
Vibration (cps)	10–3,000 40 g	10–3,000 40 g	nuclear weapons
Air-induced Vib (cps)	150–9,600 cps 165 db	150–9,600 cps 165 db	air, missiles and nuclear weapons
Acceleration	50 g 11 msec	50 g 11 msec	all
Radiation			
n/cm²/sec	10^{15}, 1,000 hr	10^{16}, 1,000 hr	nuclear aircraft,
photons/cm/sec	10^{15}, 1,000 hr	10^{11}, 1,000 hr	nuclear weapons,
n/cm²/sec	.....	10^{17}, 80 msec	missiles
gamma r/sec	.....	10^{8}, 80 msec	

(a) Classes of equipment as defined in 1959. The classes of equipment used in the 1957 list of environmental goals have been redefined

temperatures and meteorites in space. Environments inside the satellites have been mild. While the life of components held in the Van Allen radiation belt might be as low as a few days, quick passage through the belt has little effect. Micrometeorite sandblasting—which could destroy heat stabilizing satellite coatings—has apparently been negligible. Meteorite puncture of Explorer III was suspected.

HEAT AND RADIATION—High speed flight creates aircraft temperatures to 500 C, higher on exposed surfaces (Fig. 2).[2] Temperatures to 5,000 C are faced for brief periods by radomes under reentry conditions. The military electronic materials goals are 500 C for nuclear weapons, 350 C for high performance aircraft, 200 C with radiation resistance for nuclear-powered aircraft and missiles, and 125 C with pulse radiation resistance for interceptor type aircraft and missiles.

Many conventional materials, particularly those which are inert, will tolerate radiation. There are relatively few materials which tolerate radiation, high temperature and mechanical stress simultaneously. These materials are mainly metals and inorganics. Materials with low neutron capture cross sections are desirable in radioactive environments to prevent buildup of long-lived radioactive isotopes. Many of the popular electronic materials—aluminum, copper, germanium, silicon, silver, magnesium—have short-lived isotopes.

Radiation readily affects most organic materials, semiconductors, oil-impregnated components, boron or lead glass tubes. Inorganic capacitors, metal resistors and some magnetic materials bear up well. An example of the type of shielding needed for radiation-sensitive systems exposed to a near miss by an atomic bomb is shown in Fig. 3.[3]

MECHANICAL STRESS—Acceleration is expected to climb, in out-of-atmoshere vehicles, to three or four times the present 50 g (Fig. 4).[2] Peak vibration may go up 50 percent by 1970, in large rocket-powered vehicles. Increasing requirements brought about by air-induced vibration, however, should peak in a few years at about 170 db.

DEFINITIONS OF NUCLEAR ENERGY UNITS

nv—neutron flux: neutrons times velocity (cm per sec times neutrons per cm^3)

nvt—integrated neutron flux: total neutron flux during exposure time

ev—electron volt

Curie—radioactivity of 1 gram of radium: equal to 37 billion atomic distintegrations in 1 second

rad—radiation dose: equal to absorption of 100 ergs of energy by 1 gram of exposed matter

rem—biological measure of radiation dose. A rad of alpha rays equals 10 rem; a rad of x-rays, gamma rays or beta rays equals 1 rem

Roentgen—irradiation sufficient to produce about 2 billion positive and 2 billion negative ions in 1 cc of dry air at 0 C and 760 mm Hg (83 ergs per gram, or about $7.2X10^{?}$ 2—mev neutrons/cm^2)

2. Environmental Limits of Materials

Research is raising endurance limits of materials like structural metals, conductors and magnetic materials; components such as transducers, semiconductor devices, capacitors, resistors

STRUCTURAL METALS—The structural requirements of virtually all electronic equipment can be met on most environmental levels with currently available alloys (Fig. 5).[2] Airframe and chemical process needs have caused development of metals adequate for most electronic needs.

A rule of thumb on heat resistance is to take 40 percent, in degrees Kelvin, of the pure metal's melting point. The ratio is 60 percent or better for alloys. Under radiation, most metals become harder, stronger and increase in resistivity. With high temperature added, changes tend to anneal out as fast as they occur.

Irradiation tends to make most metals harder but less ductile. Except for titanium, metals which normally yield under tension will generally break under tension above yield stress after irradiation. But irradiation also increases the yield strength of metals by 60 to 450 percent.

Stainless steels are good materials for extreme temperature and radiation. They are widely used to protect transducers in reactors.

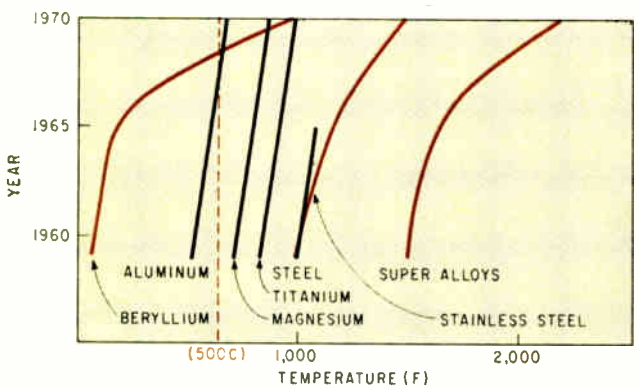


FIG. 5—Temperatures at which alloys retain structural strength

ELECTRICAL INSULATION—When subjected to radiation, ceramics may discolor, expand and change in thermal conductivity. However, magnesium oxide single crystals and boron carbide tend also to fracture; zirconium oxide changes in crystal structure; silicon carbide, cordierite and zircon tend to lose crystallinity.

Quartz decreases in density and may dissolve into glass. In one series of tests on quartz crystals, 75 percent failed. Remedies (for crystal oscillators)

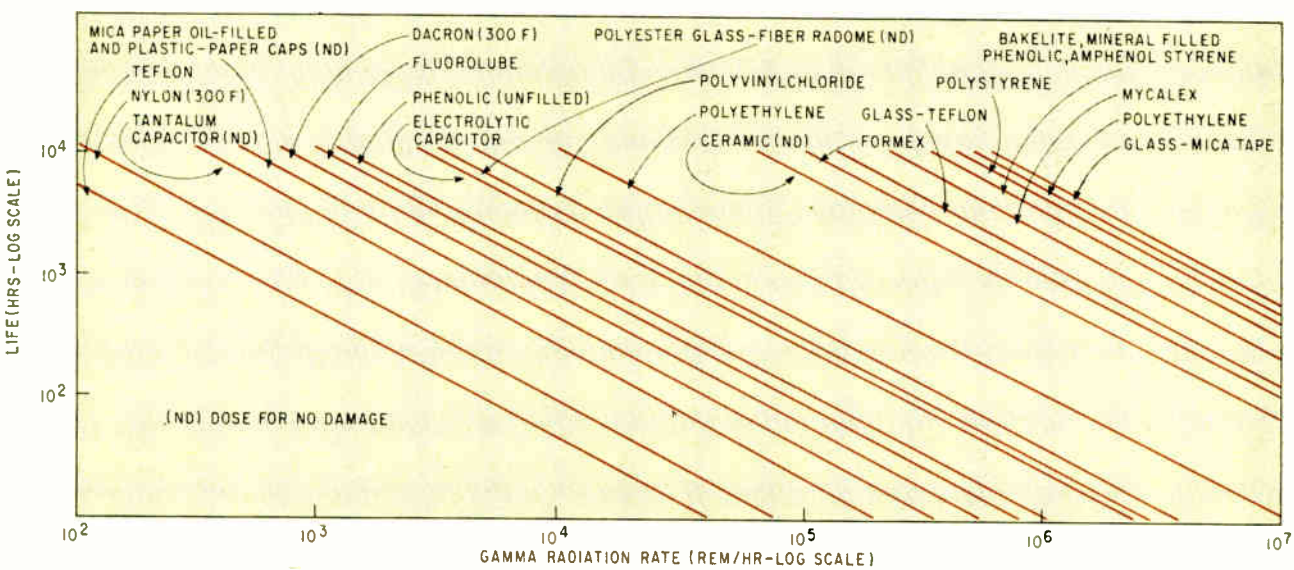


FIG. 6—Approximate life expectancy of some dielectric materials and tantalum, oil-filled and electrolytic capacitors

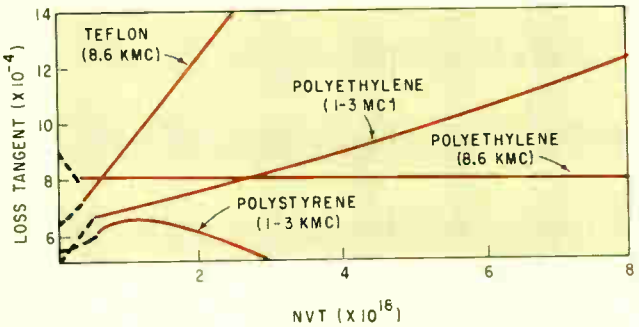


FIG. 7—Loss tangents of some commonly used dielectrics at medium to high frequency, after irradiation

may be found in more inert supporting materials and more selective cuts.

Silica and soda-lime glasses change color. Borosilicates suffer severe surface checking in addition to color change. Lead glasses devitrify to lead and other materials. The above effects were noted after irradiation of about 10^{20} nvt and 10^{7} r.

Most plastics tend to lose tensile strength and impermeability under irradiation and they are often useless at 10^{20} n/cm^2 even at normal temperatures. Halogenated polymers like fluorocarbons can give off corrosive gases. Moderate radiation, however, strengthens such plastics as polyethylene and styrene. Radiation stability can be improved by inorganic fillers, rigid plastics are more resistant than soft materials. Filled epoxies, polyesters and phenolics and silicone resins are radiation-resistant (Figs. 6 and 7).[4, 5]

HIGH-TEMPERATURE INSULATIONS—Natural and synthetic glass-bonded micas, sapphire and glasses of the fused quartz, fused silica, lime, barium and calcium aluminosilicates, and the glass-ceramics are all servicable at high temperatures. Glasses with resistivities as high as 10^{14} ohm-cm at 250 C, $10^{9.5}$ at 350 C and $10^{9.4}$ at 500 C are available.

Some ceramics with service temperatures over 1,000 C are listed in Table II. Beryllia must be used with caution since it is toxic and decomposes when not protected from moisture. Thoria is slightly radioactive. Plastics limits for structural use are given in Fig. 8[2].

Glass, in various fibrous, matted, woven and pellet forms, mica flakes, synthetic mica and similar materials will upgrade organic materials. Plastics molded with glass fiber fillers provide strong structural parts and permit more or heavier parts to be placed on circuit boards. Teflon and silicones are usable at 400 C and over for short periods. Several inorganic materials absorb moisture unless provided with a glaze or other seal coat.

PRINTED-CIRCUIT BOARDS—Ceramic, glass-ceramic and glass-bonded mica are suited to applications at 400 C and up. Miniature printed circuits with moly-manganese wiring fired on alumina are reported to withstand 700 C; platinum wires and silver contacts embedded in Forsterite got an 800 C report. Conductors may also be molded or plated into the substrate to provide a flush surface for contact wiping.

The effect of radiation on the dry flexural strength of glass-reinforced laminates is shown in Fig. 9.[6] Heat resistant laminates were also tested at 260 C after irradiation. Other strength tests results were roughly parallel, except for a non-heat-resistant epoxy which delaminated at about 10^{8} r during wet flexure and tensile tests. The dielectric constants of these materials remained essentially constant between exposures of 10^{5} to 10^{9} r.

Organic laminates for continuous service at 200 C and short term service at 250 C are found in the

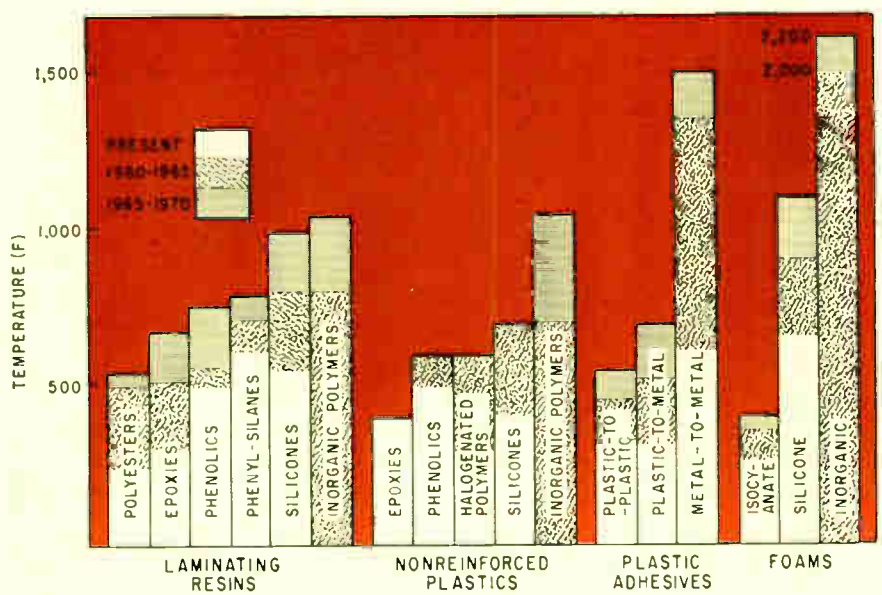


FIG. 8—Approximate temperature limitations of selected plastics (200 hours)

Table II—Some Inorganic Insulations Servicable at 1,000 C

Sapphire Crystal
Alumina
Alumina Porcelain
Alumina Silicate
Cordierite
Fired Talc
Zircon Porcelain
Steatite
Forsterite
Lithia Porcelain
Beryllia
Magnesia
Thoria
Silica Glass

Table III—Properties of Bonded Synthetic Fluorphlogopite Mica

Properties	Binder Material Silica Sol[a]	Glass
Max Fabrication Temp (C)	200	732
Max Service Temp (C)	1,100	500
Volume Resistivity (dry)		
ohm-cm at 25 C	4.02×10^{10}	2.6×10^{13}
500 C	6.68×10^{6}	8.5×10^{7}
Dielectric Strength 25C	55 v/mil min	112 v/mil min
Dielectric Constant (dry)		
10^6 cps at 25 C	3.35	6.47
500 C	5.94	8.02
Loss Tangent (dry)		
10^6 cps at 25 C	0.0045	0.0056
500 C	0.37	

(a) Eccoceram SM-25

Table IV—Temperature Limits of Foams

Material	Max Temp (F)	Material	Max Temp (F)
Silica, Alumina	2,500	Silicone (sponge)	500
Wollastonite	1,500	Cellulose	350
Ceramic	1,200	Polystyrene	165
		Cross-linked	350
Silicone (filled)	800	Polyurethane	350
Silicone	700	Phenolic	300
Epoxy	600		

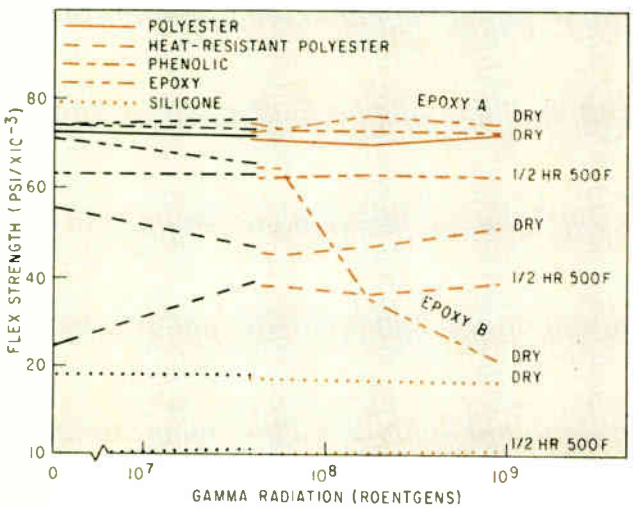


FIG. 9—Glass-reinforced laminates (⅛-inch thick) retain structural strength under gamma irradiation

NEMA grades. Felted asbestos-phenolic laminates have a 250 C continuous rating and a 475-500 C short term capability. At low frequencies, heating raises the dielectric constants. At high frequencies, heating has little effect on reinforced polyester, asbestos phenolic or glass-phenolic at a given frequency.

ENCAPSULANTS AND IMPREGNANTS—Organic potting compounds are generally not usable beyond 200 to 250 C unless filled. Among the exceptions are silicones, which retain some 80 percent of their original properties at 315 C; butadiene-based resins, 260 C, and epoxies, 315 C. Silicone varnishes containing phenyls are said to be radiation resistant. Under irradiation, a silicone oil may become rubbery; silicone rubber may become brittle. The former provides a potential means of low-temperature cures for oil-impregnated material such as cable insulation.

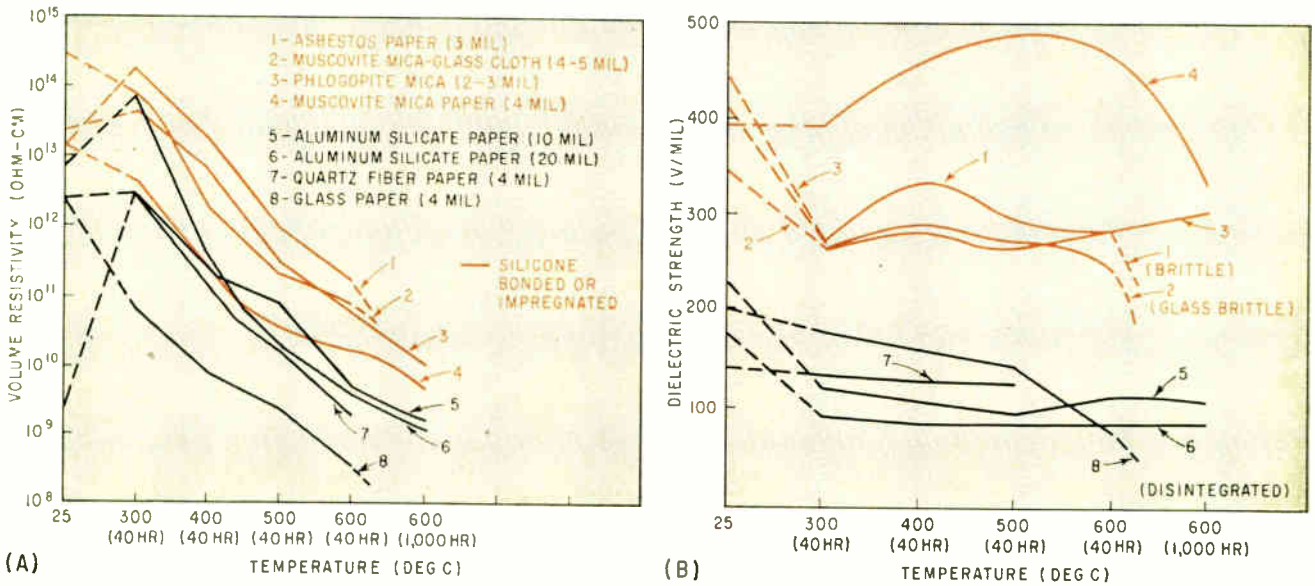


FIG. 10—Results of an evaluation of sheet insulation for a transformer to operate at 500 C. Silicone-mica was selected

One of the problems of inorganic potting compounds is that they are applied as a slurry. The liquid, as it evaporates at high temperature, may leave gaps in the insulation or cause corrosion. If the component permits tamping or pouring in powdered oxides or other inert materials, this problem is minimized. Cements such as those based on magnesite, phosphate-bonded zircon and calcium aluminate are satisfactory provided they do not form corrosive chlorides. Low melting glasses may also be used for moderate temperature applications. Properties of two inorganic compounds are given in Table III.[7]

FOAMS—Foams (Table IV) are used for radomes, microwave absorbers, encapsulants, protective packaging. The inorganic types are generally tamped in place or cut to size. Teflon is "foamed" by filling it with low temperature materials which are sintered out. Plastics can generally be foamed in place. If internal heat must be dissipated, cooling ducts or metallic paths should be molded into the foam to draw off heat.

Ceramic foams can be made with excellent elec-

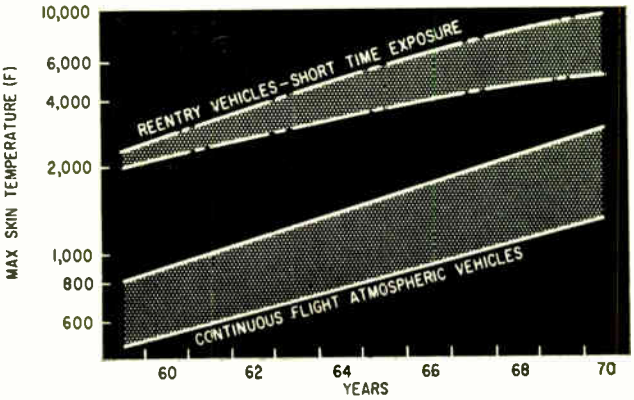


FIG. 11—Anticipated aerodynamic heating temperatures. The atmospheric flight is projected to a speed of Mach 4

Table V—Weight Loss of Some Materials When Exposed to Plasma Arc

Resin and Filler	Loss[a]
High Temp Phenolic	
—chopped Refrasil cloth	2.3
—Orlon fiber	1.3
—chopped Nylon cloth	1.1
—acid leached asbestos	2.1, 2.9
—chopped asbestos fabric	2.1
Phenolic Molding Compound	
—Mil Type MFG	2.1
—high temp	1.7
Phenolic	
—graded magnesium oxide	1.8
—graphite molding compound	1.7
Melamine	
—Fiberglas (NEMA G-5)	3.6, 5.4
—cotton (NEMA MC)	2.6
Silicone	
—Fiberglas (NEMA G-7)	3.3
—chopped glass fiber mold comp	2.9
Epoxy	
—electrical grade laminate	2.3
epoxy-pyromellitic dianhydride in Fiberglas	3.0
Hard Rubber	
—no carbon	2.8
vulcanized fiber	2.7
copper rod (for comparison)	60

(a) Weight loss in mg/kw-sec: ½-inch diameter rods

Table VI—Properties of Radome Materials

Material	Temp (F)	Dielectric Constant @ 8,600 mc	Loss Tangent @ 8,600 mc
Silicone resin-inorganic bead sandwich	room	3.99	0.022
	660	3.83	0.022
	920	3.80	0.024
Phenolic resin-inorganic bead sandwich	room	5.88	0.050
	660	5.75	0.038
	900	5.20	0.033
Inorganic laminates	room	3.30	0.0089
	500	3.47	0.0167
	1,000	3.46	0.0198

Table VII—Ground Radome Coatings

Resin Type	Adhesion to Polyester Laminate	Outdoor Durability
Acrylic	fair	excellent
Alkyd	good	good
Drying oil	fair	fair
Epoxy	excellent	good
Phenolic	good	fair
Vinyl	poor to fair	fair to good
Silicone	fair	good
Chlorosulfonated Polyethylene	poor	good
Polytetrafluoro-ethylene	poor	(limited data)
Polytrifluoromono-chloroethylene	poor	fair
Polychloroprene	good	good to excellent
Polyurethane	good	good

Table VIII—Resistivities of Conductors at 500 C

Material	μohm-cm	Material	μohm-cm
Silver	4.1	Magnesium[a]	13.8
Copper	5.1	Molybdenum	15.8
—Al clad[a]	6.3	Tungsten	18.5
—Ni clad 27%	7.9	Platinum	29.1
Gold	6.6	Palladium	31.3
Silver-Mg-Ni	6.8	Titanium	14
Aluminum[a]	10	Nickel	78.3

(a) Melting points 650–660 C
Ratio between room temperature and 500 C resistivities is 2.52 for silver; 2.71, gold; 2.9, copper; 3.82, aluminum, and 10, nickel

Table IX—Ultra-High Temperature Conductors

Material	Max Service Temp (C)	Resistivity (ohm-cm) @ 20–25C	High Temp
Zirconium Oxide	2,500	a	1×10^{0} @ 2,000 C
Tin Oxide	1,500	4×10^{6}	6×10^{1} @ 1,200 C
Moly Disilicide	1,500	25×10^{-6}	80×10^{-6} @ 1,600 C

(a) Nonconductor at 20 C
Silicon carbide and zinc oxide may also be used

trical stability. Wollastonite is heavy, but has a low dielectric constant (1.4 to 1.5 for 40-pound foam at 3 mc) which is reported to be constant from 20 to 800 C.

Unlike solid materials, foams can do double duty as shock absorbers, vibration dampers or thermal shields. Instruments placed in an Atlas missile, for example, were housed in urethane. Entire chassis can be packaged in foam if the tube shields and cooling ducts are molded into the foam.

TAPES, FILMS, TUBES—Organic materials are usable to 260 C. Teflon, as a cable wrapping is reported usable for 100 hours at 350 C. Silicone-glass has up to 1,000-hour life at 300 C and short term life at 400 C. Beyond this range it is necessary to use inorganic materials or silicone-impregnated inorganic materials. The performance of some of these materials is shown in Fig. 10.[8]

GASES AND FLUIDS—Perfluorocarbon gases are suitable for cooling and insulation at temperatures around 200 to 250 C and are reported to be compatible with other electronic materials used at those temperatures. Silicones and silicate-ester-based fluids are also considered 200 C fluids. Fluids are another double-duty material, since their damping action protects against vibration and shock. The new liquid state diodes and switches, for example, are reported to be relatively insensitive to vibration. Inert gases are required at very high temperatures.

RADOMES—Radome designers have for several years been living with the thermal problems (Fig. 11)[2] now facing designers of internal aircraft and missile systems. Although most high-temperature radome materials (Table V)[9] are designed for systematic erosion, radome experiences should be instructive to persons developing other structural components.

At temperatures over 125 C, reinforced plastics lose strength more slowly than light metals. On exposure to flowing heat, the outer surface absorbs much of the heat. The surface is then cooled by discarding the hottest material, transpiration of a

Table X—Radiation Effects on Some Magnetic Core Materials

Material	% Change in D-C Properties						% Change in A-C Properties							
							Flux Density			B_r/B_m			H_c	
	u_o[a]	u_m	H_c	B_r	B_s[c]	B_r/B_m	H_p[d]	60~	400~	H_p	60~	400~	60~	400~
3.5 silicon Iron	8	−1	5.7	0.8	0	0.8	0.1	1	0.5	7	1.5	1.5	9	7
Orthonol	−31	15	−28	−24	−4	−21	0.1	−36	−41	2	−17	−17	44	85
5–79 Mo-Permalloy	−9.3[b]	−93	815	−38	−3.2	−36	0.01	−92	−84	4	−46	−37	1,000	780
2 Vanadium Permendur	2.7	1.7	−2	−0.6	−0.7	0	1	5	2.5	20	−6	−2.5	5	10
16 Alfenol	34	15	−8	7.5	−5	13	0.1	−4	−5	5	−1.5	1	8	4
Nickel Ferrite	1.2	1.4	−4.6	−4	−1.7	−2.4	4	−2.5	23	20	−0.5	8	5	3.5
2–81 Mo-Permalloy	−6.8	−3.7			0.2		1	−7	−8	20				

Irradiation to 2.74×10^{18} neutrons/cm^2 (a) Permeability at B of 20 gauss (b) Reannealing restored magnetic properties (c) B for H of 30 oersted (d) h_p is the a-c field intensity in oersted at which corresponding properties were measured; u_o is initial permeability; u_m, maximum permeability; H_c, coercive force; B_r, residual induction; B_s, saturation induction, and B_r/B_s, squareness ratio

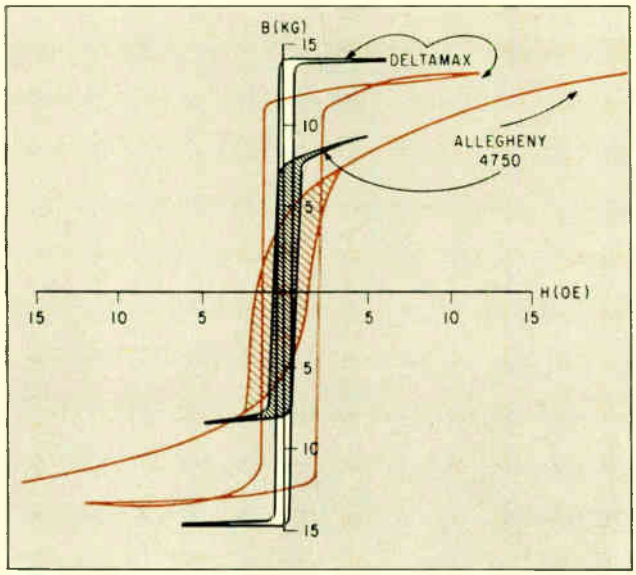


FIG. 12—Effect of irradiation on two 50-50 nickel alloys. Deltamax was irradiated at 115 C and Allegheny 4750 at 190 C

coolant through a porous wall, sublimination and similar methods.

Radome materials are frequently phenolic, silicone or other plastics supported by fibers. The laminates may be used to sandwich inorganic beads (Table VI).[10] Inorganic laminates may be made of fibers in calcium aluminate and phosphate cements, oxysulphate and oxychloride. Unsupported inorganic materials include alumina, glass-ceramics, glass-bonded mica and, for irdomes (infrared): sapphire, high temperature glasses and silica.

For service at moderate temperatures, laminates are made with silicones (500 C), phenolics (400 C), polyester (370 C), triallyl cyuranate, epoxies, phenolic honeycomb (260 C) and isocyanate foams (120 C).

Other cooling methods include heat sinks—beryllium is difficult to work with, but has good heat dissipating properties and has been chosen for Project Mercury—and heat reflective coatings. An investigation is being made of possible coatings which could change color with temperature, to automatically stabilize internal temperatures of satellites and space ships. Rain and snow-erosion-resistant coatings like neoprene are provided radomes intended for service in the atmosphere.

Reinforced plastics are also used in ground radomes. Here, wind, cold, snow and weathering are the environmental extremes. Weather norms generally prevent snow, ice and wind from becoming severe all at once. Weathering is prevented by coating. One firm tested a number of materials (Table VII)[11] and concluded that acrylic emulsions are good for polyester domes. Lithium chloride is reported to be a good anti-icing spray.

WIRE AND CABLE—Coaxial cable made with air-spaced Teflon is suitable for 300 C; ceramic fibers, silica, magnesium oxide, ceramic beads, for 500 C

Table XI—Effect of Irradiation on Some High-Permeability Cores

Material	Coercive Force	Initial Permeability
Supermalloy	815%	−93%
4–79 Mo-Permalloy	423%	−89%
Mumetal	158%	−66%
50–50 Nickel-Iron		
—unoriented	99%	−68%
—oriented	−28%	−31%

Table XII—Effect of Temperature on Some Nickel-Iron Alloys

Temp (C)	B_r (kg)	B_r/B_s	Temp (C)	B_r (kg)	B_r/B_s
Hipernik			Hipernik V		
−60	10.5	0.683	−57	14.9	0.98
250	5.4	0.445	250	7	0.554
−60	10.5	0.660	−60	13.5	0.901
Deltamax			Supermalloy		
−60	14.8	0.99	−57	4.6	0.704
250	7.2	0.592	250	3.6	0.531
−60	14.2	0.871	−61	4.6	0.695
Mo-Permalloy			Hymu 80		
−60	3.9	0.57	−57	5.5	0.858
250	3.6	0.531	250	4	0.606
−60	3.9	0.419	−60	5.5	0.816

Table XIII—High-Temperature Effects on Some Magnetic Cores

Material (Balance Fe)		μ_o (1,000)	μ_m (1,000)	B_r (kg)	B_m[c] (kg)	B_r/B_m	H_c (oe)
Transformer-A[a] (4.7 Si)	24C	0.79	10.7	9.5	14.9	0.64	0.41
	300C	1.3	11.3	7.8	14.4	0.54	0.32
	500C	0.47	12	6.6	14	0.47	0.27
3 cycles	24–500C	0.85	11.9	9.6	14.8	0.65	0.43
Audio Transf-B[a] (3.6 Si)	24C	0.8	10.7	11.3	15.1	0.75	0.48
	300C	1.3	11.3	9.3	14.6	0.63	0.39
	500C	0.5	12.2	7.7	14.1	0.55	0.28
3 cycles	24–500C	0.85	11.4	11.2	15	0.75	0.48
L-Silectron[b] (3 Si)	24C	1	28	15.5	18.5	0.84	0.28
	300C	3.6	30	13.5	17.4	0.78	0.2
	500C	0.67	25.2	9.4	15.4	0.61	0.16
3 cycles	24–500C	1.7	18.3	12.5	18.4	0.68	0.3
Z-Silectron[b] (3 Si)	24C	1.6	23	14.4	18.5	0.78	0.33
	300C	1.6	23	12.1	17.5	0.69	0.29
	500C	0.9	23	8.3	15.5	0.53	0.18
3 cycles	24–500C	1.9	16	11.3	18.5	0.61	0.32

Values of H_c, B_r, B_m and B_r/B_m are for $H_m = 30$ oersteds
(a) Toroidal laminations (b) Spiral tape (c) Maximum induction

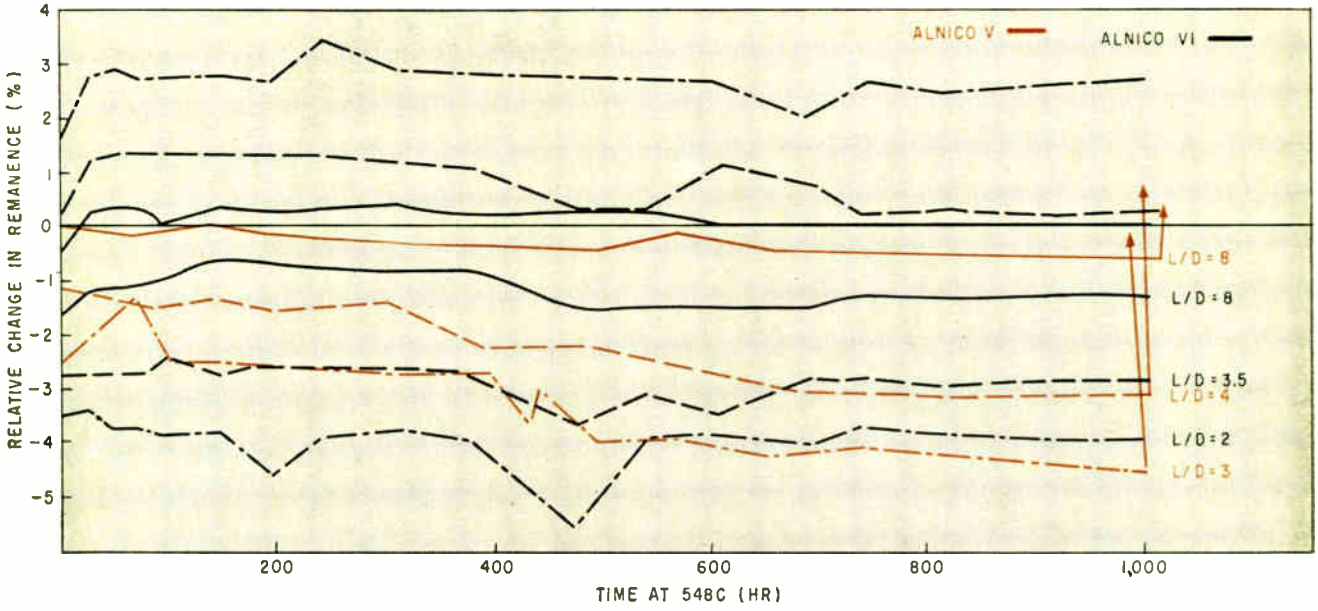


FIG. 13—Temperature effects in Alnicos 5 and 6. Material effects are seen above the zero line. Material and irreversible effects are below the line. The vertical arrows show results of remagnetizing Alnico 5

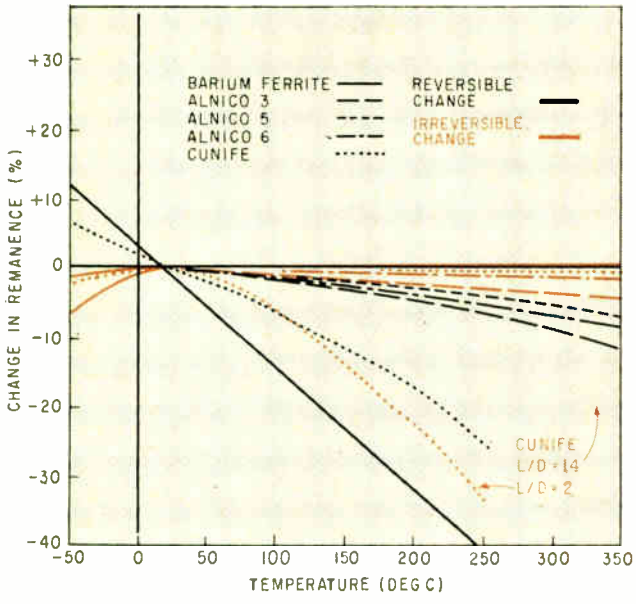


FIG. 14—Effect of temperature on some permanent magnets. Two curves are given for Cunife to show the influence that length-diameter ratios have on temperature stability of permanent magnets

and over. Glass-bonded mica, boron nitride, silica foam, glass-ceramic and polyparaxylene are potential high temperature dielectrics. Capabilities of the metallic conductor and sheathing are the limiting factors.

Asbestos, glass and ceramic fibers, and anodized aluminum oxide provide 500 C wire insulation. When good windability is required, the fibers can be supported by an organic binder which is driven off by high temperature baking. High temperature wires may also be made by plating copper with aluminum and then anodizing the aluminum. The oxide film can be supported with a ceramic-resin mixture. The resin is then baked out. Chemically-produced fluoride coatings on copper and aluminum are also reported good at 500 C.

CONDUCTORS—Providing allowances are made for changes in properties, conductive metals are suitable in radiation environments. Since tinning is ineffective at high temperatures and copper oxidizes at 250 C, copper must be plated or clad to protect the insulation and conductivity. Silver and thick nickel cladding are adequate. Silver is a good 500 C conductor (Table VIII).[12] Suitable wire joints can be made by brazing like metals or welding silver, Terminal connections for 500 C have been made by brazing silver, aluminum or nickel-clad wires to silver, nickel and stainless steel terminals. Some ceramic materials are potentially useful as electrical conductors at ultra-high temperatures. (Table IX).[13]

CONNECTORS—Beryllium copper and phosphor bronze contact spring materials are reported to lose tension at high temperatures. Inconel and stainless steel can be used. Noble metal is used in high temperature contacts, or as cladding or plate over nickel over base metal. Noble metal oxides may be good alternatives. Rhenium is recognized as a good tube metal and it is also a potential high temperature contact material. An oxide is formed at about 600 C, but it has low resistance.

SOLDERS AND BRAZES—Tin-lead base solders are acceptable for radiation environments providing the temperature is low. Silver solders and brazing materials are required at high temperatures. Alternative fastening methods include welding and cold welding. The integrity of solder joints subjected to vibration and shock is best preserved by cleanliness and stress-free design. For strong joints in aluminum wire, the wire can be dipped in

Table XIV—Curie Temperatures of Ferroelectric Materials

Material	T_c (C)	Material	T_c (C)
Titanates		Niobates	
Barium	120	Potassium	435
Lead[a]	490	Sodium	−110
Strontium	−269	Cadmium	− 88
Cadmium	−223	$Pb_2Nb_2O_7$	−258
Iron	~700		
Nickel	~700	$Pb(NbO_3)_2$	570
Tantalates		Stannates	
Sodium	475	Lead	150
Potassium	−260		
Lead	260	Zirconates	
Rubidium	247	Lead	230
Rhenium Trioxide		Gallate	
Tungsten Oxide	710	Lanthanum	~475
Moly Oxide	>530		

(a) Lead zirconate-titanate is reported elsewhere to have a T_c of 570 C

Table XV—Potential High-Temperature Materials

Material	Melt Pt (C)	Material	Melt Pt (C)
Carbides		Nitrides	
Hafnium	4,160	Tantalum	3,360
Tantalum	4,150	Titanium[b]	3,220
Titanium[a]	3,140	Boron[a]	2,730
Tungsten	2,820	Oxides	
Vanadium	2,810	Zirconium[a]	2,900
Thorium	2,770	Hafnium	2,812
Silicon[b]	2,700	Thorium	2,800
Molybdenum	2,570	Beryllium[a]	2,570
Aluminum	2,200	Magnesium[a]	2,540
Carbon[b,c]	3,500	Aluminum[a]	2,050

(a) 500 C capacitors in development (b) Used in resistors (c) Deposited

copper chloride. The chemical removes the oxide and deposits a copper coating. Lead-tin solder strength is improved by adding cerium. Soldering to aluminum is improved by using a zinc solder, alloys of zinc, cadmium and silver, or rubbing warm aluminum with gallium.

MAGNETIC CORE MATERIALS—Radiation generally produces significant changes in structure-sensitive properties such as coercive force, permeability and remanence. The effects of temperature and radiation on some core materials are shown in Tables X, XI, XII and XIII and Fig. 12.[14, 15, 16, 17, 18] Extreme changes in Supermalloy may permit its use as a dosimeter. 2 V Permendur contains 49 percent cobalt and becomes highly radioactive. The hysteresis loop of Deltamax changes gradually but squareness ratio is little affected. The loop of 4-79 Permalloy remains square. Carbonyl iron powder cores with glass or plastic binders showed negligible changes in high frequency loss under irradiation. Loss factors at 25 to 50 kc increased over 90 percent in 2-81 Mo Permalloy and Sendust, and 47 percent in nickel ferrite.

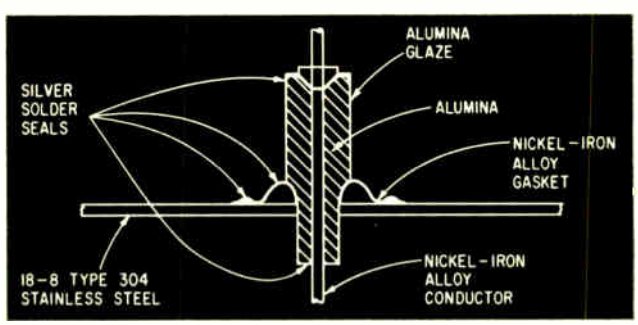


FIG. 16—Hermetic terminal seal used in 500 C transformer

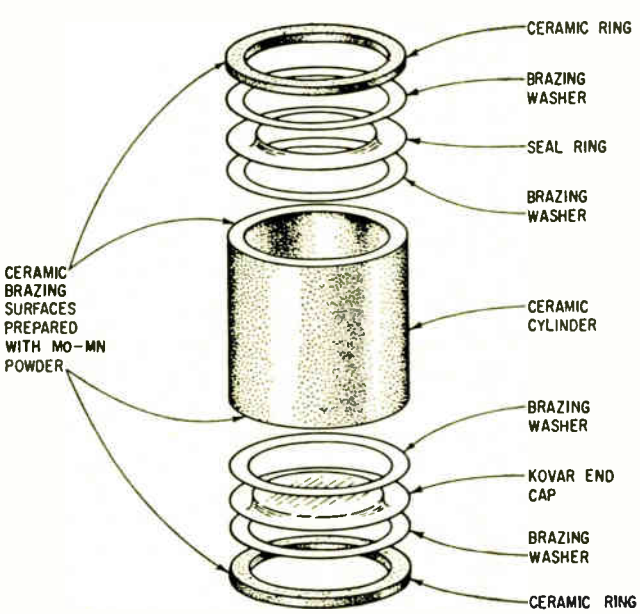


FIG. 15—Exploded view of a ceramic tube envelope fabricated by the moly-mongonese process

PERMANENT MAGNETS—High temperatures produce three types of change in permanent magnets: reversible changes which are self-recovering as temperature drops, irreversible changes which are restored by remagnetization and material effects. If remagnetization after high temperature exposure does not restore the original properties, the difference is probably due to changes in the material. Material effects may increase remanence, but irreversible effects always lower remanence. The degree of change is affected by the length-to-diameter ratio, as indicated in Figs. 13[19] and 14.[20] Alnicos V and VI are usable to 550 C. Other high temperature magnets include Remalloy, Indalloy, car-

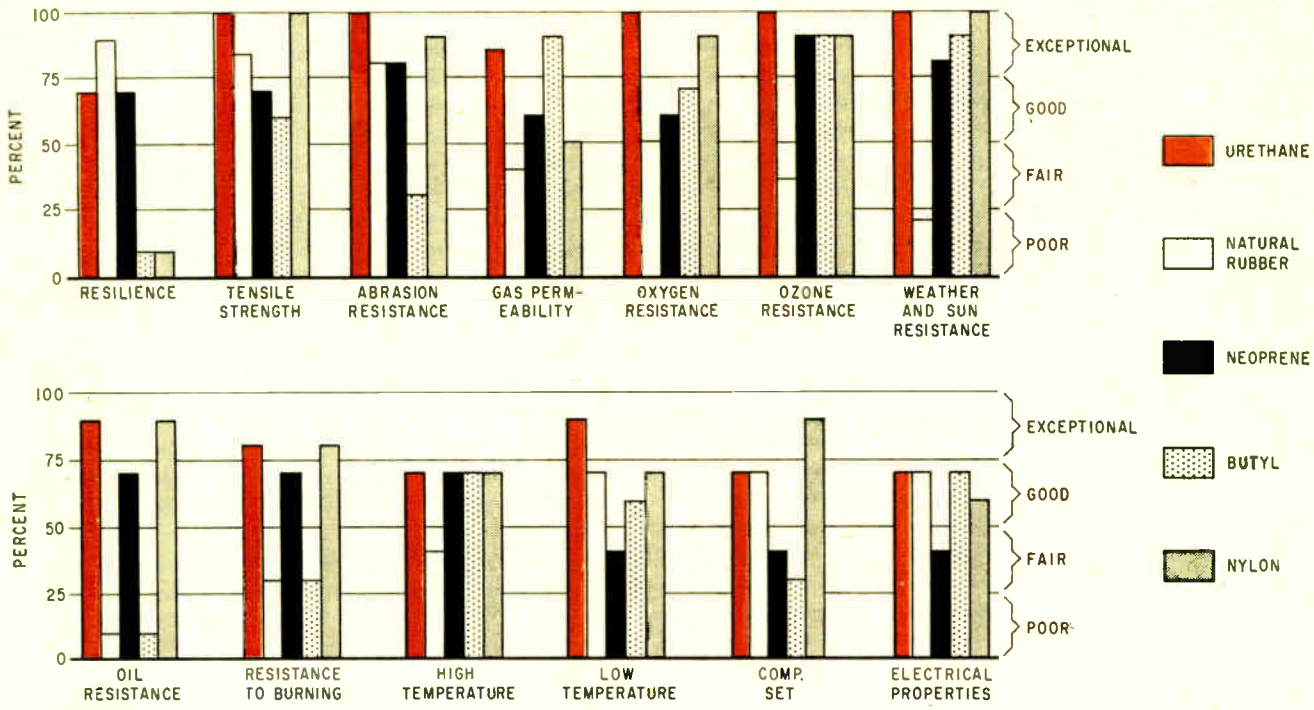


FIG. 17—Properties of some elastomers and nylon under various use conditions

bon or tungsten steel and other Alnicos.

FERRITES—Most ferrites are not significantly damaged by irradiation, but a high Curie temperature is desirable to offset gamma radiation heating. If they are used in fairly large magnets, they are susceptible to thermal shock. Expansion coefficients show a sharp peak at or just slightly below their Curie temperature. However, ferrites with Curie temperatures over 500 C, usable around 250 C, are available.

TRANSDUCER MATERIALS—Under irradiation, the following effects have been noted in magnetostrictive materials: silicon iron alloys showed no change in anisotropy, but significant changes in saturation magnetostriction; there was no appreciable effect on nickel ferrite. Adding cobalt to nickel ferrites stabilizes temperature drift. Cobalt-substituted nickel-zinc ferrites should be suitable at 250 C. In the metals, nickel is useful over 250 C and 50-50 nickel-iron to 520 C. The temperature resistance of cobalt-irons is still higher, depending on the amount of cobalt contained.

Barium titanate piezoelectric transducers have a low Curie temperature and limited temperature range. Table XIV[21] gives the top Curie temperatures of various materials systems. Among the materials on which details are available are potassium-sodium niobates and lead-titanate-zirconates.

Resistance strain gages made of intermetallic resins processed with rare earths and zirconium tetrachloride are reported to be useful to almost 600 C. The material is used to measure explosive forces and has a high shock rating.

SEMICONDUCTORS—Conventional semiconductor devices exposed to radiation are reported to have failure rates up to 50 percent.

Radiation effects are pronounced in crystals functioning by minority carrier action. Tunnel diodes, which depend on majority carrier action showed no effect at fluxes to 10^{13} nvt and are also usable to 315 C. Derating germanium transistor circuits should permit their operation at fluxes of 10^{15} n/cm^2.

Wide band gap materials which can be operated at high temperatures will likely be radiation-resistant. The heat would cause radiation-produced defects in the crystal structure to be annealed out at or shortly after the time the defects are produced. Gallium arsenide anneals rapidly at about 300 C and 470 C.

Gallium arsenide devices have been operated at 450 C and silicon carbide rectifiers at 650 C. It is hoped that silicon carbide and boron phosphide may provide devices useful to 1,000 C. Low-temperature indium antimonide infrared detectors operating in the photoelectromagnetic (pem) mode are considered radiation-resistant.

Intermetallics are also raising the temperature of solar batteries. Cadmium sulfide has produced electricity to 400 C compared with 260 C for silicon. Higher temperatures mean greater efficiency, according to one report. In space, solar batteries are protected from surface damage by fused silica windows. Solar X-rays have only slight effect and would cause a 25 percent loss in power output over seven years. Thermoelectric elements with a service temperature of 1,500 C are anticipated in the selenides, oxides and sulfides. Indium arsenide phosphide has been found usable at temperatures of 450—800 C.

CAPACITORS AND RESISTORS—Inorganic dielectrics have raised capacitors to the 300 C to 500 C range. A stacked mica capacitor in a stainless steel case has been reported at 600 C. High temperature ceramics show promise. These materials are also radiation resistant, but high purity is necessary to avoid semiconductor effects.

Experimental 500 C capacitors have been made of boron nitride, magnesium oxide and aluminum oxides, which yield the desired R-C product of five megohm-microfarads. The oxides withstood nuclear irradiation at 400 C, but boron nitride was converted to boron oxide. Melting points of materials applicable to high temperature resistors or capacitors are given in Table XV.[22]

The ceramics may be applied as slurries on platinum electrodes or chemically formed on metals. Refractory metals can be sputtered on glass or ceramic substrates. Inconel and Hastelloy may also be used as electrodes.

High temperature resistor materials, in addition to carbon and silicon carbide, include antimony alloyed with rhodium or tin, and combinations of noble metals. The metals can be deposited on ceramics or glass, wire-wound or applied as chlorides, nitrides, silicides or oxides. Chrome-silicon films, servicable at 250 C, changed only a few percent on short term exposure at 750 C. Platinum films have a linear temperature coefficient of resistance from 28 to 500 C. Boron carbide thermistor films are stable at 750 C, but crack when cycled between 200 C and 300 C.

ELECTRON TUBES—High temperature tubes are needed not only to withstand high ambient temperatures, but also to permit high temperature bakeout and heaterless operation. The hard metal and ceramic structures adopted also make for mechanical ruggedness. A representative construction is shown in Fig. 15[23]. Parts are assembled by metallizing and vacuum brazing. High temperature metallurgical problems were tackled years ago by tube designers and progress has been steady. Stacked construction is also employed for rugged relays.

SEALS AND ADHESIVES—High temperature ceramic to metal seals are produced by firing oxides into the ceramic surfaces, then plating and vacuum brazing. Transition materials include copper or nickel plated moly-manganese, copper-titanium, copper-zirconium and nickel-titanium. At temperatures to 500 C, components may be sealed with refractory cements, solder glasses or alloy gaskets (Fig. 16).[24] Lead-copper-titanium and other brazes are satisfactory to about 300 C. Pressurized tubing with soft metal coating provides a reusable 400 C seal. Lower temperature seals include plastic-base adhesives and elastomers. The properties of some elastomers are given in Fig. 17[25]. Phenolic-loaded epoxy can be used to 250 C; epoxy also adheres at cryogenic temperatures.

Table XVI—Service Temperatures of Some Lubricants

Lubricant	Temperature (F)
Sodium Greases	−45 to 325
Silicone Greases and Oils	−100 to 350
High Temperature Oils	−40 to 500
Alkyl Silanes	to 550
Meta-Polyphenyl Ethers	20 to 900
Molybdenum Disulfide—in air	−100 to 750
—in vacuum	to 2,000
Molybdenum Disulfide-Graphite	750 F long time 1,200 F short term (24 hr)
Gas	over 1,200
Liquid Metals	to 1,400

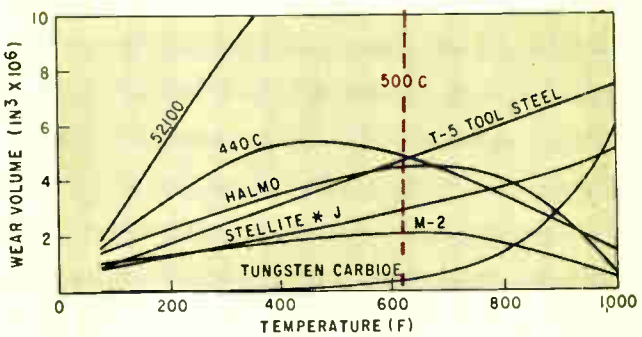


FIG. 18—Effect of temperature on wear of some materials considered for bearing use

BEARINGS AND LUBRICANTS—Fig. 18 summarizes high-temperature wear of some bearing metals[26]. Iron-base alloys must be protected from oxidation at high temperatures. Austenitic stainless steels, nickel and cobalt alloys and cemented carbides require less protection.

Nominal temperature limits of present and proposed lubricants are given in Table XVI. Organic lubes may break down under irradiation. Molydisulfide is reported to be unaffected by radiation and is used as a lubricant in nuclear power plants. It is inert, can be used as a dry film or added to greases, oils or plastic bushings.

Other materials which show promise at high temperatures include air with additives to prevent corrosion, vapors, alkyl silanes, polyphenyls, organometallics, liquid metals; phosphorous, boron or flourine additives. Lubricating coatings may be formed by chlorides, sulfides or phosphides, or such nonseizing metals as silver, cadmium, indium, tin, antimony, thallium, lead, bismuth and germanium. Meta-polyphenyl ethers, while not suited to low temperatures, are radiation resistant. Gas "bearings" are receiving considerable attention.

3. Compatibility of Materials

Here is a system approach to guide you in selection of contacting metals, plating processes, protective coatings and insulating materials

DATA ON THE compatibility of materials at 500 C is limited since relatively few assemblies have been operated at this temperature. Generally, if the material can stand the temperature alone, it can stand it in combination with other materials. Materials which give off corrosive products during a temperature rise are usually degraded themselves.

High temperature materials systems, therefore, are usually inert. When it is necessary to use a material, such as transformer steel, which oxidizes or corrodes at high temperature, it is protected by an inert gas or an inert solid insulation. In some cases, oxides and other films are permissible when these films, such as aluminum oxide, prevent further corrosion.

Of paramount importance is the selection of materials with similar coefficients of expansion. Low expansion materials are desirable and, fortunately, many of the high temperature materials are in this class. Precautions against materials which degrade by decomposing or which change size also apply to assemblies for radiation environments.

Table XVII—Corrosion Causes and Cures

Galvanic: Caused by a difference in potential. Cured by selecting metals with similar potentials, coating the cathodic metal with the anodic metal, breaking the galvanic circuit with an insulating coating or bushing, plating both metals with compatible materials, using a sacrificial anode or a corrosion inhibitor

Pitting: Similar to galvanic with variations in the metal causing local differences in potential. Cured by protective coatings or plating

Stress: Caused by differences in potential between parts of the crystal lattice. Cured by stress-annealing and stress-free design

Intergranular: Caused by grain differences resulting from such joining methods as welding. Cured by using weldable materials or another fastening method

METALS CORROSION—At all temperatures, corrosion is a major problem associated with commonly-used metals. The main causes and cures for corrosion are given in Table XVII. Table XVIII gives a number of metal combinations to be avoided[27]. Fig. 19 shows the amount of corrosion which other metals produce in aluminum[28].

Although salt spray is the generally-used metals corrosion test, long-term exposure in an industrial atmosphere is more destructive than salt air (Table XIX).[29] Materials with good corrosion resistance at temperatures over 500 C include steel, stainless steels, nickel, Monel, Inconel, Hastelloy and brass (if low strength at 500 C is tolerable).

PLATINGS AND COATINGS—The present and anticipated temperature limitations of various finishes are shown in Fig. 20.[2] In addition to standard finishes for light metals the following finishes are reported to be suitable for moderate to high temperature service: magnesium can be plated with aluminum which is then anodized, or plated with copper and tin. Fusing the tin with hot oil pre-

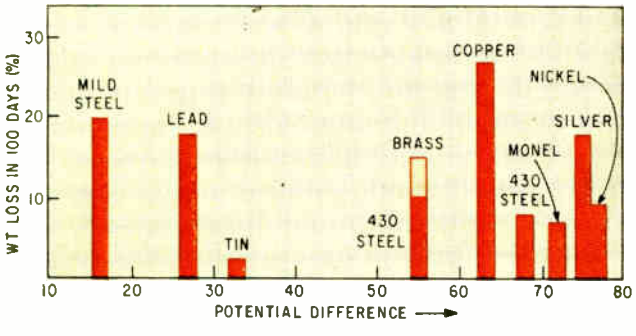


FIG. 19—Corrosion of aluminum alloy (1100) when coupled with other metals

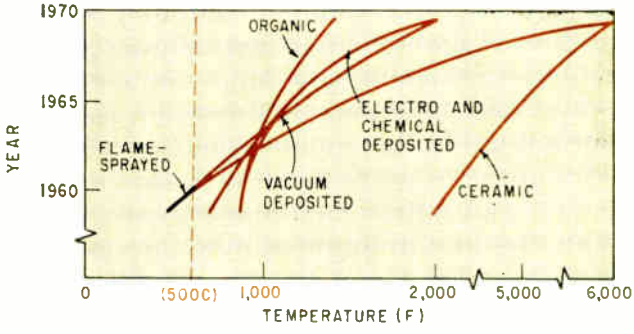


FIG. 20—Temperature limits of protective finishes for metals and anticipated improvements

Table XVIII—Corrosion of Some Metals

Metal Considered	Corroded By
1. Noble Metals	none
2. Monel, Inconel, Nickel-Moly Alloys	(a) 1, 14, 15
3. Cupronickels, Silver Solder, Aluminum and Tin Bronzes	(a) 2, 11, 12, 14 (b) 1, 11, 14, 15
4. Copper, Brasses, Nickel Silver	(a) 2, 3, 5, 6, 11, 12, 14 (b) 1–3, 5, 6, 11, 12, 14, 15
5. Nickel	(a) 2, 11, 12, 14 (b) 1, 11, 12, 14, 15
6. Lead, Tin, Soft Solder	(a) 2–5, 11–14 (b) 2, 3, 4, 7, 9, 11–15
7. Steel	(b) 1–6, 11–15 (c) 16
8. Cadmium	(a) 7, 16 (b) 1–5, 7, 11–15
9. Zinc	(a) 6, 8 (b) 1–5, 7, 11–16
10. Magnesium	(a) 8, 9, 16 (b) 4, 6–16 (c) 1, 2, 3, 5
11. Aust 18-8 St St	none
12. 18-2 Cr-Ni St St	(b) 1–4
13. 13 Chrome Stainless	(a) 6 (b) 1–5, 11–15
14. Chromium	none
15. Titanium	none
16. Aluminum	(a) 6, 7, 11–14 (b) 2, 5, 6, 7, 11–15 (c) 1, 3, 4

Table XIX—Atmospheric Corrosion

Metal	Industrial % Wt Loss[a]	Atmosphere Mils/Year	Salt Air % Wt Loss[b]
Tough Pitch Copper	6.1	0.0546	2.4
3 Si, 1 Mn-copper	7.4	0.0651	....
Tin Bronze	10.6	0.0883	3.2
Aluminum Bronze	7.2	0.0644	5.7
Aluminum	3.4	0.0289	1.3
Manganese Bronze	58.3	0.453	21.9
Brass (15 Zn)	8.5	0.0741	2.5
Brass (30 Zn)	13.7	0.120	0.9
20 Ni, 5 Zn-copper	11.3	0.102	1.0
Cu 32-nickel	8.8	0.0756	0.5
Lead	1.8	0.0151	....
High Grade Zinc	35.3	0.309	8.5
Commercial Tin	7.5	0.0659	....
Al-coated Duralumin	3.5	0.0293	0.2

(a) Weight loss over approximately 20 years at Altoona, Pa., or New York, N. Y. (b) Approximately 20 years at Key West, Fla., or Sandy Hook, N. J.

(a) Corrosion slightly increased by contact (b) Corrosion significantly increased, especially in salt or polluted air (c) Don't use in presence of moisture

vents deterioration by pitting corrosion.

Whisker formation in waveguide is prevented by gold plating. Silver will also stop whiskers, but may migrate through insulations. Nickel and precious metal platings improve the contact properties of base metals and will stand up in corrosive atmospheres provided platings are carefully chosen and are of optimum thickness.

High temperature insulating coatings are provided copper and aluminum by fluorination. Silicon monoxide is also a good protector. Wear and corrosion resistance is gained by such processes as flame-plating, nitriding, carburizing and chromizing. Flame-sprayed cermets are reported to withstand 500 C temperature. Cermets are formed from mixtures of carbides, borides or silicides with high temperature metals or reducible oxides. Their conductivity is about equal to solder. Alumina can also be flame-sprayed.

Most plastic coatings adhere well to metal and have good weathering properties, salt-spray resistance and electrical properties. Silicone, vinyl, chlorinated rubber, urethane and fluorocarbon coatings have the good heat resistance combined with insulation properties.

Modified epoxy coatings for printed circuits are usable at 350 C for short periods. Flexible formulations are necessary for vibration and shock resistance. Plastic-metal laminates are not suited to high temperature, but the covering has excellent wearability. The metal can be fabricated and welded without damaging the coating.

PLASTICS—Within their temperature limitations, the electrical grades of plastics and laminates are not always compatible with other organic materials.

Including modifications of the basic insulating plastics, resins, oils and fillers, there are literally thousands of possible insulating systems. Practical approaches include choosing proven combinations, confining the materials to those with similar bases, or testing new combinations.

Expansion rates and other physical properties of organic insulations can be adjusted with fillers. Fairly wide ranges are possible in epoxies and phenolics. When adjoining materials are stress-sensitive, relief from strains resulting from curing the more rigid encapsulants should be sought. One method is to first coat the part with silica gel or other elastic material.

When the component or system is slated for an industrial application, an insulation with good all-around chemical resistance is desirable. Polyvinyl chloride and its rubber blends, polycarbonate, polyethylene, fluorocarbons, polyester, vinyl, phenolic and some epoxies and alkyds are among the suitable materials. Another routine precaution is to plate all hardware with a corrosion resistant metal.

4. Materials Development Needs

What is being done to improve materials for extreme environments? Measures include: seeking high purity in materials, environmental testing of complete systems and uniform standards

FIRST IMPRESSIONS given by the large number of military-sponsored high temperature-nuclear radiation materials studies, contract reports, conference papers and trade publications is that there is an ample choice of materials to satisfy anticipated environmental needs.

The facts are that many of the materials and components are prepared under laboratory conditions. Devices made from the more familiar inorganic dielectrics and tube-type metals are being produced: for example, high temperature tubes, relays, switches, cables, connectors and magnetic metals. Many of the novel materials mentioned in this report are not being produced in sufficient quantities with sufficient purity. This means, for the time being, limited variety in components.

The second major necessity is across-the-board miniaturization. This should work itself out. Some of the production methods associated with refractory materials—sputtering, powder metallurgy, vacuum deposition, chemical conversion, inked and fired circuits—are more suited to miniaturization than conventional production methods.

A third major necessity, perhaps the most important, is combined environments testing of materials, components and eventually systems. There seems to be little of this in comparison to the standard methods of shuttling materials from one single or double environment to another. A primary problem is the difficulty of doing anything more than radiation testing in a reactor. More convenient types of radiation can be used, but it is difficult to estimate neutron flux resistance on the basis, for example, of gamma radiation resistance.

Superimposed on the combined environment testing needs is the fact that final evaluations of materials cannot be made until the tests also simulate the life of a system through a series of storage and use cycles. This will probably result in a second round of materials research and development programs after the products of the current round are put into use. An ultimate solution may be selecting materials for their known characteristics at specific temperatures above ambient and then holding the system at that temperature. The procedure is followed now, at lower temperatures, for components and circuits which must operate with extreme accuracy.

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PROGRESS IN PLASTICS

THE TROUBLE WITH PRINTED CIRCUITS— AND HOW CDF WORKS TO SOLVE IT

The honeymoon is long since over; suppliers and manufacturers are engaged now in the humdrum activity of making printed circuits *work*. The industry found in time that there was still a long way to go before the *magic* of printed circuitry was proved incontrovertibly in practice. The truth: Too many mass-produced printed circuits simply were no good. Why?

The trouble was not in the theory. Or in approved manufacturing techniques. It lay—and still lies—in raw materials, primarily in the consistency of quality of base laminates.

We're not here to say that CDF has a totally rosy record in this field. No, we've had our share of failures along with our many triumphs. In fact, our failures during the early years of copper-clad laminates taught us certain important things that our competitors have yet to learn.

But we do emphasize this: We've made—and are still making—great progress at CDF in licking problems that have beset the printed-circuit producer and the printed-circuit user in obtaining top-quality laminates on every order, regardless of grade.

Here, for example, are a few areas where CDF R&D has been particularly active:

1. Consistent quality. A major cause for printed-circuit rejects has been delamination and blistering of the base laminates when subjected to high temperatures in processing. New developments in CDF raw-materials control promise a heartening break-through in this respect. Also, CDF technical personnel are engaged in counseling circuit manufacturers in optimum handling and processing techniques.

2. Foil-bond strength. Certain metal-clad laminates seem to pass the most rigid laboratory tests, only to fail at the end of manufacture when dipped in solder or when put through long-term operational tests at elevated temperatures. The foil-bonding strength of CDF Di-Clad® laminates, however, is recognized throughout the industry as superior in every grade.

Nevertheless, improvements are being made daily in foil adhesives and bonding methods at CDF, and bond strengths are being increased—not only in number of pounds required for foil separation, but in length of safe solder-immersion and high-temperature operation time.

3. Range of selection. CDF has consistently offered the widest range of metal-clad grades—in phenolic and epoxy paper-base, epoxy-glass, and Teflon*-glass. And CDF Di-Clad Teflon-glass grades remain the only laminates of their kind approved by the military. CDF Technical Bulletin 11,900 gives the latest information on all Di-Clad printed-circuit grades.

* du Pont's TFE fluorocarbon resin

4. Flexible grades. Newly-perfected *flexible* grades of CDF Di-Clad promise the designer even greater freedom. One of the headaches in the use of printed circuits has been their rigidity. They tend to hamper independent movement and vibration of connected systems. They occasionally dictate inconvenient housing shapes. Flexible printed circuits, however, overcome these objections and provide many additional benefits of their own. Details on how CDF flexible Di-Clad materials can help see you out of a printed-circuit problem can be obtained from your CDF sales engineer. Look up his phone number in the Product Design File (Sweet's), Electronics Buyers' Guide, or your own CDF catalog. Or send us your print or your problem, and we'll return recommendations based on your individual needs.

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Information on new grades, special applications, and outstanding properties of CDF insulating materials is made available regularly through CDF Technical Bulletins and Folders. The following literature is new. For copies of any bulletins listed, send the coupon below.

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An Advertising Manager Asks Some Questions About

Fansteel Developments

. . . and uncovers additional facts about new developments of interest to engineers concerned with product reliability. Joseph V. Di Masi, Fansteel Advertising Manager, turned reporter and here's what he found out from his company's Rectifier-Capacitor Division.

Glen Ramsey, Vice President Fansteel Metallurgical Corporation and General Manager of the Rectifier-Capacitor Division

What do you feel was the most important Fansteel development in 1959?

The GOLD-CAP Tantalum Capacitor, beyond a doubt! Certified pre-testing of every single GOLD-CAP is a new concept that has set a pattern in the industry and has satisfied the increasing reliability demands of both military and civilian applications. But it's only one step in our program to achieve the ultimate in reliability for all Fansteel products.

What are the reports from the field on our GOLD-CAP?

All good! I think we've proved that engineers require the kind of reliability we're offering in the GOLD-CAP Capacitor for two good reasons. They want to be *sure* of getting 100 good, reliable capacitors out of every 100 they buy—we furnish complete test results—and, doubly important, they urgently need a product like the GOLD-CAP as a basis to achieve the overall reliability they're trying to build into their products.

What about our new silicon controlled rectifier?

I'll tell you this . . . it's going to embody a brand new concept in rectifier encapsulation. It will be something different—something better than any controlled rectifier the industry has ever seen. Research and development is completed . . . laboratory and field testing is over, and we now know that this rectifier will perform even better than expected . . . and full production will be under way early in 1960.

Paul Weirich
Assistant General Manager

FANSTEEL® RELIABILITY

X599

That Made News In 1959

Howard Brauer
Manager, Quality Control

Paul Weirich

Glen Ramsey

James H. Hall
Staff Engineer

When will our new silicon rectifier plant be in production?

By next month, the new plant will be supplementing our current silicon rectifier output by an additional 60,000 units per day. This will include our complete line of new industrial power rectifiers and the brand new silicon controlled rectifiers. The new facilities will also be used for producing our automotive silicon rectifier which, as you know, was featured in the November 15th issue of AUTOMOTIVE INDUSTRIES and the August issue of INDUSTRIAL LABORATORIES among other publications.

Are we expanding to keep up with solid tantalum capacitor demands?

Yes, we have recently completed the second phase of our S-T-A expansion program and the third phase is well under way. We are now able to deliver normal requirements from stock. Our current expansion program anticipates production requirements in 1960 approaching existing wet capacitor production. I might also mention in connection with our S-T-A, that we are actively participating in the micro-modular program.

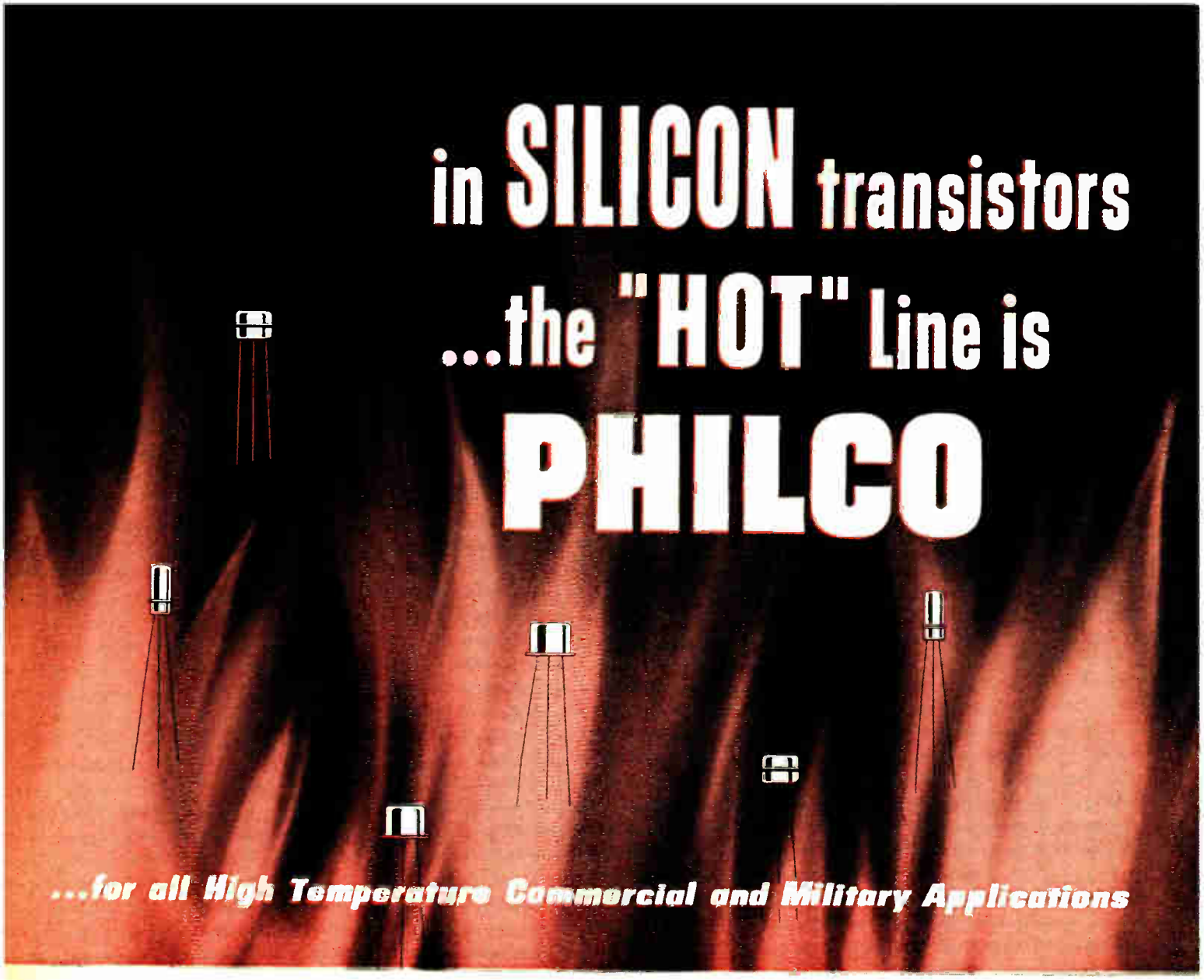
What steps were taken to further improve product reliability?

Enlargement, consolidation and, in general, improvement of our quality control program was the latest move—another complete step in our long-range reliability plan. You know, quality control doesn't just *meet* reliability requirements . . . it *leads*.

We believe that the only purpose of quality control is to assure the reliability that is engineered and designed into the product. Following this belief has always kept us years ahead of industry's reliability needs—and we intend keeping that lead.

FANSTEEL METALLURGICAL CORPORATION
NORTH CHICAGO, ILLINOIS, U. S. A.

FANSTEEL RELIABILITY



...High Speed Switches

Philco's full range of silicon high speed switching transistors, in both PNP and NPN types, provides the designer with a wide choice to meet the requirements of all high temperature applications. They are engineered and specified to permit simple, straightforward design of practical circuits up to 5 mc pulse rates, using saturated configurations and up to 30 mc pulse rates with non-saturating techniques. Packaged in TO-1, TO-5 and TO-9 cases.

PNP 2N496, 2N1119, 2N1429 **NPN** 2N1199

...High Frequency Amplifiers

Philco amplifying transistors are available in nine types, covering the complete high frequency range. The designer will find both PNP and NPN types that permit the design of communications systems at frequencies up to 60 mc. They have low collector capacitance and are available with restricted beta ranges to simplify design problems. All offer excellent performance at junction temperatures up to +140°C. Packaged in TO-1, TO-5 and TO-9 cases.

PNP 2N495, 2N1118, 2N1428 **NPN** 2N1267, 2N1268, 2N1269, 2N1270, 2N1271, 2N1272

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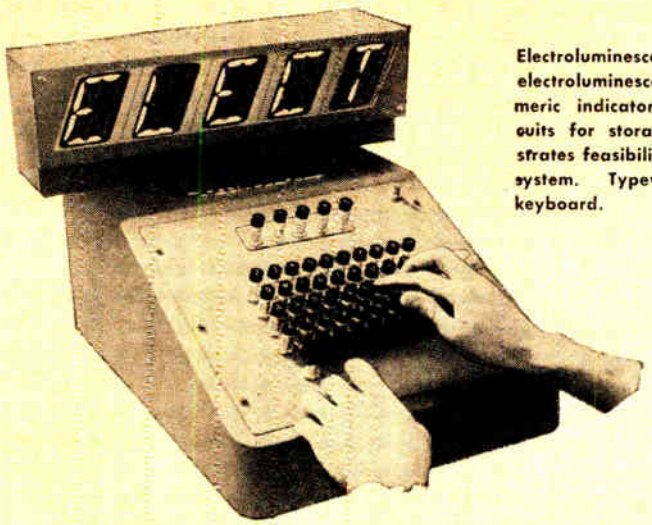
DECEMBER 4, 1959



Electroluminescent typewriter utilizing electroluminescent panels as alpha-numeric indicators and ferro-resonant circuits for storage and switching demonstrates feasibility of a new type of display system. Typewriter uses conventional keyboard.

New Developments Revealed at NEC

Subjects of a selection of papers presented at the 1959 National Electronics Conference show a cross-section of electronic devices ranging from microcircuits to airborne data acquisition systems. Interest in transistorized circuits remains high as manufacturers continue to reduce size and power consumption

By LESLIE SOLOMON and M. M. PERUGINI, Associate Editors

SEVERAL NEW and interesting circuits were shown at the NEC in October. The emphasis at this conference was on systems rather than components (see ELECTRONICS, p 51, Oct. 16).

Among the systems shown were an electroluminescent typewriter, ultrasensitive thermistor bridge, magnetic-amplifier controlled d-c power regulator, electronic switchboard and high-speed encoder. The state-of-the-art and future developments in microcircuits and airborne data acquisition systems were also discussed.

MICROCIRCUITS IN THE FUTURE — Solid-state devices are assuming the configuration of functional electronic blocks.[1] Designers insist that miniaturization must not be achieved at the expense of

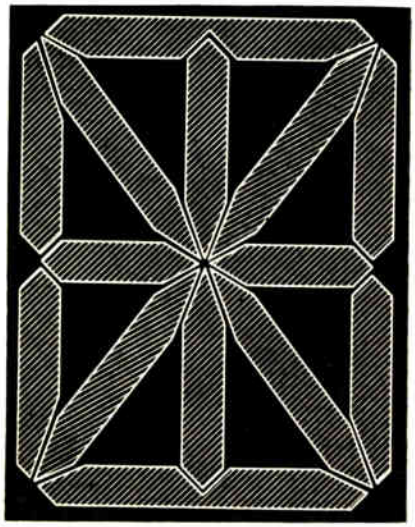


FIG. 1—Exciting combinations of segments can create numbers or letters

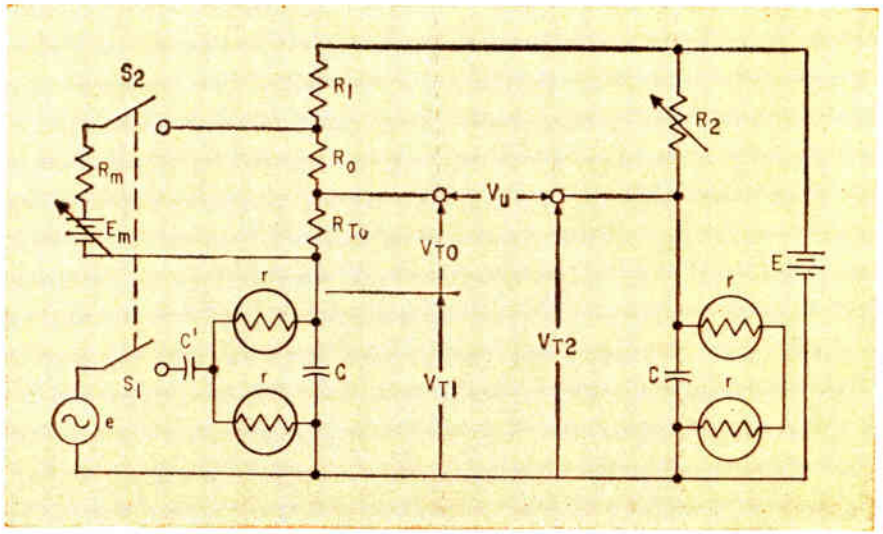


FIG. 2—Sensitive thermistor bridge uses temperature-compensated balanced design. Use of identical thermistor units increases sensitivity

reliability and performance. Towards this goal, several approaches have been tried. Individual components made in a uniform square format with dimensions 0.3 × 0.3 in. will facilitate assembly by automatic machinery and as the art progresses, multiple components and single circuits would be incorporated on each wafer and assembled into the micromodule block. The major problem in this area is the physical size and reliability of the interconnections.

A new interconnection technique called weld-pack (ELECTRONICS, Oct. 9, 1959) joins the components by resistance welding using nickel ribbon as required. A factor of ten increase in packing density is claimed when compared with conventional printed circuit wiring. In the weld-pack development, a computer determines the optimum layout of components and interconnections and prints a physical layout of the equipment.

One approach to placing multiple components on a single substrate is the deposition and insertion of components, devices and connections into a single substrate. One example of this construction uses a steatite ceramic as a base on which resistors and connecting wiring are silk screened. The capacitors are inserted into recesses and diffused germanium transistors and diodes are fabricated and connected to the circuit using photo-lithographic techniques.

Other manufacturers are using the evaporation of resistive materials into a dielectric substrate such as barium titanate, while others are using silk screen techniques on dielectric plates.

Another step to integrated circuits is using the same material to perform more than one component type function. An early English approach was to use an insulating panel grooved for the conductive paths. The grooving may also constitute the inductance and some capacitance. This method did not produce a high degree of miniaturization.

A recent technique produces resistors, capacitors and interconnections with a single layer of tantalum. In this method a photoengraved undercoat of copper is sputtered with tantalum film to produce the desired pattern. Fine resolution (one mil lines and spacings) have been produced.

One company has produced solid circuits with all components produced within a single crystal of semiconductor material using diffusion techniques with a photolithographic process.

In the field of special-purpose devices, the dual-hook collector transistor, which can perform complex logical operations for full binary addition, has been developed. In this transistor, the *npnp* layer configuration has been utilized to design a stepping transistor element. These devices can be fabricated and interconnected on one piece of silicon to produce counting and decoding circuits. Other devices have been developed using the field effect, impact ionization at low temperatures, evaporated magnetic films and evaporated semiconductors.

ELECTROLUMINESCENT TYPEWRITER — The Westinghouse Electric Corporation has developed an electroluminescent typewriter[2] to demonstrate the feasibility of a new type of display system. This system utilizes electroluminescent alpha-numeric indicators and ferro-resonant storage and switching. The electroluminescent typewriter consists of a conventional typewriter keyboard upon which information is entered and then displayed sequentially on five alpha-numeric indicators. After the information has been written, the five characters may be selectively or totally erased. It is possible to write letters, numbers or symbols on any chosen indicator.

Electroluminescence produces light by exciting phosphors with an electric field, produced in conventional cells, by an alternating voltage. The phosphors are embodied in a dielectric medium which is sandwiched between two conducting electrodes and the entire structure is then encapsulated in epoxy

resin for moisture proofing.

By segmenting the panels as shown in Fig. 1, and exciting them in certain sequences, various combinations of numbers, letters or symbols may be produced. The light output cannot fail suddenly as an incandescent lamp often does, but failure is indicated as the segment slowly diminishes in light output. The light output is sufficient for the display to be read at ambient lighting. The color of the light is a function of the phosphor used and the frequency of the excitation voltage.

ULTRASENSITIVE THERMISTOR BRIDGE — Thermistor bridge techniques find wide use in the measurement of low-level r-f power (0-10 mw) from audio through microwave frequencies. The Illinois Institute of Technology has developed an ultrasensitive d-c operated, temperature-compensated balanced thermistor bridge[2]. The bridge is maintained at balance in the presence of r-f power by removing from the thermistor an equal and easily measured amount of d-c power. The r-f and d-c calibrating signals are applied simultaneously in pulses to diminish the effect of d-c drift in the bridge output. The thermistor response to pulsed energy is analyzed on the basis of thermal equilibrium considerations.

The sensitivity of a thermistor bridge is limited by the temperature sensitivity of the thermistors used. Fluctuations and drift in both the ambient temperature and bridge driving voltage cause variations of the thermistor resistance that are reflected in the bridge output voltage. However, if two identical thermistor units biased at the same resistance are employed, one for sensing the r-f signal and the other for compensation, then the undesired output signals are minimized thus increasing the sensitivity of the bridge.

As shown in Fig. 2 the circuit has two pairs of thermistors r and two capacitors C. Capacitor C acts as an r-f short to keep r-f current out of the bridge and the two thermistors in parallel are presented to the r-f generator e while two series thermistors are presented to the d-c bridge. Capacitor C' is used as an r-f short to isolate d-c from the r-f system.

Each of the sensing thermistors is biased at a resistance $r = R_T$ where R_T is twice the characteristic impedance of the r-f system thus terminating the r-f system in a matched load. The two thermistor mounts are placed alongside each other in a cork-insulated heat-reflecting metal box so as to be exposed to similar thermal environment and also to protect the thermistors from ambient temperature fluctuations.

By using a stable driving voltage source, temperature insensitive resistors and good solder connections, the major source of bridge instability will be minimized.

During operation, the sensing thermistors are biased by a switch which alternately inserts the thermistors and a standard 200-ohm resistor (not shown in Fig. 2). The supply voltage E is adjusted until the same bridge output is observed regardless of whether the standard resistor or sensing thermistors are in the bridge. The bridge is then balanced by adjustment of R_2 which is variable but nominally the same value as R_1.

When an r-f signal e is applied to the sensing thermistors, the thermistor resistance changes and the bridge output meter will show a deflection. Voltage E_m is then increased from zero until the output meter returns to its initial position. The effect of increasing E_m is to reduce the d-c until the removed d-c thermistor power is equal to the applied r-f power, and the series thermistor resistance comes back to its initial value provided $R_{Tm}/R_m = 2R_T/R_1$.

PULSING—Despite use of compensating thermistors, the bridge output may still drift from balance due to drift during the rebalancing interval and deflections due to E_m and its associated resistors. When the r-f and d-c signals are alternately applied and removed, the observed pulsations of the output indicator will decrease towards zero as adjustments are made. With this technique, the bridge need not be at perfect null initially since the required rebalance is indicated when the output pulsations cease regardless of the voltage level about which they occur.

MAGNETIC CONTROLS—A system using sensitive magnetic amplifiers has been devised[1] to replace voltage-sensitive relays as the basic element in a d-c bus voltage regulator. The use of magnetic amplifiers facilitates changes in bus voltage settings,

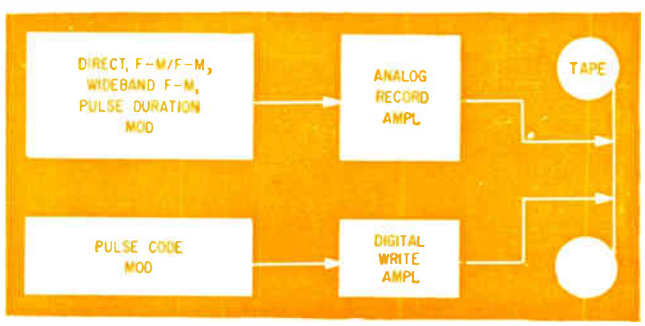


FIG. 3—Combination recording simplifies data editing

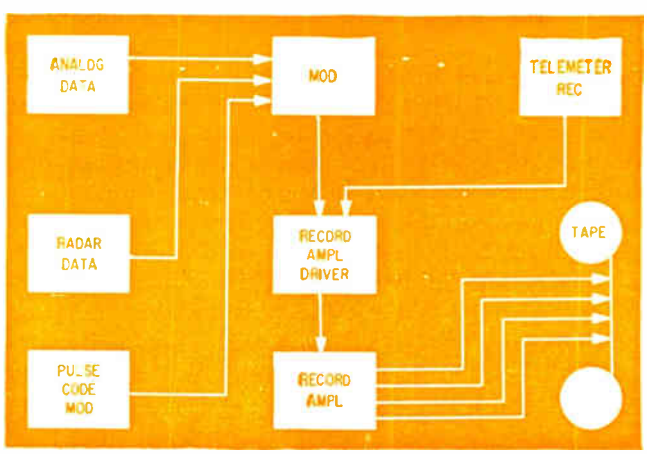


FIG. 4—Wideband recording increases flexibility of data acquisition systems

eliminates the need for recalibration, reduces maintenance and improves the ruggedness of the basic sensing device. Regulation of bus voltages up to 700 v has been successful with this approach. This magnetic regulator scheme is similar to that which uses voltage sensitive relays as the detection element but the use of magnetic amplifiers permits the voltage limits to be set by positioning control panel rheostats.

AIRBORNE DATA ACQUISITION—Magnetic recording has become a major tool in airborne data acquisition.[3] Conventional fixed-head recorders can record from d-c to 250 kc while recorders using rotating heads have recorded as high as 7½ mc. In addition, the time relation between events can be preserved precisely on magnetic tape. Recent advances in system components and new techniques have made combinations and wideband recording practical.

COMBINATION RECORDING — Improvements in recording heads and tape guidance make it possible to record 32 tracks across an inch of tape. The increase in area utilization is accomplished without

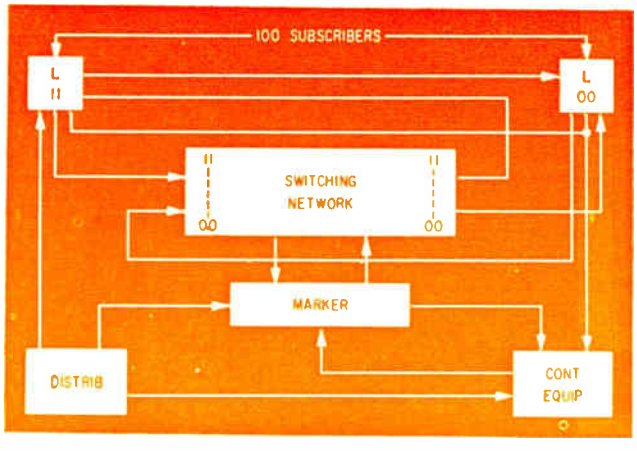


FIG. 5—Electronic switchboard uses marker to find free route between called and calling parties

sacrificing performance while reducing effects of tape skew.

Another practical advantage of better area utilization is that it allows combination recording of analog and digital data, Fig. 3. Sixteen tracks of digital information and seven of analog information can be recorded on 1-in. tape. The technique of recording digital and analog data simultaneously is used to obtain data on aircraft and missile tests.

As combination recording requires only one transport the size, cost and complexity of the acquisition system are reduced considerably. Data editing is simplified because all data for a test are located on one tape in the same time sequence and location.

WIDEBAND RECORDING—A significant advance in airborne data acquisition is an instrumentation wideband recorder now under development. The recorder is based on the rotating magnetic head principles originally used in television recorders. Because of the 4-mc response of this two-track recorder, the data acquisition capabilities of magnetic recording will be increased.

The most promising future for telemetry recording seems to be in the use of wideband and predetection recording techniques. This concept, outlined in Fig. 4, uses the wideband recorder's ability to record the i-f output of a telemetry receiver. An increase in signal-to-noise ratio is achieved by compensating for signal fading or excessive noise after the raw data are captured on the tape. Later, the tape can be reproduced and the recorded data discriminated or demodulated in an optimum manner.

Since data recorded prior to demodulation or discrimination may be thought of as intelligence within a bandwidth, the wideband recorder will permit direct recording regardless of the modulation scheme employed. This ability to record any and all types of modulation data becomes important as the bulk of weapons testing shifts from aircraft to missiles to space vehicles.

ELECTRONIC SWITCHBOARD—The use of *pnpn* silicon diodes make it possible to eliminate electromechanical switching in automatic telephone exchanges.[5] These diodes, which act as nearly ideal switches, are used in the four-stage switching network of the fully electronic private exchange shown in Fig. 5. Centralized control equipment in this experimental 100-line crosspoint switching is time-logic circuits.

SYSTEM DESCRIPTION — Each suberiber's line terminates in its corresponding line equipment, *L*, and is transformed from a two-wire line into a single wire connection to both sides of the switching network. Audio-frequency connections between subscribers are made and ended by the switching network under the control of the marker.

The marker, composed of registers and associated logic circuits, receives connect commands from the control equipment. Connect commands are accompanied by the addresses of both calling and called parties. The time required for a connect operation is 32 millisec; for disconnect, 16 millisec.

Since all connect and disconnect operations involve the marker, connections are established and terminated on a one-at-a-time basis. This does not introduce appreciable delays. Even if all 100 subscribers finished dialing at the same moment, the marker would accommodate all subscribers within 2.4 sec.

CONTROL EQUIPMENT—The control equipment collects, stores and modifies the information used by the marker. It contains a ferrite core memory of 100 words (one per subscriber), a register and logic circuits.

The information in the 100 words, each containing 16 bits, makes it possible for the marker to se-

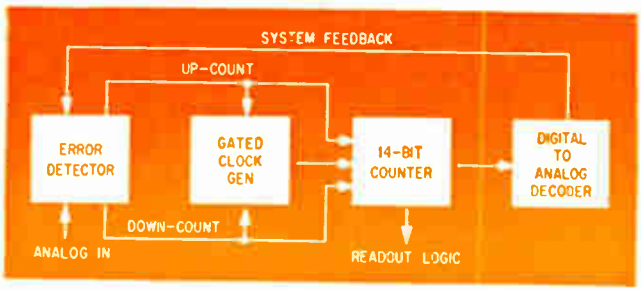


FIG. 6—Simplified diagram illustrates feedback nature of encoder

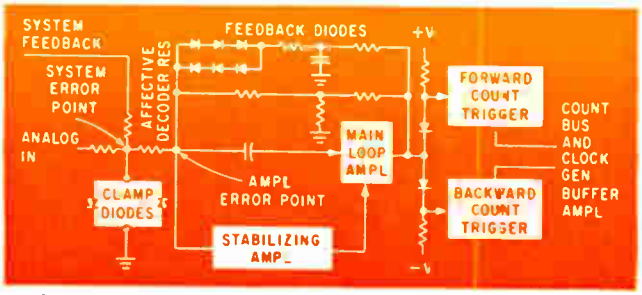


FIG. 7—Noise levels at outputs of error detector are less than 100 mv peak-to-peak

lect a free route between called and calling parties.

Words in the ferrite core memory are modified either by new information generated by the subscriber or by commands from the marker.

To provide a time-sharing control method, the distributor generates 100 sequential timing pulses, each 160 microsec long and recurring every 16 millisec. These pulses divide the system time base into 100 time slots of 160 microsec each, each slot being associated with one subscriber.

Since the ferrite memory of the control equipment contains a storage location for every subscriber, a subscriber can start dialing as soon as he lifts the handset. Because of this, no dial tone is needed.

The ringing and ringback signal is transmitted through the crosspoint switching network to both called and calling subscribers. To amplify this signal, each telephone contains a transistor amplifier that is ON only when the telephone handset is on the hook. Thus, the ringing signal is amplified in the called party's handset and fed into the receiver capsule to produce an audible tone.

HIGH-SPEED ENCODER—A new analog-to-digital encoder provides continuous conversion of analog voltages at a rate of one bit per 4 microsec.[7] This corresponds to an input rate of 2,500 v per sec. Resolution of this transistorized, servo-type encoder is one part in 2,000 and conversion accuracy is ±0.10 percent, ±1 bit. When used as a static encoder, conversion time is less than 16 millisec. This time can be reduced by one or two orders of magnitude with little added complexity and with no loss of accuracy.

Figure 6 is a simplified block diagram of the encoder. An error signal flowing into the error detector starts conversion. If this signal is greater than the error detector threshold level, the detector energizes the clock generator and the appropriate count bus. Clock pulses are impressed upon the counter and, depending upon the error signal polarity, are either added to or subtracted from the number in the counter.

Since the counter flip-flop drive the decoder switches, the system feedback current is corrected at the rate of one bit per clock pulse. Correction continues until the error current is below the system threshold. When this occurs, the count bus is de-energized and the clock pulses are inhibited; stopping the counter.

The error signal is the difference between the analog input and the decoder feedback currents. The analog input voltage varies from d-c to several kilocycles. This voltage may be applied suddenly, as in a static converter application, causing full-scale step errors. System feedback currents are essentially staircase functions with step frequencies as high as 250 kc and contain switching spikes of random amplitude. These spikes are as high as one-half full scale and may persist for as long as 3 microsec. They are responsible for the major delay in the loop response.

ERROR DETECTOR—The error detector, shown functionally in Fig. 7, consists of a wide band, chopper-stabilized, d-c amplifier with complementary Schmitt trigger outputs. The main loop amplifier contains direct coupled circuits, capacitively coupled to the error point. The stabilizing amplifier coupled to the main loop amplifier corrects for drift in the loop.

The overall amplifier loop is closed through a nonlinear feedback network designed to reduce the effect of saturation and to permit rapid recovery from system overloads. Separating the amplifier and system error points and clamping the system error point with diodes gives additional overload protection. These circuits enable the amplifier to respond properly to full scale transient errors.

Gain-frequency characteristics of the main loop and stabilizing amplifiers are shaped to provide a closed-loop gain of 52 db, flat from d-c to 1-mc. To prevent loading the amplifier and thereby reducing loop gain, the Schmitt triggers are coupled to the amplifier output by AND gates.

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(6) J. G. Van Bosse, General Telephone Laboratories, Inc., Northlake, Ill., A Fully Electronic Private Automatic Telephone Switchboard.
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TWT's and Paramps for

Recently developed techniques indicate that there is no theoretical limit to the noise reduction that can be achieved with traveling-wave tubes. Comparison of twt's and parametric amplifiers leads to some interesting predictions

By D. A. WATKINS and G. WADE, Stanford University, Stanford, California

DETECTION OF extremely weak signals has been of great interest from the inception of radio and microwave engineering. But now, as developments are realized in other fields, the necessity of achieving better sensitivity such as is offered by traveling-wave tubes and parametric amplifiers becomes more apparent.

For example, the job of early warning radars is to detect at distances up to several thousand miles the presence, direction of travel and speed of a ballistic missile. Although these radars are capable of megawatt peaks of transmitted signal, the power in the returning echo may be only a few millimicromicrowatts. Receivers with low noise characteristics are needed.

Satellite Repeaters

Artificial earth satellites have opened the way for alternatives to cable transmission and tropospheric scatter for transoceanic communication. It is now possible to put into orbit a satellite capable of serving as an orbital radio repeater. Such a repeater could be either passive or active.

A simple passive repeater already proposed[1] would consist of a metallized 100-foot diameter plastic sphere (Fig. 1). One such sphere in a polar orbit at a height of 3,000 miles would be visible to both sides of the Atlantic for more than one-fifth of the time. Several such spheres properly spaced could constitute a full-time relay system.

Orbital repeaters of the active type have also been proposed[1] involving fixed satellites (that is, satellites in the equatorial plane with 24 hour orbits) carrying microwave repeater equipment. Orbital heights of about 22,000 miles would be necessary. Because of present limitations on the amounts of power that can be transmitted, receivers in both the passive and active systems would require extremely low noise figures.

Since the discovery a quarter of a century ago of atmospheric noise coming from outer space, the findings of radio astronomy have played an important part in shaping our concepts of the universe. For example, radio astronomy has been largely responsible for mapping the Milky Way and showing that the solar system is positioned along the inner edge of one spiral arm of a tightly wound spiral galaxy.

Radio observations are being made in a variety of different ways in search for information concerning a variety of phenomena. For example, detection can involve a single radio spectral line or it can involve the total radiation flux from an extremely broadband source. For this latter case, which constitutes the bulk of the work, minimum detectable signal is directly proportional to the noise figure minus one and inversely proportional to the square root of the bandwidth of the receiving equipment. Hence, in this application, both low noise and wide bandwidth are necessary.

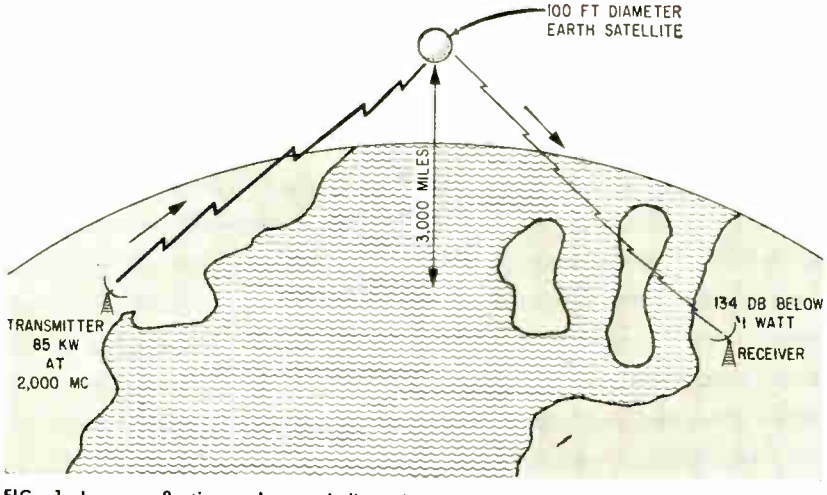

FIG. 1—Large reflecting spheres circling the earth at properly spaced intervals can function as passive links in a transoceanic communication system, provided receiving equipment is sufficiently sensitive

Low Noise Amplifiers

Two types of amplifiers, the traveling-wave tube and the parametric amplifier, are finding wide use where low noise is a requirement.

In comparing these two types of amplifiers it is advisable to exercise some caution. Effective use of any type of amplifier requires not only an understanding of its capabilities in terms of the usually measured characteristics, but also an understanding of its physical operation. For example, because the parametric amplifier is a negative resistance device and because it generates an auxiliary signal (called the idler signal), its noise behavior is markedly different from that of the traveling-wave tube. A simple

Low-Noise Reception

examination of measured noise figure data does not tell the whole story, and in fact can be quite misleading.

This discussion is limited to single-channel operation in unrefrigerated parametric amplifiers, where the operation is similar to that of traveling-wave tubes. Parametric amplifiers operating in the degenerate mode are not considered.

Traveling-Wave Tube

Important new techniques have been discovered recently for reducing noise in traveling-wave tubes. At one time it was widely believed on the basis of theoretical calculations that the minimum possible noise figure for any type of microwave tube was about 6 db. At the present time noise figures lower than 3 db have been measured at S-band on a backward-wave amplifier, a particular form of traveling-wave tube. Present theory indicates that there is no limit to the amount of noise reduction which can be achieved with backward-wave amplifier tubes.

In its simplest form the traveling-wave tube consists of a pencil-shaped electron beam traveling near a slow-wave structure, usually a helix. The beam velocity is nearly equal to the velocity of propagation of an electromagnetic wave on the helix. Amplification comes about through a continuous interaction between the electrons of the beam and the traveling electromagnetic wave on the slow-wave structure.

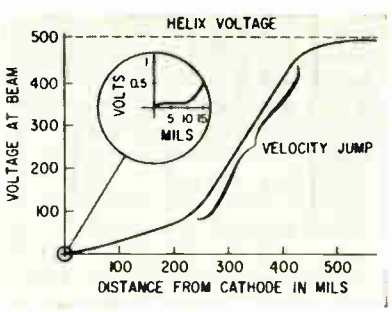

FIG. 2—Typical beam potential profile for new noise reduction technique in twt's shows the extended low velocity region where beam voltage is low

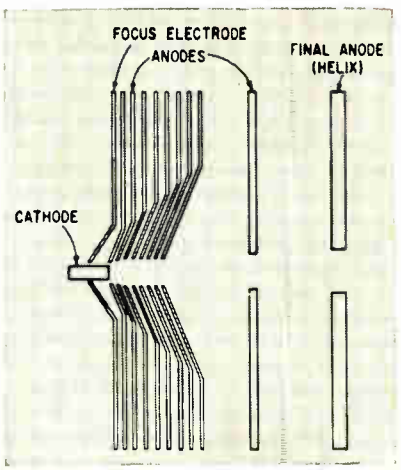

FIG. 3—Stacked array of anodes produces low velocity potential profile for noise reduction

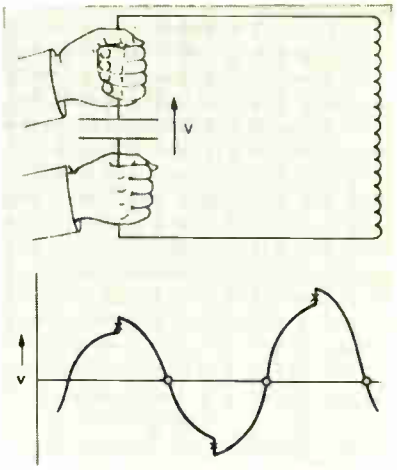

FIG. 4—This simple resonant circuit and pump illustrate the mechanism for energy transfer in parametric excitation

Electrons on the average are slowed down by this interaction. The amount of energy extracted from the beam for amplifying the signal is equal to the difference between the kinetic energy of the electrons at the beginning of the slow-wave structure and that at the end. The interaction with each electron extends over the entire length of the helix and therefore lasts for a relatively long period of time. This fact makes possible high amplification with nonresonant structures of relatively low impedance. As a consequence of the nonresonant structure, it is possible to obtain extremely wide bandwidth in a traveling-wave tube.

TWT Noise

Main source of noise in a traveling-wave tube is shot noise from the electron beam. Assume that the beam is suddenly accelerated to a velocity as high as or higher than that corresponding to a few volts immediately after the beam emerges from the cathode. Theory shows that under these conditions there is a limit to the amount of shot noise reduction.

No practical noise reduction technique or combination of techniques is capable of reducing the noise figure to below about 6 db if the beam voltage always remains above a few volts. This fact gave rise in the past to the erroneous belief that the minimum possible noise figure under any condition was about 6 db.

TWT Noise Reduction

A new technique for noise reduction, which was discovered by researchers at Stanford University[2] and Hughes Aircraft Company[3], involves an operation on the beam in the vicinity of the cathode or where the thermal velocity spread is large relative to the average velocity of the electrons. Specifically, the beam is made to flow through an extended low velocity region, shown in Fig. 2, where the beam voltage is below a few tenths of a volt. Under these conditions, effective noise reduction has already produced measured noise figures at S-band of slightly less than 3 db and at X-band of slightly above 4 db.

A practical method of producing a potential profile involving a low velocity region is to use a stacked array of anodes as shown in Fig. 3. The potential of each anode can be adjusted individually in an experimental determination of the optimum profile for producing the lowest noise figure.

This technique is operable both with conventional wide-band traveling-wave tubes and with narrow-band backward-wave amplifiers (voltage tunable over wide frequency ranges). Either of these

types of tube is capable of amplifying a single channel of frequencies with high gain and excellent stability. The noise figures already obtained are low. There is every reason to expect that lower noise figures will be achieved in future tubes.

Parametric Amplifier

The term parametric excitation has been used for a number of years to refer to a method of exciting and maintaining oscillations in a dynamical system. The system can be either electrical or mechanical. Excitation is brought about by a periodic variation in an energy storage element of the system such as a capacitor, an inductor or a spring constant.

Although the principle involved in this type of oscillator has been known and rather well understood for over a hundred years, it was only recently suggested that this principle could be used in building amplifiers and that it would be particularly valuable at microwave frequencies.

The principle is classical in nature; and this fact suggests the possibility of a number of physical embodiments. Parametric devices have been built involving the use of pendulums, vibrating strings, electron beams, ferrites and semiconductor material, the last three at microwave frequencies. However different in appearance the various devices may be, they all operate by virtue of a periodic variation in an energy storage element.

Table I—Possible Typical Characteristics for Future Low-Noise Amplifiers

Characteristic	TWT	PA	PA (TW)
Approx. noise figure at 3,000 mc (db)	2	2	2
Approx dynamic range for 1 mc bandwidth (db)	80	100	100
Maximum stable gain	70 (short-circuit stable)	25 (with circulator)	35 (with circulator)
Life (hr)	10,000	10,000	10,000
Est. overall weight (lb)	10	2	4
Power consumption (w)	1	2	20

At present, development of ferrite amplifiers is much less advanced than that of diode amplifiers. Although ferrite devices may ultimately prove to have certain advantages over diode devices, too little is known about them now to be able to predict their future usefulness. Good low noise operation with excellent gain and stability has been obtained from electron-beam parametric amplifiers. However, to date, all such amplifiers have been built to operate in the degenerate mode. For these reasons, discussion here is confined to parametric amplifiers using semiconductor diodes.

Parametric Excitation

A semiconductor diode is capable of providing a periodic variation in an energy storage element, the necessary ingredient in parametric excitation. The diode can easily be made to look like a time-varying capacitance.

Consider the mechanism by means of which energy can be transferred into the fields of a resonant tank from a pump which produces the time variation in the capacitance. Figure 4 shows a simple resonant circuit and a pair of hands which pull the condenser plates apart and push them together again. The hands represent the pump.

Assume that before the hands go to work there is already some energy stored in the circuit. At the moment the voltage goes through a positive or a negative maximum, the hands suddenly pull the condenser plates apart. Work is done in separating the charge on the two plates and the energy goes into the electric fields existing across the plates. Capacitance is reduced and, since voltage is inversely proportional to capacitance, the voltage is amplified. Each time the voltage goes through zero the hands suddenly push the plates back together again. When the plates are pushed together there is no charge on the capacitor and no work is required. By repeating the process indefinitely, the voltage across the capacitor is amplified indefinitely. Figure 4 shows the resultant voltage curve. A net flow of energy takes place from the pump into the fields of the resonant tank.

Actual circuits for parametric amplifiers are, of course, more complicated than this. However, the energy exchange mechanism is basically the same. Whatever it is that brings about a capacitance variation (that is, the pump) does so in such a fashion that on the average the capacitance is reduced when the voltage across the plates is at a positive or negative maximum, and the capacitance is increased when the voltage is zero.

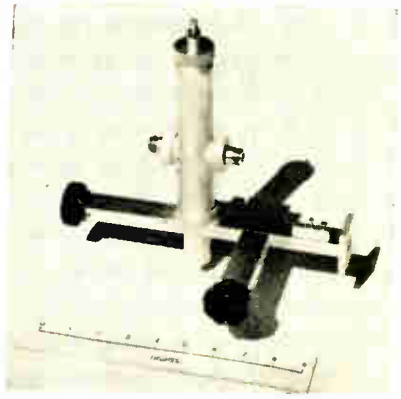

FIG. 5—In this experimental parametric amplifier, amplification takes place over a single band of frequencies

With a semiconductor diode, the pump is simply a source of microwave voltage at the proper frequency. The diode exhibits a capacitance whose value is a function of the voltage across it. By providing a microwave pump voltage across the diode, the diode capacitance can be made to vary at the pump frequency.

Frequency Relationships

A word of explanation is necessary concerning the frequency relationships among the fundamental signals found in a simple parametric amplifier. From the preceding explanation of energy transfer it is apparent that in a microwave parametric amplifier the energy for producing the amplification is supplied to the amplifier at a microwave frequency rate. The signal to be amplified is at a different microwave frequency. Because of the nature of the parametric principle a beat phenomenon takes place between the pump signal and the amplifying signal. Consequently, a third signal is produced having a frequency equal to the difference between the pump frequency and the amplifying frequency. Since in the conventional

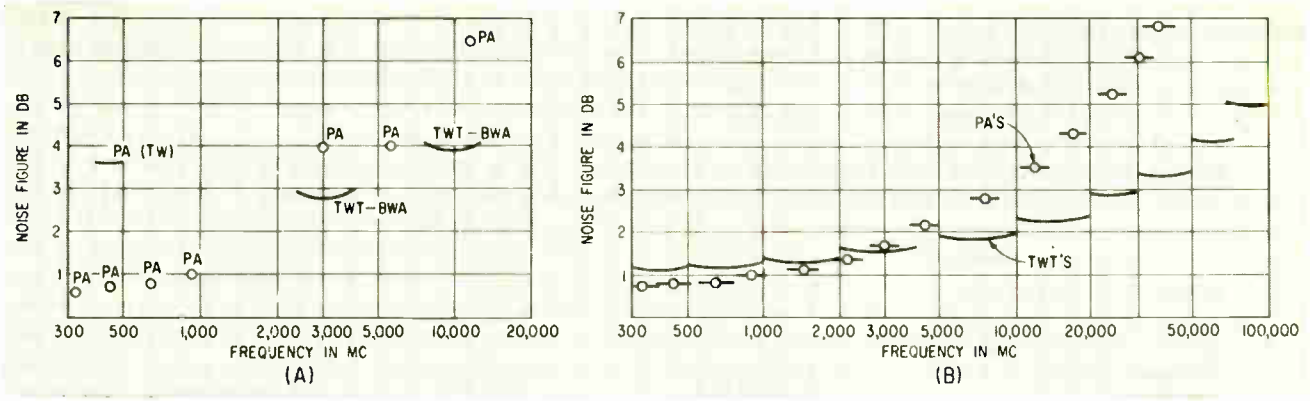

FIG. 6—Present status of measured noise figures (A) and possible future status (B) for parametric amplifiers, PA, and for traveling-wave tubes, TWT. For traveling-wave amplifiers of the backward-wave type, BWA, the bandwidth indicated represents tunable bandwidth. Parametric amplifiers using multiple diodes in traveling-wave circuits are marked PA(TW)

parametric amplifier this signal is a more-or-less useless by-product of the parametric process, the signal is called the idler.

When the pump frequency is double the amplifying frequency, the idler frequency is the same as the amplifying frequency. This mode of operation is referred to as the degenerate mode.

Single-Channel Operation

Where it is desirable for the amplification to take place only over a single band of frequencies (that is, in a single channel) the idler frequency band is filtered out at both the amplifier input and output. If this were not done an idler signal would appear at the output with each amplifying signal. Also a spurious signal at the amplifying frequency would be generated and would appear at the output for each input signal at the idler frequency. When the above filters are provided, only amplified versions of input signals at the amplifying frequency appear at the output. This mode of operation is referred to as single-channel operation.

Figure 5 shows an experimental parametric amplifier which operates in the single-channel mode. In this amplifier, the pump signal at 10 kmc is supplied to the waveguide from the right; the input signal at 780 mc is supplied to the coaxial line connection on the right, and the amplified output is taken from the coaxial line connection on the left.

For single-channel operation when the amplifier is at room temperature the minimum theoretical noise figure is equal to the ratio of pump frequency to idler frequency. By increasing the pump frequency to values very much higher than the amplifying frequency, this ratio, and hence the minimum noise figure, will tend to unity. To make the noise figure as low as possible the pump frequency should be made as high as possible.

Comparisons

A plot of noise figure as a function of frequency for various low-noise traveling-wave tubes and single-channel parametric amplifiers is shown in Fig. 6A. Where bandwidth is significant, a line rather than a point is used to designate the noise figure. A smooth line through the parametric-amplifier noise figures would intersect such a line through the traveling-wave-tube noise figures in the S-band region. Below S-band the parametric amplifier noise figures are lower, while above S-band the traveling-wave tube noise figures are lower.

Theoretically there is no limit to the noise reduction which can take place in either device. However, there are inherent practical limitations in each. A consideration of these limitations indicates that the present relative noise figure situation may be more or less permanent.

Performance Predictions

Although any prediction of future performance is extremely hazardous in these fast changing fields, a prediction is ventured in Fig. 6B. In addition to low noise figures for both parametric amplifiers and traveling-wave tubes, wide bandwidths are indicated for the parametric amplifiers. Increasing bandwidth in these amplifiers has already been accomplished by using several diodes in a traveling-wave circuit and by using a single diode along with filter networks.

Traveling-wave tubes should continue to have good characteristics for broadband applications, for high-gain applications and for applications where high stability is needed. Parametric amplifiers should perform well at the lower frequencies where the bandwidth requirements are modest.

Table I presents a prediction of typical characteristics for three types of amplifiers operating at S band. The three types referred to are the traveling-wave tube, the single-diode parametric amplifier and the multiple-diode (traveling-wave) parametric amplifier.

For each type a noise figure of about 2 db has been assumed. The figures used in estimating life, overall weight and power consumption take into account the vacuum tube which is required to provide the pump power for the parametric amplifiers.

Predicted values for maximum stable gain give the twt's a wide edge.

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Synthetic Sapphires for Electronic Components

Grown single crystals of aluminum oxide retain useful properties at extreme temperatures. Here is how sapphire is built into components

By **R. D. OLT**, Linde Co., Division of Union Carbide Corp., New York, N. Y.

SYNTHETIC SAPPHIRES, grown from high-purity alumina by the flame fusion process, offer engineering advantages in advanced electronic component design. Some applications are reviewed in Table I. Sapphires are also used as ball, rod and washer insulators, tuning slugs and optical parts in infrared systems.

In addition to the properties listed in Table II, sapphire has zero porosity (no outgassing) and is chemically stable to all common acids and most alkalis. It is optically transparent, with 85 percent transmission at wavelengths from 1,450 angstroms (ultraviolet), through the visible light spectrum, to 5.5 microns in the infrared spectrum.

BONDING—Techniques chosen for bonding sapphire to metal, glass or ceramic depend largely on the operating environment (Table III). Materials with a similar coefficient of expansion are desirable. However, housekeeper techniques, graded seals or compressive joints may be used where expansion is not matched.

Materials with thermal expansion coefficients similar to sapphire include alloys of 42 percent nickel and 48 percent iron (Driver Harris 146, Allegheny Ludlum 4750), nickel-chrome-iron alloys (Allegheny Ludlum Sealmet 4, Carpenter 426), low-alloy titanium, tantalum-molybdenum, high alumina ceramics and Corning 7520 glass. Most epoxy resins, platinum or silver coatings, and copper or nickel vapor depositions will form a mechanical bond with clean sapphire. Certain glasses wet sapphire.

High temperature bonds to metal require that the sapphire first be metallized. High alumina techniques are generally applicable. Either an 80 percent molybdenum—20 percent manganese metallizer, sometimes with CaO and SiO_2 added, or the titanium hydride technique have been used successfully. The metallizer is then nickel or copper plated and the sapphire is brazed to the metal member. Suitable brazes include gold-nickel, copper-silver or other eutectics. A one-step process, using 12 percent titanium-cored copper-silver eutectic solder, has been employed extensively.

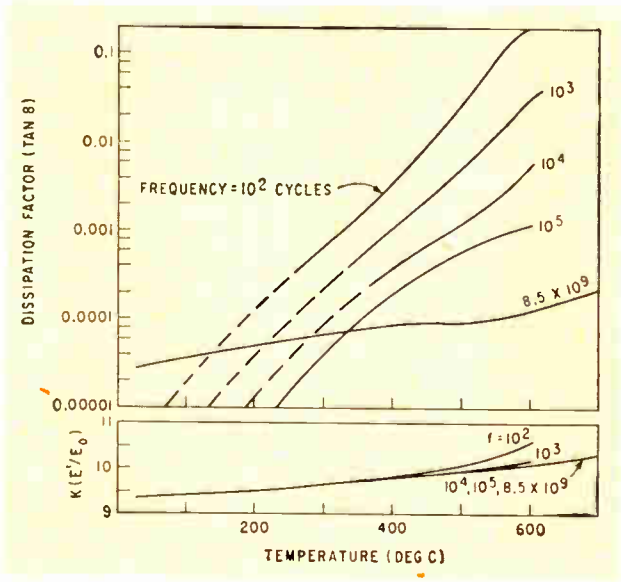

FIG. 1—Dissipation factor (top) and dielectric constant of synthetic sapphire at varying frequencies and temperatures, with electrical field perpendicular to optical axis (after Von Hipple)

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Table I—Electronic Uses of Sapphire

Application	Comments
Supports in Electron Tubes, TWT Helix Rods	high temperature strength, dielectric uniformity, low camber, small diameter rigidity, low loss
Electron Guns	flame polish for cleaning ease, reduced surface current leakage, high temperature resistivity, low cost
Microwave Output Windows	visible transparency, low adsorption, thin section strength, no glassy binder (punctures), high thermal conductivity
Stacked Ceramic Tubes	improved heat dissipation by radiation and higher thermal conductivity
Arc Lamps	ultraviolet and infrared transmission, surface electrical stability at high temperatures

Table II—Properties of Synthetic Sapphire

Property	Temp	Value
Density (gms/cc)	room	3.98
Hardness (Moh)	room	9
Compressive Strength (psi)	room	300,000
Young's Modulus (psi × 10^6)	room	50–56
Tensile Strength (psi, design minimum)	20 C	58,000
	500 C	40,000
	1,000 C	52,000
Modulus of Rupture[a] (psi × 10^3)	room	65–100
Modulus of Rigidity (psi × 10^6)	room	27
Thermal Conductivity (cal/cm, °C, sec)	2.5 K	0.08
	20 K	8
	77 K	3
	0 C	0.11
	100 C	0.06
	400 C	0.03
	1,000 C	0.02
Specific Heat (cal/gm)	20 C	0.18
Heat Capacity (abs joules/deg mole)	20 C	78
	1,000 C	125
Average Coefficients of Thermal Expansion, 60 degrees orientation (cm/cm °C × 10^{-7})	20–50 C	58
	20–500 C	77
	20–1,000 C	84
	20–1,500 C	90
Volume Resistivity (Ref 1) (order of, in ohm/cm)	500 C	10^{11}
	1,000 C	10^9
	1,500 C	10^5
	2,000 C	10^3
Te Value (deg C)	—	1,222 ± 8
Dielectric Strength (v/cm)	room	480,000
60 cycle (v/mil) (Ref 2)	room	1,200

	Dielectric Constant	Loss Tan	Loss Factor
10 kmc[b] (Ref 3)	11	0.0002	0.0022
8.5 kmc[c] (Ref 4)	13.5	0.00021	0.0028
8.5 kmc[d] (Ref 4)	10.4	0.00043	0.0045

(a) Maximum bending stress, depending on orientation (b) At 20 C, field 60 degrees to optical axis (c) At 800 C, field parallel to optical axis (d) At 800 C, field perpendicular to optical axis

Table III—Representative Sapphire Bonding Techniques and Materials

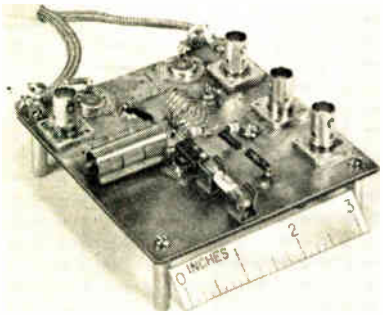
Operating Conditions	Bonding Techniques and Materials[a]
LOW TEMPERATURES	
To 4 K (−269 C, Liquid Helium), Vacuum	Araldite Type 1 resin (Ciba) bond
77 K (−196 C, Liq N_2) to 120 C	Tygoweld 38-C, Activator 41 (U. S. Stoneware) bond
77 K to 400 C, Vacuum	7520 glass (Corning) graded to Kovar[6]
Liquid Oxygen (90 K or −183 C)	bond to 321 or 347 stainless steel by Epon 8 with 6% Activator A (Shell)
ROOM TEMPERATURE	
To 140 C	bond with C-2 epoxy (Armstrong)
To 150 C, Non-vacuum	platinize with Platinum Paste 12 (Hanovia) and soft solder
To 75,000 psi	rubber O-rings[7]
To 150,000 psi	copper washers, or directly supported by lapped steel disk[8]
To 470,000 psi	unsupported Neoprene Teflon washer[9]
HIGH TEMPERATURES	
To 500 C, Vacuum	glass frit. Example: 165 grams of >325 mesh powders[b] is suspended in collodion, parts are joined and fired in atmosphere of 85 N_2—15 H_2 at 1,240 C for 20 minutes
To 600 C, Vacuum	titanium hydride metallizer, copper-silver solder, processed in vacuum at 960 C[10]
To 600 C, Vacuum	12% titanium-cored BT solder (Handy & Harmon), processed in vacuum at 1,000 C
To 700 C, Vacuum	moly-manganese metallizer, copper-plated, electroformed into copper waveguide[c]
To 800 C, Vacuum	Telefunken process; moly-manganese metallizer, nickel plate, Nioro nickel-gold alloy (Western Gold & Platinum) or BT solder, processed in wet H_2 atmosphere furnace at 1,650 C, 30 minutes, 3 steps[5,10]
SYNTHETIC SAPPHIRE TO GLASS[d] SEALS[11]	
Kovar	sapphire to 7520 to 7052
Graded Glass	sapphire to 7520 (direct at 650 C) to 7052—7050—7070—7740
Frit to Graded Glass	sapphire to 7280 (frit at 275 C) to 7800—3320—7740

(a) Superscript numerals indicate references. (b) Mixture of 12.7% weight of $LiCO_3$, 8.7% $CaCO_3$, 17.6% $BaCO_3$, 16.9% Al_2O_3, 42.4% SiO_2 and 1.7% Cr_2O_3; collodion is 26 grams A-10 acryloid (Roehm & Haas) and 110 grams cellosolve acetate (Eimend and Abend). This frit is used at Stanford University and was developed by Bell Telephone Laboratories. (c) Used by Stanford University Electronics Research Laboratory. (d) Corning codes

Wideband F-M With

Here are two practical circuits which use voltage-variable capacitances as the means of modulating an oscillator tube

By **COLLINS ARSEM,** Diamond Ordnance Fuze Laboratories, Washington, D. C.



Schematic of this lab model of 100-mc oscillator is shown in Fig. 1

THERE ARE many useful systems for producing frequency modulation of vhf oscillators.[1, 2, 3, 4] The system described here uses variable-capacitance diodes to produce frequency deviations as great as or greater than those obtainable with the other systems, without many of their shortcomings.

If a reverse voltage is applied to a semiconductor junction diode, the two regions adjacent to the junction are swept free of mobile carriers (holes and electrons) and assume opposite net charges due to the immobile impurity ions (donors and acceptors). The device thus forms a charged capacitor. Variation of the applied voltage will change the capacitance in a manner determined by the way in which the impurity-ion concentration changes with distance in the junction region. Capacitance variation is usually a function of the method of fabrication. For example, the capacitance of a fused-junction diode is proportional to $V^{-1/2}$, while the capacitance of a grown junction is proportional to $V^{-1/3}$.[5]

100-mc Oscillator

Choice of the type of variable capacitance diode is largely determined by oscillator frequency, desired deviation, maximum diode dissipation and the allowable load that can be presented to the oscillator by the modulator circuit. One complication is the fact that many circuit configurations which reduce the loading due to the diodes also tend to reduce the frequency deviation.

The oscillator tube should be chosen to produce an oscillator circuit of low internal impedance. This is especially important at high frequencies since the relatively low equivalent parallel resistance of the diodes might cause excessive loading of a high-impedance oscillator, particularly when the diode network shunts the tank directly.

One of the most satisfactory circuits of those investigated is the Hartley oscillator of Fig. 1 in which the plate current is limited by plate resistor R_1 instead of by grid-leak bias. The tube operates with the grid at essentially zero d-c potential, thus causing the values of transconductance (g_m) to be higher and the values of a-c plate resistance (r_p) to be lower than their negative-grid-region values. This type of operation thus tends to reduce the internal impedance of the oscillator tube and makes it better suited for this application.

Inductance L_1 is a ¾-in. diameter air-core coil. The cathode is tapped to the 4½-turn coil at 2½ turns above ground.

The modulator circuit is a practical compromise between high deviation and low internal diode loss. This circuit consists of two similar variable-capacitance diodes (D_1, D_2) which are in series with respect to r-f and in parallel with respect to audio modulating signals and d-c bias. The net result is a variable capacitor having half the capacitance, but the same percent change in capacitance-per-volt as a single diode.

Oscillator frequency, which was about 100 mc, was deviated as much as 28 mc peak-to-peak (p-p) with modulating signals of less than 28 v p-p and negligible modulating power. Diode d-c bias is adjusted so that the peak modulating voltage does not cause diode conduction, and hence severe r-f losses.

Figure 2 shows frequency spectra obtained with a carrier frequency of 100 mc which is modulated by a 100-kc and a 10-kc sine-wave. Only the envelopes of the spectra are actually observable with 10-kc modulation because the minimum resolution of the spectrum analyzer that was used in testing was 25 kc. Individual sidebands are discernible in the spectra for 100-kc modulation and deviations up to 4 mc p-p; but as the deviation is increased, the patterns tend to show only the envelopes of the spectra. Here once again the analyzer's resolution prevented the

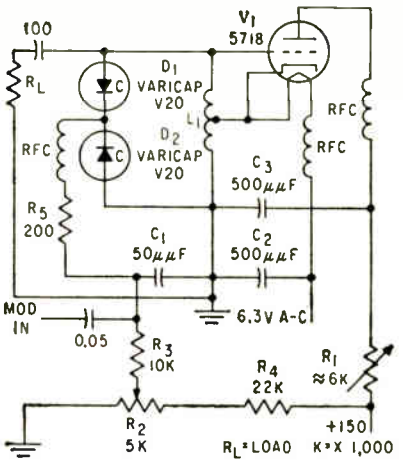


FIG. 1—100-mc lumped-constant oscillator

Capacitance Diodes

separation of the greatly increased number of sidebands.

Shown in Fig. 3A is a typical output curve of a lumped-constant oscillator similar to that shown in Fig. 1. The curve shows variation in the r-f voltage across the oscillator load for a frequency swing of 20 percent, peak-to-peak. Over all change in voltage is approximately 2.5 db. Figure 3B shows oscillator frequency as a function of diode bias. For all these measurements the d-c plate input power was about ½ W; the plate voltage and current were approximately 30 v and 17 ma, respectively.

400-mc Oscillator

Wide-band frequency modulation of a 400-mc distributed-parameter Colpitts oscillator (Fig. 4) was obtained with a bilateral (symmetrical) transistor in the modulator circuit. Transistor Q_1 is equivalent to two reverse-biased diodes connected in series with respect to r-f and in parallel with respect to modulating signals and d-c bias.

Inductances L_1 and L_2 are sections of transmission line; L_1 is 3¼-in. long and L_2 is 2⅝-in. long. Both inductances are constructed of brass ¼ in. diameter rod which is centered in a 1-in.² cross section channel. Collector and emitter of Q_1 are connected respectively to the rod (L_1) and channel wall; collector and emitter connections are approximately 1.8 in. away from the channel-wall connection of L_1.

Figure 5A shows the spectrum obtained for a frequency deviation of 15 mc peak-to-peak and Fig. 5B shows the nearly flat r-f output voltage obtained over this 15-mc band. The upper line in Fig. 5B is the voltage curve and the lower line is the base-line. Figure 5 was obtained while the oscillator was delivering 685 mw to a 50-ohm load with a plate efficiency of 22 percent.

The above results are typical examples of wide-deviation frequency modulated vhf oscillators. Useful frequency deviations of 10 percent or more are possible with the capacitance diodes mentioned. Operation at uhf should be possible if distributed-parameter type circuits are used.

Further increases in bandwidth and reduced a-m will be obtained by using improved variable-capacitance diodes now appearing on the commercial market.

Because of the high input impedance these variable-reactance diode modulators are ideally suited to wide-band high-frequency modulation with complex waveforms and little modulation power.

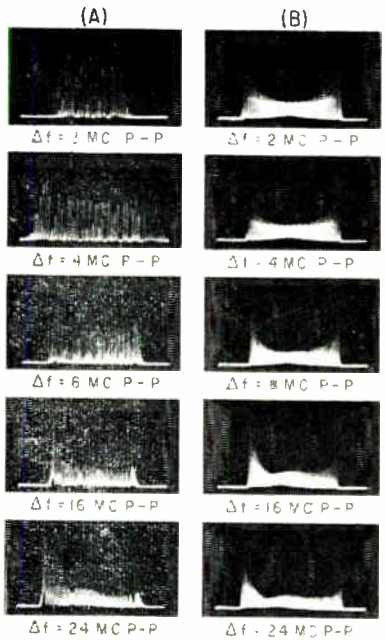


FIG. 2—Sinewave modulation of 100-mc oscillator at 100-kc (A) and 10-kc (B)

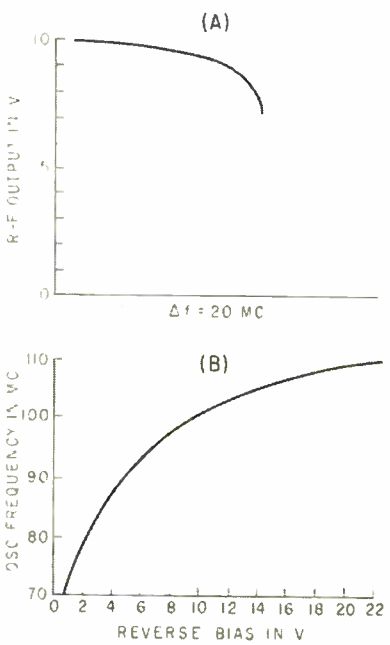


FIG. 3—Output for a 20-mc p-p deviation (A); f vs bias with R_L=2,000 ohms (B)

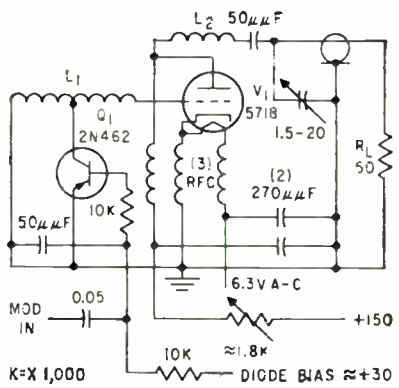


FIG. 4—400-mc oscillator uses a symmetrical transistor

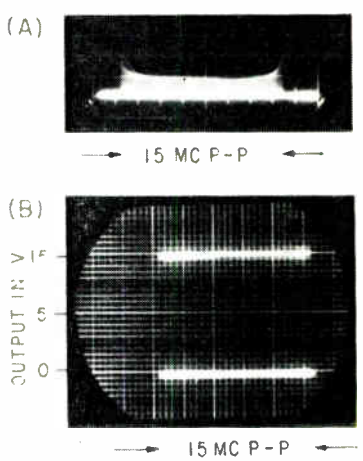


FIG. 5—400-mc-osc. spectrum (A) and output voltage (B) for 15-mc p-p deviation

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Automatic Measurement Of Transistor Beta

Transistorized checker sets and holds collector current to a predetermined value while base current is measured and beta determined. Accuracy and speed of testing are increased with consequent cost savings

By **E. P. HOJAK,** International Business Machines Corp., Federal Systems Division, Owego, New York

DIRECT CURRENT gain, or beta, is a reliable measure of the usefulness of most transistors. For production lot transistors, beta (also called h_{fe}) has wide variations and it is usual practice to test all units of a given batch.

But the circuits for measuring beta usually require a number of manual adjustments. Since beta varies widely from transistor to transistor, and since it also varies significantly with the magnitude of the collector current, it is typical to make the tests at a specified collector current. Typically, the base current is increased until the desired collector current is obtained. Beta is then the ratio I_c/I_b, where I_c is collector current and I_b is base current.

When a large volume of transistors must be tested, the manual operations are time consuming and subject to error by the operator. A circuit has therefore been developed which automatically adjusts the base current to give a preset collector current. The collector current is held constant while the reading of the base current is being made. Base current is thus a direct measure of beta and the output meter is calibrated in terms of this parameter.

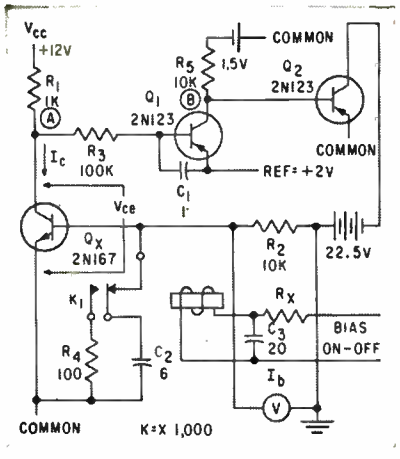


FIG. 1—Automatic beta checker holds collector current of test transistor Q_x at a preset value. Points marked common indicate bus bar connections

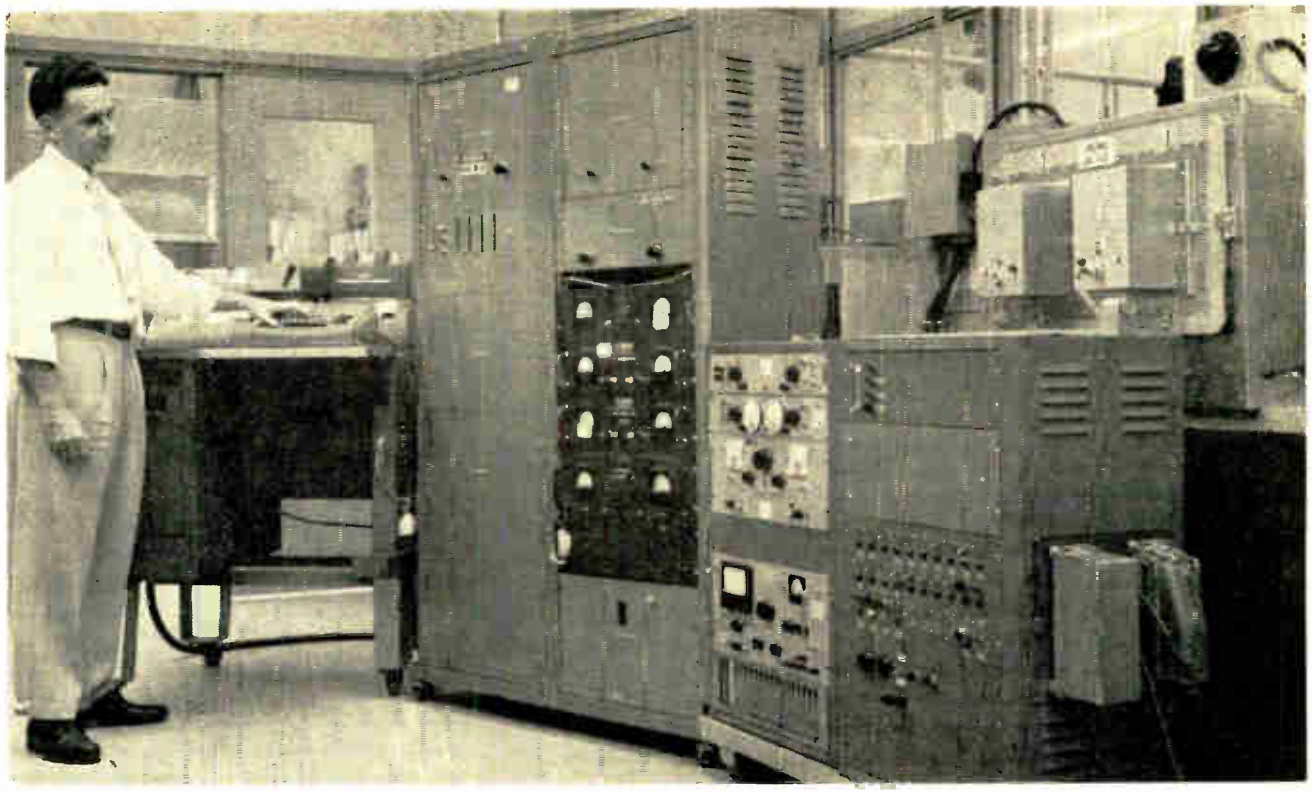
Circuit Operation

Assume that beta, (h_{fe}), of a group of *npn* transistors is to be measured. Since beta varies with collector current, all measurements are to be made at a collector current of 10 ma and a collector voltage of 2 volts. The test circuit is shown in Fig. 1 where the supply voltage V_{cc} is set at 12 volts. With 10 ma flowing through R_1, producing a 10 volt drop, a 2-volt drop, V_{ce}, is available across the test transistor. The reference voltage is set to the desired value of V_{ce}, in this case to 2 volts. The battery voltages remain constant (1.5 and 22.5 volts as shown) for any bias values within the limits of the tester. The circuits of the tester are such that Q_1 and Q_2 must be type *pnp* if the transistor being tested is type *npn*. All polarities must be reversed if the transistor being tested is type *pnp*.

The test transistor is placed in the circuit and then the switch (not shown), that connects the circuit voltages is turned on. The operating voltage for relay K_1 is also applied with this same switch. But capacitor C_3 across the coil of K_1 acts to delay the closing of the relay. Thus the 22.5 volts available at the base of the transistor under test is shunted through C_2. The circuit protects the test transistor from a high current surge into the base.

The collector of Q_x, point A on the drawing, is momentarily at 12 volts when the bias is initially applied. Point B, the collector of Q_1, and the base of Q_2, is initially at -1.5 volts. Maximum current thus flows in the base circuit of Q_2 and produces maximum collector current in this transistor. The collector circuit of Q_2 includes the 22.5-volt battery, 10-k resistor R_2 and the base circuit of Q_x. Since the relay is not energized during the first part of the sequence, Q_2 collector current is shunted by C_2. As C_2 begins to charge, base current starts to flow in Q_x. With current flowing through Q_x and R_1, point A begins to drop from its initial value of 12 volts.

Relay K_1 now operates, removing C_2 from the base circuit, and test transistor Q_x can go into saturation. The collector current of Q_x will attempt to go beyond the desired current of 10 ma. At just 10 ma, point A is at 2 volts, with 10 volts being dropped across R_1. As the collector current tries to go above 10 ma, point A drops below 2 volts and the base of transistor Q_1 becomes more negative than its emitter,



Automatic transistor measuring system has console, digital voltmeter and punch card readout. Beta is just one of the transistor parameters that the system can measure

which is at a +2-volt reference.

Because Q_1 is a *pnp* transistor, base and collector current will flow from these bias conditions and the voltage drop across R_2 will increase. The initial voltage drop across R_2 was small and was caused by the small base current of Q_2. Since point B is now less negative, the base current of Q_1 is reduced. Collector current of Q_2 and thus base current of Q_3 are therefore reduced. Point A now becomes more positive again because of the decreasing collector current in the test transistor. As point A attempts to go above 2 volts, transistor Q_1 will cut off. The turning-off and turning-on action is filtered by R_3 and C_1, thereby presenting a smooth d-c bias to the circuit.

The actuation of K_1 removes C_2 and shunts it with a discharge resistor so the circuit will be ready for the next transistor. With the collector current of Q_3 held at the desired value, the base current is measured and beta is determined. Base current is determined from the voltage drop across R_2.

Adjustments

Bias adjustments should be completed with a test transistor in the circuit because when transistor Q_1 is turned on it will have about 0.1-volt drop between emitter and base. The reference voltage, therefore, will always be about 0.1 volt more than the desired collector voltage. Supply voltage V_{cc} and the reference voltages may be adjusted while monitoring point A for collector voltage and voltage drop across R_1 for collector current.

For testing transistors at a low collector current (about 1 ma), the beta of Q_1 should be at least 60. Base current of Q_1 will then be negligible compared to the collector current of the test transistor.

The discussion has assumed that an *npn* transistor was being tested, with *pnp* units in the test circuits. For testing *pnp* elements, the test circuits use *npn* units and all voltage polarities are reversed. In the production model of the tester, these polarity changes are made with a switch.

For minimum noise pick-up at the readout equipment, a shielded cable is used as a return. Because this requirement means that one side of base-current-measuring resistor R_2 must be grounded, all other points in the circuit are left ungrounded. A bus bar wire is used to connect the points marked common in the drawing.

Accuracy and Limitations

With the type transistors shown in Fig. 1, h_{fe} values from 6.5 to 125 were measured. These values are well within the usual range for most transistors of this type. Collector currents from 1.0 ma to 100 ma were realized without difficulty. Using one-percent precision resistors for R_1 and R_2, and maintaining one-percent accuracy in the associated readout equipment, over-all system accuracy of the transistor tester is about two percent.

High power transistors can be measured with the same basic technique. Higher power transistors are used for Q_2 and the capacity of the bias and power supply are increased accordingly.

Because of its accuracy and speed of operation in measuring transistor parameters, the automatic beta tester is an improvement over other methods of measuring this parameter. The bias points are automatically established at the same levels each time, thus minimizing error and allowing a greater number of units to be tested in a given period of time.

Radar Jamming Chart

Improved radar interference nomograph provides solution to off-target jamming problem. Two examples are given

By **RICHARD A. WALL**, Systems Research Laboratory, Motorola, Inc., Riverside, California

MOST EXISTING NOMOGRAPHS are unsuitable for radar interference calculations where the interference comes from a location other than that of the target. A radar jamming nomograph is provided which is applicable whether the interference is located at the target or elsewhere.

In this article the term jamming will be understood to apply to either intentional or unintentional interference.

Jamming Equation

The nomograph is based on the jamming equation which is obtained by combining the radar and beacon equations.[1] It is expressed as

$$\frac{P_j}{P_r} = \left(\frac{R_j^2}{R_t^4}\right)\left(\frac{G_r^2}{G_{rj}G_{jr}}\right)\left(\frac{\sigma}{4\pi}\right)Q_j$$

The vulnerability factor Q_j represents the ratio of jamming power to signal power necessary to obscure target signals or cause the radar to malfunction. It is given by

$$Q_j = \left(\frac{B_j}{B_r}\right)\left(\frac{D}{FL}\right)\left(\frac{N_r}{N_j}\right)^{1/2}$$

In actual practice Q_j is seldom evaluated directly because of the uncertainties associated with the correlation factor and radar integration capabilities. The Q_j term can be evaluated or estimated for specific conditions but in general it is specified as an arbitrary number of db.

The effect of propagation losses under conditions of interference is often overlooked. A radar designed to give adequate performance under specified conditions of interference or propagation loss may fail when both occur simultaneously, since the interference suffers a one-way loss while the radar echoes suffer a two-way loss. Interference allowances should always be augmented by propagation allowances rather than letting the larger of the two govern.

The nomograph scales can be multiplied by appropriate factors to get desired values. Multiplying R_j by ten, for example, increases P_j/P_r by 20 db, while multiplying R_t by ten decreases P_j/P_r by 40 db.

Examples

A proposed 100-kw radar will be subjected to interference from a fixed transmitter 20 miles away. The jammer has an antenna gain of 10 db toward the radar and puts out an effective power of 3 kw in the radar receiver passband. The radar antenna will have a main beam gain of 40 db with sidelobes 20 db down. If the vulnerability factor is estimated at 15 db, what detection range can be expected against targets with an echoing area of 5 square meters?

The antenna factor is $2 \times 40 - 40 - 10 = 30$ db for the main lobe, and $2 \times 40 - 20 - 10 = 50$ db for the sidelobes. Starting with the given values for P_j and P_r a straightedge is aligned as shown by the solid lines on the nomograph and the anticipated detection range is found to be 2.8 pointing toward the jammer. Using the alignment illustrated by the dashed lines the range is found to be 9 miles when the main beam is pointing away from the jammer.

Table I—Symbols

P_j	Interfering transmitter power
P_r	Radar transmitter power
R_j	Distance between jammer and radar
R_t	Distance between target and radar
G_r	Radar antenna maximum gain
G_{rj}	Radar antenna gain in jammer direction
G_{jr}	Jammer gain in radar direction
σ	Effective target echoing area
B_j	Jamming signal bandwidth
B_r	Radar receiver bandwidth
D	Ratio between jammer and radar duty cycles
F	Correlation factor between jamming signal and radar receiver acceptance characteristics
L	Propagation loss (see text)
N_r	Effective number of radar returns integrated per unit sampling time or per azimuth scan
N_j	Effective number of jamming pulses integrated (by radar) per unit sampling time or per azimuth scan

The author wishes to acknowledge the assistance of Glenn Garrison in preparing the nomograph.

(Continued on p 118)

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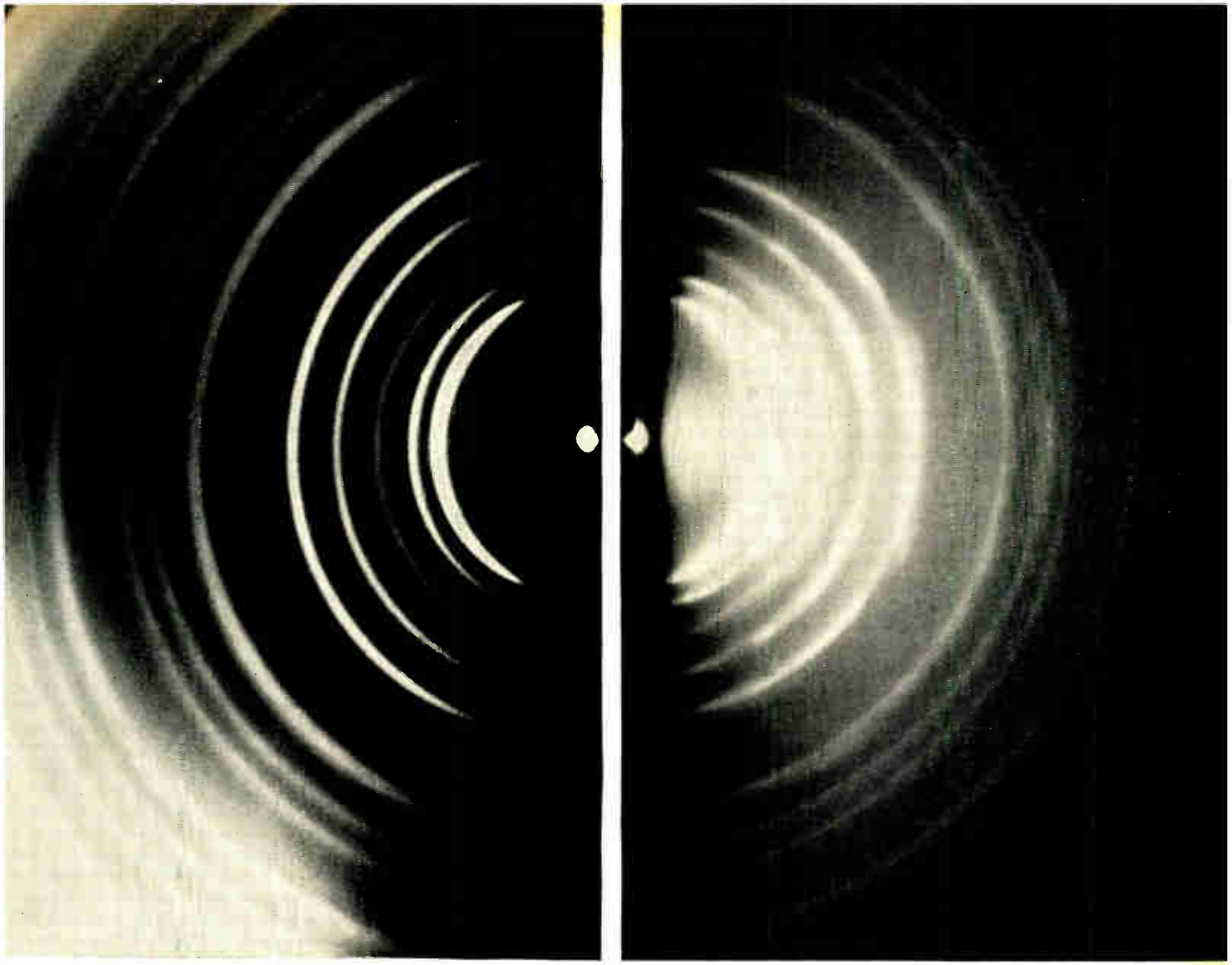

Report from IBM *Yorktown Research Center, New York*

MAGNETIC EXPLORATION ALONG THE CRYSTAL AXIS

How does the orientation of crystallites within a thin metallic film relate to its magnetic properties? This is the question under study by a group of scientists at Zurich, Switzerland—one of the laboratories coordinated from the IBM Yorktown Research Center.

Electron-diffraction permits the investigation of the crystal structure of thin magnetic films prepared by evaporation in vacuum. In particular the orientation of the numerous small crystals in a polycrystalline film can be detected. The uniform distribution of density along the rings in the left-hand picture results from a random distribution of crystal axes, whereas the arcing of the rings at the right indicates a preferred orientation, known as fiber texture. Alignment of the axes of the individual crystallites contributes to the film's magnetic anisotropy—the variation of magnetic energy with different directions of magnetization.

Techniques for producing predictable anisotropy in thin films and for measuring magneto-crystalline relationships are among the goals of the present work. Thorough understanding of all factors influencing the magnetic anisotropy is mandatory for the development of optimal operation of magnetic thin film logic and memory devices. Mastery of anisotropic films may thus offer a promising route to greater capabilities in tomorrow's computers.

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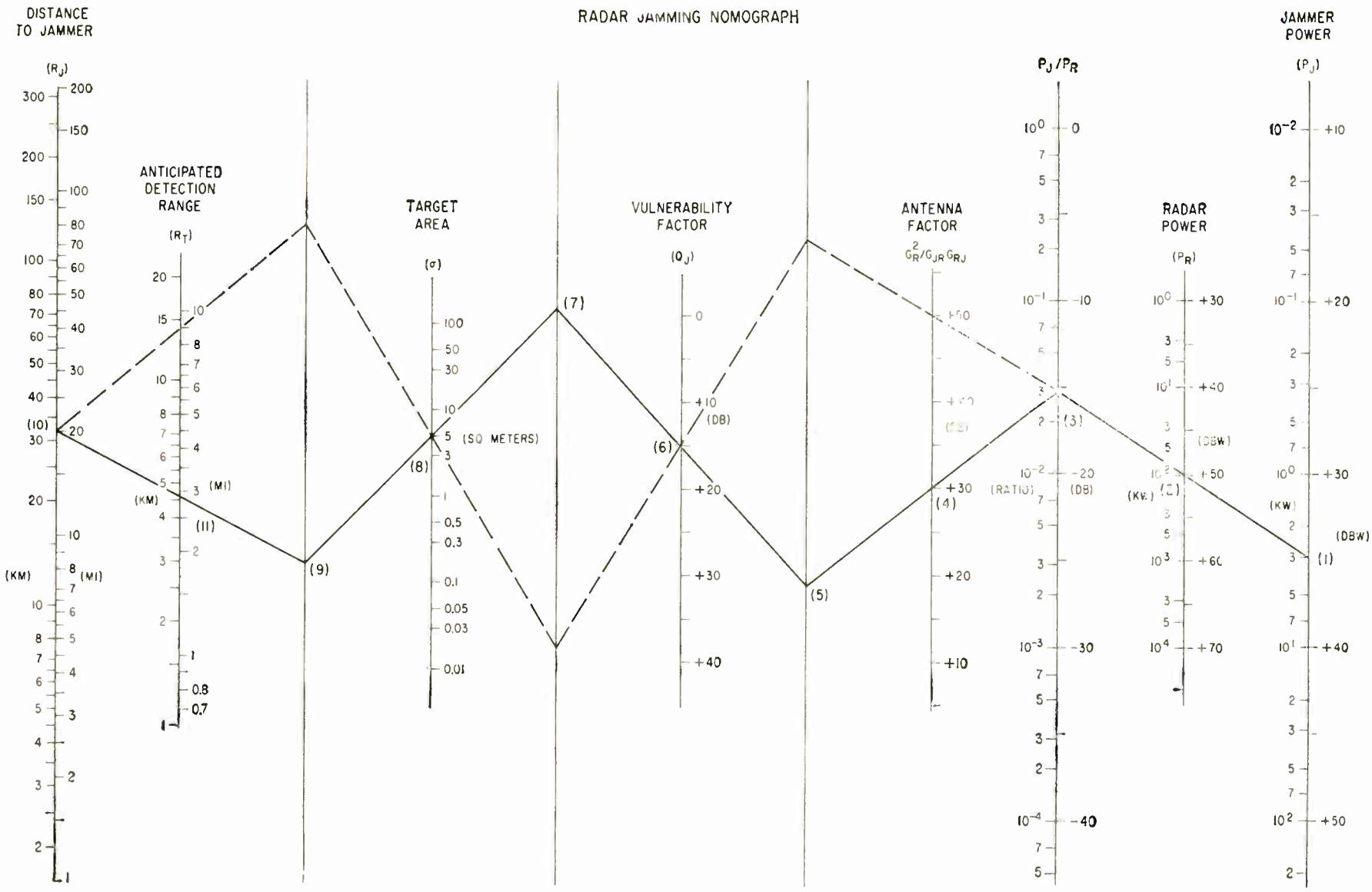

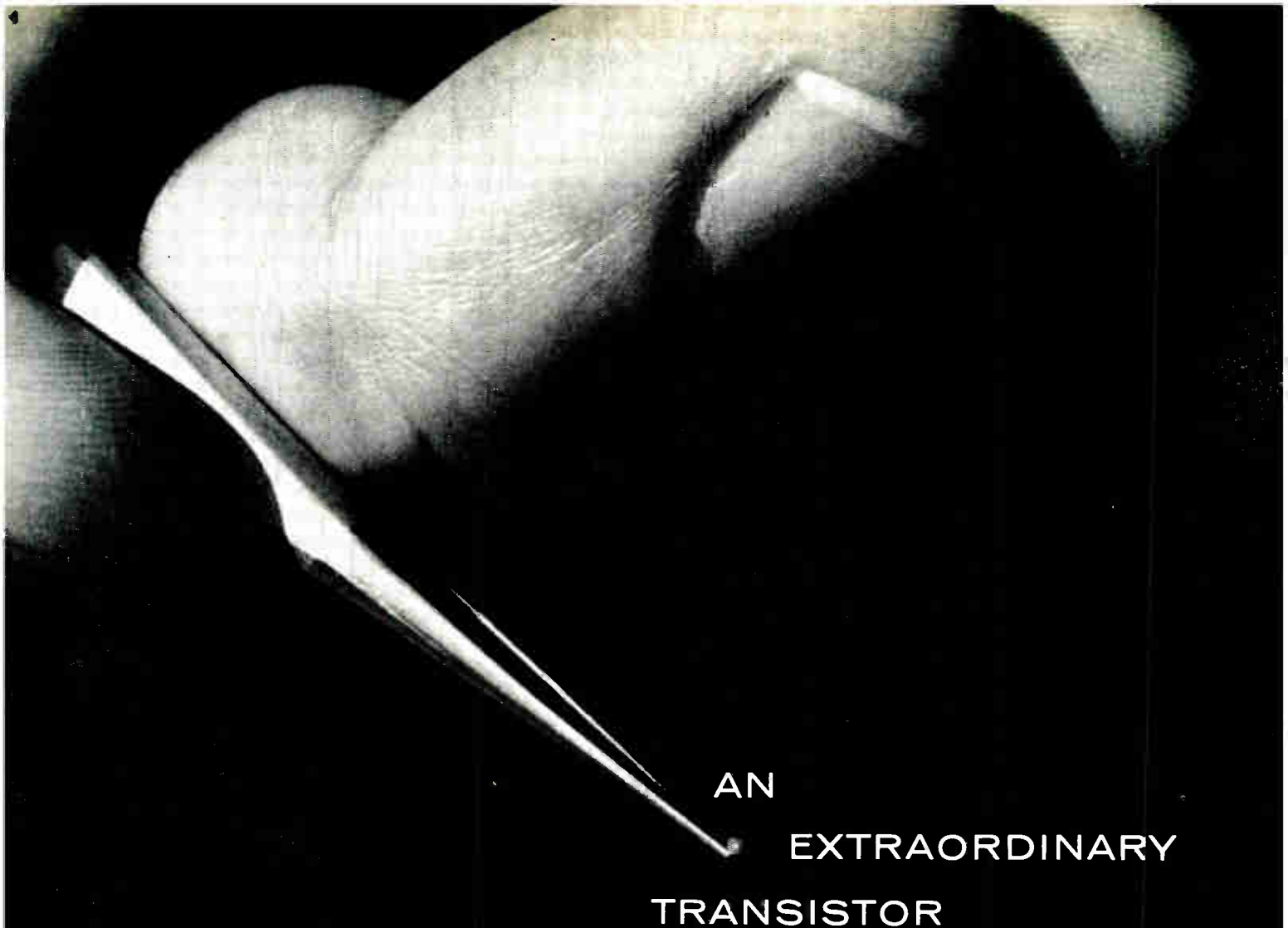

AN EXTRAORDINARY TRANSISTOR

This tiny silicon chip does something no other transistor can do. It achieves the speed of the fastest germanium plus having the superior temperature characteristics and reliability inherent to silicon. It is the Fairchild 2N706.

This extraordinary transistor was introduced to industry in August of 1959. Within two months, many thousands of units had been shipped and the 2N706 was being designed into highest performance computer circuits. No "blue sky" project, the 2N706 is applicable and extremely advantageous to all types of high speed computer logic.

The 2N706 is also extraordinary as a success story in people—solid-state physicists, physical chemists, metallurgists, electrical engineers, mechanical engineers and industrial engineers. Free flow of ideas and enthusiasm produced an accumulation of advanced semiconductor technologies at an unprecedented rate. From the beginning, only two years ago, the 2N706 was the goal. En route, these technologies resulted in the production of eight other silicon transistors. These devices have clearly established Fairchild as the leader in advanced semiconductor development.

Step by step, the Fairchild program was planned and held in focus by a top management team of advanced degree scientists. And now, this same program is being zeroed in on new targets, among them Esaki diodes and integrated solid-state circuitry. If yours is a relevant background and you like the way we work, why not drop us a line? We would like to hear from you.

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Calibrating Microwave Attenuators

LOWER RANGE microwave variable attenuators can be calibrated to accuracies better than 0.0001 db. This accuracy exceeds the precision to which available attenuators can be set and read.

The method was evolved by the National Bureau of Standards in connection with its program to develop microwave standards and precision measurement methods at microwave frequencies.

Calibrated microwave attenuators and directional couplers are used in such instruments as field-strength meters and signal generators and in alignment of radar transmitters and receivers. Attenuators used for power measurements reduce high power outputs by a known amount to a level that can be conveniently measured with milliwatt instruments. Microwave equipment manufacturers need their transfer standards calibrated against a national standard to ensure accuracy of attenuators. The present development provides the required accuracy in the lower ranges.

The improved accuracy was made possible by adapting a very stable power measurement system to attenuation measurements. The resulting calibration system consists of an amplitude-stabilized microwave signal source and a bolometer detector operated in a temperature-stabilized water bath. There are provisions for tuning out reflections at the place where the test attenuator is inserted and for accurately measuring d-c power supplied to the bolometer detector. A second bolometer detector forms part of the amplitude stabilization loop.[1]

As the attenuator dial is moved from zero position, microwave power input to the bolometer mount changes from its initial level, P_1, to a second level, P_2. Measured attenuation is $A = 10 \log_{10} (P_1/P_2)$.

Measuring Technique

Microwave power as measured by the bolometer technique is proportional to the amount of d-c power withdrawn to maintain constant bolometer resistance. The constant of proportionality is the effective efficiency of the bolometer mount. This factor cancels out in the expression for attenuation if it is independent of power level. Previous experiments verify that it is.[2]

The bolometric measurements are made by a self-balancing d-c bridge[3], a constant-current generator and associated d-c measurement apparatus. This instrumentation provides a direct indication of changes in microwave power input, which makes possible determination of small attenuation values.

Actual Measurements

Attenuation of a rotary-vane type variable attenuator was measured by this method. To obtain an indication of repeatability of attenuator setting, results of three independent settings were recorded. Although prime interest was in the lower range, the full range of the attenuator was measured.

Two sources of error were considered in estimating error limits in resulting data—mismatch error and the error arising from uncertainty in measuring d-c power differences. Calculations of the limits of mismatch error[1] are based on system reflections corresponding to a vswr less than 1.005 and on changes in attenuator characteristics determined from separate measurements. The error in measuring d-c power differences is estimated to be less than 0.1 percent +0.1 microwatt.

A statistical analysis of the data indicates that accuracy exceeds the precision with which the attenuator can be set and read. This finding suggests that variable microwave attenuators with expanded scales and precise gears are needed if full advantage is to be taken of this calibration accuracy.

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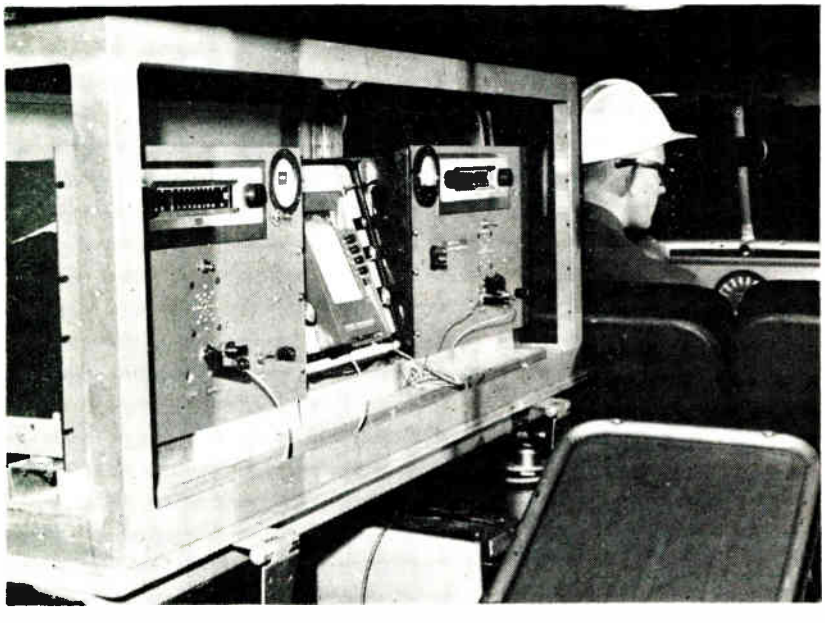
(2) G. F. Engen, Recent Developments in the Field of Microwave Power Measurements at the National Bureau of Standards, *IRE Trans on Inst*, I-7, p 304-306, Dec. 1958.
(3) G. F. Engen, A self-Balancing D-C Bridge for Accurate Bolometric Power

Telemetering Power Line Stress



Receivers and recorder mounted in patrol vehicle are part of Preformed Line Products system for measuring stress in power lines carrying high voltages. Battery-powered transmitter and transducer fastened to line under test provide fm/fm signal. With appropriate transducers, system can be used for many other measurements

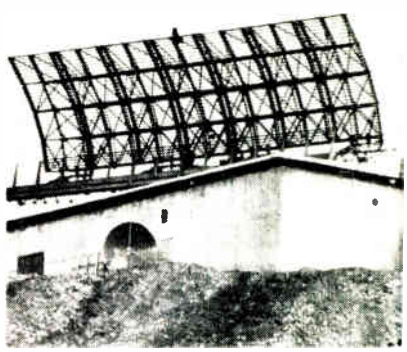
Measurements, *J. Res.* NBS, 59, p. 101-105, Aug. 1957.
(4) R. W. Beatty, Mismatch Errors in the Measurement of Ultrahigh Frequency and Microwave Variable Attenuators, *J. Res.* NBS, 52, p. 7-9, Jan. 1954.

MTI Airport Radar Reduces Clutter

HIGH-POWER 50-cm radar has been installed at Wellington Airport, N. Z., which has just been officially opened. The 500-kw system, supplied and installed by Marconi's Wireless Telegraph Co. Ltd., is a dual transmitter-receiver installation. Either unit can be switched to the common antenna.

The system provides both long-range airways cover and short-range airport approach control in a single equipment.

Two-way microwave radio links are provided over which radar signals are passed to displays at the airport and the control center four miles away. The links also provide a path for remote control of the radar antenna. The radio links were chosen over coaxial lines because of the cost factor and because of the risk of cable damage from earthquakes and tremors in the area.



Airport radar antenna in New Zealand has been designed to withstand high winds. Dish antenna shown at base of building is one of two used for microwave link to transmit radar signals to airport and to four-mile distant control center

The 50-cm wavelength was selected because of heavy rainstorms encountered at Wellington. It is claimed that no form of precipitation obscures aircraft from the system. However, storm centers can be seen faintly on the screens, enabling aircraft to be guided through or around them.

The mountainous terrain surrounding the airport would normally cause considerable clutter. The fully coherent moving target indicator radar is said to remove the clutter to provide effective short-range coverage.

The antenna has been designed to rotate at full speed in winds up to 60 knots, at half speed up to 90 knots and to withstand effects of 120-knot wind.

Data System Records Weather Variables

DIGITAL data system designed by Datex Corp. for Rome Air Development Center is monitoring environmental variables during operational tests of intrusion alarm systems. Digital and analog recordings and direct analog indications of meteorological variables are provided by the system.

As part of the Security Devices Development Program, RADC is checking out commercial anti-intrusion equipment to determine potential Air Force application. The anti-intrusion equipment is primarily concerned with detecting penetration of classified areas.

Since Air Force application will require that the equipment operate in various geographical locations, the equipment must be checked out during typical environmental variations. The new data-recording equipment, essentially a weather-logging system, will record prevalent weather conditions during operational testing of the security equipment.

The system is arranged to receive 60 alarm contacts and will—upon closure of one or more of these contacts—initiate a data-recording cycle. A single data recording cycle will include wind direction, wind velocity, temperature, relative humidity, precipitation, line voltage, time and two decimal digits identifying site. Information from each recording cycle will be recorded on a single card. In addition, the system provides continuous analog indications of the meteorological variables and provides an analog record of wind velocity, wind direction, humidity and temperature.

CIRCLE 123 ON READER SERVICE CARD →

graphite is 2.26 gm per cc. Ordinary commercial graphites run from 1.6 to 1.7; densified graphites range from 1.7 to 2 gm per cc. Pyrographite has been prepared with measured densities as high as 2.22. Density increases with temperature of preparation, due to a higher degree of crystallite orientation at higher temperature.

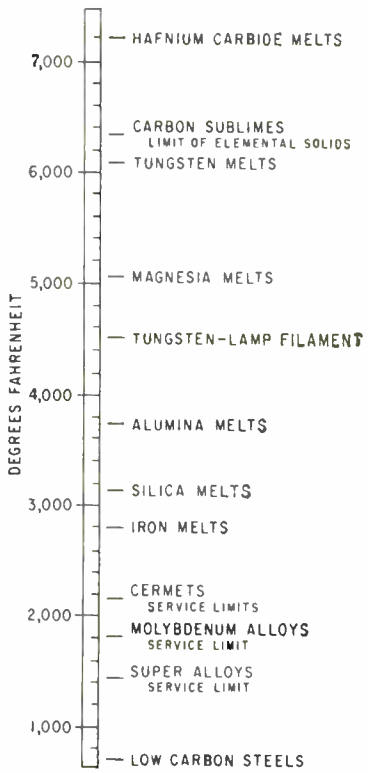


FIG. 2—Temperature limits of materials

Pyrographite has a strength-to-weight ratio along the planes higher than series 310 stainless steel at low temperatures. Above 2,000 C, where normal graphite has one of the highest strength-to-weight ratios known, Pyrographite has a ratio five times as great.

Figure 2 gives the temperature limits of some other materials. Figure 3 is a graph showing thermal conductivity comparisons of Pyrographite. And Fig. 4 compares strength-to-weight ratios.

Various tests in highly erosive atmospheres shows little erosion compared to almost complete breakdown for graphite. This property, like many others can be attributed to the high degree of order in the crystal lattice.

Of particular interest for applications in nuclear reactors is im-

permeability to gases. Using a standards mass spectrometer leak detector, no permeation by helium has been detected. The material exhibits this property after heating to 2,500 C and recooling, even in films as thin as one or two mils.

Although work to date has been concentrated chiefly on developing classified products for military applications, Raytheon expects that their development will be applied to numerous other products, both military and commercial. It is believed that the physical properties of Pyrographite will make it particularly suitable for applications where strength, impermeability and chemical inertness are required at high temperatures.

Further property studies, particularly in the electrical and microwave field may open up many more potential applications. The thermoelectric properties of modified

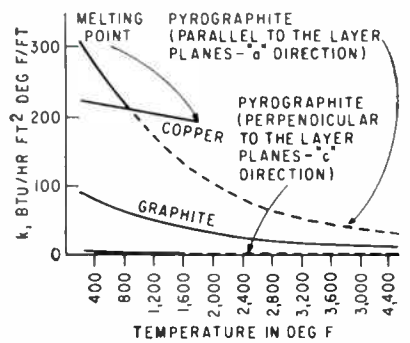


FIG. 3—Thermal conductivity vs temp

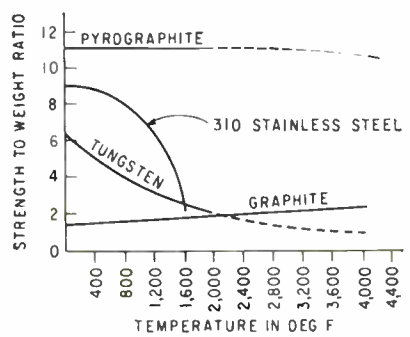


FIG. 4—Strength-to-weight ratio vs temperature

Pyrographites, for example, may make the material ideal for electrical heating and cooling.

Raytheon has recently established a large-scale pilot facility in Lawrence, Mass., for the production of Pyrographite and plans to supply significant quantities of the material in various forms and shapes.

Deposition Forms Metals in Plastic

METAL ELECTRODEPOSITION enables the production of integrated metal-plastic components with a minimum of piece-by-piece assembly and promotes miniaturization since the plastic body can be molded and machined to close tolerances as a preliminary step. The process has been used for several years by Electro Tec Corp., S. Hackensack, N. J., to make slip rings for gyros and other precision applications.

Gold and silver rings are deposited to 0.5 inch thick routinely and thicknesses over an inch are feasible. Sizes have ranged from 0.040 inch diameter on 8-ring subminiature assemblies, 0.14 inch diameter on 45-ring assemblies and 53 rings have been deposited on the face of a disk 50 inches in diameter.

A half-section of a typical ring is shown in Fig. 1. The body is molded around the lead wires and machined. Rings are keyed to the body and leads via recesses in the bottom of the ring groove, producing a strong bond.

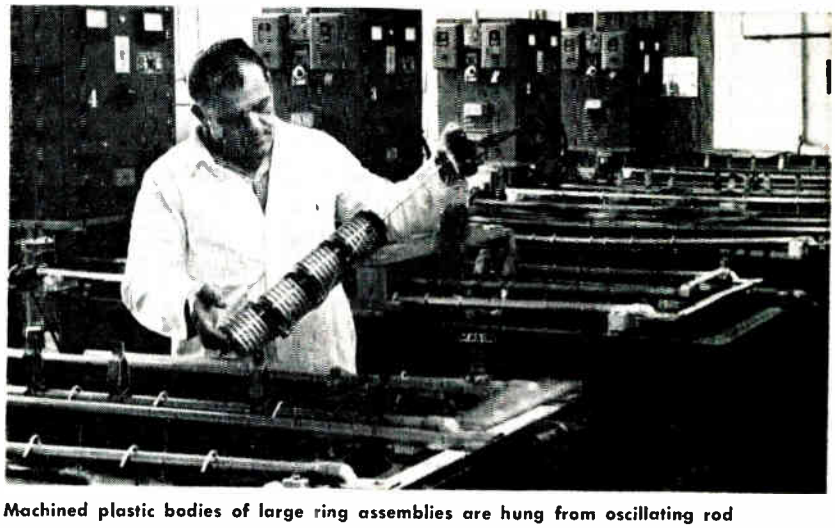
Metallic surfaces not to be plated are masked. Leads are inserted in Teflon tubing which is sealed. Projecting ends of leads are soldered to twisted pairs of copper wires which form the top frame of the fixture (Fig. 2). Small assemblies are spaced by a serrated plastic plate and are held in position by elastic bands.

Bare copper thief wires form a cage around the slip ring bodies. Initially, the thieves help concentrate plating current around the bodies by adding to plating area. This also makes it easier to calculate plating area, particularly for miniature rings. As the deposition builds up, the thieves protect against possible overloads and soften plating action, aiding slow buildup of stress-free deposit.

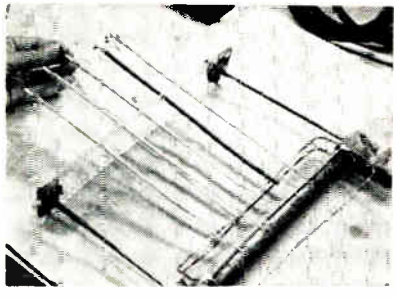
Bodies are first cleaned by degreasing and ultrasonic washing. They are then dipped in soap solution. Six volts are impressed on the workpieces, making the solution gassify and scrub the metallic surfaces. Acid dips are used to neutralize the soap or activate the surface. Dips are alternated with rinses in cascade water baths.

Oscillating rods agitate workpieces in large tanks. The solution is agitated in smaller tanks by magnetic stirrers, turned by a rotating field in the tank pedestal. Bath makeup is monitored by chemical analysis. Cyanide solutions are generally used. These are prepared in the plant since commercial solutions are not satisfactory for heavy deposition. Current, temperature and agitation rate must also be calculated for specific types of assemblies.

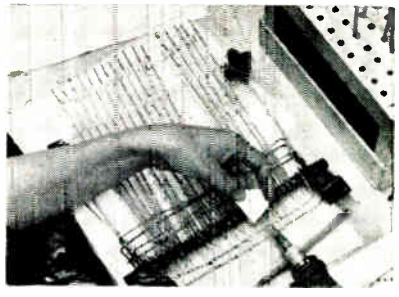
Anode ingots are wrapped in filter paper and hung in nylon cloth bags. Mesh bags would permit undissolved



Machined plastic bodies of large ring assemblies are hung from oscillating rod



Protruding center wire is capped with plastic to prevent plating



Leads are soldered to fixture frame. Note thief wires

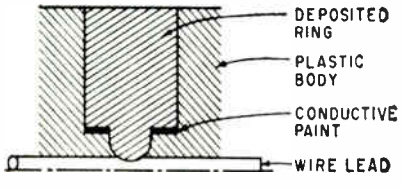


FIG. 1—Cross section of ring, showing method of keying to lead

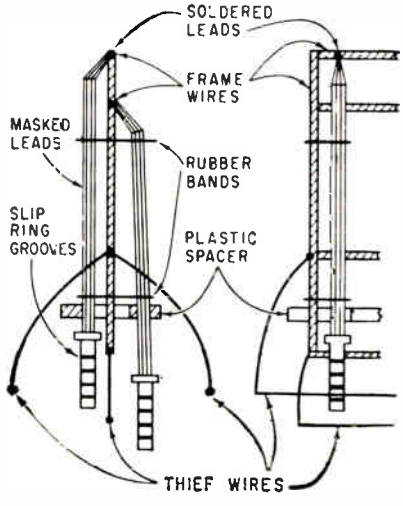
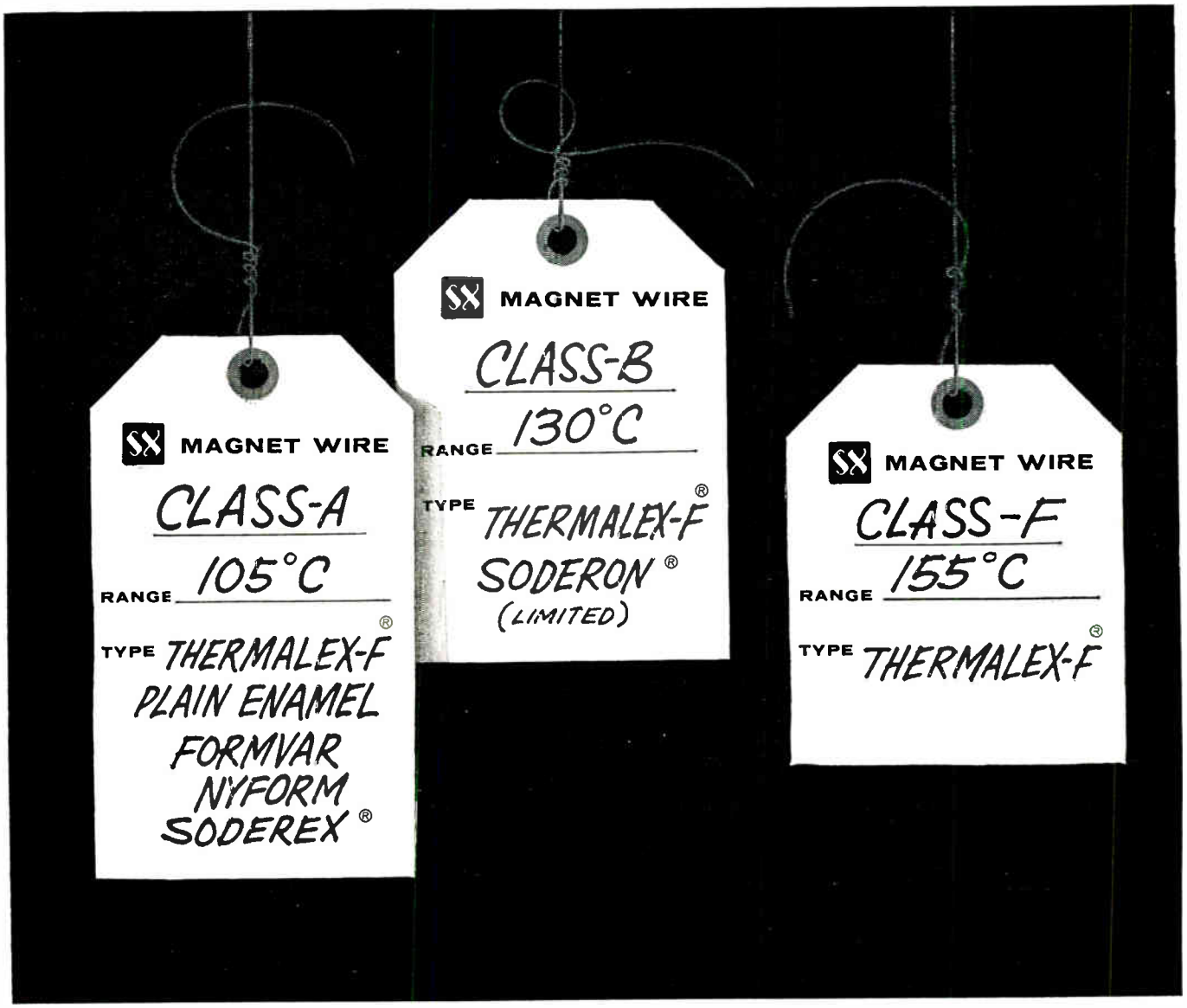


FIG. 2—Fixture used for miniature cylindrical slip rings



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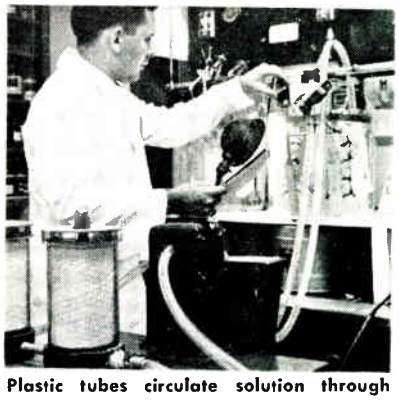
particles to enter the bath and become inclusions in the deposition. Ingots are pure metal, frequently reprocessed to raise purity. Alloys are not used because, the firm reports, alloying metals cause variations in contact resistance and noise in the signal through the ring.

Pumps which will not contaminate the solution are used to constantly filter the solution. One such pump is the milk type used to pump blood during heart operations. Solution is circulated in plastic tubes which are milked by the pump's metal fingers. The closed system also avoids leakage which is expensive and a health hazard. Five tubes, each circulating 12 to 15 gallons an hour, may be used in each pump.



Plastic tubes circulate solution through filter. Black object in center is milk pump

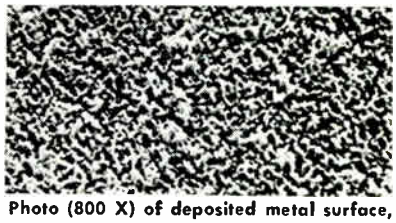


Photo (800 X) of deposited metal surface, etched with chromic acid, shows regularity of structure

Some rings are deposited in ultrasonically-agitated baths. The deposition is reported to be exceptionally pore-free, stress-free and of regular crystalline structure. Deposits of gold an inch thick are readily obtained.

Flow through filters is stepped up in this method of deposition. The ultrasonic energy, while continually driving fresh solution onto the plating surface, is continually cleaning everything in the bath and attacking maskants. The work is agitated by oscillating rods to avoid variations in deposits which could

be caused by standing waves in the solution. Tanks are 40 kc commercial cleaning units fitted with controls, pumps, filters and oscillators.

Rings are deposited with excess diameter and machined and polished back to finished size. If an overplate of gold on silver, or rhodium, is specified, assemblies are recleaned. A typical procedure is electroclean in soap solution, pickle in 10 percent sulfuric acid and electroclean in phosphoric acid (for rhodium) with rinses. The rhodium bath is housed in a constant-temperature cabinet. Fixtures are hand-dipped since flash plates require only a quick dip. An 18-second dip plates 10-millionths of an inch. Plates up to 40 millionths may be applied. (Photos of miniature rings were taken in Blacksburg, Va., plant, and large rings in Ormond Beach, Fla., plant.)

Guide and Stop End Wire Stripping Hazard

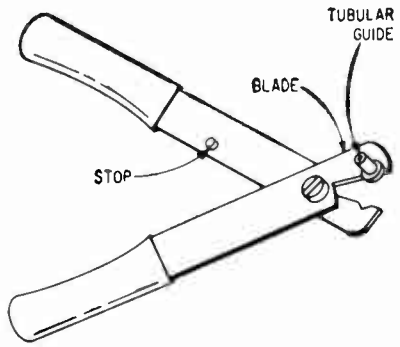


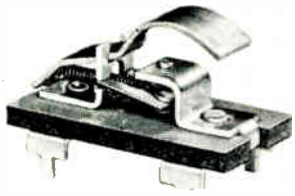
FIG. 1—Positions on guide and stop on stripper

IN STRIPPING insulation from wire wrap and solder connections, any nicking of the metal may cause the wire to break during vibration and excessive handling. A stripper modification (Fig. 1), devised by F. D. Pessia and R. N. Sweetland, of International Business Machines Corp., New York, prevents this.

A wire will be nicked if it is presented to the stripper blades at any angle other than approximately 90 degrees. By welding a tubular guide to a blade of the stripper, this angle is assured. The guide tube is sized to accept the wire size for which the stripper is set. A permanent stop on the other blade limits closure of the stripping blades to an aperture slightly larger than the wire size.

CIRCLE 131 ON READER SERVICE CARD →

On The Market



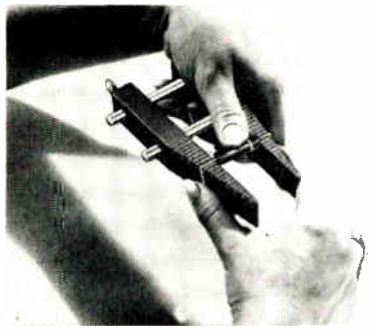
Snap-Action Switch for p-c use

CHERRY ELECTRICAL PRODUCTS CORP., 1650 Deerfield Road, Highland Park, Ill. Series S30-42B switches feature special terminals for easy p-c insertion, positive over-travel stop and over 50 actuator variations. Gold flash and other special contact material is available for special l-v applications. Switch measures ⅛ in. by ½ in. by 1 in. It is rated: 10 amperes/125v a-c, 5 amperes/250 v a-c, ½ h-p/125/250 v a-c.

CIRCLE 301 ON READER SERVICE CARD

Lead Bending Block no plier damage

BY-BUK CO., 4314 W. Pico Blvd., Los Angeles 19, Calif. No. 700 universal component bending block is designed for bending leads to accurately register with their holes in p-c panels. Tool can be quickly adjusted to the body length of any component measuring from 0 to 1¾ in. long. The leads are bent by finger pressure thus eliminating plier damage, and avoiding replacement of costly component parts. It is possible to bend both leads as close as 0.070 in. to the ends of the component. The bends can be made for panel holes as wide as 3 in. apart and will handle any diameter lead up to 0.045 in.



CIRCLE 302 ON READER SERVICE CARD

Precision Film Pot miniaturized

COMPUTER INSTRUMENTS CORP., 92 Madison Ave., Hempstead, L. I., N. Y. Model 50 is a single turn precision pot which utilizes the Super-Con film resistance element offering virtually infinite resolution. Linearity to 0.2 percent is available with life in excess of 30 million revolutions at 100 rpm. Non-linear outputs, tapped elements and ganged units are also available. Unit will operate over a temperature range of −55 C to 150 C and under the most severe environmental conditions.

CIRCLE 303 ON READER SERVICE CARD

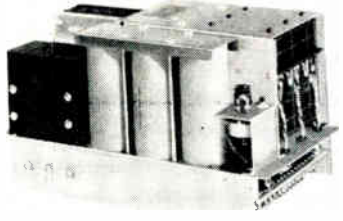
P-M Geared Motor meets MIL-I-6181B

ELECTRO PRODUCTS DIVISION, Western Gear Corp., 132 W. Colorado Blvd., Pasadena, Calif. Model P7P-6TFRP, a 28 v d-c permanent magnet geared motor, is designed for services as a magnetron tube drive. It develops 16 oz in. of torque at 1,000 rpm and has a thermal protector for overload and stall conditions as well as a radio filter.

CIRCLE 304 ON READER SERVICE CARD

D-C Power Supplies transistorized

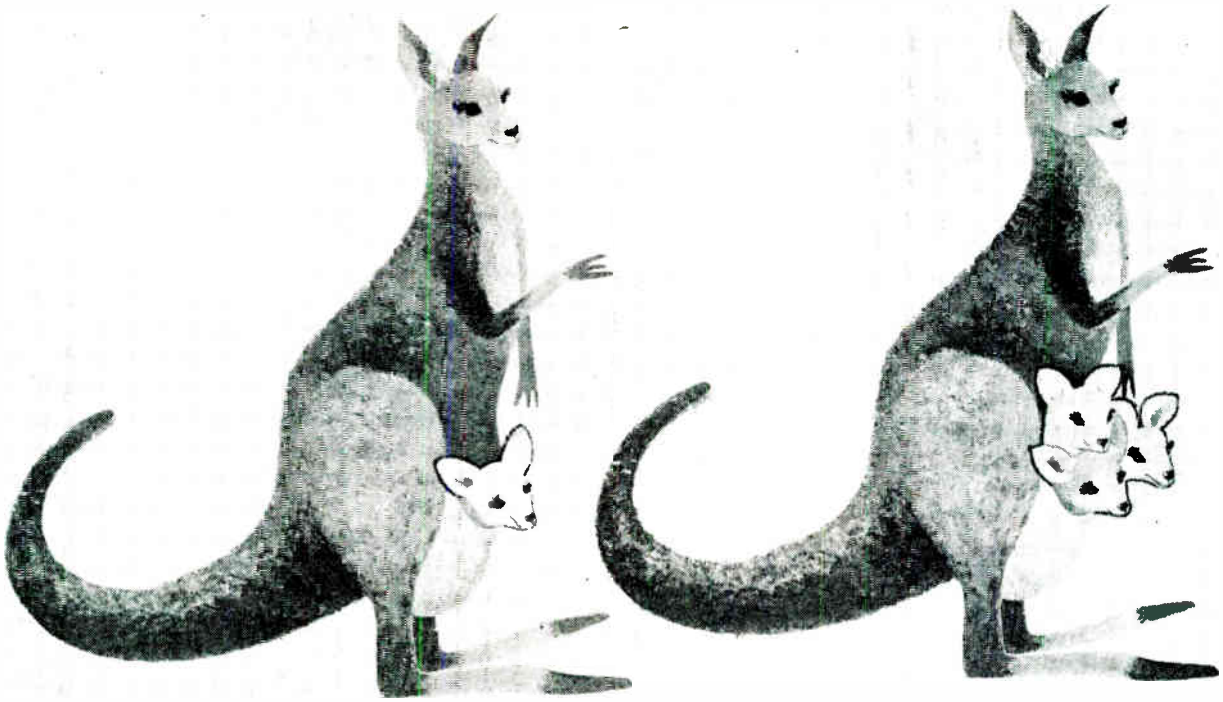
DRESSEN-BARNES CORP., 250 N. Vinedo Ave., Pasadena, Calif. Four new fully transistorized d-c power supply modules provide d-c power over ranges including 5 to 32 v and up to 6 amperes. By combining the modules in series, the upper voltage range is increased to 64 v. Input is 105-125 v a-c, 60 cps; ripple, less than 2 mv rms. The modules are designed for optional mounting in the 70-101 rack mounting kit.



CIRCLE 305 ON READER SERVICE CARD

Pulse Transformer subminiature

PULSE ENGINEERING, INC., 560 Robert Ave., Santa Clara, Calif. The Micro-Stat pulse transformer features clamped ferrite core construction. Use of core-gapped construction instead of the conventional toroid and cup core is said to pro-



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MC604	1.0 42.0	29/32 "	5/16"
MC606	1.0 60.0	1 5/32 "	5/16"
MC609	1.0 90.0	1 3/4 "	5/16"

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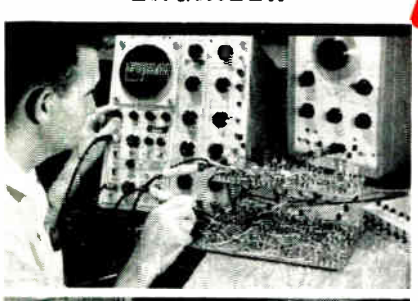

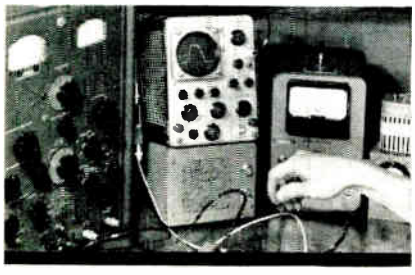

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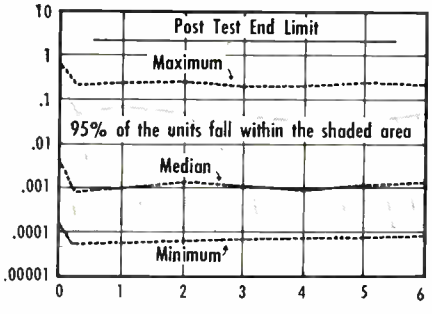
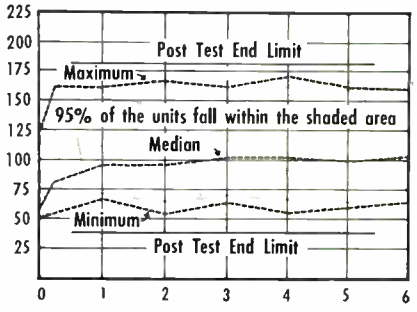
PARAMETER MEASURED	TEST CONDITIONS	ACCEPTANCE LIMIT	
		MIN	MAX
I_{CBO}	$V_{CB} = 20$ vdc, $I_E = 0$, $T_A = 25°C$	—	2 μa

PARAMETER TEST CONDITIONS AND LIMITS

PARAMETER MEASURED	TEST CONDITIONS	ACCEPTANCE LIMIT	
		MIN	MAX
h_{FE} pulse	$V_{CE} = 5$ vdc, $I_C = 10$ ma, $T_A = 25°C$	45	150





I_{CBO} and h_{FE} characteristics of a sample of 60 TI 2N337 and 2N338 units over a 6-week period. These tests are conducted by TI's independently operated Quality Assurance Branch, and are representative of the complete parameter behavior test information in the Silicon Transistor Reliability Data brochure listed below.

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SILICON TRANSISTOR RELIABILITY DATA
Complete parameter analysis of TI 2N332 through 2N343 — a graphic presentation of parameter behavior with time when one type transistor from a series is subjected to stated tests. The graphs above are representative of this data.

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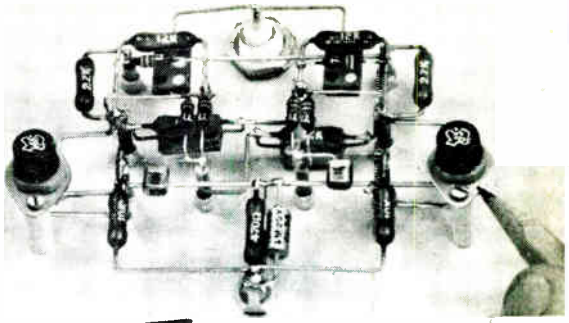

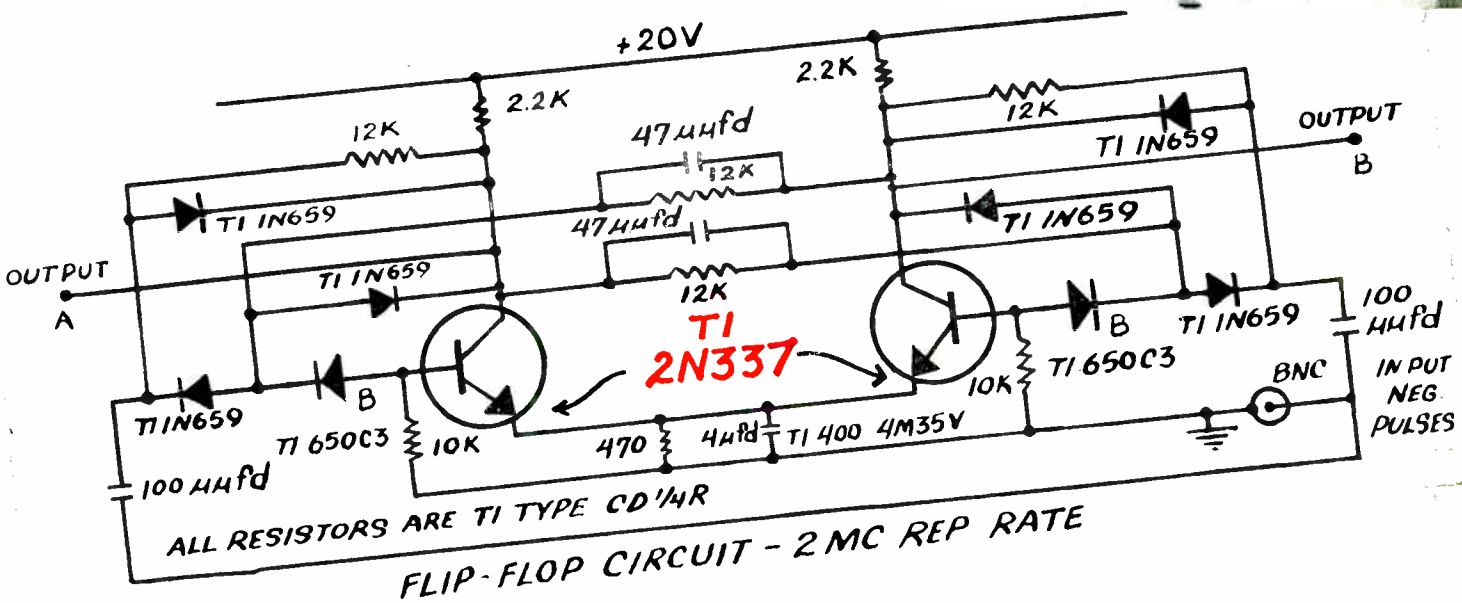

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design characteristics at 25° C ambient (except where advanced temperatures are indicated)

		test conditions		2N337 min	2N337 design center	2N337 max	2N338 min	2N338 design center	2N338 max	unit
I_{CBO}	Collector Cutoff Current	V_{CB} = 20V	I_E = 0	—	—	1	—	—	1	μA
	at 150°C	V_{CB} = 20V	I_E = 0	—	—	100	—	—	100	μA
BV_{CBO}	Breakdown Voltage	I_{CB} = 50μA	I_E = 0	45	—	—	45	—	—	V
BV_{EBO}	Breakdown Voltage	I_{EB} = 50μA	I_C = 0	1	—	—	1	—	—	V
h_{ib}	Input Impedance	V_{CB} = 20V	I_E = −1mA	30	50	80	30	50	80	Ohm
h_{ob}	Output Admittance	V_{CB} = 20V	I_E = −1mA	—	0.2	1	—	0.2	1	μmho
h_{rb}	Feedback Voltage Ratio	V_{CB} = 20V	I_E = −1mA	—	200	2000	—	300	2000	X10⁻⁶
h_{fb}	Current Transfer Ratio	V_{CB} = 20V	I_E = −1mA	0.95	0.985	—	0.975	0.99	—	—
h_{FE}	DC Beta	V_{CE} = 5V	I_C = 10mA	20	35	55	45	80	150	—
$f_{\alpha b}$	Frequency Cutoff	V_{CB} = 20V	I_E = −1mA	10	20	—	20	30	—	mc
C_{ob}	Collector Capacitance*	V_{CB} = 20V	I_E = −1mA	—	1.2	3	—	1.2	3	μμf
R_{cs}	Saturation Resistance†	I_B ‡	I_C = 10mA	—	75	150	—	75	150	Ohm
h_{fe}	Current Transfer Ratio	V_{CB} = 20V	I_E = −1mA, f = 2.5mc	14	22	—	20	24	—	db
t_r	Rise time§			—	0.05	—	—	0.06	—	μsec
t_s	Storage Time			—	0.02	—	—	0.02	—	μsec
t_f	Fall time			—	0.08	—	—	0.14	—	μsec

* Measured at 1 mc † Common Emitter ‡ I_B = 1mA for 2N337, 0.5mA for 2N338 § Includes delay time (t_d)

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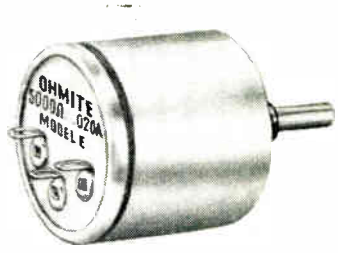
vide improved voltage breakdown and insulation resistance. Design also features faster reset and less B_r, higher power capabilities, lower losses, and increased total flux swing capability. Micro-Stats are available in either epoxy construction or in hermetically-sealed metal casings.

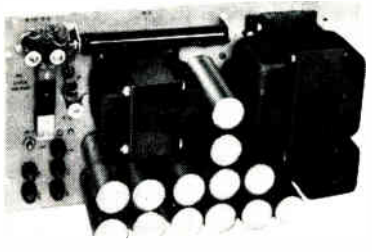
CIRCLE 306 ON READER SERVICE CARD



Miniature Rheostat in enclosed style

OHMITE MFG. CO., 3661 Howard St., Skokie, Ill. Model E miniature rheostat can now be furnished in a lightweight drawn aluminum dust-tight housing. The three rheostat terminals are brought out to corresponding terminals on the back panel. Exclusive of shaft, the entire enclosure measures 1⅝ in. diameter by 1½ in. long. Units are rated 12½ w at 40 C ambient. Model E is applicable to many military uses (particularly in aircraft), and to industrial applications.

CIRCLE 307 ON READER SERVICE CARD

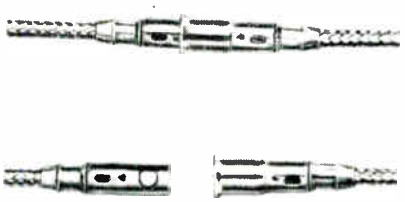


Power Supply all solid-state

WESTERN DESIGN DIVISION of U. S. Industries, Inc., Santa Barbara, Calif. Model 738-001 is designed to provide an output up to 3 amperes at 130 v d-c for laboratory and instrumentation use. It operates at an efficiency in excess of 80 percent under full load conditions where

the input supply is 125 v a-c. Unit provides regulation to ± 2 percent at primary power inputs of 105 to 125 v a-c, 50 to 60 cps. Ripple is less than 1 percent rms. For line of load changes of 1.5 amperes, the output voltage transient remains within ± 3 v of the steady value.

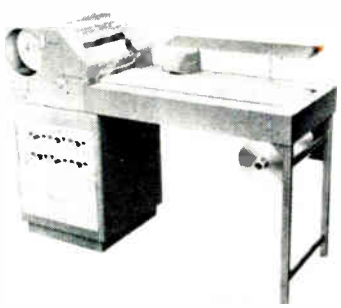
CIRCLE 308 ON READER SERVICE CARD



Cable Disconnect fits many sizes

AMP Inc., Harrisburg, Pa. Coaxicon, the new coaxial and shielded cable disconnect, has been expanded to fit a wider range of cable sizes. The unit now fits all cables up to ¾ in. o-d. Interchangeable contacts permit a greater variation of inner conductor diameters in each cable size—either solid or stranded. Application technique requires one crimp for complete assembly.

CIRCLE 309 ON READER SERVICE CARD



Recorder six-channel

The Gerber Scientific Instrument Co., 89 Spruce St., Hartford 1, Conn. Unit illustrated was designed to fill the need for a recorder which would allow the user to obtain a view of the oscillogram and make notes or corrections with the oscillogram in motion. The oscillogram is transported on a belt along the top of the readout table allowing the operator a full and undisturbed view of nearly three

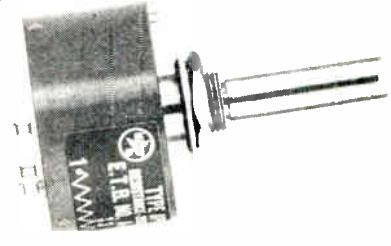
feet of record. A top-mounted fluorescent lamp evenly illuminates this area. A time stamp is built into the machine which prints the year, month, day, hour, minute, and tenths of a minute directly on the oscillogram at preset intervals for future reference.

CIRCLE 310 ON READER SERVICE CARD

Controlled Rectifier
inverter type

GENERAL ELECTRIC CO., Liverpool, N. Y. Five new inverter-type controlled rectifiers have a maximum 12-μsec turn-off time at their highest rated junction temperature. Turn-off time is defined as the time interval required for the silicon controlled rectifier to regain its forward blocking state after forward current conduction. They are available in piv ratings of 100, 150, 200, 250 and 300 v. Devices are rated for operation, in the junction temperature range from −65 C to +125 C. Prices range from $38 each for the 100-v unit to $116 each for the 300-v device in large quantities to original equipment manufacturers.

CIRCLE 311 ON READER SERVICE CARD



Precision Pot
infinite resolution

ACE ELECTRONICS ASSOCIATES, 99 Dover St., Somerville 44, Mass. The Acemho is a conductive plastic precision pot offering long life with low noise. It is environmentally

protected against shock, vibration, acceleration, moisture, humidity and other factors. Unit is available in standard sizes and configurations, linear and nonlinear.

CIRCLE 312 ON READER SERVICE CARD

Control Systems
for aircraft

AIRBORNE ACCESSORIES CORP., 1414 Chestnut Ave., Hillside 5, N. J. Packaged modular control systems built or assembled entirely from stock units, assemblies and subassemblies are now available to manufacturers in the aircraft, missile, electronic control and related fields. Systems include transducer, preamplifier, power amplifier, linear or rotary actuator plus auxiliary equipment as required—rectifier, inverter, voltage regulator, etc.

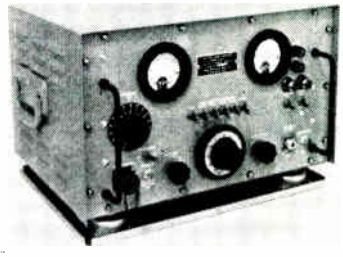
CIRCLE 313 ON READER SERVICE CARD

Power Connectors
center screwlock

DEJUR-AMSCO CORP., 45-01 Northern Blvd., Long Island City 1, N. Y., announces series 1900 miniature rectangular power connectors with center screwlock and closed entry contacts. Terminals for solderless wire wrap, solderless taper pin or solder cup are available. The closed entry contacts supplied, provide increased reliability and maintain a low millivolt drop under constant and uniform insertion pressure. In addition to the 152-contact type illustrated, this series can also be supplied with 104, 78 or 34 contacts. Body material is molded from

glass filled Diallyl Phthalate (MIL-M-19833, type GDI-30).

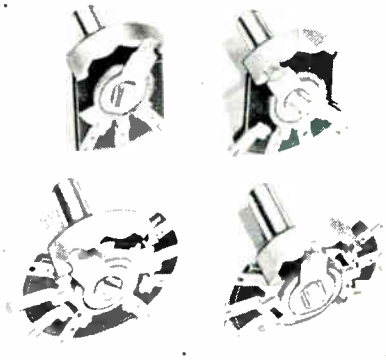
CIRCLE 314 ON READER SERVICE CARD



Signal Generator
400-450 mc

BABCOCK RADIO ENGINEERING, INC., 1640 Monrovia Ave., Costa Mesa, Calif. Primarily developed as a test unit for f-m radio receivers, the BSG-7 may be used wherever frequency modulated r-f carrier signals of precise frequency and amplitude are required. Units are available covering any consecutive 15 frequencies of discrete 1 mc spacing over the range of 400-450 mc with variable carrier deviation from 0 to ±300 kc and r-f signal accuracy of 0.01 percent. Internal modulation providing the first six standard a-f channels or external modulation up to 80 kc is included as a design feature.

CIRCLE 315 ON READER SERVICE CARD

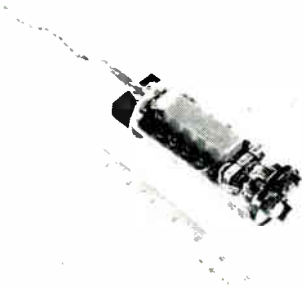


Tone Switch
2- or 3-position

CENTRALAB, a division of Globe-Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wisc. Series 200 Ultra-Economy tone switch has the mounting and index frame die cast as a single unit, affording substantial savings in the cost of parts and assembly. Switch has a current rating of 250 ma at 115 v a-c and 1.75

amperes at 24 v d-c. It can be supplied as a two or three position switch with 3, 4, 6 or 9 contacts clips. Insulation is laminated phenolic type PBE per military spec MIL-P-3115. Voltage breakdown between critical parts is 1,000 v rms.

CIRCLE 316 ON READER SERVICE CARD



Receiver marker beacon

TWENTY-FIRST CENTURY ELECTRONICS INC., 6227 Columbus Ave., Riverside, Calif. New transistorized marker beacon receiver can occupy a standard 2¼ in. instrument panel hole. The signal frequency is for a standard marker beacon at 75 mc, plus three audio modulation frequencies which illuminate one of the three indicators on the front panel to enable the pilot to accurately position his aircraft for approach or holding. Both visual and aural signals are provided when tuned to a standard marker beacon transmitter. Power consumption is 13.75 v d-c, 0.5 ampere, or 27.5 v d-c at 0.25 ampere. Antenna (input) impedance is 52 ohms. Price is $295.

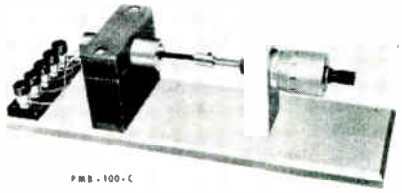
CIRCLE 317 ON READER SERVICE CARD

Spectrum Analyzer real-time

FEDERAL SCIENTIFIC CORP., 615 W. 131st St., New York 27, N. Y., announces a line of real-time Simoramic spectrum analyzers. Unit synthesizes the equivalent of thousands of bandpass filters located side by side in the frequency domain through the use of a single delay line in a well-controlled closed loop. The outputs of the individual synthesized filters are presented sequentially for either human observation or computer consumption. Model 4A Simoramic analyzer

covers the frequency band 1 cps to 200 cps with approximately 1 cps resolution.

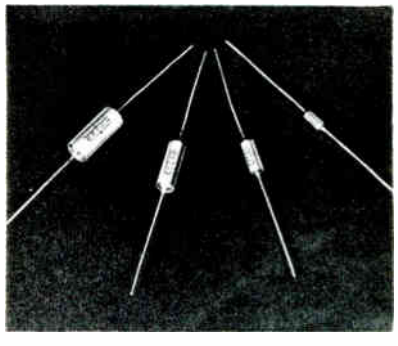
CIRCLE 318 ON READER SERVICE CARD



Test Stand
for checking lvdt's

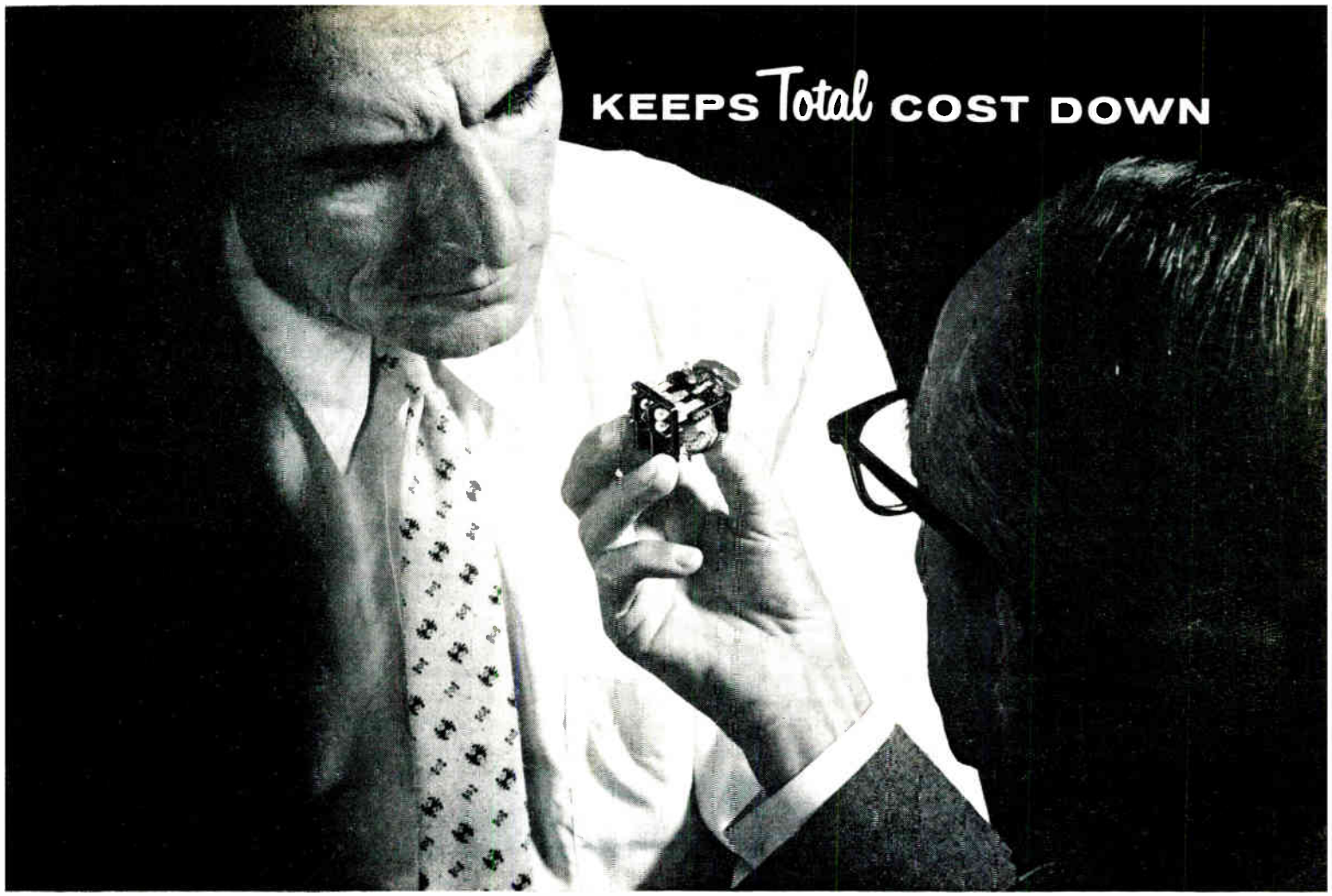
SCHAEVITZ ENGINEERING, Pennsauken, N. J. Model PMB-100-C test stand has been designed for precise measurements of linear variable differential transformer response to linear core motion independently of installation. The lvdt is clamped in the mount, and a nonmagnetic, nonconductive core rod is used to position and support the core as the micrometer is adjusted. The test stand is normally used with a signal generator, amplifier, precision potentiometer, voltmeter and an oscilloscope, to measure and test linearity, phase, input and output volts and operations at various frequencies.

CIRCLE 319 ON READER SERVICE CARD



Capacitors
solid tantalum

ELECTRONIC FABRICATORS, INC., 682 Broadway, New York, N. Y. Line of solid tantalum capacitors offers a capacitance range from 1.0 μf to 330 μf. They provide $\pm$20 percent tolerance of rated value when measured at 25 C and at 120 cps. Dissipation factor is below 6 percent and leakage current measured at rated voltage and 25 C is below 0.03 μa



IF INSTALLED-COST IS A DESIGN PROBLEM

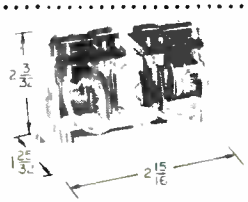
Look at the KA general purpose RELAY

What do your relays cost *installed?* Initial cost is never the whole story.

Our KA Relays are engineered for modern production methods. They're available with printed circuit, taper tab, quick-disconnect or hook solder terminals . . . are simple, economical to install. This fact, combined with low original cost, keeps your total cost down.

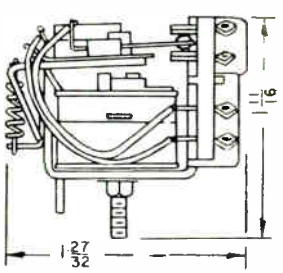
Another source for savings! All standard KA ac relays bear U/L and Canadian Standard Association seals of approval.

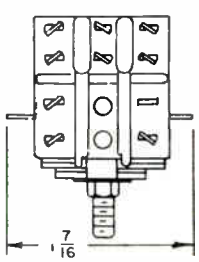
Write or call for more information or see the complete P&B catalog in Sweet's Product Design File.



KB LATCHING RELAY consists of two KA Relays, forming a mechanical latching relay, featuring a large number of contact arrangements.

KA ENGINEERING DATA





GENERAL:

Insulation Resistance: 100 megohms min.
Breakdown Voltage: 1500 V. rms between all elements.
Temperature Range:
−55 C. to +85° C. DC
−55 C. to +70° C. AC
Weight: 2.0 ozs.
Pull-In: DC 75% of nominal voltage.
AC 78% of nominal voltage.
Terminals: Taper tabs.
Printed circuit.
Quick-disconnect.
Pierced solder lugs.
Enclosures: Dust Cover
(max. 55 C. ambient for AC relays)
(max. 70° C. ambient for DC relays)

CONTACTS:

Arrangements: 3 Form C (3PDT) max.
Material: Movable—⅛" silver; stationary—5/32" wide silver overlay.
Load: 5 amps @ 115 V. AC 60 cps res.

COILS:

Resistance: 16,500 ohms max.
Power: 1.2 watts (DC), 2 volt amps (AC)
Duty: Continuous AC or DC (DC coils will stand 4.5 watts at 25° C.)

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

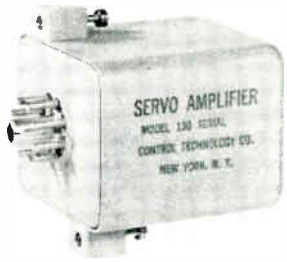
POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

per μf per v—or 2 μa—whichever is greater. Operating temperature range is from −55 C to +125 C.

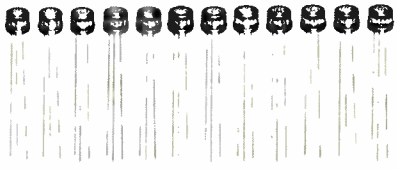
CIRCLE 320 ON READER SERVICE CARD



Servo Amplifier transistorized

CONTROL TECHNOLOGY CO., 1186 Broadway, New York 1, N. Y. Model 130 amplifier will drive either 3.5 w or 6 w servo motors from low level 400 cps signals. Maximum gain is 2,000 and may be adjusted by external resistor. Gain stability is 3 db over temperature range. Input impedance (100 K to 1 megohm) and isolated input make the unit ideal for all computing applications as well as servo designs. Internal limiting prevents overdrive for high input signals. Unit meets MIL-E-5272 environmentals. Company manufactures many variations of this unit and will also design amplifiers for special applications.

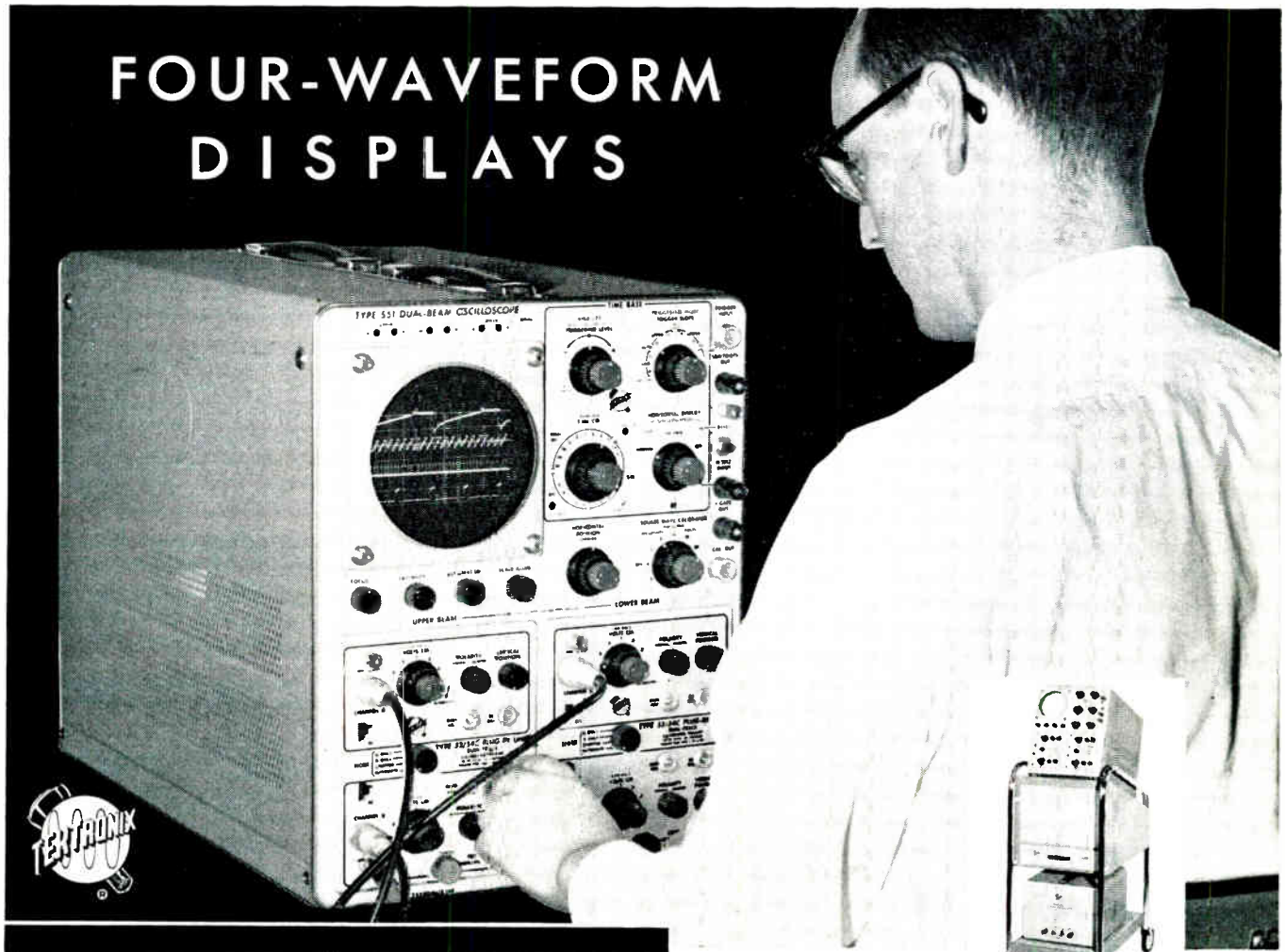
CIRCLE 321 ON READER SERVICE CARD

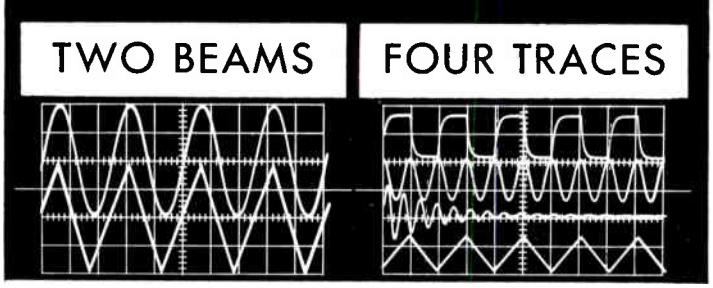


NPN Transistors 25 computer types

CBS ELECTRONICS, 100 Endicott St., Danvers, Mass. A line of *npn* transistors for high-speed switching and h-f amplification comprises 25 computer types suited for logic-circuit, core-driver, and other switching applications. These alloy-junction germanium units feature high current and voltage, flat gain, and low saturation resistance. They use a reliable, welded JETEC TO-9 package. Alpha-cutoff frequencies

FOUR-WAVEFORM DISPLAYS



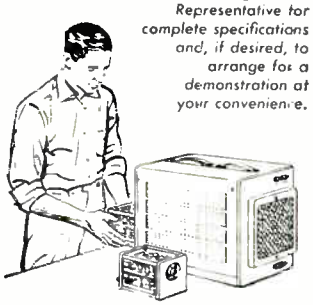


When the job requires it, you can double up and display four different waveforms at once with this dual-beam oscilloscope. Type 53/54C and/or Type C-A Dual-Trace Plug-In Units in both channels make possible the four-trace display.

Less spectacular but more frequent uses of this versatile fast-rise oscilloscope include waveform comparison measurements on a dual-beam display in the dc-to-25 mc range, and all the usual and unusual applications of a high-performance laboratory oscilloscope.

PRICE
without plug-in units.....**$1800**
Type 500/53A
Scope-Mobile **$110**
Type K Fast-Rise
Plug-In Preamplifiers, each.....**$135**
Type C-A Dual-Trace
Plug-In Preamplifiers, each.....**$250**
(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.



ENGINEERS—interested in furthering the advancement of the oscilloscope? We have openings for men with creative ability in circuit and instrument design, cathode-ray tube design, and semiconductor research. Please write Richard Ropiequet, V. P., Eng.

TYPE 551 *DC-to-25 MC*

Special Features

WIDE-BAND VERTICAL AMPLIFIERS
Main-unit risetimes—12 mμsec.
Passbands and risetimes with Type K (53 54K) units—dc-to-25 mc, 0.014 μsec.

SIGNAL-HANDLING VERSATILITY
All Tektronix A to Z Plug-In Preamplifiers can be used in both channels.

0.2 μsec DELAY NETWORKS

WIDE SWEEP RANGE
0.02 μsec cm to 12 sec cm.

SINGLE SWEEPS
Lockout-reset circuitry.

COMPLETE TRIGGERING
Fully-automatic or amplitude-level selection with preset or manual stability control.

10-kv ACCELERATING POTENTIAL
Brighter display for fast sweeps and low repetition rates.

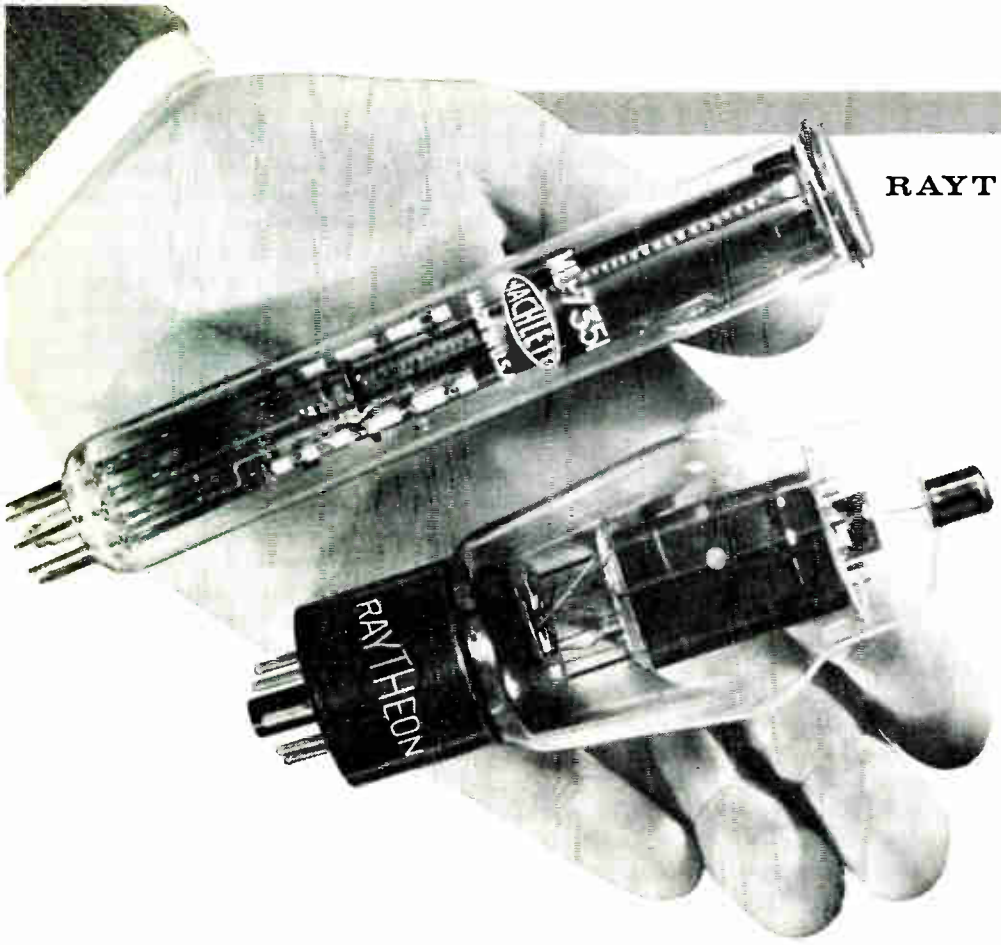
Tektronix, Inc.

P. O. Box 831 • Portland 7, Oregon
Phone CYpress 2-2611 • TWX-PD 311 • Cable: TEKTRONIX

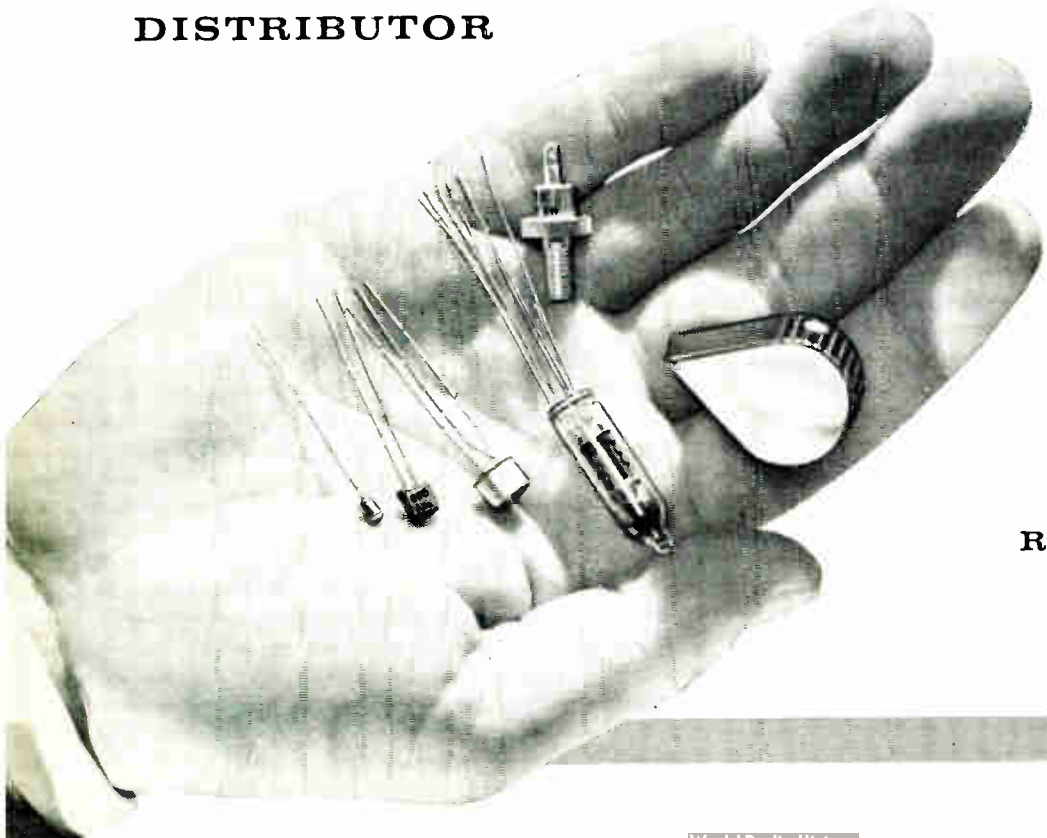
TEKTRONIX FIELD OFFICES: Albertson, L. I., N.Y. • Albuquerque • Annandale, Va. • Atlanta, Ga. • Buffalo • Cleveland • Dallas • Dayton • Endwell, N.Y. • Houston • Lathrup Village, Mich. Lexington, Mass. • East Los Angeles • West Los Angeles • Minneapolis • Mission, Kansas Orlando, Fla. • Palo Alto, Calif. • Park Ridge, Ill. • Philadelphia • San Diego • St. Petersburg, Fla. Scottsdale, Ariz. • Stamford, Conn. • Syracuse • Towson, Md. • Union, N.J. • Willowdale, Ont.

TEKTRONIX ENGINEERING REPRESENTATIVES: Hawthorne Electronics, Portland, Oregon, Seattle, Wash.; Hytronic Measurements, Denver, Colo., Salt Lake City, Utah.

Tektronix is represented in 20 overseas countries by qualified engineering organizations.



THE FINEST ELECTRONIC COMPONENTS ALWAYS ON HAND... CALL YOUR RAYTHEON DISTRIBUTOR



RAYTHEON DISTRIBUTORS*

Radio Specialties Company, Inc.
Alamogordo, New Mexico
HEmlock 7-0307

Radio Specialties Company, Inc.
Albuquerque, New Mexico
AM 8-3901

Wedemeyer Electronic Supply Co.
Ann Arbor, Michigan
NOrmandy 2-4457

Electronic Expeditors, Inc.
Appleton, Wisconsin
REgent 3-1755

Wholesale Radio Parts Co., Inc.
Baltimore, Maryland
MUlberry 5-2134

Forbes Distributing Company
Birmingham, Alabama

Cramer Electronics, Inc.
Boston, Massachusetts
COpley 7-4700

DeMambro Radio Supply Co., Inc.
Boston, Massachusetts
AL 4-9000

Lafayette Radio Corp. of Mass.
Boston, Massachusetts
HUbbard 2-7850

Marks Parts Company
Braddock, Pennsylvania
ELectric 1-1314

Valley Electronic Supply Co.
Burbank, California
VIctoria 9-4641

Electrical Supply Corporation
Cambridge, Massachusetts
UNiversity 4-6300

Allied Radio Corporation
Chicago, Illinois
HAymarket 1-6800

Newark Electric Company
Chicago, Illinois
EState 2-2950

United Radio Inc.
Cincinnati, Ohio
CHerry 1-6530

Main Line Cleveland, Inc.
Cleveland, Ohio
EXpress 1-1800

Pioneer Electronic Supply Co.
Cleveland, Ohio
SUperior 1-9411

Buckeye Electronic
Distributors, Inc.
Columbus, Ohio
CA 8-3265

Graybar Electric Company
Dallas, Texas
RIverside 2-6451

Srepco, Inc.
Dayton, Ohio
BAldwin 4-3871

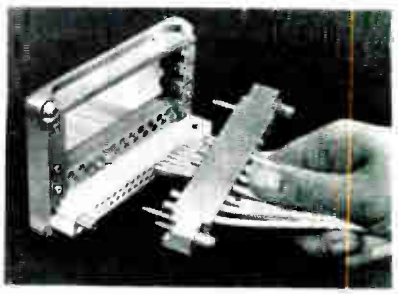
RAYTHEON COMPANY

RECEIVING AND INDUSTRIAL TUBES
SEMICONDUCTOR PRODUCTS
MECHANICAL COMPONENTS

CIRCLE 146 ON READER SERVICE CARD

range from 1 to 17 mc, and maximum dissipations from 50 to 150 mw.

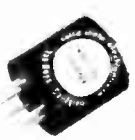
CIRCLE 322 ON READER SERVICE CARD



Versatile Connector for miniature coax

BURNDY CORP., Norwalk, Conn., announces a compression-type Hyfen gang connector for miniature coaxial cable. Connector's pin and socket contacts are crimped to both inner and outer conductors. Connector frames will accommodate three, five or eight inserts, snapped in from either front or back. Inserts for coax cable accommodate up to 21 pins or sockets. A plug or receptacle insert may hold either male or female contacts, or they may be intermixed. Coax cable inserts and standard wire inserts may be mounted in the same frame. Contacts can be crimped to cable ends either after the harness is in place, or on a high-speed production basis, away from the equipment to be wired.

CIRCLE 323 ON READER SERVICE CARD

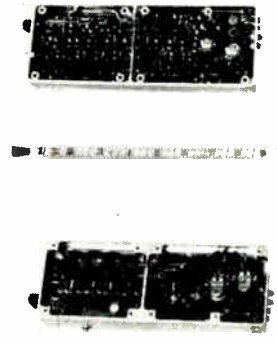


Plug-In Chopper transistorized

SOLID STATE ELECTRONICS CO., 8158 Orion Ave., Van Nuys, Calif. Model 65 plug-in chopper (or modulator) incorporates a transformer-coupled isolating drive network so that it can, for example, be driven from a 400 cycle power line or from a drive source that is common to the d-c voltage being chopped. Sinusoidal or square wave drive may be utilized over a frequency range extend-

ing from 270 cps to 30 kc. Unit may also be used as a synchronous demodulator to convert an a-c signal to d-c.

CIRCLE 324 ON READER SERVICE CARD



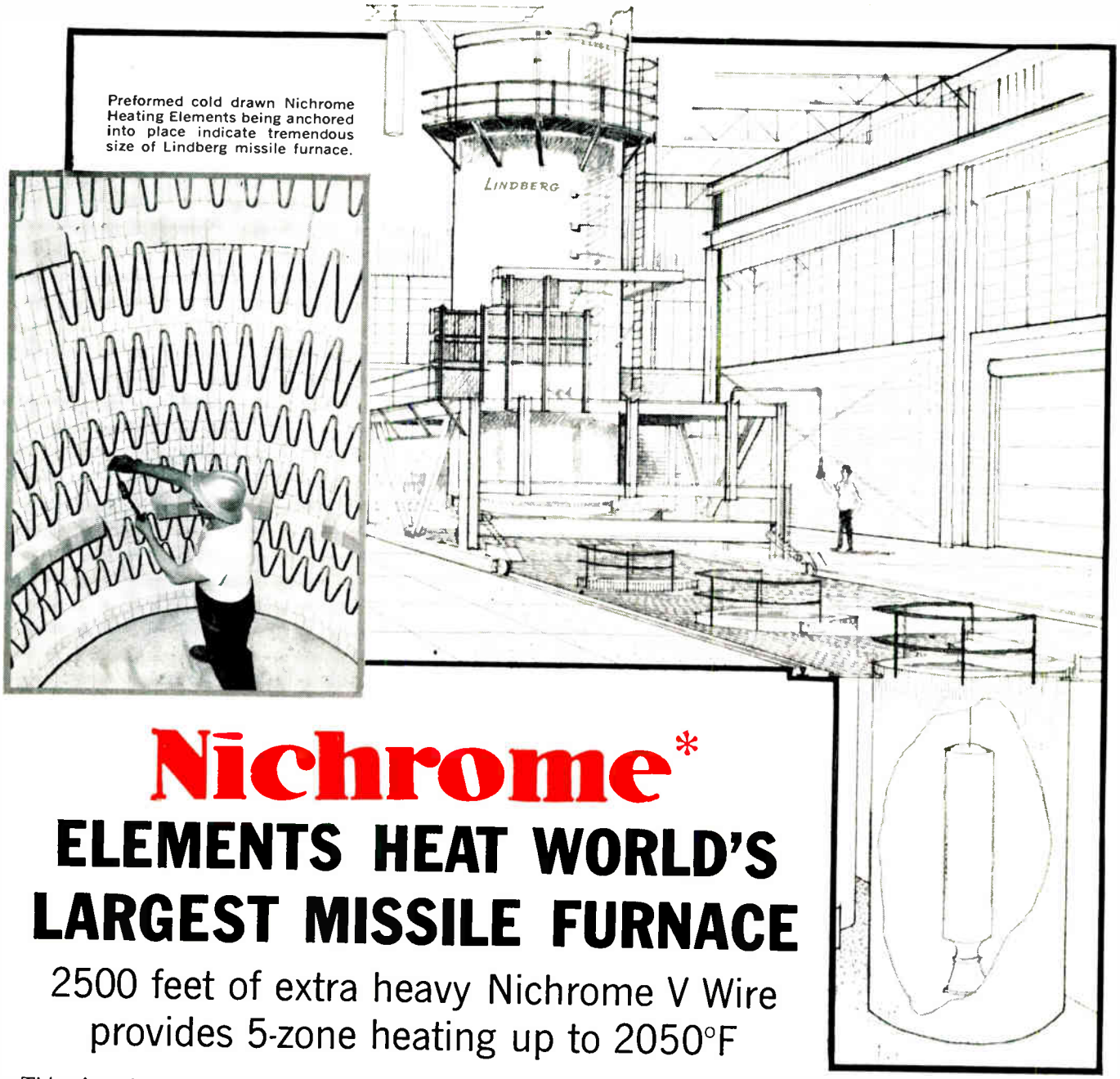
I-F Amplifiers transistorized

REMANCO, INC., 1630 Euclid, Santa Monica, Calif. A line of i-f amplifiers utilize silicon tetrode transistors. Five models are available at 30 mc and 60 mc frequencies. Special units may be obtained at any center frequency up to 80 mc. Two basic types are available: (1) A hybrid unit incorporating a 7077 ceramic triode front end yielding a noise figure of 3.5 db at 60 mc and 2.0 db at 30 mc. (2) All transistor i-f's with the front end designed for minimum vswr. Units have exceptionally fast recovery time, wide dynamic range, and are quite compact in size. They withstand temperatures up to 85 C.

CIRCLE 325 ON READER SERVICE CARD

Oscillogram Scanner instant response

THE GERBER SCIENTIFIC INSTRUMENT CO., 89 Spruce St., Hartford 1, Conn. Model S-25 oscillogram scanner permits the user to either independently or simultaneously scan up to four records. Oscillogram rolls up to 3 in. in diameter can be handled directly. Instrument consists of a Formica tabletop, 90 in. by 30 in. with guide rails for



Preformed cold drawn Nichrome Heating Elements being anchored into place indicate tremendous size of Lindberg missile furnace.

Nichrome*

ELEMENTS HEAT WORLD'S LARGEST MISSILE FURNACE

2500 feet of extra heavy Nichrome V Wire provides 5-zone heating up to 2050°F

This giant 500 KW gantry type Lindberg† hardening furnace is the newest and largest ever built to meet the most exacting heat treating requirements of today's, and tomorrow's, missile metals. It accommodates an effective work load nearly 7 ft. in diameter and 24 ft. long.

Now in operation at Lindberg Steel Treating Company's Melrose Park Plant, the controlled atmosphere installation is both bottom loading and bottom quenching. The 19′ by 57′ pit—28′ deep, beneath the towering electrically heated furnace, houses the loading station, 2 quench tanks (atmosphere and salt) and water wash tank. Work loads pass from furnace to quench through an airtight seal, permitting complete control and precise duplication of atmospheres and treating cycles.

In the hardening furnace there are five control zones which operate between 250°F and 2050°F. Saturable core reactors automatically vary the voltage to the Nichrome*V heating elements between 2.2 and 220 volts, depending on temperature and load.

The selection of Nichrome V by Lindberg to supply reliable and closely controlled heat and temperature in this furnace is further evidence of the confidence that industrial leaders have in the quality and performance of Driver-Harris high-nickel alloys. Why not benefit from their experience. Tell us about your requirements. *T.M. Reg. U.S. Pat. Off. †Lindberg Engineering Company

DRIVER-HARRIS* COMPANY

HARRISON, NEW JERSEY • BRANCHES: Chicago, Detroit, Cleveland, Louisville

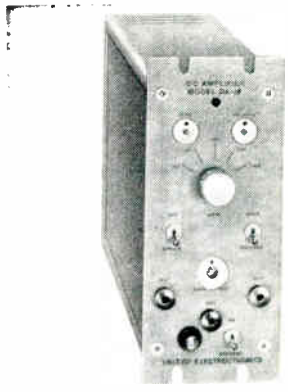
Distributor: ANGUS-CAMPBELL, INC., Los Angeles, San Francisco • In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario

MAKERS OF THE MOST COMPLETE LINE OF ALLOYS FOR THE ELECTRICAL, ELECTRONIC, AND HEAT-TREATING INDUSTRIES

SPECIAL PURPOSE ALLOYS SINCE 1888 — D/H — TRADE MARK REG. U.S. PAT. OFF.

each channel. A control panel permits the user to drive any one or all rolls either separately or jointly in either direction. Speed is adjusted by means of a rheostat. Special reading heads are available for either digital or analog readout to permit the operator to print or punch amplitude as well as time information into cards.

CIRCLE 326 ON READER SERVICE CARD



D-C Amplifier transistorized

UNITED ELECTRODYNAMICS, 200 Allendale Road, Pasadena, Calif., announces a laboratory d-c amplifier with noise of only 5.0 μv, peak to peak, a response time to a step function input of only 7 μsec, an overload recovery time of 50 μsec and a special heat control system which insures exceptionally low drift. Model DA-12 instrumentation amplifier is supplied with both differential input and differential output circuits which also function with either or both input and output single-ended.

CIRCLE 327 ON READER SERVICE CARD

Antenna Tower heavy-duty

ROHN MFG. CO., 116 Limestone, Bellevue, Peoria, Ill., is producing a heavy-duty self-supporting tower to height of 130 ft and suitable for all types of communication needs. It is constructed by using 13 different tower sections of varying size, weight, structural strength and taper. The individual sections can be used in making additional combinations to build self-supporting towers of variable heights and structural capacities so as to fit the

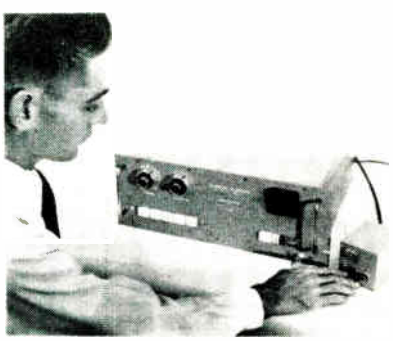
particular need as required by the type antenna being used. Tower fulfills a large range of uses in mounting antennas for microwave, radio communications and tv reception.

CIRCLE 328 ON READER SERVICE CARD

Silicon Diodes
fast switching

RHEEM SEMICONDUCTOR CORP., 327 Moffett Blvd., Mountain View, Calif. Designed to meet military specifications, types RD2121-RD-2124 are for very fast computer switching applications. The diodes recover to 200 K ohms in 0.2 μsec and have a typical capacitance of 1.5 $\mu\mu$f. Units are available now in the standard subminiature glass package.

CIRCLE 329 ON READER SERVICE CARD



Telemetry Calibrator
transistorized

RAMO-WOOLDRIDGE, a division of Thompson Ramo Wooldridge Inc., P.O. Box 90534 Airport Station, Los Angeles 45, Calif. Model TG-72 transistorized telemetry calibrator features small size and optimum flexibility, and can be used in a variety of applications. It has 18 IRIG channels, which can be scanned ±7.5 percent of center frequency. Three and 11 point frequency checks are available per channel on an optional basis, and all frequencies are accurate within 0.01 percent.

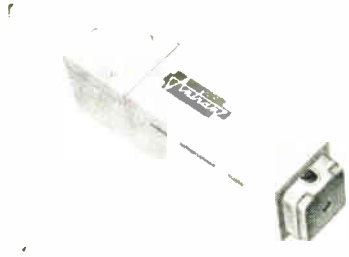
CIRCLE 330 ON READER SERVICE CARD

Metal Film Resistor
molded unit

ELECTRA MFG. CO., 4051 Broadway, Kansas City, Mo. Molded precision metal film resistor features low con-

trolled temperature coefficient, low noise level and high stability under severe humidity conditions. According to the manufacturer, it is smaller and lower in cost than a precision wire wound resistor, and features uniformity in size over wide resistance ranges. It is available in five sizes, ½ through 2 w.

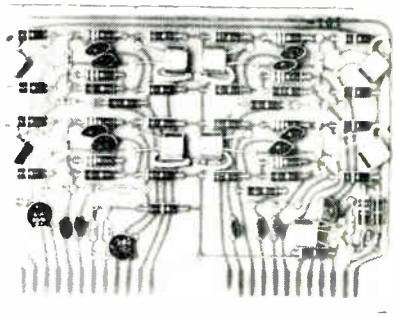
CIRCLE 331 ON READER SERVICE CARD



R-I Filter
for screen rooms

ANTRAN, Greenwood Acres, Annapolis, Md. A filter with the attenuation characteristics necessary for filtering screen room telephone lines with no loss is announced. Unit permits the use of telephones and intercoms in the screen rooms without introducing interference. The 600-ohm impedance matches that of the telephone line. Unit has a telephone connector block for wiring to telephone lines. A balanced filter, it can be employed for any audio purpose. It is rated at 0.5 ampere, 300 v, 0 to 60 cycles. Resistance is 12 ohms.

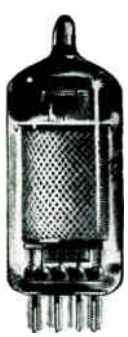
CIRCLE 332 ON READER SERVICE CARD



Digital Module
transistorized

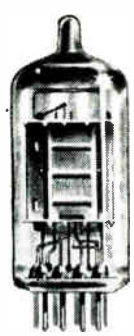
COMPUTER CONTROL CO., INC., 983 Concord St., Framingham, Mass. Model BD-101 digital module consists of four transistor flip-flops which may be externally connected as a binary counter, as a binary

SEVEN TUBES FOR STEREO



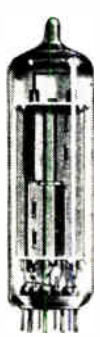
EF86 6267

High gain AF input pentode with exceptionally low noise, low hum and low microphony.



ECC83 12AX7

Double triode, low hum, low microphony, low noise, high gain tube.

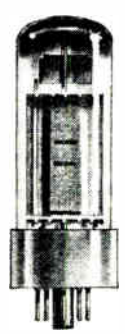


ECL82 6BM8

Miniature triode pentode for use as audio amplifier and output tube. Two tubes in ultralinear push-pull can supply up to 7 watts of stereo power per channel.

EL84 6BQ5

Miniature 12 watt high slope pentode. A medium power high fidelity tube particularly suitable for compact stereo circuits, up to 17 watts per channel.

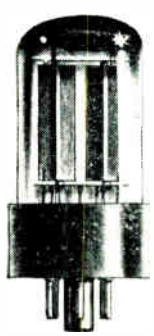


EL34 6CA7

Highly sensitive 25 watt pentode. Two tubes in ultralinear push-pull providing up to 34 watts output, particularly suited for compact integrated stereo amplifiers.

EZ81 6CA4

Miniature full wave cathode type rectifier with high voltage and with good regulation supplying up to 150mA.



GZ34 5AR4

Bantal full wave cathode type rectifier, supplying high voltage with good regulation for currents up to 250mA.

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81 Spring Street, New York, 12, N.Y.
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Rogers Electronic Tubes & Components
116 Vanderhoof Avenue, Toronto 17,
Ontario, Canada. *Hudson 5-8621.*

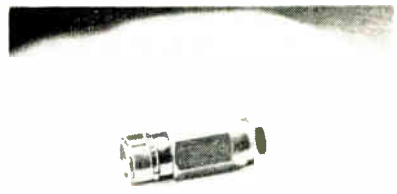
MULLARD OVERSEAS LTD., MULLARD HOUSE,

TORRINGTON PLACE, LONDON, ENGLAND

MEV94

coded decimal counter, or as other multistage counter that requires feedback. Power required is +20 v at 20 ma and −90 v at 1 ma. Maximum input rate is 100 kc.

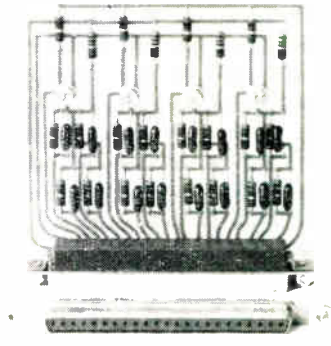
CIRCLE 333 ON READER SERVICE CARD



Cable Connectors subminiature

SEALECTRO CORP., 139 Hoyt St., Mamaroneck, N. Y., has developed snap-on versions of its standard 50- and 75-ohm ConheX connectors. A spring ring or band around the slotted coupling sleeve provides the attachment means. These connectors are reduced in length and diameter for greater convenience as well as eye appeal.

CIRCLE 334 ON READER SERVICE CARD

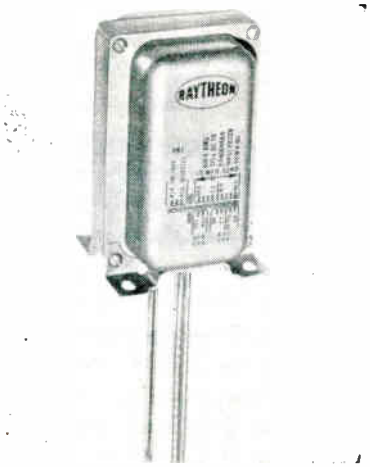


Module Blocks transistorized

WANG LABORATORIES, INC., 12 Huron Drive, Natick, Mass. Series 200 Logiblock transistorized module building blocks include "NOR" circuits, flip-flops, one-shot multivibrators blocking oscillators, coupling circuits, drivers for indicators or electromechanical devices. Each modular unit can perform many functions by using different connections on the socket. Floating sleeves and pins are used for the plug-in connection to insure very

low contact resistance after repeated insertions. Blocks are rated to operate at 200 kc although some may operate at 400 kc or higher.

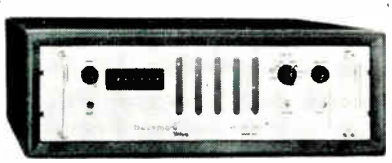
CIRCLE 335 ON READER SERVICE CARD



Transformer voltage regulating

RAYTHEON Co., Industrial Apparatus Division, Manchester, N. H. New voltage regulating plate-filament transformer performs the same functions as a conventional transformer while maintaining voltage within ±3 percent of rated output with line variations from 100 to 130 v. Regulating voltages for both plates and filaments, the unit prolongs tube life and improves overall reliability and performance of the equipment in which it is installed.

CIRCLE 336 ON READER SERVICE CARD

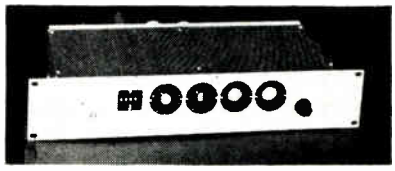


Solid-State Counter weighs 21 lb

BERKELEY DIVISION, Beckman Instruments, Inc., 2200 Wright Ave., Richmond 3, Calif. Model 5311 is equipped with a highly variable counting interval so that users may obtain indications of flow, pressure and speed in desired units, such as gals/sec, psi or rpm. The counting interval may be varied in 10 μsec steps from 10 μsec to 1 sec. Frequency counting range is 10 cps to

200 kc. Transistorized circuitry offers maximum reliability over the ambient temperature range of − 5 F to + 150 F. The counter also makes highly accurate period measurements by timing the duration of from 1 to 100,000 cps in 10 μsec units.

CIRCLE 337 ON READER SERVICE CARD



High-Speed Counter eight-digit

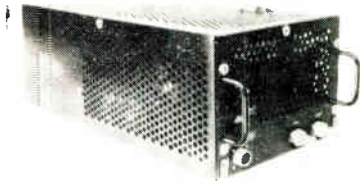
OXFORD ENGINEERING CO., 47A River St., Wellesley Hills 81, Mass. Model 271A is an 8-digit high-speed counter which totalizes impulses up to a maximum rate of 1,200,000 counts per minute. The instrument is completely transistorized and utilizes cold-cathode decade counting tubes, affording low power consumption of less than 10 w, and extreme reliability.

CIRCLE 338 ON READER SERVICE CARD

Filters tungsten carbide

ENGINEERED MATERIALS, P. O. Box 363, Church St. Station, New York 8, N. Y., is offering tungsten carbide filters of 60 percent density. They are said to withstand temperatures well above stainless-steel filters and have very high resistance to corrosion. The low density filters can be made to any desired shape.

CIRCLE 339 ON READER SERVICE CARD



Cooling Units self-contained

ELECTRO IMPULSE LABORATORY, 208 River St., Red Bank, N. J. These units are used to cool electronic tubes and high power resistors; can

also be used as the heat exchanger for calorimeters. Units include heat exchanger, circulating pump, storage tank, flow and pressure interlocks. Sizes are available between 10 w and 50,000 w. Model shown dissipates 1,500 w. Fluids used are transformer oil OS45 or DC200 fluid.

CIRCLE 340 ON READER SERVICE CARD

Plug-In Circuits transistorized

VITRO LABORATORIES, 200 Pleasant Valley Way, West Orange, N. J. A series of transistorized, digital, plug-in circuits features complete input and output buffering. Built for rugged applications, the cylindrical modules are designed to minimize system design problems and assure functional reliability. Built-in buffering allows engineers to go directly from logic diagrams to circuitry. Modules for binary and linear counter stages, pulse shapers, pulse generators, multiple coincidence gates, and relay and neon drivers are provided as shelf items. Special circuits are readily available.

CIRCLE 341 ON READER SERVICE CARD

Calibrator time/frequency

GENERAL RADIO CO., West Concord, Mass. Type 1213-D is a compact, crystal-controlled time/frequency

calibrator, with a short-time stability of 1 part in 10^7, which furnishes standard frequencies from 10 kc to 1,000 mc not only for the calibration of electronic equipment, but also for the measurement of unknown frequencies. The instrument also provides timing markers at decade intervals from 0.1 to 100 μsec.

CIRCLE 342 ON READER SERVICE CARD

P-M Oscillator
no cooling required

HUGGINS LABORATORIES, 999 East Arques Ave., Sunnyvale, Calif. Model HO22 backward wave oscillator is focused in a periodic permanent magnet structure. This development opens a wide range of new uses for the bwo. With no cooling required, all need for auxiliary power is completely eliminated. A capsule, 11½ in. by 2½ in., weighing 3.5 lb, replaces solenoid and power supply weighing approximately 50 lb.

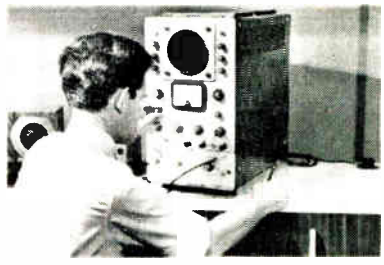
CIRCLE 343 ON READER SERVICE CARD

Bias Regulator
dual unit

ARKAY ENGINEERING, INC., 225 Santa Monica Blvd., Santa Monica. Calif. Model RK60 is a transistorized unit with two independent bias-voltage regulators for use in transistor or tube circuit design. Each regulator provides continuously variable 0 to −6 or −6 to −30 v d-c. Each regulated output can be metered with automatic range switching. Maximum input 35 v d-c; minimum input, 5v

greater than desired output. Load regulation is 0.3 percent zero to full load; 0.1 percent regulation for ± 10 percent change of input v d-c.

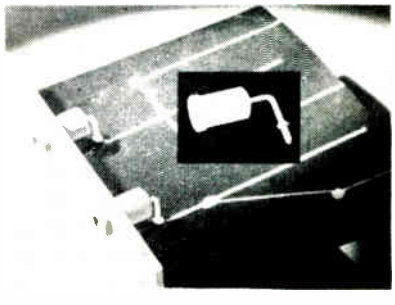
CIRCLE 344 ON READER SERVICE CARD



Oscilloscope general-purpose

E.M.I. ELECTRONICS LTD., Hayes, Middlesex, England. The W.M.8 oscilloscope provides a wide variety of facilities which make it particularly suitable for tv waveform analysis, pulse measurement, computer development and production testing. The amplifier has differential inputs with a common attenuator switch. The fine gain control enables any signal to be displayed at a convenient size on the 5 in. crt. Oscilloscope has a bandwidth of d-c to 15 mc (−3 db); sensitivity is 1 v/cm to 25 v/cm (50 mv/cm to 25 v/cm using amplifier type 8).

CIRCLE 345 ON READER SERVICE CARD

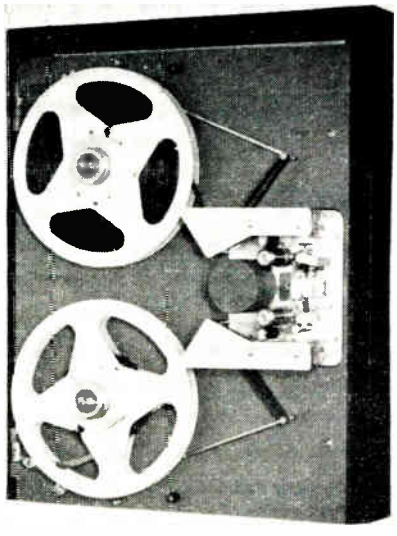


Simplified Jack for printed wiring

SEALECTRO CORP., 610 Fayette Ave., Mamaroneck, N. Y. Press-Fit type SKT-100 PC mounts in a metal angle-iron edging for the printed-wiring board, while the rear right-angle lug fits in a hole for the connection. It accepts a 0.080 in. diameter probe up to 0.025 in. long. Beryllium-copper contacts in the Teflon insulator body maintain high

retention with no signs of fatigue even after many insertions and withdrawals of an oversized probe.

CIRCLE 346 ON READER SERVICE CARD



Digital Transport for low-speed use

POTTER INSTRUMENT CO., INC., Sunnyside Blvd., Plainview, N. Y. Model 3280 transport serves in a typical application as a coupling device to digital communication circuits or as a recorder of long term data occurring at low rates. Speed range of from 10 ips to 0.1 ips is offered with fast start-stop capability to enable slaved operation for single character transfer. Dual speed combinations are available with standardized ratios. Completely transistorized electronics, end of tape sensors, and adaptability to various reel configurations are some of the featured characteristics.

CIRCLE 347 ON READER SERVICE CARD

Trimmer Pots panel-mount

ATOHM ELECTRONICS, 7648 San Fernando Road, Sun Valley, Calif., announces a series of panel-mount trimmer potentiometers. The panel-mount, fabricated entirely of stainless steel, is available as an integral part on all trimmer types, or can be furnished as an accessory, complete with mounting hardware. Use of panel-mount trimmers permits greatest ease of circuit calibration without removal of cov-

1959 IRE SHOW REGISTRATION:

60,052

and we're set to handle even more of you in 1960 looking for

NEW IDEAS *in* RADIO-ELECTRONICS!

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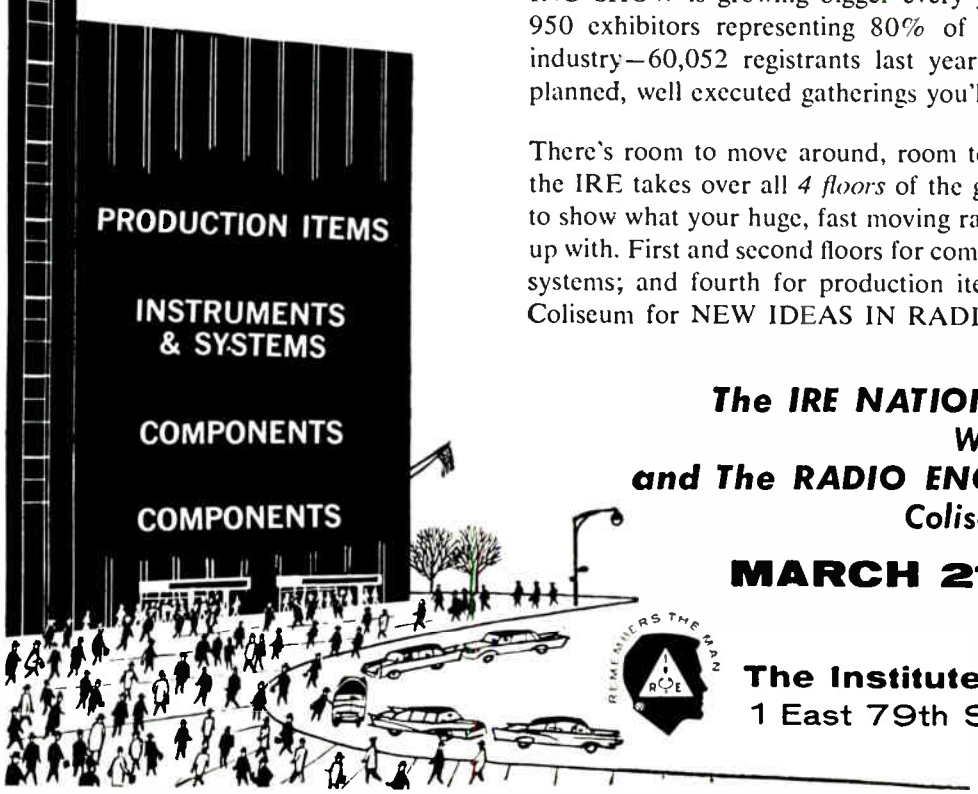

The IRE NATIONAL CONVENTION
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and The RADIO ENGINEERING SHOW
Coliseum, New York City

MARCH 21, 22, 23, 24

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1 East 79th St., New York 21, N. Y.

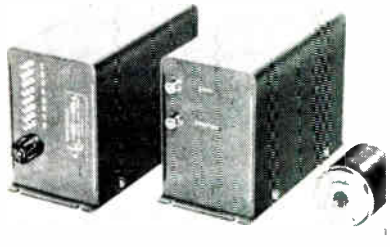
ers or housings, thus saving considerable time, and removing the possibilities of accidental damage to precision components and assemblies.

CIRCLE 348 ON READER SERVICE CARD

Preamplifier for telemetering

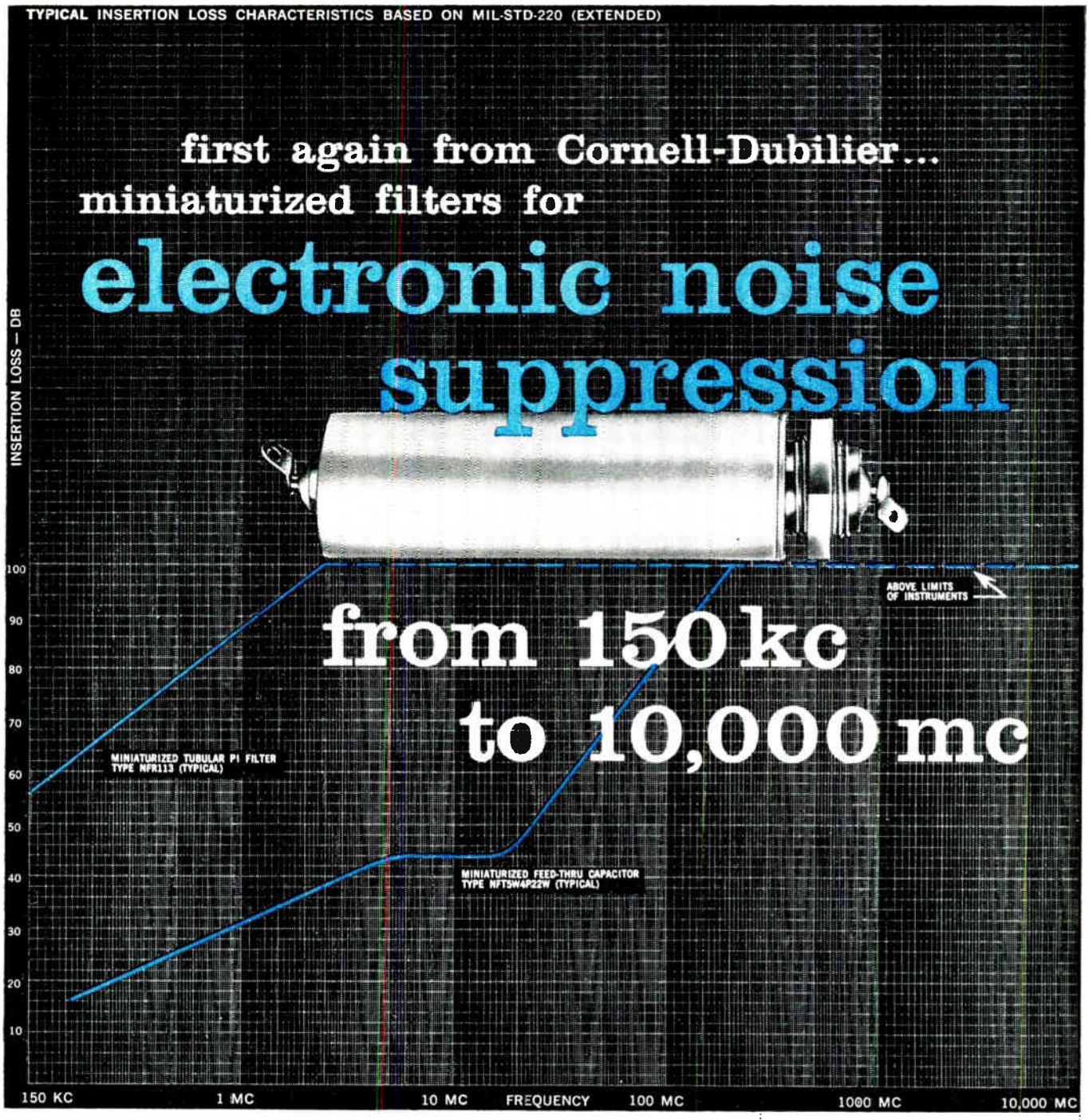
LEL, INC., 380 Oak St., Copiague, L. I., N. Y. Designed to meet severe environmental conditions, the TP-4 telemetering preamplifier is enclosed in a weatherproof housing for antenna tower mounting and is complete with self contained power supply. Each is provided with a sun shield for use in tropical areas. Unit is designed to operate from a 50 ohm source, has 22 db minimum gain, 4 db maximum noise figure, and covers the 215 to 260 mc telemetering band. Individual test data, including a plot of noise figure vs frequency, are supplied.

CIRCLE 349 ON READER SERVICE CARD



Servo Amplifier transistorized

INDUSTRIAL CONTROL CO., 805 Albin Ave., Lindenhurst, L. I., N. Y. The 762A is a 60 cps servo amplifier designed to drive a size 18 servo motor from synchro resolver, or a-c pot



Another First From The Cornell-Dubilier Filter Laboratories.

Now... MINIATURIZED pi filters and 3-terminal feed-thru capacitors for interference suppression at any frequency from 150 kc to 10,000 mc. No matter how unusual your design requirements, the C-D Filter Laboratories can deliver the precise suppression component you need. Tubular shapes, neck-mounting designs and smallest possible case sizes save space and weight, and provide easy installation. C-D's *miniaturized* tubular pi filters and feed-thru's also provide better insertion loss per unit volume, lighter unit weight and lower unit cost as compared to other types of suppression devices at identical ratings. To obtain complete specifications, write for Engineering Bulletins 171, 172 and 166 to Cornell-Dubilier Electric Corp., South Plainfield, N. J.

MINIATURIZED SUPPRESSION COMPONENTS

Typical Specifications

Tubular PI Filter TYPE NFR113
Voltage: 120 VAC (60 cycles), 300 VDC
Current: 0.5 Amperes, Weight: 4.0 oz.
Dimensions: 1" x 2-11/16"

Feed-Through Capacitor TYPE NFT5W1P22W
Voltage: 125 VAC (60 cycles) 400 VDC
Current: 25.4 Amperes Capacitance: 0.22 mfd.
Dimensions: .562" x 1-29/32" Weight: 0.83 oz

Consistently Dependable
CORNELL-DUBILIER
CAPACITORS

data. Twin controls are provided for gain and damping with which the loop performance can be optimized. Full output is obtained for 200 mv rms, into the input impedance of 100 K. The amplifier's carrier phase shift is +90 deg. Damping is adjustable, error-rate. Weight is 3¼ lb; dimensions, 6¼ by 2¾ by 4¼ in.

CIRCLE 350 ON READER SERVICE CARD

Microwave Filter for C-band

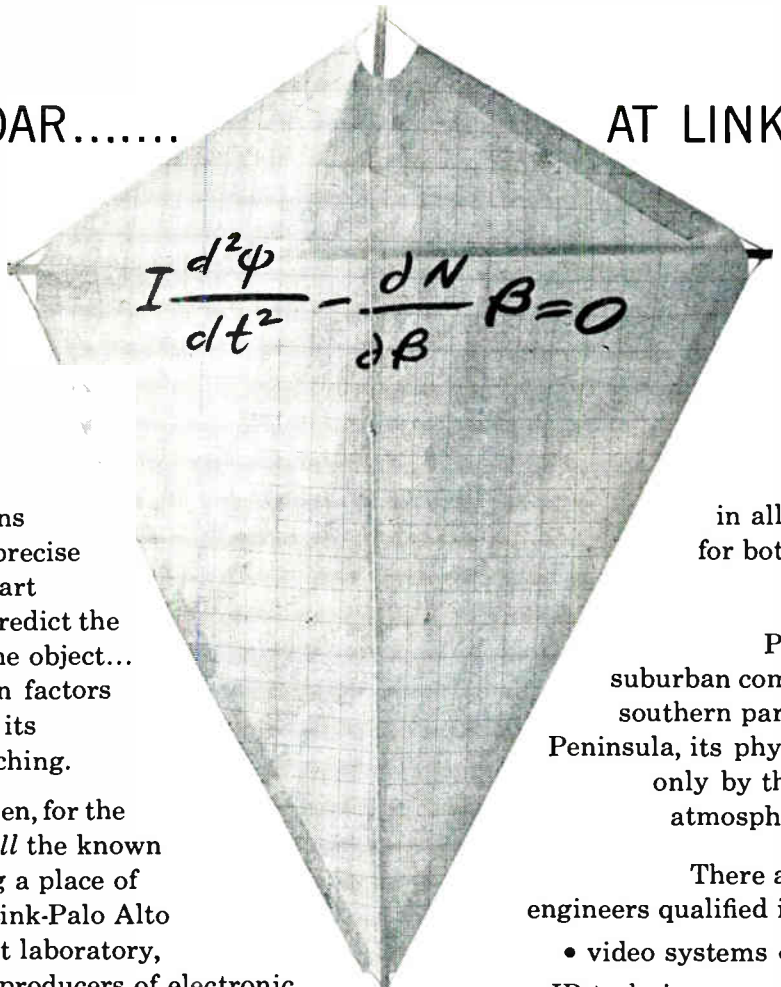
AIRTRON, INC., a Division of Litton Industries, Morris Plains, N. J., announces a compact microwave filter which passes a specific frequency band while sharply rejecting other frequencies above the pass band. Designed for C-band operation, the unit consists of a straight section of waveguide with four E-plane cutoff stub arms located along one broad wall of the waveguide. Higher rejection in the stop band is obtained by employing additional stub sections. Characteristics are: insertion loss in the pass band of 0.3 db max.; vswr in the pass band, 1.40 max.; rejection in the stop band, 30 db min.; and power handling capacity, 0.5 megawatt c-w.

CIRCLE 351 ON READER SERVICE CARD

Servomotors high temperature

KEARFOTT CO., INC., 1500 Main Ave., Clifton, N. J. The R133-003 pinion shaft and R133-004 plain shaft size 11 servomotors are constructed of temperature resistant parts and impregnating materials and operate effectively at temperatures ranging from −54 C to +150 C. Extremely high torque-to-inertia ratios recommend the motors for use in critical applications. In addition, stators are integrally cast in a thermoset-

CAREERS SOAR..... AT LINK-PALO ALTO



An engineer soon learns that in order to make precise projections, he must start with precise facts. To predict the reactions of an airborne object... even a kite...all known factors must be considered in its construction and launching.

How important it is, then, for the engineer to consider *all* the known factors when choosing a place of employment. At the Link-Palo Alto electronic development laboratory, (pioneers and leading producers of electronic flight simulators) *all* the facts are favorable.

Link has three distinct and diverse development departments: *Industrial products development... Military electronics... Advanced computer development.*

This arrangement opens up a great diversity of assignments and excellent opportunity for advancement, as the lab is expanding rapidly in all areas of development for both our commercial and military customers.

Palo Alto is a charming, suburban community located on the southern part of the San Francisco Peninsula, its physical climate matched only by the benign professional atmosphere at the Laboratory.

There are many openings for engineers qualified in the following fields:

- video systems • electronic packaging
- IR techniques • engineering psychology
- advanced data processing systems
- advanced electro-mechanical design
- circuit analysis • computer design
- weapon system analysis

Move up! Write to
Mr. B. T. Rutman, Link Aviation, Inc.
P.O. Box 1318, Palo Alto, California

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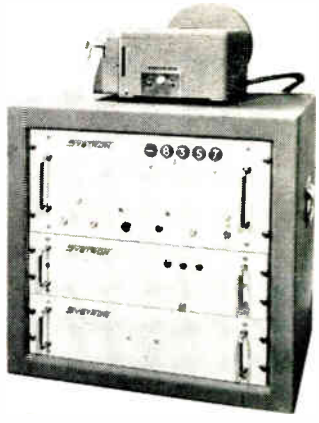
ting resin to provide greater efficiency by permitting straight-through bores and minimum air gaps.

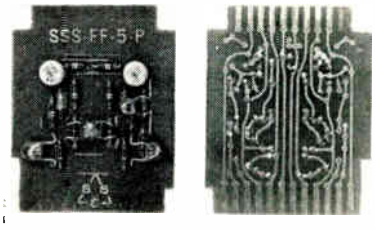
CIRCLE 352 ON READER SERVICE CARD



Data Processor high-speed

SYSTRON CORP., 950 Galindo St., Concord, Calif., announces a single channel analog to digital conversion system providing a punch paper tape processed in binary coded decimal form for use with most special-purpose digital computers. The 161 system measures d-c voltages from 3 μv to 1,000 v with an accuracy of $\pm$ 0.05 percent and at a recording speed of 10 per sec.

CIRCLE 353 ON READER SERVICE CARD



Plug-In Modules control and logic

SOLID STATE SYSTEMS, INC., 5716 Camille Ave., Culver City, Calif. A line of transistorized plug-in modules includes flip-flops, gates, triggers, diode AND and OR logic units, power switching amplifiers and other modules for complete implementation of static control or computer systems with capabilities of accepting pulse repetition rates of 100,000 pps. Modules are 2$\frac{1}{4}$ in. wide by 2$\frac{29}{32}$ in. high by $\frac{1}{16}$ in. thick and fit a standard 12-terminal p-c

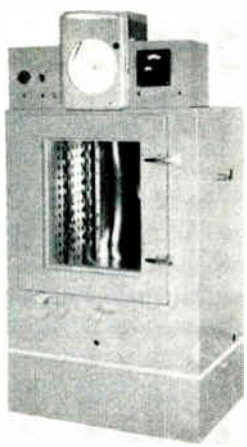
connector. All p-c conductors are hard gold alloy plated, minimizing contact resistance of tabs and improving solderability of the assembly.

CIRCLE 354 ON READER SERVICE CARD

Potentiometers trimming type

HELIPOT DIVISION of Beckman Instruments, Inc., 2500 Fullerton Road, Fullerton, Calif. Helitrim trimming potentiometers use ceramic-metal resistance elements. Characteristics include: infinite resolution; 1.5 w power rating at 125 C ambient, derating to zero at 200 C; ±100 ppm/deg C tempco above 500 ohms; 100 to 50,000 ohms resistance range; 2 ohms maximum end resistance and zero backlash. Environmental requirements of MIL-S-202, NAS-710 and MIL-R-19A as applicable are met or exceeded.

CIRCLE 355 ON READER SERVICE CARD



Test Chamber hot-cold

ELECTRIC HOTPACK CO., INC., Cottman & Melrose Sts., Philadelphia 35, Pa. Designed for thermal shock and other controlled temperature testing and conditioning processes involving electronic components and parts, these chambers have tempera-

ture ranges from −65 F to 540 F. Maximum temperature uniformity and CO_2 dispersal is achieved by a built-in air circulation system. Controls include separate thermostats for operation above and below ambient temperatures.

CIRCLE 356 ON READER SERVICE CARD

Power Supply high-temperature

ARNOUX CORP., 11924 W. Washington Blvd., Los Angeles 66, Calif. A line of precision regulated power supplies operate at such temperature extremes as +120 C and −55 C. Each is silicon transistor regulated with silicon rectifiers, tantalum capacitors and a Zener diode reference. Other characteristics include low ripple and low output impedance.

CIRCLE 357 ON READER SERVICE CARD

Indicator Lamps microminiature

THE MENINGER CO., P. O. Box 243, West Caldwell, N. J. Models M-1 and M-2 incandescent lamps are designed for use in microminiature modules. They operate in the range of 1-1½ v and draw 25-35 ma. They measure 0.050 in. o-d, about 0.090 in. in length. The filament is wound from 0.0005 and 0.00025 in. tungsten wire over a 0.0015 mandrel. Bulbs feature long life and ruggedness.

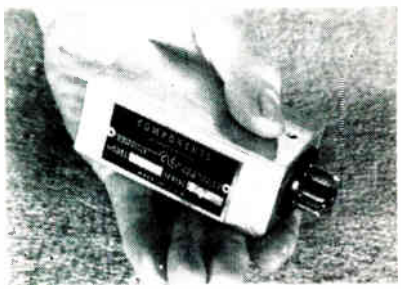
CIRCLE 358 ON READER SERVICE CARD

Tape Unwinder weighs 1½ lb

WESTERN APPARATUS CO., 2001 Greenleaf St., Evanston, Ill. Model TU-1 portable unit can be set on any flat surface of proper dimensions. Wound tape can be removed

from the company's TW tape winder and placed over the core of the unwinder reel for feeding from the center of the roll into a transmitter. Unit is 5 in. high, 12¼ in. wide, 12 in. reel.

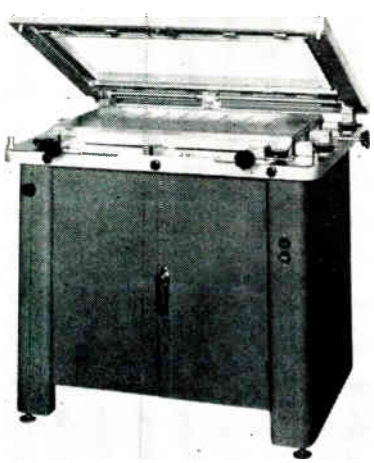
CIRCLE 359 ON READER SERVICE CARD



H-V Supply
regulated unit

COMPONENTS CORP., Denville, N. J. Model 61-R transistorized supply operates from 6 v d-c. Its high voltage output can be externally set from 900 to 1,200 v. A special Zener bridge is used for reference to regulate the output by means of a closed loop servo system. Units can be operated over a wide temperature range (up to 85 C). Price is $200.

CIRCLE 360 ON READER SERVICE CARD

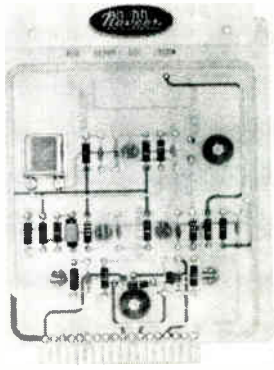


Screening Table
produces p-c boards

WYRCO PROJECTS, INC., 60 Main St., Binghamton, N. Y. Notably useful in the production screening of precision miniaturized boards and components, this screen printer will duplicate any number of identical circuit patterns from an original set up. Production fidelity of the circuit boards will not vary more than

0.005 in. in two dimensions. Machine offers a chase frame adjustable in 0.5 in. increments up to 24 in. by 36 in., and capable of accommodating circuit boards as large as 29½ in. by 17½ in. by ⅜ in. thick.

CIRCLE 361 ON READER SERVICE CARD



Pulse Generator
all-transistor

NAVIGATION COMPUTER CORP., 1621 Snyder Ave., Philadelphia 45, Pa. Model 300X pulse generator provides accurately timed clock pulses at crystal controlled frequencies. A standardized 2.5 v pulse of both polarities is generated by a crystal controlled oscillator. The output stage is transformer-coupled and has a constant voltage characteristic which maintains an undeteriorated pulse when loaded between 0 and 100 ma output current. It is accurate to 0.01 percent of crystal frequency and will operate from 0 to 135 F.

CIRCLE 362 ON READER SERVICE CARD

Telemetering System
silicon solid state

SOLID STATE ELECTRONICS CO., 8158 Orion Ave., Van Nuys, Calif. Model T-108 is a high temperature, ruggedized tone generating system capable of operation within associated f-m/f-m telemetering systems. Unit is designed to indicate the precise

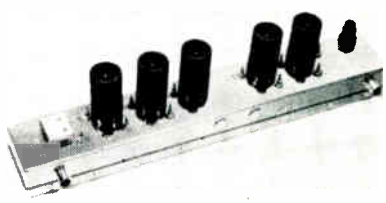
occurrence and sequence of remote functions through environmental extremes. Standard unit contains 11 sine wave oscillators. Each oscillator output is controlled by means of a remote 28 v d-c supply through a gated switch. The opening of any or all gates allows the respective oscillator outputs to appear on the common bus of the summing amplifier where they are mixed. The mixed composite signal is amplified and may then be fed to a transmission line or to a voltage-controlled subcarrier oscillator for conversion to f-m within a specified IRIG band.

CIRCLE 363 ON READER SERVICE CARD

Frequency Standard transistorized

NATIONAL CO., INC., Malden, Mass. Model NC-1200 frequency standard uses a transistorized crystal oscillator identical with the one used in the most advanced models of the Atomichron. It provides outputs of 0.1, 1.0 and 5.0 mc, all stable to one part in 10^{9} parts per day. All three outputs may be used simultaneously and each is capable of developing an output voltage of 200 mv across a 50 ohm load. Oscillator meets MIL-E 16400 shock and vibration specifications.

CIRCLE 364 ON READER SERVICE CARD

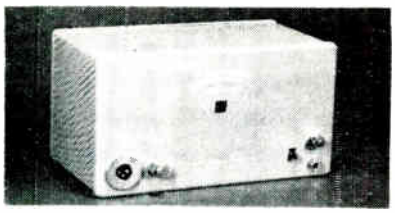


I-F Amplifier extended range

LEL, INC., 380 Oak St., Copiague, N. Y. The I.F. 39 has a gain of 120 db, 3 mc bandwidth, 200 mc center frequency, detector output, and provision for gain control. A matched input noise figure of 6.5 db is stand-

ard; lower noise figure input circuitry can be supplied if required.

CIRCLE 365 ON READER SERVICE CARD



Limiter-Expander compact unit

ELECTRONIC SYSTEMS ENGINEERING Co., 903 Cravens Bldg., Oklahoma City, Oklahoma. Model LE-20 Limpander features a plug-in input transformer and an adjustable power output control, in addition to such operational characteristics as a 50 μsec limiter attack and 25 millisec limiter release. Major design objectives were a small and compact unit that can be easily adapted to fit into any existing audio system, and provide the advantages of "voice intelligibility improvement" plus "background noise suppression". Unit produces 25 db of "soft sound" amplification, that penetrates dead spots, and overcomes room noises; combined with 50 db of automatic audio power control.

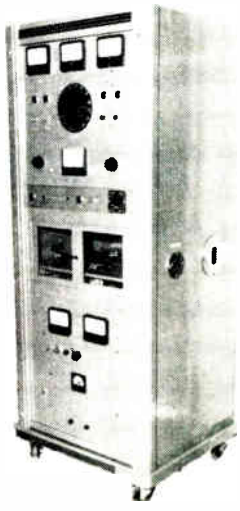
CIRCLE 366 ON READER SERVICE CARD

Power Transformers for control uses

MICROTRAN CO., INC., 145 E. Minedla Ave., Valley Stream, N. Y., announces miniature epoxy molded control transformers. They are available on special order in va ranges up to 25 va and frequencies from 50 through 2,600 cycles. Nickel plated brass screw stud terminals are furnished. Strap, insert

or stud mounting is available. These units can be supplied to meet MIL-T-27 grades 2 and 5.

CIRCLE 367 ON READER SERVICE CARD



R-F Signal Sources
varied applications

BURMAC ELECTRONICS CO., INC., Rockville Centre, N. Y. Model 700 is now available to the radar and microwave industry. Series is available for c-w pulse or dual modes of operation. Unit incorporates optimum wave shape and circuit parameters to insure proper operation of the r-f generator tube and is available from uhf through and including the K band, microwave frequency spectrum. Antenna measurements, component testing and auxiliary transmitter functions are typical applications.

CIRCLE 368 ON READER SERVICE CARD

Ultrasonic Cleaner
high-power

NATIONAL ULTRASONIC CORP., 111 Montgomery Ave., Irvington, N. J. Model 240 is designed for use where high energy density ultrasonic cleaning is required. It features a 5-gallon heavy-gage polished stainless steel tank 12 in. long, 12 in.

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- Ideal for checking V T V M's
- Calibrate on D.C. or 60 cycles/sec.
- Can be certified by Bureau of Standards
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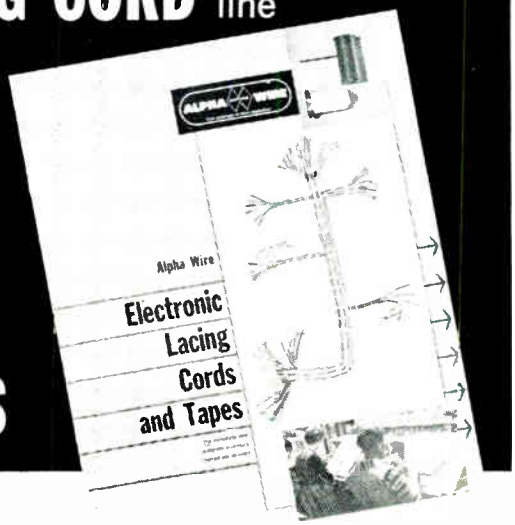

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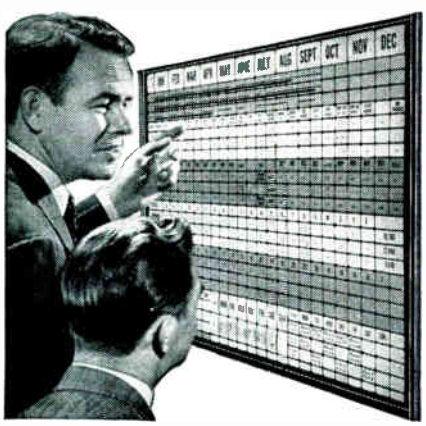

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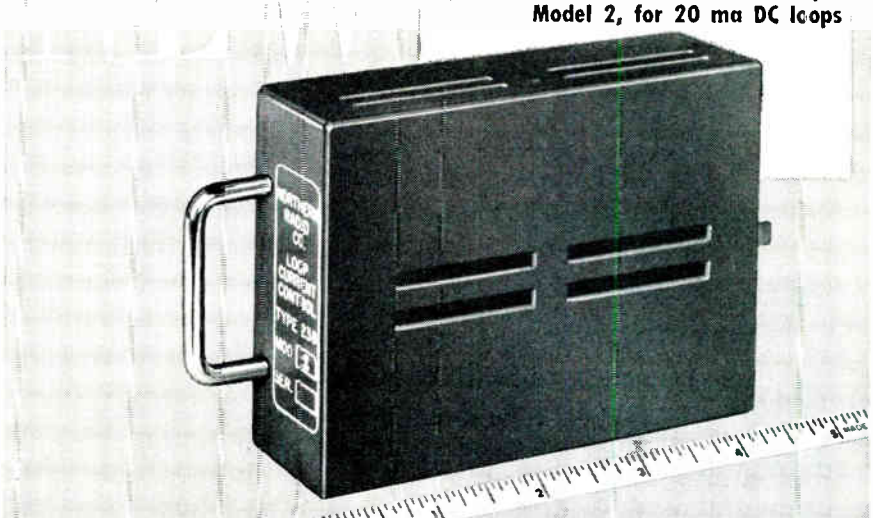
- effects savings in maintenance costs
- may be used on polar or neutral DC circuits
- requires no supplemental power supply

TRANSISTORIZED LOOP CURRENT CONTROL

Type 238: Model 1, for 60 ma DC loops;
Model 2, for 20 ma DC loops



Pace-Setters in Quality Communication Equipment

NORTHERN RADIO COMPANY, inc.
147 WEST 22nd ST., NEW YORK 11, NEW YORK
In Canada: Northern Radio Mfg. Co., Ltd., 1950 Bank St., Billings Bridge, Ottawa, Ontario.

CIRCLE 177 ON READER SERVICE CARD

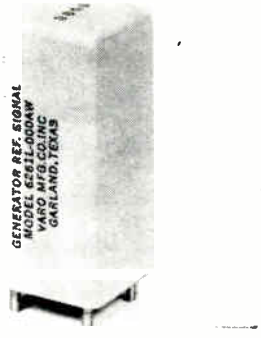
deep and 9 in. wide; 44½ percent of the tank bottom being covered with driving elements. Actual radiating surface is 48 sq in. The 115-v a-c single phase 60-cycle generator delivers an average power output of 250 w and produces peaks of 1,000 w. Features include 0-60 minute timer, one tube oscillator, and provision for remote control of equipment. Price is $990.

CIRCLE 369 ON READER SERVICE CARD

Power Supply
multi output

MID-EASTERN ELECTRONICS, INC., 32 Commerce St., Springfield, N. J. Model 157 transistorized power supply provides three simultaneous outputs, all regulated within 0.25 percent for line and load changes. Input power is 115 v, 400 cps, 3-phase. Output ratings are 22½ v d-c at 1 ampere; −12 v d-c at 1 ampere; and −6 v d-c at 0.5 ampere all slightly adjustable. Ripple is 0.01 percent; recovery, less than 50 μsec; and overshoot will not exceed 1.0 percent of voltage setting.

CIRCLE 370 ON READER SERVICE CARD



Frequency Generator
hermetically sealed

VARO MFG. CO., INC., 2201 Walnut St., Garland, Texas. Model 6261 incorporates a bimetallic tuning fork to provide precision frequency. Oscillator circuit uses silicon transistors, precision wire wound resist-

CIRCLE 215 ON READER SERVICE CARD

CIRCLE 216 ON READER SERVICE CARD

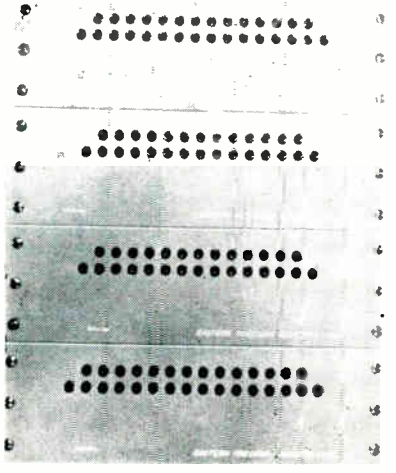
ors and metallized mylar capacitors to achieve reliable operation to 125C. The generator has an output of 2.5 v with frequencies from 300 to 4,000 cps at accuracies of 0.1 percent to 0.01 percent.

CIRCLE 371 ON READER SERVICE CARD

D-C/D-C Converter transistorized

STANDARD ELECTRONICS CO., 1611 W. 63rd St., Chicago 21, Ill. The 200 series d-c to d-c converters are available custom-designed to O.E.M. specifications. They can be designed to handle power ratings up to 500 w. Conversion efficiencies are offered up to 85 percent with operating temperature range up to 80 C. Regulation is available up to 1 percent. All units meet Military requirements for radio interference.

CIRCLE 372 ON READER SERVICE CARD



Delay Lines 100 millisec

EASTERN PRECISION RESISTOR CORP., 675 Barbey St., Brooklyn 7, N. Y. Series DL-1000-10,000/25T constant delay lines feature extremely

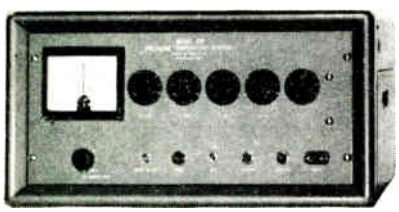
Using Thermistors

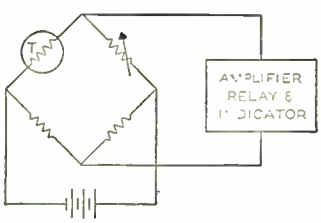
Edited by
FENWAL ELECTRONICS, INC.

STABLE THERMISTORS PERMIT HIGH CONTROL ACCURACY WITH SIMPLE CIRCUITRY

Circuit shown for the Fenwal Electronics' Model 150 Temperature Controller is typical. It has a sensitivity of 0.001°C throughout its working range!

New, extremely stable, probes permit full exploitation of thermistors' inherently high sensitivity to temperature change.





Fenwal Model 150 Thermistor Controller

Operating characteristics of the new probes are precisely predictable and repeatable over the entire control range. Furthermore, the large change in resistivity of a probe in response to a small temperature change greatly simplifies circuit design. (Resistance can change as much as 4000 ohms — or more — for a change of only 1° in temperature.) In most cases, a standard resistance bridge circuit is ample for measurement of signal output.

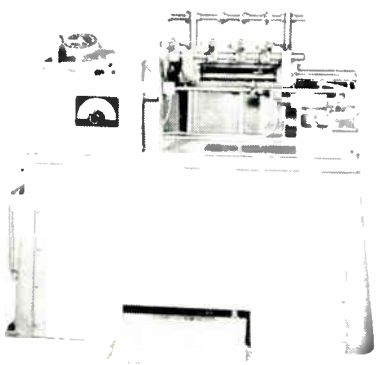
For full details on thermistors, send for Catalog EMC-2. Further details on Model 150 also available on request. Write FENWAL ELECTRONICS, Inc., 211 Mellen Street, Framingham, Mass. And simplify your circuit design problems with a G200 Experimental Kit of thermistors. Available from Fenwal Distributors or the Framingham plant.

Fenwal Electronics

Making Precision Thermistors
to Make Your Design Ideas Come True

long delay and low attenuation, together with excellent phase linearity. It has 100 external taps, permitting 1-millisec increments to be selected. The line consists of four identical 0 to 25 millisec tapped delay lines in cascade. Each of these separate delay lines contains 25 sections of m-derived LC networks utilizing high-Q toroidal inductances and ultrastable capacitors. An 18-page technical brochure and catalog is available.

CIRCLE 373 ON READER SERVICE CARD



Coil Winder
multiple unit

GEO. STEVENS MFG. CO., INC., Pulaski Rd. at Peterson, Chicago 46, Ill. Model 500-AM multiple transformer/bobbin winder eliminates gear changes and permits virtually instant change-over from one wire gage to another. Complete transformers may be wound without removing mandrels from machine. Dial is calibrated in wire sizes from 10 to 31 Awg, permitting instant selection of correct winding pitch. Maximum coil o-d is 16 in. Winding speeds are up to 380 rpm.

CIRCLE 374 ON READER SERVICE CARD

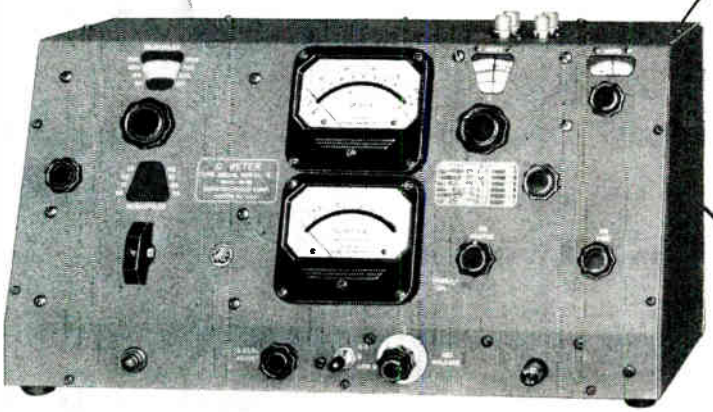
Relay Miss Tester
electronic gate

SHASTA ELECTRONIC CO., P.O. Box 316, Palo Alto, Calif. Machine will cycle relays for testing under dry circuit conditions. The relay contacts are tested dynamically at open circuit voltages as low as 1 mv with closed circuit currents as low as 1μa. An electronic gate is provided to eliminate erroneous miss indications.

CIRCLE 375 ON READER SERVICE CARD

Accurate Q Measurements

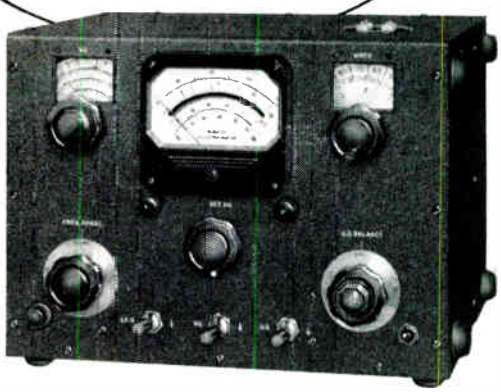
1 KC to 260 MC



PRODUCTS OF 25 YEARS SPECIALIZED EXPERIENCE IN Q METER DESIGN!

Model 260-A Q Meter

Model 190-A Q Meter



These BRC instruments incorporate many exclusive design features resulting in improved accuracy and reliability—

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- Extremely wide direct reading Q range: 5-1200 (190-A), 10-625 (260-A)
- △ Q Scales permit accurate measurement of capacitors, dielectrics, and resistors
- Mirror meter scales eliminate parallax
- Electronically regulated power supplies provide maximum stability
- Extremely low injection impedance provides maximum Q accuracy

BRC Q Meters are versatile, general-purpose instruments with a broad field of application in the laboratory and on the production line. They are designed to measure coils, capacitors, resistors, transformers, dielectrics, networks and filters through either series or parallel connection to a calibrated resonant tank circuit.

To Users of Earlier Models of BRC Q Meters!

While older models of the world-famous BRC Q Meters are still performing satisfactorily after many years of continuous service, users of these instruments are invited to investigate the greatly improved accuracy and convenience of the Types 190-A and 260-A.

Specifications

	TYPE 190-A	TYPE 260-A
Freq. Range:	20 Mc. to 260 Mc.	50 Kc.* to 50 Mc.
Q Range:		
Total Range:	5 to 1200	10 to 625
Low Range:	10 to 100	10 to 60
△ Q Range:	0 to 100	0 to 50
Q Accuracy:	±7%* 20 Mc. to 100 Mc. ±15%* 100 Mc. to 260 Mc. *for circuit Q of 400 read directly on indicating meter.	±5%* 50 Kc. to 30 Mc. ±10%* 30 Mc. to 50 Mc. *for circuit Q of 250 read directly on indicating meter.
Capacitor Range:	7.5 to 100μμf	30 to 460μμf
Capacitor Accuracy:	±0.2μμf, 7.5-20μμf ±0.3μμf, 20-50μμf ±0.5μμf, 50-100μμf	±1% or 1μμf, whichever is greater.
Price:	$875.00 F.O.B. Boonton, N. J.	$850.00 F.O.B. Boonton, N. J.

*1 Kc. to 50 Kc. with external oscillator.

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BOONTON, NEW JERSEY
Precision Electronic Instruments since 1934

NEW BOOKS

Electronic Measuring Instruments

By E. H. W. BANNER.

The MacMillan Company, New York, 496 *p*, $7.95.

THIS book is almost exclusively devoted to instruments that are manufactured in Britain. Much of the writing deals with devices that are unfamiliar to the average electronics engineer. Here many of the technical terms are undefined, and the reader, especially the American reader, will have to fashion their definitions from the text.

In describing a particular device, the author discusses the main features, sometimes including specialized construction and manufacturing techniques. Simple design equations, where applicable, are also used. Most of the devices are illustrated by a photograph and/or schematic. The bibliography is brief but sufficient.

Prices are not given. Inclusion of this vital information would have made the book even more useful without increasing its size. Also, the 4½ page index is inadequate for a book of this type.

Every designer and consumer of electronic measuring equipment will find that this book is a rich source of ideas. Transistors are only mentioned in four places in the book, but this partly results from the time lapse between manuscript and publication.

SID DEUTSCH, *Associate Professor of Electrical Engineering, Polytechnic Institute of Brooklyn, N. Y.*

Magnetic Amplifier Engineering

By GEORGE M. ATTURA.

McGraw-Hill Book Co., Inc., New York, 1959, 229 *p*, $7.50.

THIS book presents a clear and cohesive treatment of the theory and design of magnetic amplifiers. Covered in individual chapters are saturable reactors, the reactor-rectifier amplifier and reset control. Attura's diagrams are especially good. Many books on magnetic amplifiers have

needlessly complicated diagrams by a physical representation of the cores and windings. On the other hand, Attura uses the functional approach. In most cases, the circuit diagrams are accompanied with magnetization curves that present a step-by-step picture of magnetizing force versus magnetization. There are also voltage waveforms showing the voltage across reactor and load.

In the circuit schematics, communications symbols are used instead of the power type symbols often used in magnetic amplifier texts.

The book also covers magnetic amplifier components such as cores and rectifiers. A thorough treatment of magnetic theory is given which furnishes a solid basis for designing magnetic amplifiers.

There are examples of design of cascaded magnetic amplifiers and of hybrid amplifiers that use electron tubes and/or transistors as well as magnetic amplifiers. These hybrid circuits are becoming increasingly important in equipment such as servos.

The book can be recommended to all practicing engineers and students as a means for removing the magnetic-amplifier blind spot that plagues so many in the electronics industry.—J.M.C.

Solid State Magnetic and Dielectric Devices

By H. W. KATZ.

John Wiley and Sons, Inc., New York, 1959, 542 *p*, $13.50.

IN ADDITION to the transistor, a wide variety of solid state devices are currently being developed and are assuming considerable importance in engineering. The purpose of this book is to fulfill the need for a comprehensive treatment of the theory and applications of such devices exclusive of the transistor. The fourteen contributing authors have covered a very large field and the editor, H. W. Katz, has succeeded in integrating the material into a consistent development.

In the first four chapters, the basic theory of electrostatic and magnetostatic fields and of the electric and magnetic properties of

solid state materials is developed. The succeeding seven chapters discuss the practical applications of these theories. For instance, microwave ferrite devices, magnetic and dielectric amplifiers, solid state memory devices, the principles of magnetic recording, and the techniques of magnetic and dielectric measurements are all discussed.

ARMEN H. ZEMANIAN, *College of Engineering, New York University, N. Y.*

THUMBNAIL REVIEWS

Principles of Electronics. By M. R. Gavin and J. E. Houldin, D. Van Nostrand Co., Inc., Princeton, N. J., 1959, 347 p, $5.75. This is an introductory text suitable for an undergraduate course in physics or electronics. Emphasis is on basic principles of tubes, transistors and other electron devices, rather than on specific applications in systems. Final section contains about 250 problems with answers arranged to correspond with chapter topics.

Mathematics Dictionary. Edited by G. James and R. C. James, D. Van Nostrand Co., Inc., 1959, 546 p, $15.00. This revised and enlarged second edition contains more than 7,000 mathematical terms, concepts and relationships. Additions include basic terms in modern algebra, number theory, topology, vector spaces, game theory, linear and dynamic programming, numerical analysis and computing machines. A multilingual index lists English equivalents of French, German, Russian and Spanish terms.

Materials for Rockets and Missiles. By R. G. Frank and W. F. Zimmerman, The Macmillan Co., New York, 1959, 124 p, $4.50. This is a materials handbook which also includes tables, graphs and photomicrographs rounding up compositions and mechanical characteristics of modern alloys, cermets and ceramics used as structural and mechanical parts in high temperature applications. Text discusses use and fabrication of materials. No data is given on electrical properties.

Principles of Transistors Circuit. By S. W. Amos, John F. Rider Pub., Inc., New York, 1959, 176 p, $3.90. This book begins with introductory chapters on the physical processes occurring in transistors and then goes on to emphasize applications. Most of the book is devoted to determination of input resistance, stage gain, optimum load, power output, coupling capacitor values and transformer winding inductances in various types of circuits.

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The Physics of Electricity and Magnetism. By W. T. Scott, John Wiley and Sons, Inc., New York, 1959, 635 p. This is a textbook for juniors, seniors and first year graduate students which provides an explanation of the basic theory of electricity and magnetism in a rigorous manner from the viewpoint of a physicist.

An Approach to Electrical Science. By H. G. Booker, McGraw-Hill Book Co., Inc., New York, 1959, 826 p, $9.50. Treats basic electromagnetic theory, electron devices, circuits and components from physical science viewpoint. Designed as a sophomore engineering text, it crosses lines of physics, mathematics and electrical engineering.

Modern Trends in Documentation. By Dr. Martha Boaz, Pergamon Press, Ltd., New York, 1959, 103 p, $5.00. Proceedings of symposium held at University of Southern California in April 1958 including eight papers on information retrieval, two papers on machine translation of foreign languages, and 15 pages of panel discussion of the papers. Applications of computers and smaller machines to the problems of librarians are stressed.

Theory of Functionals and of Integral and Integro-differential Equations. By V. Volterra, Dover Publications, New York, 1959, 226 p, $1.75. This is a reprint of Volterra's classical work which was first published about thirty years ago. It is mainly of interest to the student or scientist possessing a firm foundation in mathematics.

The Radio Amateur's Handbook. American Radio Relay League, Inc., West Hartford, Conn., 1959, 746 p. $3.50. This latest version of an old favorite has been brought up to date in all sections, with a complete revision of the vacuum-tube characteristics section.

Programming for Digital Computers. By Joachim Jeenel, McGraw-Hill Book Co., Inc., New York, 1959, 517 p, $12.00. Methodical approach to programming problems for stored-program computers. Presumes no previous experience. Covers both scientific and data-processing applications.

Proceedings of the Fourth National Conference on Tube Techniques. Sponsored by Advisory Group on Electron Tubes, New York University Press, New York, 1959, 270 p, $7.50. Pattern of previous conferences is followed giving a wide-angle view of recent developments in tube design, tube component and material analyses, and production and test techniques. Emission and cathodes receive special attention.

Literature of

MEASUREMENT INSTRUMENTATION. Telemetering Corp., P. O. Box 645, Mesa, Arizona. A booklet outlines research, development and production facilities of this new company specializing in electronic measurement instrumentation.

CIRCLE 380 ON READER SERVICE CARD

METALS FOR SEMICONDUCTORS. Sigmund Cohn Corp., 121 S. Columbus Ave., Mt. Vernon, N. Y., has prepared a brochure entitled "Metals and Alloys for use in Conjunction with Semiconductor Products."

CIRCLE 381 ON READER SERVICE CARD

COMMERCIAL CAPACITORS. The Astron Sales Corp., East Newark, N. J. A 6-page illustrated brochure contains listings of complete lines of capacitors for commercial use.

CIRCLE 382 ON READER SERVICE CARD

MICROWAVE TERMINATIONS. Radar Design Corp., Pickard Drive, Syracuse 11, N. Y. An 8-page brochure describing a wide range of low- and high-power coaxial and waveguide terminations give complete specifications and applications.

CIRCLE 383 ON READER SERVICE CARD

FACILITIES BROCHURE. Instrument Systems Corp., 129-07 18th Ave., College Point 56, N. Y. A new brochure outlines the company's knowledge, experience and management, and shows its facilities in the fields of electronics, precision mechanisms, and instrumentation.

CIRCLE 384 ON READER SERVICE CARD

SILICONE RUBBER. General Electric Co., Waterford, N. Y. Bulletin CDS-179 features silicone rubber for lead wire insulation. It also offers a comparison between silicone rubber, polyvinyl chloride, neoprene and natural rubber, as insulating materials.

CIRCLE 385 ON READER SERVICE CARD

INSULATING MATERIALS. Columbia Technical Corp., 61-02 Thirty-First Ave., Woodside 77, N. Y., has available a handy-to-use data sheet on the complete line of HumiSeal synthetic resin coatings

the Week

for insulation and protection of electronic components and assemblies against corrosion, moisture and similar environmental stresses.

CIRCLE 386 ON READER SERVICE CARD

FERRITES. Kearfott Co., Inc., 1500 Main Ave., Clifton, N. J. A 19-page booklet contains information on ferrites for missile and advanced electronics applications.

CIRCLE 387 ON READER SERVICE CARD

CONTROLS AND CONTROL SYSTEMS. Whittaker Controls, Division of Telecomputing Corp., 915 N. Citrus Ave., Los Angeles, Calif. A 16-page general capabilities and background brochure, containing over 25 photographs, graphically discusses the organization's active technical diversity.

CIRCLE 388 ON READER SERVICE CARD

THERMAL MAGNETIC CIRCUIT. E-T-A Products Co., 6284 N. Cicero Ave., Chicago 46, Ill. A specification sheet contains detailed information on low-cost circuit breakers featuring model variations with and without auxiliary or alarm circuits.

CIRCLE 389 ON READER SERVICE CARD

MOLDING COMPOUNDS. Durez Plastics Division of Hooker Chemical Corp., North Tonawanda, N. Y. A 16-page reference booklet lists the physical properties of 33 phenolic and 3 diallyl phthalate molding compounds.

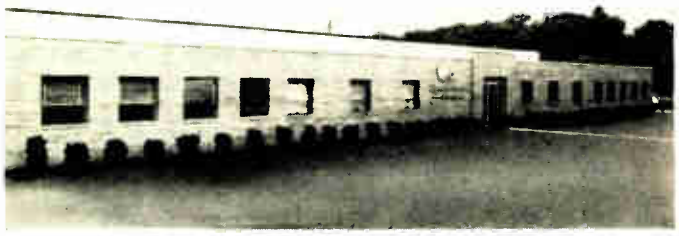
CIRCLE 390 ON READER SERVICE CARD

PULSE TRANSFORMERS. Technitrol Engineering Co., 1952 E. Allegheny Ave., Philadelphia 34, Pa., has published three new technical brochures to help circuit design engineers accurately specify the design of low power pulse transformers.

CIRCLE 391 ON READER SERVICE CARD

TAPE WOUND CORES. G-L Electronics, 2921 Admiral Wilson Blvd., Camden 5, N. J. Precision-made tape wound cores can now be obtained in two new core materials to precise limits, and these materials and limits are described in the 8-page bulletin TB-105.

CIRCLE 392 ON READER SERVICE CARD



Dynamic Gear in New Home

DYNAMIC GEAR CO., designer and manufacturer of miniaturized precision gears, differentials and allied components for application in the electromechanical field, recently moved into a new and larger plant in Amityville, N. Y.

William A. Wiegand, president of the 11-year-old firm, says the new plant's total area covers 20,250 sq ft, of which 15,000 sq ft is utilized for increased production facilities. A portion of this area includes the quality control section and a temperature, humidity-controlled precision assembly room. In this room, precision components such as gear trains and servomechanisms are assembled under critical conditions. Also a part of the new plant operation is an extended engineering service. DG engineers can take a client's spec sheet and work it into a complete set of finalized drawings or, if desired, do the final assembly of the component, the company says.

Dynamic Gear Co. was founded in 1948 by Wiegand in a Brooklyn barn that rented for $25 a week. The new Amityville plant was constructed at a cost of more than $250,000.

The miniature, precision gears—both stock and custom—are known as Dynaco gears and are used in the guidance systems of the Thor, Atlas and Titan missiles, says the firm. More recently, the company adds, these gears were utilized in the inertial navigational system of the Navy's new nuclear-powered submarines capable of firing the Polaris missile.

Name Kenny V-P At Super-Temp

AMERICAN SUPER - TEMPERATURE WIRES, INC., has appointed James Kenny as vice president in charge of engineering. He had previously been chief engineer and has been with the Winooski, Vt., company since 1956.

In his new capacity Kenny will have administrative and technical supervision of engineering activities at the company's three plants. He will also be available for consultation on development and production problems relating to new wire and cable designs.

Georgia Company Plans Expansion

SCIENTIFIC-ATLANTA, INC., manufacturer of microwave instrumentation, has completed the purchase of 64 acres of land just outside Norcross, Ga. The tract will be used for expansion of the company's manufacturing facilities.

In making the announcement, Glen P. Robinson, Jr., president, pointed out that the company had grown from 41 employees in the summer of 1957 to 125 at the present time.

Elect Day REL Director

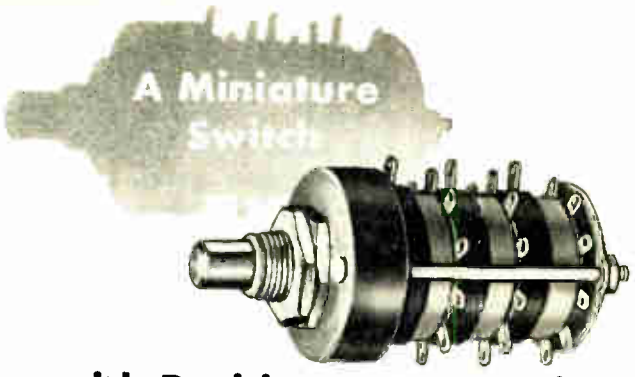
JAMES R. DAY, close collaborator of the late Major E. H. Armstrong in the development of wide-band frequency modulation, and himself the inventor of many important devices in this field, has been elected a director of Radio Engineering Laboratories, Inc., Long Island City, N. Y., communications subsidiary of Dynamics Corp. of America.

A vice president of REL since 1949, Day joined the company in 1945. REL produces tropospheric scatter communications equipment and also ssb radio equipment and tv-radio transmitting equipment.

Organize New Microwave Corp.

THE PRESIDENT of Norfolk Precision Machine Corp., J. L. Travers, announces the formation of a new division, Precision Microwave Corp., in Millis, Mass., to design, manufacture and test microwave systems and components.

Precision Microwave division is headed by Eugene G. Slotta, who was for the past 7 years with Raytheon Co., Waltham, Mass. There he served as microwave methods engineer, founder and general foreman of Government Equipment di-



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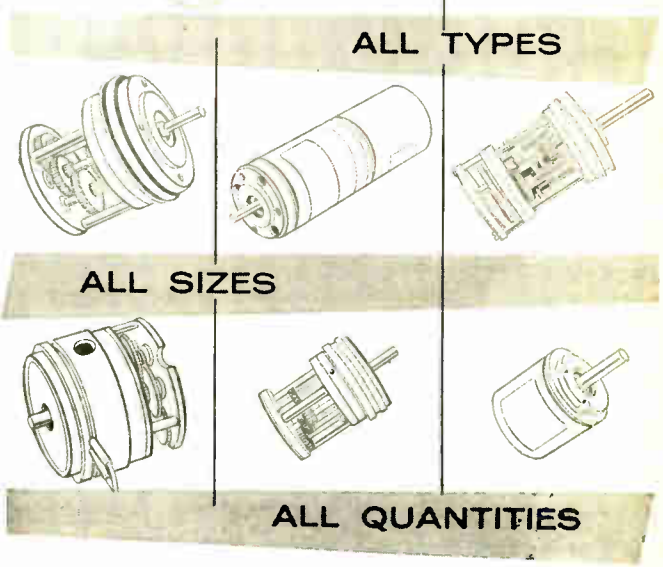

Bowmar designs and manufactures all types of precision geared components, assemblies and packages for all types of precision control systems. Dozens of semi-standard speed reducer and gearhead sizes are offered in most ratios; but these types may be altered, or entirely new types can be developed to fit new requirements. Typical of many Bowmar designs currently being manufactured ——

TWO SPEED GEARHEAD X-709. Unit shown has speed reductions of 2400:1 and 24000:1 for fast approach and slow zeroing. Unit is electrically actuated and is completely self contained. Typical of many Bowmar designs currently being manufactured.

PRECISION SERVO MOTOR GEARHEAD 750-GH (with housing). Standard ratios to 2000:1; Starting torque: .005 in.-oz.; Load torque: 5 in.-oz.; Backlash: 30 min. max.; Diameter: .750 in. Typical of many Bowmar designs currently being manufactured.

PRECISION MINIATURE SPEED REDUCER 1062. Standard ratios to 4000:1. Starting torque: .005 in.-oz.; Load torque: 25 in.-oz.; Backlash: 45 min. max.; Diameter: 1.062 in. Typical of many Bowmar designs currently being manufactured.

CONCENTRIC SHAFT SPEED REDUCER X-530. Single ended unit has optional internal slip clutch set to customer requirements. Most ratios available. Starting torque: .01 in.-oz.; Backlash: 30 min. max.; Diameter: 1.062 in. Typical of many Bowmar designs currently being manufactured.

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CIRCLE 191 ON READER SERVICE CARD

vision microwave shop, and general shop superintendent of Waltham's Plant No. 1, respectively.

David A. Fulton, engaged in microwave engineering, production sales and consulting work for 7 years, has been appointed chief engineer of the new firm.

Name Benjamin Sales Manager

CHRISTIE ELECTRIC CORP., Los Angeles, Calif., has appointed Fred Benjamin sales manager of the firm's Industrial Division. He will devote his activities to the company's complete and diversified line of d-c power supplies and industrial battery charging equipment.

Prior to joining the Christie organization, Benjamin held positions as director of research and development at American Electronics and a director of sales and engineering at Magnetic Systems.

News of Reps

McCarthy Associates Inc., electronics manufacturers reps, Pasadena, Calif., has promoted **Ron Klaas** to the newly created position of business manager and treasurer.

Appointment of five additional sales rep firms by Electronics International Co., Burbank, Calif., is announced. Reps are: **Allan Crawford Associates** of Willodale, Ontario, covering all Canadian provinces, except British Columbia; **E. G. Holmes & Associates** of Atlanta, Ga., and Orlando, Fla.,

for Alabama, Georgia, North Carolina, South Carolina and Florida; **N. R. Schultz Co.** of Seattle, Wash., for Oregon, Washington and Idaho; **Technical Instruments, Inc.**, of Reading, Mass., and Bridgeport, Conn., for Connecticut, Rhode Island, Massachusetts, Maine; and **Instruments For Measurements** of Sunnydale, Calif., covering California.

Kiva Sales Co. of Phoenix, Arizona, has been appointed by Mid-Eastern Electronics, Inc., for the entire state. Kiva will handle Mid-Eastern's line of power supplies, ultra high resistance measuring instruments and special test equipment.

Six new reps throughout the U. S. have been appointed by Babcock Relays, Inc., Costa Mesa, Calif. Firm manufactures miniaturized precision relays for use in both airborne and ground commercial and military applications.

The newly appointed reps include **Stan Colthier Co.** of Minneapolis, Minn.; **Jas. J. Backer Co.** of Seattle, Wash.; **G&H Sales Co.** of Cincinnati, Ohio; **Kay Sales Co.** of Kansas City, Mo.; **Packard Associates**, Dallas, Texas; and **Reed-Tollefson Corp.** of Rochester, N. Y.

Pyramid Electric Co., Darlington, S. C., announces appointment of **Ken Steinke Sales** of Milwaukee, Wisc., as rep for its line of capacitors and silicon rectifiers in the state of Wisconsin.

Alfred Electronics, Inc., Palo Alto, Calif., manufacturer of broad band microwave instruments and power supplies, names **George Gostenhofer & Associates, Inc.**, of Waltham, Mass., as engineering sales rep in the New England area.

Industrial X-Ray Engineers of Seattle, Wash., has been appointed to represent Sperry Products Co. in the Pacific Northwest, to include Oregon, Washington, Idaho and western Montana. Company will handle sales and service of the full Sperry ultrasonic line—instruments, accessories and automated testing systems.

Comment

Help Wanted

I have a problem. I have been receiving your magazine for four months now and feel that among your contributors may be one with the answer.

I have an old reed pump organ handsomely carved in a black ebony-type finish. It is my desire to build an electronic organ with two-manual full bass, or the bass of a Hammond or other make with two or three octaves in the bass section. I also am desirous of building this organ with transistors instead of vacuum tubes because of space limitations.

So far I cannot find circuits drawn or pictured with layouts of what I need. I figure I will need tone generators or oscillators, power supplies, audio (high-fidelity if possible), and manuals. Is there a book or books which would enable me to pick up the basic circuits involved, or am I reaching for the moon?

I would buy an electronic organ but at $1,800 or so I figure I'd better do it myself. With the circuits, I could build it as I could afford the parts . . .

VICTOR A. FRAPPIER

ALEXANDRIA, VA.

It may seem an easy way to fob off responsibility, but we recommend that reader Frappier peruse our annual indexes, which appear in the last issue for each year.

We picked up our own 1958 index just now and found listed an article "Electronic Organ Uses Neon Tone Generators," p 36, Aug. 29 '58. This article, we recall, describes a basic circuit which provides the 12 notes of the diatonic scale, plus the necessary dividers for subharmonics at octave intervals, and tone-coloring circuitry. The organ resulting was a two-manual 25-stop instrument with a 13-key pedal clavier (full pedal keyboards of 2½ octaves are rarely found on home organs).

Another article on tone generators appeared in our Jan. '51 issue. And we have carried many articles on regulated power supplies of all types, and on high-fidelity audio reproduction systems.

By the way, the Hammond organ produces its tones electrically, not

electronically. It might not be wise to try to mix the breeds.

Credit Where Due

With reference to our article "Function Generation With Operational Amplifiers" (p 66, Nov. 6), you are to be congratulated for your speedy handling of the editing and production.

The first of the precision limiter circuits shown (our Fig. 1B) was originally published by C. D. Morrill and R. V. Baum (in "Diode Limiters Simulate Mechanical Phenomena," ELECTRONICS, p 122, Nov. '52). Due to the omission of a reference mark included in our original manuscript, Messrs. Morrill and Baum were not given proper credit for this remarkable circuit, although the reference to their paper was correctly included at the end of the article.

I should appreciate your printing this, because I feel strongly about giving credit where it is due.

GRANINO A. KORN

UNIVERSITY OF ARIZONA
TUCSON, ARIZ.

So do we.

Grammatical Errors?

Mr. Upson is to be commended for his letter (Comment, p 139, Nov. 13), in which he points out frequent grammatical errors found in technical journals.

Whether Mr. Upson knows it or not, however, his letter illustrates another rather common error in the use of the term *whether or not*.

MARTIN BREMMER
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"Whether reader Bremmer knows it or knows it not" yields, by ellipsis, "whether he knows it or not," and that, by transposition, "whether or not he knows it." (The direct construction was the one reader Upson used.) The alternative "whether or no" is not so easily accounted for, since "no" is not ordinarily an adverb—as "not" is. In England, "whether or not" is used less frequently than "whether or no," but either form is acceptable and "whether or not" is standard American.

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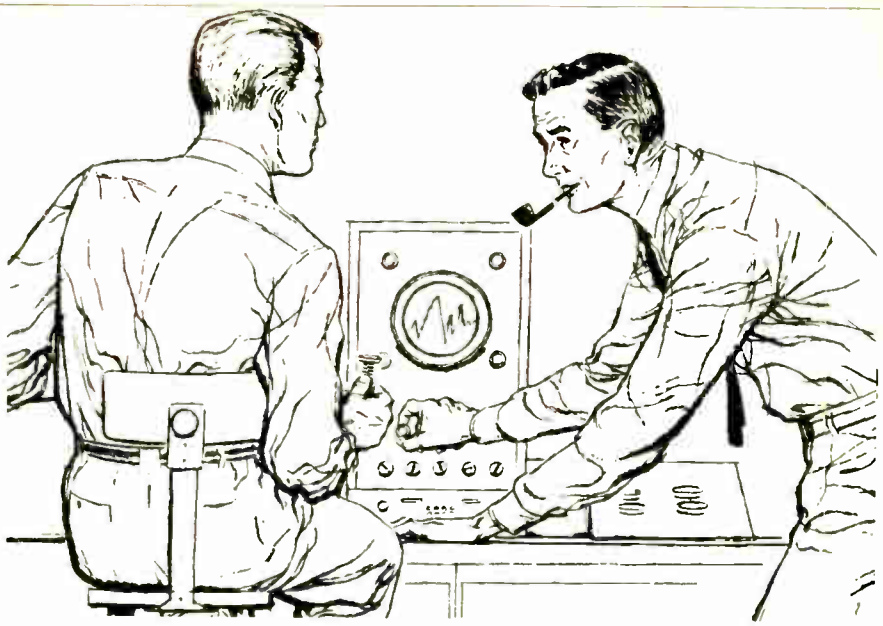

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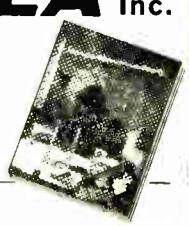

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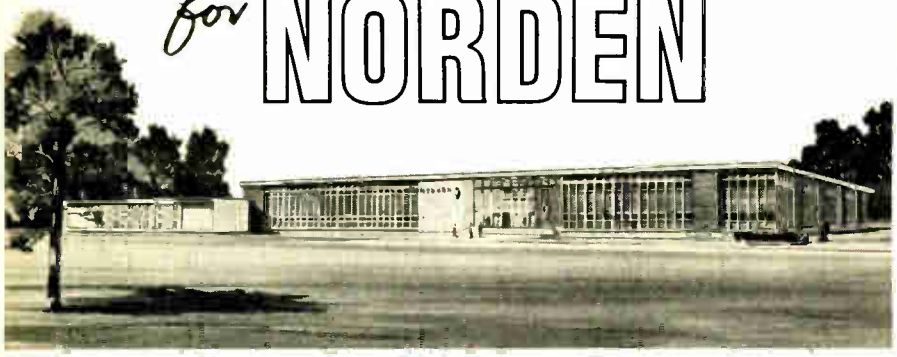

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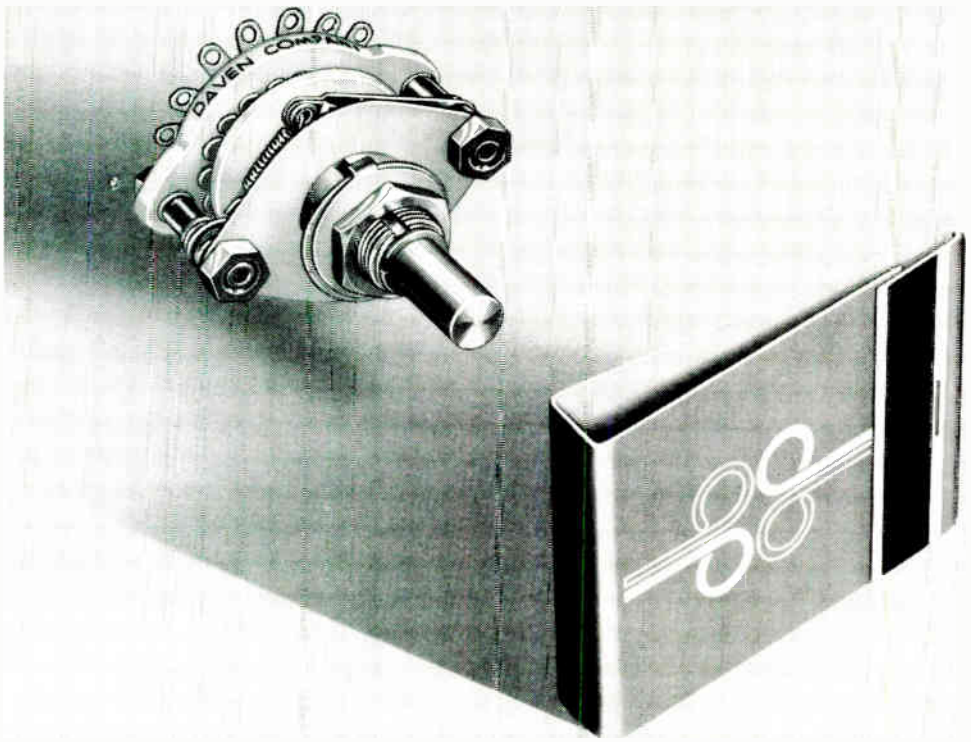

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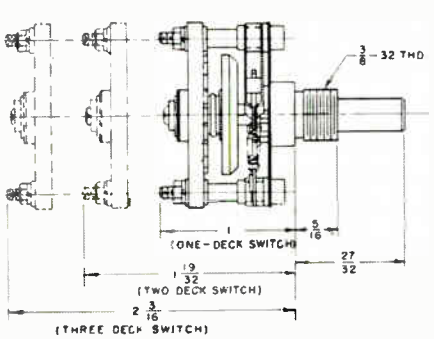

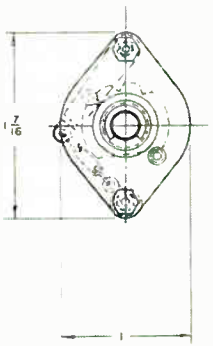

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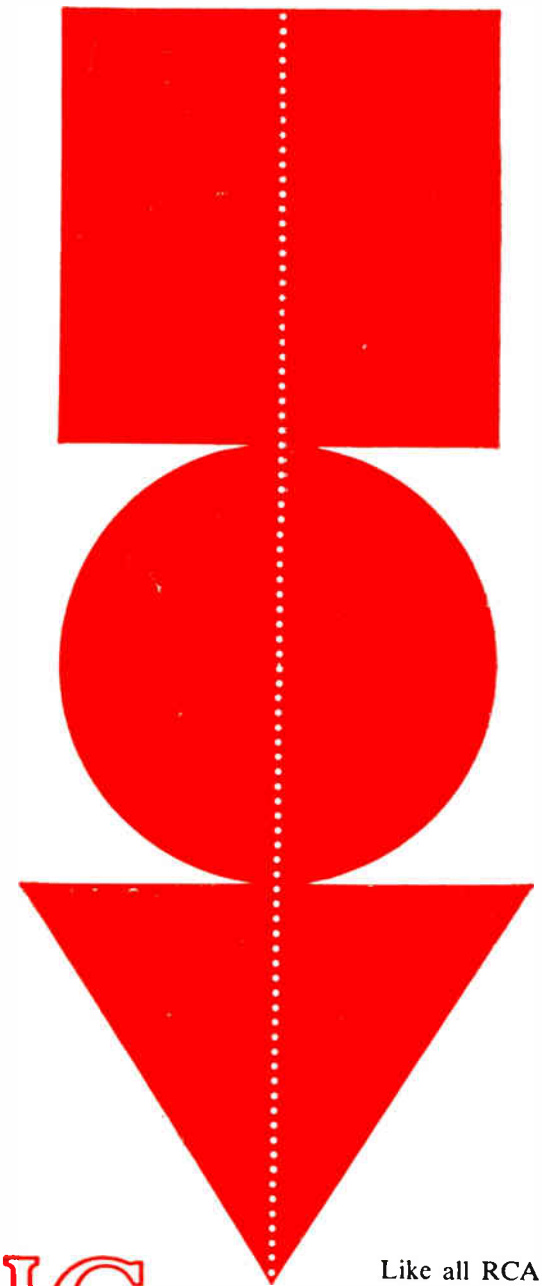

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