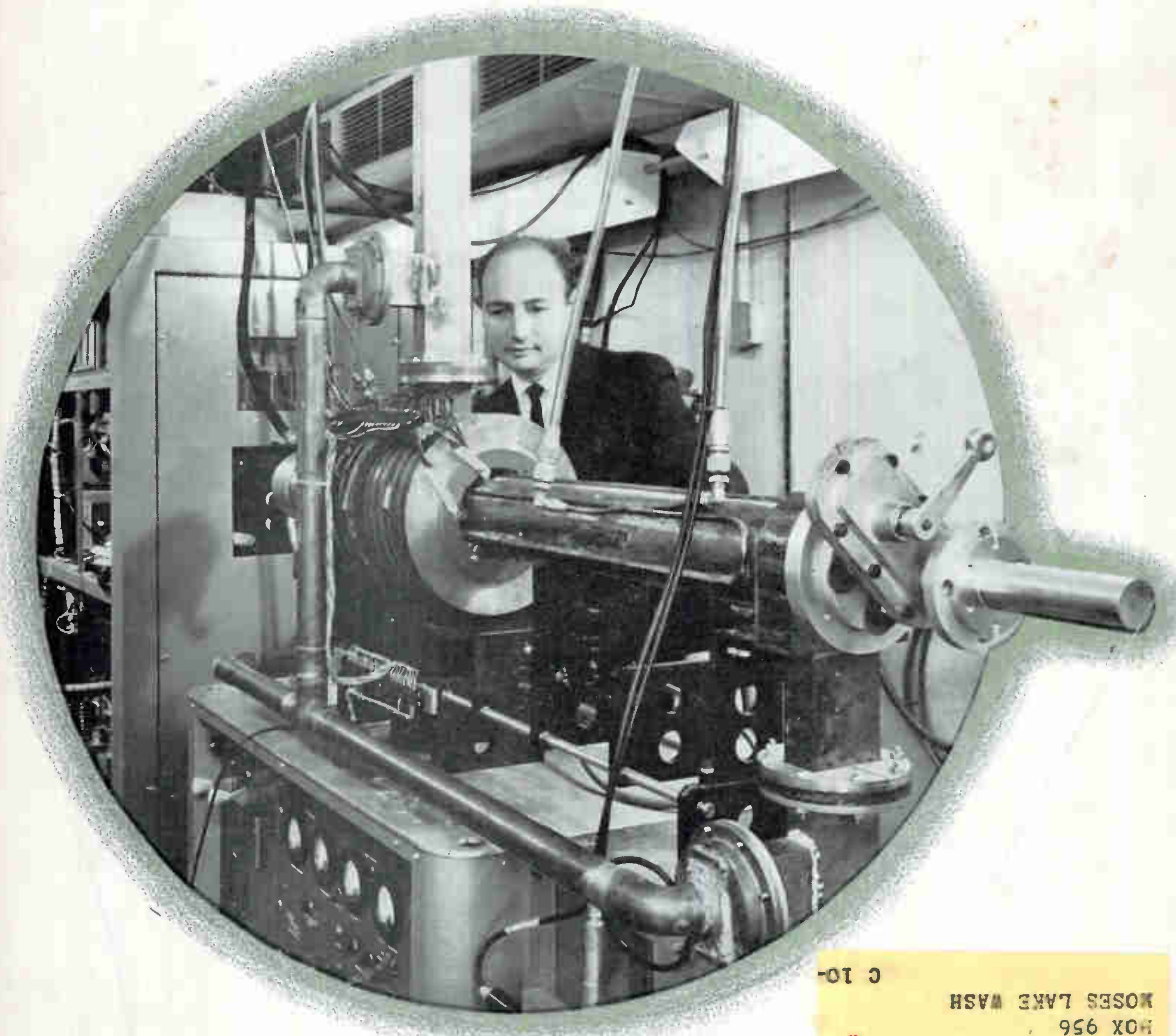
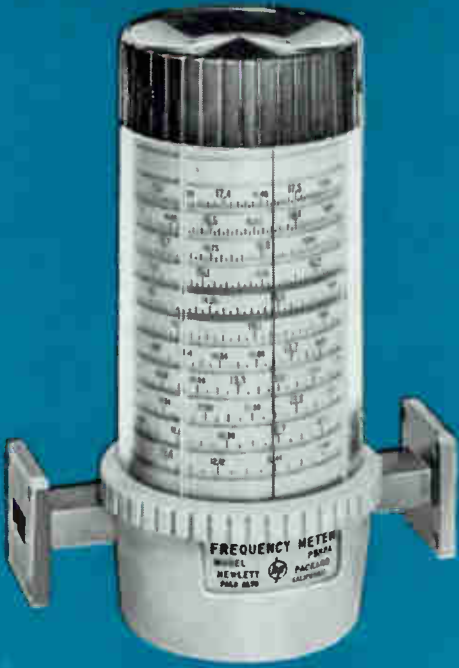
February 10, 1961

electronics

Transient malfunctions are induced in electronic circuits by gamma radiation from this electron linear accelerator as designers study how to cope with nuclear environments. *See p 62*

A McGraw-Hill Publication 75 Cents





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Now hp offers you high quality, moderately priced precision Frequency Meters covering eight important microwave bands.

Frequency is read directly in KMC on the large, precisely calibrated spiral scale. No charts or interpolation are required. Accuracy is high—up to 0.06% including 0 to 100% relative humidity change, 20° C temperature variation and dial accuracy (See Specifications).

Model 532 Frequency Meters comprise a special waveguide section mounting a high Q resonant cavity tuned by a choke plunger. A 1 db or greater dip in output indicates resonance. There are no spurious modes or resonances. Tuning is by a precision lead screw, spring loaded to eliminate backlash. Minimum calibration spacing is 1/32" to provide good resolution.

SPECIFICATIONS

Model No.	Overall Accuracy (%)	Frequency Range KMC	Dial Calib. Accuracy (%)	Calibration Increment (MC)	Max. Temp. Coefficient % per ° C	Price
G532A	0.065	3.95 - 5.85	0.033	1	0.0012	$325.00
J532A	0.065	5.30 - 8.20*	0.033	2	0.0012	300.00
H532A	0.075	7.00 - 10.0	0.040	2	0.0015	250.00
X532B	0.080	8.20 - 12.4	0.050	5	0.0010	175.00
M532A	0.085	10.0 - 15.0	0.053	5	0.0012	275.00
P532A	0.100	12.4 - 18.0	0.068	5	0.0012	210.00
K532A	0.110	18.0 - 26.5	0.077	10	0.0013	280.00
R532A	0.120	26.5 - 40.0	0.083	10	0.0017	300.00

K and R band models available with circular flange adapters; specify K532AC and R532AC respectively.

*When used between 5.3 to 7.5 KMC, or 5.7 to 8.2 KMC, single mode resonance is achieved.

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

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hp complete instrumentation for microwave measurements

February 10, 1961

electronics

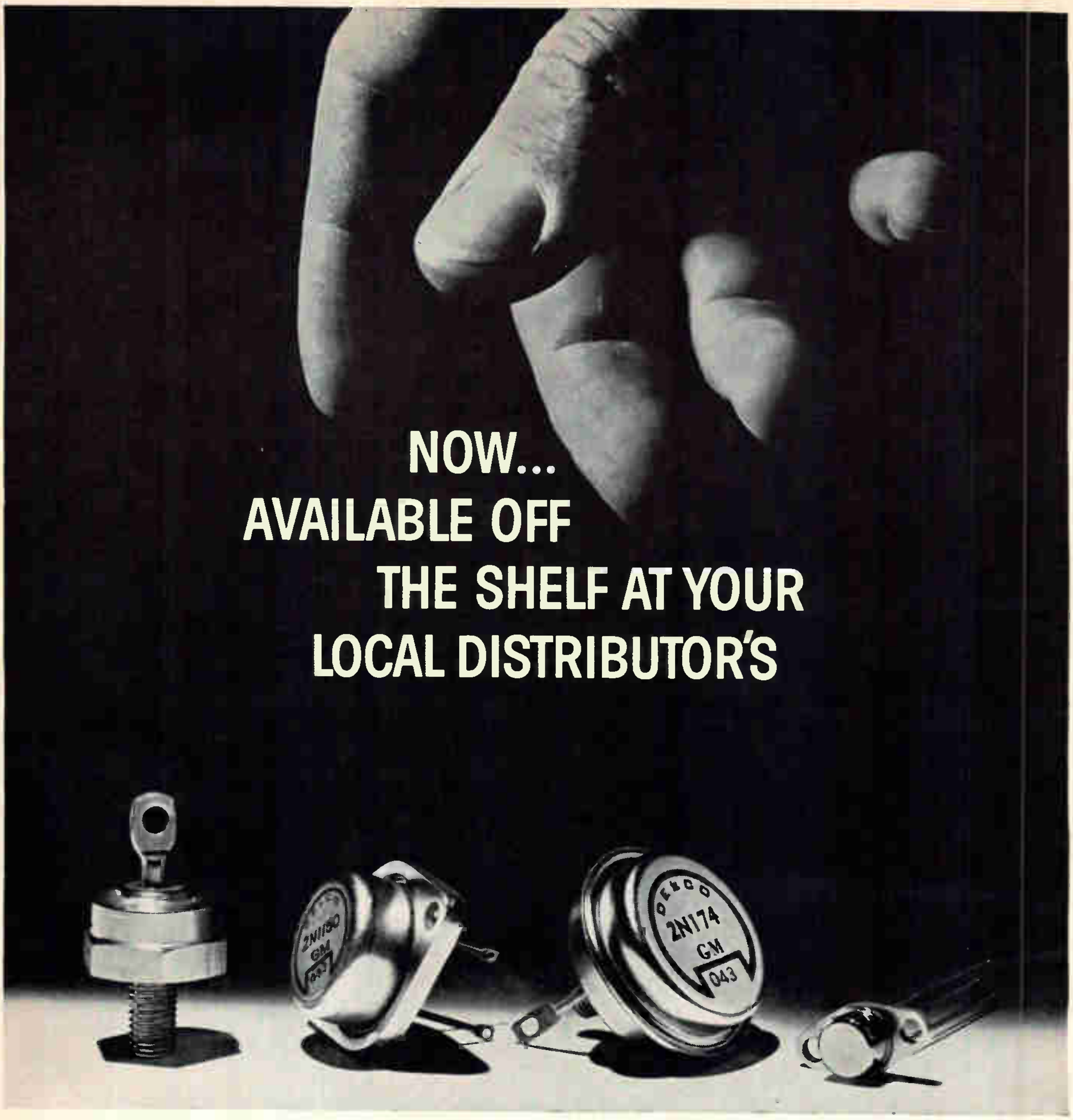
A McGraw-Hill Publication 75 Cents

W. W. MacDONALD, Editor

BUSINESS

ENGINEERING

DEPARTMENTS



Delco Radio's complete line of semiconductors is now available at your local distributor's. You can get fast off-the-shelf service on military and industrial transistors for high and low voltage switching and power supplies, for low-leakage DC amplifiers and for audio amplification. Your distributor has Delco silicon power rectifiers, too. The distributor nearest you has a complete catalog of application-proved semiconductors.

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SWEEP SIGNAL SOURCES

X775A

DELIVERY FROM STOCK

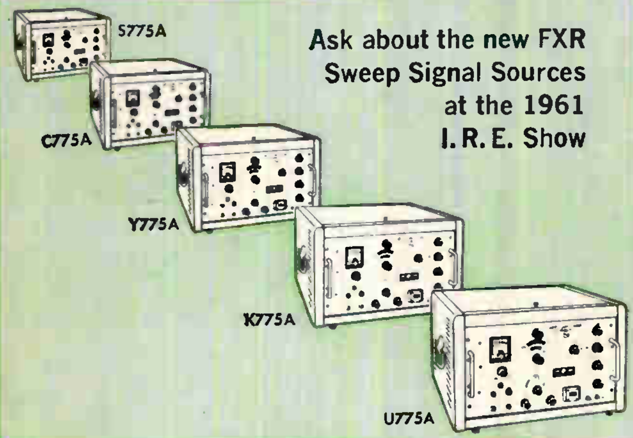
- Direct Reading Frequency Dials for Setting Upper and Lower Band Ends
- Integral AGC Circuit Keeps Output Flat to ±0.5 db
- AGC Provision Eliminates Need for Slow Response Ratiometer Set-ups
- Convenient, Portable, Versatile

for fast, visual reflectometer tests ranges from 2 to 40 KMC

Another breakthrough in measuring convenience has been achieved by the newly expanded FXR family of self-contained, direct reading sweep signal sources. Coverage is now provided as high as 40 KMC. Each unit utilizes a permanent magnet BWO as the tunable RF source.

Output power can be equalized at any detection point relative to the response of the detection element through use of FXR's exclusive built-in AGC circuit. This circuit provides a flat (±0.5 db level) on modulated signal throughout the swept frequency range when used with matched bolometers and directional couplers. This AGC provision eliminates the need for using slow response ratiometers, and allows for visual VSWR or Reflection Coefficient tests.

FXR FAMILY OF ALL ELECTRONIC SWEEP SIGNAL SOURCES



Ask about the new FXR Sweep Signal Sources at the 1961 I.R.E. Show

Model Number	Frequency Range (KMC)	Approx. Minimum Power Out.	OUTPUT Waveguide Type	OUTPUT Connector	Price
S775A	2.0 – 4.0	70 mw	(⅜" Coax Type N)		$2750.
C775A	4.0 – 8.0	20 mw	(⅜" Coax Type N)		$2800.
X775A	8.2-12.4	20 mw	WR-90	UG-39/U	$2900.
Y775A	12.4-18.0	10 mw	WR-62	UG-419/U	$3300.
K775A	18.0-27.0	5 mw	WR-42	UG-595/U	$3700.
U775A	27.0-40.0	5 mw	WR-28	UG-599/U	$4300.

Characteristics and prices subject to change without notice.

GENERAL SPECIFICATIONS

SWEEP RATE (Resolution): 0.3 to 300 KMC/sec linear with time
SWEEP WIDTH: approximately 200 KC to full frequency range
OUTPUT SIGNAL: CW, square wave (internal 800 to 1200 cps)
FREQUENCY DIAL ACCURACY: ±1% for fixed frequency operation
±2% for sweep frequency operation
POWER REQUIREMENTS: 115/230 v., 50/60 cycles, 200 w.
DIMENSIONS: 12⅞" high x 21¾" wide x 18" deep
WEIGHT: 78 lbs.

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CIRCLE 3 ON READER SERVICE CARD

electronics
February 10, 1961 Volume 34 Number 6

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CROSSTALK

BRITISH SHOW. "Even by British standards, the Exhibition of the Institute of Physics and the Physical Society held here late last month was singularly noncommercial." This is the way Editor W. W. MacDonald begins his exclusive story in this week's issue (p 24).

He points out that solid-state was the theme of the event. Most instruments on display were electronic. Many used transistors. Devices on exhibit included S-band maser, parametric amplifiers, new high-temperature ceramics and magnetic-film memory. MacDonald's interesting story also touches on booth chairs (lack of) and technical papers (depth of).

TUNNEL DIODES. Wen-Hsiung Ko's informative article on designing tunnel diode oscillators (p 68) is another in a growing list of features aimed at keeping you up to date on tunnel diode circuit techniques. Our first tunnel diode feature (p 54, Nov. 6, 1959) described the diode's action and properties. Since then we have carried several circuit articles including: p 60, Nov. 27, 1959; p 110, May 27, 1960; p 82, June 3, 1960; p 103, June 24, 1960; p 93, Nov. 18, 1960; and p 124, Nov. 25, 1960.

AIR COLLISIONS. Manufacturers in the field will be interested in knowing the Federal Aviation Agency may write specifications for air-collision avoidance equipment soon. FAA is now investigating a number of techniques and collecting basic data. Flight tests on two techniques are scheduled to begin this month and continue into April.

The FAA thinks the ultimate approach to the midair collision problem is positive ground control. Thus the flights of all aircraft would be continuously under surveillance by ground control centers. But a complete system for the nation's airways is some time away. Collision avoidance gear, when available, will back up positive ground control and perhaps assist it. But if the scheduled tests are successful, such equipment might be put to use within four years. See Associate Editor Flynn's story on p 26.

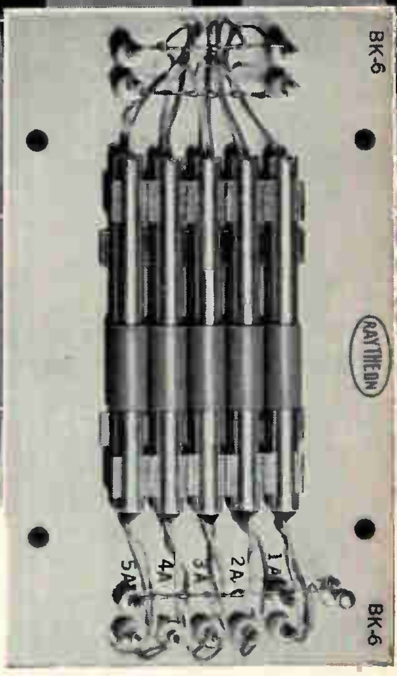
Coming In Our February 17 Issue

TUNNEL DIODE R-F AMPLIFIER. Another tunnel diode design article features the combination of stripline filters and a tunnel-diode amplifier to provide a selective r-f amplifier. In our next issue E. D. Long and C. P. Womack of Wilcox Electric Co. in Kansas City, describe the design of such an amplifier having a stable insertion gain of 25 db and a theoretical noise figure of 2.7.

IN ADDITION. Interesting feature material to appear next week includes: a self-adaptive filter by C. V. Jakowatz and G. M. White of General Electric; combined display of radar surveillance signals by G. E. Martin of Westinghouse Electric; domain behavior in thin magnetic films by J. W. Hart of Burroughs; and root-mean-square sensors for voltage regulators by R. L. Frank of Sperry Gyroscope.

CIRCLE 5 ON READER SERVICE CARD→

RAYTHEON FILTER ARRAYS



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Arrays are smaller and lighter—A bank of ten filters can be mounted on a 1¾" x 3" panel—total assembly weighs only ten ounces.

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For additional data on Raytheon Magnetostriction Filters please write to: Raytheon, Industrial Components Division, 55 Chapel Street, Newton 58, Mass.

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SEE PAGE 20 FOR RAYTHEON DISTRIBUTORS IN YOUR AREA.

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COMMENT

A Better Term

Truly, is not *transistorized* a cumbersome and unpleasant-sounding word?

Do you not agree that it had its period of usefulness and significance during the conversion to transistorized circuitry? This period is past. Things today are designed directly to use either tubes or transistors.

Are not today's devices using transistors better described as "transistor oscillators," "transistor amplifiers," and so forth? The term has a parallel in "vacuum-tube oscillators," "vacuum-tube amplifiers," and so forth. The word is easier to say, write and read, and would appear to be considerably more suitable for the present and future descriptions of transistor electronics.

If you agree, I know of no better influence for the adoption of the term than the pages of your excellent publication.

JOHN T. MULLIN
MINNESOTA MINING & MANUFACTURING CO.
LOS ANGELES

We do agree with reader Mullin; in general, we speak of a transistor circuit when the circuit has been designed from the ground up using transistors. We have been attempting to foster this usage for some time now.

A Misplaced Solar Event

I note that in the Jan. 6 issue of ELECTRONICS, under Research & Development on p 128 with the title "Solar-Radio Event Not Explained by Theories," there appears in the first paragraph a statement that there was a severe communications blackout on June 16, 1959.

Our records show no evidence of a blackout on June 16, 1959. In fact, we enjoyed perfect signals for the entire week of June 14 to 20.

The records do show, however, a solar flare type of blackout that lasted for 55 minutes on June 9. Except for this 55-minute blackout, signals were perfect for the entire week of June 7 to 13.

The blackout on June 9 is recorded as beginning at 1640 UT and ending at 1735 UT, and affected signals from Europe, Africa and South America. The fadeout was gradual, whereas normally the fadeout from a flare would be abrupt.

It appears from the foregoing that an error has been made in the date given in your magazine.

J. H. NELSON
RCA COMMUNICATIONS INC.
NEW YORK

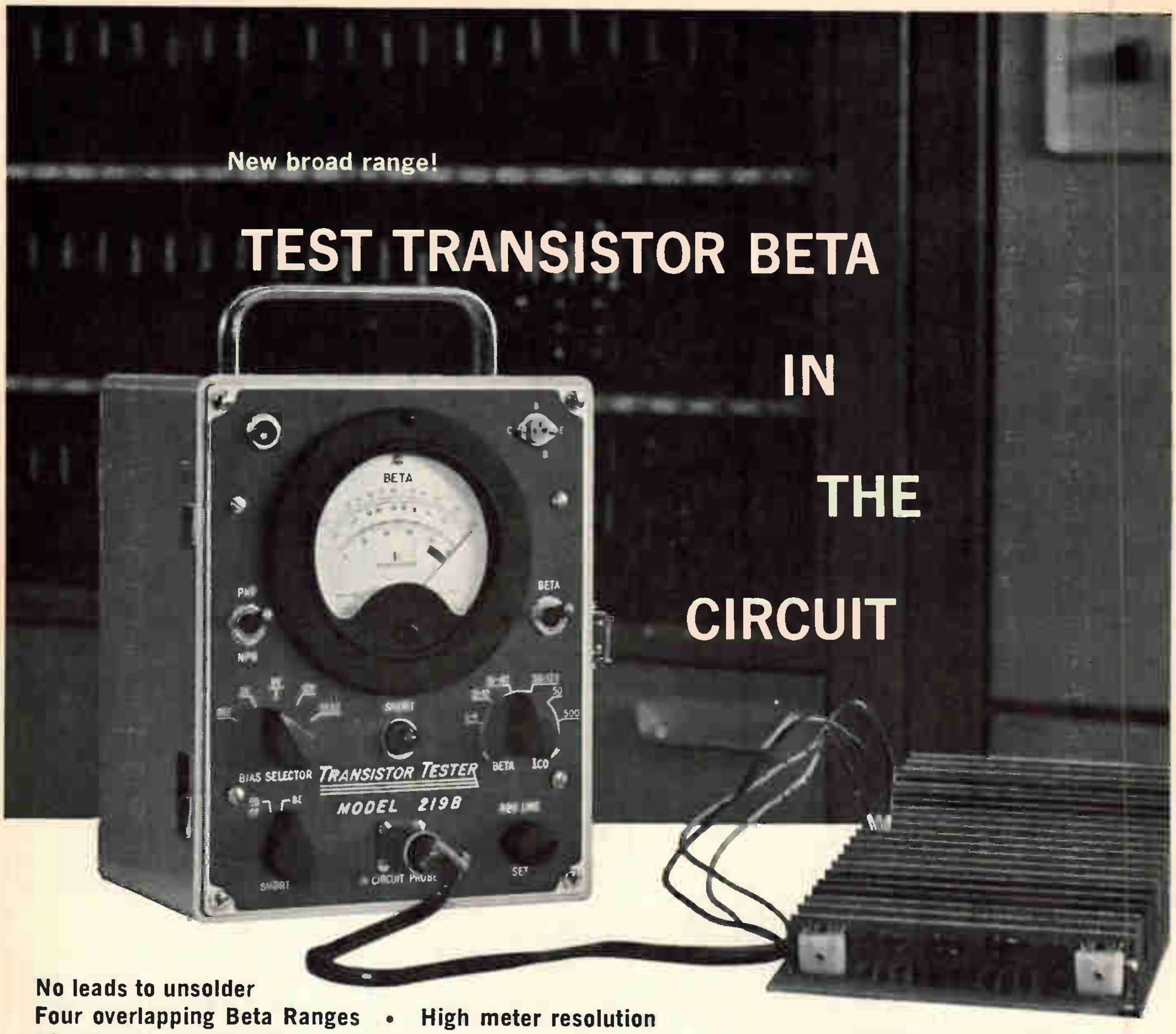
An error was indeed made; one of our typists apparently experienced a blackout not explained by any known theory, and transcribed what was a "9" in the original copy as a "16." Reader Nelson, as propagation analyst for RCA Communications, knows every behavior anomaly in transatlantic communications by its first name.

Antisub Flop?

I was reading your "Navy Testing Antisub Alarms (p 26, Jan. 13) at the precise time that our Navy and others were trying to find the good ship *Santa Maria*. My reaction to the story was a horse-laugh: here we see the Navy filling the ocean with equipment, playing a cloak-and-dagger game with code names and coining new words like lofar and sofar; the result is supposed to be a system or systems to locate and track intruding submarines—and a crude comic-opera piracy leaves them helpless. If all our talents couldn't serve to locate a great big cruise ship, how will we ever expect to find a silent deep-sounding submarine?

A. E. LANDER
WASHINGTON, D C.

We're fairly certain that "all our talents" weren't brought to bear on the Santa Maria; *Task Group Alfa, for instance, wasn't in on the game, and that group is our best tactical antisubmarine force. But even so, reader Lander merely points up what we've suggested before: that the antisubmarine effort needs a great deal more attention from the electronics technology than we've heretofore given it.*



No leads to unsolder
Four overlapping Beta Ranges • High meter resolution
Direct reading with test circuit power off

New Sierra 219B 4-range Transistor Tester reads Beta directly in the circuit; also measures I_{co}, Beta out of circuit.

Less downtime and less danger of damage to transistors under test with this new Sierra instrument—battery-operated, light weight, portable, easy to use.

Maintenance, quality control, incoming inspection and production testing are just a few of the applications where you save time and money by testing transistors, even complete assemblies, without unsoldering leads. Model 219B reads Beta in the circuit, 1 to 120. I_{co} is measured on a straightforward basis; collector potentials of 3, 6 or 12 vdc may be selected. All controls are on the front panel . . . an instrument of convenience, speed, accuracy.

Write or phone today for information and demonstration.

SPECIFICATIONS

Test ranges	
Beta	1-4, 3-12, 10-40, 30-120*
I_{co}:	0-50, 0-500 ua
Accuracy	
In circuit:	±20% for external loads over 500 ohms. Improved accuracy above 500 ohms, usable readings below 500 ohms.
Out of circuit:	±10%
Power:	Internal battery, mercury or zinc-carbon type, 600 hrs. av. life; output indicated on front-panel meter.
Operating Temperature:	32 to 149° F
Size:	9" high, 7⅝" wide, 6½" deep, weight, 10¼ lb., including batteries.
Price:	$275.00

*Beta readings to 300 may be approximated.

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6919

ELECTRONICS NEWSLETTER

Gas Maser Operates In Near Infrared

CONTINUOUS-WAVE maser operating in the near-infrared was demonstrated last week by scientists from Bell Telephone Laboratories. Device is a gaseous-discharge maser, thus differing from previously reported optical masers which use solid state phenomena (ELECTRONICS, p 43 July 22 '60 and p 11, Dec. 23, '60).

The Bell optical maser operates when a low-powered electrical discharge—of the order of tens of watts—is induced through external electrodes in a tube filled with a neon-helium mixture. Energy radiated, on demand, by the stimulated neon atoms has been observed in present laboratory model as a coherent stream of ir at five wavelengths between 11,180 and 12,070 angstroms. Strongest oscillation occurs at 11,530 A with an output power of 15 milliwatts. Lines measure between ten and eighty kilocycles wide, and the angular spread of the beam is less than one minute of arc.

Bell scientists have been experimenting with several methods of modulation. They demonstrated the impression of a telephone conversation by using a Kerr cell modulator. Broadband modulation has been accomplished at frequencies up to 60 Kc. Effort over the next few years will be aimed at developing efficient and economical modulation schemes for operation in the gigacycle range.

Air Force Will Get Big Special-Purpose Computer

GIANT SPECIAL-PURPOSE digital data-processing system is being delivered by Melpar to the Air Force. The system is called Finder, occupies some 7,000 sq ft, employs about 70,000 transistors.

A Burroughs 220 computer is incorporated into Finder, as well as buffer storage units from Ampex Computer Products and an Anelex high-speed printer. Data in either analog or digital form come in on tape, are translated to computer language. Drum memory of 31.5 million bits (on seven drums) holds input and stored correlation data. Two arithmetic units operate on 300-Kc and 500-Kc clocks. A plotting board is included among output units.

Air Force is thought to be using Finder as a countermeasures analyzer.

1960 Worst Year For British Tv Sales

TELEVISION SALES in Britain fell further in December to make 1960 the worst year for tv in the records of the Radio-Tv Retailers Association. Sales were 9.5 sets per shop in December, compared against 10 in November and 15.8 in December '59. Radio sales meanwhile rose from 12.7 sets per shop in November to 17.4 in December; year-ago figure was 22.3 sets.

Physicists Hear Reports On Ion Pulses, Plasma

CONCLAVE of the American Physical Society held last week in New York heard reports on many physical phenomena of interest to electronics. Among them:

A research technique for timing and studying atomic events on a nanosecond scale which uses a pulsed ion linear accelerator. The device, built by High Voltage Engineering, consists of a 3-Mev Van de Graaff positive-ion accelerator equipped with a preacceleration pulsing system capable of producing 10-nanosec bursts, and a post-acceleration Mobley magnet which concentrates the ion burst into less than a nanosecond. Preliminary considerations suggest that, with suitable changes, useful compression could be achieved at energies in the 10-12-Mev range, so that the Mobley magnet might be a useful accessory for a tandem accelerator.

General Electric has used hot ionized gas passing through a magnetic field of 2,300 gauss at a shock velocity of Mach 30 to produce an open-circuit voltage across terminal electrodes of 236 v. Maximum current obtained from the plasma was 115 amp lasting for a few microseconds; maximum power output was 7.8 Kw.

Possibility of a magneto-triode—a two-element device that uses a magnetic field to serve the function of a control grid—was also discussed at sessions dealing with tunneling in superconductors.

Develop Low-Current Peltier Cooling Device

RECENTLY DEVELOPED thermoelectric heating-cooling device, reportedly requiring a tenth the current of previous Peltier units, has been revealed by Hughes Aircraft. Operating on 2 amp of current, the device can freeze or boil a drop of water depending on current direction. A three-stage cascade can produce temperatures of –100 C and is currently being evaluated in an infrared detector application.

Prime applications, Hughes predicts, will be for maintaining even temperatures aboard spacecraft and serving as an instant-defrosting refrigerator. Spot cooling of critical electronic components with the Peltier unit may increase reliability by as much as 500 percent, Hughes thinks. Extremely low power requirement of the device, which is smaller than a paper clip, is due to a novel technique for fabricating the thermoelectric material.

Alloy Remains Superconductive In 88,000-Gauss Field

RESEARCHERS at Bell Telephone Labs report having observed superconductivity in the unusual alloy niobium-three-tin at average current densities of 100 kilamps per sq cm in magnetic fields as large as 88 kilogauss, with indications that superconductivity persists at still higher field strengths.

Observations suggest feasibility of constructing superconducting solenoid magnets capable of producing fields approaching 100 kilogauss with very small expenditures of electrical current. Such fields would be useful in lab work and for containing thermonuclear plasmas.

High transition temperature of

Nb_3Sn had previously been predicted by Bell scientists. The material is normally brittle and thus difficult to draw into magnet wire. To solve the problem, tubes of niobium 0.6 cm o.d. and 0.3 cm i.d. were packed with a mixture of powdered Nb_3Sn plus a 10-percent-by-weight excess of powdered tin (or similar mixtures of unreacted tin and niobium). Ends of the tubes were closed with niobium plugs; the tubes were then mechanically reduced to 0.038 cm o.d. and heated to between 970 C and 1,400 C for periods up to 24 hours.

Soviets Report Space-Flight Bio Effects

COMMENTING on the Mercury test that lofted a chimpanzee down the Atlantic Missile Range recently, Soviet academicians commented that flights below the Van Allen belts don't cause "major disturbances of physiological functions," went on to say:

Successful use of telemetry and television has made possible the comparison of life processes in spaceflight and on earth. Cellular fission is speeded up under spaceflight conditions in the case of pea, corn and wheat seeds. Definite modifications were noticed in cellular mitosis of mouse marrow. Soviet scientists ascribe the stimulating—and perhaps harmful—effects to "a whole complex of factors," according to Tass, which did not list the factors.

Japan Exports to U.S. Reported Leveling Off

BUSINESS & DEFENSE SERVICES Administration reported last week that Japanese exports of electronic products to the U. S. totaled $24.3-million for the third quarter of 1960, up only slightly from the $24.1 million of third-quarter 1959.

Imports of sound recorders and reproducers increased fivefold; receiving-tube shipments increased more than 50 percent; radiophonograph imports doubled; tube-type radio imports trebled. Quotas on shipments of transistors, and on radios with three or more transistors, were responsible for cutting sales of transistor radios by a third and transistors by two thirds. Items in which shipments increased are not subject to quotas.

Tv exports to the U. S. were not significant (2,555 units valued at $124,000 in third-quarter 1960). However, indications are strong that Japan may be trying to open a market for tv sets in Canada. One Japanese manufacturer has asked to have an 8-in. portable tv approved by the Canadian Standards Association. Entertainment-type tubes of Japanese manufacture have been embargoed out of Canadian markets since late last year; transistor-radio quotas for 1961 are now being negotiated.

Air Force Testing Nuclear Thermoelectric Unit

LIGHTWEIGHT NUCLEAR GENERATOR that converts heat directly into electrical power is undergoing performance test at USAF's special weapons center in New Mexico. Unit weighs less than 40 lb, was designed by Westinghouse. Air Force hopes to use it for powering unmanned surface radio beacons and weather stations.

Generator produces 150 w, can work for a year. Curium-242 and similar radioisotopes serve as heat source; 144 semiconductors convert the 1,000-F heat into power.

Finned heat exchangers will be used to keep external element temperatures at 300 F.

Space Agency Will Launch Ionosphere Beacon Satellite

FORTHCOMING launch of a Juno II from Cape Canaveral—which will be assigned an Explorer-sequence number of successful—will attempt to gain more knowledge of the ionosphere. Payload satellite is temporarily designated S-45, resembles Explorers VII and VIII, has a 6-ft loop antenna around its waist for transmitting low-frequency signals.

The 74-lb satellite will be aimed into a fairly low 2-hour orbit, will transmit signals on six frequencies at various power levels.

Various ground stations will analyze the signals for changes in polarization or doppler shift to explore ionospheric topography and density.

Suggest Balloon Relay For Communications Use

RADIO PROPAGATION DIVISION of Japan's Communications Laboratory (part of the Postal Ministry) told ELECTRONICS last week that a combination of kite and balloon—a kytoon, as the lab is calling it—is being considered as a stratospheric relay for communications use.

Kytoons would float about 12 miles up, be fairly well fixed in position. RPD chief Sukemoto Kawazu figures that 10 of the relay stations could reach the U. S. from Japan running along the Aleutians; he also estimates that, skipping via India, 20 could reach London. Cost to cover the Northern Pacific route would be about $8.3 million. Use of frequencies above 10 Gc would eliminate fading, the RPD chief says.

European Firm Resists Soviet Trade Pressure

CHIEF EDITOR W. W. MacDonald of ELECTRONICS, currently working his way across Europe, cables that at least one of the major manufacturers on the continent has firmly resisted a suggestion from his own country's Foreign Office to ship electronic goods to the USSR.

Compatriot companies have accepted shipbuilding and other business from behind the Iron Curtain; the company in question objects as a matter of principle to what comes back in return—exported political propaganda. The firm sells nothing knowingly in either the USSR or Communist China.

Space Surveillance Station To Close Mid-Continent Gap

PRESENT GAP in the transcontinental fence of space surveillance stations will be closed this spring when a 560-Kw transmitter is completed near Archer City, Tex.

RCA is building the transmitter gear for the Navy. The mile-long surveillance antenna is being built by Antenna Systems of Hingham, Mass.

3 in 1

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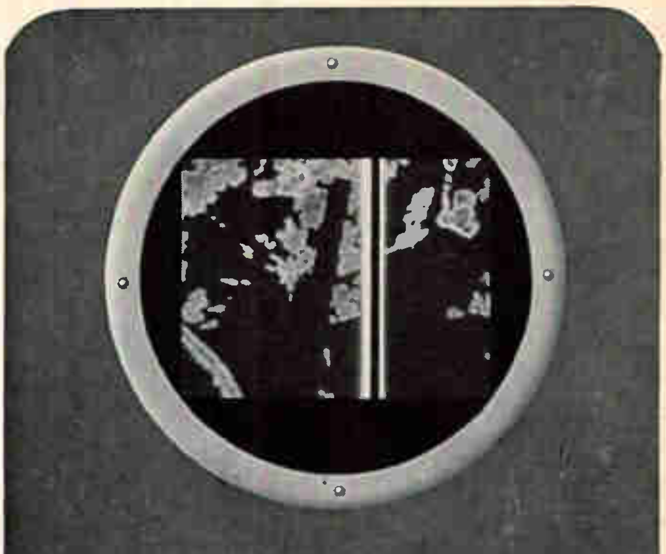
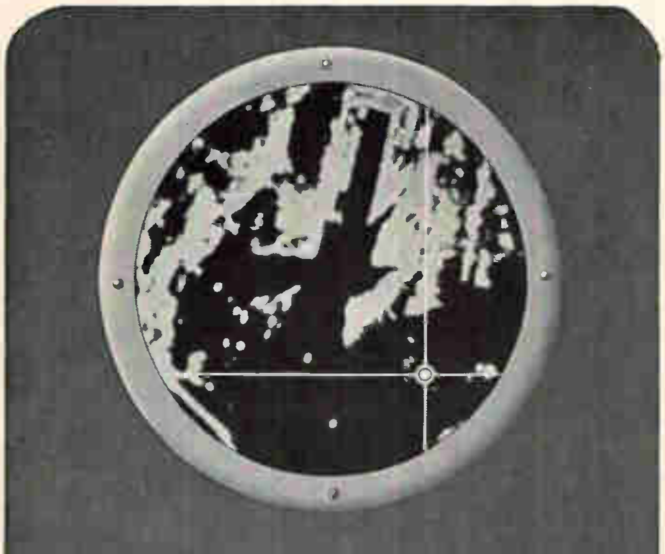
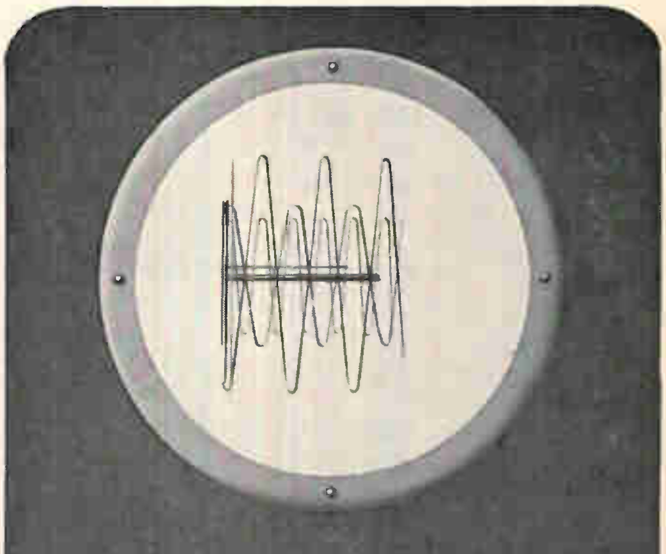


SELECTIVE ERASURE



NON-STORING DYNAMIC CURSOR



DARK TRACE WRITING

With this unique Hughes BIC* Storage Tube you can now:

- **Maintain continuous optimum display brightness**
- **Present dynamic cursors on stored displays**
- **Produce dark trace line or half-tone images**
- **Selectively eliminate screen clutter**
- **Obtain much higher resolution on all displays**

The new Hughes BIC* Storage Tube retains all of the characteristics of the TONOTRON** storage tube—controllable persistence, high picture brightness, full half-tone (grey) scale—and gives you the *added advantages* of selective erasure, simultaneous presentation of stored and non-stored information and high resolution dark trace writing.

For full information on the new Hughes BIC* Storage Tube, write or wire *today:* HUGHES, Vacuum Tube Products Division, 2020 Short Street, Oceanside, Calif. For export information, write: Hughes International, Culver City, California.

* Bombardment Induced Conductivity ** Trademark Hughes Aircraft Company

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HUGHES

HUGHES AIRCRAFT COMPANY
VACUUM TUBE PRODUCTS DIVISION

Only EX-CELL-O Contour Projectors* Give You ALL!

CHECK THESE FEATURES!

LARGEST WORK AREA—Constant eight inches of work space from lens to focal plane regardless of magnification. Plenty of room for large objects.

UNSURPASSED ACCURACY—Famed Kodak Ektar® lenses guarantee reliable measurements with clear *accurate* images over entire screen.

BRILLIANT SURFACE ILLUMINATION—Original design, "direct-on" built-in surface illuminator gives extra bright image and *full work clearance* at all magnifications.

ERECT–UNREVERSED IMAGE—Correct, normal appearing images at all magnifications, eliminate confusion, simplify operation and save time.

COATED LENSES AND MIRRORS—Produce clear sharp images characteristic of Ex-Cell-O Contour Projectors. Have been standard on all models for many years.

BRIGHT, GLARE-FREE SCREEN—The "Fresnel" lens is exclusive with Ex-Cell-O, permits operator to see entire screen evenly illuminated from normal position. No "hot spots".

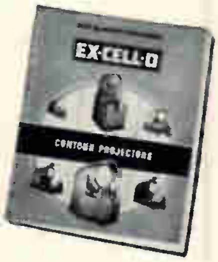
TRUE MEASURING PRECISION—All Ex-Cell-O Contour Projectors not only read to tenths—they measure to tenths.

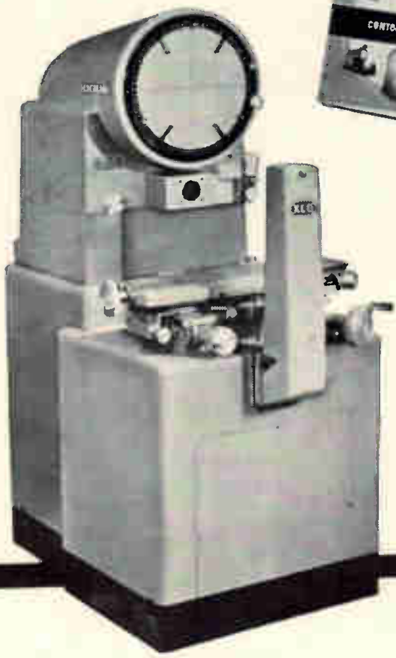
FINGERTIP CONTROLS—Ex-Cell-O Contour Projectors are designed for maximum convenience and comfortable all day operation. Easy-to-reach controls.

RUGGED CONSTRUCTION—The long established reputation of Ex-Cell-O for precision and quality assures years of trouble free operation.

YOUR OGP REPRESENTATIVE—Will help you make sure you get the right Ex-Cell-O Contour Projector to fit your optical gaging requirements. Call him today!

Write for new edition of EX-CELL-O Contour Projector Booklet—Available Now!





*Manufactured by EX-CELL-O Corporation at Detroit, Mich.

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26 FORBES STREET ROCHESTER 11, N. Y.

(A subsidiary of EX-CELL-O Corporation)

WASHINGTON OUTLOOK

NEW ADMINISTRATION is speeding up Navy's Polaris program and production of transport aircraft. Contracts for at least five Polaris submarines and close to 100 additional missiles will be awarded by June, some nine months earlier than called for in original schedules.

Six Polaris-type subs have already been launched; eight others are in various stages of construction and will be ready at intervals between now and early 1963; the new orders will affect the 15th through 19th vessels. Navy's objective is a Polaris fleet of 45 submarines, originally scheduled at the rate of five new starts a year. The speedup doubles the number of starts for this year.

It's still unclear how much transport aircraft production will be stepped up. The Air Force has $310.7 million this year for airlift modernization. It will now be authorized to award the contracts faster. Next year's budget proposal, as it now stands, earmarks only $194 million for transport-craft procurement.

INTENSIVE REAPPRAISAL of the nation's defense is now underway; it is aimed at reshaping basic defense policies in line with a reassessment of the military threat and a different evaluation of how to meet it.

The Pentagon has set up four task forces to make inquiries into strategic weapons systems, U. S. military commitments and limited-war requirements, over-all weapons development, and base requirements. The results will show up in amendments to ex-President Eisenhower's budget for fiscal 1962, and will provide the framework for longer-range strategic planning.

Besides adding about $1.5 billion to the $42-billion military appropriation request submitted by the outgoing administration, the reevaluation of defense policies will probably cause a reshuffling of funds for individual projects. The mood of the new administration has changed from its preelection feverishness; as one top-level Kennedy official puts it, it now seems that "There's much more to be gained by spending $42 billion or so more nearly correctly than by simply adding billions to the budget."

By ordering a speedup in defense spending during the current fiscal year, President Kennedy faces the possibility that he may need to go before Congress for supplemental appropriation requests before July 1.

NATIONAL AERONAUTICS & SPACE ADMINISTRATION has earmarked $35.8-million in the fiscal 1962 budget for its project Relay, the active communications satellite for which it asked bids last week (ELECTRONICS Newsletter, p 10, Feb. 3). NASA also expects industry to contribute $10 million or so in joint work on the system.

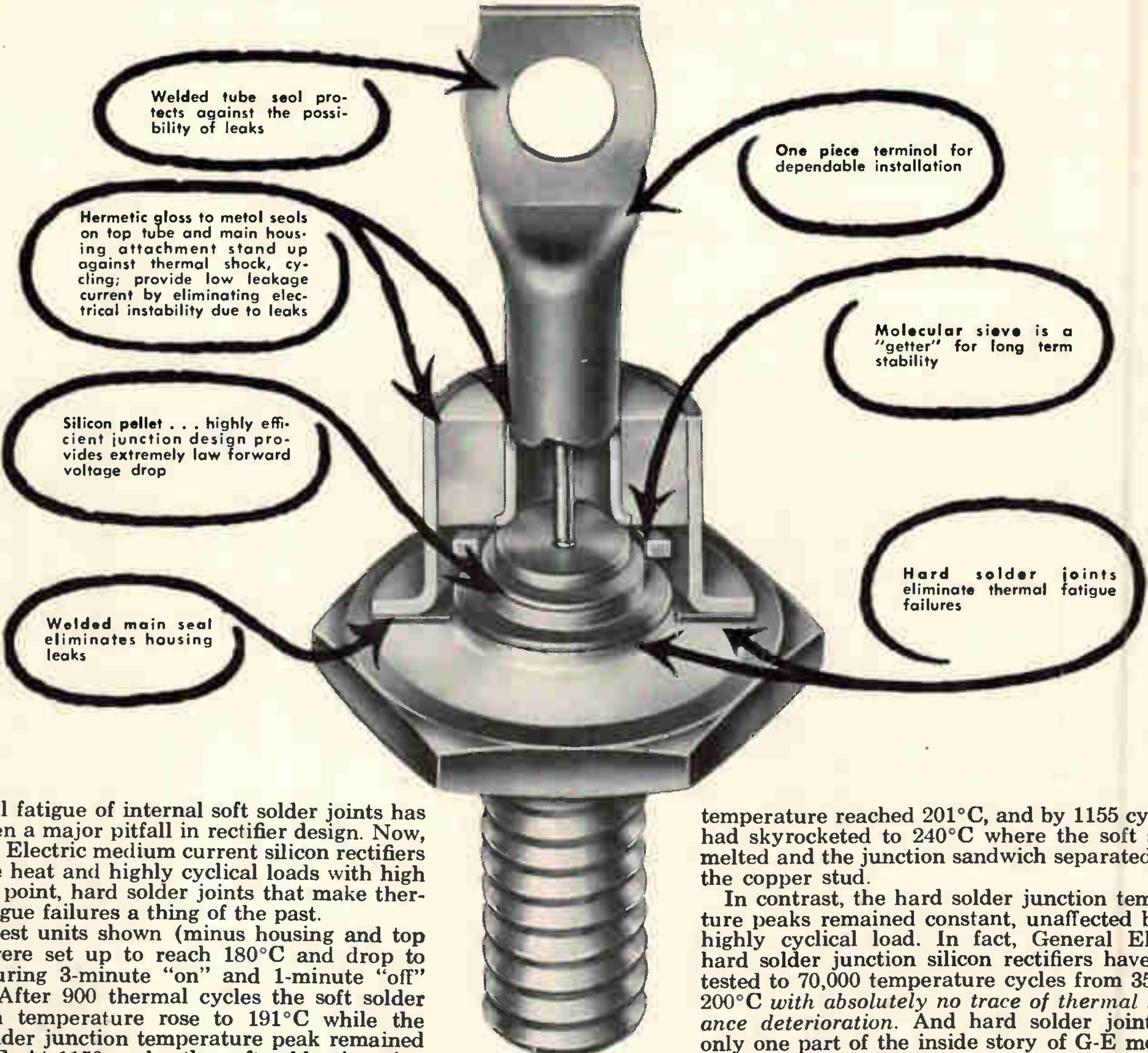
Appointment of James E. Webb to head NASA indicates cooperation between the agency and the Senate. Webb is an associate of Sen. R. S. Kerr (D., Okla.), Vice President Johnson's right hand man for space matters. Hugh Dryden continues as deputy administrator of NASA.

Meanwhile, the Federal Communications Commission has cleared the way for AT&T to proceed with experimental work on the company's plan to develop its own satellite communications system. The company hopes to launch its first satellite within a year, ultimately plans to have a system of 50 satellites and 13 ground terminal stations.

ALPHANUMERIC PAGE-READER for use in commercial data-processing systems is now in production. The solid-state device was developed by Intelligent Machines Research subsidiary of Farrington Manufacturing.

The page-reader scans a page at a time, then translates the information to paper tape at a rate of 240 characters a second. Unconfirmed reports suggest that Western Union has contracted for two machines for use in over-the-phone telegrams. Telephone operators would type incoming messages, then merely put the typewritten message in the scanner for processing and transmission.

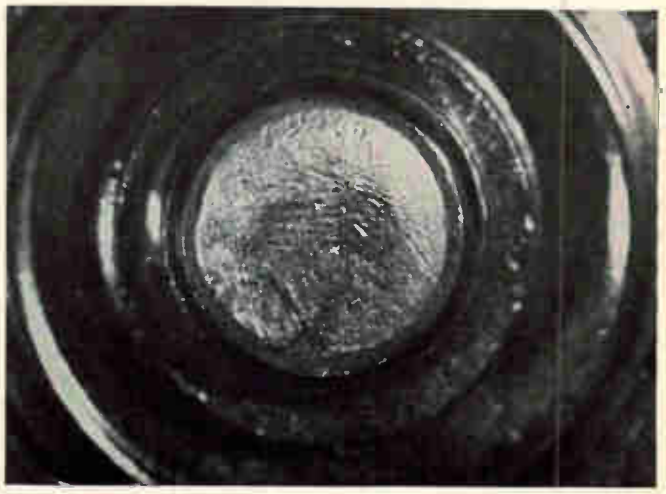
Free from Thermal Fatigue – the



Thermal fatigue of internal soft solder joints has long been a major pitfall in rectifier design. Now, General Electric medium current silicon rectifiers beat the heat and highly cyclical loads with high melting point, hard solder joints that make thermal fatigue failures a thing of the past.

The test units shown (minus housing and top lead) were set up to reach 180°C and drop to 40°C during 3-minute "on" and 1-minute "off" cycles. After 900 thermal cycles the soft solder junction temperature rose to 191°C while the hard solder junction temperature peak remained at 180°C. At 1150 cycles the soft solder junction temperature reached 201°C, and by 1155 cycles it had skyrocketed to 240°C where the soft solder melted and the junction sandwich separated from the copper stud.

In contrast, the hard solder junction temperature peaks remained constant, unaffected by the highly cyclical load. In fact, General Electric hard solder junction silicon rectifiers have been tested to 70,000 temperature cycles from 35°C to 200°C *with absolutely no trace of thermal resistance deterioration.* And hard solder joints are only one part of the inside story of G-E medium current silicon rectifiers.



The two test units are shown here. Before the test they were identical in every respect, except that the unit on the left uses conventional tin-lead soft solder, while the unit on the right uses exclusive G-E hard solder joints.

Inside Story of General Electric Medium Current Silicon Rectifiers

DESIGNED FOR THE 2 TO 30 AMPERE RANGE... General Electric medium current silicon rectifiers offer important extra advantages for your circuit designs:

- high current operation with minimum space requirements
- high junction temperature rating and extremely low voltage drop and thermal impedance
- available with negative polarity (stud is anode)
- transient PRV ratings mean safer application
- may be mounted directly to chassis or fin, or may be electrically insulated from heat sink using mica washer insulating kit provided
- conservative ratings for maximum reliability under all operating conditions
- all of these same rectifiers are available in a wide range of rugged stack assemblies complete with cooling fins, connection terminals and mounting brackets.

Medium Current Silicon Rectifier Cells

JEDEC & GE Type Number	Repetitive PRV	Transient PRV	Max I_{DC} @ 145°C Stud Single Phase	Max. Rev. Cur. (Full Cycle Av. @ Full Load)	Max. Full Load Voltage Drop	Max. Oper. °C
				@ 150°C Stud	@ 150°C Stud	
1N1341A	50	100	6A	3.0 ma	.64V	200°
1N1342A	100	200	6A	2.5 ma	.64V	200°
1N1343A	150	300	6A	2.25 ma	.64V	200°
1N1344A	200	350	6A	2.0 ma	.64V	200°
1N1345A	300	450	6A	1.75 ma	.64V	200°
1N1346A	400	600	6A	1.5 ma	.64V	200°
1N1347A	500	700	6A	1.25 ma	.64V	200°
1N1348A	600	800	6A	1.0 ma	.64V	200°
1N1199A	50	100	12A	3.0 ma	.55V	200°
1N1200A	100	200	12A	2.5 ma	.55V	200°
1N1201A	150	300	12A	2.25 ma	.55V	200°
1N1202A	200	350	12A	2.0 ma	.55V	200°
1N1203A	300	450	12A	1.75 ma	.55V	200°
1N1204A	400	600	12A	1.5 ma	.55V	200°
1N1205A	500	700	12A	1.25 ma	.55V	200°
1N1206A	600	800	12A	1.0 ma	.55V	200°
					25°C T_J	
1N248	50		10A	5.0 ma	1.5V*	175°
1N249	100		10A	5.0 ma	1.5V*	175°
1N250	200		10A	5.0 ma	1.5V*	175°
1N248A	50		20A	5.0 ma	1.5V**	175°
1N249A†	100		20A	5.0 ma	1.5V**	175°
1N250A†	200		20A	5.0 ma	1.5V**	175°
				@ 145°C Stud		
1N2154	50	100	25A	5.0 ma	0.6V	200°
1N2155	100	200	25A	4.5 ma	0.6V	200°
1N2156	200	350	25A	4.0 ma	0.6V	200°
1N2157	300	450	25A	3.5 ma	0.6V	200°
1N2158††	400	600	25A	3.0 ma	0.6V	200°
1N2159	500	700	25A	2.5 ma	0.6V	200°
1N2160	600	800	25A	2.0 ma	0.6V	200°

*@25A — †B types available as SIGNAL CORPS approved units.

**@50A — ††Signal Corps approved units available as USA 1N2135A.

For complete information on General Electric thermal-fatigue free medium and high current silicon rectifiers, see your G-E Semiconductor District Sales Manager. For additional technical data, write Section 25B2, Rectifier Components Department, General Electric Company, Auburn, New York. In Canada: Canadian General Electric Company, 189 Dufferin St., Toronto, Ontario. Export: International General Electric Company, 150 East 42nd Street, New York, N. Y.

For fast delivery at factory-low prices in quantities up to 999, see your local G-E Distributor

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R&D Tab May Hit $16 Billion In '62

THIS YEAR'S R&D expenditures will run to about $14 billion and may hit $16 billion by 1962 according to L. A. DuBridge, president of California Institute of Technology.

These forecasts and others came out of a recent Business Outlook Conference sponsored by the Los Angeles Chamber of Commerce.

DuBridge said today's growth rate of 10 to 15 percent for research and development should continue through the year. He added that southern California's share of such spending should increase.

The highest growth rate in southern California's economy is in industrial electronics according to J. H. Richardson, vice president of marketing at Hughes Aircraft. Industrial electronics, largely composed of computers and measurement and control devices, should expand 15 percent a year during the next decade according to Richardson. The industrial sales outlook this year is for a ten-percent gain; consumer products may see a two-percent rise. Defense activity will increase four percent.

W. J. Pattison, Garrett Corp. vice president of sales, said defense spending was between $40 and $42 million for the period 1956 to 1960. He anticipates that 1961 will see the total swell to $43.5 and continue to about $55 million by 1970. Expenditures by National Aeronautics and Space Administration will grow from the $500-million level in 1960, hit just under $1 billion in 1961 and amount to $2.2 billion by 1970.

Air Force spending is expected to near $19 billion during this fiscal year of which $5 billion will go for aircraft procurement, $3 billion will go for missiles and astronautics and $1 billion for other weapons. By 1970, the $19-billion figure is expected to rise to $23 billion. Pattison sees these figures as pointing up the continued importance of manned aircraft, adds that Minuteman will be the largest single AF project in fiscal 1962 and is expected to absorb $800 million.

Navy expenditures are expected to total $13 billion next year, rise to $16 billion in 1970. The budget for Navy's biggest project, Polaris, came to $1.234 billion this year with an equal amount requested for 1962. Total bill for the missile, submarines and associated equipment is expected to hit $8 to $10 billion in 1966.

If the cold war continues, said Pattison, the Army budget of $12 billion for fiscal 1962 will rise to between $14 and $15 billion for direct procurement of aircraft and missiles. He added that funding for Nike-Zeus may be reduced from 1960's $500 billion to $300 billion this year.

U. S. IMPORTS of Japanese transistor radio batteries will rise 255 percent this year according to predictions by Battery Information Committee of the National Electrical Manufacturers Association.

Chairman of BIC, L. Schub, president of Acme Battery Corp., reports that last year 42 percent of the transistor radio batteries sold in this country were Japanese made, more than double the 1959 figure. The Committee forecasts a rise to 55 percent in 1961.

Based on Bureau of Census figures for battery imports from Japan in 1960, BIC says 8½ million Japanese transistor radio batteries entered the country last year. Prediction for this year is that the count will rise to near 20 million, about half of total Japanese production. This figure does not include batteries prepacked in radio sets, 3½ million of which were imported in the U.S. from Japan last year.

NOVEMBER was the best month in 1960 for sales of monaural phonographs, with factory sales up by 34,626 sets over the October total and retail sales up 47,994 according to the Marketing Data Department of the Electronic Industries

Association. Sales of stereophonic phonographs, however, were under the October total by 48,815 sets. Retailers sold 8,919 fewer stereos in November than in the previous month.

Total year's sales of monaural phonos for 1959 were 1,113,207 for factory. For 1960: 1,059,617.

Stereo fared better in both years with 1959 factory sales of 2,628,092 rising to 3,044,702 in 1960.

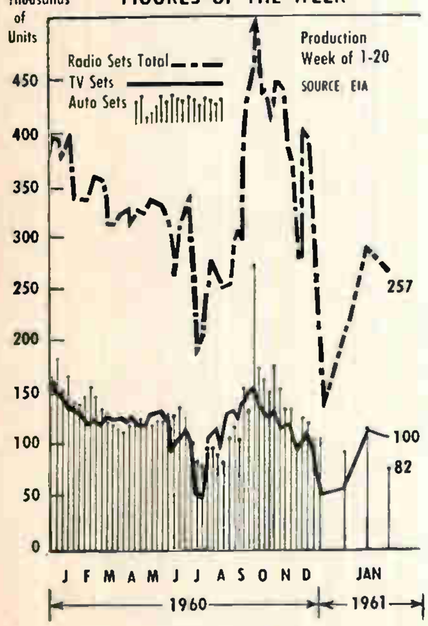
The corresponding retail sales figures are: monaural 1960-995,-784, 1959-1,423,148; stereo 1960-2,663,330; 1959-2,151,948.

NEW PROGRAM for compiling sales data on industrial electronic equipment has been established by EIA's Marketing Data Committee.

Under the group's proposed reporting format, manufacturers participating in the program will be asked to give sales figures in such categories as testing and measuring gear, computing and processing equipment, communications and navigational aids. Also slated for attention are medical electronics equipment and power supplies as well as other devices.

Data will be collected initially in broad product categories. As participation grows, however, the group hopes to refine the information. Plans are to compile and distribute the data quarterly.

FIGURES OF THE WEEK



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Phoenix
Radio Specialties & Appl. Corp.
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Tucson
Standard Radio Parts, Inc.
MA 3-4326
CALIFORNIA
Burbank
Valley Electronic Supply Co.
Victoria 9-3944
Glendale
R. V. Weatherford Co.
Victoria 9-2471
Hollywood
Hollywood Radio & Electronics, Inc.
HO 4-8321
Inglewood
Newark Electronics Company
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Federated Purchaser
BRadshaw 2-8771
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Brill Electronics
TE 2-6100
Elmar Electronics
TEmplar 4-3311
Palo Alto
Zack Electronics
DA 6-5432
San Diego
Radio Parts Company
BE 9-9361
San Francisco
Fortune Electronics
UN 1-2434
Santa Ana
Airtonic Sales, Inc.
Kimberly 5-9441
Santa Monica
Santa Monica Radio Parts Corp.
EXbrook 3-8231

COLORADO
Denver
Ward Terry Company
AMherst 6-3181
CONNECTICUT
East Haven
J. V. Electronics
HObart 9-1310
DISTRICT OF COLUMBIA
Electronic Industrial Sales, Inc.
HUdson 3-5200
FLORIDA
Miami
East Coast Radio & Television Co.
FRanklin 1-4636
Electronic Equipment Co., Inc.
NEwton 5-0421
West Palm Beach
Goddard Distributors, Inc.
TEmple 3-5701
ILLINOIS
Chicago
Allied Radio Corporation
HAymarket 1-6800
Newark Electronics Corp.
STate 2-2944
INDIANA
Indianapolis
Graham Electronics Supply Inc.
MElrose 4-8486
LOUISIANA
New Orleans
Columbia Radio and Supply Co.
TW 7-0111
MARYLAND
Baltimore
Wholesale Radio Parts Co., Inc.
MUlberry 5-2134
MASSACHUSETTS
Boston
Cramer Electronics, Inc.
COpley 7-4700
DeMambro Radio Supply Co., Inc.
AL 4-9000
Graybar Electric Co.
HUbbard 2-9320
Lafayette Radio Corp. of Mass.
HUbbard 2-7850
MICHIGAN
Ann Arbor
Wedemeyer Electronic Supply Co.
NOrmandy 2-4457
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UN 1-6700

MISSISSIPPI
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Ellington Radio, Inc.
FL 3-2769
MISSOURI
Kansas City
Burnstein-Applebee Company
BAltimore 1-1155
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Graybar Electric Company
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Evans Radio
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DElaware 9661
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ITthaca 2-3221
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BEekman 3-2980
Sun Radio & Electronics Co., Inc.
ORegon 5-8600
Terminal Electronics, Inc.
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OHIO
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Pioneer Electronic Supply Co.
SUperior 1-9411

Columbus
Buckeye Electronic Distributors, Inc.
CA 8-3265
Dayton
Srepco, Inc.
BAldwin 4-3871
OKLAHOMA
Tulsa
S & S Radio Supply
LU 2-7173
OREGON
Portland
Lou Johnson Company, Inc.
CApital 2-9551
PENNSYLVANIA
Philadelphia
Almo Radio Company
WAlnut 2-5918
Radio Electric Service Co.
WAlnut 5-5840
Pittsburgh
Marks Parts Company
FAirfax 1-3700
Reading
The George D. Barbey Co., Inc.
FR 6-7451
TENNESSEE
Knoxville
Bondurant Brothers Company
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TEXAS
Dallas
Graybar Electric Company
Riverside 2-6451
Houston
Busacker Electronic Equipment Co.
JAckson 6-4661
Harrison Equipment Company
CApitol 4-9131
UTAH
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Standard Supply Company
EL 5-2971
VIRGINIA
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Priest Electronics
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DAvenport 5-9151

SEE PAGE 5 FOR FURTHER INFORMATION.

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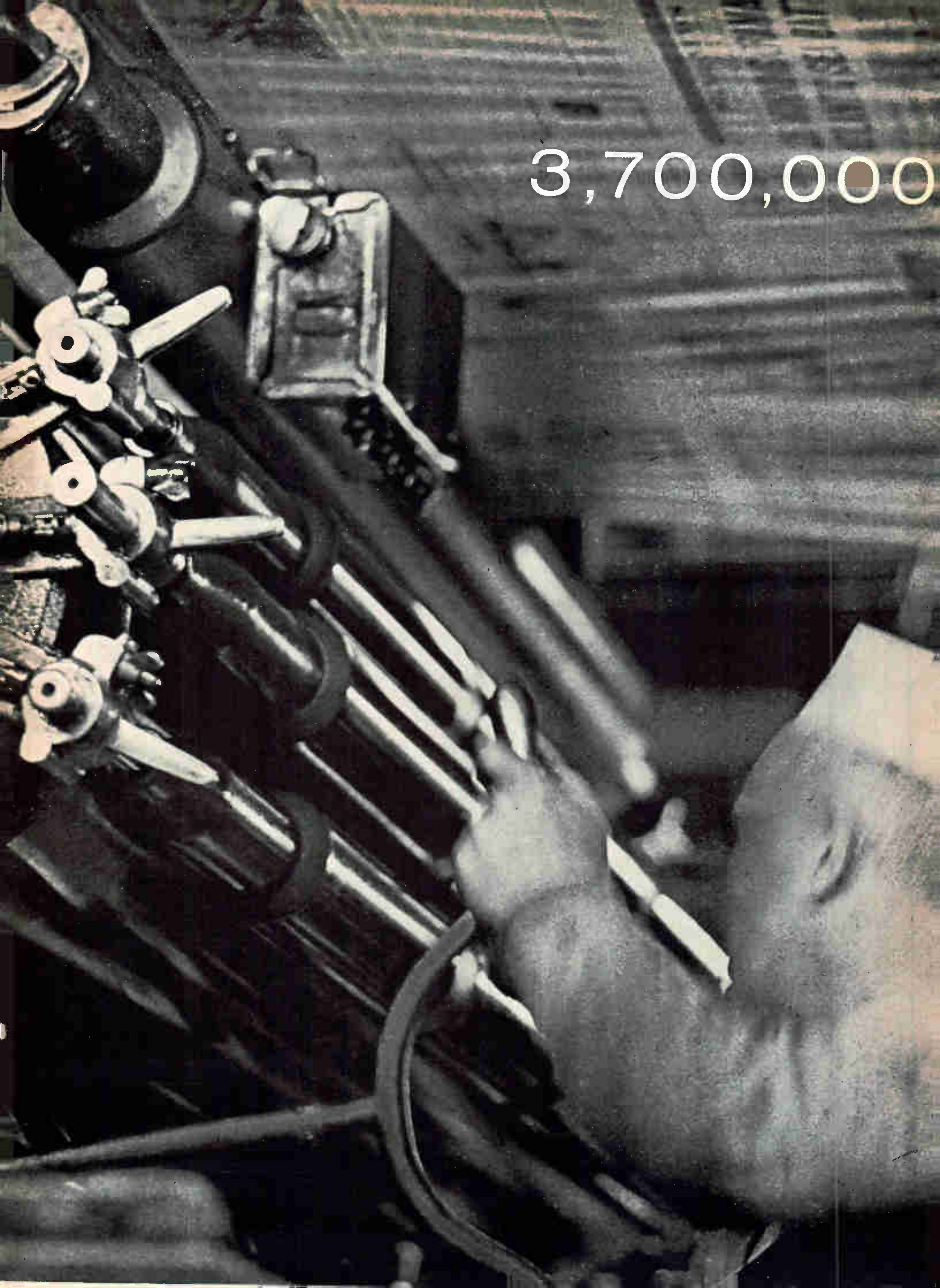

3,700,000

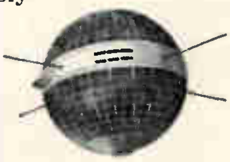
WORDS A DAY...

or more words than are teletyped every day by every wire service in the U. S.

This gives you some idea of the capacity of the new 500-pound Courier teletype satellite now orbiting the earth 14 times a day, 600 miles up.

Heart of the U. S. Army Courier system is a cluster of five five-pound magnetic tape recorder/reproducers made by Consolidated Electrodynamics. Four of them store and transmit teletyped messages. The other carries analog or voice messages.

Each CEC unit is programmed separately and has the capacity to record 55,000 data-bits per second, for five minutes on one channel, at a tape speed of 30 inches per second. After recording, the tape drive is reversed by command from the ground to reproduce the signal backwards.



The Courier satellite project is obviously important to our current defense effort. Less obvious, yet more important to us and our children, is its far-reaching implication of world-wide ground-space-ground communications. When a phone call to Antarctica will be as simple as one to your next door neighbor.

Why did the Department of Defense choose CEC for this delicate and far-reaching assignment? Experience, mostly. And imagination. They didn't ask "Can it be done?" They said, ***"Do it."***

And the company that (1) records 90% of *all* Atlantic-range missile-test flights, (2) went down with the Nautilus using mass spectrometers to test air contaminants, (3) went up with the B-58 to flight test the world's fastest bomber, (4) went higher with a satellite-carrying spectrometer to measure radiation, (5) designed "Micro-plant"—first unattended petroleum pilot plant, and (6) monitors, measures, analyses, controls and records almost anything for industry and defense ***did it.***

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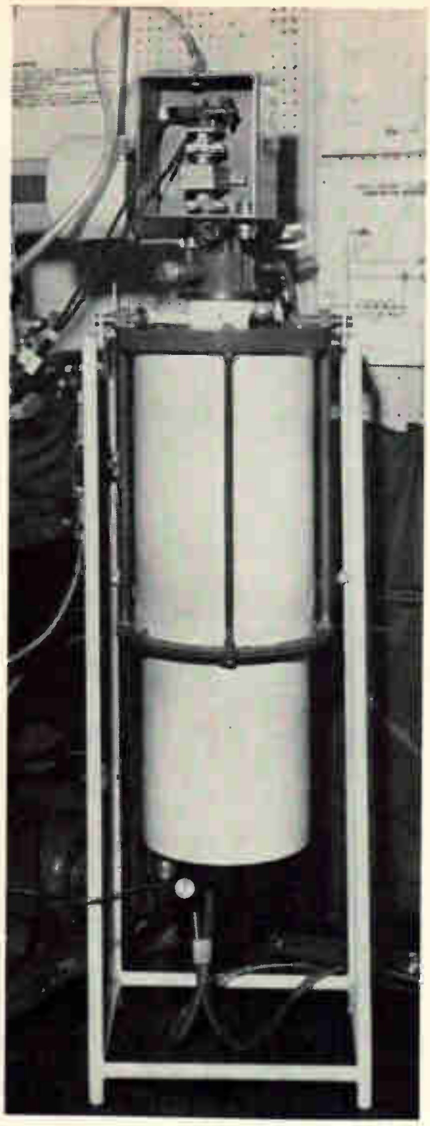
CIRCLE 23 ON READER SERVICE CARD

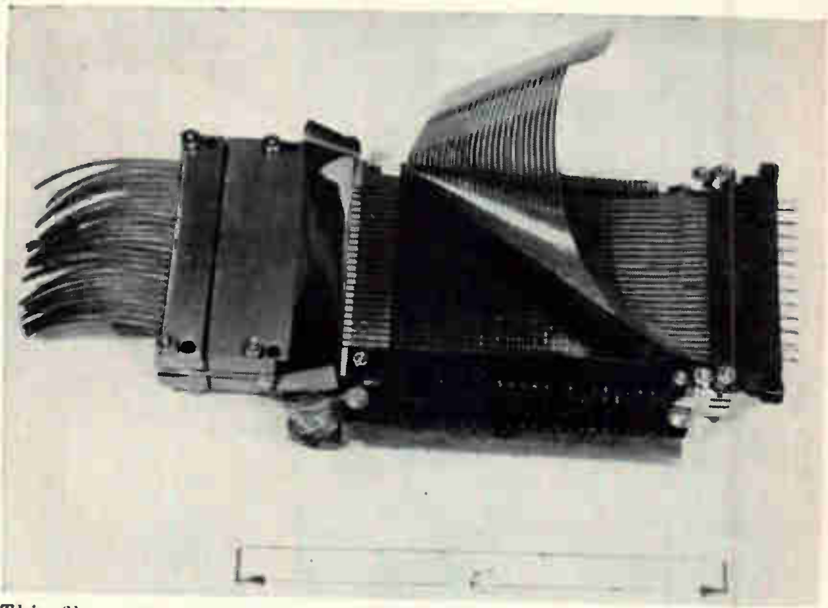
SOLID-STATE IS

Devices shown include magnetic-film memory, S-band maser, parametric amplifiers and new high-temperature ceramics. Majority of the instruments on display were electronic and many used transistors

By W. W. MACDONALD, Editor



Packaged S-band maser by Mullard



Thin-film memory by International Computers and Tabulators

British physics exhibition is short on creature comforts, long on technical information

THEME OF BRITISH PHYSICS SHOW

LONDON—EVEN BY BRITISH standards, the Exhibition of the Institute of Physics and the Physical Society held here late last month was singularly noncommercial. The 146 booths emphasized equipment, were otherwise unadorned, even for chairs. But engineers were in attendance at the booths and technical information in depth was readily available. There were only three technical papers. They were presented in the evening and were outstanding.

Here are a few high points of the exhibition.

A new principle in quadrature modulation for single-sideband operation was announced by Associated Electrical Industries. The signal is split by two phase-shift networks into quadrature components S_1 and S_2. The carrier is split into quadrature components C_1 and C_2. These are combined and signals $(S_1 + C_2)$ and $(S_2 + C_1)$ are applied to the input ports of a multiplier. The output signal is then $(S_1C_1 + S_2C_2) + (S_1S_2 + C_1C_2)$. The first term is the desired single-sideband output. The second term is unwanted but easy to suppress. The term C_1C_2 represents twice the carrier frequency and none of the components of S_1S_2 is above twice the highest speech frequency.

An experimental magnetic-film memory by International Computers and Tabulators stores fifty 50-bit words. The film matrix exploits a coherent rotational switching mode. Cycle time is a fraction of a microsecond. The memory consists of two aluminum plates covered with magnetic film, and the selection wires.

An instrument by the Royal Radar Establishment puts out pulses each separately variable in delay, width and amplitude. The equipment is made up of a square-wave generator, one or more triggered delayed-pulse generators and one or more output units. Each of four outputs from the square-wave generator can drive a triggered delayed-pulse generator. Each delayed-pulse generator can feed one or more output units. Output pulses can be on different lines or on one common line. System can deliver sharp 5-nsec pulses into 50-ohm cable. The system uses transistors good to 300 Mc.

An ultrahigh-frequency parametric amplifier by Marconi is contained in a single length of X-band waveguide. The uhf signal is converted to X-band. The amplifying element is a varactor diode. Pump frequency is 9 Gc. The X-band amplified output is reconverted to uhf by a conventional mixer crystal.

A radar beam position indicator by Elliott Brothers tells accurately and continuously the direction of a scanning radar at any time. Microwave phase sampled at two points in the near field of the beam is used to compute the angle of scan.

A swept-frequency X-band oscillator by Decca Radar has a ferrite rod in the rear cavity of a klystron. The tube is swept several megacycles in frequency by varying current in a coil around the rod. The oscillator is useful in automatic-frequency-control systems and broadband spectrum analyzers.

High-temperature ceramics by British Ceramic Research Association now being produced in pilot-plant quantities use boron nitride, silicon nitride and self-bonded silicon carbide.

Solid tantalum capacitors by Standard Telephone use a sintered porous tantalum body on which an oxide layer has been formed. Contact is made by a manganese-dioxide semiconductor.

Electroluminescent panels placed beneath maps and charts in airplanes make the maps and charts readily readable (Thorn Electrical).

Special resistors shown by Edward High Vacuum are made by depositing thin films of chromium or nickel-chromium alloy on glass.

Eye-movement measuring apparatus (ELECTRONICS, p 67, Sept. 25, 1959) made by EMI is now fully transistorized.

Mullard displayed a package S-Band cavity maser; Texas Instruments showed solid semiconductor networks of the type recently shown in the U. S.

Twin Planar Transistor Eases Matching Problems

TWIN TRANSISTOR—made up of two planar silicon units sharing a common collector—is being produced by RCA. The device eases problems involving the close matching of characteristics, normally done by selecting and testing for identity, the company claims.

"The twins are united in production and undergo almost identical stress, temperature, environment and other conditions critical in manufacture," says RCA's C. N. Lane.

"When completed and packaged as a single unit, he adds, they are similar "in electrical and thermal problems . . . and maintain the match over a wide range of operating points and temperatures."

African Site Readied For Space Tracking

JOHANNESBURG—Equipment is arriving at an isolated farm 20 miles from Krugersdorp in the western Transvaal, where the latest link in a space tracking network is going up.

Technicians from Patrick Air Force Base are assembling the 85-ft antenna that will track orbiting satellites. The tripod-mounted unit will weigh 120 tons. The station will also be able to pick up cosmic noises.

The South African installation will complete National Aeronautical & Space Administration's deep space network consisting of three identical radiotelescopes. The other two are at Goldstone, Calif., and Woomera, Australia.

The Krugersdorp station cost more than $6 million and will be linked to the United States by telex.

Air-Collision Avoidance Tests Begin

Federal Aviation Agency is checking several techniques, may write specs this year

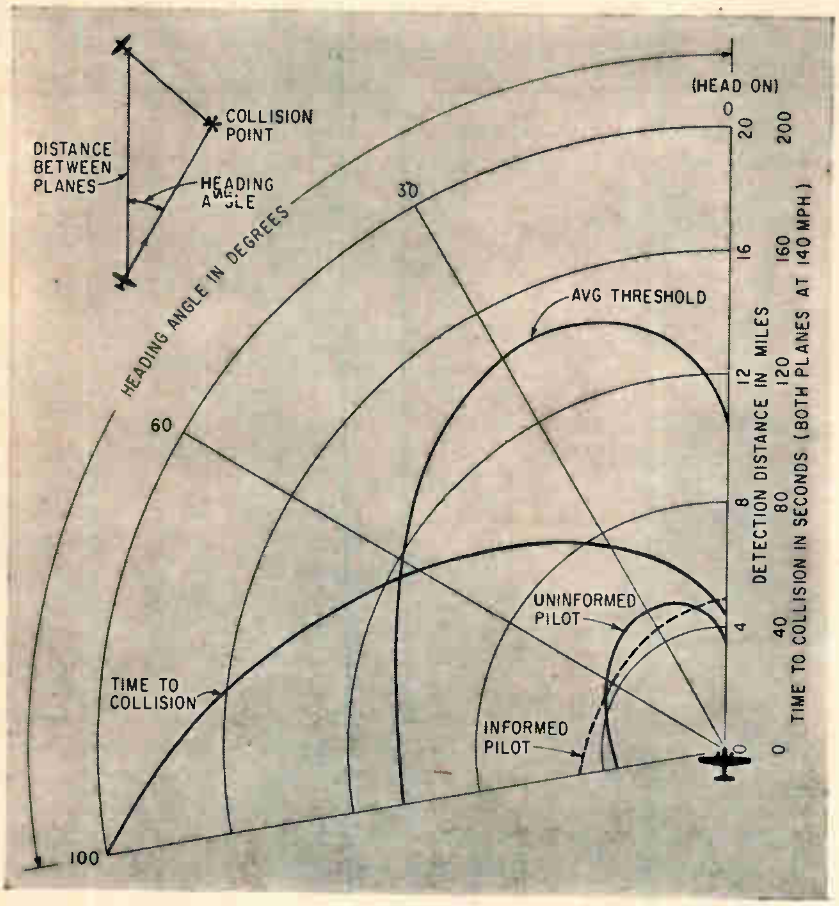
FLIGHT TESTS of two midair collision avoidance techniques have started and are to continue into April. The tests, by the Federal Aviation Agency, are feasibility and system studies, not tests of hardware or prototype equipment.

The former Civil Aeronautics Authority (superseded in 1958 by FAA) started a test program in 1948 to determine the ability of pilots to detect another plane on a collision course. Results, published in May 1957, indicated that pilots need to be told when and where to look if they are to avoid another aircraft. Information of this kind is necessary even in good weather.

The planes were DC-3's, flown in clear weather at 140 mph by airline pilots. Two types of flights were made: in one case the pilot did not know he was flying a collision course; in the other test he knew he was on a collision course but did not know the angle of approach. There was little difference in performance between the two types of tests. The threshold value (see figure) was established by a CAA observer who knew where and when to look.

Forty seconds, including airplane response time are usually required before an evasive maneuver can be effective. For two jets approaching head-on at 500 mph, decision must occur 11 miles before point of impact. The figure shows that for the average case, detection distance for zero heading is a little less than 4 miles.

That more collisions have not occurred is because planes must fly in assigned corridors and at assigned altitudes. Nevertheless, in 1959 there were 1,112 reports of near misses. Of these, planes came within 500 feet (defined as a near miss) in 425 cases and within 100 feet in 170 cases. In 75 percent of the near misses, visibility was 5 miles or better, and in half there was no time for evasive action.



Difference in sighting distance for a pilot who knows he is on a collision course and one who does not is minor, according to tests. Heading angles used were 0, 30, 60, and 100 degrees

The FAA believes the primary solution is positive ground control, with the flight of all aircraft continuously under surveillance by ground control centers. While positive ground control is several years away, collision avoidance equipment might be put to use within four years.

There are two approaches to airborne equipment for avoiding collisions. The first is CAS (Collision Avoidance System). It is a complete system that evaluates any collision threat and then either tells the pilot how and when to maneuver or performs the maneuver through the autopilot. It performs computation.

The other system is PWI (Pilot Warning Instrument); it furnishes the pilot with range, bearing and other flight parameters, but does not calculate the evasive maneuver. The pilot is the computer.

Two types of cooperative equipment that enables two planes on a collision course to exchange information and coordinate evasive maneuver are now being considered by FAA: one uses a transponder on each plane. In the other type, a series of pulses is sent out continually every five or ten seconds.

A CAS system proposed by Bendix Radio division, Towson, Md., is to be evaluated in flight tests. All aircraft transmit pulses that are spaced to provide altitude information. A listening aircraft receives a direct pulse and an echo pulse bounced from the ground. If the altitudes of the two planes provide safety, no further action is taken; if the altitudes are in the danger zone, collision threat is evaluated. Each aircraft, knowing its own altitude, the altitude of the intruder, and the time difference between the direct and first echo pulse, computes the distance to the intruder. Successive pulses are interpreted and the rate at which the range is changing is determined. The CAS calculates the time remaining before a plane must execute its escape maneuver. At a preselected time the listening plane makes a change in altitude, upward if it is above the intruder, downward if it is below.

Preliminary flight tests were made in Dec. 1960. A complete system is soon to be delivered to FAA and will undergo approximately 80 hours of flight time over 2 months.

Another cooperative CAS technique, proposed by Sperry Gyroscope Co., requires a transponder, flush-mounted Luneberg antenna, and computing circuits. The technique would also develop PWI information and might have advantages in congested terminal areas.

These two CAS systems will be tested to determine technique feasibility. But there are other active projects. A system by Motorola, is to be used to determine the information and accuracy a pilot needs from a PWI system.

A simulator study at NAFEC at Pleasantville, N. J. uses a cockpit mockup to study pilot reactions to collision threats. Initial studies are to find what information is needed in good weather, which exists during 80 percent of flights. Additional studies will be for night flights.

Tests have been conducted at NOTS, China Lake, Calif. using infrared techniques. Preliminary tests using aircraft engines as the ir source were not promising, but tests using the anticollision beacon on aircraft stabilizers showed aircraft could be detected ten miles away. Further tests using ir are to be conducted this June.

A number of other projects in being or proposed include: high intensity and fluorescent paint to improve aircraft spotting; artificial contrail techniques; psychological studies of visual factors; modification of airborne weather radar to include PWI information; analysis of advanced communication coding and data smoothing; exterior aircraft lighting for both day and night; and other activities and studies in altitude measuring equipment, air-traffic models, and effectiveness and feasibility of various aircraft escape maneuvers.

U.S. ARMY PHOTO

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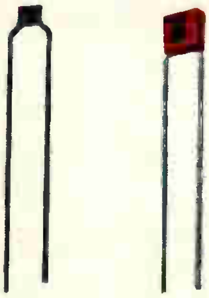

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NASA to Build Active Communications Satellite

SEVERAL ELECTRONICS firms will submit bid proposals to the National Aeronautics and Space Administration on March 6 for the agency's first active communications relay satellite system.

NASA recently described the requirements of Project Relay to representatives from 41 firms at a two-day briefing at the Goddard Space Flight Center, Greenbelt, Md.

NASA wants an 85-lb active relay satellite to be launched from Cape Canaveral, Fla. by a Delta rocket into an elliptical orbit (apogee—2,800 to 3,400 statute miles; perigee—650 to 1,600 mi) with an orbital period of 180 minutes.

Wide-band communication signals covering the range of tv, multichannel telegraphy and data handling will be transmitted between the east coast of the U. S. and Western Europe.

The payload will also carry instruments to detect radiation damage and other environmental effects on critical components, such as solar cells, as the satellite passes through the radiation belts.

Though money for this specific project was not announced, it is known that NASA's supplemental budget request for active and passive satellites (these latter are to be heavier and sturdier than Echo) for fiscal year 1961 was $24 million. R & D funds requested for 1962 was $44 million.

Project Relay, NASA says, in no way cancels out its offer of last October to launch and evaluate at cost promising spacecraft developed and built by industry. Companies who have expressed interest include: AT&T, Hughes, ITT, Philco, RCA and GE.

NASA's Chief of Communications Satellite Programs, Leonard Jaffe, set forth his views on communications satellites at the recent annual meeting of the Institute of Aerospace Sciences in New York. He described advantages, disadvantages and problems involved in three categories of satellites: (1) synchronous orbit (high altitude) active repeater, (2) nonsynchronous orbit (low altitude) active repeater, and (3) nonsynchronous passive satellites.

"Conspicuously absent" from the list, Jaffe pointed out, were delayed repeaters, like Army's Courier, and chaff systems. As for the delayed repeater—"even for telegraphy there is the desire for instantaneous communications," Jaffe said. "And chaff systems would be inherently of limited capacity. Too little is known of the behavior or desirability of chaff in space today."

(1) Synchronous orbit active satellites (22,300 mi altitude)—only three would be needed to cover the world, except for the polar regions; fixed ground antennas would be inexpensive.

Needed in the satellite, however, are: earth oriented antenna system; attitude stabilizer; and capability of adjusting velocity to reposition the satellite. Both latter controls, at present, require the use of a propellant supply abroad—thus weakening the system from a reliability standpoint. Cold gas and wheel systems have an estimated life of one year. Should either attitude or velocity controls fail, the system is lost.

Time delay caused by the long propagation path makes a two-way telephone almost a push-to-talk system. Time required to get a response is 0.6 sec using one satellite and 1.02 sec using two satellites. Besides this delay there are still echo suppression problems.

Time delay is not a problem for data transmission and tv purposes. In fact, constancy of the delay makes the high-altitude satellite desirable for these purposes.

Launching the stationary satellite "is perhaps the most difficult mission currently contemplated." This will have to await the Centaur vehicle, operational in late 1963, costing $10 million each.

(2) A nonsynchronous active satellite orbiting at from 3,000 to 6,000 mi shows promise of providing longer life much sooner than the synchronous orbit satellite, Jaffe said. Requirements: large number of small and simple satellites, reasonable power requirements aboard satellite, absence of attitude or position controls.

Considerable work needs to be done on solar cells, Jaffe said. Present solar cells are damaged by high energy protons, trapped in the radiation belts. A more basic understanding of the damage processes and knowledge of the spectral distribution of particles in space are required for the development of new materials and for a prediction of an actual operating lifetime.

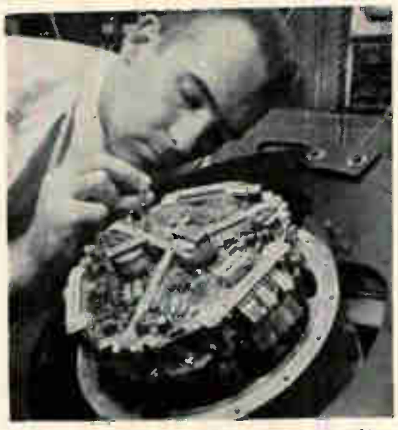
An alternative to improved components is to operate at higher altitudes, above the radiation belts. This, however, ups power requirements, satellite size and costs. The same vehicle that places a satellite in a high orbit can place a number of satellites in a lower orbit.

Disadvantages to the low-altitude system are more complex and costly ground facilities: tracking and switching are necessary for satellites as they move in and out of the area of mutual visibility; the propagation time delay, although short, is variable and hard to deal with.

Passive systems need high power transmitters and large transmitting antennas for high capacity communications; also, orbital perturbations are difficult to predict.

An advantage is long life—10 to 20 years can be achieved. Also, cost of ground gear is based on individual user requirements: for tv, 85-ft antennas and 50-Kw transmitters may be required while a user needing only teletypewriter channels can get by with 20-ft antennas and a few kilowatts.

Control for Delta Rocket



Three 14-ounce gyros (Minneapolis-Honeywell) sensed attitude change in Tiros II's Delta flight control

See Firm Tv Sales for 1961

Color tv still in running, prices shift on B&W sets

PREDICTION that more than 50,000 color tv sets will have been sold in the four-month period ending 18 days from now will soon be put to the test.

Check by ELECTRONICS with RCA, whose chairman, David Sarnoff made the prediction early in January, elicited the comment that "things are going nicely" but no details.

Observers note that color television did not sustain any significant losses during 1960 and expects to hold its own or advance during 1961. Considerable thrust is expected from a series of colorcasts built around Walt Disney presentations. Negotiations between color-championing NBC and Disney are now at the high end of the countdown with RCA ready to join in on the corporate level.

Most of the publicly voiced optimism continues to come from RCA's Chairman Sarnoff and President John Burns along the lines that within three years every major set manufacturer will be driven into color tv by popular pressure. Those currently known to be producing color tv sets include Admiral, Motorola, and Packard Bell with frequent industry guesses that Zenith will rejoin the ranks. RCA's current estimate of color tv is that it is a $100 million dollar industry.

In black-and-white tv, pricing and picture tube size appear to dominate most 1961 discussions. General Electric has introduced 19-in. transformer-powered receiver at a list price of $159.95. A similar sized Philco portable sells for $10 higher.

Some softening in prices is indicated by models shown at last month's Home Furnishings Show in Chicago. Motorola, for example displayed a 23-in. monochrome set at $199.95, a drop of about $20 from earlier models the same size. A Sylvania 19-in. receiver at the low end of the price list is being tagged about $10 below last year's comparable model which was selling for the price of $199.95.

There is still no unanimity of industry opinion on the reasons for last November's decline in volume as compared with November of 1959. November figures slumped about 12 percent going from 560,770 sets in 1959 to 429,757 for 1960.

Magnavox president Frank Frieman has blamed the drop on the controversy between square corners and rounded corners, and dispersed attention brought on by too many screen sizes. "In my opinion, the industry's shrinkage in sales and profits last year was partly attributable to the all-out promotion of the 23-inch square cornered sets," he said. He added that manufacturer promotion convinced the public that 17 and 21-in sets were obsolete with the result that half these sets were sold at liquidation, and sales in general suffered for the year.

One major eastern manufacturer says part of the trouble is that too much was being said about too many different set sizes and nothing had a chance to really take hold.

Other spokesmen say part of the decline came about as a result of the controversy over bonded and nonbonded picture tubes. "Buyers had too many decisions to make, and often decided to let the old set do for another year."

Most manufacturers interviewed by ELECTRONICS are optimistic about 1961 and are relying on design changes, new sales approaches and new warranty policies to stimulate buyer interest.

Zenith, for example has introduced a neutralized frame grid triode tuner that eliminates the need for conventional fine tuning. Mounted at the front of the set, the tuner includes a gear to tune the oscillator slug for each channel strip without disturbing the alignment of other channel strips. The assembly is designed for field conversion to uhf.

Magnavox has come out with an automatic light meter using a light sensitive camera-type resistor. Connected to the cathode-ray tube, the device automatically adjusts brightness or contrast in accordance with ambient light conditions.

In new sales approaches, Westinghouse allows set purchasers to get free decorating help for the room that will house the tv set. Through the dealer, the customer obtains a packet based on the room description. The kit includes swatches of fabrics, floor plan suggestions.

British Phone Line Handles 100 Calls

DOLLIS HILL—British researchers here announce a technique allowing one phone line to carry 100 voice conversations simultaneously without crosstalk or interference.

Workers at the Post Office Research Station say spoken words are sampled and converted into a spectrographic representation. At line's receiving end the word increments are resynthesized into a continuous speech pattern.

Increments move in pulse form at a 10-kc frequency in groups of 100. Each 100th is a sample of the speech transmission. Synchronizing equipment at each end of the phone line assures that only one of the 100 channels is in use between the two conversing parties.

Designed by Computer

First computer designed by another computer (Bell Labs) will be used with Nike-Zeus radar at Ascension Island

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A SUMMIT

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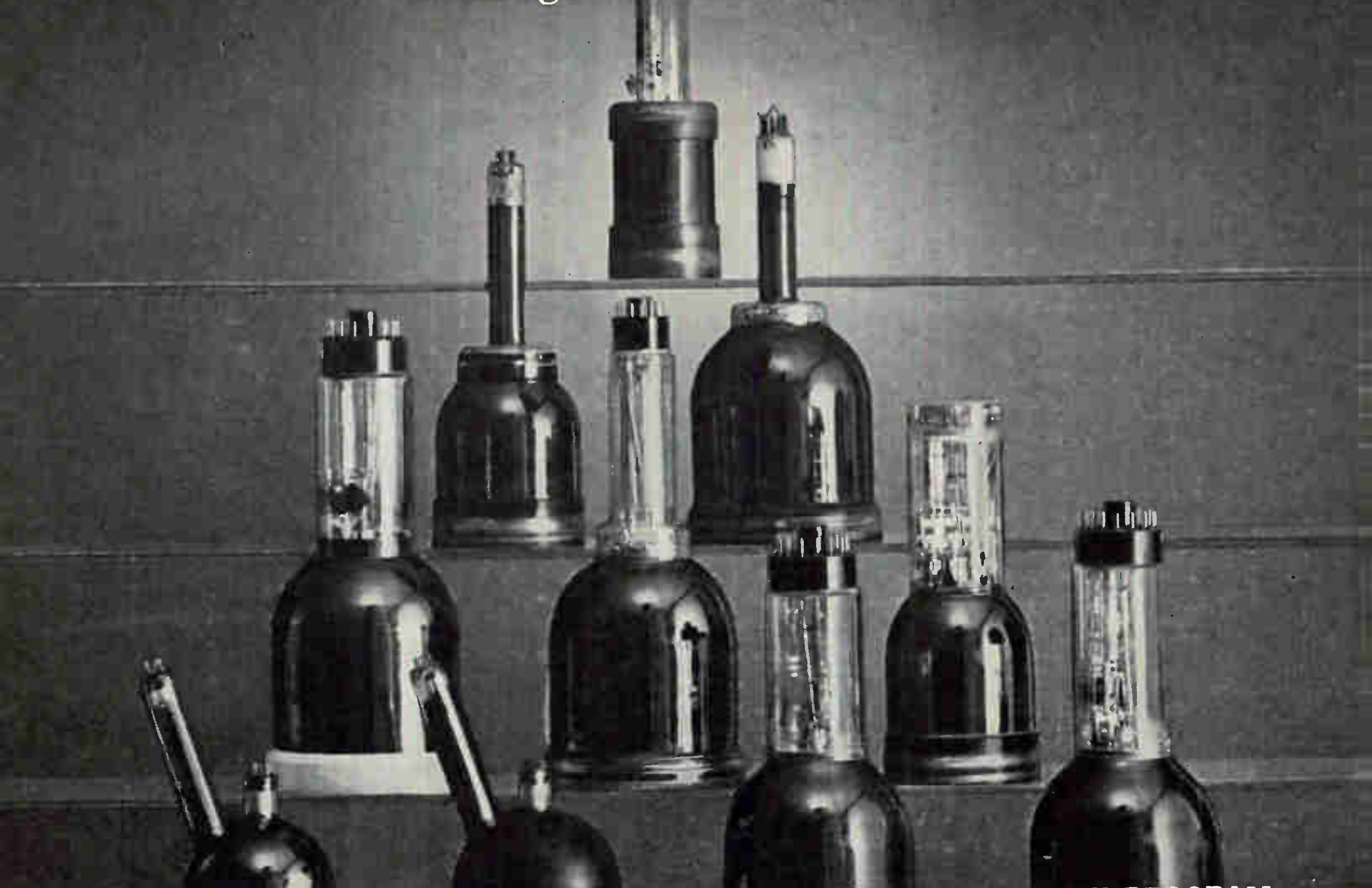

EXCLUSIVE COAXIAL GUN DESIGN A NEW HIGH POINT IN ITT IATRON* PROGRAM

Latest additions to the ever-increasing line of ITT Iatron storage tubes are several new models in which both the writing and the flooding guns are symmetrically disposed about the axis of the cathode-ray display tube. This imaginative solution to a difficult packaging problem in radar indicator design eliminates at the same time all possibility of trapezoidal distortion.

Added to the full line of ITT Iatrons with the more conventional off-axis writing gun arrangement, the new coaxial gun models make it possible to specify an ITT Iatron for virtually any storage tube application—in any diameter from 2½ to 7 inches, to satisfy any requirement with regard to weight, size and desired brilliance under high ambient light conditions.

New and further improved ITT Iatrons, in an even wider range of types, are scheduled for release in the near future. ITT's unlimited access to world-wide research, development and production facilities turns a new design concept into a production model at record pace—in Iatrons as well as other electron tube types.

Write for information on the complete line of ITT Iatrons. Application assistance is available for your specific requirements.

ITT IATRON STORAGE TUBES

TYPE	DIAMETER (in.)	SPECIAL FEATURES	FOCUS†	DEFLECTION†	TYPE	DIAMETER (in.)	SPECIAL FEATURES	FOCUS†	DEFLECTION†
7172	2½	Coaxial gun	ES	ES	FW-204	5	Coaxial gun	EM	EM
FW-211	2½	Coaxial gun	ES	ES	D-3001	5	—	ES	ES
7173	4	—	EM	EM	FW-212	5	Coaxial gun	ES	ES
7174	4	—	EM	EM	FW-223	5	Coaxial gun	ES	EM
FW-227	4	2 writing guns	ES	ES	FW-208	7	—	EM	EM
7423	5	—	ES	ES					

†EM = Electromagnetic ES = Electrostatic

ITT

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Harvard Studying U.S. Weapons Spending

DOES THE GOVERNMENT presently have the in-house capability for timely, efficient development and purchase of advanced weapons systems costing some $12 billion per year?

This is only one of the critical problem areas tackled in a nearly-completed study by a team from the Harvard Business School. The research in the area of advanced weapons acquisition, conceived at Harvard, is supported by a $265,000 grant from the Ford Foundation. It is the first study of its kind since the Robertson Report on manned aircraft in 1957.

The first volume, to be published this Fall, will deal with the economics of weapons systems, particularly the economic environment in which systems are purchased.

Second part of the report will deal with the administrative structure under which weapons are bought—technical and administrative management in the government and in industrial contractors. Third section will recommend changes in government or business policy aimed at improvements in the weapons acquisition process. It is also hoped to publish individual case studies.

Project director is Harvard Prof. Paul W. Cherington. The impartial study was not financially supported by either government or industry, but the research team got the cooperation of the Department of Defense and many contractors. They also met with some resistance from contractors.

Exploratory work was begun in the Summer of 1958. And in 1959, the group examined the development and acquisition of 12 systems, primarily missiles and planes: Atlas, Polaris, Jupiter, Sparrow III, Nike-Ajax, Nike-Hercules, Talos, the F4-H, B-58, F-105, Bomarc and Zeus. Case studies also included some subsystems. The L-systems for command-control were not included. It is estimated that electronics accounts for about 30 percent of the cost of weapons systems.

In addition to the government's own in-house capability, the team looked into criteria for selection of contractors, citing overall system management capability as the primary norm; regardless of whether the bidder is in aviation, electronics or metal bending.

Unattended Stations To Record Weather

SAN FRANCISCO—In the near future the Bonneville Power Administration will set up seven unattended battery-powered digital-data collection stations with equipment to read meteorological instruments. Data, stored on paper tape, will be used to draw correlations between weather conditions and r-f interference emitted by power lines.

At the heart of the system purchased by BPA is a shaft-position digitizer that reads the position of the pointer on a dial and a shaft-velocity digitizer that translates the rotating action of an indicator into an rpm, mph or related discrete figures. Both instruments and the system were developed by Advanced Instrument Corp, Emeryville, Calif.

The instruments will read gages denoting wind direction, wind ve-

Fly-Speck Size Bearing

A microminiature bearing with possible applications in analog computers has been developed by GM's New Departure division. Inside diameter is 0.01 in., outside diameter 0.047 in. Eight 0.01 in.-diameter balls are used locity, temperature, barometric pressure, moisture content and rainfall. These factors will later be correlated with r-f noise as denoted by the output of a milliammeter, also read automatically.

Shaft position digitizer mounts over a pointer-type instrument, three inches in diameter or larger, whose needle has been fitted with a tiny mirror. Four signal wires and a common return connect each digitizer to a central logic unit. On a −12-v d-c interrogate command, a motor-driven arm sweeps the path of the dial pointer. It carries a lamp and photoelectric cell, along with contact wipers that ride on a stationary commutator disk. When a contact reaches the zero reference point in the disk, it gives the start counting signal. As the arm continues to rotate, the contact sweeps a series of conducting segments corresponding to dial divisions. Each segment completes a circuit that provides an information pulse. When the rotating arm reaches the mirror-carrying dial pointer, reflected light from the lamp activates the photocell, sending a stop-counting pulse to central logic.

In the shaft velocity digitizer works, the photocell remains stationary while a disk holding several equally spaced mirror segments is mounted on the rotating shaft. An information pulse is generated at every pass of a mirror segment, which occurs within a precisely timed interval. The number of pulses counted is made to correspond directly with the mph, rpm or other velocity figure.

Air Agency to Discuss Two Electronic Systems

FEDERAL AVIATION AGENCY has called two industry-Agency conferences of interest to the electronics technology. They are scheduled for March 7-8 and March 22, to discuss respectively: the need for all large aircraft to carry flight recorders; and the need for distance-measuring equipment on all high-speed aircraft operating in areas of high traffic density and, ultimately, on all aircraft operating under instrument-flight rules. Manufacturers are invited to express views.

Japan Develops Color Tv Tape Recorder

Monochrome television tape recorder will soon be marketed from Japan at prices 20 percent below present figures

TOKYO—New product unveiled last week by Tokyo Shibaura's Matsuda laboratory is a color television tape recorder in the prototype stage.

Developers describe the device as an experimental adaptation of the single-head, single-track monochrome unit which, they say, was previously designed by Toshiba.

The new color equipment consists of the same basic circuits used by the black and white recorder but incorporates additional circuits for color. Tokyo reports the black and white units will soon be appearing on the market at prices 20 percent lower than imported models.

Thermoelectric Generator To Use Waste Chimney Heat

NORTHERN ILLINOIS GAS Company is using a 100-watt Westinghouse thermoelectric generator to conduct tests on the feasibility of using the waste heat in the flues of gas-fired furnaces to produce enough power to run the furnace control system and, in addition, other electrical equipment.

NIG feels that, with efficiencies presently hovering around 6 percent and cost-per-watt still up around \$50, thermoelectric power seems worthwhile only where waste heat is available. Fuel cells of 70-percent efficiency or better are still at least five years away, company researchers report.

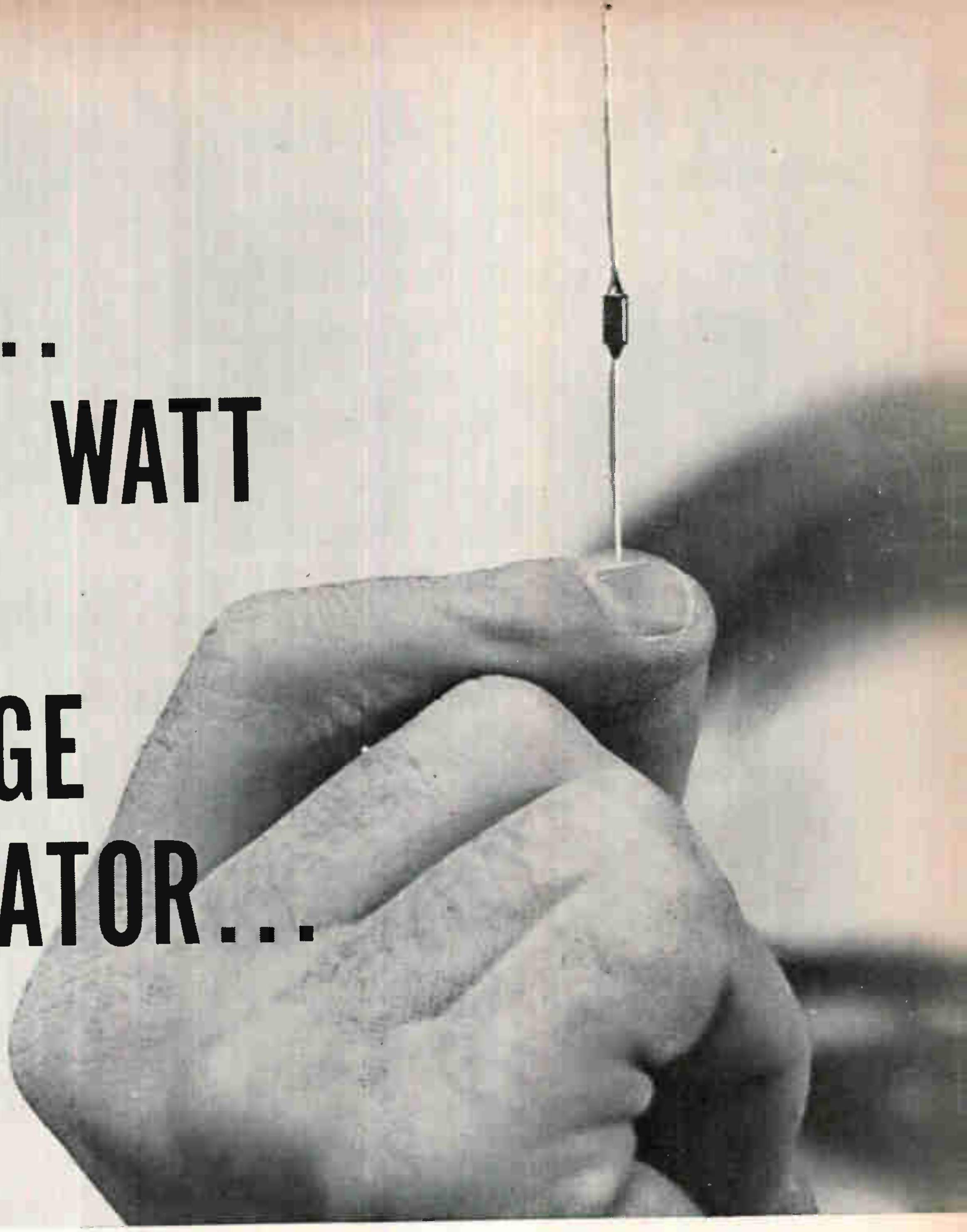
Thermoelectric generators are being used for cathodic protection of pipelines. The generators take fuel from the protected pipeline, convert it into a current to oppose electricity generated by underground corrosion to supplement the 98-percent protection provided by pipe coatings. NIG has been using 10- and 20-watt units from Minnesota Mining & Manufacturing for the last year to serve in this capacity.

Computer Plans London Bus Schedules

LONDON—Bus line operators here are using a computer to compile schedules. The computer, an EMIDEC 1100, recently cut the time needed to compose a schedule on a simple bus route from an hour to 30 seconds.

Complete scheduling programs, including statistics, time cards and inspector's time books, will be produced electronically. It's also expected the computer will help assess public transit needs more accurately.

NOW!...
A ONE WATT
ZENER
VOLTAGE
REGULATOR...



IN THE SMALLEST POSSIBLE PACKAGE!

(ceramic case)

Saratoga Semiconductor Division introduces the first one (1) Watt Silicon Zener Regulator in a ceramic case.* It combines high power with low weight; rugged construction in the smallest possible package; requires less than one fifth (1/5) the space of equivalent units.

The power rating is one watt at 25°C air ambient — derate 8 milliwatts per degree centigrade above 50°C. Ratings from 9.1 volts to 200 volts are available in ±10% or ±5% tolerances.

Send for our technical data sheet 10-223 for complete details and specifications.

SARATOGA SEMICONDUCTOR DIVISION, Saratoga Springs, N.Y.

ESPEY MFG. & ELECTRONICS CORP.

* Meets all requirements of MIL-E-1 and MIL-s-19500B

MEETINGS AHEAD

Feb. 13-16: Information Storage and Retrieval Machine Indexing; American Univ., Washington, D. C.

Feb. 13-15: Better Writing for Science & Industry, American Industrial Writing Institute; Statler-Hilton Hotel, Los Angeles.

Feb. 14-16: Nondestructive Testing of Aircraft & Missile Components, Southwest Research Institute, South Texas Section of the Society for Nondestructive Testing Inc.; Gunter Hotel, San Antonio, Tex.

Feb. 15-17: Solid State Circuit Conf.; International, PGCT of IRE, AIEE; Univ. of Penn. & Sheraton Hotel, Philadelphia.

Feb. 17-21: Electronic Components Exposition, International, French Federation of Electronic Industries, Port de Versailles, Paris.

Feb. 20-25: Semiconductor Exposition, International, Societe Francaise des Electroniciens et Des Radio-Electriciens; Maison de L'Unesco, Paris.

Feb. 26-Mar. 1: Pacific Electronic Trade Show; Great Western Exhibit Center, Los Angeles.

Mar. 1-2: Society of Vacuum Coaters, Thin-Film Structure; Conrad-Hilton Hotel, Chicago.

Mar. 9-10: Engineering Aspects of Magnetohydrodynamics, PGNS of IRE, AIEE, IAS; University of Penn., Philadelphia.

Mar. 11: Quality Control, American Society for; Hart House, Univ. of Toronto, Ontario.

Mar. 15-19: High-Fidelity Show, Magnetic Recording Industry Assoc.; Cow Palace, San Francisco.

Mar. 20-23: Institute of Radio Engineers, International Convention, All PG's; Coliseum & Waldorf-Astoria Hotel, New York City.

Mar. 21-22: Institute of Printed Circuits, Annual; New York City.

Mar. 28: Rochester Soc. of Quality Control, ASQC; Univ. of Rochester, Rochester, N. Y.

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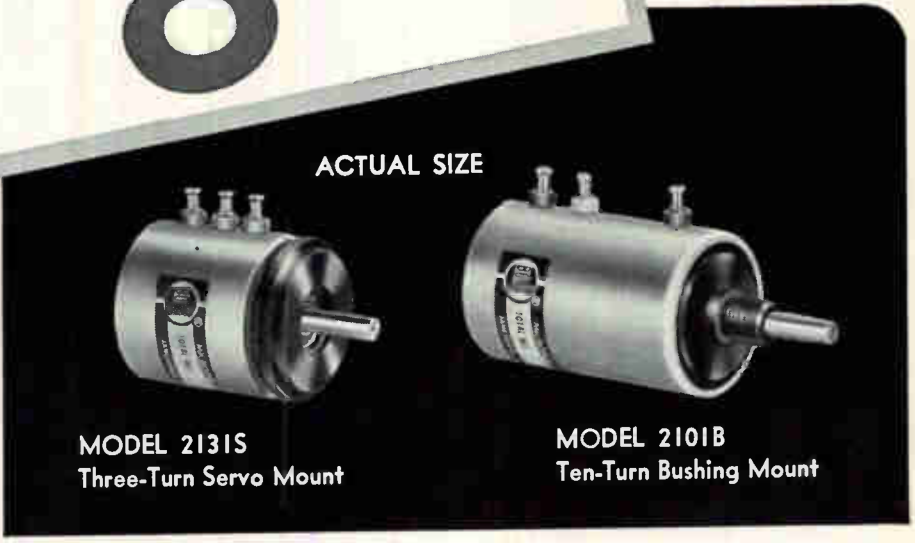

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✓ *Color-Coded Terminals to Identify Slider and Rotation*

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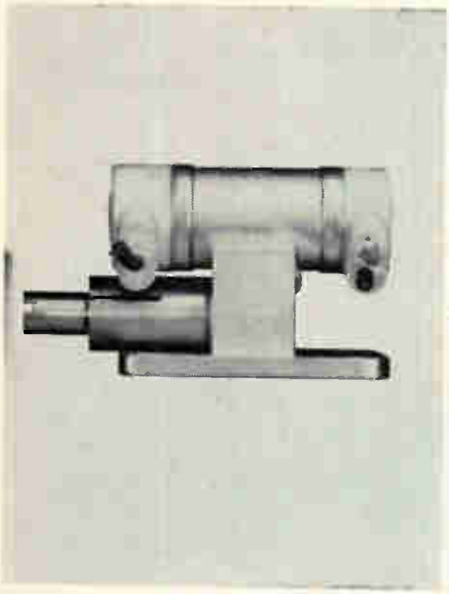

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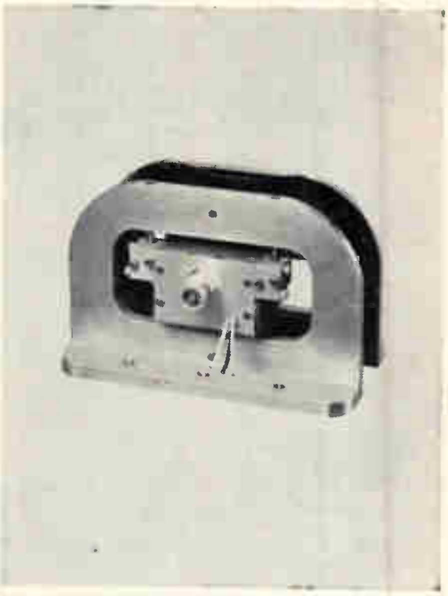

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Defining "Loss" in Wave-Filter Specifications

There are two kinds of power-loss measurements of primary concern in filter work. These are called *Transducer Loss* and *Insertion Loss.* Because of their similarity, they are often used indiscriminately with the result that filter-design specifications are sometimes ambiguous. Much of this confusion can be eliminated when exact meanings of these two terms and differences between them are understood clearly. It is the purpose of this article to tie down meanings of the terms *Transducer Loss* and *Insertion Loss.*

Filters Are Transducers

A transducer is, by definition, any device that can receive energy from one system or systems and deliver it to another system or systems. A wave-filter is a transducer in the field of inductive components since it is capable of being actuated by waves from one or more transmission systems and of supplying related waves to one or more other transmission systems.

Text and derivations that follow make reference to an *ideal transducer.* While, of course, there is no such thing as an ideal or theoretically perfect transducer, concept of such a device is most useful. An ideal transducer is defined as one that transfers the maximum possible power from source to load without dissipation of power.

Such a hypothetical ideal transducer: (a) dissipates no energy; and (b) when connected between source and load presents to each its conjugate impedance. Conjugate impedances occur when two connected networks have equal resistive components, and reactive components are equal in magnitude but opposite in sign ($R_S = R_L$ and $X_S = -X_L$).

Transducer Loss

Transducer Loss is the ratio of power which an *ideal* transducer would deliver to a specified load from a specified source to the power delivered from the same source to the same load by the *actual* transducer.

Transducer loss is determined as follows. Power relationships are derived from the elementary circuit diagrams of Figs. 1(a) and 1(b).

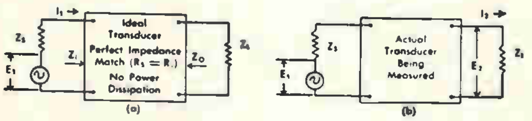


Fig. 1

Transducer Loss in db

$$= 10 \log \left[\frac{(I_1)^2 R_S}{(I_2)^2 R_L}\right] \qquad (1)$$

and, since Z_S and Z_1 are conjugate by definition and $R_S = R_1$,

$$I_1 = \frac{E_1}{2R_S}, \text{ and } I_2 = \frac{E_2}{Z_L}$$

Substituting and clearing,

Transducer Loss in db

$$= 10 \log \left[\frac{(E_1)^2 Z_L^2}{4(E_2)^2 R_L R_S}\right] \qquad (2)$$

This article considers only the majority of cases where Z_S and Z_L are purely resistive. Substituting, in such cases, R_L for its equal, Z_L in equation (2) gives

Transducer Loss in db

$$= 10 \log \left[\frac{(E_1)^2 R_L}{4\,(E_2)^2 R_S}\right] \qquad (3)$$

Equation (3) is correct even if reactance is present in the load impedance Z_L, provided that R_L represents the equivalent parallel resistance of Z_L.

Insertion Loss

Insertion loss resulting from connecting a transducer into a transmission system is the ratio of power delivered to that part of the system following the transducer, before insertion of the transducer, to power delivered to that same part of the system after insertion of the transducer.

Power relationships for determination of insertion loss are derived from the elementary circuit diagrams of Fig. 2.

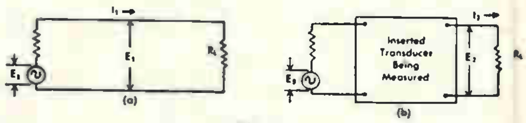


Fig. 2

Insertion Loss in db

$$= 10 \log \left[\frac{(I_1)^2 R_L}{(I_2)^2 R_L}\right] \qquad (4)$$

Or, since E_1 and E_2 are proportional to I_1 and I_2 respectively, equation (4) becomes

Insertion Loss in db

$$= 10 \log \left[\frac{(E_1)^2}{(E_2)^2}\right] = 20 \log \left[\frac{E_1}{E_2}\right] \qquad (5)$$

Circuit impedances do not enter into the expression even though they obviously affect the quantities involved and, hence, the numerical result. However, equations do represent a true power ratio under all conditions.

Comparison Between Transducer And Insertion Losses

It is obvious that *Transducer Loss* and *Insertion Loss* are not the same. Both ratios use power delivered to the load through the actual transducer as denominators of the expressions but numerators differ. *Transducer Loss compares power delivered to the load through an ideal transducer with power delivered to the load through the actual transducer. Insertion Loss compares power delivered to the load with the transducer omitted completely from the circuit with power delivered to the load through the actual transducer.*

Special note should be made that the value of E_1 in equation (3) and E_1 in equation(5)are *NOT* equal. With this fact in mind, the two equations can be defined in the same terms by writing E_1 in equation (5) in terms of E_1 in equation (3). This yields the following expression of *Insertion Loss* in terms of *Transducer Loss:*

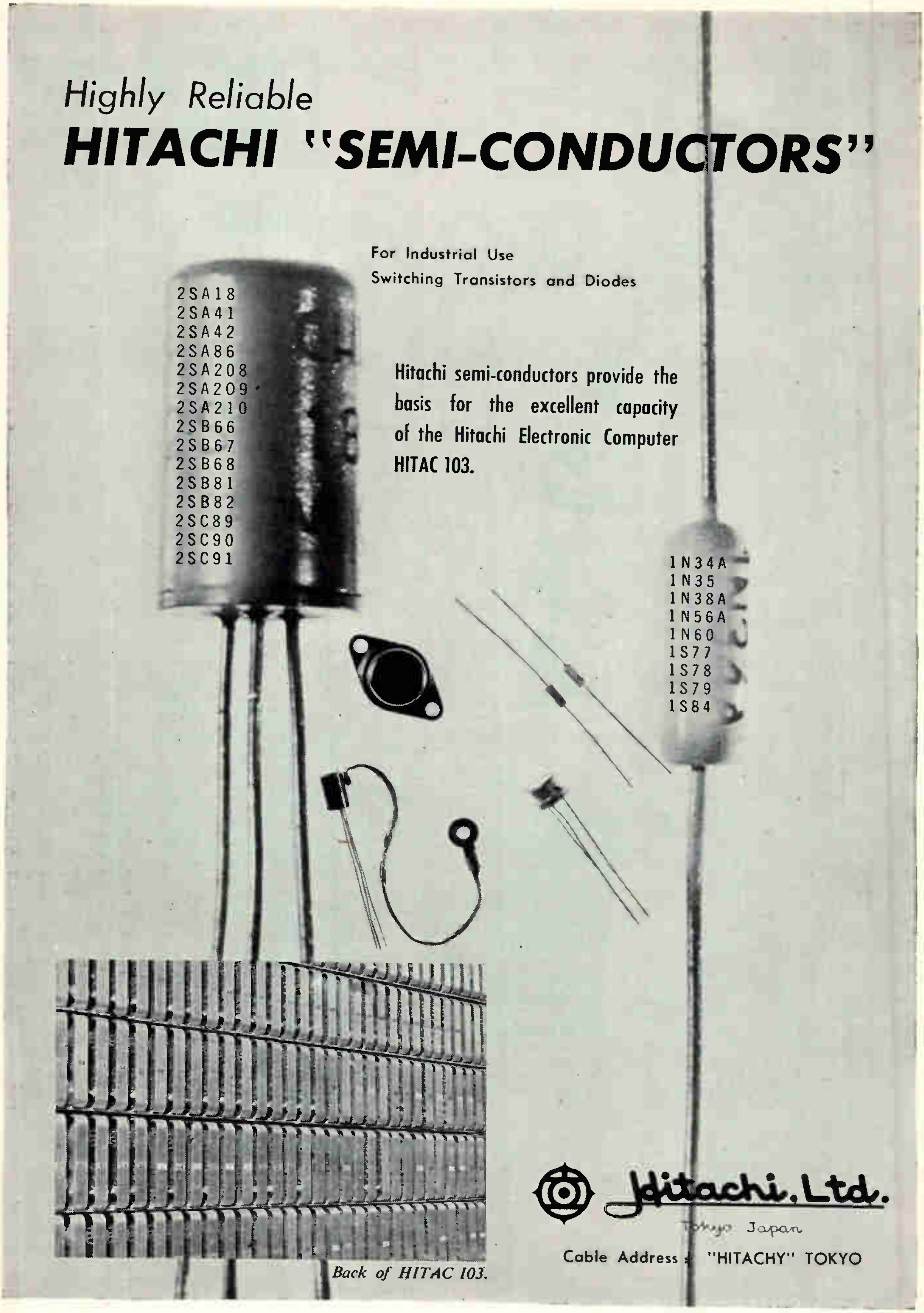
$$\text{Insertion Loss} = \text{Transducer Loss} + 10 \log \left[\frac{R_L}{R_L + R_S}\right]^2 - 10 \log \left[\frac{R_L}{4R_S}\right] \qquad (6)$$

It is now obvious what results from indiscriminate use of the term *Transducer Loss* and *Insertion Loss.* If a filter is required with an insertion loss of 7.5 db but transducer loss is specified, the filter is manufactured with a T. L. of 7.5 db. When measured by the customer it exhibits an insertion loss of 7.5 db plus a factor of $10 \log \left[\frac{R_L}{R_L + R_S}\right]^2 - 10 \log \left[\frac{R_L}{4R_S}\right]$ which puts it out of specification.

It is the purpose of this article to emphasize the fact that *Insertion Loss* and *Transducer Loss* are different. The only time they can be considered to have the same value is the condition under which $R_L = R_S$. That this is true can readily be seen if the reader will refer to equation (6) and observe that the last two terms cancel out. This is the *only* time Insertion Loss Equals Transducer Loss.

Reference: IRE Standards on Audio Systems and Components, 56 IRE3.S1.

SC 60-10A



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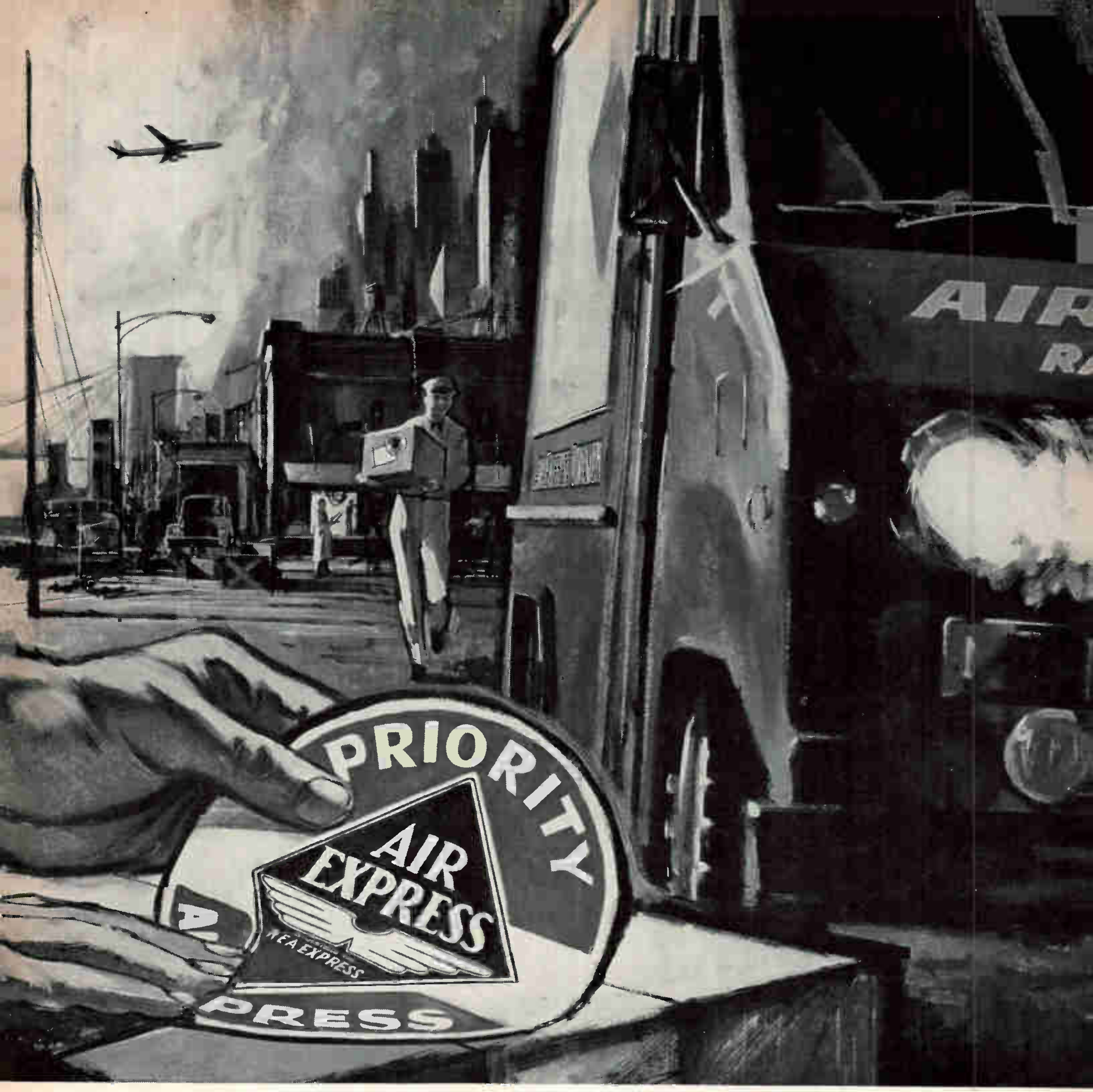

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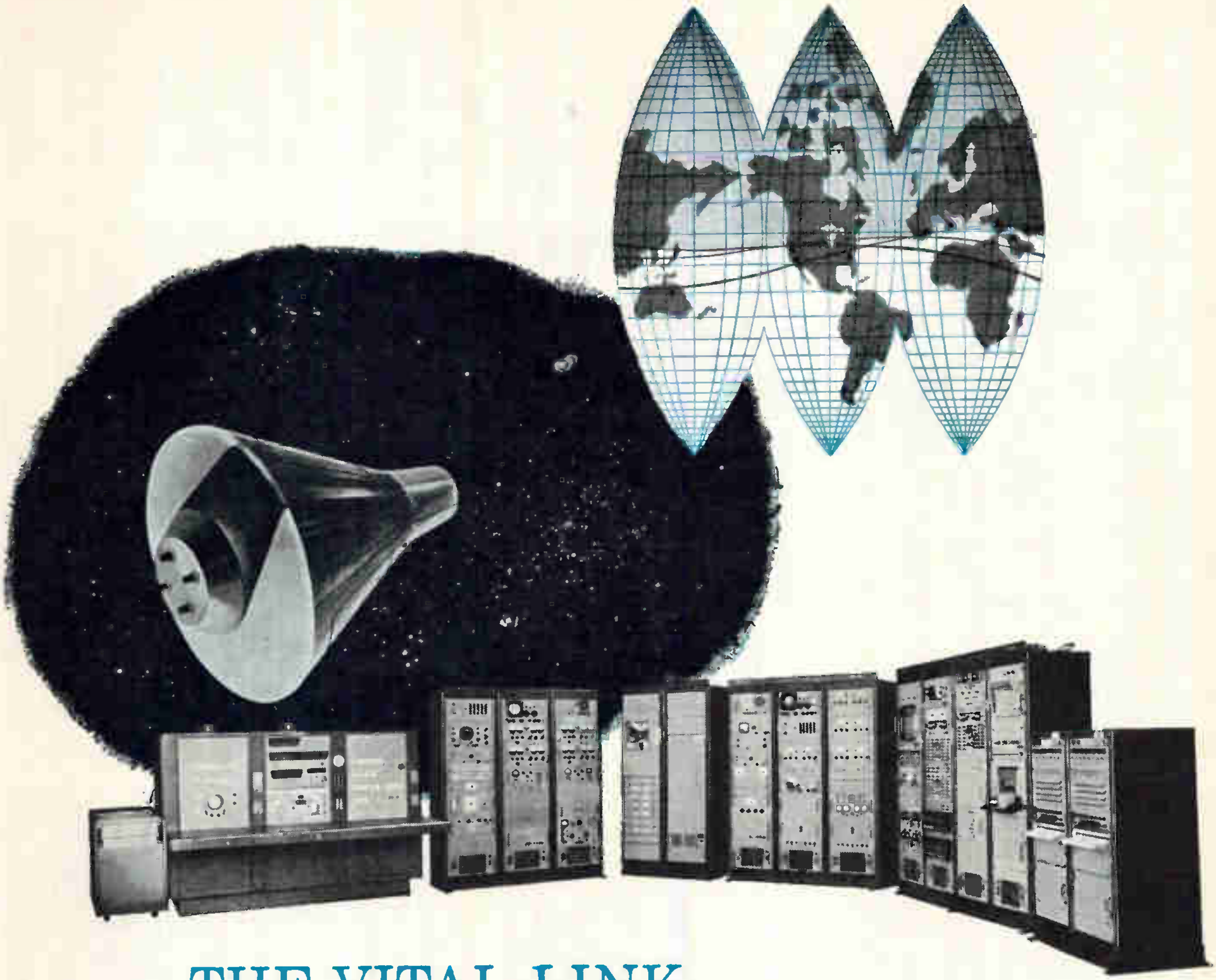

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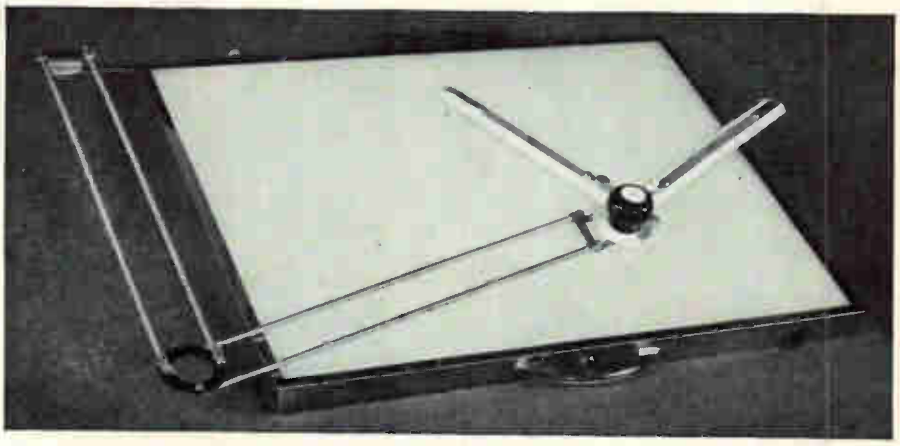

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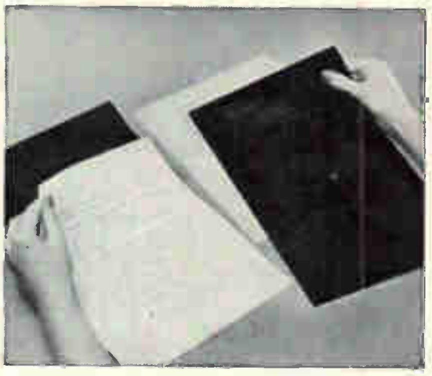

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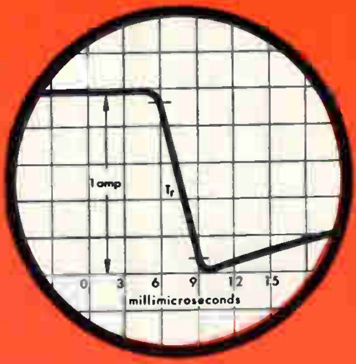

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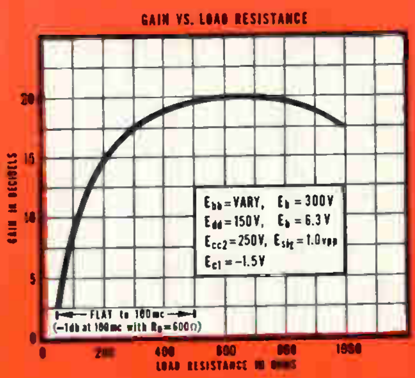

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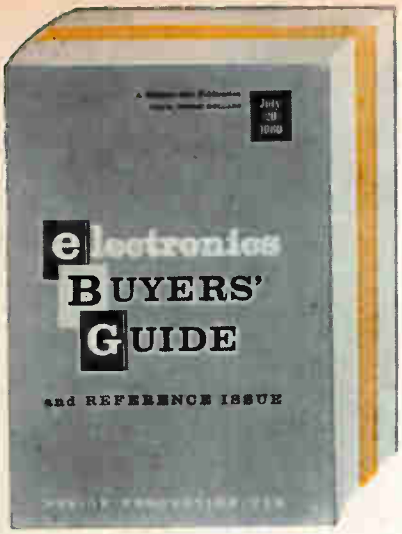

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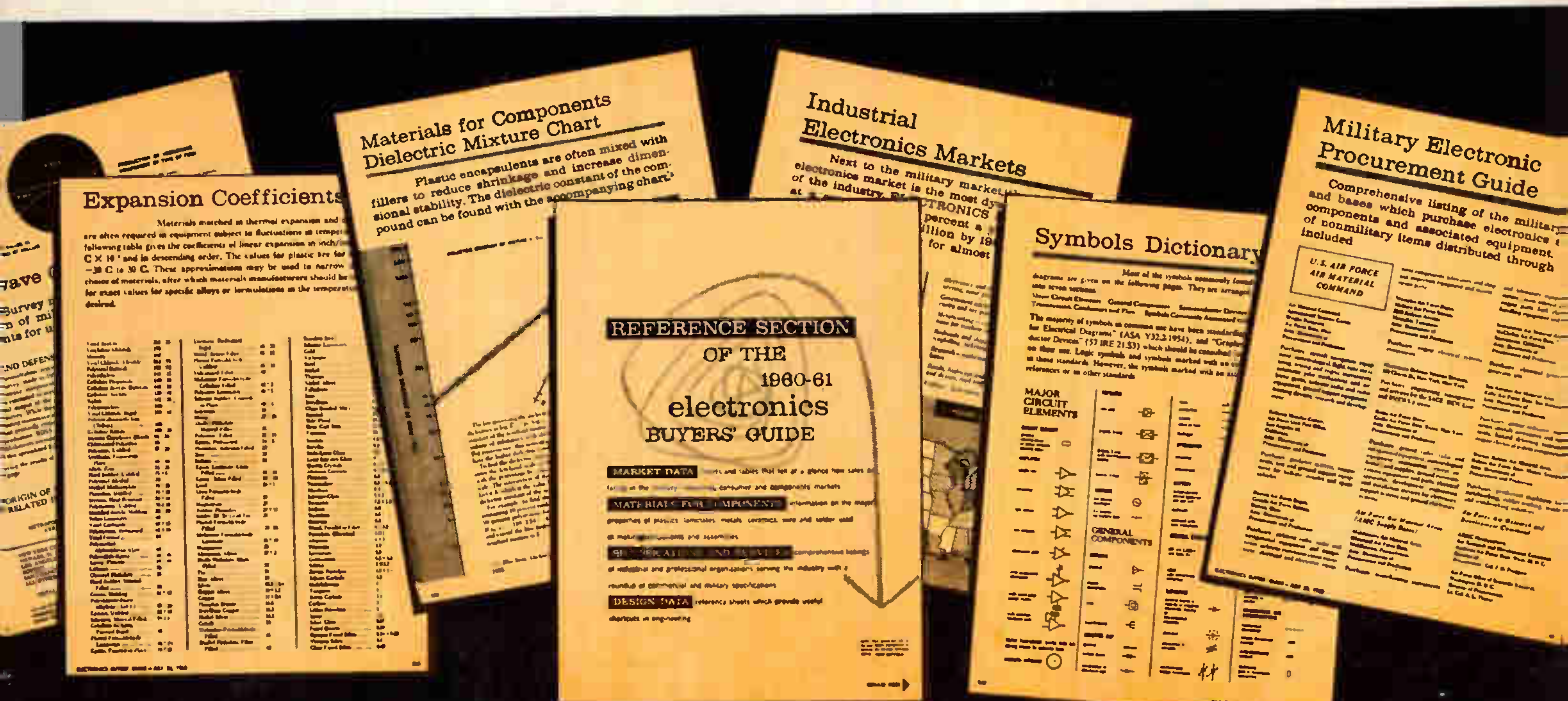

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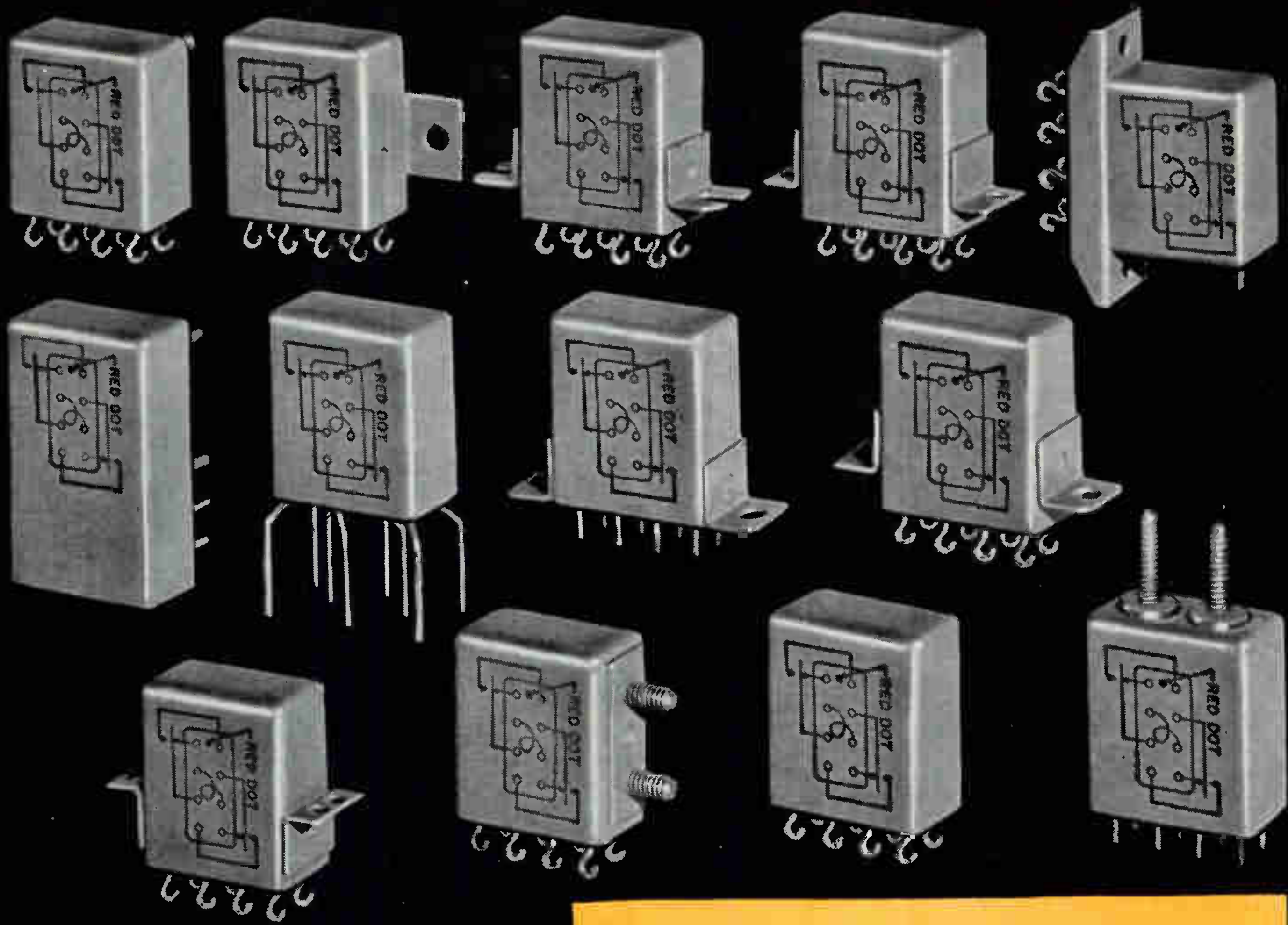

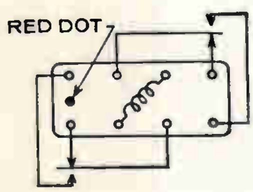

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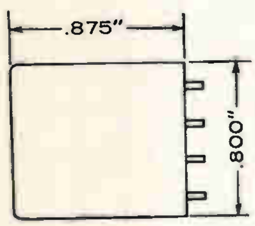

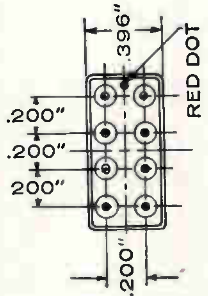

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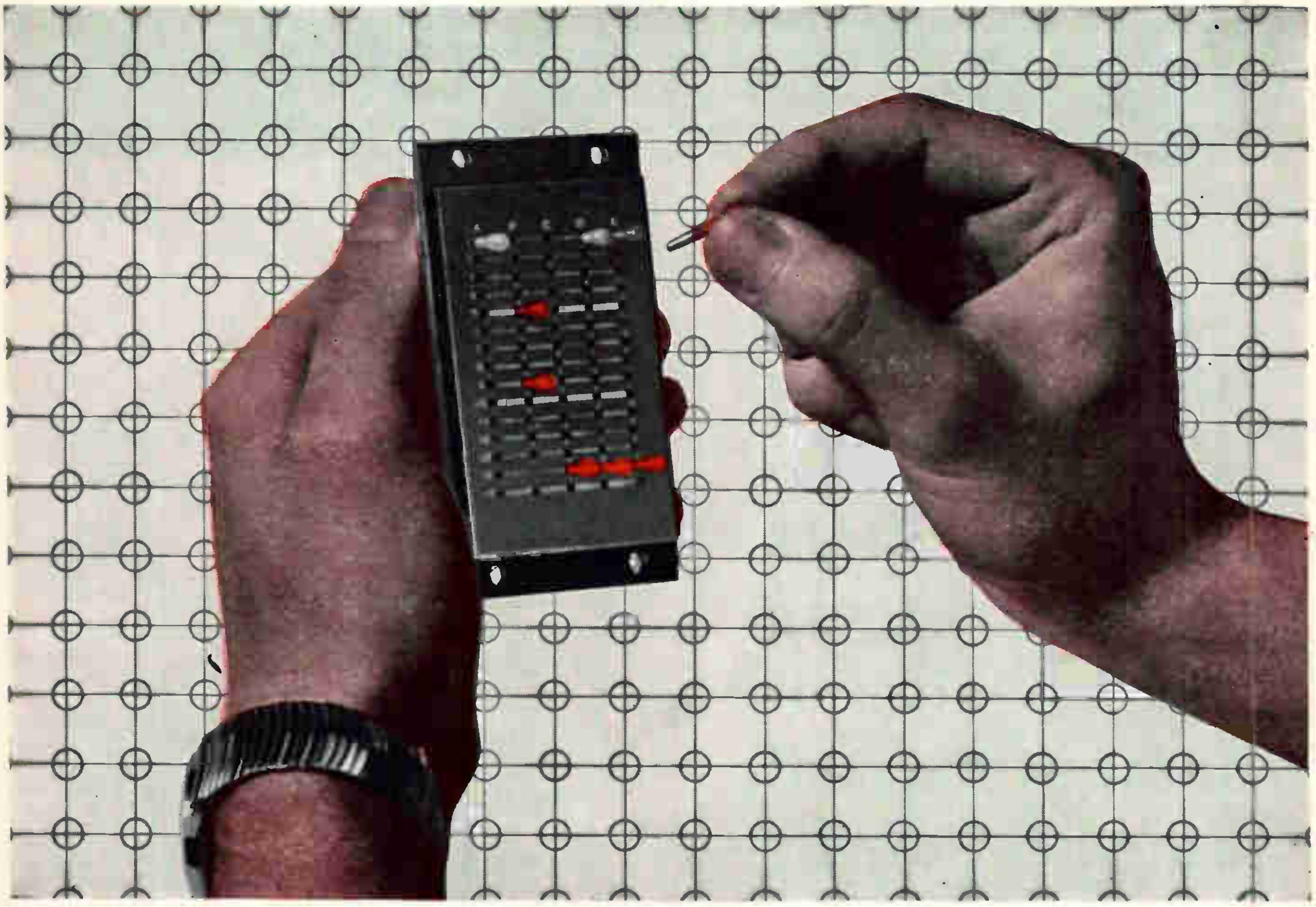

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electronics
February 10, 1961

Automatic Beacon Radar Identifies Aircraft

Beacon controller at radar display console. Box at left is used to preselect code and interrogate aircraft. Light gun determines the code of a selected target on the ppi

Interrogation system may be next step to automatic air traffic control

By W. L. WOODSON,
Electronic Systems Division,
Telecomputing Corporation,
North Hollywood, California

INTRODUCTION OF HIGH-SPEED jet aircraft has brought about an increased necessity for fast, accurate data acquisition in air traffic control. Until recently, communications and primary radar were adequate to this end. This article describes an air traffic control beacon system being used by the Federal Aviation Agency for aircraft identification, and expandable to the eventual goal: automatic air traffic control.

The Air Traffic Control Beacon Ground Station, ATCBGS, is the ground equipment of the Air Traffic Control Radar Beacon System, ATCRBS. This equipment enables rapid identification of high-speed aircraft, and of aircraft in areas of high aircraft density. The ATCBGS interrogates a beacon transponder aboard the aircraft, receives a coded reply and gives the air traffic controller a positive identification on a radar screen. This interrogation and identification takes a fraction of a second and requires no action by the aircraft crew.

Normally, ATCBGS equipment is operated with a primary radar system. It receives its trigger from the radar, and its antenna is mounted on top of the radar antenna. ATCBGS equipment is divided between the transmitter site and the indicator site. The transmitter site includes the transmitter, receiver, sidelobe suppression equipment, and defruiting equipment. The indicator site includes line-compensating filters, decoding equipment and beacon control boxes.

The station can interrogate aircraft in four modes, each used to obtain a different type of information, such as identification, altitude, speed and destination. To each of these interrogations, consisting of a pair of r-f pulses, the beacon transponder replies with a coded pulse train of up to 16 pulses. Twelve of these pulses contain coded information, providing 4,096 possible reply codes.

The transmitter site is controlled remotely from the indicator site, and the operator can transfer to a standby channel without delay. The two sites are separated; the transmitter is placed for good radar coverage, the indicator in the vicinity of the air traffic controllers. The sites can be connected by a land line when the separation is not over two miles, or by microwave link.

The air traffic controller observes the aircraft in the area on the ppi display. To identify aircraft, he operates an interrogation switch. (See photo.) The interrogation command is sent to the transmitter site. On receipt of this command, pulse pairs are generated and modulate the transmitter. The synchronization with primary radar allows for the delay time in the transponder in the aircraft and for the decoding delay on the ground, so that the decoded output of the beacon system is produced at the same time as the radar output.

The radar transmission causes the aircraft to return a normal skin reflection. On receipt of the beacon transmission, the transponder in the aircraft replies with a coded pulse train. The aircraft crew is not aware of the interrogation; the reply information has been previously dialed into the transponder.

When the radar reply reaches the ground station, radar signal is displayed. The beacon signal is combined with synchronization triggers, and transmitted to the indicator site, where it is applied to the decoder. The decoder processes the

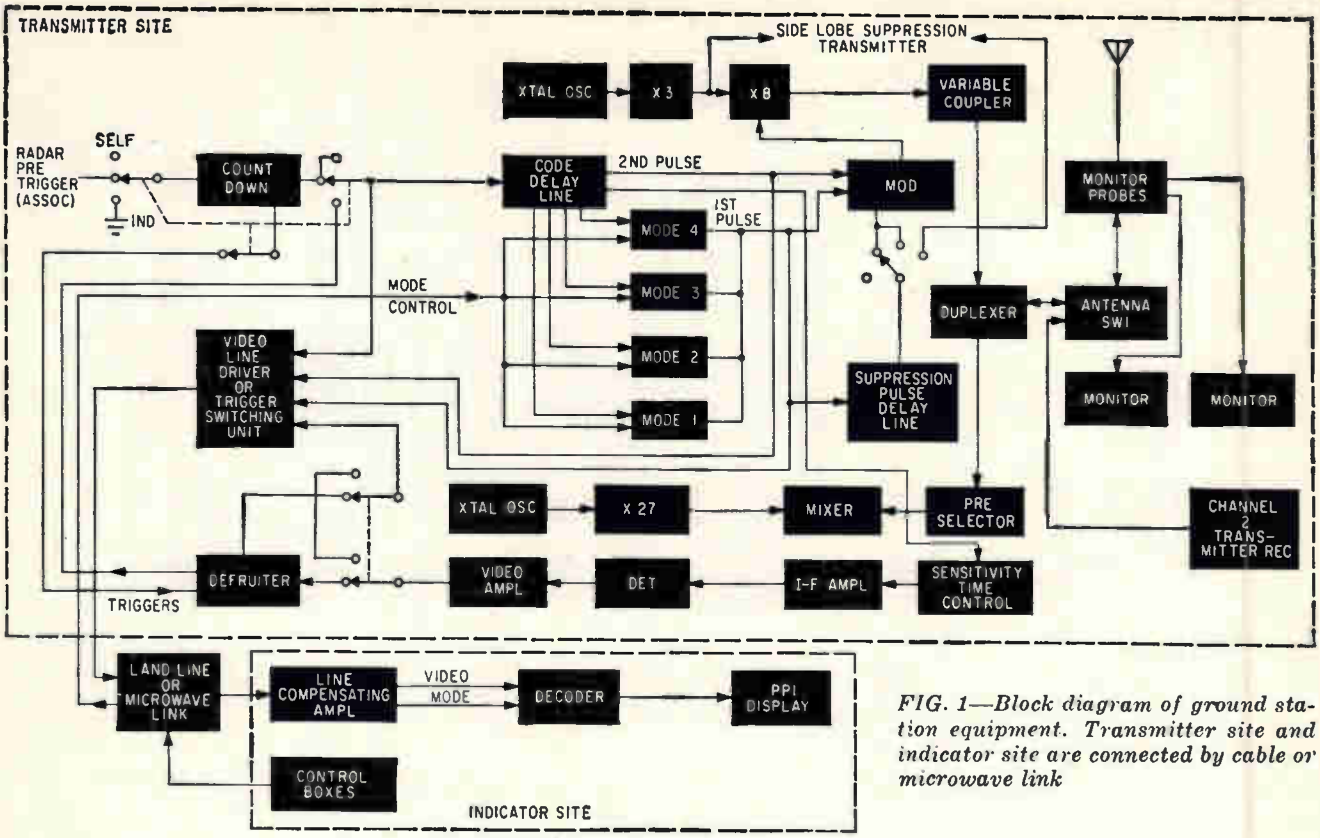


FIG. 1—Block diagram of ground station equipment. Transmitter site and indicator site are connected by cable or microwave link

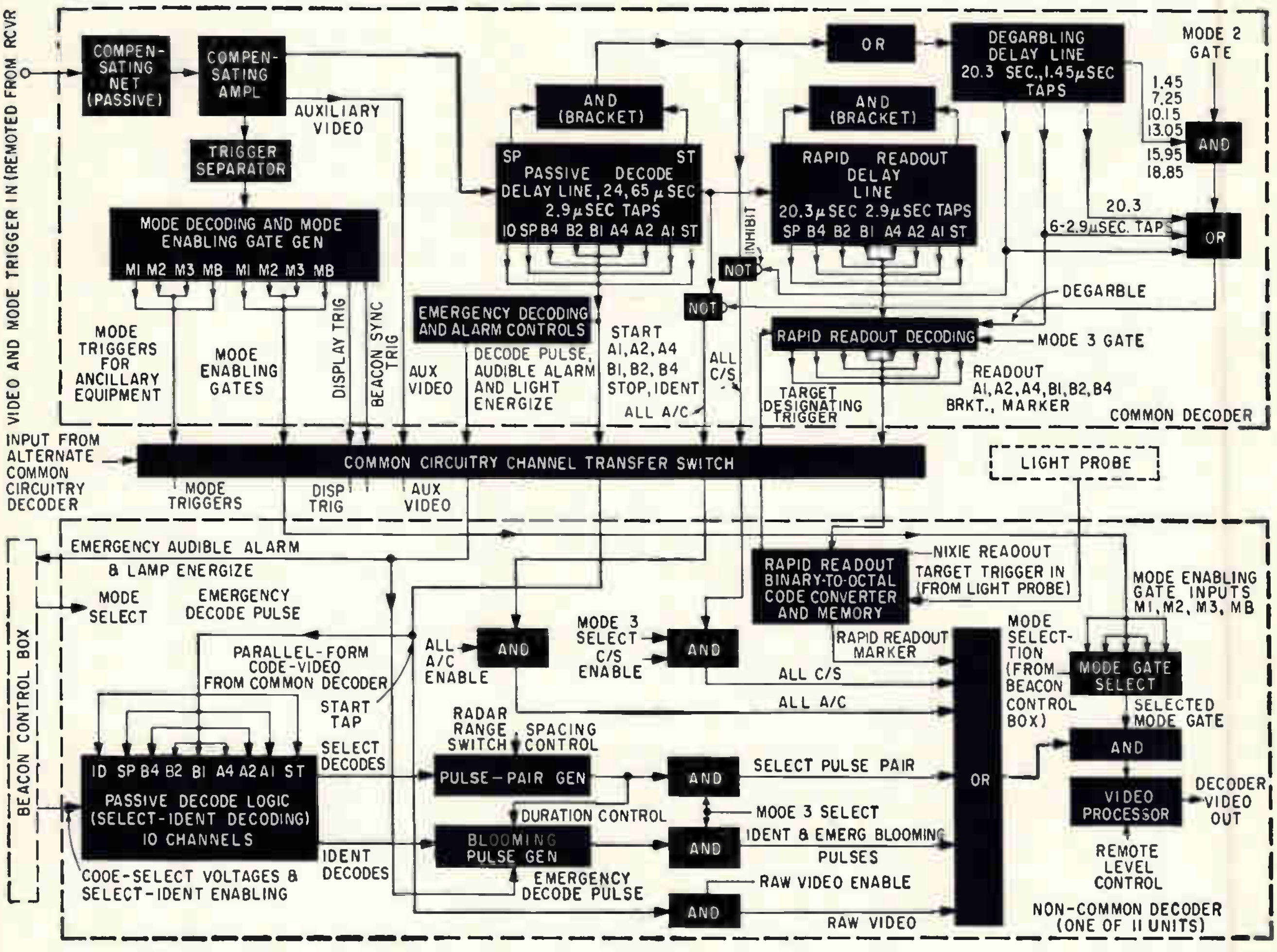


FIG. 2—Functional block diagram of beacon video decoding system. Common-system decoder is at top, noncommon decoder at the bottom

pulses according to the type of decoding called for by the air traffic controller. The decoder output is mixed with the radar video to appear on the ppi, or on a numerical readout.

Figure 1 gives the block diagram of the transmitter site and the indicator site equipment.

When the controller commands an interrogation, pulse pairs begin in the pulse mode generator and are used to key the transmitter modulator. The unit is triggered by a pretrigger pulse from the radar system. An adjustable count-down circuit ensures that the resulting pulse rate of the pulse mode generator is always a submultiple of the trigger, at a rate not over 425 pps. For independent operation, a switch disables the radar trigger and substitutes an internally generated trigger. Each trigger pulse pair is programmed by a coding delay line. The second pulse of each pair bears a constant adjustable time relation to each incoming radar trigger. The first pulse of the pair comes 3, 5 or 8 μsec ahead of the second pulse for modes 1, 2 and 3. For mode 4, it is possible to have a pulse spacing of 11, 17, 19, 21 or 25 μsec.

The transmitter unit consists of a modulator, high-voltage power supply and transmitter section. The modulator receives coded pulse pairs from the pulse mode generator. These are amplified, shaped and applied as modulation. The transmitter is crystal-controlled and can deliver 1,500 watts of peak power into a 50-ohm resistive load at a high duty cycle. Its frequency range is 1,015 to 1,045 Mc. A c-w output at a frequency of ⅛ the transmitted frequency is provided for a sidelobe suppression transmitter.

When a sidelobe suppression transmitter is used, it transmits an omnidirectional signal that is received by the aircraft transponder and compared in amplitude to the interrogation signal. If the amplitude of the omnidirectional signal equals or exceeds the beacon interrogation signal, the transponder is receiving a sidelobe signal and no reply is transmitted. If the beacon signal is greater than that from the omnidirectional antenna, the beacon sends a reply.

The receiver is a crystal-controlled superheterodyne, with tangential sensitivity of -87 dbm and a noise figure less than 10 db. Bandwidth is 9 Mc, and the center frequency of the i-f strip is 59.5 Mc. The receiver's local oscillator can be tuned to any frequency between 1,075 and 1,105 Mc. Provision exists for local or remote manual i-f gain control; sensitivity time control circuits are used. The trigger for the sensitivity time control is derived from the second pulse of the interrogation pulse pair from the pulse mode generator. The i-f amplifier output is detected and applies positive pulses to the video amplifier. The video amplifier design minimizes pulse stretching and recovery time to handle interleaved reply pulse trains for maximum traffic capacity. Output video signals, limited at a level adjustable between 1 and 4 volts peak, are available at the receiver output at a 75-ohm level.

When several beacon ground stations are in the same general area, each interrogator receives, in addition to the synchronous replies to its own interrogations, asynchronous replies resulting from interrogations of airborne transponders by other ground stations. These asynchronous replies interfere with normal decoding. The beacon video defruiting equipment eliminates these incoherent replies without deteriorating the coherent signals. This is done by storing the video reply for a time equal to one interrogation period; stored video is then compared with video from the next interrogation. If they coincide, the video is coherent; if not, the video is incoherent. Undesirable signals are thus rejected. This comparison and acceptance or rejection of signals may take place once or twice.

The defruiter must be able to operate in synchronism with the radar, and the storage period for signal rejection must match the repetition period of the radar. The defruiter storage channel includes a variable video delay that provides constant automatic adjustment of the overall storage period, by comparing the time relationship between a current and a stored trigger pulse from the primary radar.

Also at the transmitter site is the interrogator monitor unit, which measures the transmitted power. Two interrogation monitors function from individual inputs. Either monitor will give local indication of malfunction, but concurrent indication must exist before the malfunction is indicated to the controller. The monitors indicate an error whenever the power varies more than 2 db from a preset level, or whenever the beacon system loses synchronization with the radar.

The equipment at the indicator site includes the line compensator and trigger separator, control boxes, light guns, and decoders. The decoding equipment has two parts: the common circuit decoder, which contains all circuits common to all decoding positions, and the non-common decoders, which perform logic in video processing as required by the individual decoding positions of the controllers.

Video signals received are first applied to the line compensator (see Fig. 2) and trigger separator circuits. The line compensator removes the base-line integration introduced by coaxial cable. The line-compensating amplifier is tuned to emphasize frequency components from 2 to 5 Mc. This processing decreases the rise and fall times without overshoot or undershoot. When the video is transmitted by coaxial cable, mode trigger pairs and beacon sync triggers are received on the same cable at an amplitude about three times that of the video. Code video is separated from the triggers by base clipping. The triggers are amplified and applied to a mode decoding delay line. Taps of the line are aligned with the zero-delay tap to derive, on one of four wires, a single pulse for each mode trigger pair received. A mode 1 trigger will be derived for a received trigger pair spaced by three microseconds, a mode 2 for 5 microseconds. A beacon sync trigger precedes the pulse pair and triggers a long-recovery blocking oscillator.

The four mode triggers, derived through coincidence on the mode decoding delay line, are combined in an OR circuit and initiate a delay gate, adjustable from 4 to 50 microseconds, which triggers a blocking oscillator to supply a display trigger to a 75-ohm load. The four individual mode triggers trigger four monostable multivibrator delay generators, adjustable from 30 to 100

CODE COMPARATOR CIRCUIT

Each noncommon decoder contains ten channels of passive pulse decoding, that display a distinctive marker on the radar ppi when a coded video reply corresponding to a preselected code is received. The circuit shown in Fig. 3 compares received code trains against one of the ten preselected codes.

The received serial-form code train is converted to parallel form by a tapped delay line before entering the diode matrix. Thus the start and stop pulses, always present in the incoming code train, appear simultaneously at their respective inputs. In coincidence with start and stop, the six possible information pulses A1, A2, A4, B1, B2 and B4 will appear at their respective inputs if they were present in the received signal.

A set of thumbwheel code selection switches on the beacon control box determines the code is to be recognized by the comparator. If a code wire is at —10 volts, the corresponding code pulse is expected in incoming trains; zero volts indicates the pulse is not expected.

Each information pulse input is coupled, through a 0.1-microfarad capacitor, to the junction of the cathode and the anode of two diodes, designated coincidence and kill, respectively. The diodes connect to a kill bus and a coincidence bus, as shown. Due to conduction through R_1 and R_2 and the start and stop coincidence diodes, the coincidence bus has a quiescent voltage of —10 volts. Quiescent voltage of the kill bus is zero. When a code control wire is switched to zero or —10 volts, the junction of the corresponding diode pair is brought to that voltage. Switching A1, for example, to —10 volts, denoting pulse expected, brings the A1 coincidence diode to the threshold of conduction and back-biases the A1 kill diode by 10 volts. Switching the control voltage to zero volts, denoting pulse not expected, brings the kill diode to the threshold of conduction and back-biases the coincidence diode. Thus switching a code control for pulse expected connects the corresponding video input as an AND input to the coincidence bus, and switching the code control to pulse not expected connects the video input as an OR input to the kill bus. When pulses appear at start and stop and at all inputs switched for pulse expected, all coincidence diodes open and allow the coincidence bus to reach zero volts, producing on it a pulse of the amplitude and duration of the individual input pulses. Any pulse appearing at an input switched for pulse not expected, representing an extraneous pulse, is coupled to the kill bus.

A positive pulse on the coincidence bus, indicating that all expected pulses are present, is coupled to V_{1A}, which operates as a cathode follower, driving the cathode of V_{1B}. Unless there is a kill pulse at its grid, V_{1B} acts as a grounded-grid amplifier and reproduces the coincidence signal at its plate output. A kill pulse at the grid of V_{1B} indicates an extraneous pulse in the signal; the kill pulse will reverse the net grid-to-cathode voltage swing and thus inhibit the positive plate signal. Tube V_1 then acts as a NOT circuit. A positive pulse at the plate of V_{1B} indicates that the received video code corresponds to the code to be recognized.

This decode pulse is buffered by cathode follower V_2 and initiates the select decode pulse pair for ppi display.

microseconds. The trailing edges of pulses from these multivibrators trigger four mode-enabling gate generators corresponding to modes 1, 2, 3 and 4. These gates are adjustable from 300 to 2,500 microseconds.

The decoder uses three primary delay lines for serial-to-parallel conversion of the received code trains, degarbling and other functions. The type of decoding is determined by the air traffic controller.

The controller can require any of the following types of decoding:

(1) All aircraft: This indication on the ppi is a single blip, coincident with the radar return, that shows the aircraft interrogated has a beacon transponder.

(2) All common system: This processing also places a single blip coincident with the radar return on the ppi and indicates to the operator that the aircraft is replying with a code using framing pulses spaced by 20.3 microseconds (the common system).

(3) Select: Each control box has 10 sets of thumbwheel switches on which the controller can dial the code of an aircraft he wishes to identify. If he operates the select switch by this code, the aircraft replying with this code will show as a double blip, the first pulse coincident with radar return.

(4) Ident: This operates similarly to Select except that the pilot has pressed his Ident button to place a heavy blip or blooming reply coincident with the radar return on the ppi.

(5) Emergency: If the aircraft pilot has dialed the emergency code into his coder, identification will show as two heavy blips coincident with the radar return. In addition, there are audible and visual alarms.

(6) Rapid readout: If the controller places his light-gun over a radar target on his ppi, the reply code for that target will be read out on the control box numerical display tubes.

(7) Raw video: If the operator selects raw video, there is no decoding and the pulses in the train are displayed as blips coincident with the radar target return.

The 16-pulse code train processed by the decoder (the common system) includes a start pulse, up to 12 code pulses, a special pulse, stop pulse and ident pulse. The presence of the start pulse and stop pulse determines that the transponder has replied with the common system; the presence of these two pulses is detected in the decoder and is referred to as a bracket decode. A common-system reply is processed through the first delay line and a bracket decode signal is sent to the all-common-system channel and to the degarbling delay line. The pulse train is sent to the second delay line, and from the taps of the first delay line a parallel-form output code is derived. These pulses go to the noncommon decoders, where they determine the presence or absence of pulses in the coded train according to the code selected by the operator. A common-system reply in the second delay line will produce a bracket decode that will go to the degarbling delay line, and the tapped out-

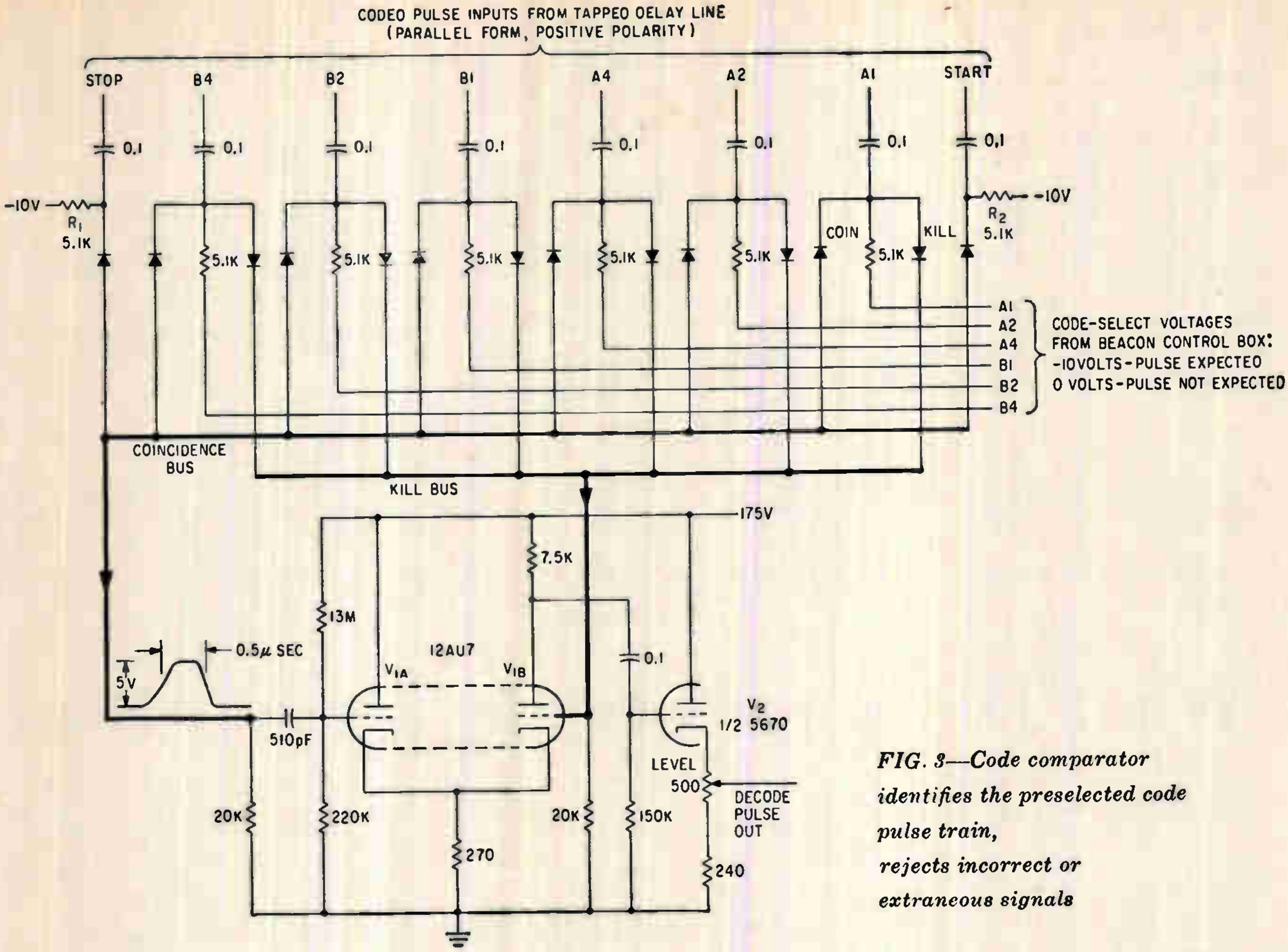


FIG. 3—Code comparator identifies the preselected code pulse train, rejects incorrect or extraneous signals

puts of the delay line will read out in parallel for the pulses present; these will be applied to the rapid readout decode processing circuit.

This rapid readout circuit processes the received code to the noncommon decoders, if it is received twice in succession and is preceded by three bracket decodes. The degarbling delay line generates pulses at 1.45-microsecond intervals, which is the spacing of pulses in the normal common system reply code, each time a bracket decode reaches it through either the first or second delay line. This degarbling delay line inhibits the all-common-system decode for pulse trains succeeding the first train and following each other with 4.35-microsecond spacing and is used in deriving the all-aircraft decode. This degarbling input is also used with the rapid readout decode processing circuit to inhibit a decoded output if there is any pulse in information pulse positions of the pulse train due to an interleaved train.

Degarbling is necessary, because in high aircraft density areas there can be two or more replies interleaved so that it is impossible to tell whether a pulse belongs to the train being decoded or to the interleaved train. In this case the decoder outputs are inhibited to prevent display of erroneous information.

The noncommon decoders receive processed parallel-form information from the common decoders, decoding commands from the control box and the target-designating from the light gun. Within the noncommon decoder there are 10 comparator circuits (see Fig. 3) that determine correspondence between the code-received output from the common decoder and the codes selected on the control box. The noncommon decoder also contains circuits to energize the numerical readout device on the control box when the common decoder determines the code of a selected target on the ppi. The decoded modes from the common decoder are also compared with the modes selected on the control box to ensure that no display exists unless the received video is in the selected mode. All the circuits to generate the displays superimposed on the ppi with the radar target returns are contained in the noncommon decoder.

The antenna transmits and receives vertically polarized waves in the 1,015 to 1,105-Mc band and has a horizontal beam width of 2.5 deg between half-power points. Radio-frequency energy reaches the antenna from the transmitter through a 50-ohm coaxial cable. An r-f filter between this cable and the feeder system attenuates received signals between 1,280 and 11,000 Mc.

Stations are being installed at major airports at intermediate sites. Jet aircraft flying above 24,000 feet are now required to have beacon transponders, and this requirement may eventually apply to all aircraft. At this time, only the use of mode 3 has been established, to interrogate aircraft for an identification number.

The other three modes will eventually be used to obtain other information such as altitude, speed and destination.

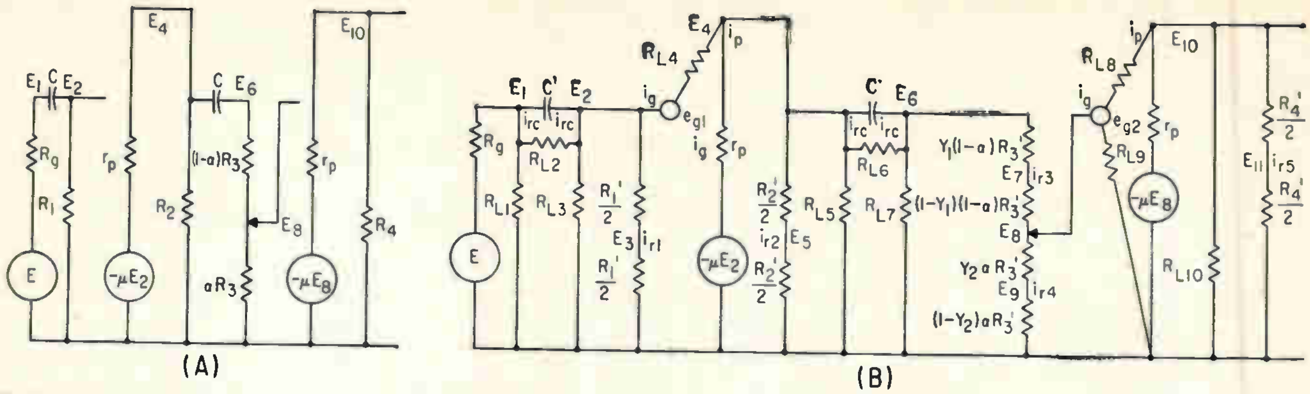


FIG. 1—Linear equivalent circuit of amplifier (A) is modified by nuclear radiation (B)

Transient malfunctions introduced into electronic equipment by nuclear radiation may cause mission failure. Here's a design guide for the nuclear environment

What Designers Should Know About

By JOHN W. CLARK, THOMAS D. HANSCOME and HERBERT L. WISER, Nuclear Electronics Laboratory,

INCREASING USE of nuclear energy in propulsion systems and weapons, as well as the exposure of space systems to Van Allen and cosmic radiation, is causing growing interest in the effects of nuclear radiation on complex electronic systems. One of the more significant phenomena that occur under high-level nuclear radiation is the transient effect, leading to circuit malfunction as opposed to permanent damage. This article is a preliminary survey of these radiation-induced transient malfunctions.

The principal physical cause of transient malfunctions in electronic systems is the production by the nuclear radiation of current carriers: ions or electron-hole pairs. The nuclear radiations of most interest are penetrating, consisting of gamma radiation and neutrons having energies usually greater than one million electron volts. Thus, the shields or protective covers that surround typical electronic systems are almost completely transparent to these radiations. Therefore, the components are filled with ions upon exposure to a brief pulse of radiation. Also, these shields or other surrounding objects will alter incident radiation, usually to make it more rather than less damaging. It is therefore important to duplicate accurately the surroundings in which a circuit or subsystem will be installed to obtain realistic experimental data.

The ions and other current carriers produced by nuclear radiation will persist for a relatively long time after the incident radiation pulse has disappeared. Lifetimes range from a fraction of a microsecond to many milliseconds. The voltages and currents that appear in circuits usually persist for a still longer time due to the circuit time constants, which may range from microseconds to seconds.

The effect of nuclear radiation exposure is to produce additional shunt resistors and transient currents (which appear to be produced by virtual constant-current generators) at numerous points in the circuit. These are superimposed upon the circuit elements and may have a severe effect upon circuit performance. The virtual circuit elements persist for a brief period (this time is set by the relaxation processes in the current carriers, not by the duration of the nuclear radiation pulse), and disappear exponentially with time. Some progress is being made towards developing analytical methods that will result in the solution in closed forms of circuit behavior under transient radiation conditions.

As an illustration of the complexity of this problem, Fig. 1A shows

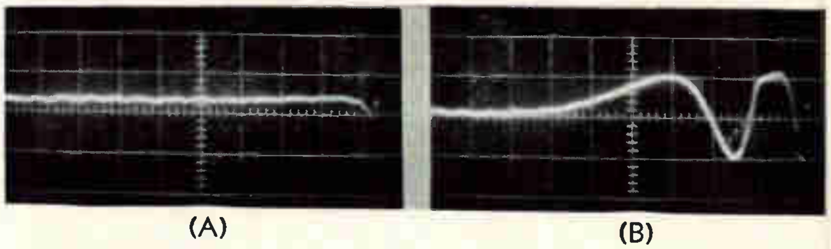
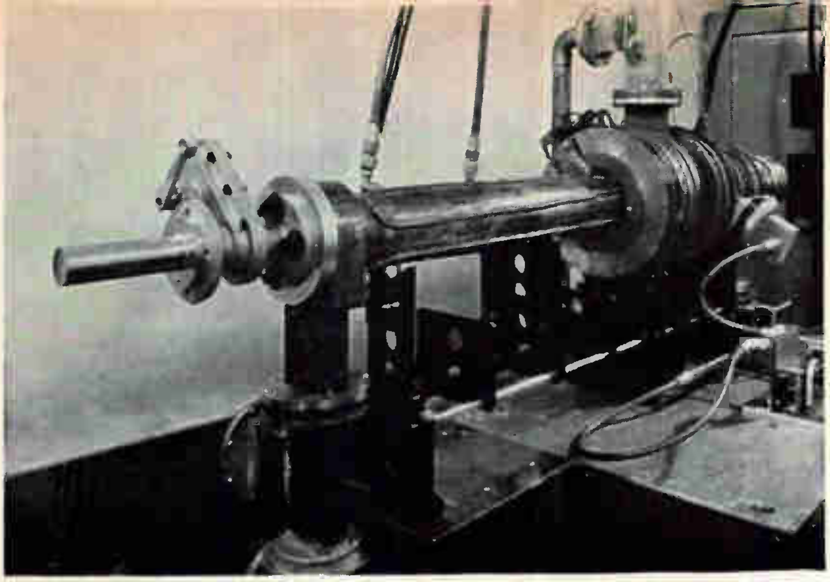


FIG. 2—Output of low-level amplifier (A) is saturated by gamma radiation of 1.4×10^5 r/sec (B)



THE FRONT COVER—Electrons are accelerated to a velocity equivalent to 10 Mev in the accelerating tube of this gamma linac. Heavy metallic target can be used to convert electrons to gamma radiation

Transient Radiation

Hughes Aircraft Co., Los Angeles, California

the linear equivalent circuit of a typical resistance-coupled amplifier. Fig. 1B shows the same circuit as modified by nuclear radiation.

An experimental example of a malfunction produced by radiation is shown in Fig. 2, where sweep speed is 10 ms per cm and deflection sensitivity is 10 v per cm. A low-level amplifier was subjected to 8-microsecond gamma radiation pulses. The amplifier was part of a feedback loop and provided an error signal for control. Figure 2A shows the normal output of this amplifier essentially undisturbed by peak gamma radiation of 2.4×10^3 roentgens per sec. In contrast, Fig. 2B shows the complete saturation of the amplifier and the disappearance of the normal slight variations in output voltage caused by gamma radiation of 1.4×10^5 r per sec. The disturbance shown in Fig. 2B lasted about 50 milliseconds, although the radiation pulse that caused the disturbance lasted only 8 microseconds.

It is useful to distinguish between rate and dose phenomena. This distinction can be made without reference to physical mechanisms. However the familiar dose effects, which are often referred to as radiation damage, are due to different physical mechanisms than those discussed above. Permanent radiation damage is caused primarily by production of lattice defects and similar physical degradation of the structure of the material. These effects are cumulative; pure dose effects are independent of the rate of application of nuclear radiation.

Figure 3 illustrates graphically the difference between these effects. Some measurable property of the object under test is plotted; for example its electrical resistance. For a dose effect, this property changes gradually during radiation exposure and upon termination of the radiation exposure retains its altered value. On the other hand, a rate, or transient, effect causes an instantaneous parameter change that persists as long as radiation is applied and disappears as soon as exposure is terminated. These effects are seldom seen in a pure state, but rather there is a combination of both rate and dose effects, as illustrated in Fig. 3C.

Exposure for periods long compared to the relaxation time results in pure cumulative or dose effects. Exposure for periods shorter than the relaxation time results in pure transient or rate effects. This emphasizes the importance of relaxation time in evaluating transient radiation phenomena.

Techniques for designing radiation-resistant systems are now being developed; in the interim the following design procedure may be laid out. The procedure must be empirical because design guidance in some cases is qualitative. The designer should proceed as follows:

(1) Determine the radiation environment in which the system must perform. Radiation composition (gammas, neutrons, charged particles), rates, and integrated fluxes should be determined. Particular attention must be paid to distinguishing between sustained exposure (as near a nuclear reactor) and transient exposure (as near a nuclear weapon).

(2) Classify the subsystems by functions: amplifiers, power supplies, computer circuits, electromechanical circuits, sensors, de-

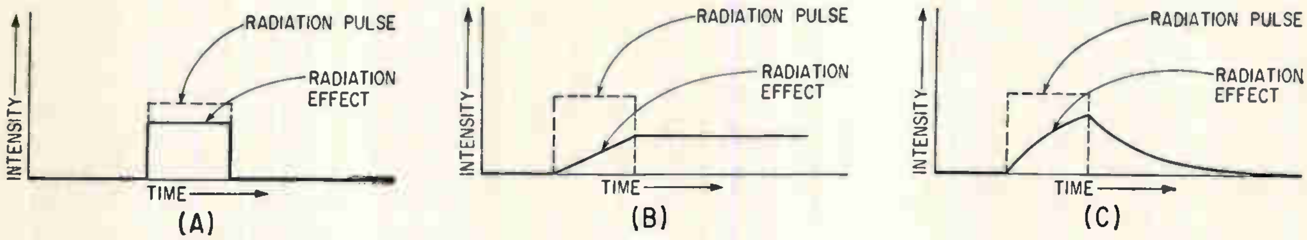


FIG. 3—Idealized configurations of transient effects (A), dose effects (B) and combined effects (C)

modulators and the like.

(3) Eliminate those subassemblies known to be impervious to transient radiation effects. (Here it is assumed that integrated flux is small compared to that which produces permanent damage.)

(4) Provide, in the design of sensitive circuits, for reliable performance in the presence of interference by pulses introduced throughout the circuit by the radiation pulse. The designer should be guided by the following principles.

Since the voltage induced by a given amount of radiation-injected charge is proportional to the circuit impedance, the interfering signal can be reduced by low-impedance designs; hence, choose low-impedance designs, trading increased I^2R loss for radiation hardness when necessary.

In bistable circuits, design for extra margin of stability against radiation pulse flipping. This may require relatively insensitive binaries and, thus, driving signals larger than usual.

Avoid leakage paths that can conduct when local ionization is produced by the radiation. Judicious use of potting materials minimizes this interference.

Avoid unnecessarily sophisticated circuits. The simpler and more direct the circuit function, the easier it is to provide radiation hardness.

Provide protection for circuit components that could be damaged by the release of stored energy in the circuit. Power supplies, multiplexers, isolators, T-R and ATR devices should be considered as possibly susceptible.

Avoid components known to be particularly susceptible to transient radiation damage. Transistors, optical and ir sensors and diodes should be selected on the basis of radiation hardness in the application.

(5) Breadboard models of the subsystems (after test for functional performance) are next submitted to radiation test in an environment that simulates the radiation environment to be encountered. Performance of each subsystem is observed in the radiation environment, and radiation effects on the performance are reduced to tolerable levels by empirical trouble shooting; that is, by locating the source of disturbance and minimizing it by redesign or choice of alternate components.

(6) After the hardening operation has been performed on the subassemblies, the complete system is tested. In the worst case, the system function may depend on the performance of a subassembly that cannot be adequately hardened. Here, overall design must be reexamined and new trades made between performance and reliability. In general, however, it will be found that certain subassemblies must be hardened further, and the design process continues cyclically until the whole system is resistant to radiation pulses.

Unfortunately, there is no magic or elegant solution to the problems produced by radiation. The study of transient radiation effects in electronics develops in the researcher a variety of interdisciplinary techniques which enable him to design for the radiation environment. Continuing work will produce component radiation ratings, deratings and preferred circuits for radiation applications.

Investigation of malfunctions induced by nuclear transients, and the evaluation of corrective methods, will be best accomplished with realistic simulating equipment.

The criteria for evaluating a weapon simulator are duration, spectrum, and rate. Most important is the duration, or pulse width, of the radiation produced by the simulator. Simulators of variable pulse duration are valuable since the relaxation times of any item under test can be measured with such simulators. Knowledge of these times is essential to interpreting simulator data in terms of performance under actual field conditions.

The spectrum or energy distribution of the radiation produced by a simulator is next in importance. Although the phenomena that produce radiation-induced transients are not strongly energy-dependent, the detailed manner of energy deposition within a system may have a considerable bearing upon the malfunctions produced. This energy distribution is determined entirely by the spectrum of the incident radiation. Radiation low in energy (as compared with the actual radiation from a weapon) will be too strongly absorbed by shields, cases, and other surrounding equipment,

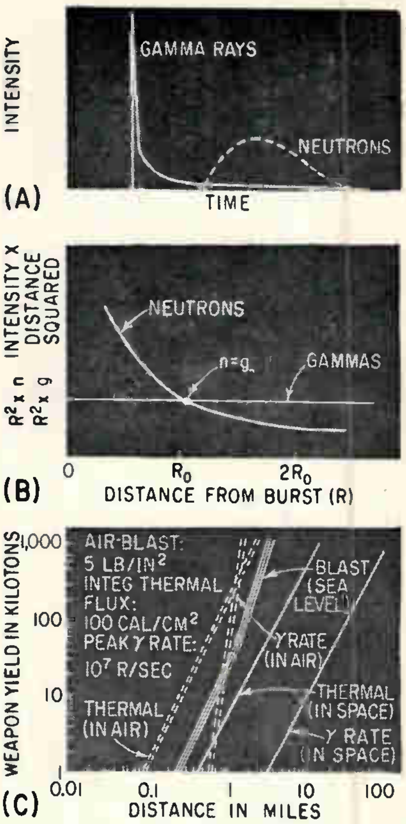


FIG. 4—Typical variation with time of nuclear radiations (A), relative importance of effects due to gamma radiation and neutrons (B) and variation with distance of several lethal phenomena as function of weapon yield (C)

and will deposit an inadequate amount of energy within the sensitive portions of the system. On the other hand, if the energy is too high, the entire system will be penetrated by the radiation and relatively little will be deposited to cause malfunctions. In either case a measurement of the incident radiation intensity and a comparison with calculated conditions in the field may give misleading results. It is essential to match the spectrum of the radiation simulator as closely as possible to that of the actual weapon.

Third in importance is the radiation rate or flux produced by the simulator. This attribute can be considered only if the simulator is proper in pulse duration and energy spectrum. After having satisfied these criteria, it is not possible to have too high a radiation rate in a simulator. On the other hand, if the radiation produced by a simulator is sufficiently great as to cause malfunctions or damage to typical

THE WEAPON ENVIRONMENT

Upon detonation of a nuclear weapon, one creates in addition to numerous other forms of energy a large quantity of gamma radiation and a correspondingly large number of fast neutrons. These are referred to, respectively, as prompt gammas and prompt neutrons.

Prompt gammas propagate with the speed of light, arriving at any distant point simultaneously and appearing as a short, intense gamma spike. In the typical situation of interest where a guided missile enroute to its target is exposed to a brief burst of radiation from a distant explosion, the neutrons which are created simultaneously with the gamma radiation travel with a much lower velocity, and hence arrive at an appreciably later time. Furthermore, these neutrons vary considerably in energy, having approximately the energy distribution characteristic of the fission process. The most energetic (fastest) neutrons arrive at the point of interest first, followed in rapid succession by neutrons of decreasing energy, as well as by neutrons which are subject to multiple scattering by the atmosphere and which travel by devious routes. (See Fig. 4A.)

From these considerations one can draw some fundamental conclusions. In the absence of atmosphere, the intensity of gamma radiation varies inversely with the square of the distance, since it is produced by a source of essentially point dimensions. The neutron flux (maximum value of the neutron rate curve in Fig. 4A) varies as the inverse cube of the distance, since the width to half-flux points of the neutron intensity curve varies inversely as the distance. Accordingly, the neutron flux decreases much more rapidly with distance than does the gamma flux, leading to the conclusion that neutron phenomena are important only at relatively short distances and that the range of gamma phenomena tends to be considerably greater than that of neutron phenomena. These relations are indicated in Fig. 4B which shows the effect of velocity dispersion on the peak intensity of neutrons as compared with that of gamma rays. Normalized coordinates are used, indicating that beyond some range R_0 neutron effects decrease with distance more rapidly than gamma effects.

Within the atmosphere, the geometrical attenuations discussed are further increased by scattering and absorption. This has a far greater effect upon the neutron component of the radiation than upon the gamma component, resulting in a further reduction in the relative importance of neutrons as compared to gammas. Fig. 4C shows qualitatively the relation between peak gamma rate at sea level and at a sufficiently high altitude as to be free of atmospheric absorption as a function of weapon yield. For comparison, this figure also shows the variation with weapon yield of thermal radiation and blast. The values chosen for illustration are typical of thresholds within which serious malfunction or permanent damage may be produced by the several phenomena noted. The most significant conclusion to be drawn from Fig. 4C is that outside the atmosphere the range of radiation-induced malfunctions is much greater than that of other weapon phenomena. Within the atmosphere, the range of gamma-induced malfunctions is comparable with those of the other weapon phenomena. A detailed analysis must of course be made for each individual system and tactical situation

electronic systems, this simulator will have considerable practical utility. It is not necessary, although it is desirable, to be able to simulate conditions equivalent to those well within the lethal envelopes produced by thermal or mechanical phenomena from the weapon.

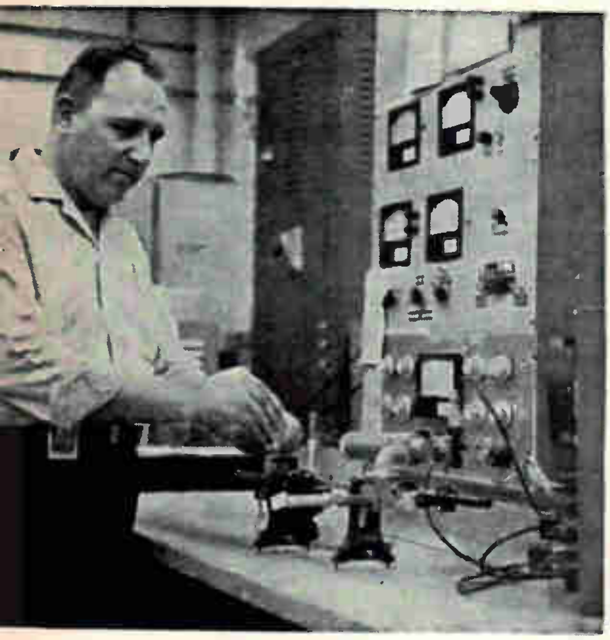
Consider the simulation of the two major components of weapon radiation. A gamma linac (microwave linear electron accelerator), when operated at a nominal electron energy of 10 Mev, produces X-rays whose spectral distribution is surprisingly close to that of the fission gamma rays of a nuclear explosion. These machines can be constructed with pulse widths variable from about 0.01 to 10 microseconds, a range more than adequate to bracket the relaxation times of interest. It is more important to bracket a realistic range of relaxation times than merely to duplicate exactly the detailed shape of the gamma time history produced by a nuclear explosion. Gamma radiation rates produced by peak beam current of 1 ampere or more are more than adequate to produce serious malfunctions in typical electronic circuits. Hence, the 10-Mev gamma linac, shown in the photograph, can be considered an adequate simulator for the gamma spike and a useful research instrument.

The lesser range of neutron flux from a weapon makes its simulation of somewhat less importance. Nevertheless, a complete evaluation of the performance of any given electronic system should include an evaluation of neutron phenomena. For this purpose, the bare critical assembly, or Godiva, is suitable. The neutrons produced by this device have a degraded fission spectrum, as is to be expected since they are produced by the fission process. This is not unlike the spectrum produced by a weapon. The duration of pulses produced by machines of this type may in principle be varied over a range from roughly 40 to 100 microseconds. This also is realistic as compared with the duration of neutron pulses at a reasonable distance from a nuclear explosion. Finally, numerous experimenters have demonstrated a great variety of malfunctions with the Godiva II, which is located at Los Alamos Scientific Laboratory in New Mexico, demonstrating that the nuclear flux rates are adequate.

The fast neutrons produced by fusion weapons are emitted in a pulse whose duration is usually a few microseconds; they can be simulated by a 30-Mev linac which uses the photofission process to produce neutrons from Bremsstrahlung. A 30-Mev linac may be visualized as three of the 10-Mev accelerating sections shown in the photograph placed in tandem. The neutron linac is also a practical experimental tool and is valuable for determining relaxation times of malfunctions induced by neutron transients.

NEW KLYSTRON DESIGN FOR

Usable power at constant repeller voltage over a 10-percent band is available from klystron with movable grid. Design principle requires careful choice of tube dimensions but can be used over the complete klystron frequency range



Constant repeller-voltage klystron in test setup

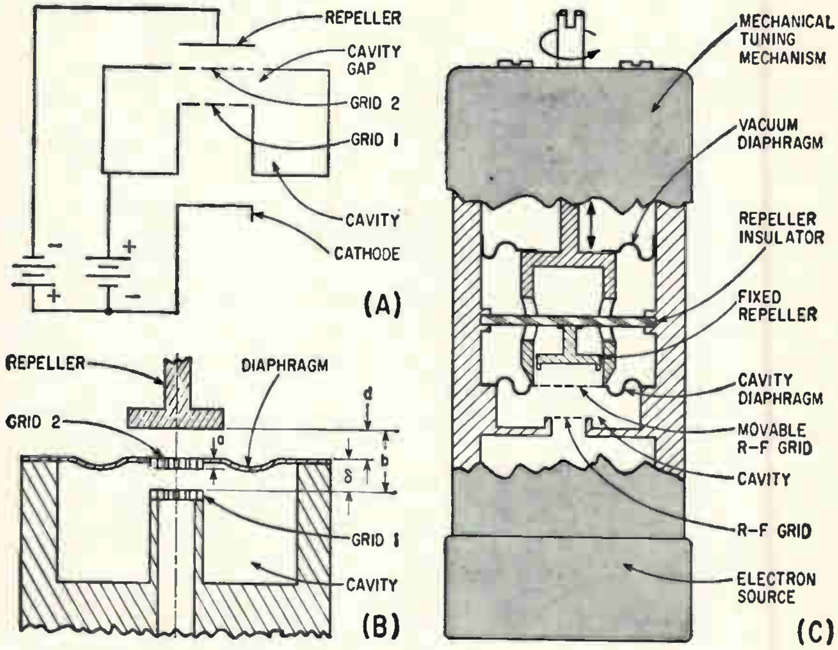


FIG. 1—Simplified schematic of reflex klystron (A), mechanical structure and critical dimensions (B), method of obtaining motion of grid 2 (C)

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REFLEX KLYSTRONS, widely used as low-power oscillators in microwave systems, are compact, operate at low voltages, require no auxiliary focusing and can easily be frequency modulated. But the electronic tuning range of reflex tubes is typically less than 1 percent of center frequency; to cover any appreciable band, mechanical tuning of the resonant cavity (or a cavity tightly coupled to it) is required. It is also usually necessary to change the repeller voltage. Thus, two adjustments are needed to change frequency.

When the klystron is tuned remotely, by a motor for example, a potentiometer to control repeller voltage is commonly ganged to the klystron tuner shaft. Since the required repeller voltage does not vary linearly with frequency, and cavity frequency is rarely a linear function of tuner shaft rotation, cams or non-linear precision potentiometers are required. Further, tube-to-tube variations may require adjusting the tracking mechanism when tubes are replaced.

A new variant of the reflex klystron requires no change in repeller voltage to tune over a band as wide as 10 percent of the center frequency. The tracking potentiometer and its gearing can thus be eliminated, reducing circuit cost and weight, and increasing reliability.

The principal upon which the new development is based is straightforward.[1, 2] In a reflex klystron (Fig. 1A), electrons originate at the cathode, are accelerated by the field between cathode and cavity, and arrive at the gap at uniform velocity. If there is an r-f voltage across the gap, electrons will be velocity modulated as they enter the repeller space. The repeller is negative with respect to the cathode and no electrons can reach it. The returning electron beam is bunched by the action of the repeller field; electrons that leave the gap when the field is changing from accelerating to decelerating become the center of the bunch. The bunch should return when the field is at its peak accelerating value (decelerating as far as the bunch is concerned), which first occurs $\frac{3}{4}$ of an r-f cycle later. Proper phasing is maintained if the bunch returns $N + \frac{3}{4}$ cycles later, where N is an integer that identifies the mode. In practical reflex tubes N is typically 3, 4 or 5.

The necessity for tracking the repeller is now apparent. Since, for the same mode, the number of

CONSTANT REPELLER VOLTAGE

cycles the electrons spend in the repeller space must remain constant, the electrons must return in a shorter time at a higher frequency than at a lower one. Hence the repeller must be more negative at the higher frequency.

Reflex klystron cavities may be broadly divided into two classes: fixed-gap and gap-tuned. In the fixed-gap type, the resonant frequency of the cavity can be changed by an inductive slug in the cavity wall, by a capacitive flag that approaches the gap, or by tuning an auxiliary cavity that is tightly coupled to the main cavity of the tube. Gap-tuned klystrons vary the spacing between grids and gap. Increasing the separation of the grids tunes the cavity to higher frequencies. Gap-tuning offers the possibility of nearly constant repeller voltage.

If the repeller is fixed with respect to grid 2 (holding dimension d constant in Fig. 1B), the spacing from the center of the gap to the repeller increases as the cavity is tuned to higher frequencies, and a change in repeller voltage larger than in the fixed-gap case is required.

If, however, the repeller is fixed with respect to grid 1 (holding dimension b constant), the repeller-to-cavity spacing decreases as the tube is tuned to higher frequencies, and the required change in repeller voltage is decreased.

Repeller voltage required to stay at the top of a mode is:

$$V_R \approx \left(\frac{4dV_o}{(N+3/4)23.3\sqrt{V_o}/f-\delta-2a}\right)-V_o$$

where V_o is beam voltage, d is the spacing from grid 2 to repeller in thousandths of an inch, N is mode number, f is frequency in Gc, δ is spacing between the r-f grids in thousandths of an inch, and a is the thickness of grid 2 in thousandths of an inch.

The equation neglects the presence of space charge in the repeller region and assumes a constant d-c retarding field. It does not predict repeller voltage with accuracy but it does closely predict the required change in repeller voltage.

In the case of the constant repeller voltage (CRV) klystron under discussion, d and δ both change with f, and the change in the numerator compensates for the change in the denominator. With gap tuning, resonant frequency of the cavity is approximately $f \approx f_o\sqrt{\delta/\delta_o}$ where f_o is the resonant frequency at gap spacing δ_o. With CRV construction $d = b - \delta$ where b is the spacing from grid 1 to repeller. If these relations are substituted into the equation for repeller voltage

$$V_r \approx \frac{4[b-\delta_o(f/f_o)^2]V_o}{23.3(N+3/4)\sqrt{V_o}/f-\delta_o(f/f_o)^2-2a}-V_o$$

Since numerator and denominator do not vary in the same way, repeller voltage cannot be made completely independent of frequency. However, by an appropriate choice of dimensions, the change in repeller voltage required for a 10 percent frequency change can be made less than the half-power bandwidth (in voltage) of the repeller mode. Operation at constant repeller voltage is therefore practical. But repeller voltage, and b, cannot be made too small without introducing hysteresis. Power, half-power bandwidth, and modulation sensitivity requirements may dictate the choice of N.

A CRV klystron still has all the properties of a reflex klystron; it has several modes of oscillation with repeller voltage and can easily be frequency modulated by varying repeller voltage.

Figure 2A shows output power versus frequency for a representative K_u band CRV klystron and for a tube with conventional repeller structure, with both tubes operating with repeller voltage held constant. Figures 2B and 2C show output power versus repeller voltage for the same two tubes at three tuned settings.

Because the change in transit angle in the repeller space for a given change in repeller voltage is nearly independent of frequency, the modulation sensitivity of the CRV klystron varies with frequency much less than does the conventional gap-tuned or fixed-tuned klystron, thus providing nearly constant modulated output without compensation or adjustment. (Transit angle is the electron time in the repeller space multiplied by angular frequency.) The principle described is applicable to all frequency ranges in which gap-tuned reflex klystrons are practical, from several hundred Mc to at least as high as 40 Gc.

The authors acknowledge the contributions of J. H. Walters, N. M. Banes, and A. S. Rhoads, Jr., all of the Sperry Electronic Tube Division.

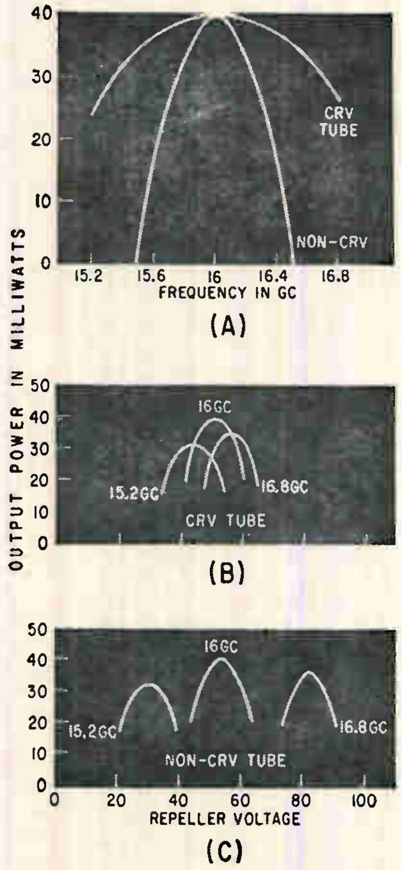

FIG. 2—Usable power is obtained over 1.6-Gc band at constant repeller voltage with new design (A). In (B) and (C), power output is plotted against repeller voltage at fixed frequencies

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DESIGNING TUNNEL

Tunnel diode relaxation oscillators are analyzed and the circuits for frequency-stabilized sinusoidal and square-wave generators are derived. Push-pull as well as cascade oscillator circuit design raises output power levels

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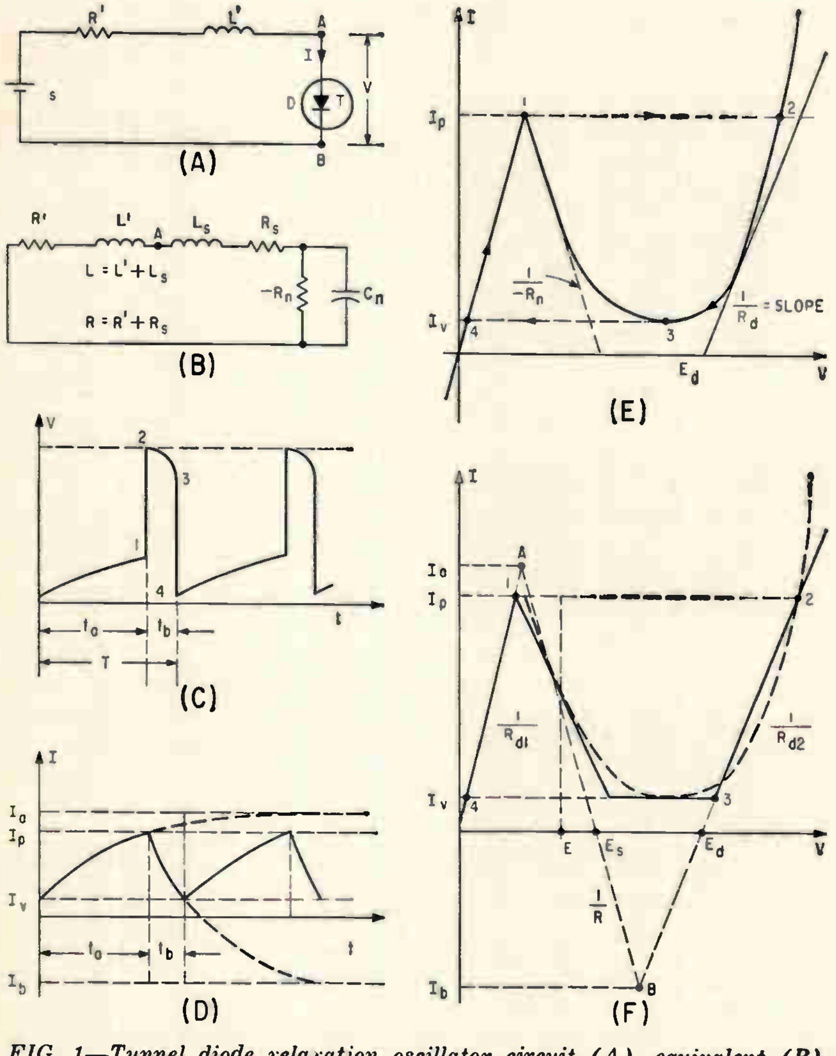


FIG. 1—*Tunnel diode relaxation oscillator circuit (A), equivalent (B), voltage waveform (C), current waveform (D), actual characteristic (E) and sectional linearized approximation (F)*

THE NEGATIVE CONDUCTANCE property of a tunnel diode makes it a convenient and desirable device for oscillators. It may oscillate at all frequencies up to a few thousand megacycles. The simplest oscillator circuit is shown in Fig. 1A, the a-c equivalent circuit (1B), the voltage wave form (1C), and the current wave form (1D). If $-R_n$ is the negative resistance of tunnel diode at the operating point, C_n the diode capacitance, $L = (L' + L_s)$ the total inductance in the a-c circuit, and $R = (R' + R_s)$ the total resistance in the oscillating loop, the condition for oscillation is[1, 2]

$$R_n > R; \quad L > C_n R_n R$$

During each cycle of oscillation the current and voltage relation of the diode traces the path (1-2-3-4-1) along the tunnel diode characteristic in Fig. 1E. If C_n is small and can be neglected at the oscillating frequency, the line sections (1-2) and (3-4) will be horizontal. The time required to trace these sections can also be neglected as compared to that for tracing sections (2-3) and (4-1). Let t_a and t_b be the time required to trace path sections (4-1) and (2-3) respectively. The instantaneous equivalent circuit of tunnel diode during time t_a or t_b may be represented by a voltage source, E_d, in series with a positive incremental resistance, R_d. The

DIODE OSCILLATORS

value of R_d is obtained from the reciprocal of the slope at the point in question on the characteristic curve, while E_d is the intercept of the $1/R_d$ slope line with the V-axis. The values of R_d and E_d are not constant but are functions of the bias voltage across the diode. The time t_a and t_b may be found by solving the nonlinear differential equation

$$\begin{aligned} E_s - E_d(v) &= L(di/dt) + [R + R_d(v)]i \\ &= L(di/dt) + R_T(v)i \qquad (1) \end{aligned}$$

if $E_d(v)$ and $R_d(v)$ are known. For simplicity, straight line segments are used to approximate the characteristic of tunnel diodes as shown in Fig. 1F, then R_d and E_d can be considered as constants during the operation over each line segment. Therefore, the equivalent circuits of this relaxation oscillator, in t_a or t_b, is now the well known single time constant (L-R) circuit. From the equivalent circuit given in Fig. 2A;

$$\begin{aligned} t_a &= L/R_{T1} \ln [(I_a - I_v)/(I_a - I_p)] \\ &= L/R_{T1} \ln [(E_a - E_4)/(E_a - E_1)] \qquad (2) \end{aligned}$$

where $R_{T1} = R + R_{d1}$, $I_a = E_s/R_{T1}$
$E_a = E_s R_{d1}/(R + R_{d1})$

$$\begin{aligned} t_b &= (L/R_{T2}) \ln [(I_p - I_b)/(I_v - I_b)] \\ &= (L/R_{T2}) \ln [(E_3 - E_b)/(E_2 - E_b)] \qquad (3) \end{aligned}$$

where $R_{T2} = R + R_{d2}$, $I_b = (E_s - E_{d2})/R_{T2}$, $(I_b < 0)$ and
$E_b = E_s + (E_{d2} - E_s)[R/R + R_{d2})]$

Therefore, $f = 1/T = 1/(t_a + t_b)$ (4)

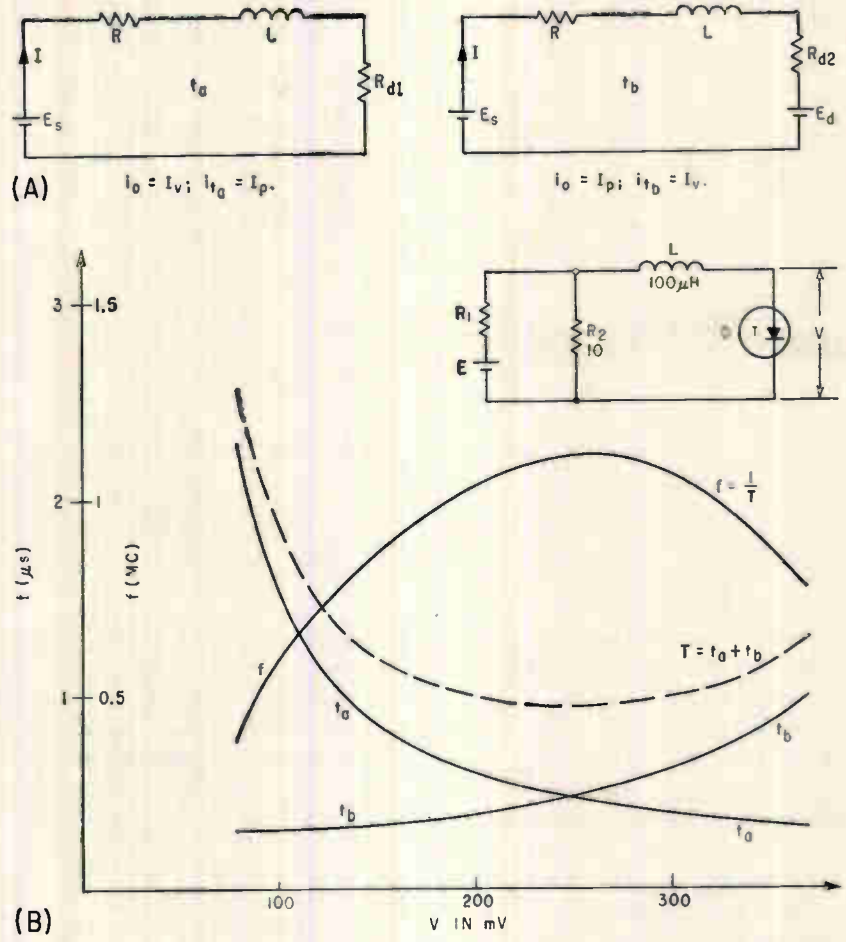


FIG. 2—Equivalent circuit of relaxation oscillator (A) and observed data from oscillator (B)

From Fig. 1F it can be seen that the sectional straight line (4-1) gives good approximation to the actual characteristic, while the line (2-3) is selected rather arbitrarily and is not an accurate approximation of the characteristic. Furthermore, it is shown graphically that I_a is nearly equal to I_p, while I_b differs from I_v by a considerable amount. These observations account for the experimental facts that Eq. (2) is more accurate than Eq. (3) under varying circuit conditions, and that for a given circuit configuration, t_a can be varied over a wide range by the bias voltage E_s while t_b will be varied over a smaller range. Figure 2B represents a set of the observed data from the relaxation oscillator circuit shown in the same illustration. The frequency drops off at both extremes of bias and has its maximum value near the bias that gives $t_a = t_b$. In spite of the large frequency variation (three to one) with bias voltage, the amplitude and the shape of the oscillating voltage in t_a or t_b remain substantially constant.

This simple oscillator is not useful for most practical purposes because of its large variation of frequency with supply voltage and its poor wave form which is neither sinusoidal nor rectangular. The following parts of this article will discuss the methods to stabilize the frequency and the circuits that will generate sinusoidal voltage or rectangular voltage.

To stabilize the frequency of tunnel diode oscillators, a resonant circuit may be incorporated in the oscillator circuits. The resonant circuit is excited by the tunnel diode oscillation and oscillates at nearly its resonant frequency which in turn serves as a synchronizing signal to the tunnel diode. The condition for oscillation of a resonant circuit coupled to a negative resistance device requires that the total shunt conductance, g_p, of a parallel resonant circuit or the total series resistance, r_s, of a series resonant

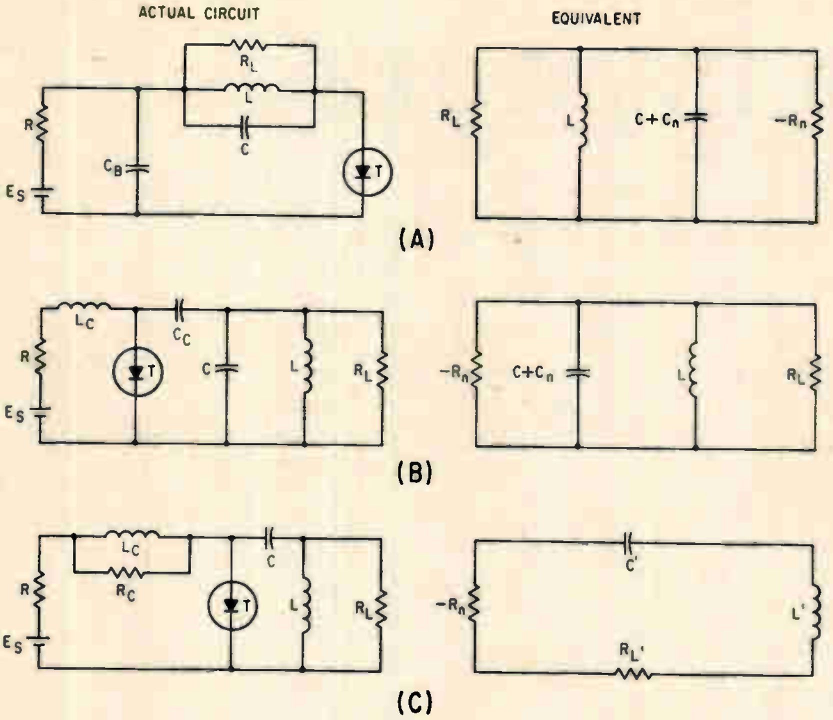


FIG. 3—Resonant-circuit stabilized tunnel diode oscillators where C_c and C_n are large

circuit be zero or negative. If we retain the definition for $Q = (1/r_s)\sqrt{L/C} = \omega L/r_s$ for series resonance and $Q = \omega C/g_p$ for parallel resonance, then, $r_s = 0$ or $g_p = 0$ means Q is infinite and this may also be specified as the condition for sustained oscillation. Negative r_s or g_p will give negative Q which means oscillations will grow until limited by some nonlinearity which changes the parameters of the negative resistance until $r_s = 0$ or $g_p = 0$. Three of the possible circuits, using parallel or series L C resonant circuits for stabilization, are shown in Fig. 3. In Fig. 3A a parallel resonant circuit is used in series with the diode and the d-c supply. In Fig. 3B the frequency determining circuit is in parallel with the tunnel diode. Here the high frequency choke L_c and coupling condenser C_c provide the isolation between a-c and d-c circuits. The choke inductance L_c is much greater than L and should be large enough to provide the isolation, while C_c should be so large that for any oscillation associated with L_c the tunnel diode is effectively shunted by C_c to make $L_c < (C_c + C_n) R_nR$. This is the condition for the suppression of the unwanted mode.

In Fig. 3C, C and L form a series resonant circuit through the negative resistance of tunnel diode (the inductance and capacitance of the diode can be lumped into the C and L). The inductance L_c provides both shunt feed and isolation of d-c. Resistance R_c is used to stabilize the loop with L_c and diode in series. A series R_c' may be used to replace the L_c and R_c combination, if R_c' will stabilize the d-c loop. The series resonant circuit blocks d-c, therefore it cannot be used in series with the tunnel diode without another shunt element to supply the d-c bias.

For accurate frequency control a crystal may be used to form part of the resonant circuit. Figure 4 shows two of the circuits using crystals to control the frequency[1, 4].

These circuits provide reasonable frequency stability (a few percent change over the entire bias range). If R,C, and L are adjusted so the condition of instability is just satisfied, then the oscillation will be nearly sinusoidal. However, in this case if there is any sizable change of bias, load, or capacitance, the oscillation will stop. This might be useful for some purposes; it is not desirable for most applications.

A stable sinusoidal oscillation may be obtained from the following reasoning. Let the instability condition ($L > C\,R_nR$) be satisfied with considerable margin. The oscillation will be stable but the voltage wave form will be approxi-

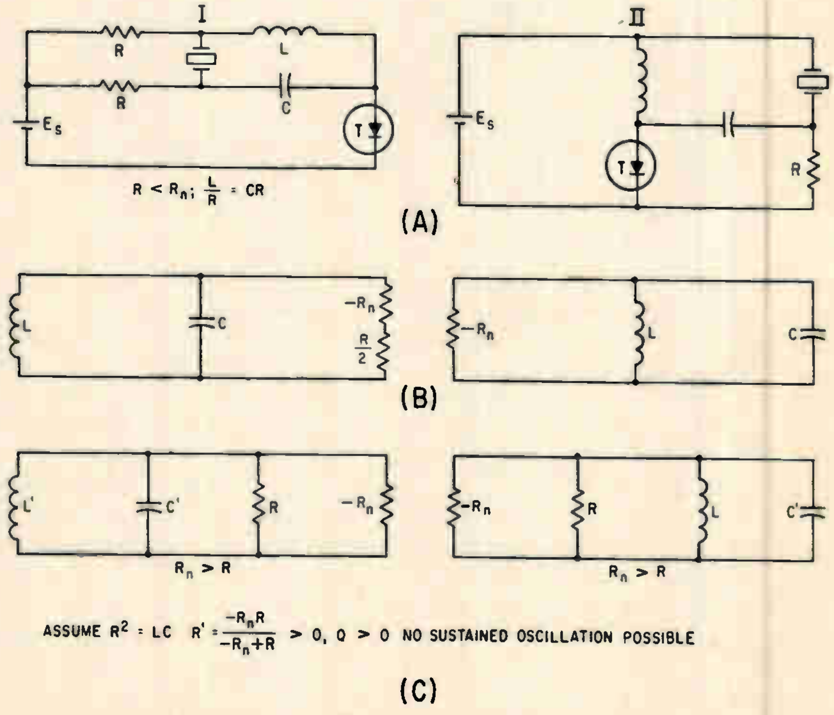
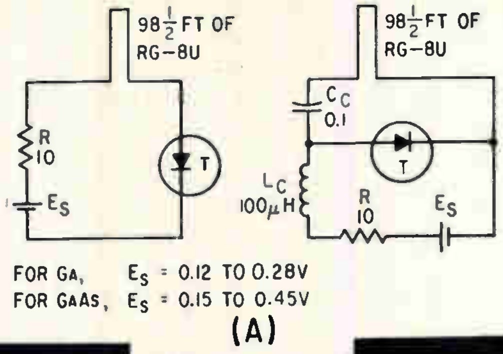
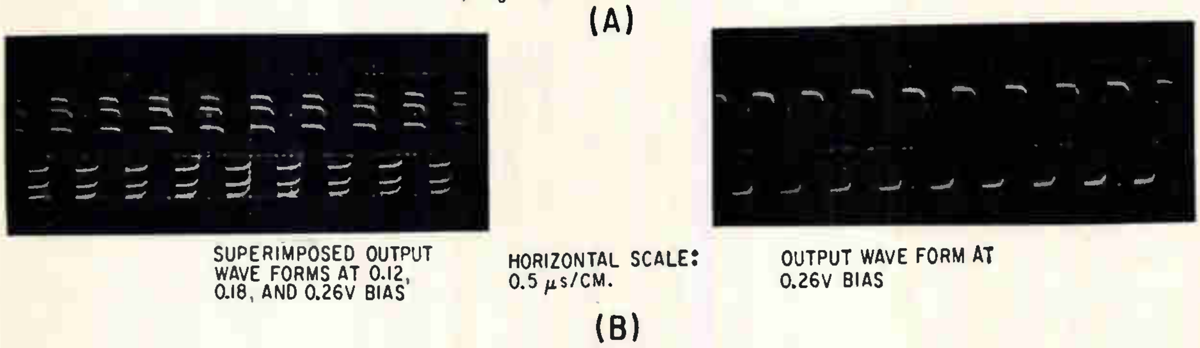


FIG. 4—Crystal-stabilized tunnel diode oscillators showing circuits (A), equivalent circuit at series resonance of crystal (B) and equivalent circuit at off-resonant frequency (C)

FIG. 5—*Circuits (A) and output waveforms (B) of square-wave oscillators*





mately of the shape shown in Fig. 1C. This wave consists of the desired fundamental and many other harmonics. The desired frequency may be selected with filters or by the simple circuits illustrated in Figs. 6C and 6D.

In Fig. 6C, high impedance Z is in series with the parallel resonant circuit. For all harmonics, the voltage is taken up by the series Z, while for the resonant frequency the oscillating voltage is nearly all dropped across the tank. In Fig. 6D, low impedance Z is in parallel with the series-resonant circuit. At the series-resonant frequency nearly all the signal current passes through the resonant circuit while at other frequencies the current passes through the shunt impedance. Therefore, the voltage across the resonant capacitance will be sinusoidal. Both circuits provide little loss for the fundamental signal. Figure 6A represents the two sine-wave oscillators discussed above; Fig. 6B shows the relation between frequency and bias voltage. It should be noted that it is also possible to use only a tapped portion of a resonant circuit in the tunnel diode oscillating loop. This raises the output voltage and impedance level, and may improve the wave form across the total resonant circuit.

When a short circuited coaxial cable, transmission line or artificial delay line is used instead of the series inductance in the simple relaxation oscillator of Fig. 1, a good square wave is generated with excellent frequency stability over the entire bias range.[3] The period of the square wave closely approximates four times the period required for the electromagnetic wave to travel the length of cable. The rise and fall time of the square wave is about 10 nsec with a germanium tunnel diode and can be improved by circuit arrangement. The short-circuited coaxial cable may be connected in series or in parallel with the diode. A suitable capacitor may be used in place of the short-circuit of the cable. Figure 5 illustrates two of the square-wave oscillator circuits and the output waveform across the cable at

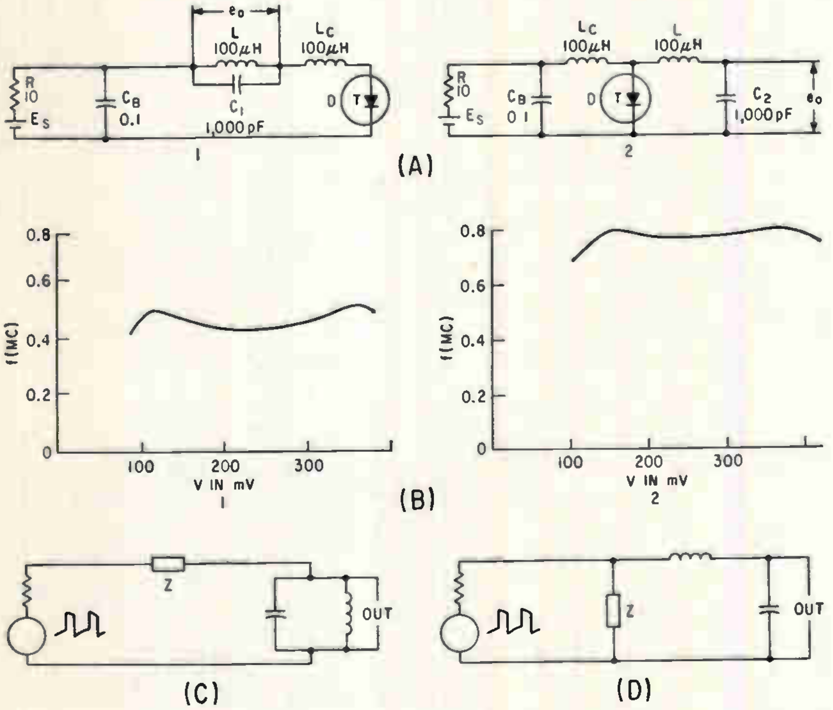


FIG. 6—*Circuit (A) and frequency versus bias curves (B) of two relaxation oscillators. Principles of deriving sinusoidal output are shown at (C) and (D)*

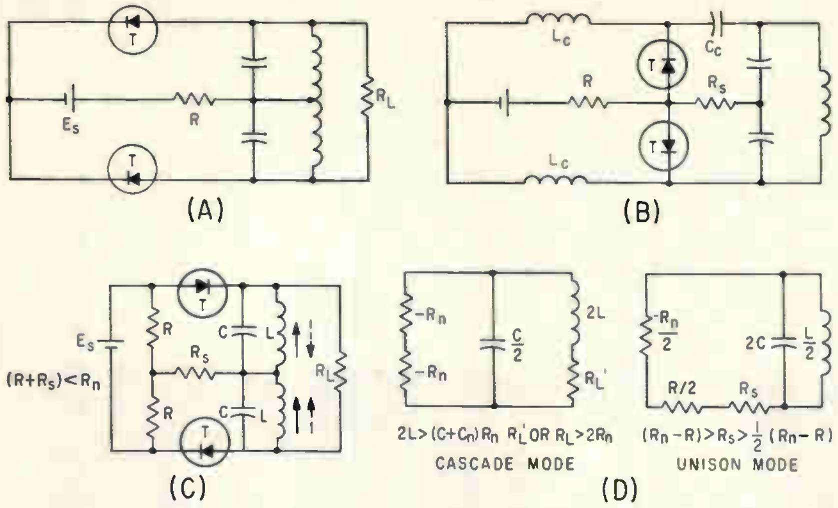


FIG. 7—Push-pull oscillator circuits shown at (A) and (B). Cascade oscillator circuit shown at (C) with equivalent shown in (D)

different values of bias. These waveforms are superimposed to show the constancy of the period.

Power output of the tunnel diode is limited. For an oscillator using a germanium tunnel diode with 10-ma peak current the d-c power input is about one milliwatt and the maximum sinusoidal output is about one-half milliwatt, with a voltage swing of about half a volt. To increase the power or the voltage output, the push-pull and the cascade circuit may be used. The push-pull circuit and its stabilization is discussed in a paper by Hines[2]. The circuits shown in Fig. 7A and 7B were tested with satisfactory results. In the circuit of Fig. 7B, the resonant tank circuit is connected in shunt with the tunnel diodes.

Figure 7C and 7D show the series feed cascade oscillator. The difference between the cascade and the push-pull circuit is in the method of supplying d-c to the diodes. In the cascade circuit the diodes are supplied by two different d-c sources in series, while for push-pull the two diodes are supplied by the same d-c source. The former gives better efficiency when using a dry battery as the power supply. Furthermore, the scheme of cascade oscillator circuits can be used for more than two diodes connected together.

Oscillation of the two diodes in cascade may be in the cascade mode or the common mode (unison mode). In the former the a-c voltage of the two sections of tank circuit add to give twice the output voltage across load R_L, as indicated by the solid arrows. In the latter, the voltages cancel across R_L, as indicated by dotted arrows.

The a-c equivalent circuit of the two modes and the stability criteria were analyzed and are illustrated in Fig. 7D. If the circuit elements are so selected that the unison mode is suppressed and the cascade mode is self starting, the oscillator will give the same output as the push-pull circuit.

Figure 8 shows a three-diode cascade oscillation circuit and the pertinent voltage wave forms across the total tank as well as across each diode.

Thus, frequency stabilized sinusoidal and square wave oscillators are obtainable with simple circuits. To increase the power or voltage output, push-pull and cascade circuits may be used. The cascade circuit provides a more efficient way of using the available d-c supply and also permits the incorporation of more than two diodes in an oscillator.

Although sine- and square-wave oscillators maintain relatively stable frequencies with respect to change of bias, the amplitude of the outputs does vary with bias. This provides a simple method of modulation.

The author thanks Dr. R. Plonsey for his assistance in preparing this manuscript and for helpful discussions.

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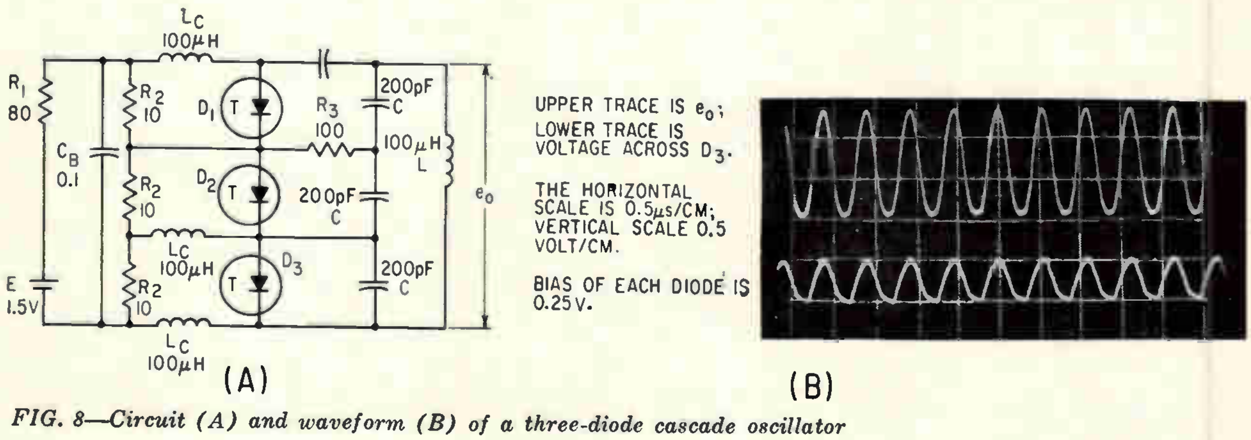

FIG. 8—Circuit (A) and waveform (B) of a three-diode cascade oscillator

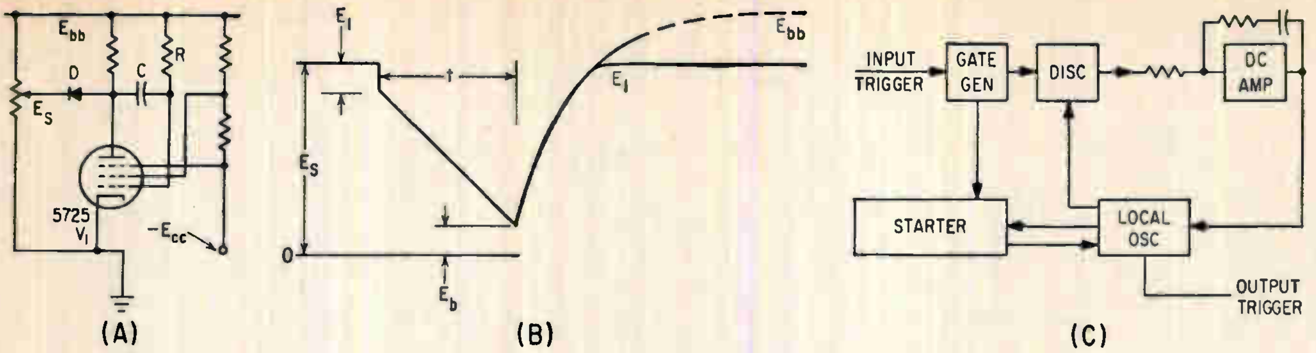

FIG. 1—Basic phantastron has sweep duration controlled by adjustment of rundown starting voltage E_s (A); plate waveform (B); method of synchronizing free-running phantastron by closed-loop comparison of frequency with that of received sync pulses (C)

PLATE VOLTAGE CONTROL OF

PHANTASTRON FREQUENCY

Two pentodes, each forming a phantastron circuit, are interconnected so that both mark and space of their combined output waveforms are controlled by linear rather than exponential sweeps. Circuit jitter is less than 0.003 percent at 5 pps repetition rate

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A GROUND-BASED decoder in a data-transmission link required ground generated pulses that were synchronized with the incoming video data and required the train of pulses to continue in synchronism even when the received sync pulse was missing, or when its amplitude was below ambient noise level. This required, among other circuits, a free-running oscillator that could be electronically corrected in both phase and frequency until its generated pulse occurred at the same time as the received sync pulse was supposed to occur, whether the sync pulse actually occurred or not.

Other circuit requirements called for an additional pulse midway in time between the received sync pulses, regardless of the input frequency.

A basic voltage controlled phantastron circuit is shown in Fig. 1A, and the plate waveform in Fig. 1B. The timing equation is

$$t = RC\,(E_s - E_b)\,/\,(E_{bb} + E_1) \qquad (1)$$

where E_s is the starting voltage of the plate ramp, and E_b and E_1 are the plate bottoming and initial step voltages, respectively. They are approximately 3 and 6 volts for the 5725 tube.

The monostable circuit of Fig. 1 can be made astable by capacitive rather than resistive feedback in the suppressor circuit. However, the resulting suppressor circuit time constant is then an exponential function, and thus possesses more inherent jitter than the linear Miller sweep of the monostable phantastron. An additional disadvantage arises when, as in this case, both on and off periods of the circuit need to be varied by adjusting the level of input control voltage. A block diagram of the local oscillator control circuit Fig. 1C shows how the phantastron is adjusted in frequency until it is synchronized with the incoming low-frequency data pulses. Both incoming sync pulses and phantastron output pulses are fed to the discriminator circuit, which generates an output proportional to the phase difference between discriminator and phantastron. The discriminator's output feeds a d-c amplifier that in turn delivers the control voltage shown as E_s in Fig. 1A. The direction of change of this control voltage is such that it reduces the phantastron frequency when it exceeds that of the incoming sync pulses and raises the frequency in the converse case.

Figure 2 is the oscillator whose output is synchronized to the frequency of incoming data pulses. Two phantastrons (V_3 and V_4) are coupled screen-to-plate so that the negative slope of the pulse from the screen of one tube (at the end of rundown) triggers the second tube into *its* rundown. Thus, phantastrons V_3 and V_4 produce alternate voltage ramps whose starting level E_s is controlled by the potential fed in from the discriminator d-c amplifier. Variation of this d-c voltage E_s controls the period of rundown, and hence the over-all frequency of oscillation.

Diodes D_2 and D_3 act as switches, disconnecting the plates from the (opposite screen) trigger sources whenever the plate voltage is less positive than that trigger, which has been referenced in turn to E_s,

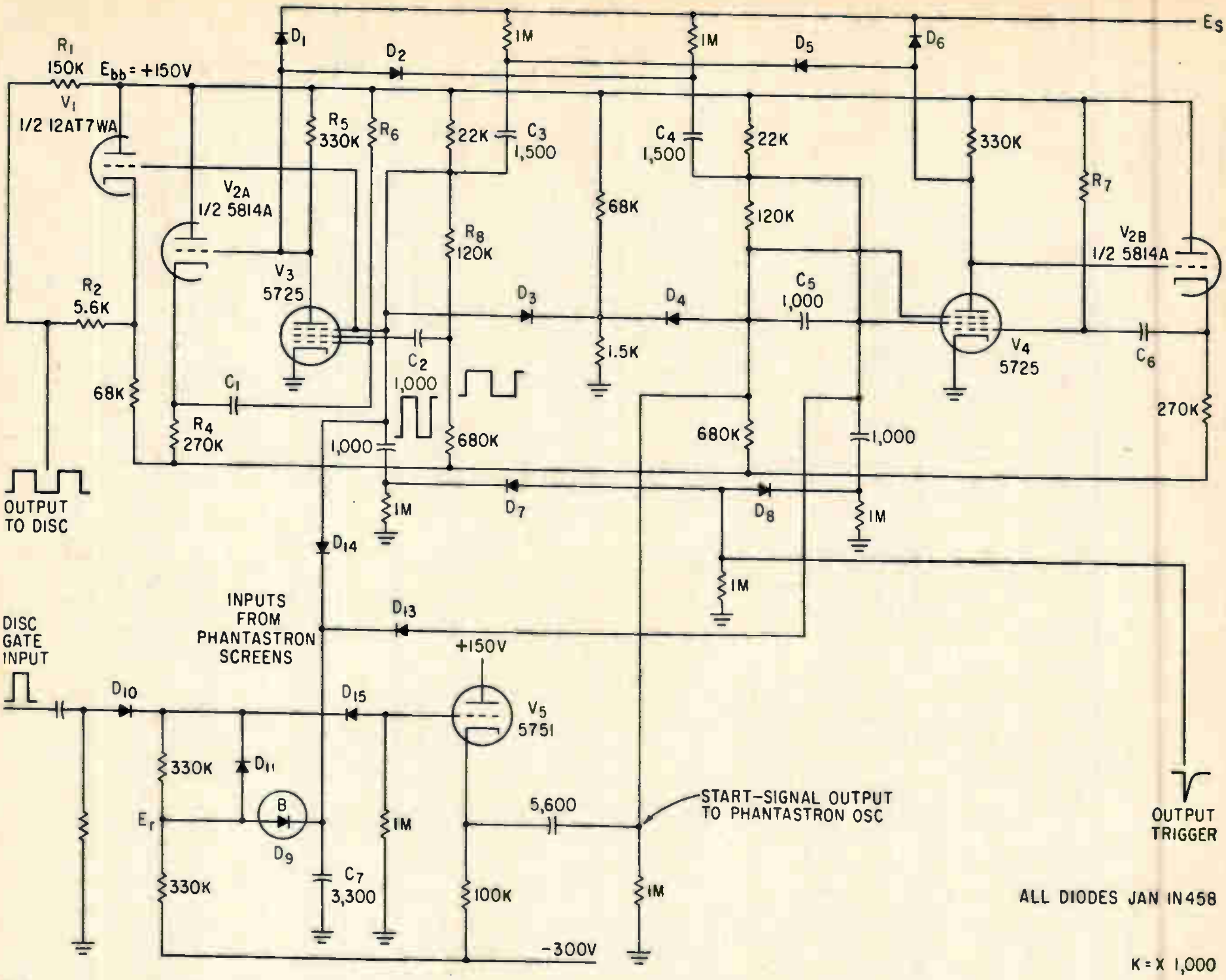


FIG. 2—Pentodes V_3 and V_4 form a free-running twin-phantastron oscillator whose frequency is set by the level of control voltage E_s; this voltage comes from the frequency correcting circuit of Fig. 1C. Triode V_5 gates starting pulses to the phantastron whenever it fails to oscillate

the output of the d-c amplifier.

Capacitors C_2 and C_5 decrease the fall time of the screen waveforms for more rapid triggering of the next stage.

Since the recovery period of the plate ramp Fig. 1A is about the same duration as the ramp itself, the recovery action must be speeded up. Otherwise timing capacitor C (C_1 in Fig. 2) will not be fully charged by the time the plate should begin its next rundown, the plate potential will not have returned to E_s, and the resulting pulse-width will be less than desired width. To shorten this plate rise-time, cathode followers V_{2A} and V_{2B} give the capacitors low impedance charge paths.

Cathode follower V_1 is a low-impedance output stage and the network R_1 and R_2 is a d-c level shifter to zero-center the 15 v peak-to-peak output pulse for direct coupling to the discriminator.

Both suppressors are clamped by diodes D_3 and D_4 to a voltage divider, giving a flat top to the pulses and overcoming any possible effects of secondary emission. Thus by the proper choice of R, C and E_s, a free running oscillator of any natural frequency f_n, and with an extremely wide range of duty cycles, can be designed from Eq.

$$f_n = 1/T_n = (E_{bb} + E_1)/[(R_6C_1 + R_7C_6)(E_s - E_B)] \quad (2)$$

By rearranging and solving for E_s

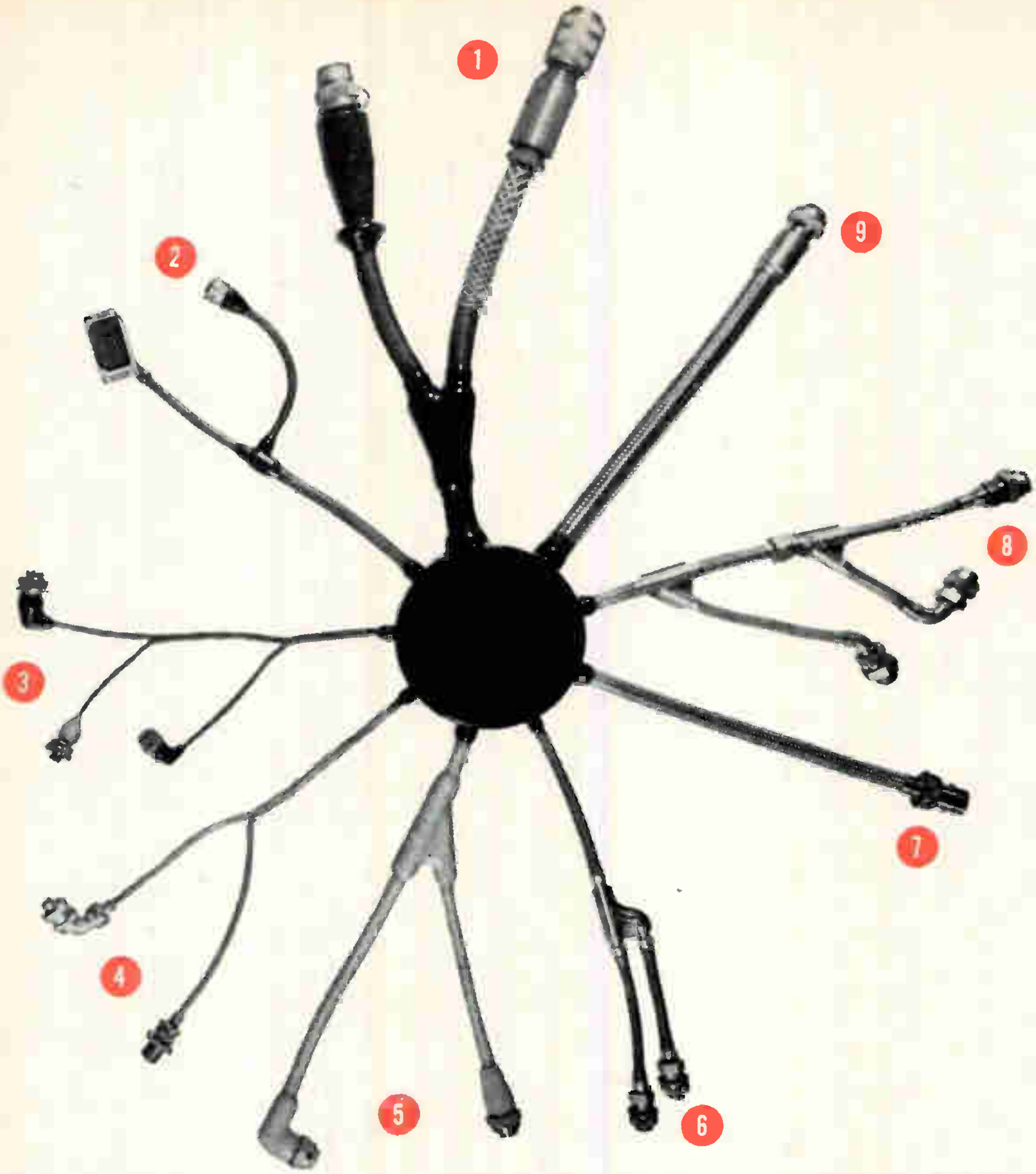
$$E_s = [T_n(E_{bb} + E_1)/(R_6C_1 + R_7C_6)] + E_b$$
$$\text{or, } \Delta E_s = T_n(E_{bb} + E_1)/(R_6C_1 + R_7C_6) \quad (3)$$

The required range of d-c amplifier output voltages (E_s) can be determined for the desired range of periods T_n from Eq. 3 and the gain of the d-c amplifier can next be determined. The transfer function K of the oscillator can also be determined by rearranging Eq. 2

$$T_n/(E_s - E_B) = (R_6C_1 + R_7C_6)/(E_{bb} + E_1)$$
$$\text{or } K = \Delta T_n/\Delta E_s = (R_6C_1 + R_7C_6)/(E_{bb} + E_1) \quad (4)$$

Equation 4 demonstrates rundown linearity for any given T_n.

As long as the two R-C products in the timing network of Fig. 2 are different, turning on the power supply provides sufficient agitation to start oscillation. However, as the two R-C products approach equality, application of power becomes a less-certain starting method because the two capacitors will acquire charge at equal rates. Consequently a starter circuit, V_5, was added to the basic phantastron; the starter becomes inactive after oscillations begin, but works immediately if oscillator stops.



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Measuring Dielectric Constant Graphically

By RICHARD HEIMER, Electrical Engineer, Budd Electronics Inc., L. I. C., New York

DIELECTRIC constants can be directly measured by dielectrometers, but due to their high cost, such dielectrometers are not readily available. The graphical method to be shown evaluates dielectric constants using only a microwave signal generator, a slotted-line and a standing-wave indicator at X-band.

For any material[1] $C \angle -\psi = (\tanh T \angle \tau)/(T \angle \tau)$ where $T \angle \tau = \gamma_2 d = \alpha_2 d + j \beta_2 d$. Assuming a near lossless material, then $\alpha \cong 0$ and $C \angle -\psi = [\tanh (j \beta d)/[j \beta d] = [\tan \beta d]/\beta d$.

In addition, $C \angle -\psi = [-j \lambda_g/2 \pi d] [Z(0)/Z_o]$ where $Z(0)/Z_o = (E_{min}/E_{max}) -j \tan [2 \pi (d - Y_o)/\lambda_g]/1 - j (E_{min}/E_{max}) \tan [2 \pi (d - Y_o)/\lambda_g$. If the line is shorted, $E_{min}/E_{max} = 0$.

The equations can then be manipulated to yield

$$(\tan Bd)/Bd = [-(1/K_1 d)] [\tan K_1 (d - Y_o)] \quad (1)$$

where $K_1 = 2 \pi/\lambda_g$ when λ_g is constant and $B = \beta_2 = \beta$.

Since $Bd = (2 \pi d/\lambda_o) (\sqrt{\epsilon - (\lambda_o/\lambda_g)^2})$, it is possible to solve for ϵ, the dielectric constant

$$\epsilon = K_2 B^2 + K_3 \quad (2)$$

If small losses are assumed in the waveguide walls, then the loss tangent is

$$\tan \delta = (\Delta W/\epsilon d) K_4 \quad (3)$$

Equation 3 is valid for a sample size equal to $\frac{3}{4} \lambda_o \pm 2$ percent. The constants in Eq. 1, 2 and 3 can be evaluated since $K_1 = 2 \pi/\lambda_g$, $K_2 = (\lambda_o/2 \pi)^2$, $K_3 = (\lambda_o/\lambda_c)^2$ and $K_4 = (\lambda_o/\lambda_g)_2$.

Since most American dial gages are calibrated in inches and 9,375

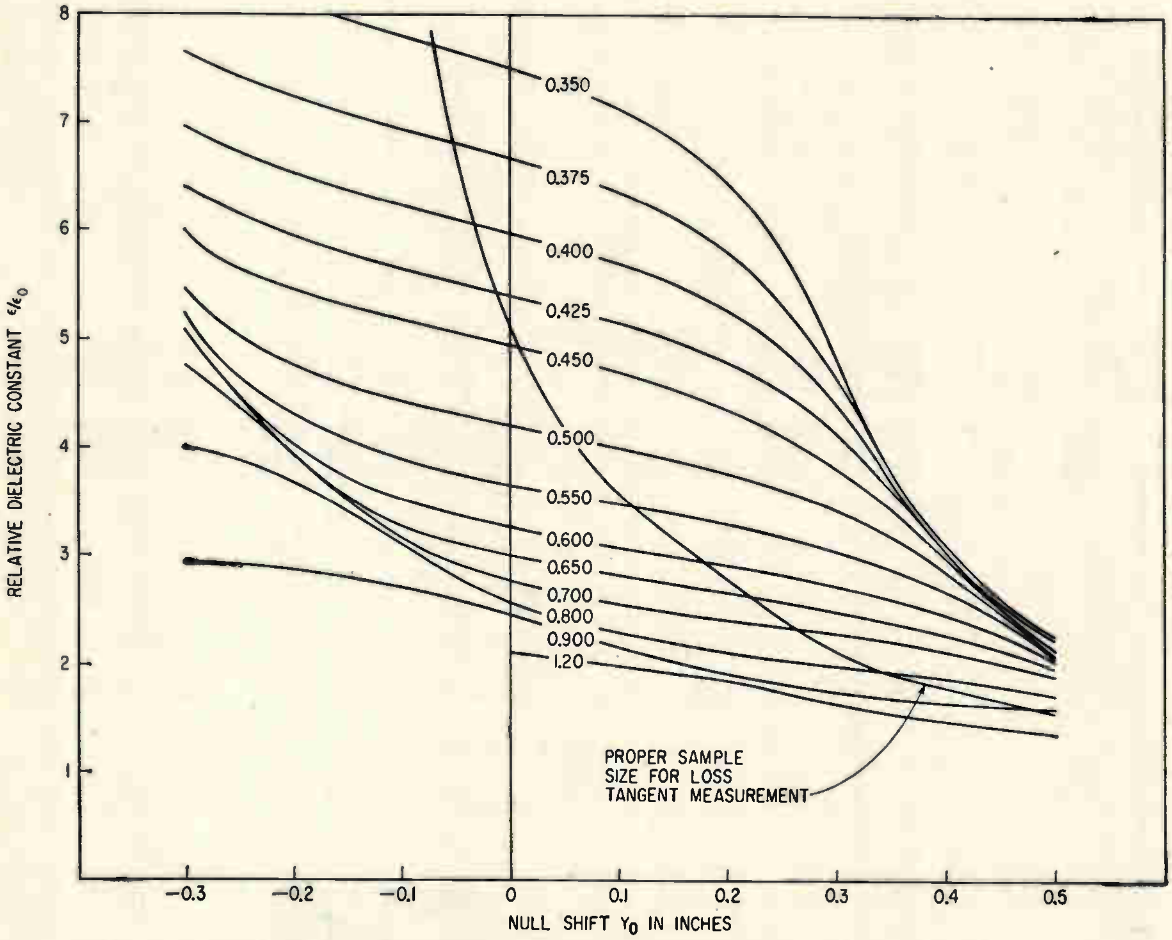

FIG. 1—Dielectric constant plotted against null shift in an X-band slotted line at 9,375 Mc

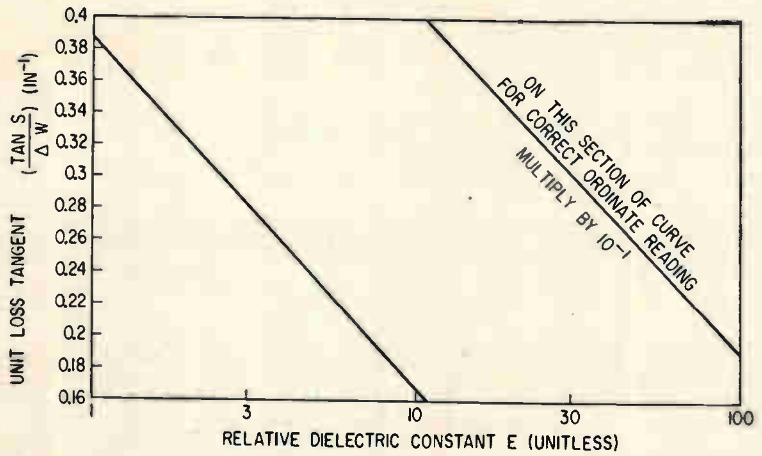

FIG. 2—Relative dielectric constant plotted against unit tangent loss to determine dielectric constant at X-band of any low-loss material

Definition of Terms

- $C\angle-\psi$ intermediate variable
- $T\angle\tau$ intermediate variable
- γ_2 propagation constant in dielectric
- α_2 attenuation constant in dielectric
- β_2 phase constant in dielectric = $\beta = B$
- $Z(0)$ impedance at boundary of dielectric and space in waveguide
- Z_o waveguide characteristic impedance
- λg waveguide wavelength
- d depth of sample
- Y_o as defined in Fig. 4
- λ_o free space wavelength
- ϵ dielectric constant relative to free space
- $\tan\delta$ loss tangent
- ΔW as defined in Fig. 4
- λc cutoff wavelength in waveguide

Mc (X-band) is used, these constants are evaluated as $K_1 = 3.5667$, $K_2 = 0.04016$, $K_3 = 0.48922$ and $K_4 = 0.54434$.

With the constants known, Eq. 2 and 3 can be solved using d as a parameter. Figures 1 and 2 show the family of curves resulting from repeated solutions to these equations. These graphs can be used to determine the dielectric constant at X-band of any low-loss material.

To use this method to determine the dielectric constant, first accurately measure thickness (d) of the sample to be tested. Insert the material in a sample holder and connect a short across the holder. A Hewlett-Packard X930A shorting switch can be used as a sample holder. Machine the dielectric to fit into the X-band waveguide: specifically 0.900 by 0.400 by the thickness (d) (all measurements in inches). This should be a snug fit.

Assuming that d is known approximately to 1-digit accuracy. Let the first thickness approximation be $d = \frac{3}{4}\lambda_o$. Connect the circuit as shown in Fig. 3. The standing-wave pattern shown in Fig. 4 will exist along the slotted line. The dial gage can be used to measure Y_o.

Locate the measured distance Y_o on the abscissa of Fig. 1. Locate the intersection of Y_o and the curve corresponding to the sample thickness d previously measured. Projecting this point horizontally to the ordinate yields the required dielectric constant ϵ.

One of the conditions placed on this solution is that for loss tangent measurements d should be $\frac{3}{4}\lambda_o$ in the dielectric medium. If $d \neq \frac{3}{4}\lambda_o$ the intersection of Y_o and d, (determined above) will not fall within 2-percent of the line labeled proper sample size. The sample thickness can be corrected by drawing a horizontal line through the ϵ just determined until it intersects the proper sample size line. Correct the size of the sample in the holder and determine the loss tangent's value.

Measure ΔW (Fig. 4). The loss tangent now can be determined using the value for ϵ determined from Fig. 1.

Locate this value of ϵ on the abscissa of Fig. 2. Read the value of ($\tan\delta/\Delta W$). Multiplying ΔW by the value obtained for ($\tan\delta/\Delta W$) yields the loss tangent.

As an illustrative example, assume a polystyrene sample with a d of 0.5 inch and a Y_o (measured) of 4.40 inch.

On Fig. 1, the resulting ϵ is 2.55; the sample thickness is corrected to 0.67 inch; the ΔW is measured; ($\tan\delta/\Delta W$) for an ϵ of 2.55 is 0.297 (as read from Fig. 2). Multiply 0.297 by ΔW to get $\tan\delta$.

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(1) Arthur R. Von Hippel, "Dielectric Materials and Applications", Technology Press of M.I.T. and John Wiley and Sons, Inc., New York, 1954.

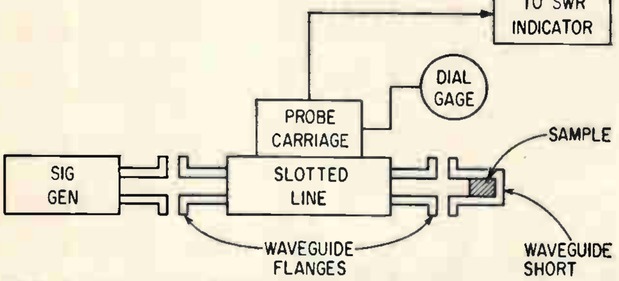

FIG. 3—Test circuit used in measurements

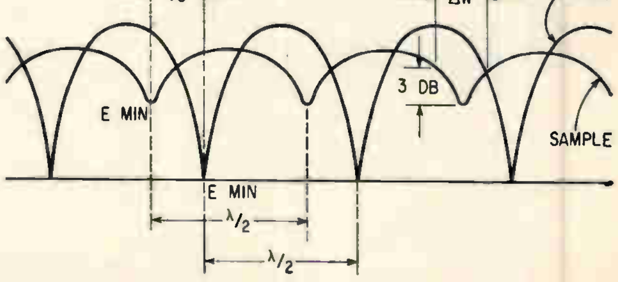

FIG. 4—Standing-wave pattern along slotted line

Atomic Time Standards May Fill Future Needs

TIMING accuracies of at least one part per billion will be required in the future for satellite tracking, long-range missile guidance, astronomical observations and similar scientific activities. Radio transmissions of standard frequencies based on astronomical observations related to rotations of the earth cannot fulfill this need. Atomic frequecy standards are potentially three orders of magnitude more precise for time-interval determination.[1,2,3] The National Bureau of Standards is therefore investigating them to meet the expected requirements.

Two dissimilar cesium-beam atomic frequency standards were constructed at the NBS Boulder Laboratories. The devices were tested independently, the pertinent parameters measured and frequency comparisons made. Relatively short devices (55 cm between the oscillating fields for the shorter apparatus) had precisions of ± 2 parts in 10^{12} for measurement periods from one to several hours. Frequency difference between them was 1×10^{-12} and has remained within $\pm 2 \times 10^{-12}$ for 9 months: Accuracy at least an order of magnitude greater should be attainable with some improvements in the apparatus.

Radio transmissions in which frequency is controlled by master quartz oscillators are being monitored with the cesium-beam frequency standards. Corrections for the 60-Kc standard frequency broadcasts from WWVB are being made each week and are available on request. Corrections for the 20-Kc transmission from WWVL will be available shortly.

In the past, the most uniform time intervals available were those derived from astronomical observations of the rotation of the earth relative to the fixed stars corrected to the orbital motion of the earth about the sun, which is the basis of Ephemeris Time. It has been measured with a probable error of 2 parts in 10^9 in a period of three years. Higher precision is expected for longer measurement times.

In 1956, the second of Ephemeris Time was adopted as the fundamental unit of time by the International Committee of Weights and Measures and confirmed by the General Conference on Weights and Measures in 1960. Steps were taken by the Conference toward adopting an atomic standard.

A time scale approximating Ephemeris Time can be made available immediately using atomic standards, quartz oscillators and counters. In terms of the Ephemeris second, frequency of the cesium transition is found experimentally to be 9192631770 ± 20 cps.[4] The probable error of ± 20 cps (2 parts in 10^9) results from limited precision of the astronomical measurements. The frequency of the transition is assumed to be exactly 9192631770 cps for the purpose of maintaining constancy of broadcast frequencies.

Measurement of a frequency or time interval in terms of the cesium transition can be made with a precision of ± 0.2 cps and is not limited by measurement instrument difficulties like those encountered in astronomical observations. However, it does not supplant the present definition of a scale for time based on the uniform apparent motion of the sun.

A standard based on a physical process or experimental technique provides the most uniform and the most accessible interval. The precision of measurement for the atomic standards is two orders of magnitude better over a 2-minute period than astronomical measurements made over 3 years.

The cesium-beam frequency standard is essentially an atomic beam spectrometer that is excited by a crystal oscillator driving a frequency-multiplier chain. The spectrometer provides a signal only when the excited atoms go through a quantum transition. The exciting signal from the frequency-multiplier chain is designed to have a frequency very nearly equal to the transition frequency. If the spectrometer produces an output when it is excited by the signal generator, generator frequency is known to be equal to transition frequency of the cesium atom.

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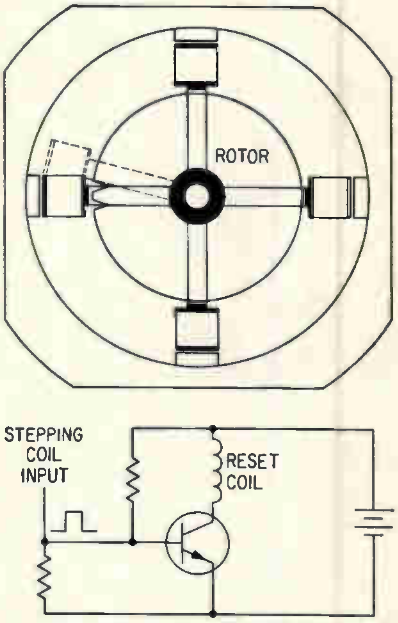
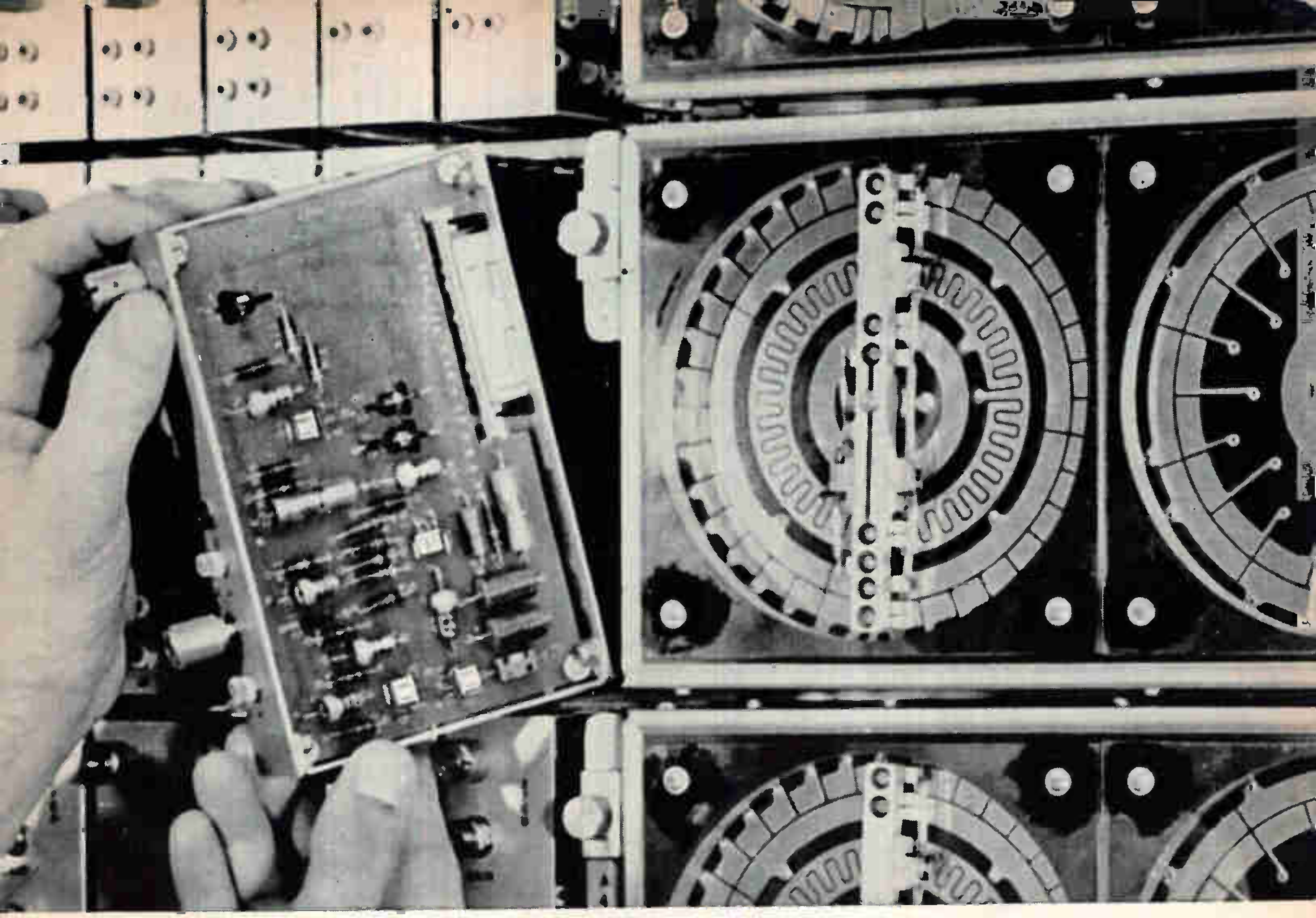
Stepping Motor Provides Acceleration Analog

By F. W. KEAR, Supervisor,
Research and Development Lab.,
Lytle Corp., Albuquerque, N. M.

ACCELEROMETER pulse outputs can be converted into analogs by a specially designed stepping motor. The simply constructed motor improves reliability of inertial guid-



Precise control of angular displacement and reliable stepping from a wide variety of pulse inputs make high-speed stepping motor a dependable pulse to analog converter. Reset coil with circuit at bottom adds usable torque



ance systems. The low inertia unit provides high stepping speeds at usable torque levels.

Flexibility and precision in angular displacement per pulse and reliable stepping from a wide variety of pulse sources add to the usefulness of the motor shown in the figure. Magnetic iron is used for the pole piece of the stepping coil, for slugs mounted in the motor case and for the rotor, which has teeth spaced at predetermined intervals.

The stepping coils are mounted on a frame that can rotate within predetermined limits about the motor axis independently of the rotor. When no energy is provided to the coils, the frame is kept by a helical spring at the position shown by dashed lines in the figure. Stops prevent further rotation. In this de-energized condition, one tooth on the rotor is more closely aligned with the pole piece of the coil than any other tooth.

When a pulse is provided to the stepping coils, the resulting magnetic field pulls the nearest tooth into alignment with the coil. Simultaneously, both the rotor tooth and the coil are pulled into alignment with the slugs inside the motor case. Thus both the coil and the rotor have been displaced from the angular position shown in dashed lines to that shown in solid lines in the figure. A mechanical stop prevents further rotation.

The stepping coil frame remains in the new position for the duration of the pulse to the coils. When energy is no longer supplied to the coils, the stepping coil frame is returned to its original position by the helical spring, while the rotor remains at the new position.

Angular displacement of the drive shaft for each pulse is governed by the number of teeth on the rotor and the angular displacement between the two positions of the stepping coil frame. Rotors can be changed easily and quickly to get a desired angular displacement per pulse. Only one rotor is used in each motor and replacement presents no rotor orientation problems.

Removal of the face plate, which is attached by four screws, permits the drive shaft and rotor to be removed from the motor case. The rotor is attached to the drive shaft by hexagonal set screws. The stepping coil frame can also be removed from the motor case since it is held in position by the rotor bearings.

Within the limits determined by rotor tooth spacing, angular displacement per pulse can be adjusted by set screws accessible from outside the case. One set screw is provided for each direction of rotation. Some models of the stepping motor have been equipped with ratchets to prevent rotation when the coils are not energized.

In applications in which motor torque must be conserved, a second coil or set of coils can be provided in place of the helical spring for resetting the stepping coil frame. The reset coils are shielded magnetically from the stepping coils and the rotor. The transistor switching circuit in the figure keeps the reset coil energized at all times when there is no input pulse to the stepping coils.

Test Bench Aids Plasma Stream Calibration

CONTROLLED experiments at extremely high temperatures may be facilitated by a plasma jet calibration test stand. It is said to provide a precise method for determining specific enthalpy and total pressure.

Measurements of these quantities have been made using laboratory equipment assembled by the user. The test stand designed for this purpose by Plasmadyne Corp., a subsidiary of Giannini Scientific Corp., is said to be simple to use yet very precise.

The calibration stand comprises a rigid plasma jet mounting stand and a variable-position instrument platform. Inserts permit mounting of plasma jet units having different diameters.

The platform accommodates both measuring instruments and a material sample holder. A heat flux calorimeter and a total pressure probe are presently available.

Positioning of the material sample relative to the plasma stream is said to be quite precise despite simplicity of the operation. The positioning mechanism allows longitudinal movement of the sample during the test.

Semiconductors Fused in Glass Ambient

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CHARACTERISTICS OF AVAILABLE GLASS-BONDED DIODES

Unitrode Type Numbers	EIA (JEDEC) Equivalents	PIV	Maximum Reverse Current @ PIV @ 25 C	Maximum Forward D-C Voltage @ Stated Current	Maximum Average Forward Current @ 25 C
UT211 to UT215	1N645 to 1N649	225–600v	0.2 μa	400 ma @ 1v	750ma
UT221 to UT233	1N676 to 1N689	100–600v	1 μa	200 ma @ 1v	500 ma
				400 ma @ 1v	750 ma
UT111 to UT118	1N536 1N1096	50–600v	10 μa	500 ma @ 1v	750 ma
UT21 to UT27	1N482 to 1N488	30–380v	0.25 μa	100 ma @ 1.1v	300 ma
UT11 to UT14	1N461 to 1N464				
UT15 to UT18	1N461A to 1N461A	25–175v	0.5 μa	1 to 100 ma @ 1v	150 to 400 ma
UT241 to UT217	....	50–600v	10 μa	500 ma @ 1v	1,500 ma
UT251 to UT257	....	50–600v	10 μa	1,000 ma @ 1v	2,000 ma

Operating temp range: −100 C to +250 C
Storage temp range: −195 C to +300 C

UNTIL RECENTLY, the problem with long-term reliability of glass and top-hat diodes was two-fold: surges, even though small, caused catastrophic failures; and electrical characteristics changed radically with aging or exposure to the extremes of hostile environments.

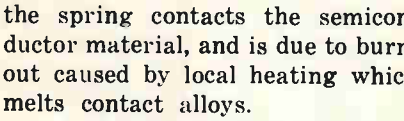
The ohmic contact to the semiconductor has been an extremely fragile whisker or spring which may fail for mechanical or electrical reasons. The mechanical vulnerability of a fine diameter wire spring exposed to heat, vibration, shock, or acceleration is unavoidable. Even more important is failure of the spring when exposed to electrical overloads barely exceeding the diode rating. Failure occurs, usually, at the point where the spring contacts the semiconductor material, and is due to burnout caused by local heating which melts contact alloys.

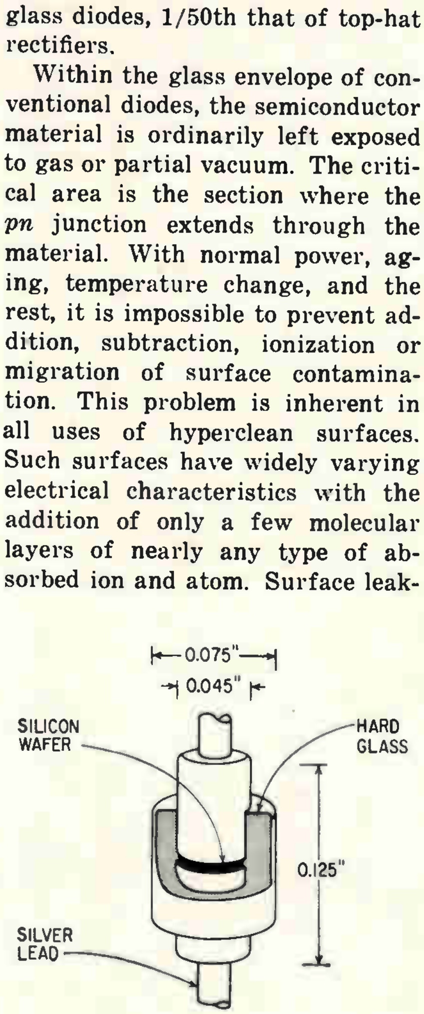
To solve this problem, Unitrode Transistor Products, Inc., of Waltham, Mass. has developed a new technique of diode construction that bonds the diffused silicon wafer directly between terminal pins, and fuses a hard glass sleeve continuously to all exposed silicon surfaces and much of the terminal pins.[1] Thus the whisker spring has been eliminated, and by fusing glass to the silicon surface, electrical characteristics are permanently stabilized. The Unitrode diode assures long-term stability in severe environments, even with extreme continuous overloads, provides significantly higher power ratings and temperature range, and is unaffected by shock, vibration and acceleration. The units are one-fourth the size of conventional glass diodes, 1/50th that of top-hat rectifiers.

Within the glass envelope of conventional diodes, the semiconductor material is ordinarily left exposed to gas or partial vacuum. The critical area is the section where the *pn* junction extends through the material. With normal power, aging, temperature change, and the rest, it is impossible to prevent addition, subtraction, ionization or migration of surface contamination. This problem is inherent in all uses of hyperclean surfaces. Such surfaces have widely varying electrical characteristics with the addition of only a few molecular layers of nearly any type of absorbed ion and atom. Surface leakage changes show up as increases in diode leakage and a rounding of the knee of the reverse voltage-current curve.

Surfaces of germanium or silicon becomes coated with thin layers of oxide upon exposure to air. In the presence of only very minute quantities of oxygen, at least a monolayer is formed. Thin layers of the dioxides are extremely hygroscopic exhibiting the same characteristics as silica gel. The application of organic varnishes and the controlled oxidation of the silicon surface have made possible the relatively consistent reverse characteristics of present-day diodes as shipped from semiconductor plants, but have not produced the stable surfaces in the inert environments which will yield unchanging characteristics with age, overload and exposure to thermal and mechanical extremes.

The Unitrode packaging concept places the only exposed surface of the silicon in an ambient of inert hard glass, permitting continuous overloads to a minimum of 10 watts with no failure. The Unitrode can be dip soldered and subjected to thermal shocks between −195 C and 300 C. In this construction, leads, terminal pins, and the diffused silicon wafer are bonded together into a single assembly. The glass is in intimate contact with the silicon and the pins, leaving no voids in which gas, air, or other





Actual size of Unitrode, in black (above) compared to top-hat diode. Cut-away view of diode (right) shows the high-dielectric glass (cross-hatched area) fused to the surface of both the silicon and terminal pins. With all gas and voids excluded from the package, the diodes make 10,000-v piv's an actuality

KAY *Precision* RANDOM NOISE GENERATORS

1 KC TO 26,500 MC

COAXIAL NOISE SOURCES

1 MC to 3000 MC . . . THE *Mega-Node®* 3000

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- Noise figure, 0-20 db • Output impedance, 50 ohms unbalanced
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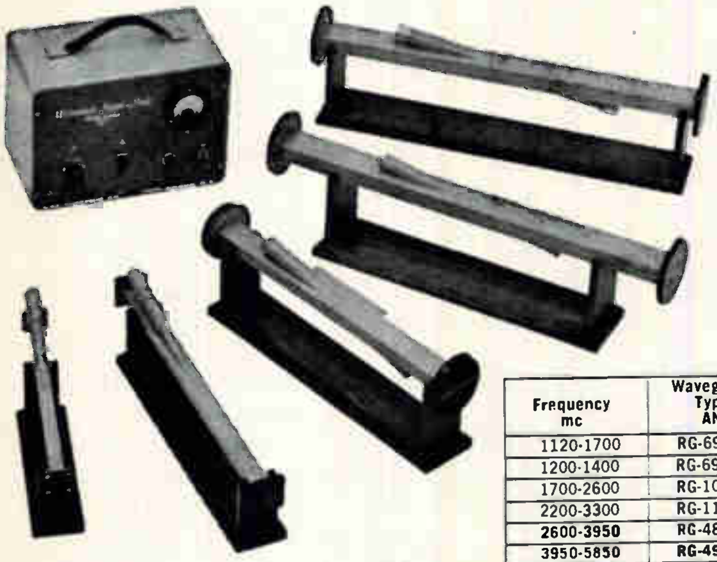
WAVEGUIDE NOISE SOURCES

1120 MC to 26,500 MC



THE *Microwave Mega-Nodes®*

The Microwave Mega-Nodes are precision machined and plated waveguide fixtures, utilizing argon, fluorescent, or neon gas discharge tubes. Single power supply operates all units. (Power Supply, $125.00.)

- Noise output of 15.8 ±.025 db for fluorescent tubes, 15.45 ±0.2 db for argon, 18.0 ±0.2 db for neon. Supplied with power cables and fittings.

Frequency mc	Waveguide Type AN	Flange AN	Catalog No. Argon	Catalog No. Fluor.	Catalog No. Neon	Price*
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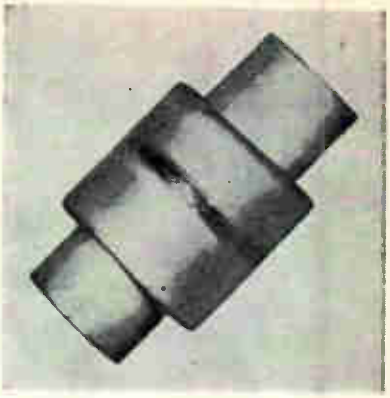
1200-1400	RG-69/U	UG-417/U	311-A	310-A	313-A	$395.00
1700-2600	RG-104/U	UG-435A/U	**	870-A	**	$495.00
2200-3300	RG-112/U	UG-553/U	**	880-A	**	$495.00
2600-3950	RG-48/U	UG-214/U	261-A	260-A	262-A	$175.00††
3950-5850	RG-49/U	UG-149A/U	271-A	270-A	272-A	$175.00††
5850-8200	RG-50/U	UG-344/U	281-A	280-A	282-A	$175.00††
7050-10 000	RG-51/U	UG-51/U	291-A	290-A	292-A	$175.00††
8200-12,400	RG-52/U	UG-39/U	301-A	300-A	302-A	$175.00††
12,400-18,000	RG-91/U	UG-419/U	521-A	**	522-A	$250.00
18,000-26,500	RG-53/U	UG-425/U	531-A	**	532-A	$250.00

†† Any three plus power supply: $620.00. Any in excess of three: $167.00 ea.
** None available.
* All prices f.o.b. factory, plus 10% for export.

Write for Complete Catalog Information

KAY ELECTRIC COMPANY
Dept. E-2 Maple Avenue, Pine Brook, N. J.
CApital 6-4000

VISIT KAY AT THE IRE SHOW—BOOTHS 3512-3518



Photomicrograph showing silicon dice bonded between terminal pins and surrounded by the hard glass. Center section, including the silicon and half the pins, is magnified by the glass

contaminants would accumulate. The electrical characteristics of the diode are fixed and independent of overloads and environmental changes.

A high power dissipation safety factor is provided by the two terminal pins which are fused to both sides of the silicon wafer. The metal pins have the same diameter as the wafer and therefore conduct heat away from the silicon and the silver leads at a rapid rate. This is in contrast to conventional diodes where the whisker spring is bonded to a small area on one side of the wafer.

All materials, including the silicon and the bonds between materials, stand up well as 500 C, compared with the 150-200 C top temperature of other silicon diodes.

Since the glass and terminal pin metal have been carefully matched to the same thermal coefficient of expansion as the silicon, fabrication of the diode produces an unstressed structure. Because this common coefficient is low, no ill effects are experienced in wide temperature cycling, thermal shock or other heat and cold testing. No special precautions are necessary for either iron or dip-soldering assembly procedures.

Although Unitrode is now developing may additional types of diodes, rectifiers, and transistors using the new construction, 40 general purpose types of silicon diodes, as listed in the table, are presently in production at competitive prices.

Presently in final stages of development is a line of single diodes with piv's up to 10,000 volts. These diodes will be somewhat longer to prevent voltage breakdown in the atmosphere outside the package, increasing the length of glass between the terminal pins.

REFERENCE

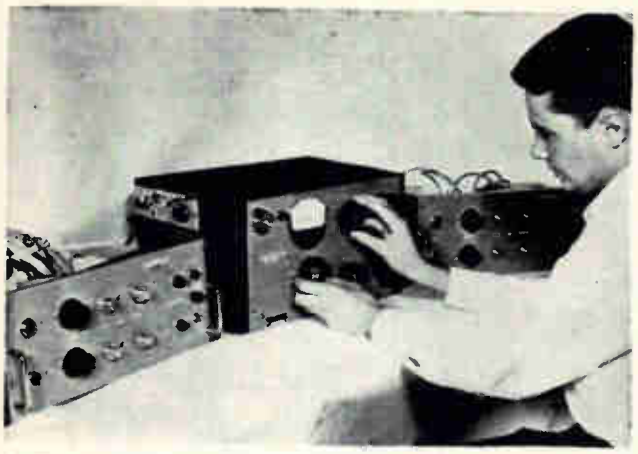
(1) Malcolm Hecht, Jr., Justice N. Carman, and George Berman, Unitrode Transistor Products, Inc., 214 Calvary Street, Waltham 54, Mass.

Brushless D-c Motors Find Missile Applications

FOLLOWING STORIES that have appeared in this column (ELECTRONICS, 22 April, 1960) that such motors were possible, brushless, d-c synchronous prototype motors have been furnished to leading manufacturers in the missile field. A motor of this type, designed primarily for missile applications by Crosby Research Institute, Los Angeles, delivers constant speed regardless of line voltage of load variation. Weight is 6.8 oz., torque delivered is 0.1 oz. inch at 3,000 rpm. Motor will run on battery power for weeks.

Tunnel Diodes Up Computer Speeds One Thousandfold

This tiny tunnel diode wafer, left, is an integral part of basic circuitry devised by Radio Corporation of America as the first big step toward an ultra swift electronic computer for the U. S. Navy. Four of the midget units will perform the same job as the circuit board, center, now used in business computers—but 1,000 times faster. The device permits electronic switching at speeds approaching 186,300 miles per second, the speed of light



Inspector uses comparison circuit tester to check dual channel d-c amplifier (right) against a previously tested amplifier (left)

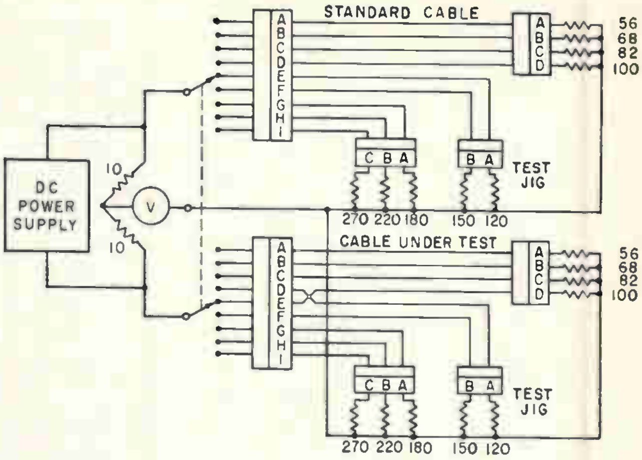


FIG. 2—Cable testing setup. Resistance imbalance locates crossover between wires D and E of cable under test

Comparator Trouble-Shoots Short Runs

By ERIK T. SOHLBERG,
Senior Test Equipment Engineer,
Sanborn Co., Waltham, Mass.

COMPARISON CIRCUIT TESTER economically checks and trouble-shoots cables, amplifiers, power supplies and other assemblies. Its simplicity allows an inspector to do much of the work normally assigned a more highly-paid technician. Wiring errors and faulty components are located by the inspector, restricting the technician's problems on final test to correction of a-c troubles and calibration.

The tester was designed with short production runs in mind. Five, 10 or 100 assemblies can be tested whether they are made in monthly or annual runs. Engineering changes are easily accommodated since a previously tested unit, known to be good, is used as a comparison standard. A direct comparison is made of the resistance between ground and every available point such as each transfer or tube socket pin, in the standard unit and the unit under test.

Tests are made without energizing the equipment under test. Visual wiring inspection, except for solder joints, is eliminated. The method is superior to conventional cable continuity checks. Open circuits, short circuits between wires and crossed connections are all located in the same operation.

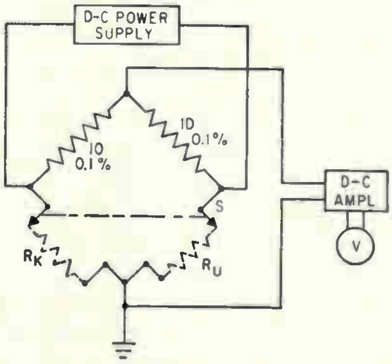


FIG. 1—Unbalance of bridge circuit indicates fault in circuit

The tester is diagrammed in Fig. 1. *S* is a manual selector switch which simultaneously selects the same points in the standard and test units. R_k and R_u are the resistances between the selected point and ground in the two units. The bridge unbalance detector is a vacuum tube millivoltmeter with a zero center pointer. The power supply delivers constant d-c voltage.

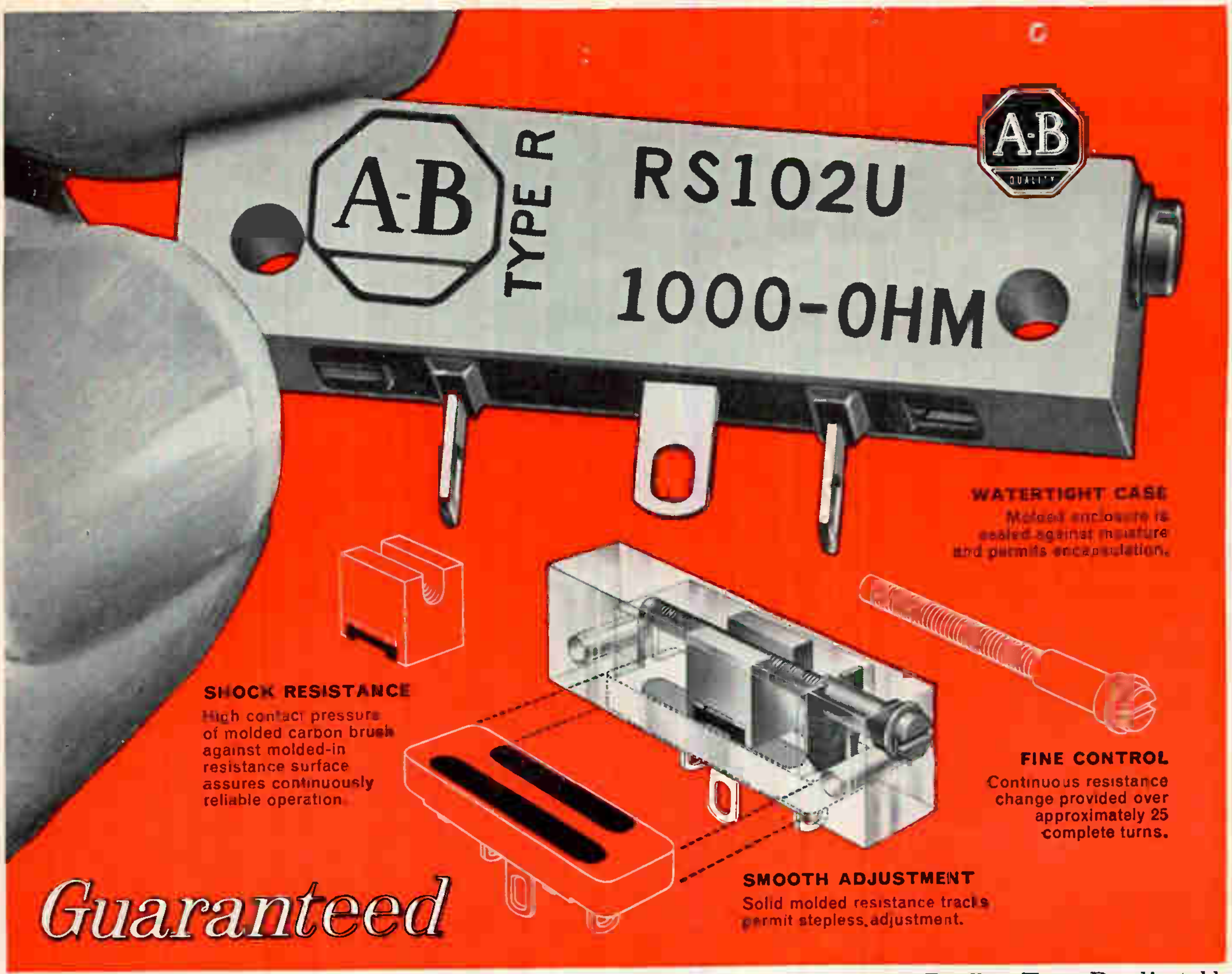
The switch has a balance position, for setting zero on the meter, and a 10 percent unbalance position, for setting vtvm sensitivity to an appropriate deflection. A deflection greater than the setting indicates an error in the unit under test.

For example, if five percent tolerance resistors are used in the units, a 10 percent difference between the two units is acceptable. The sensitivity is set for one major division deflection of the meter pointer for 10 percent unbalance.

When a circuit assembly is to be tested, the inspector is supplied a set of cables to connect the tester, a standard unit and the units to be tested. The cables contain tube and transistor socket plugs, input and outpu plugs, power supply plugs, etc. He is also given a tabulation of connections corresponding to the tester's switch positions.

As the operator rotates the switches, sequentially inserting each of the connections into complementary legs of the bridge, he observes the meter. If meter deflection indicates a defect, the inspector notes the switch position. He refers to the tabulation for the connection point on the product schematic. Observation of the wiring

Rear of test setup for a-c/d-c preamplifiers



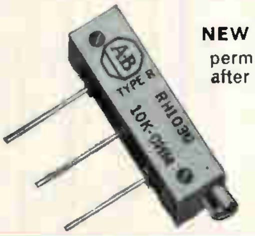
Reliable Performance and Stable Settings

UNDER EXTREME ENVIRONMENTAL CONDITIONS

In critical applications, Allen-Bradley Type R adjustable fixed resistors are *without equal*. For example, in recent tests* Type R resistors successfully withstood acceleration, shock, and vibration *five times* better than the latest MIL Spec requirements. Such wide margin of safety is your assurance of complete reliability. Virtual indestructibility is obtained through an *exclusive* Allen-Bradley process in which the solid resistance elements and the insulating mounting are hot molded into one integral unit. The moving element is self-locking for absolutely stable settings. Also, the Type R control allows "stepless" adjustment of its resistance.

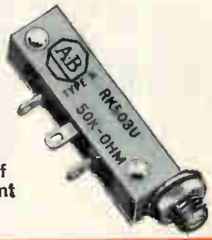
The molded case of the Type R control is watertight and dust-tight. Rated ¼ watt at 70°C, these Type R controls are available in values from 100 ohms to 2.5 megohms.

**Test Report #71801, Sept. 1960, United States Testing Company, Inc.*



NEW CUP GUARD
permits adjustment after encapsulation

NEW PANEL MOUNTING
permits front of panel adjustment



ALLEN-BRADLEY

QUALITY ELECTRONIC COMPONENTS

Allen-Bradley Co., 110 W. Greenfield Ave., Milwaukee 4, Wisconsin
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

and components between the indicated point and ground on the unit tested usually locates the trouble.

Although the inspector must be able to read the schematic, he does not need to know how the circuit operates.

Diodes, transistors or large capacitors permanently wired in place may have to be shorted out with clip leads. Wide variations in diode resistance can upset the bridge balance. Transistor action may cause an abnormal bridge current.

Black connectors contain cable-testing resistors

Large capacitors will confuse the operator by causing a large deflection, recovering to zero very slowly. If the diodes or transistors are plugged in, their sockets provide additional test connection points or are left open as the programmer sees fit.

The only additional apparatus needed to test complex cables are jigs made up with ordinary carbon resistors. Similar mating connectors are placed on the remote ends of the standard and test cables. Resistors of different values are connected between each pin of the mating connectors and a common point (Fig. 2).

Each point on the near end of the standard and test cables are compared simultaneously in the bridge. Meter deflection again indicates a wiring error. Unwanted short circuits are revealed as continuity is checked. Checking for shorts is often omitted during conventional continuity checks because of the time required to check each pin against every other pin.

Crossover errors also show up as an unbalance in the bridge. For example, the crossover between wires D and E of the cable under test in Fig. 2 will cause unbalance at the fourth and fifth position of the manual selector switch.

Sanborn Company is currently using two of these testers for inspection on the electronic equipment production line and one in the cable department. They cut the time for continuity-testing batches of 50 of a particular cabinet cable from 9 hours to a half hour and have drastically reduced equipment final test time.

Cable Analyzer Makes Four-Way Wiring Tests

AUTOMATIC CIRCUIT and cable analyzer recently completed by Associated Research, Inc., Chicago, Ill., checks up to 120 circuits for continuity, insulation resistance and a-c or d-c voltage breakdown. It will run unattended up to 25 hours.

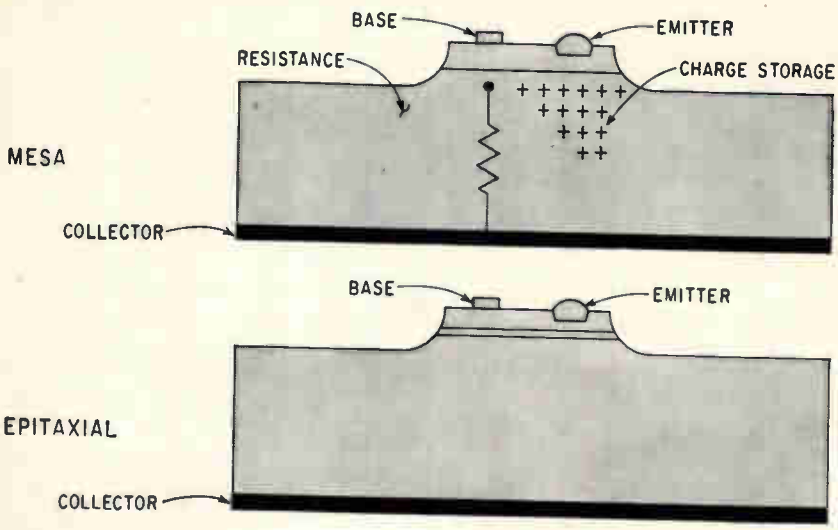
Conductor resistance, within limits of 0.5 to 200 ohms, is used to measure continuity. Insulation resistance is measured at 500 v within limits of 1 megohm to 50,000 megohms.

Tape records test results

Breakdown test voltage is adjusted between zero and 5,000 v. Leakage current for rejection can be varied from 1 μa to 2.5 ma on d-c, and from 0.5 ma to 3 amperes on a-c. Test speeds are adjustable from three seconds to four minutes, for continuity, and from one second to 15 minutes for other tests.

To shorten test time, tests may be performed on groups of several conductors at a time. If a failure occurs in the group, the analyzer will make a conductor-by-conductor search for the faults.

New On The Market



Epitaxial Transistor

26 nSEC SWITCHING

TWO ULTRA-FAST switching transistors made by the epitaxial manufacturing process are announced by Texas Instruments Incorporated, P. O. Box 312, Dallas 21, Texas.

The epitaxial TI 2N743 switching transistor will switch in 26 nsec total time at 10 ma, and 24 nsec at 100 ma. The 2N744 has typical total switching times of 27 nsec at 10 ma, and 29 nsec at 100 ma.

Maximum switching times (all in nsec) in saturated circuits for the TO-18 packaged units are

at 10 *ma*	2N743	2N744
t_{on}	16 max	16 max
t_{off}	24 max	24 max
at 100 *ma*		
t_{on}	12 max	12 max
t_{off}	40 max	45 max
Storage time constant	14 max	18 max

A significant characteristic of the units is a saturation resistance practically insensitive to temperature. Both types exhibit almost negligible R_{CS} change from −65 to +175 C. In contrast to a 2N706 transistor which exhibits a typical rise in $V_{CE(sat)}$ at 100 ma from 2.2 volts at 25 C to 4 volts at 170 C, maximum saturation voltage of the TI 2N743 remains constant at 1 volt from −55 to +170 C. In addition, both new epitaxial transistors have capacitance of 3.5 pf at 5 volts and a typical f_T of 400 Mc. The transistors can be in use in NOR logic circuitry without requiring an I_{B2} turn-off source.

The d-c forward current transfer ratio, h_{FE}, for the 2N744 is 20 minimum at 1 and 100 ma, and 40 min to 120 max at 10 ma. The 2N743 has h_{FE} specified at 10 min for 1 and 100 ma, and 20 min to 60 max at 10 ma. All practical d-c design parameters are guaranteed at 10 and 100 ma for −55, +25 and +170 C.

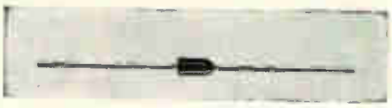
The silicon epitaxial transistors are priced competitively with conventional silicon mesa and micro alloy switching transistors and are available for immediate delivery.

CIRCLE 301 ON READER SERVICE CARD

Noise Generator

SOLID STATE

SOLID STATE device, called a Sounvister, produces random noise across a white noise spectrum. Random noise can be produced in selected frequency ranges known as yellow and pink noise bands. A



white noise generator in which the $\frac{3}{8}$ inch unit has been used produces up to 18 volts output. Further research will attempt to extend the random noise to higher frequencies.

The white noise producing unit is expected to be of interest to industrial and military scientists, especially those in sonar, radar and microwaves. Another important application is anesthesia, where white noise has been used to deaden the pain of dental drilling and extraction, and as a complete anesthetic for operations. The noise generator is being manufactured by Solitron Devices, Inc., Norwood, N. J.

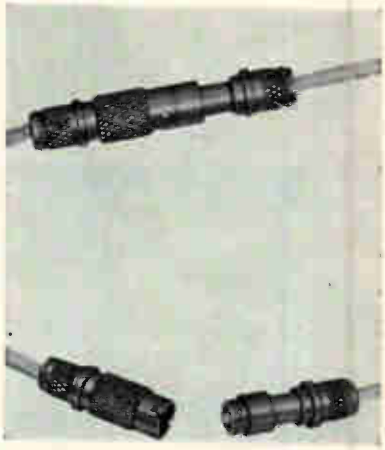
CIRCLE 302 ON READER SERVICE CARD

Coax Connector

FOR RG-196/U CABLE

QUICK-DISCONNECT coaxial connector is one of the smallest available; it measures $\frac{1}{4} \times 1\frac{3}{8}$ inch and its weight is 5 grams.

Named the Nu-Look, the connector is typical of 1100 series, and has been designed for use with 50



ohm RG-196/U coaxial cable. Its captured bayonet locking mechanism is positive acting and will withstand extreme vibration without damage or separation. When mated, the subminiature connector will resist a sustained force of over 45 pounds.

The connector is made by Nu-Line Industries, Inc., 1015 South Sixth Street, Minneapolis 4, Minn.

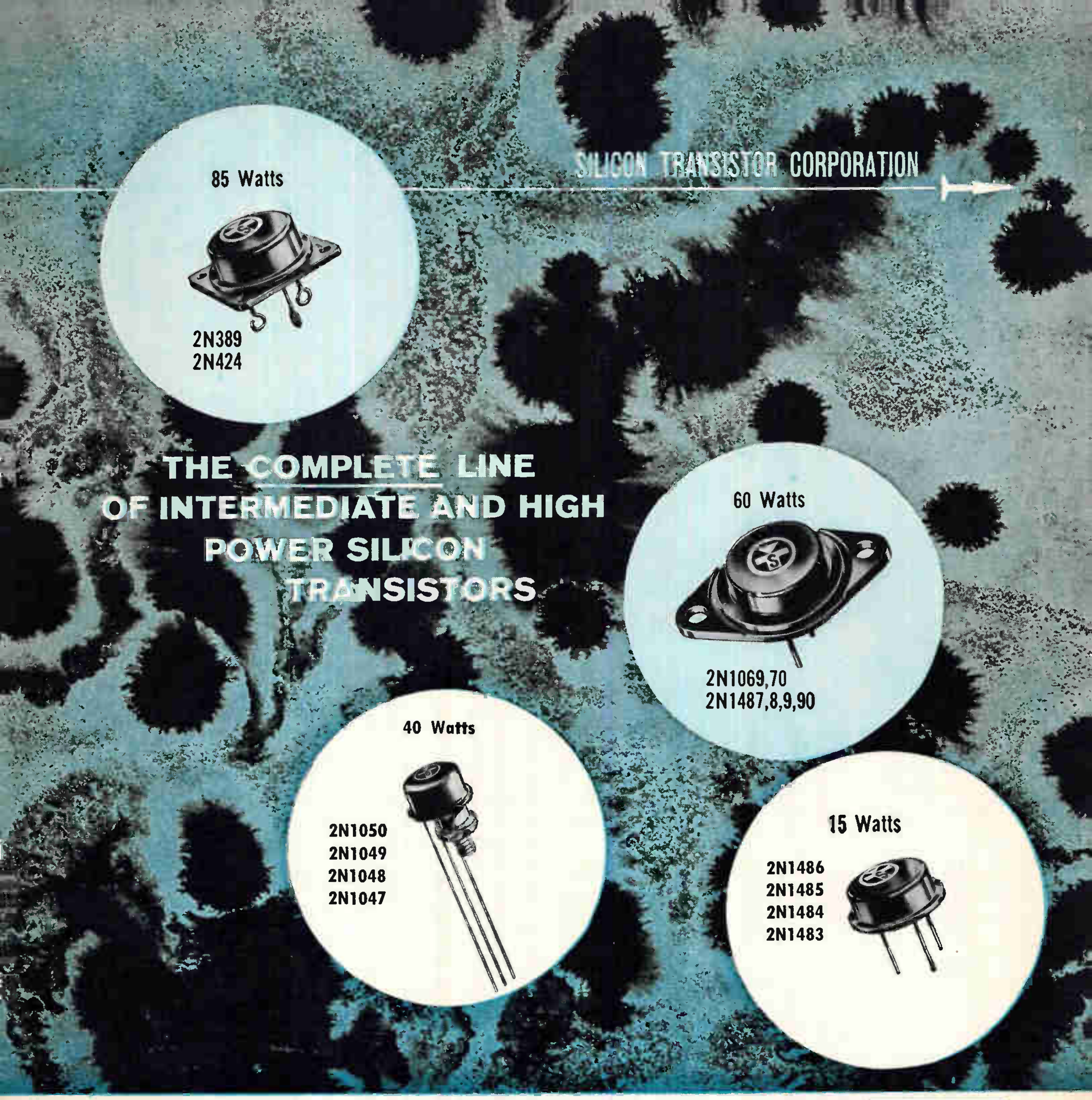
CIRCLE 303 ON READER SERVICE CARD

Hall Generators

METAL-DEPOSITED

GRH HALLTEST CO., 157 S. Morgan Blvd., Valparaiso, Ind. Types SV230 and SV240 thin film metal-deposited Hall generators, made out of in-

CIRCLE 93 ON READER SERVICE CARD→



SILICON TRANSISTOR CORPORATION ALSO MANUFACTURES A **COMPLETE** LINE OF SILICON GLASS DIODES INCLUDING JAN TYPES 1N457, 1N458, 1N459 AND SIG. C. TYPES 1N643 1N658, 1N661 & 1N663.

FOR IMMEDIATE DELIVERY, CONTACT THESE STC AUTHORIZED DISTRIBUTORS:

Ala: MG Electrical Equipment Co., Birmingham . **Calif:** Brill Semiconductor Corp., Oakland; Hollywood Radio Supply, Inc., Hollywood; Peninsula Electronic Supply, San Jose; Shelly Radio Co., Inc., Los Angeles; Wesco Electronics, Pasadena; Shanks & Wright, Inc., San Diego. **Fla:** Hammond Electronics, Inc., Orlando; Leader Distributors, Inc., Tampa. **Mass:** Durrell Distributors, Inc., Waltham. **Md:** Valley Electronics, Inc., Towson. **New York:** Arrow Electronics, Inc., Mineola, L. I.; Progress Electronics Co., Inc., New York City; Summit Distributors, Inc., Buffalo. **Penna:** Philadelphia Electronics, Inc., Phila. **Texas:** Lenert Company, Houston; Central Electronics, Dallas.

IRE: BOOTH 1326

For transistor and diode specification sheets, write to

SILICON TRANSISTOR CORPORATION / CARLE PLACE, LONG ISLAND, NEW YORK. PIONEER 2-4100 dium-arsenide, are available. Despite the lower electron mobility of the deposited indium-arsenide, the new probes are extremely sensitive due to the thin film and the higher specific current permissible therein. The Hall output voltage exceeds 1 v at 10 kilogauss. The four electrodes are attached by p-c techniques, thus making these probes considerably less expensive than probes made out of solid slabs.

CIRCLE 304 ON READER SERVICE CARD

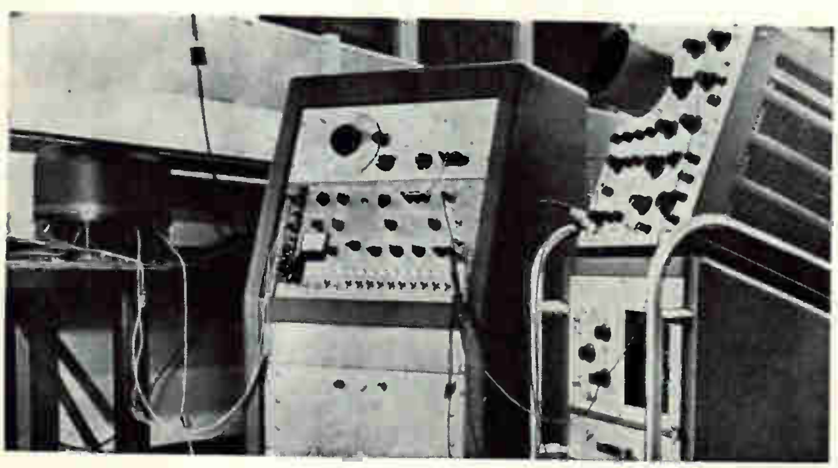
Single-Sideband Transceiver
USES DIGITAL TUNING

SINGLE-SIDEBAND communications equipment featuring digital tuning, which locks on any one of 28,000 frequencies from 2.0 to 30.0 Mc, has been developed by the Stromberg-Carlson Div. of General Dynamics Corp., Rochester 3, N. Y.

The ssb transceiver, SC-901, is the first item in a complete line of digitally tuned ssb equipment to be introduced within the next few months. Power output level ranges from 100 watts to 1Kw (peak envelope power).

Digital tuning consists of the selection of each digit corresponding to tens, units, tenths, hundredths, and thousandths of Mc. Frequencies are stable to 1 part in 10^7 per week. Size is 14 by 17 by 17 inches overall; weight is 70 pounds.

CIRCLE 305 ON READER SERVICE CARD



Magnetic Drum Check-out
RECORDS TIMING TRACKS

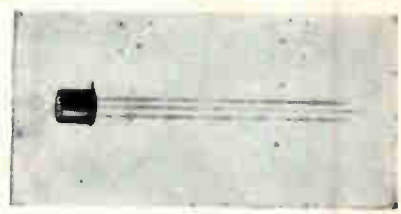
MODEL MD-100 magnetic drum check-out system is a versatile and flexible piece of test equipment for magnetic drum manufacturers and users. The system has clock recording, clock smoothing, origin and word track recording, and test pattern recording.

A clock track may be recorded circumferentially around the drum with up to 16,883 preselected bits. Closure on this timing track may be made better than 50 nsec. The system will record in either non-return-to-zero or Manchester method.

In providing origin and word track recording, a periodic pattern of a selectable number of ZEROS followed by a single ONE can be recorded. Since this pattern is selectable, a single ONE may be recorded on a track, resulting in an origin track. If the periodic pattern is set for the word length of a computer, then the resulting recorded track will be the word timing track. Recording any of these tracks is initiated at the same place on the circumference; thus, all timing marks will be in the same phase.

For test pattern applications, a selectable test pattern of ONE's and ZERO's may be recorded on a track. The magnetic drum check-out system is manufactured by FMA Inc., 142 Nevada St., El Segundo, Calif.

CIRCLE 306 ON READER SERVICE CARD



Silicon Switch
CLOSE FIRING CONTROL

HIGH SENSITIVITY silicon controlled switch series 2N884-2N889 offer firing control within ± 0.08 v, firing sensitivity of 20 μa, and surge rating to 10 amp.

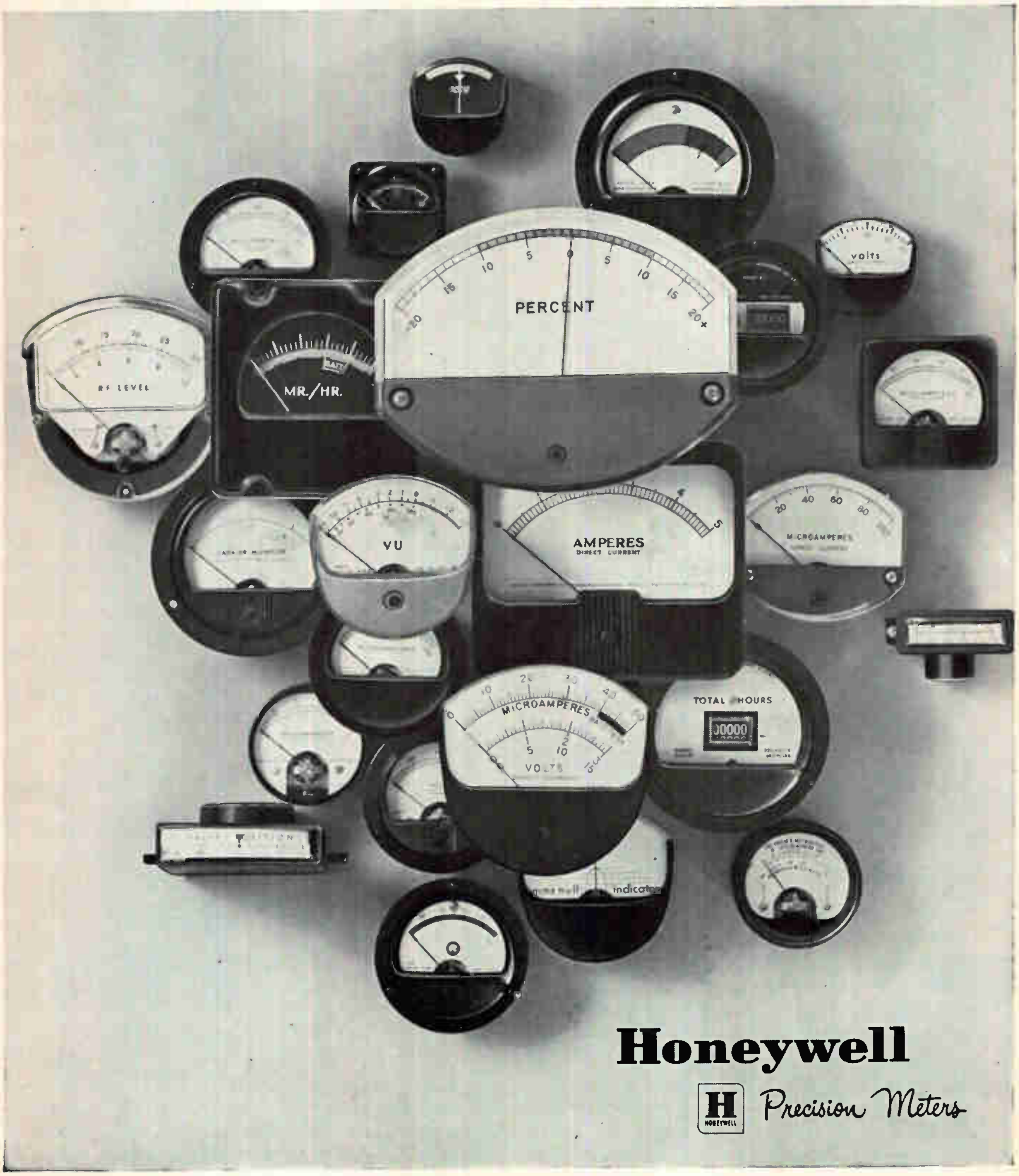
Handling peak recurrent pulse currents of 5 amperes, the devices make possible miniaturization of squib firing circuits with no sacrifice in design margin. In addition, the 1 ma holding current makes them useful in programming, control, and logic applications.

Available in miniature TO-18 size, the *pnpn* units meet Mil-S-19500, and all are subjected to extensive temperature storage and cycling as well as 100 percent ac-

What do these 24 Honeywell Precision Meters have in common?

They are various types and models, shapes and sizes. They perform a wide number of functions. Many different companies confidently utilize these meters and depend on them. This confidence stems from two significant things that all these instruments share — the unsurpassed quality that Honeywell builds into each of its products, and our ability to design and manufacture to meet customer requirements.

Can a quality meter from Honeywell help you make a better product or do a better job? Just get in touch with our representative listed in your classified telephone directory. Or with us: Precision Meter Division, Minneapolis-Honeywell Regulator Co., Manchester, N. H., U.S.A. In Canada, Honeywell Controls Limited, Toronto 17, Ontario, and around the world, HONEYWELL INTERNATIONAL Sales and Service Offices in all principal cities of the world.



ceptance testing.

The units are available from stock, from Solid State Products Inc., 1 Pingree St., Salem, Mass.

CIRCLE 307 ON READER SERVICE CARD

Dollar Scanner
FOR VENDING

PATENTED device for electronically scanning one-dollar bills is in production by Planetronics, Inc., Easton, Pa. The device, measuring $16\frac{9}{16} \times 6\frac{7}{8} \times 11\frac{3}{8}$ accepts only genuine one-dollar bills.

As a bill is inserted, face up only, it is picked up by a belt and carried past a photoelectric scanning eye, then to weight and size gages. Genuine bills drop into a collector and an electrical circuit is closed. Models without vend and return buttons are available.

The electrical circuit may be used to energize all types of electrical vending and change-making machines, and to operate turnstiles, doors, automatic bowling machines and similar devices.

CIRCLE 308 ON READER SERVICE CARD

Microwave Tuner
ROTARY TYPE

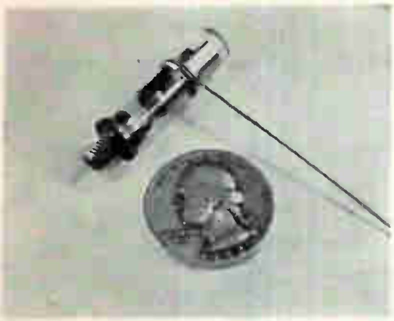
RADAR DESIGN CORP., Pickard Drive, Syracuse 11, N. Y. Model 1140 is a roving stub tuner whose stub position is changed by rotating a knob. A second (concentric) knob adjusts stub length. Therefore, any impedance can be matched to its 50 ohm (type N) system in the 900 Mc-12,400 Mc range. Price and delivery: $195—3 weeks.

CIRCLE 309 ON READER SERVICE CARD

Servo Repeater
TWO-SPEED

DATEX CORP., 1307 S. Myrtle Ave., Monrovia, Calif., offers a two-speed servo repeater system which, when used with appropriate synchro-transmitters, provides digital coded contact closures corresponding to the angular position of a remote shaft. The SR-115 is designed as an integral package and contains two control transformers, a servo motor, synchro switch, servo amplifier, two Datex shaft position encoders, and interconnecting gear trains. The coded output is suitable for entry through storage and translation circuitry to recording devices such as printers, tape punches, card punches, and lamp banks.

CIRCLE 310 ON READER SERVICE CARD



Trimmer Capacitor
TEMPERATURE VARIABLE

VARIABLE temperature coefficient capacitor provides simple and precise compensation for variations of circuit values caused by temperature changes. Model VCJ463 is available in values from 2.0 to 12.0 pf and with temperature range from −55 to 200 C. Capacitance tolerance is 3 percent at 25 C.

The capacitors can be set to any temperature coefficient from −500 ppm per degree C to + 500 ppm/C by adjusting an invar piston. As temperature changes, the piston travels axially from its original

CIRCLE 97 ON READER SERVICE CARD

preset position, thereby varying capacitance.

The variable temperature coefficient capacitor can eliminate temperature compensating circuits. Other features include sealed interior construction, quartz dielectric for high Q, shock and vibration resistant construction. Price is $5.00 each in production quantities; delivery in 4 to 5 weeks from JFD Electronics Corp., 6101 Sixteenth Ave., Brooklyn 4, N. Y.

CIRCLE 311 ON READER SERVICE CARD

High-Mu Triode
FOR TV & F-M TUNERS

RADIO CORP. OF AMERICA, Harrison, N. J. The RCA-2CW4 thimble-size Nuvistor, a high-mu triode, has a 2.1-v/450-ma heater with a controlled warm-up time. Tube was designed for use in grounded-cathode, neutralized, r-f amplifier circuits of vhf tv and f-m tuners employing series heater-string arrangements. When used in tv tuner circuits, it enables improved reception in fringe areas and other locations where signal levels are extremely weak. It has a metal envelope for self shielding and includes indexing lugs to facilitate insertion in a socket.

CIRCLE 312 ON READER SERVICE CARD

Illuminated Magnifier
INTERCHANGEABLE LENS

THE O. C. WHITE CO., 15-21 Hermon St., Worcester 8, Mass. Manual and visual tasks requiring close-up observation can now be performed with greater speed, more precisely, and with less eye fatigue and impairment by means of Magni-Lite, which both magnifies and illuminates the point of work. A distortion-free, color corrected 3-diopter magnifying lens, 5 in. in diameter, enlarges miniature objects to easy-to-see, easy-to-handle proportions. Also available with an added lens that is snapped easily into position, which doubles the magnifying power of the standard unit. A circular 22-w fluorescent lamp surrounds the magnifying lens to produce a restful, eye-strain reducing halo. Price of the model 2MC-Mag is $45.37 net complete with lamp.

CIRCLE 316 ON READER SERVICE CARD

Two-Speed Indicator

SHOWS PRECISE ANGLE

KEARFOTT DIVISION, General Precision Inc., 1150 McBride Ave., Little Falls, N. J. announces the CO2721027 high-accuracy precise angle indicator. Unit provides numerical indication of the angular position of any mechanical device to which remote two-speed (25:1) dual transmitters can be coupled. Utilization of double-speed transmission reduces errors inherent in synchros by a factor of 25, and this instrument can be supplied having dual-sensor speed ratios from 18:1 to 75:1. A remote control feature enables this unit to be operated as either a two speed or single-speed device.

CIRCLE 317 ON READER SERVICE CARD

High Current Chokes

FOIL WOUND

ATLAS TRANSFORMER CO., 1839 Moore St., San Diego 1, Calif., announces a series of high current

semiconductor products news

Silicon Performance at Germanium Prices

General Electric unijunction transistors have been simplifying circuits and providing significant savings in overall circuit costs for a couple of years now. Because of their unique characteristics (stable negative resistance, extremely low trigger current, stable trigger voltage, high pulse current capability), one unijunction transistor can often replace two conventional transistors in a circuit. Again keeping your pocketbook in mind, and the reliability of your circuits, G-E has added the 2N1671 Series to the line, giving you silicon performance at germanium prices. And just take a look at the saving possible in a couple of typical circuits.

Typical Circuit Comparisons

Transistor Time Delay Circuit	Unijunction Circuit Equivalent
3 transistors*	1 unijunction transistor
1 diode	1 Zener diode
1 Zener diode	1 relay
1 relay	1 capacitor
2 capacitors	4 resistors
8 resistors	
SAVINGS:	$3.30 (*germanium transistors) $16.50 (*silicon transistors)

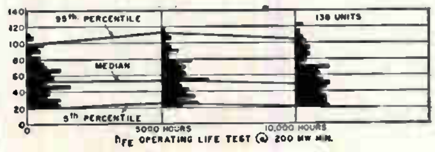
Transistor Voltage Detector	Unijunction Circuit Equivalent
2 transistors*	1 unijunction transistor
1 potentiometer	1 potentiometer
2 capacitors	1 capacitor
5 resistors	3 resistors
SAVINGS:	$0.40 (*germanium transistors) $9.20 (*silicon transistors)

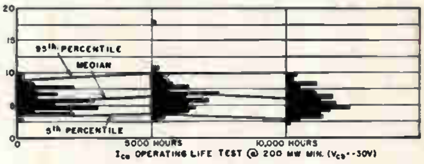
Incidentally, price reductions have also been made on the standard unijunction types 2N489 through 2N494. Your Semiconductor District Sales Manager has complete information, or write to Section 25B88.

Are you one of the thousands who read the print off the page any time you get hold of information on the Tunnel Diode? Well, with just a little patience you can feast on the most comprehensive reference work available on Tunnel Diode theory and applications. The G-E Tunnel Diode Manual is coming soon. Watch for it!

How Stable Can a PNP Low Be?

Series 2N1414 and 2N525 low-frequency germanium alloy transistors are an interesting example of the value of the extensive life testing that General Electric has conducted for years (we have test data on every transistor we've made since 1954, and some even earlier). You *know* they are the industry's most stable because parameters are *completely* spelled out, including "minimum", "typical", and "maximum" values. And our reliability story is impressive too, because it is backed up by 10,000 hour life tests (to date) on 138 units.



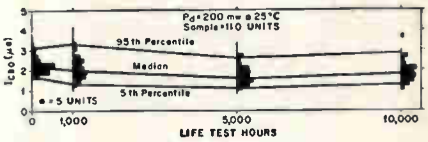


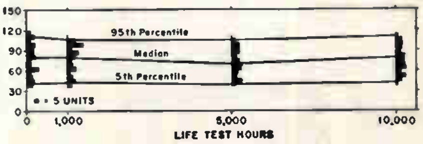
We continue the testing, too. In fact, 300 new units start life test each week. On an average, more than 30,000 General Electric transistors are on cycled life-test racks *day in and day out*. And it sure pays off in reliability!

If you can't wait for the new Tunnel Diode Manual (and we can't blame you for that), how about the new Fifth edition of the General Electric Transistor Manual? It includes Tunnel Diode switching circuits and amplifiers, and much, much more in 320 fact-filled pages. Ask your G-E Semiconductor Distributor.

Guaranteed High and Low Temp. for JAN 2N526

Speaking of the value of 10,000 hour tests (the only thing *more* valuable is 30,000 or 40,000 hour tests, and we do that too), our JAN 2N526 transistor features *guaranteed* maximum high temperature I_{CBO} and minimum low temperature h_{FE}, backed up by the stability proved by the 10,000 hour life test charts shown.





Semiconductor Products Dept., Electronics Park, Syracuse, New York. In Canada: Canadian General Electric Co., 189 Dufferin St., Toronto, Ont. Export: International General Electric Co., 150 East 42nd Street, New York, New York.

GENERAL ELECTRIC

CIRCLE 99 ON READER SERVICE CARD

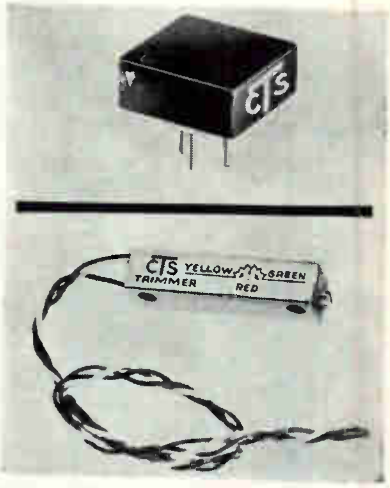
chokes for computer power supplies. All units packaged in Mil-T-20 case of AH type ($1\frac{1}{8}$ by $1\frac{1}{8}$ by $1\frac{3}{4}$). Chokes range from 500 μh at 5 amperes to 100 μh at 20 amperes, and are foil wound for best current carrying capacity and minimum hot spot temperature.

CIRCLE 318 ON READER SERVICE CARD

Pushbutton Switch
SMALL CASE DESIGN

CONTROL SWITCH DIVISION, Controls Co. of America, Folcroft, Pa. The WC1500 series pushbutton switch is designed to MIL-S-6743. Available as either a dpdt or four circuit, it features moistureproof construction, small cylindrical case design and a life of 25,000 operations minimum at rated load. Available with or without indicator light, the WC1500 is rated at 2 amperes inductive or 4 amperes resistive, 28 v d-c and will fit $\frac{5}{8}$ in. hole. This series can be obtained with six plunger cap colors.

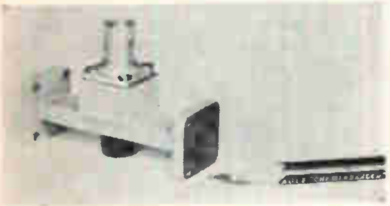
CIRCLE 319 ON READER SERVICE CARD



Trimmer Resistors
METAL-CERAMIC

CTS CORP., Elkhart, Ind., has added a 42-turn ½ in. square trimmer resistor (series 170) and a 25-turn rectangular trimmer resistor (series 180) to its metal-ceramic Cera-Trols line. Reliability and high safety factors at rated wattage are achieved by using a CTS-developed metal-ceramic element fired at temperatures exceeding 600 C, resulting in rugged, hard-surface, low-contact-resistance element. Both units have high resolution, resistance range from 100 ohms through 1 megohm and stability under all environmental conditions.

CIRCLE 320 ON READER SERVICE CARD



Single Diode Switch
FOR K-BAND USES

THE BENDIX CORP., York Division, York, Pa., announces a single diode switch for K-band. This silicon device is capable of switching greater power than 0.2 w at speeds of several nanoseconds. Total modulation voltage needed is 1.0 v peak. The on-off ratio is 20 lb with an insertion loss of 2 lb. If a greater on-off ratio is required, these units can be cascaded. A dual unit is available with the same dimensions (2½ by 1¾ by ⅞ in.), which has an on-off ratio of 40 db with an insertion loss of only 4 db. The use of a silicon junction device allows the use of this equipment under environmental conditions usually associated with silicon semiconductors.

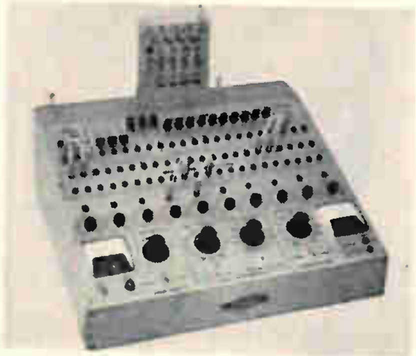
CIRCLE 321 ON READER SERVICE CARD

Telemetry Multicoupler
EIGHT OUTPUTS

DEFENSE ELECTRONICS, INC., 5451-B Randolph Road, Rockville, Md. Model TMC-2 telemetry multicoupler provides for simultaneous operation of as many as eight receivers from a single antenna or preamplifier. Each receiver may be tuned to any frequency from 225 to

256 Mc. It is unnecessary to terminate unused outputs. A characteristic is the high isolation (60 db minimum) between receiver outputs that minimizes interference when one receiver is tuned close to the local oscillator frequency of another.

CIRCLE 322 ON READER SERVICE CARD



Module Test Set
SELF CONTAINED

NAVIGATION COMPUTER CORP., 1621 Snyder Ave., Philadelphia 45, Pa. Model 1300B universal module test set is a self-contained instrument that provides standardized test signals for verifying correct operation of all NAVCOR transistorized digital system modules. The test set generates three standardized waveforms for checking the modules, and provides all supply voltages, variable loads, and controls for sensitivity, margin, and frequency checking. A single-pulse generator and output monitor meter eliminate the need for an oscilloscope during most checks, however, a monitor output is provided for rise-time measurements. The photograph shows a model 312A indicating decade counter under test.

CIRCLE 323 ON READER SERVICE CARD

Load Box
MEDIUM POWER

THE DAVEN CO., Livingston, N. J. The Mho-Box is a flexible, medium power load box for the testing of power supplies, power amplifiers and other applications requiring an accurate variable load conductance capable of dissipating about 250 w. Unit is a six dial conductance decade and differs from an ordinary resistance decade in that each dial varies the total conductance appearing between the connecting terminals in accordance with the setting of the dials. Setting all dials to zero results in zero conductance loading, that is, open circuit loading for no load measurements.

CIRCLE 324 ON READER SERVICE CARD

VHF Receiver

FIXED TUNED

ITI ELECTRONICS, INC., Clifton, N.J. Designed particularly for airport control or point-to-point applications, the type RV-9 vhf receiver is capable of highly reliable performance in unattended remote control voice circuits. The double superheterodyne design employs crystal control for both local oscillators. Normal tuning range is 108 to 152 Mc, but any vhf a-m carrier frequency can be furnished on special order. Mil-Spec components are used throughout, and electrolytic capacitors are not employed.

CIRCLE 325 ON READER SERVICE CARD

Silicon Diode

MICROMINIATURIZED

PACIFIC SEMICONDUCTORS, INC., 12955 Chadron Ave., Hawthorne, Calif. Type PD400 core driver Micro-Diode at 25 C is characterized by a stored charge of 25 micromicrocoulombs/ma; forward voltage drop of 1.5 v at ½ ampere, and 6 μsec recovery time. These characteristics, coupled with the micro configuration of the device, permit the design of optimized computer memory circuitry. Maximum stored charge has been specified to assure a small forward spike, fast forward recovery and a very low stored charge of shelf voltage.

CIRCLE 326 ON READER SERVICE CARD

Literature of

BAND-PASS FILTERS John Gombos Co., Webro Road, Clifton, N. J. Data Sheet No. F-1 covers microwave tunable band-pass filters for laboratory use and systems applications.

CIRCLE 327 ON READER SERVICE CARD

RIGID COAXIAL LINES Andrew Corp., P. O. Box 807, Chicago 12, Ill. A 20-page catalog covering rigid coaxial transmission lines and associated equipment was recently announced.

CIRCLE 328 ON READER SERVICE CARD

PHOTOTUBES CBS Electronics, Danvers, Mass. Bulletin, "Phototubes in Industry", describes high-vacuum and gas phototubes, photomultiplier tubes, photocells and photoresistive cells.

CIRCLE 329 ON READER SERVICE CARD

FLEXIBLE ELECTRICAL INSULATIONS Milam Electric Mfg. Co., 1100 Elmwood Ave., Providence 7, R. I., has prepared a comprehensive catalog containing information, data and suggestions on a wide variety of flexible composite electrical insulations.

CIRCLE 330 ON READER SERVICE CARD

SIGNAL GENERATORS Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif. Four page data sheet covers frequency doubler sets and signal generators.

CIRCLE 331 ON READER SERVICE CARD

SINGLE CRYSTAL MATERIALS Solid State Materials Corp., 5 Erie Drive, East Natick, Mass. A four-page brochure, "Single Crystal Materials for Solid State Electronics", is now available. It shows many of the company's research development, and production facilities.

CIRCLE 332 ON READER SERVICE CARD

RECTIFIERS International Rectifier Corp., El Segundo, Calif., has issued a single page bulletin that describes four rectifier models.

CIRCLE 333 ON READER SERVICE CARD

SPECIAL PURPOSE TUBES Nuclear Corp. of America, C. E. M. Division, Denville, N. J. An 8-page booklet, catalog 2250, contains quick

reference information on power and pulse tubes, high voltage, high vacuum diodes, gas noise tubes, TR tubes, and ionization gage tubes.
CIRCLE 334 ON READER SERVICE CARD

SILICON CONTROLLED RECTIFIER General Electric Co., Syracuse 1, N. Y. Bulletin covers technical data on type C50 silicon controlled rectifier. Symbols and definitions of terms are included.
CIRCLE 335 ON READER SERVICE CARD

FINE WIRE FOR ELECTRONICS Consolidated Reactive Metals, Inc., 115 Hoyt Ave., Mamaroneck, N. Y., offers a bulletin containing important data on fine wire for semiconductors, resistors, potentiometers, thermocouples, electronic tubes and other electronic applications.
CIRCLE 336 ON READER SERVICE CARD

VOLTAGE STANDARD Cohu Electronics, Kintel Division, Box 623, San Diego 12, Calif. Data sheet 20-4 describes features of a-c voltage standard model 601A.
CIRCLE 337 ON READER SERVICE CARD

FAST PULSE TRANSMISSION Electrical and Physical Instrument Corp., 42-19 27th St., Long Island City 1, N. Y. An extensive line of fast pulse transmission equipment, which is particularly useful with nanosecond rise time square pulse generators, and other fast pulse sources, is described in a 5-page bulletin.
CIRCLE 338 ON READER SERVICE CARD

SOLENOIDS Artisan Electronics, 171 Ridgedale Ave., Morristown, N. J. Bulletin provides technical data on series DS solenoids for automatic equipment requiring a moderate power source.
CIRCLE 339 ON READER SERVICE CARD

HOOK-UP WIRE Sequoia Wire and Cable Co., a subsidiary of Anaconda Wire and Cable Co., 2201 Bay Road, Redwood City, Calif. A 2-color booklet contains data on electronic hook-up wire with various insulations. Tri-tin conductors and Hy-shrink tubing and sleeving are also featured.
CIRCLE 340 ON READER SERVICE CARD

Pandapas: the $10 bill burns . . .

"I DOUBLED MY STAFF by employing another man."

Speaking is George Pandapas, president of Electro-Tec Corp., S. Hackensack, N. J. He is describing a period 16 years ago after he had been in business for some time. Pandapas has progressed. He now employs more than 500. This month in W. Caldwell, N. J., he will break ground for a new 30,000-sq-ft plant—to replace the present New Jersey plant—one of three.

The corporation expects to do $10 million in fiscal '61. (At one time in 1947 Pandapas had a net worth of $1.12). The other plants are in Blacksburg, Va. and Ormond Beach, Fla. In all, the three plants will occupy about 80,000 sq ft. The company makes slip rings, relays and switches.

George J. Pandapas isn't a big fellow (5'8" - 145). And he comes from a small city, Peabody, Mass. He is one of four children. At 13 he "started doing to learn."

He borrowed parts to build radio sets at night. Then when he knew how to build them, he started fixing them to earn extra money. Some sets were so big he had to make three trips to carry all the parts to his house. (Today Pandapas travels 100,000 miles per year.) In 1935 he graduated from high school and into the depression. He did odd jobs. In 1938 he made sound equipment for orchestras, and at one point, outfitted a sound truck for a Greater Boston politician. Even then reliability was important. "I rode in the truck to make sure the gear ran," says Pandapas. Sidelight: The candidate won and George got a 10-year-old car . . . his first . . . as a gift.

That same year, 1938, he became an electrical technician for Hytron Corp., in nearby Salem, Mass. The pay was 40¢ an hour. He was there three years and then moved to management—at $20 a week.

"In addition to picking up the technical aspects," he says, "I learned how much work it takes to make a go of business." In 1941 he moved to Wright Aeronautical Corp. in Paterson, N. J., as a process engineer.

"In 1944, I quit my job, withdrew my life savings ($1,500) and founded Electro-Tec in 450 sq ft of a defunct bank in New Jersey."

Two months later the war ended. "I had a company and no business," he says. He decided to try to find one. "I wasn't trying to get the cheese any more. I just wanted to get out of the trap." Translation: Pandapas didn't want profit, he just wanted to keep working and protect his investment. He spent five years on research for a slip ring production process and was subsequently granted a patent.

Pandapas telephones his executive vice president and general manager, Arthur Asch, once a day, no matter where he is. "I just want to offer advice from my experience—they don't have to take it."

Pandapas, 43, makes his home in Ormond Beach, Fla. He is the father of six children, and his wife's nickname is "Kelly". He relaxes with "a little bridge, poker and my family". His parents live next door. Part of his time is devoted to improving industry reliability standards and serving as a director for several companies and a bank. Some of his sayings:

"Frustration is the root of progress."

"Whoever said that stuff about a better mousetrap is crazy. You've got to build a path to their door—maybe they'll walk it, maybe they won't."

"I downplay yesterday—what's coming tomorrow is important."

"The waste of anything, especially people's talent, annoys me most."

His employees still talk about the time Pandapas was walking through a production area. He saw an employee accidentally break a wire. Without saying a word, he took out a $10 bill, lit it, watched it burn and then crushed the remains in an ash tray.

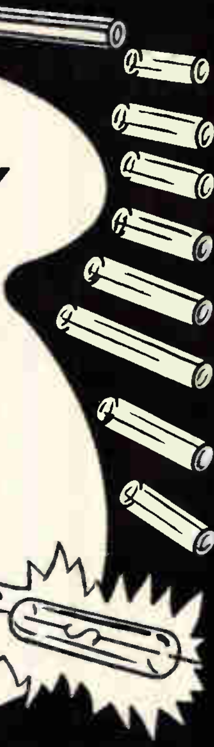
Then, quietly, he said to the worker: "I didn't do anything different than when you broke that wire."

Last week, recalling the incident, Pandapas smiled.

The ash trays were clean.

Calibration Standards Names Executive V-P

JAMES L. FOUCH has been appointed executive vice president of Calibra-



GLASS CAPILLARY REDRAW

Friedrich & Dimmock glass capillary tubing redraw for electronic components is available in a range from .020" to .125" OD in mill lengths up to approximately 36" or cut to specification.

Can be made from S/F, N/C Flint, KG-33, KG-12, and EN-1 Glasses. Also available in other types of glass. Call or write for further information.

F&D

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CIRCLE 213 ON READER SERVICE CARD

MIXER-PREAMPLIFIERS

for Short Pulse,

High Resolution SYSTEMS ENGINEERING

The LEL MMX-5 matched microwave mixer preamplifier provides design engineers with a high quality X-band receiver tuning head. Wide bandwidths needed for radio astronomy systems and short pulse radars can be realized with the MMX-5.

Featuring:

Noise Figure	11db typical
Overall Bandwidth	100mc within 3 db
Minimum Frequency Range	8.5 to 9.6kmc
Low Power Requirements	115v at 45ma, 6.3v at 0.6 amp
Gain	15db Microwave to IF

Send for comprehensive Microwave, IF, RF Amplifier Catalog.

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design

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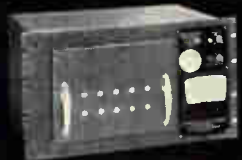
Precise

DELTA PORTABLE TEMPERATURE CHAMBERS

Model 1060W
Test Volume 16"x7"x7"



Model 1060R,
Rack Mounted
Test Volume 10"x7"x7"

Temperature Control ±½° F From -100°F to +500°F

ACCURATE TEMPERATURE CONTROL, without overshoot and without drift.

SAVES TIME by bringing the environment to the engineer instead of scheduling time in large, slow chambers.

VERSATILE—test for high and low temperatures in the same chamber.

AUTOMATIC CYCLING timer is available as auxiliary equipment.

Other chamber sizes and models are also available.

DELTA DESIGN, Inc.

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SAN DIEGO 16, CALIF.
ATwater 3-3193 TWX: SD 6488

CIRCLE 109 ON READER SERVICE CARD

tion Standards Corp., Alhambra, Calif., a subsidiary of Royal Industries, Inc.

Fouch has had extensive experience in the electronics industry, including 18 years with Universal Microphone Co., Inglewood, where he served as president and general manager. In 1948 he was president of the Western Electronic Manufacturers Association.

Ackerlind Joins Lynch R&D Staff

E. ACKERLIND has joined the research and development staff of Lynch Communication Systems Inc., San Francisco, Calif. Since 1957 he has been an electronics consultant for private industry.

Perkin Electronics Adds Fourth Plant

A FOURTH PLANT has been added as part of a general expansion program by Perkin Electronics Corp., El Segundo, Calif. Company now has a total of 42,000 sq ft of floor space.

The new facility, situated behind plants I and II, will enable Perkin to expand its manufacturing and assembly operations in d-c power supplies for commercial and missile-system applications.

Wilbur Pritchard Takes New Post

WILBUR L. PRITCHARD has been named director of engineering for Selenia SpA in Europe. Selenia, one of the largest single electronics companies in Italy, was formed last year by Raytheon Co., "Finmeccanica" and "Societa Edison".

Pritchard formerly served as chief engineer for Raytheon Europe, one of the firm's operating divisions.

With Raytheon since 1946, Pritchard is a past president of the IRE national microwave group.

Dorne & Margolin Hires Samuel Raber

SAMUEL RABER, a research development specialist, has joined the engineering staff of Dorne & Margolin, Inc., Westbury, N. Y., designer and maker of airborne antennas and microwave components, as section head of the circuit group. He was formerly associated with Fairchild Astrionics Division and prior to that, with American Bosch Arma Corp.

Eitel-McCullough Promotes Caryotakis

GEORGE CARYOTAKIS has been appointed manager of the newly formed high-power laboratory of Eitel-McCullough, Inc., in Belmont, Calif. He will direct Eimac's research and development activities for amplifier klystrons and other high-power microwave tubes.

Prior to his recent appointment, Caryotakis was senior project engineer in the company's power klystron division.

CBS Electronics Expands R&D

CLARENCE H. HOPPER, president of CBS Electronics, has announced the launching of a greatly expanded R&D program. He said that initially the emphasis will be on promising types of semiconductors and microelectronic circuits. He stated that the CBS Laboratories in Stamford, Conn., will provide most, but not all, of the additional research and development requirements.

CBS Electronics maintains plants at Danvers, Newburyport and Lowell, Mass., and in Windham, Maine. Engineering activities associated with product design and manufacturing will continue to be accomplished in these facilities.

Lockheed Electronics Names Hance

HAROLD V. HANCE has joined the systems research center of Lockheed Electronics Co. in Bedminster, N. J. He will serve as both associate director of the center and as a senior scientist.

Before coming to Lockheed Electronics, Hance worked in various capacities for nine years at Hughes Aircraft Co. in Culver City, Calif. The last position he held there was senior scientist in the research and development laboratories.

Moore Associates Gets Larger Plant

MOORE ASSOCIATES, INC., recently moved from Redwood City into a larger plant in San Carlos, Calif. Company manufactures Monitron remote control and data processing systems employing digital and solid state techniques.

Butler Elected To PPMA Board

GEORGE D. BUTLER, vice president of marketing for International Resistance Co., Philadelphia, Pa., has been elected to the board of directors of the Precision Potentiometer Manufacturers' Association.

The newly-formed professional

organization is expected to help establish standards for the entire precision potentiometer industry.

Helme Assumes New Position

APPOINTMENT of Glenn H. Helme as a senior engineer of Applied Microwave Electronics, Inc., Baltimore, Md., is announced. He was formerly a design engineer in the antenna and microwave group of the Radio Division of the Bendix Corp.

PEOPLE IN BRIEF

William H. Roberts of General Electric to head development engineering for the company's electrolytic capacitor program. **Richard B. Bean**, formerly of Automatic Electric Co., appointed program manager at Sylvania's systems engineering and management operation. **Hector V. Slade** from Garrard Engineering and Manufacturing appointed to the board of Plessey International Ltd. **I. G. Ennes** ex-Lockheed Electronics appointed sales manager of Frequency Standards Div., Harvard Industries. **Kenneth E. Mortenson**, formerly of General Electric, to head active solid-state devices group at Microwave Associates. **Hung-Chi Chang** of Westinghouse Research Labs takes post as advisory physicist in the company's semiconductor dept. **Ralph D. Bennett** leaves General Electric to join the Martin Co. as director of research. **Leroy J. Cook**, CBS Electronics, advanced to midwest regional sales manager, industrial products div. **Mazhar Hasan**, formerly Northern Illinois University professor, joins Stromberg-Carlson Div. of General Dynamics Corp. as senior physicist. **Samuel B. Fishbein** named director of customer relations, International Electric Corp. **Edward A. Talisse** promoted to production manager by Communication Measurements Labs. **William Chainey** from Lynch Carrier Systems appointed systems applications engineer at Moore Associates. **W. H. Schaumberg** advances at Maico to director of components sales.

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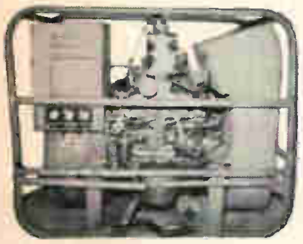
400 CYCLE PORTABLE ELECTRIC GENERATOR SETS

Completely self-contained portable power units for operating or field testing 400 cycle aircraft electronic and electrical equipment.



6.3 KVA, 5 KW, Model PU-104/U, single or three phase, 120/208 volts, 400 cycles. Permanent magnet alternator, made by Motoresearch Co. Hercules model ZXB, four cylinder liquid cooled engine. Direct coupled to generator. Operating speed 1714 RPM. Crank start, magneto ignition. Noise suppressed. Instrument panel equipped with A.C. voltmeter, ammeter, frequency meter, switches and controls. Dimensions: 22" wide, 37" long, 31" high. Shipping weight 560 lbs. FOB Chicago. GOVT. SURPLUS—New Condition. No. AS910 Our Price $345.00

12.5 KW, single phase or three phase, 400 cycle, 28 pole, 1714 RPM. Delta Connection: 120 volts, 3 wire, 3 phase, 12.5 KW, 75 amps., or 120 volts, 2 wire, 10 KW, 104 amps. per leg, 1 phase. Wye connection: 120/208 volts, 4 wire, 3 phase, 43 amps. per leg. Gasoline driven, Willys Jeep Engine, O'Keefe Merritt type PM-15 Alternator. Shipping weight 1220 lbs. FOB Chicago. Used — serviceable condition. No. AS911 Our price $645.00

37.5 KVA, 30 KW @0.8 PF, 120/208 or 240/416 volts, 3 phase, 400 cycle, 4 wire, 1714 RPM. Hercules Electric Machine & Equipment Co., Model 30-W-400. Delco Alternator direct coupled to Continental gasoline engine, type M 330. Radiator cooled, skid mounted, 24 volt battery start, housed, with pre-heater for cold weather starting. Complete control panel has full engine and generator instruments, circuit breaker, voltage regulator, etc. Dimensions: 95" long, 32" wide, 60" high. Shipping weight 3500 lbs. FOB Chicago. Used — serviceable condition. No. AS912 Our price $1845.00

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VSMF

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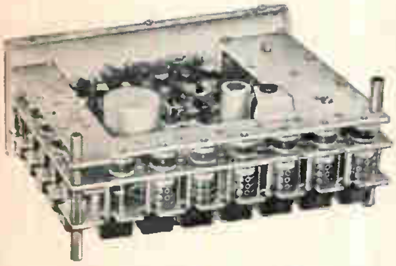
ELECTRONIC PRODUCTION PROGRAMMER

Programs Production Automatically!



Regulates and controls manufacture of electronic components, packaging, boxing, heat treating, encapsulating, baking and wide range of industrial operations.

Controls a total of 14 different functions—six of which are recorded on Veeder Root counters. Contains gear train with provision for easy variable ratio adjustment—by hand—of both sequence and duration of each function.

Compact aluminum box, 10½" x 4¾" x 8¼", weighs only 11 lbs. By interlocked system of cam and odometer operated microswitches and relays, this programmer provides on-off control all 14 functions up to a period of 7 days, depending on preset adjustments. Operates on 6 vdc.

Contains 10 rpm chronometer-type Hayden Motor No. H5305 operating on cyclic schedule, and Hayden Motor No. F5793 to drive cams, microswitches and odometers.

Built for government use with Mil quality materials and components. Complete schematic and wiring information included. Brand new with all connecting plugs. Send check with order. Satisfaction guaranteed. F.O.B. North Hollywood, Cal. $125.00

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LICENSABLE PORTABLE RADIOPHONE

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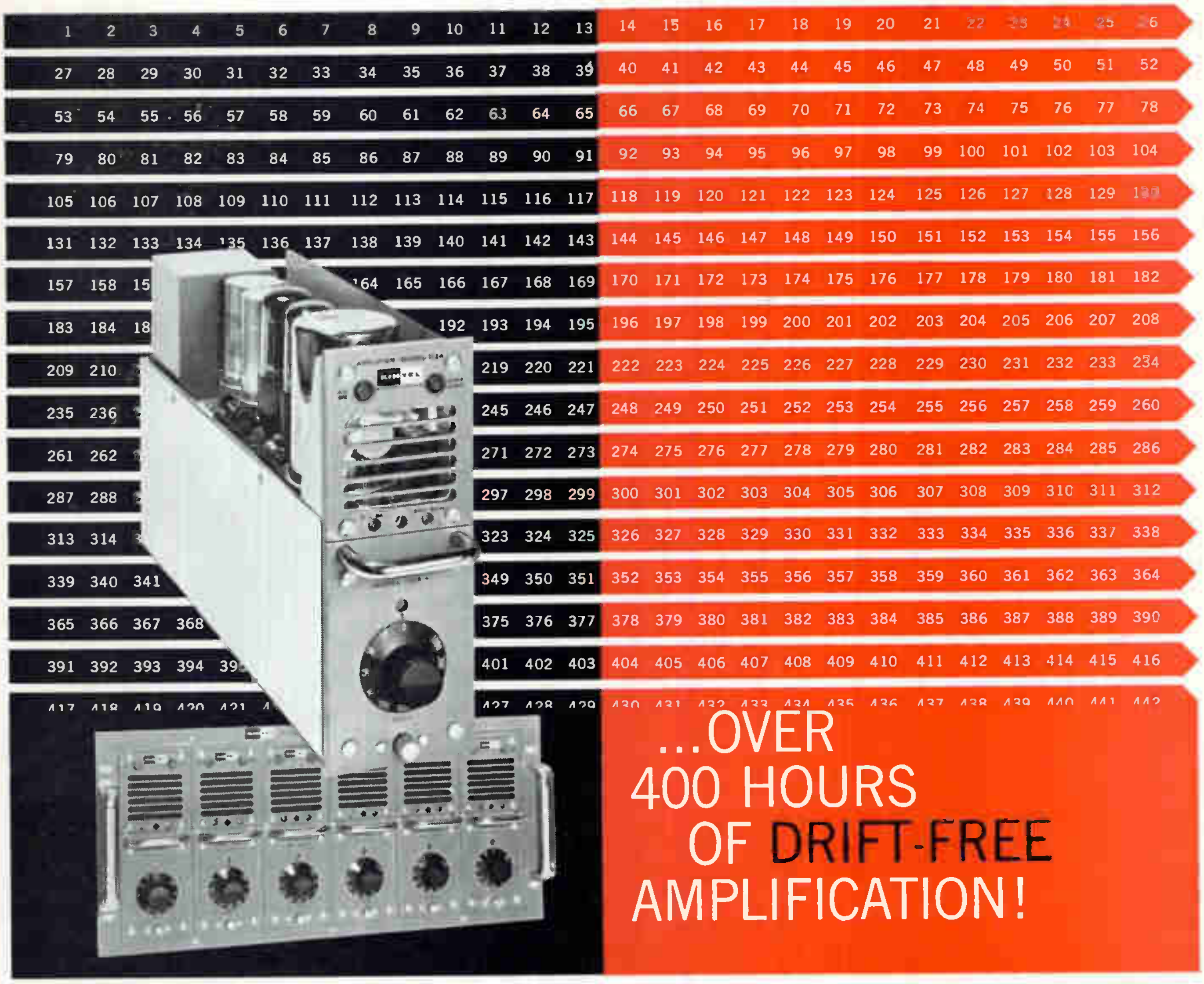

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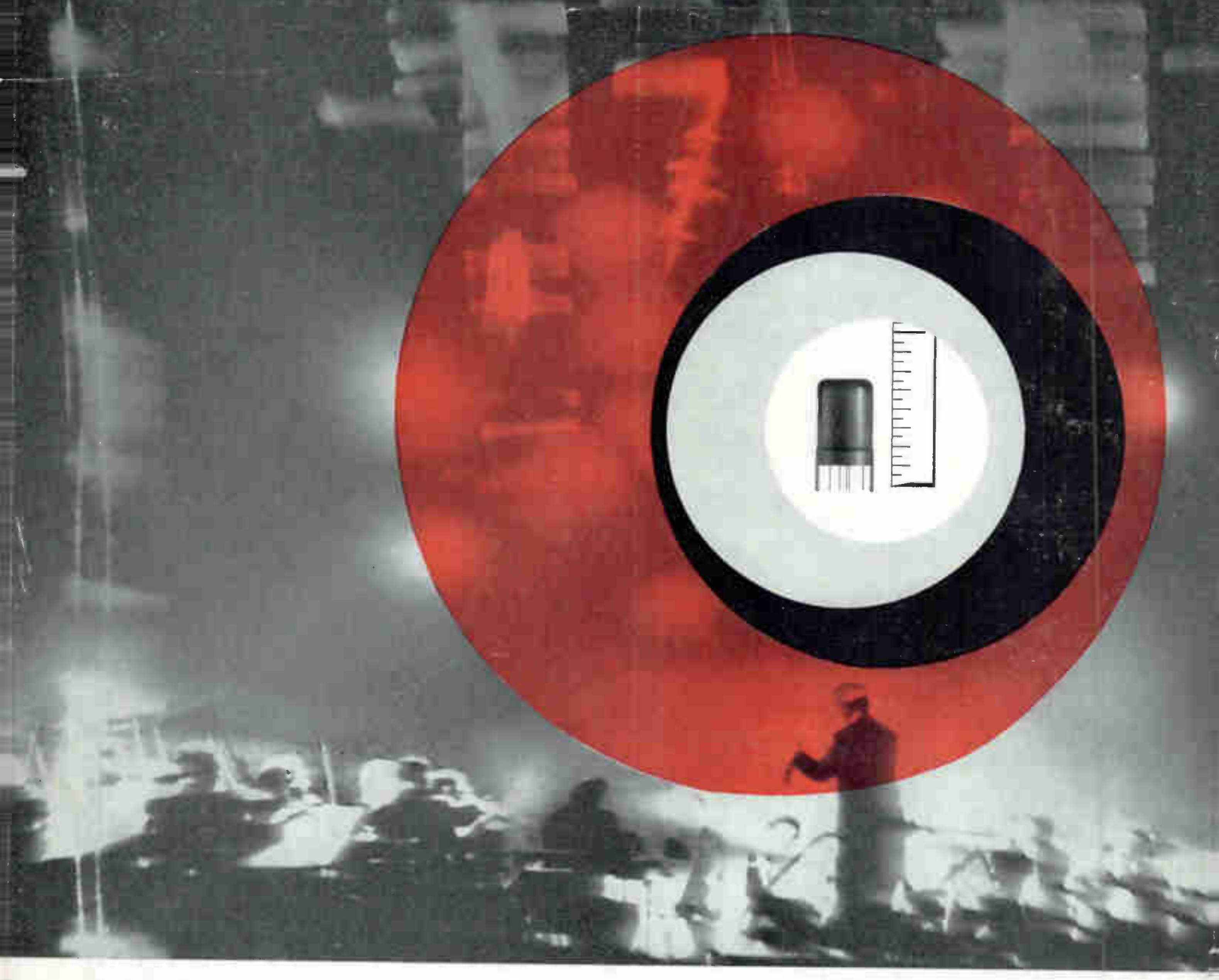

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