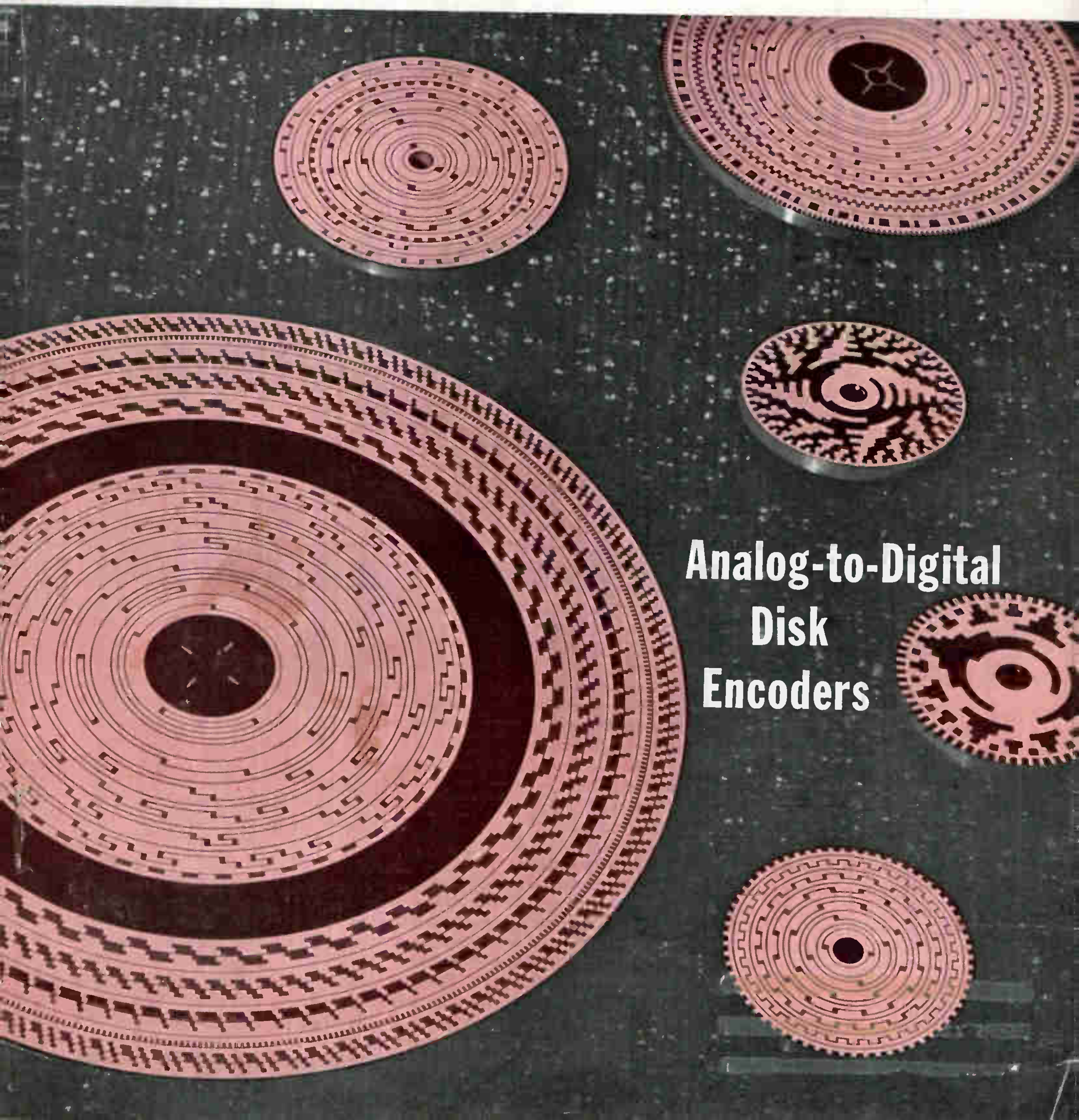
Stereo Stimulates F-M Broadcasters

page 30

electronics

A McGRAW-HILL PUBLICATION APRIL 22, 1960 PRICE SEVENTY-FIVE CENTS



electronics

APRIL 22, 1960

A McGRAW-HILL PUBLICATION
Vol. 33 No. 17

Issue at a Glance

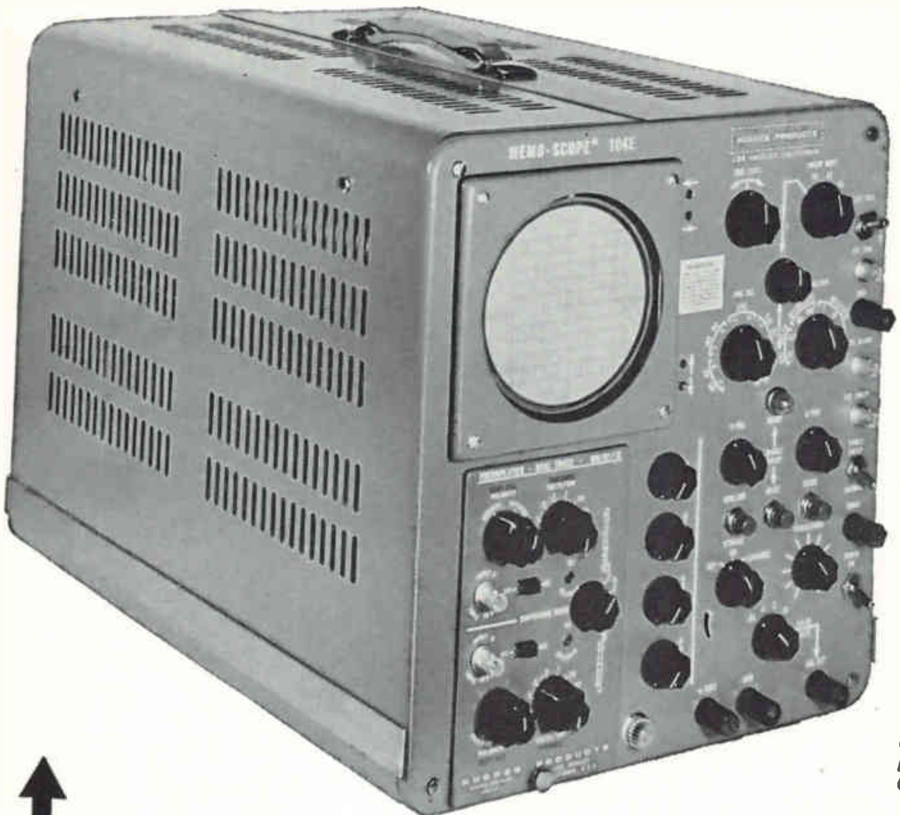
Business

Engineering

Departments

For more precise measurement of transients

Hughes MEMO-SCOPE® Oscilloscope



The new Hughes MEMO-SCOPE Oscilloscope offers you higher performance, greater dependability and easier operation in all of your transient measurements. Maximum accuracy is assured by new advanced circuitry, new panel layout, new mechanical design and many other added features.

The MEMO-SCOPE Oscilloscope eliminates expensive "hit-or-miss" methods of measuring non-recurring transients. It stores nonrepetitive events for an indefinite period—hours, or days—keeping them available for thorough study until intentionally erased.

For full information on how the MEMO-SCOPE Oscilloscope can help solve your measurement problems, write today to: Hughes, Industrial Systems Division, International Airport Station, Los Angeles 45, California.

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Hughes MEMO-SCOPE Oscilloscope: The Hughes MEMO-SCOPE Oscilloscope is one of the most versatile measuring and recording devices available to science and industry today. It is a dual service instrument—for storage or conventional oscilloscopy. Features: *simplified panel layout and carefully designed trigger circuit* for ease of operation; *built-in single sweep ("one-shot") trigger circuit* to avoid cluttered display; *advanced mechanical design* for better cooling and easier maintenance.

New Storage Tube Burn-Out Protection! A circuit designed to protect the delicate storage mesh surface is now incorporated in the Hughes MEMO-SCOPE Oscilloscope. This circuit renders it virtually impossible to burn the storage tube unintentionally as a result of improper operation of the intensity control on the instrument. The intensity control is automatically adjusted by the new protective circuit in the event the operator suddenly switches from the fastest sweep rate to the slowest without decreasing the intensity (an action which formerly might burn the tube), or in the event of similar operational errors.

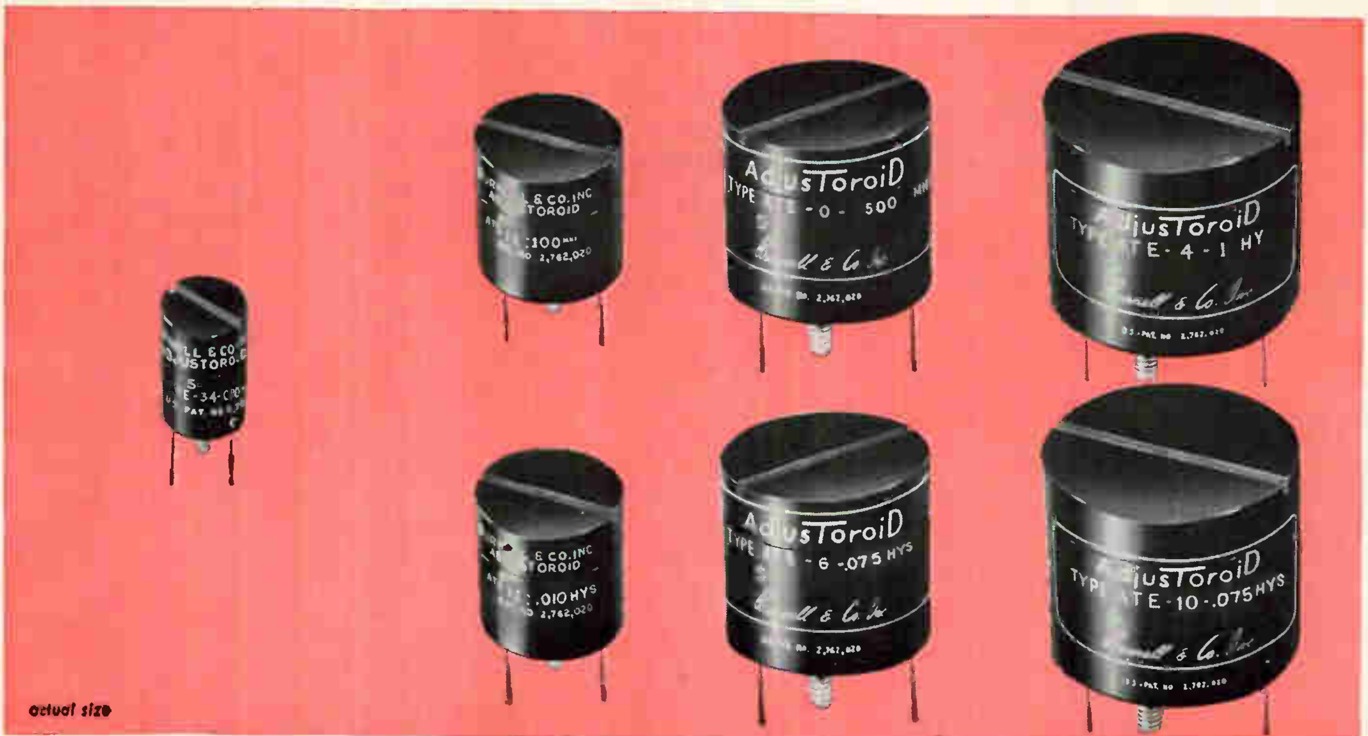
Hughes Scope Cart: Especially designed for the MEMO-SCOPE Oscilloscope, an all-aluminum scope cart facilitates movement of the instrument to different locations for varied applications. Features: *mounting provisions* for two spare amplifiers, 6' *retractable power cord* for convenience in connecting equipment, ample *drawer space, accessibility* from both sides, pull-out *writing board, full-swivel casters* for ease of movement from one area to another.

Hughes Multitracer Unit: Designed to operate in conjunction with the MEMO-SCOPE Oscilloscope, the portable Hughes Multitracer enables you to store and compare up to 20 stepped-down traces in one display. The stored sweeps appear at equal, preselected intervals forming a raster type of display. The all-electronic Multitracer is a combined attenuator, gate amplifier and storage counter designed to be placed between the signal source and the regular MEMO-SCOPE Oscilloscope input.

Creating a new world with ELECTRONICS

HUGHES

INDUSTRIAL SYSTEMS DIVISION



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NOW—Two important contributions to printed circuit design—

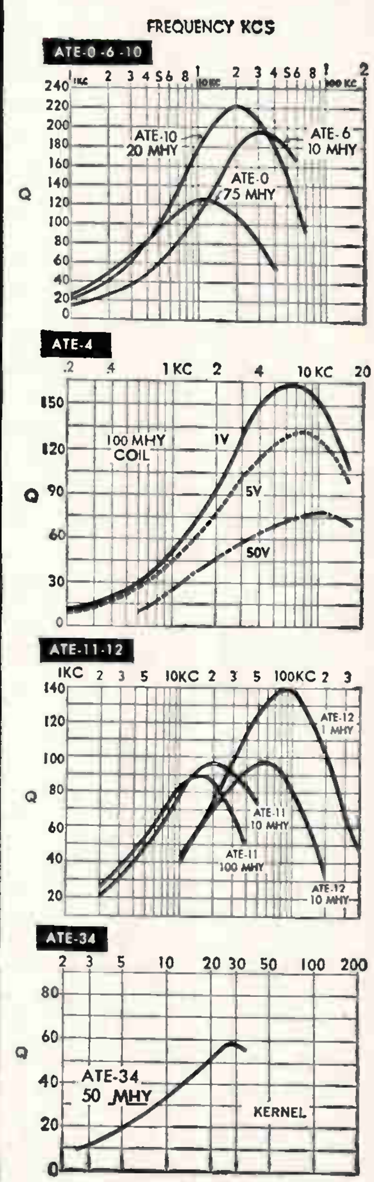
The Microminiature Kernel ATE-34 Adjustoroid® and a New Line of Miniature Encapsulated Adjustoroids

Newest addition to the Burnell Adjustoroid line is the microminiature Kernel® ATE-34 and the miniature ATE-11, ATE-0 and ATE-4. One of the unique features of these new Adjustoroids is a flush slotted head providing for ease of adjustment and economy in height.

The new microminiature Kernel ATE-34 Adjustoroid and the miniature ATE-11, ATE-0 and ATE-4 are variable over a 10% range of their inductance. Fully encapsulated, they will withstand high acceleration, shock and vibration environments. All of the above meet MIL-T specifications, 27 Grade 4 Class R and MIL-E 15305 A. Write for Stock Sheet AT-34.

	Length/ Dia.	Hgt.	Wt.	Useful Freq. Range	Max. Q	Max. L in hys
ATE-0	1 1/16"	1"	1 1/2 oz.	1 kc to 20 kc	10 kc	5 hys
ATE-4	1 5/16"	1 3/16"	3.5 oz.	1 kc to 16 kc	6 kc	15 hys
ATE-6	1 1/16"	1"	1 1/2 oz.	10 kc to 100 kc	30 kc	.75 hys
ATE-10	1 5/16"	1 3/16"	.1 oz.	3 kc to 50 kc	20 kc	.75 hys
ATE-11	3/4"	1 3/16"	.75 oz.	2 kc to 25 kc	15 kc	5 hys
ATE-12	3/4"	1 3/16"	.75 oz.	15 kc to 150 kc	60 kc	1 hy
ATE-34	27/64"	21/32"	.1 oz.	3 kc to 30 kc	55 kc	1 hy

PAT. 2,762,020



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CIRCLE 3 ON READER SERVICE CARD

electronics

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CROSSTALK . . .

WASHINGTON, D. C. The most important single market for the electronics industry, understandably, is the nation's capital. For this and many other reasons, electronic research and development companies are burgeoning in the metropolitan area near the Pentagon. Of the 130 R&D firms there, at least 60 are in electronics. And, almost daily it seems, the number increases. Fully aware of this, our Washington bureau has been doing some interviewing and checking. Result: the informative story (complete with company names) you'll find on p 34.

FOR MEN. If you speak the language of electronics engineers, think you would find it challenging to discuss technical articles with potential authors and also cover the industry's news, like to write occasionally yourself and are not above doing some indoor editing too . . . there may be an opportunity for you on our staff. In New York. Or Chicago. Write the Editor.

Coming In Our April 29 Issue . . .

ELECTRON TUBES. These days when new semiconductor and quantum-mechanical devices are being reported increasingly often, it is sometimes easy to overlook the steady gains being made in a classic field of our industry—the electron tube. Next week an ELECTRONICS Special Report will bring you up to date on advances that have been made in almost every type of tube during the past decade.

Compiled by Managing Editor Carroll on the basis of information submitted by authorities in the industry, the report spotlights the significant work underway in receiving-type tubes, power tubes, gas tubes, microwave tubes, tv tubes and many others.

Leading off this informative roundup is a discussion of receiving-type tubes by M. B. Knight of RCA's Electron Tube division in Harrison, N. J. Knight has 12 years of electron-tube experience and is presently responsible for Nuvistor application engineering. Next, improvements in high-vacuum power tubes leading to higher frequency and power levels at smaller sizes are described by D. D. Meacham of Eitel-McCullough in San Carlos, Calif. Meacham is a marketing product specialist for power tubes in the Research division.

One of the most exotic areas of electron-tube research, gas-filled tubes, is covered by H. C. Steiner of GE in Schenectady. Steiner is a consulting engineer to the Power Tube department and has 33 years' experience in gas-tube development.

Microwave technology is one of the fastest growing areas of the electron-tube field. Latest trends in linear-beam microwave tubes are explained by V. R. Learned, director of research and development for Sperry Gyroscope's Electron Tube division. Crossed-field microwave tubes are discussed by W. C. Brown, associate director of engineering for crossed-field devices at Raytheon's Microwave and Power Tube division. Both Learned and Brown are IRE Fellows. Brown is a member of the Department of Defense Advisory Group on Electron Tubes, serving as industry consultant.

Extensive effort is being devoted to tv tubes. This work, together with the latest in electroluminescent devices, is described by R. K. Gessford, Sr., W. A. Dickinson and J. H. Loughlin of Sylvania's Picture Tube Operations. The authors are chief engineer, section head for design, and coordinator of engineering, respectively. Gessford is responsible for engineering management of Picture Tube Operations and has 30 years' experience in electron-tube field.

Significant developments have been reported recently in the area of storage, counting and phototubes. These are surveyed by A. S. Kramer, senior technical specialist in DuMont's Research division.

HOW TO SELECT HIGH RELIABILITY CAPACITORS

At one time Sprague Electric was the only manufacturer offering true high reliability capacitors. The buyer had no problem. But today there are many manufacturers who claim that their capacitors meet high reliability standards. Some are even so bold as to claim that theirs are *the most reliable.*

Check the record before you choose

The only sound approach to evaluate these claims is to investigate the *reliability record* achieved by each of the companies under consideration. Remember, it takes test data to establish the reliability of a product. Claims are not enough.

Now let's look at the record

Sprague Electric can substantiate its claim that its HYREL® Q Capacitors are "the most reliable capacitors made" with the most extensive test data available in the entire electronic industry. The performance of HYREL Q Capacitors is virtually impossible to surpass . . . now and for some years to come.

But let's start at the beginning—*the specifications.* Sprague Electric's high reliability capacitors were originally made under Sprague Electric Specification PV-100—*the first high reliability capacitor specification for missiles and other critical applications.* This specification and a later revision, PV-100A, have proven so comprehensive and so successful in providing "the highest order of reliability known to capacitor manufacturing" that their provisions are currently reflected in *every* military specification covering high reliability capacitors. This is a distinction shared by no other capacitor manufacturer.

Now look at the record of HYREL Q Capacitors

On accelerated life tests the failure rate of HYREL Q Capacitors has been less than 0.05%, after more than 16 million unit hours accumulated on tests of 250 hours at 140% rated voltage, 125 C. On high frequency vibration tests, there hasn't been a single failure in the more than 50,000 units tested. On seal, moisture resistance, and temperature cycling and immersion tests, the failure rate has been less than 0.1%.

Such performance from production line capacitors can only be achieved through the most intensive (and expensive) kind of reliability program—in design and development, in production engineering, in manufacturing facilities, in testing intensity and extensity—all of which should be investigated thoroughly.

After you've checked the record, then decide for yourself which capacitor is "the most reliable made."

For complete facts and figures on HYREL Q Capacitors, call your Sprague District Office or Representative, or write for HYREL Bulletin 2900A and Specification PV-100A to Technical Literature Section, Sprague Electric Company, 35 Marshall St., North Adams, Massachusetts.

CIRCLE 5 ON READER SERVICE CARD

COMMENT

Cathode Followers

A common error related to cathode followers has been repeated in the February 26th issue of ELECTRONICS ("Unity-Gain Amplifier Offers High Stability," p 66). In table I, page 67, the output impedance of the cathode follower circuit shown in Fig. 1, page 66 is given as $Z_o = r_p\,(1+\mu)^{-1}$. This is approximately correct for a cathode follower in which the grid resistor is returned to ground, but is not correct for the circuit shown in Fig. 1 unless the grid is driven by a low impedance source. If this is not the case, the output impedance becomes a function of the source impedance as well as the other circuit parameters. Specifically, at low frequencies it is $Z_o = [R_1R_3r_p + R_3r_pR_g]/[R_1R_3 + \mu R_1R_2 + R_1r_p + \mu R_1R_3 + R_g\,(R_2 + \mu R_2 + r_p)]$. In this expression, R_1 is the grid resistor, R_2 the cathode bias resistor, R_3 the cathode load resistor, and R_g is the source impedance. Also it is assumed that $\mu >> 1$ and $R_1 >> R_3$.

With the component values given in the article, the output impedance depends on the input impedance:

R_g	Z_0
0	194
1K	194
10K	199
100K	212
1M	376
10M	1620
∞	6150

The increase does not become large until the value of R_g becomes fairly high.

Physically, it is quite apparent why this dependence on R_g exists. With the input open or terminated in a high impedance, a large fraction of any disturbance at the output is fed to the grid as well, so that only a small error signal appears between the cathode and grid of the tube. Thus the tube is essentially inoperative, so the output impedance should be substantially that of the cathode load resistor and the tube plate resistance in parallel. This checks closely with the value given above for $R_g = 0$.

It looks as if these considerations would apply to the circuits of Fig. 2 and Fig. 3 also.

WALTER S. FRIAUF

CHARLOTTESVILLE, VA.

Author Davidson replies:

Mr. Friauf's comments on the output impedance of a stepped-up cathode follower are certainly correct. Since there is a direct physical link between the input and output circuits it is to be expected that the output impedance will be a function of the source impedance. This phenomenon was not included in the original article since the circuits were designed for use in computer circuits which would normally be driven by low impedance sources. The output impedance, therefore, would be relatively unaffected.

Unfortunately, Mr. Friauf's specific expression for low frequency output impedance appears to be incorrect. The exact derivation for the simple cathode follower is:

Consider the equivalent circuit of Figs. 1 (left) and 2:

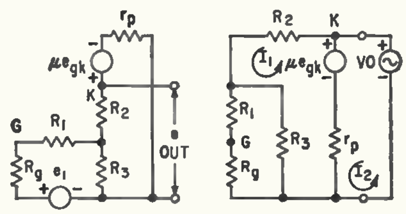

Fig. 1 is the common equivalent circuit showing input and output voltages. In Fig. 2, the input source is shorted through its generating impedance while a voltage V_o is applied across the load terminals. The output impedance will then be equal to $Z_o = V_o/I_2$. The loop equations for the equivalent circuit of Fig. 2 are written:

For loop 1, where $R_T = R_3\,(R_1 + R_g)/(R_1 + R_3 + R_g)$, $\mu e_{gk} - (R_2 + R_T + r_p) + I_2\,r_p = 0$.

For loop 2, $V_o - \mu e_{gk} - I_2\,r_p + I_1\,r_p = 0$. Also, $e_{gk} = I_1\,[R_1R_2 + R_2R_3 + R_2R_g + R_1R_3/(R_1 + R_3 + R_g)]$.

The complete expression for the output impedance Z_o is:

$$Z_0 = \frac{r_p[R_2(R_1+R_3+R_g)+R_3(R_1+R_g)]}{(R_2+r_p)\,(R_1+R_3+R_g) + R_3(R_1+R_g) + \mu\,(R_1R_2+R_2R_3+R_2R_g+R_1R_3)}$$

Even with the assumption that $\mu >> 1$ and $R_1 >> R_3$, this equation does not reduce to that contained in the letter. As stated by Mr. Friauf, the increase in output impedance is relatively small unless R_g becomes rather high. Similar considerations would apply to the circuits of Fig. 2 and 3.

ADVANCED DESIGN POWER TRANSISTORS FROM CLEVITE

Three new lines of germanium power transistors by Clevite feature new advances in controlled gain spread, fully specified collector-to-emitter voltage characteristics and low current leakage — even at maximum voltages and high temperatures.

The new 8 ampere switching series can be used to replace the older, more costly ring-emitter types in 3 to 8 ampere service.

The new 25 ampere switching type offers exceptionally low saturation voltage and is available with either pin terminals or solder lugs.

The new Spacesaver design not only affords important savings in space and weight, but its significantly improved frequency response means higher audio fidelity, faster switching and better performance in regulated power supply applications. Its low base resistance gives lower input impedance for equal power gain and lower saturation resistance, resulting in lower "switched-on" voltage drop. Lower cut off current results in better temperature stability in direct coupled circuits and a higher "switched-off" impedance.

CLEVITE NOW OFFERS THESE COMPLETE LINES

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15 ampere	
25 ampere	2 watt Spacesaver
3 ampere Spacesaver	

All Clevite germanium power transistors are designed for low thermal resistance, low base input voltage, low saturation voltage and superior current gain.

For latest data and prices or application assistance, write for Bulletin 60 . . .

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BUSINESS THIS WEEK

New Mode of Transistor Operation Being Explored Excitedly By Several Companies

A new and as yet little understood mode of transistor operation which may give the transistor a new dimension of frequency and noise performance, has been discovered at Lenkurt Electric Co., San Carlos, Calif., and is being explored excitedly by a number of companies including Hughes, Philco and Sylvania, ELECTRONICS learned this week.

While designing a transistor converter circuit for optimum performance, Lenkurt's V. W. Vodicka found that a Philco 2N502 micro-alloy diffused based transistor with maximum frequency of 700 Mc operated instead at a maximum frequency of 2,500 Mc. It was discovered that other commercially available transistors with heavily doped base regions, such as the Motorola 2N701, produced comparably startling results.

According to Vodicka, the frequency extension is possible because of a new effect which appears to have the characteristics of a combination of "tunneling" and "avalanche" effects. However, he says the tunneling is not yet fully understood and may not be true "tunneling."

Apparently, what happens is this: **When certain conditions of impedance and bias, plus a careful adjustment of the voltage and phase relationships are set up in conjunction with the Vodicka circuit, the result is a big increase in transistor bandwidth and sharply reduced noise.**

Lenkurt and Hughes scientists have been working together recently to design transistors that "favor the effect." They have quickly advanced the state of the art beyond that of an early Lenkurt configuration which used a parametric diode in addition to an MADT transistor to obtain a voltage gain of 96 db at 400 Mc with a bandwidth of 75 Kc. Noise figures approached those achieved with parametric amplifiers.

Several recently fabricated Hughes transistors have given scientists reason to conclude that "in the extremely near future" it should be possible to make transistors that will operate in the 6-8 Kmc range. ELECTRONICS learns that recent intensive exploitation of the effect found by Vodicka is changing the state of the art month by month.

A Lenkurt spokesman says that while it is believed that there are no inherent limits to the frequencies obtained, there may be a practical circuit limit of 10 Kmc. Lenkurt and Sylvania are both subsidiaries of General Telephone & Electronics Corp.

Interest in Printed Motors Mounts As Electric Auto Talk Is Revived

A surge of interest in printed motors (see p 80) for traction applications seems to be taking place because of the revival of interest in the electric automobile.

All of this ties in with several developments that are taking place simultaneously, and coming together in one place: developments in high-efficiency fuel cells in combination with developments in better performing batteries, semiconductors and printed motor techniques for gearless drives.

Last March in Chicago, at the American Power Conference, Claude R. Erickson of the Board of Water and Light of Lansing, Mich., said there was a resurgence of interest in the electric automobile. There are about 45,000 electric trucks used in England today and many thousands in this country. Allis Chalmers, Union Carbide, Chrysler and other companies are working on various types of fuel cells; Cleveland Vehicles, Electric Marketer and others are producing electric trucks.

Activity in the traction field prompts Photocircuits Inc., Glen Cove, N. Y., to produce a 3 horsepower printed-motor that shows promise for traction applications. Efficiency is 80 percent, commutation is smooth, performance is quiet and the motor fits into the wheel.

ELECTRONICS NEWSLETTER

New data-processing systems continued to make news this week. RCA announced its 301 and 601 systems, said it can now provide all-transistorized computer service for small companies with 300 employees to large corporations.

The 301, for which RCA has 35 orders, has a memory of magnetic discs, similar to 45 rpm records, in five "juke box"-like units of 5 million characters each, and will rent for up to $9,000 a month.

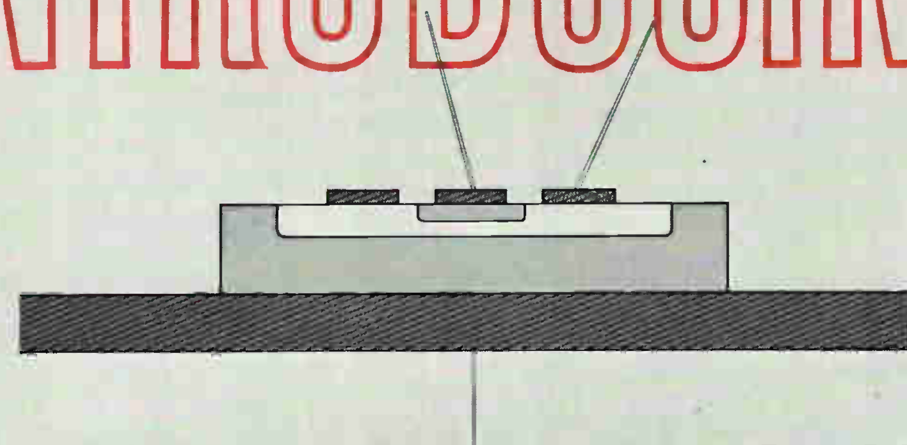
The 601, which will rent for above $20,000 a month, can make up to 666,667 decisions or add 183,000 11-digit figures in a second. RCA says the modular system has a memory expendable to 262,000 numbers, letters or symbols, adds that up to 64 tape stations can be linked to the system's main memory storage. Memory cycle is 1.5 millionths of a second, with tape speeds up to 120,000 data characters a second.

Army announces a 25-lb "ruby maser" developed by Hughes Aircraft, which is cooled to −452 F and maintained by liquid helium but requires no pump and uses a 12-oz magnet costing $10. The Army says the new maser can detect radio beeps millions of miles away.

Office of Assistant Secretary for Science and Technology in the Commerce Department has been recommended in the report of a special advisory committee of the National Academy of Sciences on "The Role of the Department of Commerce in Science and Technology."

Ten-member committee, headed by Marvin J. Kelly, former president and board chairman of Bell Labs, (ELECTRONICS, p 9, Jan. 9, '59), recommended that the office have responsibility for the Bureau of Standards, Patent Office, Coast and Geodetic Survey, Weather Bureau, Office of Technical Services and "cognizance of the science and technology activities of the Maritime Administration and the Bureau of Public Roads."

INTRODUCING...



THE PLANAR STRUCTURE

THE MOST IMPORTANT DEVELOPMENT IN SEMICONDUCTORS SINCE THE MESA, THE PLANAR STRUCTURE GUARANTEES A NEW ORDER OF RELIABILITY: SILICON SEMICONDUCTOR PRODUCTS WITH COMPLETE SURFACE STABILITY.

DEVELOPED THROUGH FAIRCHILD RESEARCH, THE PLANAR STRUCTURE HAS BEEN APPLIED AND TESTED IN TRANSISTORS AND DIODES TO AN ACCUMULATION OF MORE THAN 5,000,000 SEMICONDUCTOR HOURS.

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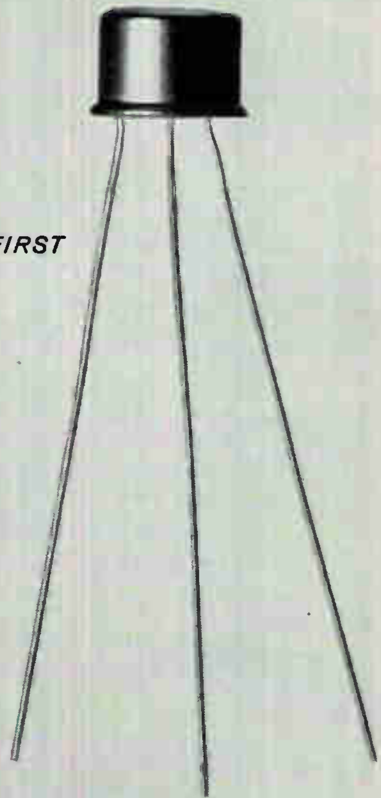

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GUARANTEED USEFUL BETAS FROM 100μA to 0.5A:
15 @ .1mA 20 @ 1mA 30 @ 150mA 15 @ 500mA
Guaranteed minimum Beta over a 5,000 to 1 range of collector current makes the 2N1613 the most versatile transistor presently on the market.

WIDE RANGE OF APPLICATIONS: in Fast Switching (logic and high current): Amplifiers (low level, low noise, wideband, VHF power).

RELIABILITY IN A NEW DIMENSION: The Planar Transistor is the most thoroughly proven transistor ever introduced commercially, with over 5,000,000 transistor hours plus 300°C. stabilization on all units.

SOME IMPORTANT PARAMETERS: 7 db—Noise Figure: 100 megacycles—Gain-bandwidth product; 0.0005μA I_{CBO} typical at 60V, 25°C.

IMMEDIATE AVAILABILITY: Quantities from 1-999 from franchised Fairchild distributors at factory prices.

TENTATIVE SPECIFICATIONS— FAIRCHILD 2N1613

f_t typical	100 mc
P_C @ 25°C. Case Temperature	3W
h_{FE} (see Beta paragraph above)	Min 30
V_{CER}	40V
V_{CBO}	75V
V_{BE}SAT. (Max.)	1.3V
V_{CE}SAT. (Max.)	1.5V
I_{CBO} @ 25°C. (Max.) measured at 60V	25mμA

FAIRCHILD SEMICONDUCTOR CORPORATION

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For full specifications, write Dept. A.

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CIRCLE 13 ON READER SERVICE CARD

WASHINGTON OUTLOOK

THE POLITICAL RUMPUS over alleged influence peddling on defense contracts by retired military brass is coming to a climax. The House has passed a bill regulating employment of former officers. The Senate will now take up the measure.

At this point, the outlook seems clear: There will be little if any direct impact on defense contractors who now hire retired military officers. So long as the ex-brass do not engage in clear-cut selling activities—something they are already barred from doing—contractors can continue to employ retired military men.

The House bill is considerably milder than the measure pushed by Rep. Hebert (D., La.), who conducted a headline-making probe last year.

It bars retired brass from "selling" to the military services for two years after retirement and requires contractors to report retired officers on their payrolls to the Pentagon. Violation of the rules calls for court martial and withholding of retirement pay for the officer, suspension of contract payments to the company.

The registration provision is new. But the two-year selling ban for the retired brass is essentially a clarification of the present law which many critics consider too vague.

Hebert and other lawmakers who've made this a hot issue have plumped for tough criminal penalties for both retired officers and their employers in cases where influence peddling on contracts can be proven.

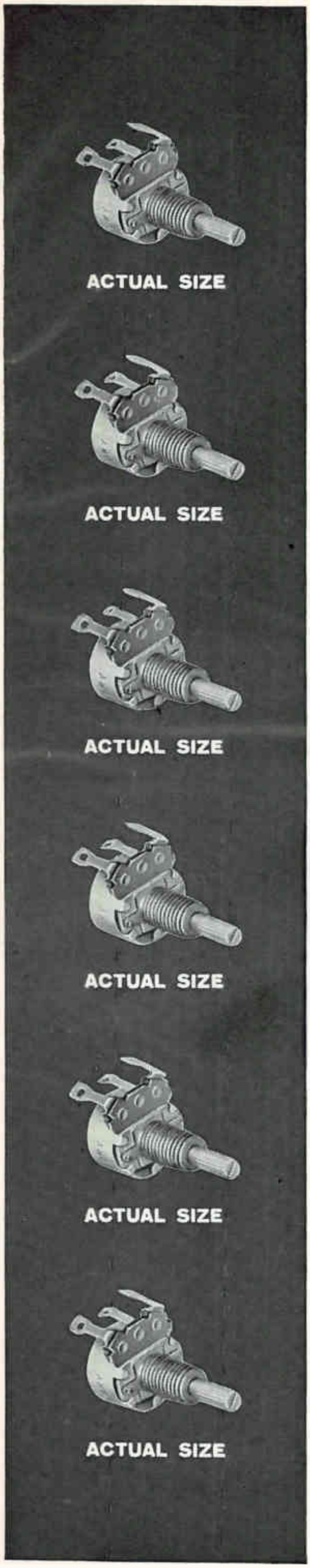
- **Complete reversal on patent policy** in government space work has been taken by the House Space Committee. It approved 14-4 an amendment allowing a contractor to keep patent rights (except for royalty-free government use) on any developments growing out of research done on a space contract.

  Industry has fought the provisions of the 1958 law setting up the space agency. This law denied patent rights to the company unless the agency made special dispensation. NASA officials convinced the committee they were having trouble placing contracts. A company which already had patent advantages in space-related work sometimes refused a NASA contract for fear of jeopardizing its patent position. Another complication was that since the Pentagon allows companies to keep patent rights, a company doing work for both Pentagon and NASA, often on related contracts, was working under two different patent arrangements.

  The original law had been designed to prevent companies from gaining patent advantages out of government-financed research in the infant field of astronautics. The committee's reversal is sure to arouse the ire of the Senate Patents Subcommittee headed by Sen. Joseph C. O'Mahoney (D., Wyo.). The Senate group has been studying government patent policies for two years in hopes of establishing among all agencies a uniform policy which would guarantee the widest possible dissemination of the fruits of government-financed research. The new amendment would also give NASA the right to change patent provisions in existing contracts.

- **Bureau of Standards** has begun new low-frequency calibration broadcasts at 20 Kc at its Boulder, Colo., laboratory. Purpose is to enable frequent calibrations of electronic gear for quality control in production, research and other projects.

  Unless you can now receive signals in the low-frequency range, you will require special receiving equipment. Bureau officials say the new broadcasts are another step in their drive to improve facilities for calibration of test and control apparatus. They say the 20-Kc frequency will provide a much more stable transmission than the short wave frequencies of WWV and WWVH.



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another Mallory "first" in miniaturization

Only ½-inch in diameter, the new Mallory carbon control is the world's smallest conventional-type control for commercial applications. It takes less cabinet space, less panel space, weighs but a fraction as much as the conventional 15⁄16″ controls. It's especially adaptable to miniature, table and clock radios; portable dictating equipment; portable television receivers; test instruments; and hi-fi amplifiers and pre-amps for small cabinets.

The tiny half-inch control retains the quality features that have gained the larger Mallory controls their reputation for outstanding performance: the same high-density, mirror-surface element for long, quiet service; the same ring-type, snap-action switch—simple in design and operation, with high, constant contact pressure, positive contact alignment and continually changing "floating" contact surface.

Available with or without rotary switch, nylon or steel shaft. Rotation: 290° without switch, 320° with switch. Linear taper: 100 ohms to 10 megohms; audio taper: 500 ohms to 5 megohms. Can be applied with element having low end resistance, for use in transistor circuits.

For further information, write to J. R. Woods, Dept. H, Mallory Controls Company, Frankfort, Indiana.

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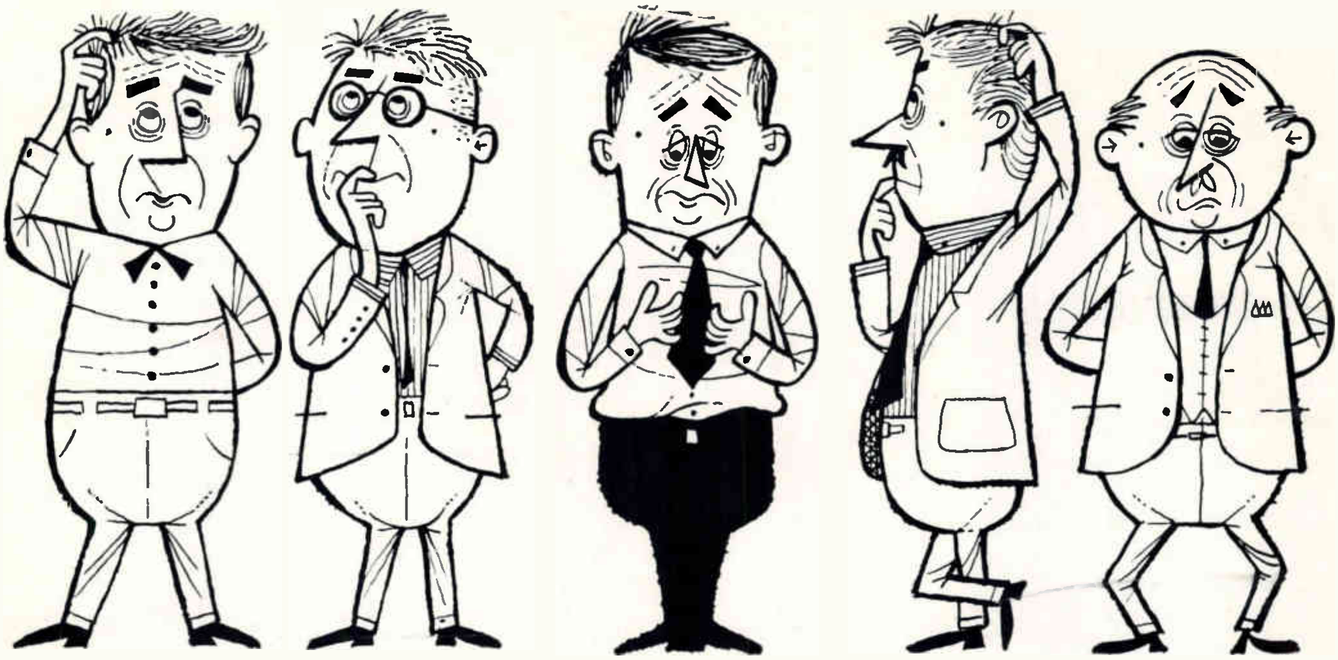
CIRCLE 15 ON READER SERVICE CARD



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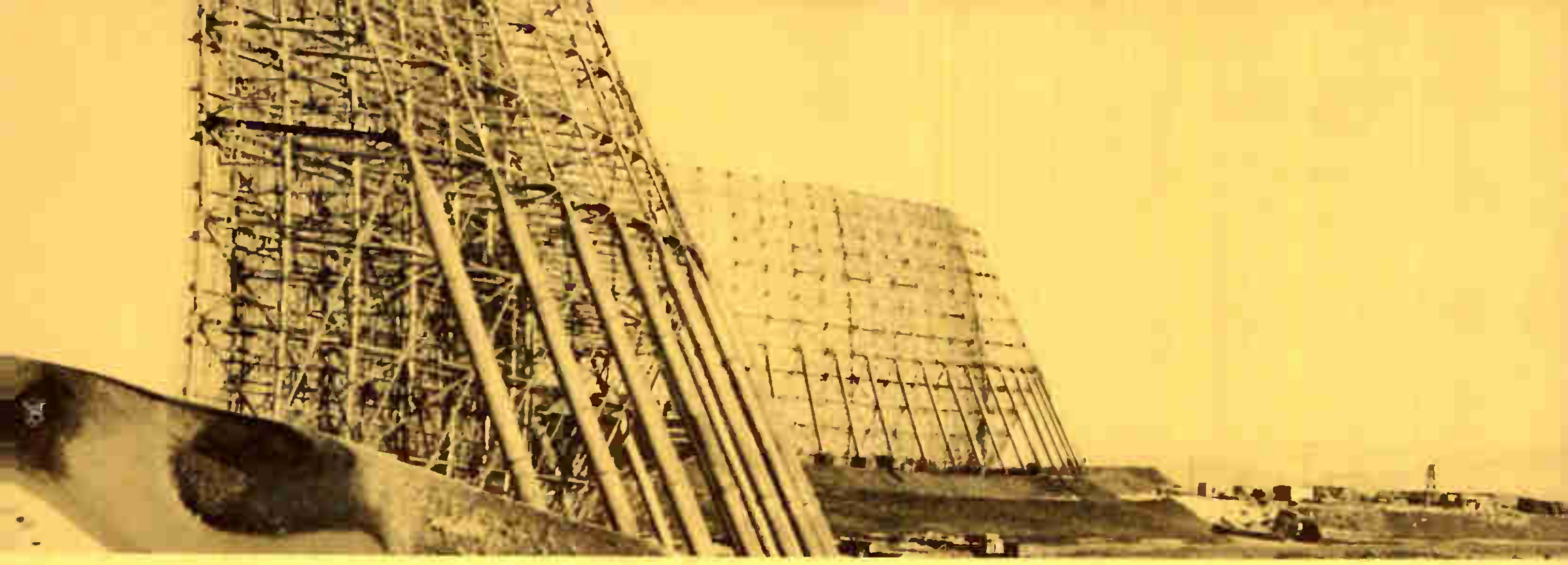


Professional placement report
for Electronics Engineers

How the continuous need to improve the nation's space surveillance capabilities opens avenues for new engineering careers

The continuous need we are talking about at General Electric refers to the fact that future-generation missiles, satellites and deep space probes will require refined or entirely new detection techniques, including many that have not yet been conceived.

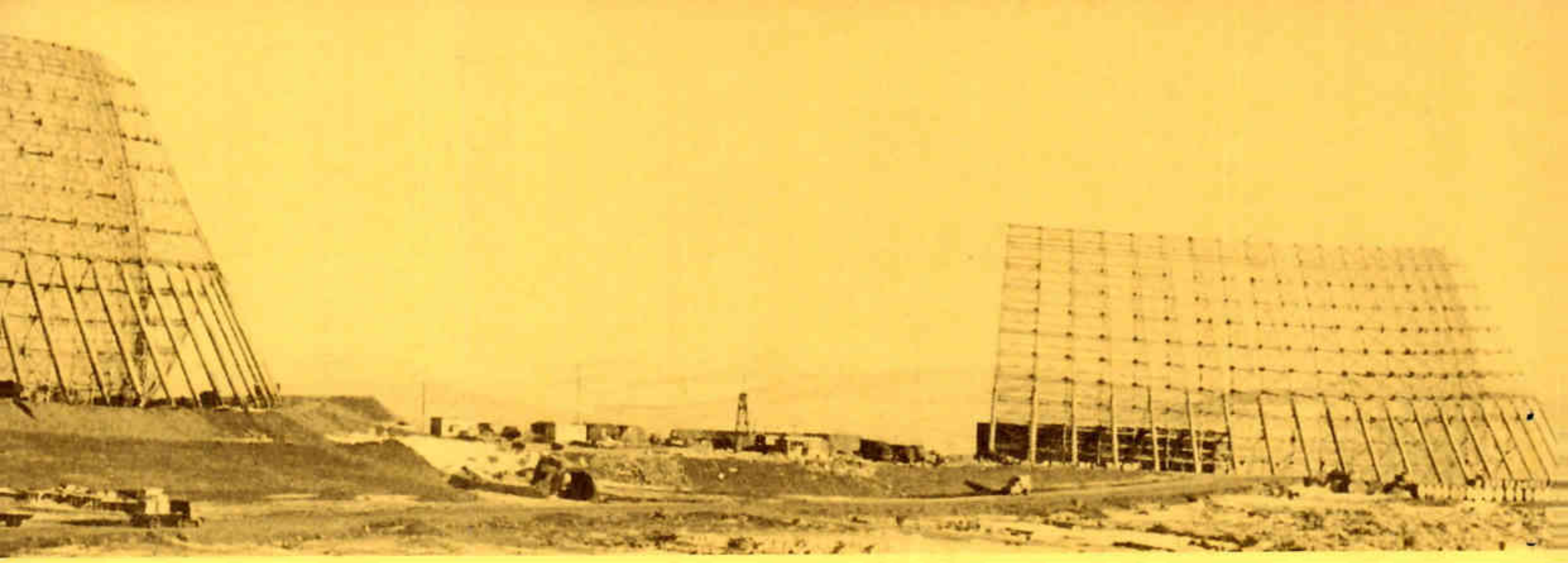
For example, it is anticipated that for every technical discipline now utilized in the detection field, at least one more must be found to apply within the next 10-year period.

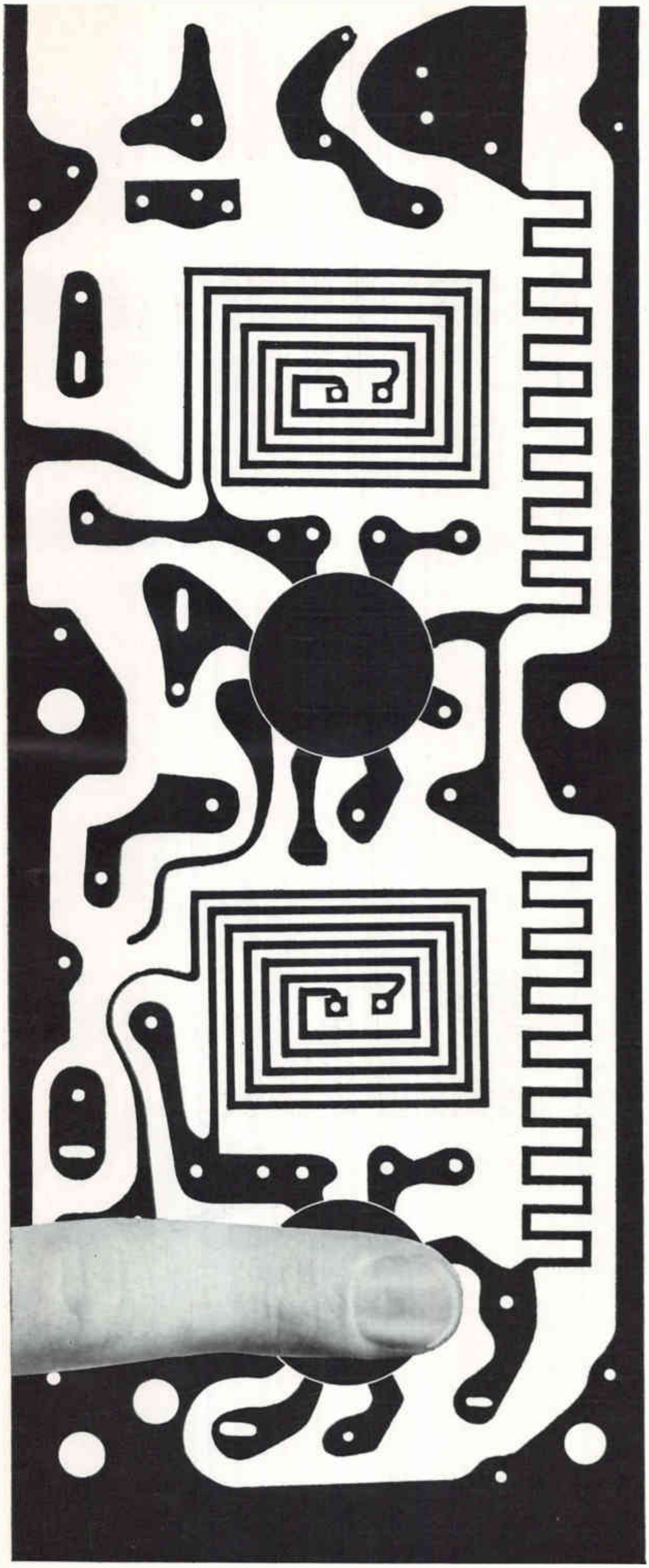
With this in mind, General Electric is increasing its electronics engineering staff now working on advanced missile, satellite and deep-space-probe detection systems. Keeping pace with this expansion, the Company added a new building last year, and another will be ready for occupancy in a few months.

First clues to this trend were obvious in General Electric's well known "Golfball Study," published five years ago. This study compared the problem of missile detection to that of locating a golfball 200 miles away, using the most advanced techniques available in 1954. The problem no longer has such proportions, thanks to the creative imagination of dedicated General Electric engineering, scientific, and technical personnel responsible for designing and developing the unique surveillance sub-system of the Ballistic Missiles Early Warning System (BMEWS) which is receiving headline attention today.

Find out more about these creative and self-expressive opportunities now open to qualified personnel in one of the most vital technologies of the space age.

GENERAL ELECTRIC





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STYLE PF

±3% "PF" VOLTAGE REGULATING PLATE-FILAMENT TRANSFORMERS

Model	Catalog No.	Input Voltages	Average DC Input Volts to Filter	Filament Windings 6.3 Volts	Filament Windings 5.0 Volts	Style	Dimensions in Inches H	L	W	Ship. Wt. Lbs.
Plate & Filament	PF-50	100/130	275 V, DC @ 50 MA	2.5 Amps. CT	2.0 Amps.	PF	4 13/16	3 1/8	3 3/16	5
	PF-110	100/130	385 V, DC @ 110 MA	3.0 Amps. CT	2.0 Amps.	PF	4 13/16	3 1/8	3 13/16	8
	PF-250	100/130	380 V, DC @ 250 MA	#1 4.0 Amps. #2 8.0 Amps. unregulated	3.0 Amps.	PF	7	4 1/2	5	19

STYLE D

±½% STANDARD VOLTAGE REGULATORS

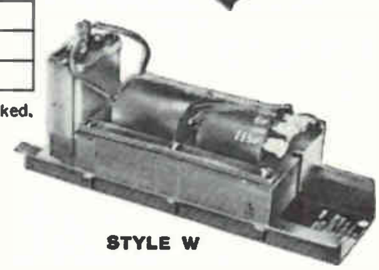
Model	Catalog No.	Output Capacity Volt-Amps.	Voltages Input	Voltages Output	Style	Dimensions in Inches L	W	H	Approx. Ship. Wt. in Lbs.
Standard[1]	VR-6110	15	95-130	115	F	6 1/4	2 3/16	3	4
	VR-6111	30	95-130	115	E	7 1/2	3 3/8	4 1/8	5
	VR-6112	60	95-130	115	E	7 1/2	3 3/8	4 3/16	6 1/2
	VR-6113	120	95-130	115	E	7 1/2	3 3/8	5 13/16	10 1/2
	VR-6114	250	95-130	115	E	12 3/8	5	7 5/8	27
	VR-6115	500	95-130	115	E	12 3/8	5	9 1/8	45
	VR-6116	1000	95-130	115	H	13 3/16	14 1/16	9 5/8	96
	VR-6117	2000	95-130	115	H	36 1/4	14 5/8	10 1/8	243
Isolated Secondary	VR-6931	60	95-130	115	E	7 1/2	3 3/8	4 3/16	8 1/2
	VR-6827	120	95-130	115	E	7 1/2	3 3/8	5 13/16	23
Harmonically Filtered (Harmonic Content Less than 3%)	VHF-6114	250	95-130	115	H	14 1/16	13 3/16	9 5/8	56
	VHF-6115	500	95-130	115	H	14 1/16	13 3/16	9 5/8	85
	VHF-6116	1000	95-130	115	H	29 1/4	14 3/8	10 1/4	220
230-Volt Output[3]	VR-6221	30	190-260	230	E	7 1/2	3 3/8	4 1/8	5
	VR-6222	60	190-260	230	E	7 1/2	3 3/8	4 3/16	6 1/2
	VR-6223	120	190-260	230	E	7 1/2	3 3/8	5 13/16	10 1/2
	VR-6224	250	190-260	230	E	12 3/8	5	7 5/8	27
	VR-6225	500	190-260	230	E	12 3/8	5	9 1/8	45
	VR-6226	1000	190-260	230	H	13 3/16	14 1/16	9 5/8	96
	VR-6227	2000	190-260	230	H	36 1/4	14 5/8	10 1/8	243
Filament	VR-6101	30	95-130	6.0/7.5	E	7 1/2	3 3/8	4 1/8	5
	VR-61F0	15	95-130	6.3	F	5 3/4	2 5/8	4 1/16	6 1/2
	VR-61D0[2]	15	100-130	6.3	D	3 1/16	2 5/8	4 11/16	5 1/2
	VR-6710	25	95-130	6.0	W	7 5/8	3 1/8	3 3/8	4

1. 50-Cycle Models also available with these specifications. 2. Regulation ± 1%. 3. 230-Volt Models not generally stocked.

STYLE E

STYLE F

STYLE H



STYLE W

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Fairchild-DuMont Plans Still On

MERGER between **Fairchild Camera & Instrument** and **Allen B. DuMont Labs** is still hanging fire. Plans announced late last month are due to be voted on within the next two weeks.

Last month, representatives of both firms were authorized to negotiate an agreement on the basis of one share of Fairchild common for each 15 shares of DuMont common—and one share of Fairchild common for each 5.7 shares of DuMont 5 percent convertible preferred. If merger plans go through, Fairchild will be the surviving company.

• **General Precision Equipment Corp.**, New York, reports record sales for 1959 of $215,588,430, 28 percent above those of 1958. Net income after taxes last year was $4,198,200, compared with $304,267 a year earlier. Per-share earnings last year were equal to $2.63. There were no earnings on common stock in 1958.

• Audited net sales for **Ling-Altec Electronics, Inc.**, last year were $48,086,785, with earnings of $3,139,639 before income taxes. Capital surplus was $4,316,215, and the balance of retained earnings on Dec. 31, 1959, was $4,634,693. Consolidated current assets came to $22,874,210, with liabilities standing at $15,113,474.

• **Systron-Donner Corp.**, Concord, Calif., manufacturer of electronic and electromechanical instruments and systems, announces net sales of $1,582,505 and net earnings of $150,244 for the four months ended Nov. 30, 1959. A public offering of 442,700 shares of stock made at $13.875 per share last month will raise $977,219 in outstanding capitalization. The firm reports the largest percentage of its sales comes from special-purpose transducers and flight control systems.

• **The Budd Company**, Philadelphia, reports acquisition of **Metrol, Inc.**, manufacturer of non-destructive testing equipment with headquarters in Pasadena, Calif. Purpose of the acquisition is to expand Budd's Instrument division non-destructive test equipment line. Metrol will continue to operate in California as a Budd division.

• **Loral Electronics**, New York, announces acquisition of **Alpha Wire Corp.** in the same city. Alpha will operate independently as a subsidiary of Loral with no changes in personnel. Initial plans call for continued expansion of Alpha's manufacturing facilities in New York and Los Angeles.

• **Victoreen Instrument Co.**, Cleveland, reports sales are at a current rate of $13 million a year for 1960. Company expects this figure will reach $20 million by December of this year. The firm reports a 1959 net income of $390,940 on sales of $7,776,761. D. H. Cogan, Victoreen president, says the company is holding $3½ million in cash and government bonds earmarked for financing expansion. The company and its subsidiaries produce radiation detection gear and electronic parts.

25 MOST ACTIVE STOCKS

WEEK ENDING APRIL 8

	SHARES (IN 100's)	HIGH	LOW	CLOSE
Philco Corp	1,879	38¼	34¼	34⅜
RCA	1,388	71¾	68¾	71
Gen Tel & Elec	1,067	83⅝	77½	82⅝
Ampex	1,051	38⅛	35¾	36⅛
Litton Ind	1,010	81½	76	77¾
Univ Controls	984	15	12⅛	15
Raytheon Mfg	876	45¾	39⅞	44⅛
Gen Electric	826	94¾	91⅛	93⅝
Int'l Tel & Tel	799	39⅝	38¾	38¾
Dumont Labs	788	9	8⅜	9
Transitron	658	49⅜	44	48¾
Magnavox	638	42⅛	37½	40¾
Sperry Rand	612	22¼	21⅝	21⅝
Westinghouse	612	53⅜	49¼	52⅝
Avco Corp	535	14⅛	13¼	13½
Varian Assoc	527	49⅞	47¼	49⅝
Burroughs	461	34	31⅞	33⅝
Collins Radio	447	61½	58¼	58¼
Texas Inst	438	211½	197	207½
Monogram Precision	378	6⅞	4	6½
Siegler Corp	365	38⅜	36¼	37
Heli Coil	360	41¾	38	39½
Gen Dynamics	346	44⅞	41⅝	44
Admiral	322	22⅛	20¼	21
Amphenol Borg	317	44⅝	41	42½

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

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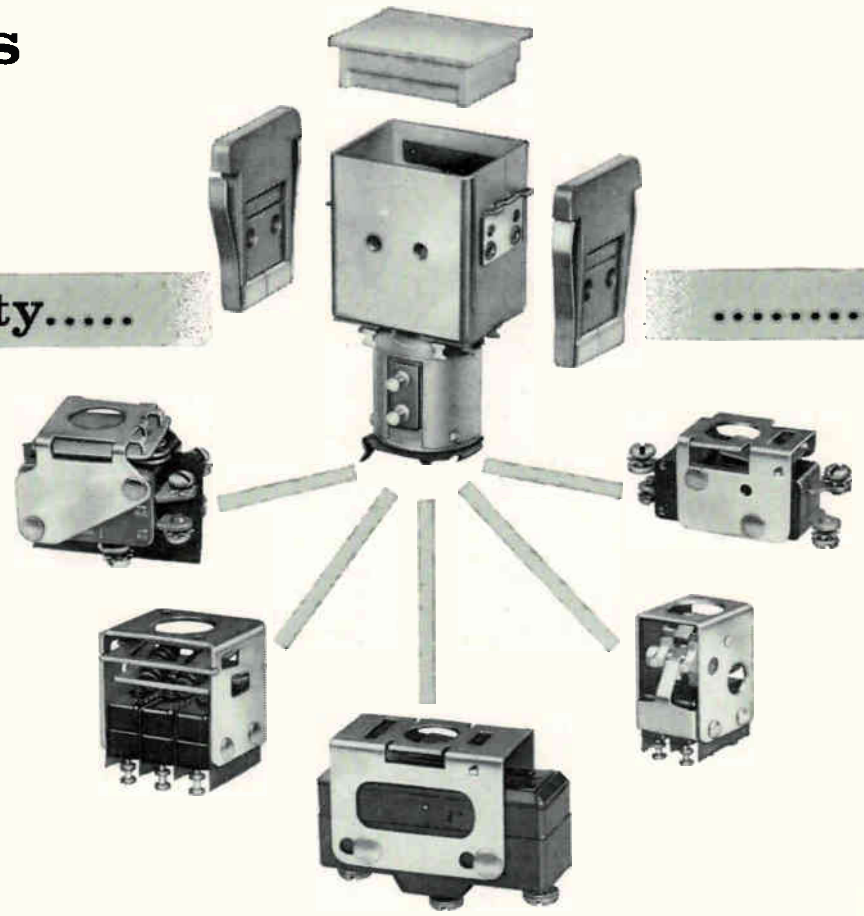

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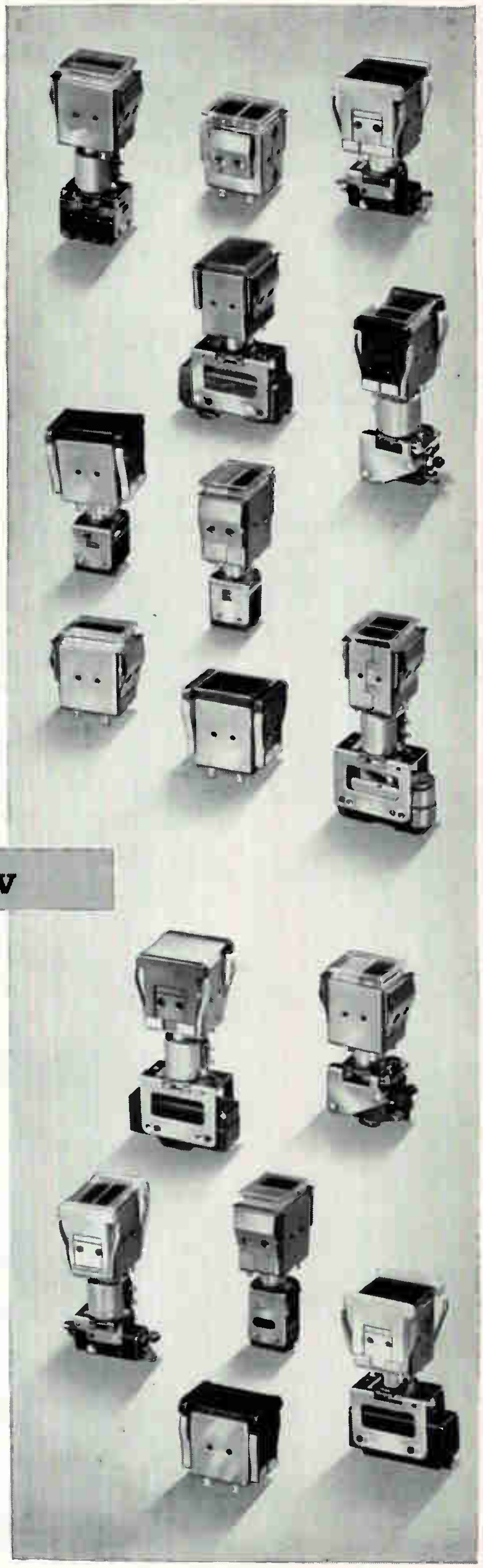
Modular Customizing...

Give your control panel a touch of tomorrow in appearance, the assurance of MICRO SWITCH reliability, and the customizing that will precisely fit your control and display functions. These Series 2 lighted push-button switches perform *both* control and indicator jobs which saves panel space on computers, graphic flow panels, electronic data-processing equipment and many other installations. They simply snap together to fit your styling requirements, then snap into slots in the mounting panel—all without tools.



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You have complete design flexibility. Select from 48 different units and 16 mounting barriers differing in size and color. Forty different color display screens include lateral and longitudinal color divisions. Indicators and operator-indicators are available with 2 or 4 lamps and light output of lamps may be colored by choice of 4 different color filters. You may choose operator-indicator switch units or indicator units only. These modular units meet the very latest requirements for panel design in the field of Human Engineering.

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Reliability... from the best in basic switches

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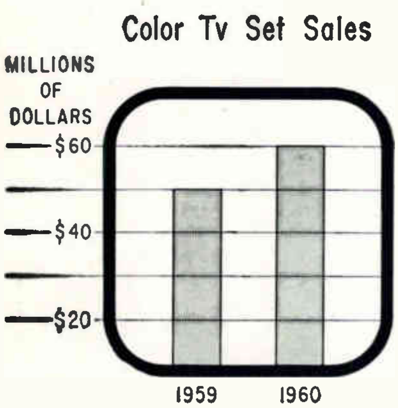
Color Tv Sales Rise $10 Million



HEIGHTENING OPTIMISM now marks manufacturers' opinions on prospects for color tv set sales.

Two facts stand out. Manufacturers are making more concrete statements about the size of the market and other evidences of sales growth. Moreover, favorable progress reports are emanating from the three active producers—RCA, Packard-Bell and Admiral.

Packard-Bell president Robert S. Bell recently estimated that color volume in 1959 was over $50 million and that it will be close to $60 million in 1960. By 1965 color television will be a factor in doubling sales of tv sets, he adds.

Bell also looks for expanding color sales and programming to attract other manufacturers to the field. Comment last month by Joseph S. Wright, president of Zenith Radio, confirms this view. Color interest may perk up within two years, he said, and if it does "we may be right in it."

RCA's chairman, David Sarnoff, recently said that RCA plans to produce twice as many color television sets this year as in 1959. Other RCA officials had previously stated that RCA color sales were running 25 percent ahead of last year and that production had passed the break-even point in the fall of 1959. Firm figures it starts to make money after production in any one year exceeds the 100,000-set mark.

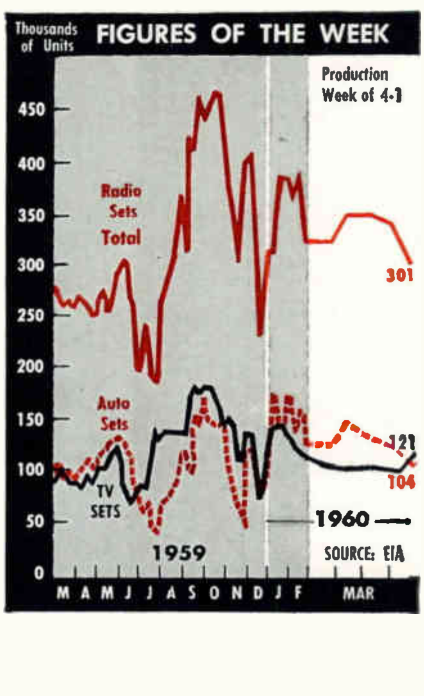
Admiral's sales were recently running 35 percent ahead of original plans, according to tv sales manager Ross Siragusa, Jr. He credits increased color programming this season for the better-than-expected showing.

Many have looked to lower set prices, now running near $500 at retail, to provide the impetus needed for a substantial rise in color set sales. High prices (and the resultant limited market) has been a factor in decisions of several manufacturers who got out of the color business. But today's domestic manufacturers hold out very little hope of lower prices in the near future.

However, Japanese firms, which are just getting into color set manufacture, could change the price picture.

• **F-M Sales**, which passed the million mark in 1959, will have an annual sales rate of 4 million units in 1963 (including one million f-m auto radios), claims Henry Fogel, president of Granco Products Inc. He was addressing the f-m day session of the National Association of Broadcasters convention in Chicago.

Fogel looks for a total of 2,000 f-m stations broadcasting full stereophonic sound by the spring of 1963. Today there are about 900 f-m stations, all monaural.



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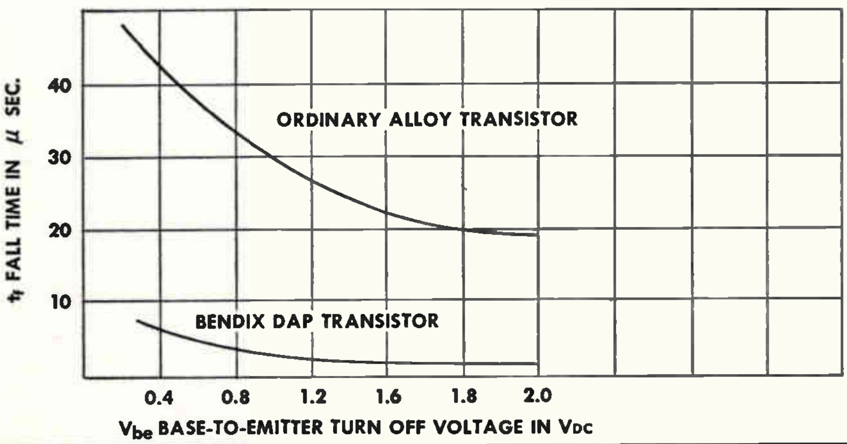
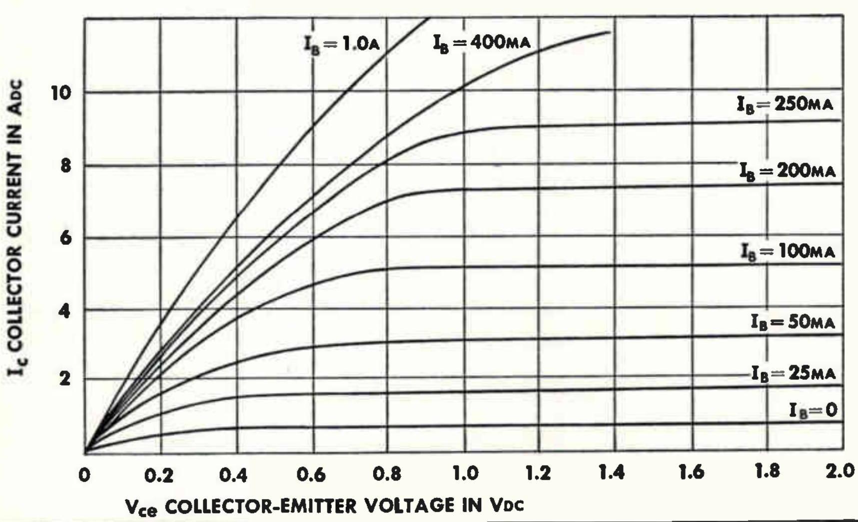


COLLECTOR-EMITTER SATURATION VOLTAGE CHARACTERISTICS FOR 2N1073, A, B



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TYPE NUMBERS	Vce Vdc	Vcb Vdc	Veb Vdc	Ic Adc	Pc W	T Storage °C	Tj °C
2N1073 2N1073A 2N1073B	− 40 − 80 −120	− 40 − 80 −120	10	10	35	−60 to +100	100

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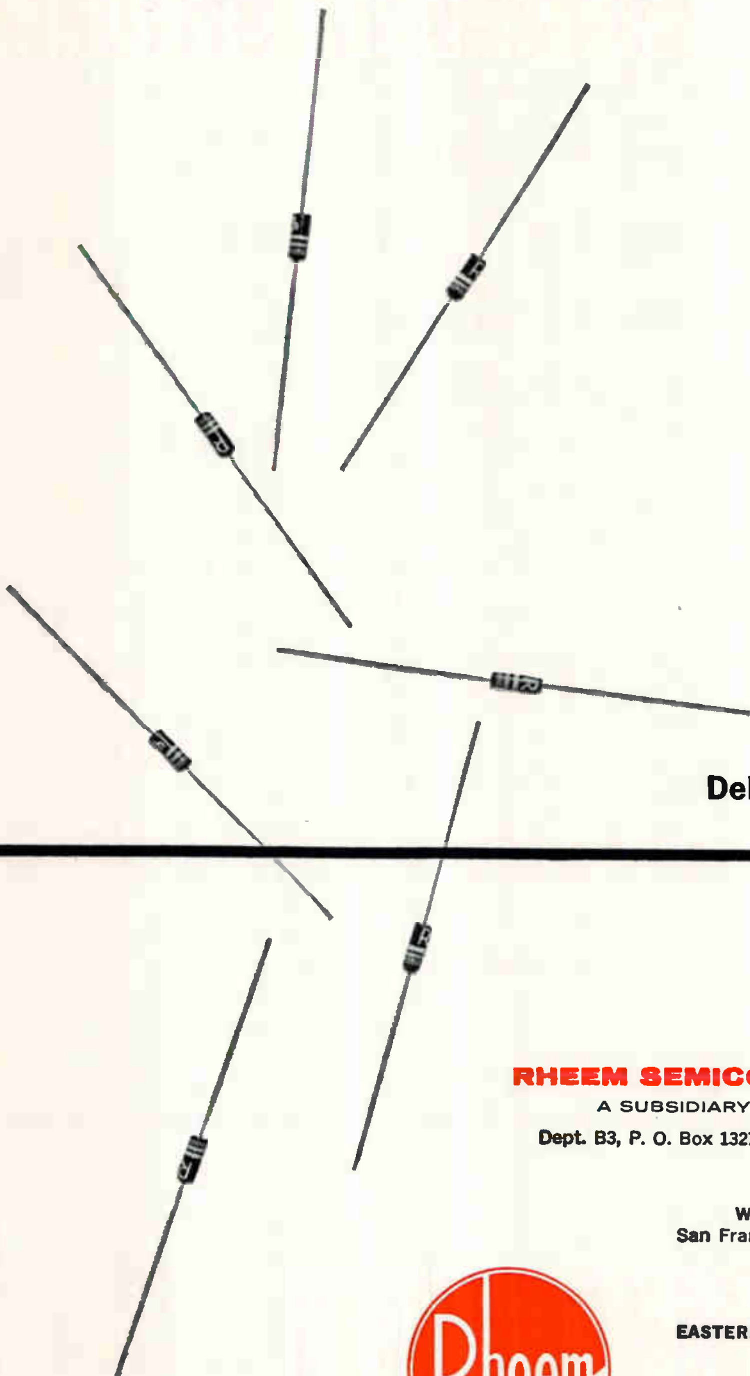

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Tube	Eimac Tube With Similar Characteristics	Length	Diameter	Frequency for Max. Ratings	Max. Plate-Diss. Rating	Heater Voltage
X578G	4CX300A	2.5″	1.65″	500 mc	300 watts	26.5
X578H	4CX125C	2.5″	1.25″	500 mc	125 watts	26.5
X578J	4CN15A	2.5″	0.9″	500 mc	15* watts	26.5

*A nominal rating. May be increased by employing a suitable heat sink or liquid immersion.

Stereo Stimulates F-M Broadcasters

Standards may be established by this fall, says FCC spokesman. Some manufacturers pledge smaller sets and more marketing effort

FUTURE of stereophonic broadcasting continues this week to be the major question holding the attention of radio broadcasters and manufacturers alike.

From all appearances, it looks as if the f-m broadcasters' future in this regard will become a reality much sooner than the a-m or the tv broadcasters.'

Awaiting Decisions

Until recently hopes were running high in broadcast circles that the end of this year would see a number of final decisions on standards for all three services. This is no longer the case since suspension of activities of the National Stereophonic Radio Committee (ELECTRONICS, p 63, Mar. 11).

At the time of the suspension, NSRC attributed the mothballing to the holdout of major groups who abstained from taking part in deliberations because of fear of antitrust complications.

However, at the recently concluded convention of the National Association of Broadcasters in Chicago, some frank comments by a spokesman for the Federal Communications Commission disclosed a number of new factors.

James E. Barr, assistant chief of the broadcast bureau, told a packed audience of broadcasters (mostly f-m) that the commission felt NSRC was biting off more than it could chew in attempting to weigh the merits and establish the standards for amplitude modulation, frequency modulation and television all at one gulp. "They got in over their heads," he said.

"Stereo looked good there for a while", added Barr. "Most of the interest started about two years ago when the commission asked for ideas on new uses for f-m facilities."

Because of stereo's promise, says the bureau chief, the FCC will first turn its attention to f-m radio broadcasters when evolving standards for stereocasting.

Barr Gives Views

An exchange of questions and answers between Barr and the broadcasters disclosed additional information. Here are some excerpts:

Q: Will a-m and tv stereo be postponed indefinitely?

A: It looks like it. F-m will be first.

Q: Is it likely that f-m stereo will take the form of a subscription service?

A: That's possible. It could go out as a special service.

Q: You mean people would pay to receive it?

A: Some promoters have shown interest. It's a possibility.

Q: Will one standard offset frequency be used all over the country?

A: Yes. We will try to standardize to prevent the need for a whole variety of receiver designs.

Q: During FCC field tests will there be public reception of broadcasts? Will any of the broadcasts be sponsored?

A: No. All field test broadcasting will be experiments, not public broadcasts.

Q: Will the broadcast industry and the manufacturers have a voice in setting up standards?

A: Definitely. It will be a regular rule-making procedure.

Regarding a date for a final decision on f-m stereo standards, Barr told ELECTRONICS it would probably be in the fall of this year, if all goes well.

Wireless Transmission Underground

Subsurface propagation of electromagnetic waves is being studied by Space Electronics Corp., Glendale, Calif., with the aid of this experimental station buried in a mine shaft in the Mojave desert. Company recently received USAF contract (ELECTRONICS, p 11, Mar. 4) to study feasibility of burying components of a communications system deep within the earth's crust

As to the possibility of f-m stereo becoming a subscription service, General Electric's C. Graydon Lloyd, who headed the NSRC, told ELECTRONICS that no research into this subject had been conducted.

May Spark Rise

It is possible the decision to concentrate on f-m stereo to the exclusion of the other two broadcast media may spark a rise in the number of f-m applications to the FCC.

Presently, most of the country's major cities find all their f-m allocations occupied.

In rural areas, however, some broadcasters tell ELECTRONICS, an f-m operation might be successful with certain changes in programming—going away from classical music most big-city f-m stations use as standard fare and concentrating more on popular and "country" music.

Broadcasters feel receiver manufacturers must help by producing more low-cost f-m receivers. They also feel the present location of many f-m receivers inside large expensive consoles reduces the number of listeners by keeping the sales volume down and by keeping console owners supplied with two other "competing" media in the same box.

In reply to these feelings, some manufacturers have already gone on record by pledging support in the areas of smaller sets, table models and more marketing effort.

F-m will eventually replace a-m, according to Henry Fogel, president of Granco, who calls the present f-m market "bullish". He points to some 15 million receivers now in use in 25 percent of U. S. radio homes. He urges advertisers to seek new customers by aiming at audiences who have never heard of f-m.

Potential Market

A spokesman for Zenith Radio sees more portable f-m receivers as part of the answer. He also urges a spread of f-m stations to urban regions and a change in programming.

Some manufacturers also see the automobile radio as a factor in the spread of f-m broadcasting. C. J. Gentry, national sales manager of Motorola, says there is a potential market of 37 million automobiles for f-m radio receivers.

Urges Overhaul of Milspecs Handling

EXTENSIVE CHANGES in management of military electronic parts specifications for reliability will be recommended to the Defense Dept. next month after an 18-month study by a special committee.

Adoption of the program would have an immediate impact on contractors and subs in setting qualification for contracts; test procedures and records; production monitoring; reliability responsibility.

First step in the proposed program is creation of a Parts Specification Management Group which would report to the Asst. Secy. of Defense for Supply and Logistics.

The advisory board, backed up by working groups and a sizable secretariat, would include representatives of the three services, Secretary of Defense and industry.

Submit Copies

Military contractors and subs would be required to submit copies of the electronic-parts procurement documents (drawings or specs) to a central organization in DOD, along with test data substantiating conformance; also, they would submit copies of company standards for electronic parts to a central organization in DOD, together with substantiating data.

Contractors would be required to use test methods of MIL-STD-202 in electronic parts procurement documents.

The study group recommends that prime responsibility for acceptance or rejection of electronic parts remain with the equipment manufacturer, but would require parts makers to conduct acceptance inspection and supply certified test data with each shipment.

Qualification approval for contractors would be for a specific reliability level that will be monitored during production. The contractor would first have to submit samples and show evidence that he has the necessary test equipment and satisfactory in-plant process control. Approval would come only on sufficient test data representative of production quality—with all qualification tests made under a government inspection service. Qualification approval would be reevaluated periodically by test-data audit and also as specifications change.

Establishment of the advisory group would "bring to bear the reservoir of experience and data resulting from the total dollar defense effort," Al Rogers, a member of the ad hoc study committee told an IRE conference in Boston. Rogers, technical director of R&D in the office of the Army's chief signal officer, outlined the proposed program to the IRE Professional Group on Reliability and Quality Control.

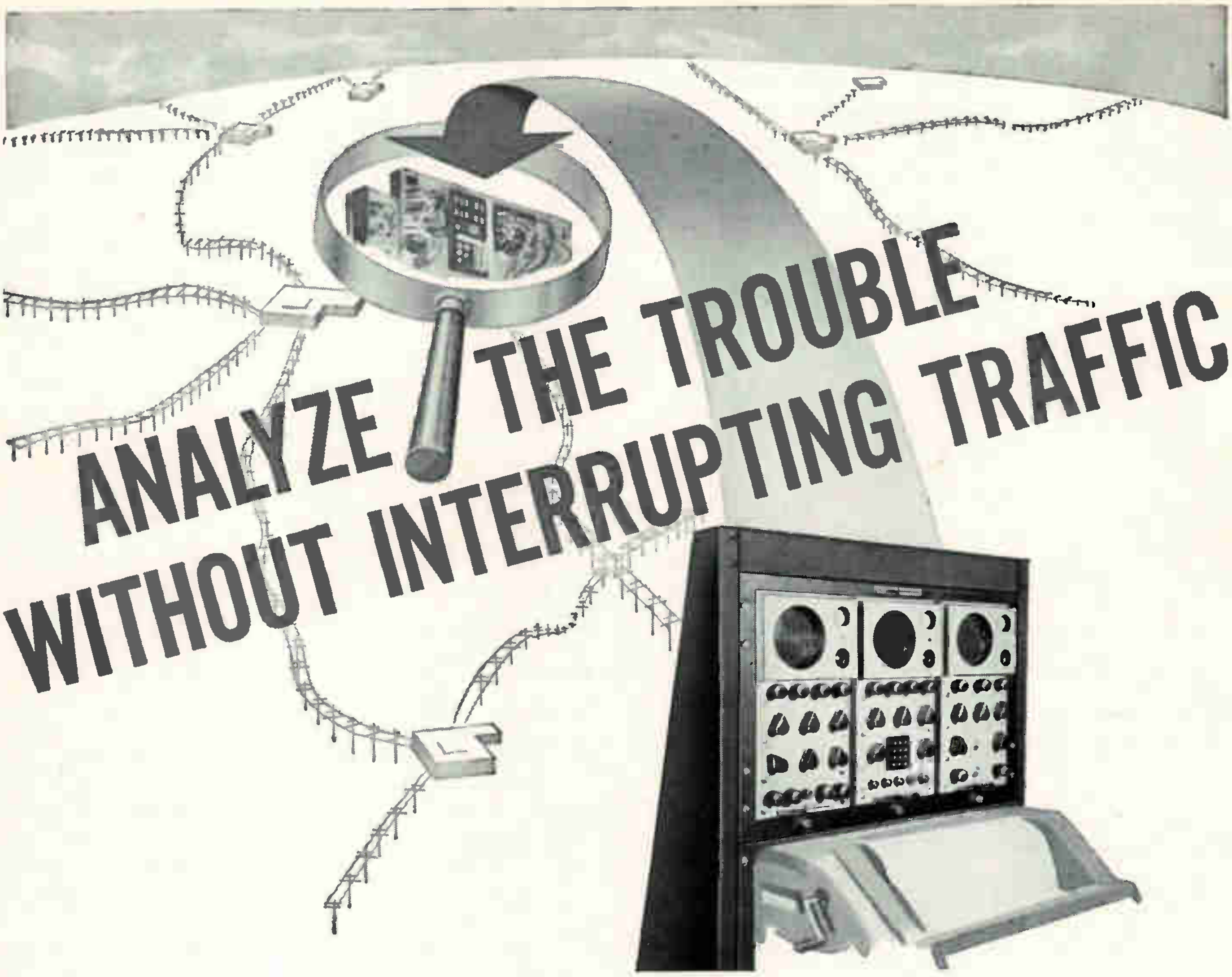
He said the need for suitable specification management is the most serious problem relating to military parts specifications.

The report recommends that the Office of the Sec. of Defense and the military departments issue directives to implement the program, based on concepts for establishing parts failure-rate levels and bringing all military electronic-parts specs up to current design demand with respect to environmental requirements.

Prototype specs and descriptions of basic concepts and objectives would be made immediately available to activities that prepare military specs, for guidance in formulation of new and revised parts specs.

First Mercury Capsule

First Project Mercury man-in-space capsule to be delivered to NASA at Wallops Island, Va., is shown here before it was shipped from the St. Louis plant of McDonnell Aircraft. Pylon atop capsule incorporates escape system



how to reduce down-time on telegraph and data transmission circuits

Radiation's new Telegraph Distortion Monitoring System (TDMS) provides in one compact assembly complete testing, monitoring and signal waveform analyses of telegraph circuits and data transmission lines. This versatile unit makes possible on-line quality control of communications links. It indicates malfunctions, analyzes their causes—without interrupting the flow of traffic.

The Radiation TDMS, with miniaturized components for space-saving compactness, can replace most test equipment now required for teletype maintenance and monitoring. Thus, in addition to reducing circuit outage, the TDMS permits reduction of test equipment costs and increases maintenance efficiency. Portability is achieved at the "push of a button".

For a detailed description of the operation and capabilities of the TDMS, write for Brochure RAD E-100B. Address Radiation Incorporated, Dept. EL-4, Melbourne, Fla.

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RADIPLEX—50—channel low-level multiplexer with broad data processing applications. Features rugged solid-state circuitry, almost unlimited programming flexibility, unique modular construction for compactness and exceptional ease of operation and maintenance.

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TELEMETRY TRANSMITTER—Model 3115 is a ruggedized 215-260 MC unit with extremely linear FM output under the most severe environmental conditions. With its record of outstanding performance in many missile programs, Model 3115 is specified by leading missile manufacturers.

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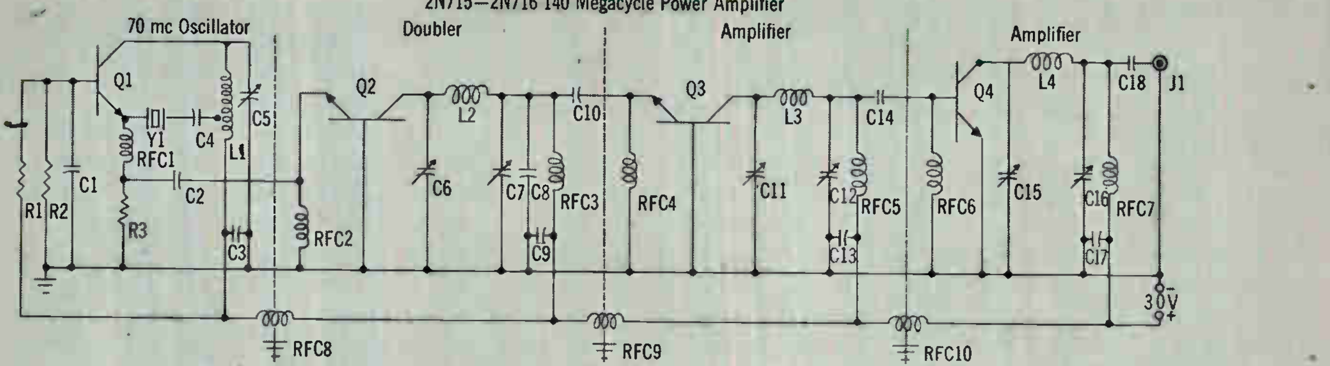
See Our Displays at NAECON, Dayton, Ohio - - - Booths 1 and 2; at AFCEA, Washington, D. C. - - - Booths S-71 and 72 and at The NTC, Santa Monica, Cal. - - - Booth N-3.

How to design 250 mw at 140 mc transistorized power amplifiers

2N715—2N716 140 Megacycle Power Amplifier

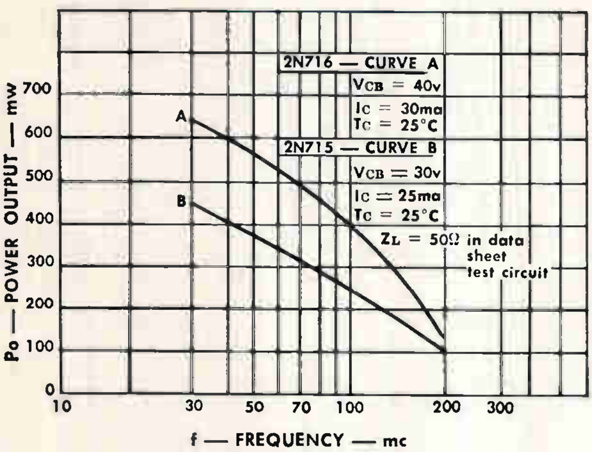


C1, C2, C3—.001 μf disc ceramic
C4,—20 $\mu\mu f$ tubular ceramic
C5, C6, C7, C11, C15—1.8-13 $\mu\mu f$
C8,—47 $\mu\mu f$ silver mica
C9, C10, C13, C14, C17, C18—500 $\mu\mu f$ disc ceramic
C12,—7—45 $\mu\mu f$ mica trimmer
C16,—3.2—50 $\mu\mu f$
L1,—8 turns #408 Airdux, tapped 2 turns from ground
L2,—4 turns #12 magnet wire, ½" D, ¾" L
L3,—3 turns #12 magnet wire, ½" D, 7/16" L

L4,—3 turns #12 magnet wire ½" D, ⅜" L
Q1, Q2, Q3, Q4,—TI 2N716
R1—5100 ohms, ½ watt
R2—680 ohms, ½ watt
R3—200 ohms, ½ watt
RFC1—.47 μh
RFC2—4.7 μf
RFC3 through RFC10
1.2 μh
Y1—70 mc crystal

ACTUAL SIZE

...with NEW TI 2N716 silicon mesa transistors



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Now . . . silicon high frequency transistors *specifically* designed for your VHF power circuits . . . another addition to the industry's broadest line of silicon mesa transistors (now 16 TI types!).

TI 2N715 and TI 2N716 *guarantee 500-mw amplifier output at 70 mc* and provide *100-mw typical power output at 200 mc.*

These subminiature (TO-18) silicon units feature . . . 1.2-w dissipation at 25°C case temperature . . . 10-50 beta spread . . . collector reverse voltages of 50 and 70v . . . maximum collector reverse currents of 1.0 μa (25°C) and 100 μa (150°C).

Check the guaranteed specs below and take immediate advantage of advanced performance in your designs. Both units are ready for your orders in every TI distributor's stocks today, and in quantities of 1,000 and up from your nearest TI sales office.

Tentative Specifications 2N715 - 2N716

P_C [1] T_C = 25°C	Tstg	V_{CB} [2]	V_{EB} [2]	V_{CE} [3]
watt 1.2	°C −65 to + 175	v dc +70 (2N716) +50 (2N715)	v dc +5	v dc +40 (2N716) +35 (2N715)

		2N715			2N716			
Parameter	**Test Condition**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Units**
**BV_{EBO}	I_{EBO} = 100 μa I_C = 0	5			5			v dc
***BV_{CBO}	I_{CBO} = 10 μa dc I_E = 0	50			70			v dc
*h_{FE}	V_{CE} = 10 v dc I_C = 15ma dc	10		50	10		50	
*V_{CE}(sat)	I_C = 15ma I_B = 3ma	1.2			1.2			v dc
C_{ob}	V_{CB} = 5 v dc I_E = 0 F = 1 mc		3	6		3	6	$\mu\mu f$
Amplifier Power Output and	(V_{CB} = 40 v dc (I_C = 30 ma dc (P (AC) = 500 mw (F = 70 mc				500 4	600 7.5		mw db
Transducer gain	(V_{CB} = 30 v dc (I_C = 25 ma dc (P (AC) = 300 mw (F = 70 mc	300 4	400 8					mw db

1 This power rating for 1000 hours expected life at a case temperature of 25°C derated linearly to +175° case temperature at the rate of .125°C per mw.
2 Maximum voltage ratings at an ambient temperature of +25°C.
3 BV_{CEO}: This is the voltage at which h_{FB} approaches one when the emitter-base diode is open circuited. This value may be exceeded in applications where the dc circuit resistance (R_{BE}) between base and emitter is a finite value.
When the emitter-base diode has a reverse voltage applied, peak collector to emitter voltage equal to BV_{CBO} minus V_{EB} may be allowed. Such conditions may be encountered in class B or C amplifiers and oscillators.
*Pulse Measurement
**Specify I_{EBO} on commercial data sheet
***Specify I_{CBO} on commercial data sheet

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Washington, D.C., is where firms go to seek an . . .

Inside Track for R&D

WASHINGTON, D. C.—This area is the most important single market for the electronics industry, with about half of its sales going to the military services, the other half to other agencies.

Electronics firms receive more than 30 percent of the $13.6 billion spent by the Pentagon on procurement. In some types of missiles and space vehicles, the cost of the military electronics runs half or more of the total expenditure.

60 Firms in Electronics

For these reasons electronic research and development firms are burgeoning in the metropolitan Washington area near the Pentagon. Of the 130 R&D firms here, at least 60 are in electronics.

Proximity to government sources is a major asset. With this in mind —and also the optimistic forecasts for military electronics business— there is every reason to believe the number and size of private companies and laboratories in the Washington area will greatly increase.

Take for example, the forecast of the Electronic Industries Association:

- Military spending for electronics will double during the present decade.
- A total of $100 billion will be available for electronics expenditures through 1970.
- The government spending for space probes and greater safety in air travel, depending heavily on electronics, will increase.

Many Washington firms have important contracts with the military services in missiles, rockets and space vehicle systems.

To cite a few examples of companies in the area that are booming ahead:

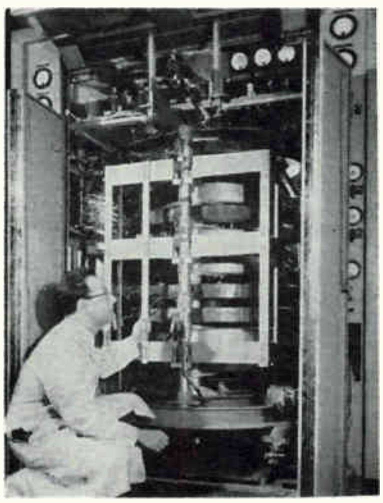
The largest is Melpar, Inc. (a subsidiary of Westinghouse Air Brake Co.), in Falls Church, Va. It employs about 6,000 and accounts for about 30 percent of WABCO's sales. Most of the work done there is for the government and a large percentage is for secret military projects.

The firm designs, develops and produces antennas and microwave components for shipboard, land-based, airborne and missile-satellite applications.

The electronics division of ACF Industries, Inc., was formed early this year by the consolidation of ACF's Avion and Nuclear Products-ERCO divisions. Division headquarters and main plant are in Riverdale, Md., formerly the site of ERCO operations.

ACF's first step into the field of applied electronics came with the acquisition of Avion Instrument Corp. in 1953. It now develops and produces flight and tactics simulators, microwave equipment, navigation display systems for both military and commercial aircraft, submarine warfare devices, etc.

SAGE Transmitter



Transmitter for SAGE warning system is inspected by engineer from ITT's Federal division, which produced it. Function of transmitter is to guide missiles, rockets and aircraft that would be sent aloft to destroy any hostile invaders. Five-foot klystron amplifier tube boosts the power input of five watts to the 20,000-watt output level. Equipment must maintain reliability in temperature range of 20 degrees below zero to 120 above

C-E-I-R, Inc., a research and computer firm located in Arlington, Va., claims to be the largest single commercial electronic computing facility in the United States. It recently announced formation of a subsidiary company in London, a new facility in Texas and the purchase of Telecomputing Services, Inc., a California data processing firm, at a reported cost of $940,000.

Atlantic Research Corp., started about 11 years ago by two scientists who left jobs at NRL with $1,000 capital, now is doing well over $10-million in business. ARC is builder of the Arcas Atmospheric sounding rocket. The company's newest subsidiary is Jansky and Bailey, well known in systems engineering and operations research.

The Applied Physics Laboratory, founded by Johns Hopkins during World War II and developer of the antiaircraft proximity fuse, is handling technical direction of Navy's shipboard missiles research.

Arinc Research Corp. is well known for its research on reliability problems. Vitro Laboratories has important contracts in the anti-submarine warfare area. Nems-Clarke, a division of Vitro Corp., recently received a contract for all ground-based rf telemetry equipment for 17 tracking stations around the world to collect data from manned space capsules.

Minneapolis-Honeywell's Industrial Systems division in Beltsville, Va., employs approximately 350 scientific and technical personnel.

Many Companies

A list of R&D companies in the Washington area (with date of establishment, some examples of work being done) includes:

ACF Electronics, Riverdale, Md., 1954, new Consolidated div., 1960, electronics; Advanced Research Associates, Kensington, Md., 1957, airborne vehicle radio control systems; Aero Geoastro Corp., Alexandria, Va., 1958, antennas, circuits; Airtronics, Inc., Bethesda, Md., guided missiles research; American Machine and Foundry Co., Alex. div., 1955, electronic gear and test equipment; American Research and Manufacturing Corp., 1954, transistors, flight safety instruments.

Analytic Services, Inc., Alex., Va., 1958, operating analysis studies of weapons systems for AF; Andromeda, Inc., Kensington, Md., 1957, automatic electronics systems, color tv; Applied Science, Inc., Bethesda, Md., 1960, electronics, atomic energy; Arinc Research Corp., Wash., D. C., 1951, data processing, reliability research; Atlantic Research Corp., Fairfax County, Va., 1949; Ernest E. Blanche and Associates, Kensington, Md., 1955, data processing, computer applications; Booz-Allen Applied Research, Inc., Bethesda, Md., 1958, atomic energy, electronics reliability and systems analysis.

C-E-I-R, Inc., Arlington, Va., 1954, high speed electronic computation; Carnegie Institution of Washington, Dept. of Terrestrial Magnetism, Wash., D. C., 1904, basic research; Cooke Engineering Co., Alex., Va., 1954, telecommunications; Developmental Engineering Corp., Wash., D. C., 1953, and Leesburg, Va., communications; Elcor, Inc., Falls Church, Va., 1956, industrial electronics, modular instruments; Emerson Research Labs, Silver Spring, Md., and Wash., D. C., 1954, electronics; Engleman & Co., Wash., D. C., 1951, data processing, communications.

Entron, Inc., Bladensburg, Md., 1952, r-f phenomena in broad band amplifiers, modulators, instruments; Frederick Research Corp., Bethesda, Md., 1950, data processing; General Electronics Lab., Inc., Silver Spring, Md., 1957, telemetry, transmitters; General Kinetics, Inc., Arlington, Va. 1955 data processing; Intelligent Machines Research Corp., Alex., Va., 1950, automatic business machines and computers; International Electronics Manufacturing Co., Wash., D. C., 1950, radio frequency interference reduction; Jansky & Bailey, subsidiary of ARC., Alex., Va., 1930-1959, radio and tv system engineering, frequency research.

Johns Hopkins-Applied Physics Lab., Silver Spring, Md., 1942, astronautics; Roe Instruments, Inc., Rockville, Md., 1954, data equipment; Litton Industries, merged with Ahrend Instrument Corp., 1958, data processing; Logetronics, Inc., Alex., Va., 1954, photographic electronics; Melpar, Inc., Falls Church, Va., also Arlington, Fairfax, and Alexandria, Va., 1946, military applications; Minneapolis-Honeywell Regulator Co., Davies Lab. div., Beltsville, Md., data processing; Industrial Systems div., magnetic data handling systems, electronic voice monitor.

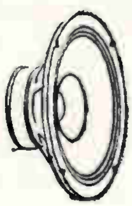
The Murray Research Co., Wash., D. C., 1957, communications; National Electronics Laboratories, Wash., D. C., 1946, military electronics; National Scientific Labs., Inc., 1949, data processing; Orbit Industries, Inc., Vienna, Va., 1960, electronic equipment for Project Mercury; Outlook Engineering Corp., Alex., Va., 1954, electronics mostly in conjunction with optics; Page Communications Engineers, Inc., subsidiary of Northrop, satellite and space communications.

Polytechnic Engineering Co., Silver Spring, Md., 1958, transistorized amplifiers, oscilloscopes, antenna tuners; Polytronic Research Inc., Rockville, Md., military electronics; Rabinow Engineering Co., Inc., Takoma Park, Md., 1954, computer mechanisms; Reed Research, Inc., Wash., D. C., 1946, electronic devices, missile research; Rixon Electronics, Inc., 1953, data processing communications; Scatter Communications, Bethesda, Md., 1957, scatter communications systems engineering; Scope, Inc., Fairfax, Va., 1958, computers, countermeasures, microwave devices.

Servonics, Inc., Alex., Va., 1955, high precision electronic gear, guided missile research; Spacetronics, Inc., Bethesda, Md., 1958, space craft electronics; James S. Spivey, Inc., Wash., D. C., 1946, communications equipment for military; John I. Thompson Co., Wash., D. C., 1943, data processing; Tracerlab, Inc., Wash., D. C., 1947, nuclear electronic circuitry; Trans-Tech, Inc., 1956, electronics, microwave materials; Versitron, Inc., Wash., D. C., 1958, electronics.

Virginia Electronics, Inc., Bethesda, Md., 1951, radio communications control equipment; Vitro Corp. of America, Silver Spring, Md., 1900 Nems-Clarke Co., Vitro Labs., electronics; Washington Technological Associates, 1950, data processing; Watson Electronics and Engineering Co., Arlington, Va., 1955, light control devices; Welex Electronics Corp., Wash., D. C., 1959, subsidiary of Welex, Inc., electronics; Weinschel Eng., Kensington, Md., 1953, high frequency power measurement, microwave research; Wellings-Reed, Inc., Wash., D. C., 1954, astronautics, data processing.

a new symbol of magnetic progress

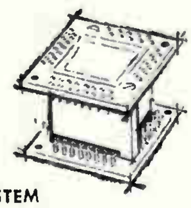


LOUD-SPEAKER
INDOX V ceramic permanent magnet provides high energy level . . . reduces speaker length and weight.

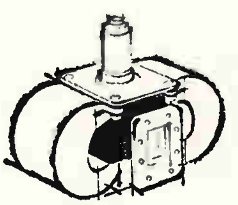
Two established leaders — Indiana Steel Products and General Ceramics — Combine to Serve You Better

This trademark is the calling card of a new leader in science-age materials — Indiana General Corporation. It is born of a union between two established leaders — The Indiana Steel Products Company in permanent magnets . . . the General Ceramics Company in ferrites and memory systems. Together, as Indiana General Corporation, they serve you better by placing at your disposal the brains and resources of two scientifically oriented concerns. Research and development have been the backbone of both of the original companies; both have records of significant achievement in their particular fields.

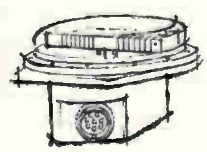
Indiana General can help you "design-engineer" your products with the latest magnetic innovations. If you have a design problem, the Indiana General sales engineer in your area will be most happy to advise you. And, behind him, our experienced scientists and design engineers are available for consultations — at no cost or obligation. Write us outlining your problems.



MEMORY SYSTEM
New microstack unit for coincident current memory systems saves 90% of space required by conventional stack, yet is more reliable.



MAGNETRON
Powerful Hyflux ALNICO V magnets improve performance in many types of microwave equipment.



AUTOMATIC DIRECTION FINDER
Ferramic "E" magnetic core material helped engineers create a new concept in aircraft antenna design.

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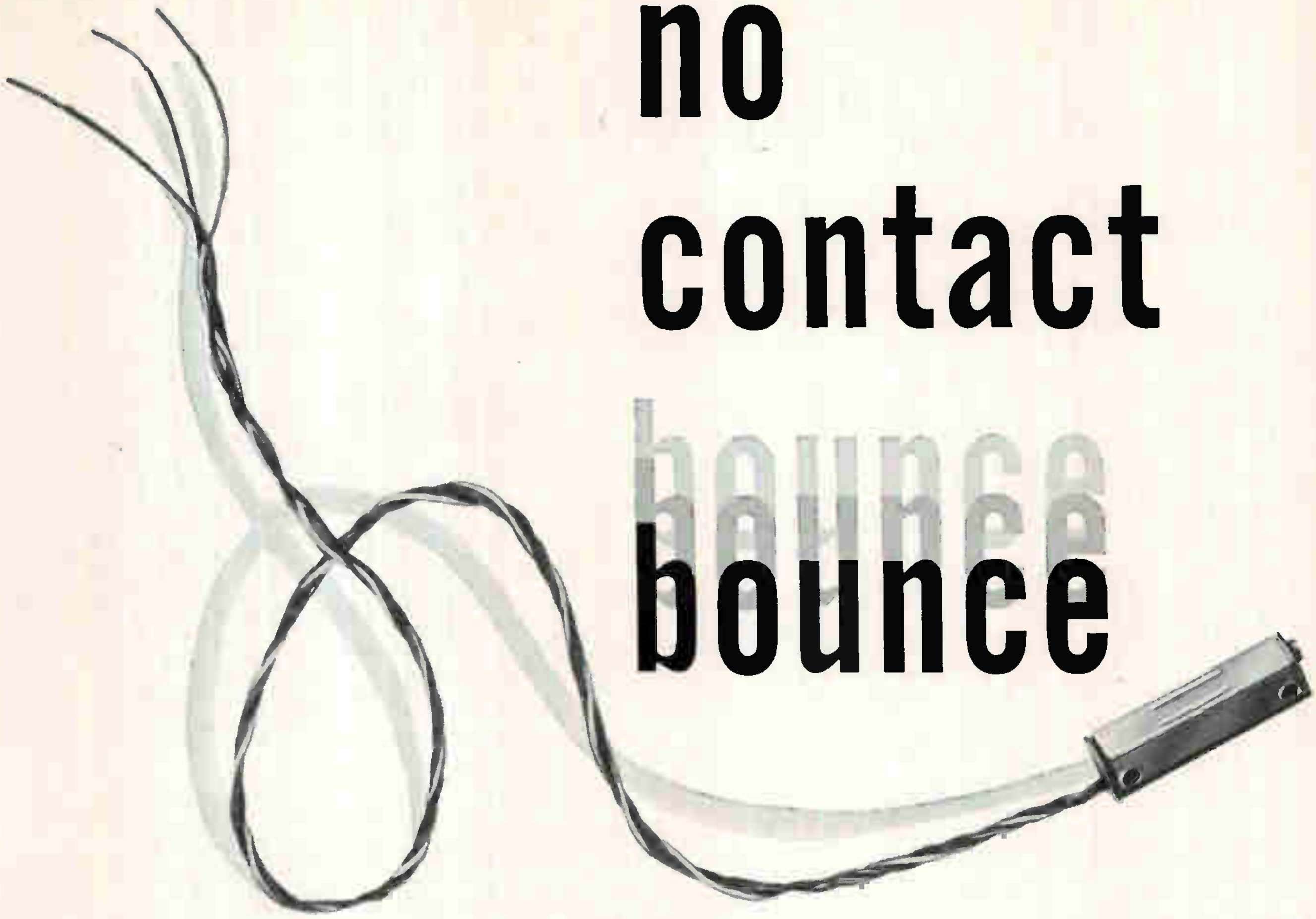

no contact bounce

with Centralab's Model 7

linear motion variable resistor

Each CENTRALAB linear motion variable resistor is individually measured for microscopic variations in shaft-case clearance, and individually adjusted to compensate for these variations and to eliminate axial movement of the contact spring. The result is a stable reliable unit with *no contact bounce* when subjected to vibration tests of 20-2000 cps at 30g's for 10 minutes in each of 3 planes.

The performance dependability of CENTRALAB's Model 7 has been continuously demonstrated since 1956, when it was first made available to a limited group of missile manufacturers. Now greatly increased production facilities make it possible to offer the Model 7 to other users.

Model 7 variable resistors are available with composition or wirewound elements, cased or hermetically sealed, with wire or printed circuit leads. The complete electrical, physical, and environmental characteristics of the Model 7 are described in CENTRALAB EP-906, available free on request.

SPECIFICATIONS:	Wirewound	Composition
Resistance Range	100-20K ohms	10K-2.5 meg.
Minimum End Resistance	>1% of total	>1% of total
Power rating at 40°C	0.25 watt	0.2 watt
derated at 100°C	0.05 watt	0.02 watt
Rotational Torque	.5 to 3.0 in. oz.	
Component Density	9/cu. in.	
Adjustment	12½ or 25 turns	
Shock —5 shocks in 3 planes at 100g, on JAN-S-44 equipment	less than 1% change in resistance	

Centralab

CRL ®

B-6022

The Electronics Division of Globe-Union Inc.
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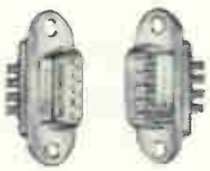
In Canada: P. O. Box 400, Ajax, Ontario

new!

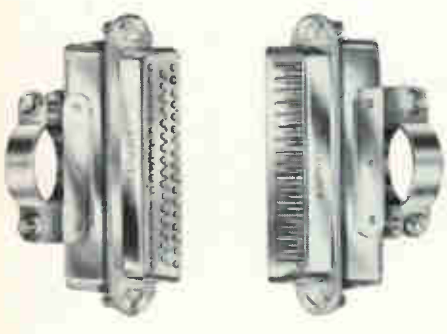
M^{in} Rac 17

miniature rack & panel connectors with POKE HOME® contacts



Solve space, weight and size problems with AMPHENOL's new Min Rac 17 connectors, true miniatures with the "Big Plus" advantage of Poke Home contacts! Min Rac 17's are rack & panel connectors ideally suited for today's compact chassis designs, connectors half the size and weight of standards, delivering full size efficiency. And with the patented Poke Home contact concept (U.S. Pat. 2,419,018), Min Rac 17's are easily, reliably assembled—contacts are crimped or soldered outside the connector body, then "poked home" for assembly.

Min Rac 17's are available in 9, 15, 25, 37 and 50 contacts in rack & panel, cable-to-chassis and cable-to-cable designs. Contacts are gold plated. Shells may be ordered with clear chromate or gold iridite finish.



These remarkable connectors are available now—write for full catalog!

AMPHENOL **CONNECTOR DIVISION**

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Amphenol-Borg Electronics Corporation

Automated Machine Trains Men

New system simulates complex electronics gear, speeds development of technical personnel by controlling every step in learning process

AUTOMATIC TEACHING MACHINE developed for electronics instruction is being produced by Western Design, a division of U. S. Industries, Goleta, Calif.

Called the "Tutor," the machine fully and precisely controls every step in the student's learning process, says the company. Functions include instruction, testing, error correction and review.

Tutor simulates complex electronics equipment. Any combination of malfunctions can be presented to a trainee at one time, with the machine providing appropriate responses to every step taken in trouble-shooting operations, just as regular gear would.

10,000 Images

Company describes the teaching machine as basically a combination microfilm-motion picture projector able to show any one of 10,000 images. It uses standard 35 mm film, each frame numbered in sequence and corresponding to a particular setting of the machine.

When a certain image is requested by pressing the appropriate buttons on the selector keyboard, a four-digit decimal counter transmits the present position of the projector to the selector keyboard where it is compared with the desired position.

The resulting "up" or "down" signal generated from the selector keyboard causes the projector motor to move the film forward or backward the required number of frames.

The search speed, or motion of the machine from one frame to any other selected frame, is the standard 24 frames per second, making it possible to include short motion studies to be analyzed by the student.

This motion picture can also be run backward or stopped on any given frame for closer study. In normal use, when the machine may jump several frames in search of a chosen answer, the screen remains blank during the search.

To use the Tutor, the trainee is seated before an 8.2 in. by 11.2 in. back projection screen and a bank of 40 numbered pushbuttons in adding machine arrangement. The screen lights up and a microfilmed image appears, with instructions on how to move to other images by operation of the push buttons.

The next image begins the tutoring sequence by providing the student with a unit of information followed by a multiple choice question. By pushing appropriate buttons on the selector keyboard, the student moves to the image number listed next to his chosen answer.

If he has answered correctly, the machine verifies the answer, gives further instruction and asks another question.

If his answer is wrong, the machine explains where he erred and tests him again, either with a new question or by sending him back to the original question to choose a different answer.

In effect, every student must score 100 percent on a multiple choice examination to complete a "Tutored" sequence.

The student seated before the machine knows he is to be tested immediately, and consequently learns to pay close attention. Should he choose a wrong answer he is given a more detailed explanation of the material and tested again. If his answer is hopelessly wrong, the machine is not above giving him a mild warning that he is not paying attention.

Material for the machine is already being prepared by Western Design on such subjects as algebra, trigonometry, electronics and trouble-shooting techniques.

Military student sees multiple choice solutions to problems on teaching machine's viewing screen, where images are controlled by pushing numbered buttons on selector keyboard. Answer chosen and time elapsed from previous answer are recorded by printing mechanism on top of cabinet

Europe to Integrate Air

Three firms are bidding on supranational system to consolidate western Europe's regional centers

By **DEREK BARLOW,** McGraw-Hill World News

LONDON—Speed with which jet aircraft cross one national area in western Europe and enter another is pushing plans for a supranational automatic air traffic control system (SATCO).

Every day regional control centers in western Europe have to cope with some 2,000 military and 400 civil flights.

Currently, Europe's air traffic control operates from 14 flight information centers. Britain, Germany, France and Sweden all have three centers each within their borders. Holland and Denmark each has one. Although well-spaced geographically, modern jet speeds make efficient manual information changeover from one center to another tricky.

The integrated control system—called Eurocontrol—proposes operation on an area basis so that flights are not limited to predetermined air lanes.

Four Groups Evaluating

To date, Eurocontrol committees have settled most of the legal aspects of an integrated system. The remaining problems are technical: how many centers should be installed? And where? Four separate technical subcommittees are now hard at work evaluating equipment and estimating costs for different ATC center configurations.

Three manufacturers have come up with systems proposals: IBM France, General Precision Systems, and Hollandsche Signaalapparatens.

While Eurocontrol is still up in the air, individual countries are making down to earth examinations of their own ATC systems. They are investigating automatic techniques for easing the controllers' load so controllers can be ready for the expected increase in data from Eurocontrol centers.

Furthest along is Holland, ready with a production automatic traffic control system suitable for either airlane or area operation. Manufactured by N. V. Hollandsche Signaalapparatens, a subsidiary of Dutch Philips, the SATCO system's Phase I with automatic flight strip printing will go into operation at Amsterdam's Schipol airport this summer. Heart of Phase I is a small, fully-transistorized two-cubicle computer using standard teleprinter code input and outputs.

Phase II, with fully automatic displays, conflict prediction, flight path calculation and automatic coordination between controllers, is ordered for delivery by Oct., 1961.

The Schipol installation includes a radar link-up extending control outside the normal prescribed air corridors. A ppi tube next to the controller carries the raw radar picture. For position monitoring, the computer will sequentially feed predicted positions and identification symbols of each aircraft into the tube.

France, England and Germany are starting their investigations. In France, IBM has completed practical experiments with RAMAC 650 and 704 computers and electric typewriter outputs to give flight strip information, conflict prediction and synthesis of plane situations.

Difference in IBM philosophy to the SATCO approach is that most of the information remains in the computer store as flight strips are only printed out 30 minutes ahead of actual time. Discussions are under way between IBM and the German authorities for an experimental system at Frankfurt. This, although based on the IBM system approach, may use Siemens or Telefunken computers.

In Britain, two experiments are due to start under the Ministry of

Control

Aviation. The first will set up an experimental automatic control system at London Airport similar to the Schipol installation. Cost figures for this vary but are estimated at about $1 million for a complete three-sector complex. Twelve firms are currently bidding on this project.

Second experiment will be an ATC center near the Prestwick, Scotland, North Atlantic terminal. Here in early 1961 an experimental ATC computer will calculate oceanic separations on the transatlantic routes.

This transistorized computer, developed by Ferranti, Ltd., is designated Apollo and will parallel the normal controllers' operations. It receives its data on aircraft flight plans from the local controllers as tape inputs. From stored programs the computer executes a conflict search and prints out flight strips for arrival times at each meridian across the Atlantic.

Result of the experiment will show whether automatic ATC methods can reduce the present separation standards on the transatlantic run from their existing two degrees of latitude, 2000-ft altitude and 30 minutes longitudinal flying time.

Mike Cancels Sound

Ordinary-voice communications in 150-db noise areas is possible with Chance Vought's sound-canceling microphone. Assembly consists of earphone headset, lip-boom of special design and a pre-amplifier on connecting cord

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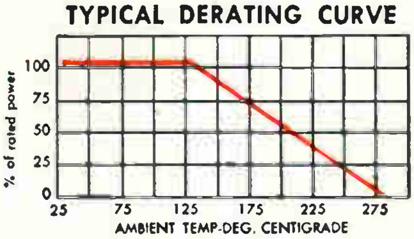

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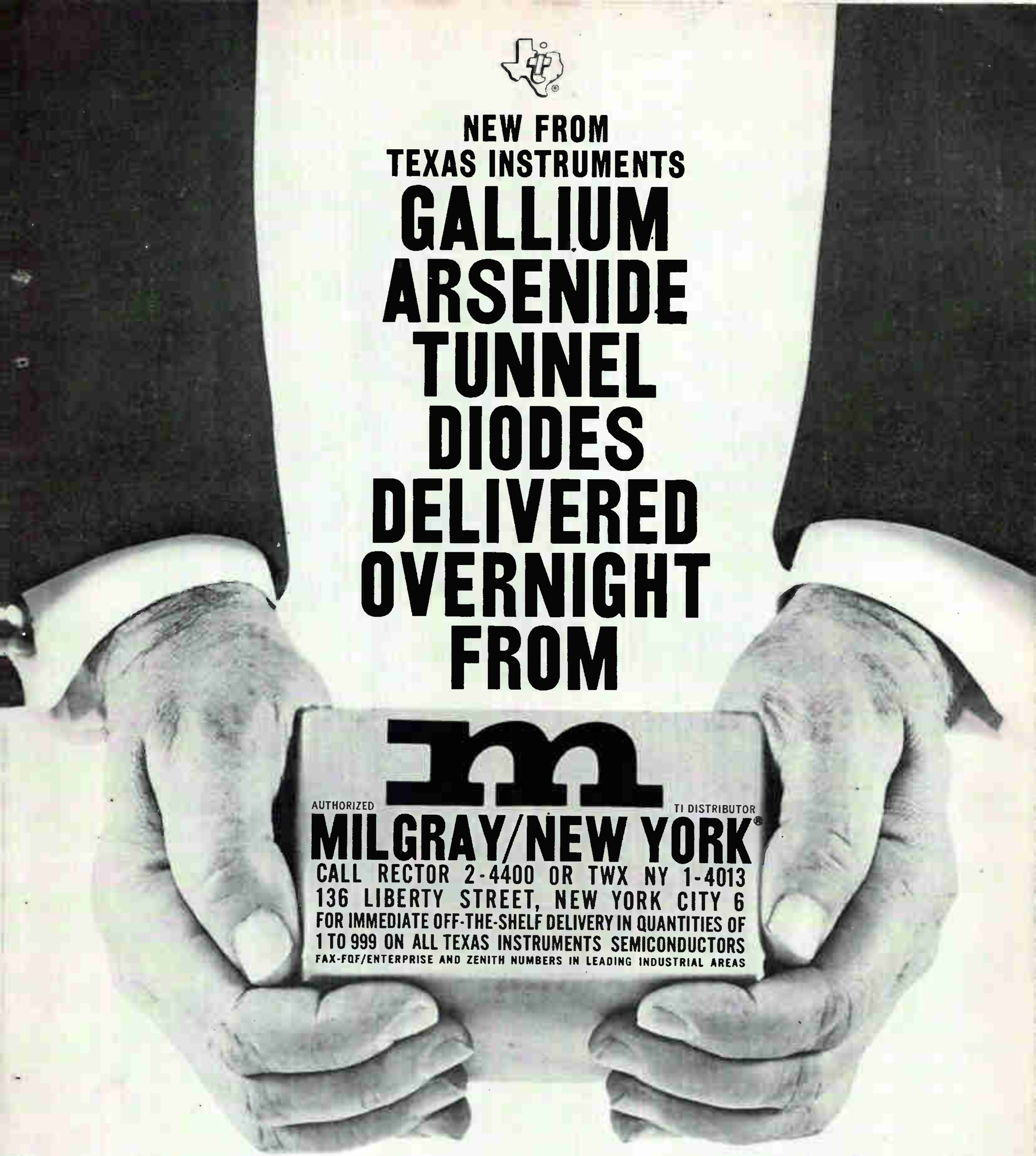

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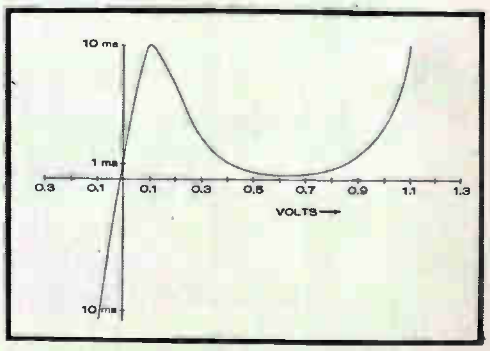
Type	Application	I_p ma	I_p/I_v ratio	Typical Capacitance @ I_p $\mu\mu f$	V_f v
1N650	Amplifier & Oscillator	10 (±10%)	>15:1	40	1.10 (±10%)
1N651	Logic & Switching	10 (±2%)	>10:1	40	1.10 (±5%)
1N652	Amplifier & Oscillator	5 (±10%)	>5:1	40	0.98 (±10%)
1N653	General Purpose	5 (±10%)	>5:1	60	0.98 (typ)



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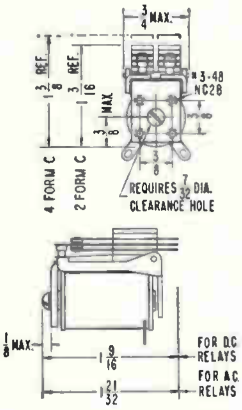
Engineers like its fast action, its small size, its light weight. They like the wide selection of contact forms . . . up to 18 springs (9 per stack, DC) as well as the fact MH relays can be furnished to switch loads ranging from dry circuit to over 5 amps at 115 volts, 60 cycle resistive.

A multiple choice of terminations add to the MH's versatility. This relay, for example, can be adapted for printed circuits, furnished with taper tabs or a long list of other terminals. Get all the facts by calling your nearest P&B sales engineer today.



MH ENGINEERING DATA

GENERAL:

Breakdown Voltage: 500 volts RMS between all elements.

Ambient Temperatures: −45° C to +85° C. (−65° C to +125° C on special order.)

Shock: 30g on special order.

Vibration: 10g from 55 to 500 cps.; .065" max. excursions from 10 to 55 cps. on special order.

Weight: 2½ ozs. max. (open relay)

Terminals: Pierced solder lugs; special lugs for printed circuits, taper tab (AMP #78).

CONTACTS:

Arrangements: Up to 9 springs per stack.

Material: 1/8" silver standard: Palladium or gold alloy alsa available.

Load: Dry circuits ta 5 amps @ 115V AC res.

COILS:

Resistance: 22,000 ohms max.

Power: 100 mw per movable min. to 4 watts at 25° C max. (200 mw min. to meet max. shock/vibration spec.)

Duty: DC: Continuous. AC: Intermittent (Two pole relay max.) open. Sealed units supplied with full wave rectifier inside can.

Voltages: DC: Up to 110 volts. AC: Up to 230 volts 60 cycles.

The relays below are variations of the MH relay structure.

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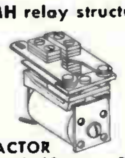
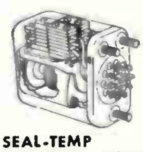
Electrical latch, mechanical reset. Small, versatile and offered with selection of contact arrangements.



MB CONTACTOR
Contacts rated 60 amp. 28 volts DC non-inductive. Will carry 150 amp. surge for a duration of 0.3 seconds.



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CIRCLE 44 ON READER SERVICE CARD

New England '70 Sales: $2 Billion

Latest survey also indicates electronics will share role as No. 1 employer in northeast area

NEW ENGLAND will capture an increasing share of military electronics and components manufacture until—by 1970—electrical machinery including electronics will become the No. 1 employer in the five-state region once dominated by non-electrical machinery and textiles.

The area's slice of the consumer electronics business will continue to shrink during the 1960's.

N.E.'s proportion of military electronics will rise by two-tenths of a percentage point each year during the decade.

Meanwhile, it will retain its grip on components production and enjoy a mildly increasing share of the mushrooming U. S. output in this field.

These are the projections of the Federal Reserve Bank of Boston, after its first full-scale survey of N.E. electronics since 1954.

Forte in Components

The study was done for the FRB by Albert H. Rubinstein and Victor L. Andrews of MIT's School of Industrial Management. Industry estimates peg electronics employment considerably higher than the FRB's 98,400 for '59. The report concedes its figures may be "conservative by 5000." Scope of the study does not include R&D electronics, in which N.E. has a leading role.

The report projects N.E. electronics employment in 1970 at nearly 158,000. Factory sales, estimated at about $800 million for '59, are expected to be about $2.07 billion by '70. The area is expected to account for between 13 and 14 percent of the components and military market, but less than 4 percent of the bulky, high-freight-cost consumer output, since N.E. is off-center in relation to the geographical distribution of U. S. purchasing power.

N.E.'s forte is in components, since the region has a large factory-trained labor force, including female labor, well adapted to intricate assembly operations, and available at lower wage rates than in most of the nation.

New England now has some of the fastest-growing producers of semiconductors.

Because of the need for continually advancing weaponry, N.E.'s advantage in the pool of talented engineers and scientists and its array of educational institutions is expected to work for an increasing share of the military electronics market.

See R&D Expansion

The critical assumption, however, in projection of the N.E. military electronics share is continued growth of Raytheon Co., the dominant military producer and employer in the area. In the last few years, the FRB report says, sales of this major producer have climbed about .16 of a percentage point of total national security expenditures per year. It is assumed that, with emphasis in military procurement shifting towards electronics goods, this figure will rise to .2 percent per year.

New Hampshire Spurts

Expansion of R&D activities in the area is expected to continue, also decisions by large non-New England companies to locate R&D facilities in N.E., to take advantage of the academic and research milieu. It is believed, however, that non-N.E. firms will attempt to do their mass production outside of N.E.

Another significant trend is the upsurge of the electronics industry in New Hampshire, where the pace of growth following the 1957-58 recession exceeded that of the region as a whole.

MEETINGS AHEAD

Apr. 26-28: Airlines Electronic Maintenance Meeting, Aeronautical Radio, Inc., Hollywood Roosevelt, Los Angeles.

Apr. 30: Sferics and Thunderstorm Electricity, Amer. Geophysical Union, Amer. Meteorological Society & U.S. Nat. Comm. of URSI, National Science Foundation, Wash., D. C.

May 1-5: Electrochemical Society, Annual, LaSalle Hotel, Chicago.

May 1-7: Motion Picture & Tv Engineers, Annual, Ambassador Hotel, Los Angeles.

May 2-4: National Aeronautical Electronics Conference, Electronics Probes the Universe, NAECON, IRE, Biltmore and Miami-Pick Hotels, Dayton, O.

May 2-5: National Academy of Sciences, U. S. Nat. Comm. of URSI, IRE, Sheraton-Park Hotel, Wash., D. C.

May 3-5: Western Joint Computer Conf., Jack Tar Hotel, San Francisco.

May 3-5: Electromagnetic Relays, National Conf., NARM, Student Union Bldg., Oklahoma State Univ., Stillwater, Okla.

May 5-6: Protective Relay Conf., Georgia Tech, Architecture Auditorium, Atlanta.

May 9-11: Microwave Theory & Techniques, National Symposium, PGMTT of IRE, Coronado Hotel, Coronado, (San Diego) Calif.

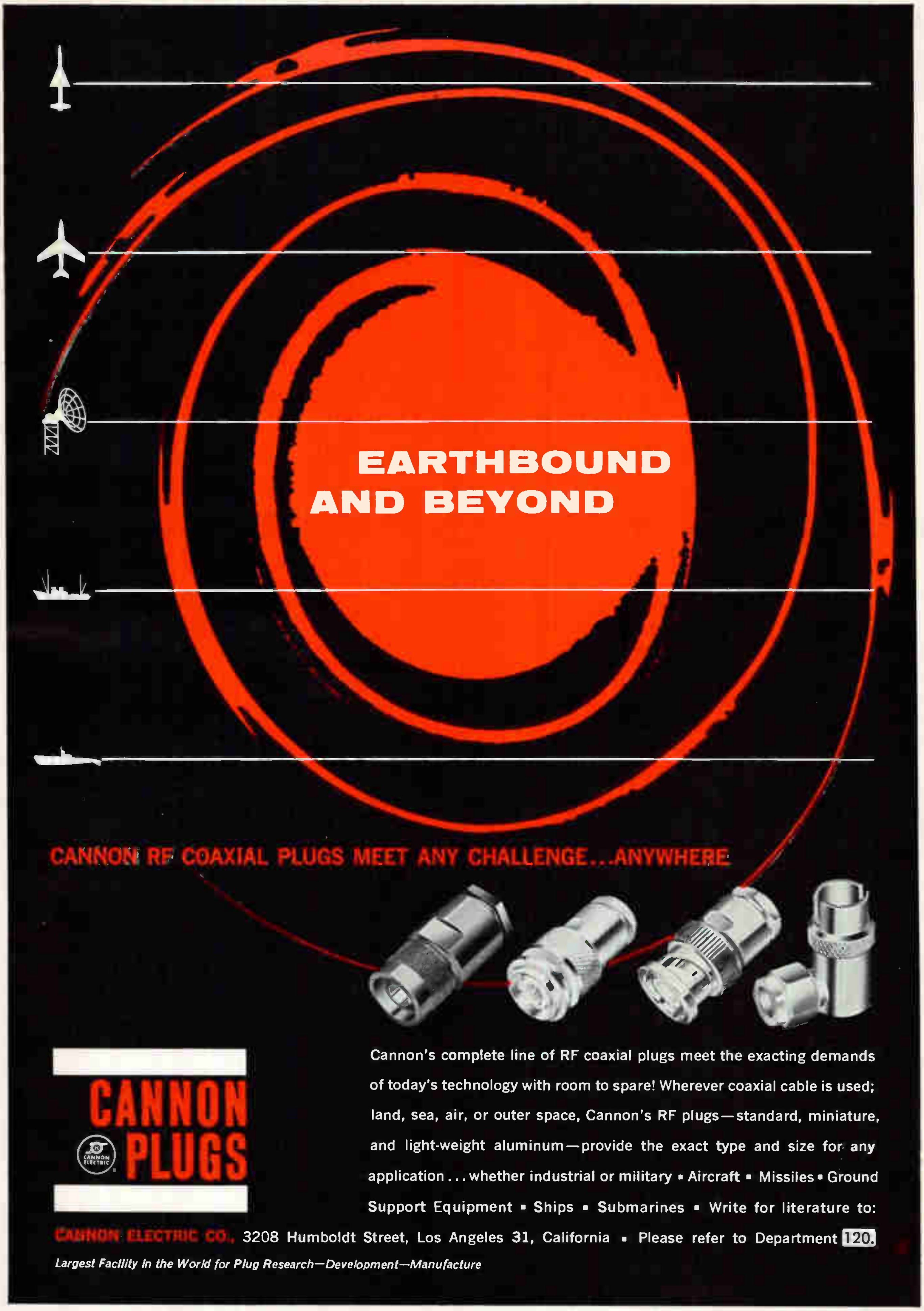
May 9-12: Instrument-Automation Conf. and Exhibit of 1960, Civic Auditorium and Brooks Hall, San Francisco.

May 10-12: Electronic Components Conference, PGCP of IRE, AIEE, EIA, WEMA, Hotel Washington, Washington, D. C.

Aug. 23-26: Western Electronic Show and Convention, WESCON, Memorial Sports Arena, Los Angeles.

Oct. 10-12: National Electronics Conf., Hotel Sherman, Chicago.

There's more news in ON the MARKET, PLANTS and PEOPLE and other departments beginning on p 88.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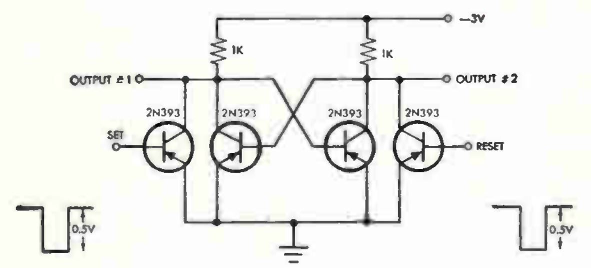
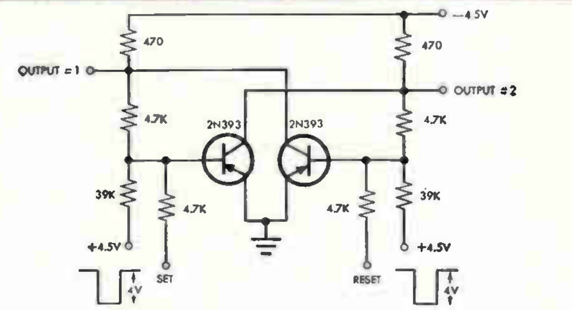
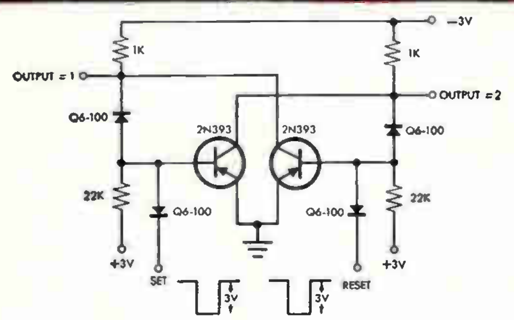


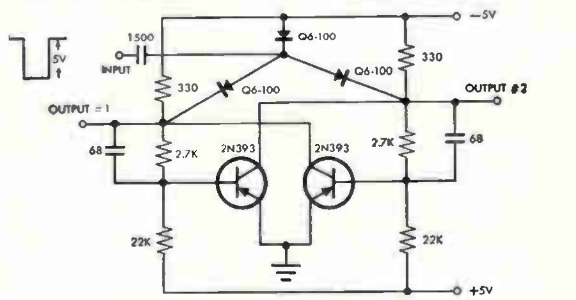
DIRECT COUPLED TRANSISTOR LOGIC FLIP-FLOP
TYPICAL SWITCHING TIMES: t_r=12 mμsec. t_f=15 mμsec.



RESISTOR COUPLED TRANSISTOR LOGIC FLIP-FLOP
TYPICAL SWITCHING TIMES: t_r=40 mμsec. t_f=110 mμsec.



DIODE COUPLED TRANSISTOR LOGIC FLIP-FLOP
TYPICAL SWITCHING TIMES: t_r=20 mμsec. t_f=60 mμsec.



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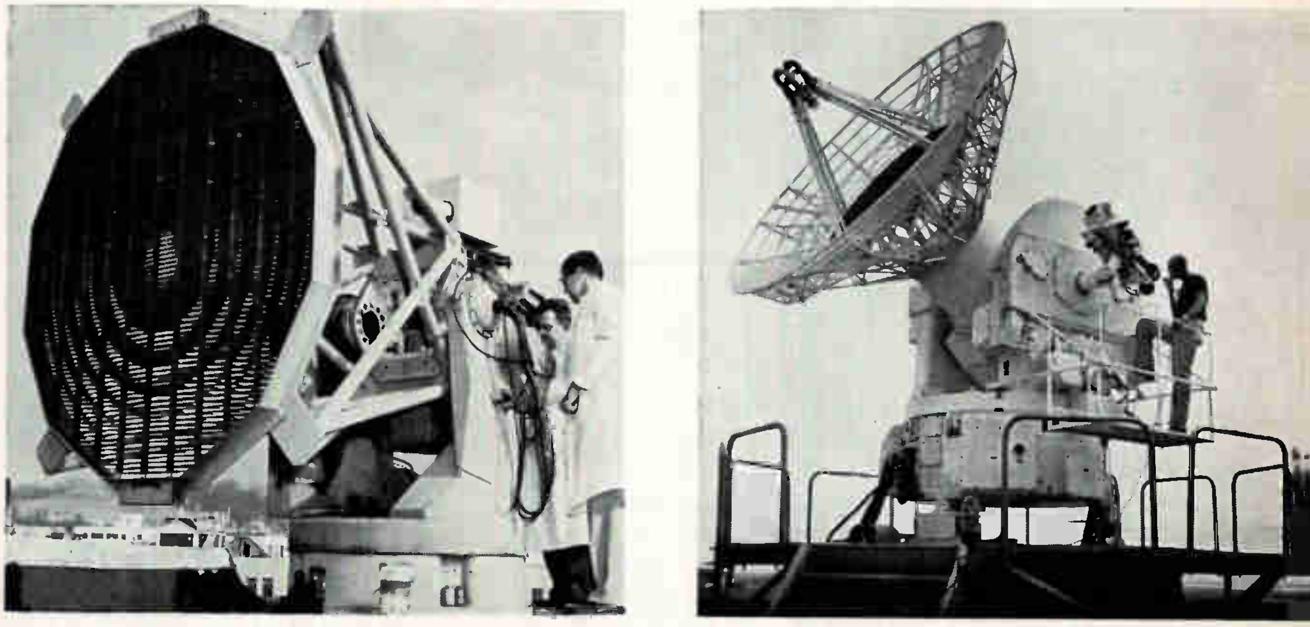

FIG. 1—Two typical comparison monopulse tracking radars. Original Mk 50 monopulse radar (left) operates in X-band using 6-foot lens system. Modern monopulse radar AN/FPS-6 (right) uses 12-foot diameter parabolic reflector and operates in C-band

Precision Tracking With Monopulse Radar

Modern monopulse tracking radars offer many advantages over other basic tracking techniques such as sequential lobing and conical scan. In this article, the principles of monopulse operation are explained and its performance compared against typical radars of other types

By JOHN H. DUNN and DEAN D. HOWARD, U. S. Naval Research Laboratory, Washington, D. C.

TRACKING RADARS are classified in three major categories whose names describe the technique used to obtain information about the position of the target in relation to the direction of the center of the radar beam. These techniques are conical scan, sequentially lobed and monopulse.

One of the principal difficulties in conical scan systems was the interaction between the lobing rate and the noise-modulation components at the same frequency on the return signal. Noise modulation on the return caused by propeller rotation was particularly trouble-some since the errors caused by such high-amplitude noise caused radar to lose the target.

In the study of possible corrective measures, one of the most apparent solutions was the use of a lobing or scanning rate which was of a higher frequency than the maximum propeller rate of the aircraft. This solution required scan rates of such a high frequency that mechanical problems arose. It was also desirable to have a scan rate that could be varied so that modulation noise peaks on the return could be avoided. This need resulted in the sequential lobing system using gas tubes as switches for turning the lobes off and on. In such systems, a four-horn feed was used with either transmission on all four and reception on each of the four in sequence or a five-horn feed using a central horn for transmitting.

The ultimate in such a system would be to obtain complete information about the position of the target on each pulse. Such a system would be equivalent to an infinite lobing rate. Practical realization of such a system requires obtaining information at the r-f frequency instead of the video frequency. This became possible through the development of a device called a rat-race. The use of this device made possible the combining of the signals from all four horns to provide a signal at r-f proportional to the error in pointing direction of the antenna, and in addition, a signal which is the sum of the energy received in all four horns. Thus three signals are provided: an elevation difference signal, an azimuth difference signal and a sum signal. Since this system obtains complete information about target position on each single pulse it is called monopulse[1] (Fig. 1).

TRACKING TECHNIQUES—Most tracking radars make use of microwave optics as lenses or parabolic reflectors for convenient beam shaping and for simplicity in mechanizing target-locating functions. Usually, the focusing lens or parabola is considered in terms of a point source located in the focal plane on the antenna axis which is focused by the lens or parabola to give a beam of desired shape as indicated in Fig. 2A. However, in describing the techniques used in tracking systems it is frequently more convenient to examine the received E-field distribution in the image plane caused by a point source of echo.

This field is described in Fig. 2B which shows the $(\sin x)/x$ shaped field distribution in the image plane of a lens[2]. The lens is used in the figures because of simplicity of illustration. The center peak of this function is what is frequently called the spot to which the radiated E-field of a distant on axis point source of echo is focused in the focal plane. The spot size even for a point source is always finite, for a finite size aperture, where d (Fig. 2B), the spot width between zeros, is $d = 2f\lambda/b$, f is the focal length of the lens or parabola, b is its diameter, and λ is the wavelength of the signal.

Figure 2C demonstrates how the spot in the focal plane moves corresponding to displacement of the point source from the tracking axis. The displacement is caused by the tilt of the arriving phase front with respect to the lens[3] such that there is a continuous variation of phase of the illumination across the lens. This phenomenon is the basis upon which tracking systems can track a target. All tracking systems, using a lens or parabola, provide some means for generating a voltage corresponding to the displacement, from the antenna axis, of the spot in the focal plane. The voltage is then used to drive the antenna in a direction which will recenter the spot, thus performing closed-loop tracking by reorienting the antenna toward the echo source.

Basic difference in the three tracking systems is the means by which it senses the displacement of the spot from the antenna axis. Figure 3A gives a three dimensional plot of the spot or E-field intensity in the focal plane to aid visualization of the three dimensional problem of sensing of the spot displacement.

The conical scan tracking system senses the spot location by moving its feed center such that it describes a circular path in the focal plane around the antenna axis. Thus, as a function of time it scans around the circular cross-section of the spot. This operation is indicated in Fig. 3B which shows the path described by the center of the nutating feed for a target on axis.

If the spot is exactly centered there will be essentially a constant receive signal throughout the scan. However, when the spot in Fig. 3B is slightly displaced, the received signal during the nearer portion of the scan will be less than that received at the far portion of the scan. This effect will result in a modulation of the carrier at the lobing rate. The phase of this modulation with respect to the feed position will depend on the direction of spot shift. Therefore, the depth of the modulation is proportional to error and the phase with respect to the lobing cycle gives the direction of error. By appropriate circuits, a corresponding error voltage is generated for driving the azimuth or elevation servos accordingly.

Most common conical-scan radars also transmit from the rotating feed. Thus, the depth of the modulation for a given squint angle, resulting from an off-axis target, is increased because the target receives a similar modulation by the illuminating signal.

The sequentially-lobed radar is similar to the conical scan radar because it does sample the E-field around the spot in the focal plane in time sequence. Yet it is similar to monopulse because it uses the four-horn aperture for its sampling process. Figure 3C shows how the four horn feed of the sequentially-lobed radar is located with its aperture in the focal plane (the phase center of the feed horn is placed in the focal plane) and centered on the antenna axis. During transmission the four horns are fed in phase such that they illuminate the lens or parabola essentially the same as a conventional single horn to obtain an optimum beam pattern for illumination of the target.

Means of sensing spot displacement in the sequentially-lobed radar is provided by the four horns since they divide a centered spot into four equal quadrants such that equal energy is received in each of the four horns. However, any movement of the signal source from the antenna axis causing a displacement of the spot will unbalance the energy received in the four horns.

By sampling the energy in the output of each horn in sequence there will be a modulation of the received energy whose depth is proportional to antenna pointing error and phase with respect to the sampling sequence is a function of the direction of error. Thus, the means is provided for generating a voltage of proper magnitude and polarity to drive servo systems in the antenna to correct the error.

The monopulse radar uses the same four-horn feed as the sequentially-lobed radar as shown in Fig. 3C. In addition, both radars transmit on all four horns

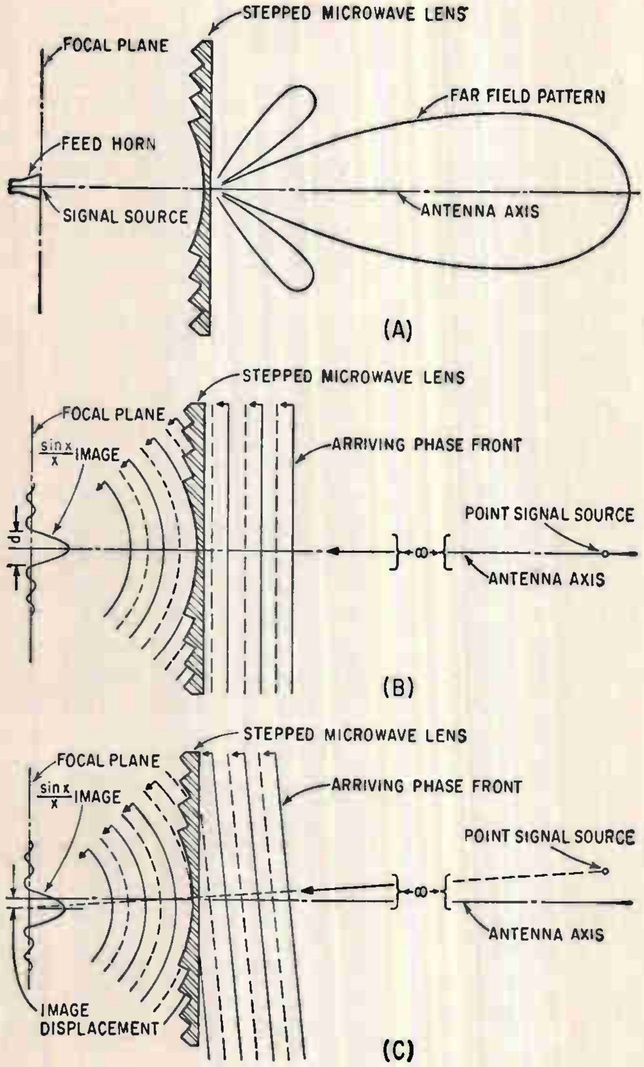

FIG. 2—Function of microwave parabolas and lenses by the conventional point source at the focal point and resultant far field pattern (A) compared with the image plane concept with a point source in the far field and resultant E-field amplitude in the focal plane for condition of on-axis source (B) and off-axis (C)

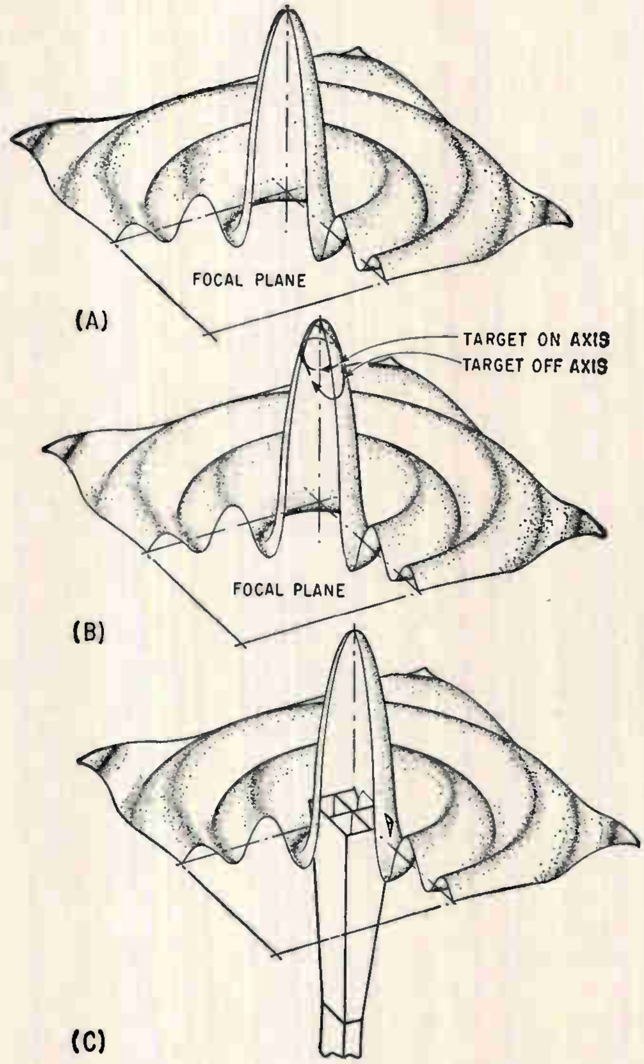

FIG. 3—Three dimensional plot of E-field amplitude in the focal plane. In (A), the phase is constant in the lobes of the pattern; (B) shows the patch described by a nutating conical scan feed for an on-axis and off-axis target; and (C) shows the three dimensional E-field in relation to the four horn feed location

simultaneously. The major difference between these radars is that where the sequentiall-lobed radar compares video from a time sequence, the monopulse radar compares r-f signals instantaneously. Through passive microwave circuits the monopulse radar gives three outputs; the sum of all four horns for range tracking and a reference to angle tracking channels, the difference of the top and bottom horn pairs for tracking in elevation and the difference of the left and right horn pairs for tracking in azimuth. The difference signals determine the magnitude of error, and the boresight line or antenna axis is the antenna pointing angle at which the difference signals are zero. The direction of error is later determined after i-f amplification by phase comparison with the sum signal.

The E-field spot in the focal plane is essentially constant phase over the main lobe of the $(\sin x)/x$ image' and the sum and difference signals will always have either a 0 deg. or 180 deg. phase relation. Therefore, the phase comparison is only to determine which of the two phases exists between the sum and difference signal in order to produce the error voltage of the correct polarity. Phase comparison has no significant effect on the boresight or electrical axis under normal condition.

MONOPULSE TECHNIQUE—To simplify the explanation of the operation of a monopulse radar, consider the diffraction pattern in the focal plane of the secondary aperture. This is shown in Fig. 3. The four feed horns are placed at the center of the main lobe of the diffraction pattern. On transmission, all four feed horns are excited in phase and the feed is designed and positioned to give the optimum beam from the lens or reflector. The maximum of the beam formed in this manner coincides with the tracking axis of the radar.

On receive, the signals in the four horns *A*, *B*, *C* and *D* are combined (Fig. 4) to provide a sum or reference signal and two difference signals. The difference signals are obtained by comparing the energy

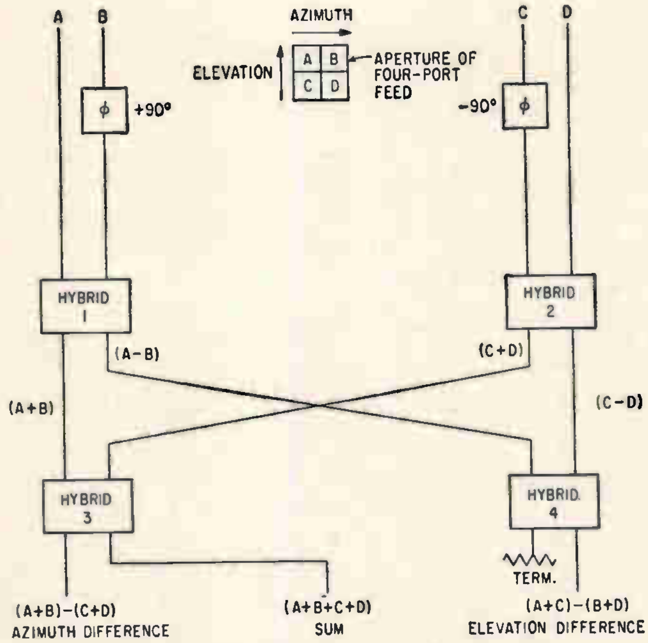

FIG. 4—Hybrids determine the sum or range track signal, and the azimuth and elevation difference signal. The difference signals, after conversion to i-f, determine the angle error signals when combined with converted sum signals in product detectors

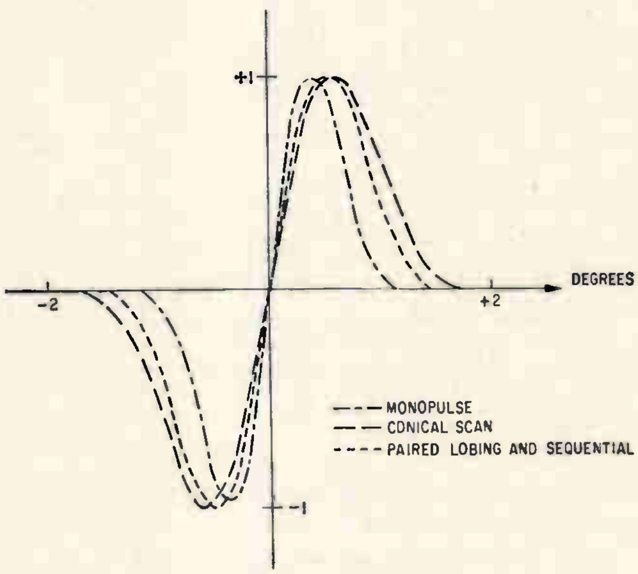

FIG. 5—Single target (point source) angle error signal of error voltage versus angular error when the target location corresponds to zero on the horizontal axis

received in the horn pairs. Thus the amplitude of the difference signal is compared with the phase of the sum signal to determine the direction of the pointing error. Figure 4 shows only the r-f comparison circuits of the system.

Earliest types of monopulse radar systems, such as the Mk 50 in Fig. 1, used a lens-type secondary aperture. Much smaller primary apertures are possible and blockage is no longer a problem. The combining of signals is accomplished within the primary feed structure through the use of short slot hybrids[5] in place of the rat race and phase stability has been greatly enhanced by the symmetrical structures made possible[6].

The most important consideration in the design of a monopulse radar is the establishment of the proper phase relationship and the elimination of phase errors in the r-f section. If proper care is used in the design of the r-f section, the boresight of the system will not be affected by phase errors or changes in phase of the i-f amplifiers.

To give a more complete picture of the effects of phase errors introduced in different points in the tracking system on the boresight of the radar, the comparison of the electrical axis in angle to the antenna axis is analyzed briefly in the appendix as a function of these phase errors. In reference to Fig. 4 and considering the azimuth plane only (for convenience), the electrical axis is determined by the sum and difference of the signals at the input to hybrid 3. These inputs are the sums of the signals from the left and right pairs of horns. When the radar is used, as previously described, with a lens or parabola, the two signals will always be in phase when the antenna feed is properly aligned.

The azimuth difference signal gives tracking error information because of the change in relative amplitude of the two signals as a function of antenna pointing angle, such that it is zero when the antenna is aligned with the target. When there are no phase errors or amplitude unbalances in the system the error detector output e_o which is the product of the sum and difference signals is simply $e_o = A^2 k\theta$ where A is the on axis amplitude in the signals from the horn pairs, k is the antenna gain constant and θ_o is the pointing angle of the antenna assuming the target is at zero angle for simplicity. This equation shows the desired condition where the electrical axis ($e_o = 0$) corresponds identically to zero antenna pointing error or $\theta_o = 0$.

If a phase error ϕ is introduced at any point after hybrid 3 either at r-f or at i-f, the error detector output (appendix) becomes $e_o = A^2 k\ \theta_o \cos\phi$. This equation shows no boresight shift since $e_o = 0$ when $\theta_o = 0$, but it does indicate a loss in sensitivity for small values of ϕ. This is not serious for a few degree phase error but if ϕ reaches 90 deg, all sensitivity is lost and if ϕ exceeded 90 deg, but is less than 270 deg, the error sense is reversed. There are possibilities that this might occur from malfunction of the equipment.

A more serious phase error is that which might occur between the two signals arriving at hybrid 3. This phase error, τ, is considered in the appendix and the error voltage derived. Analysis of e_o shows that there is a boresight shift such that when $e_o = 0$ the value of θ_o is not zero but $\theta_o \cong (\tau \tan\phi)/2k$. Thus, it is observed that in a precision tracking radar τ must be kept essentially at zero.

The need for close proximity of the comparison circuit brings up a major disadvantage of phase comparison systems which has boresight shifts that can be even more sensitive to phase error. In conventional phase comparison systems there is a large separation of feeds such that significant boresight errors can readily arise.

It is observed that r-f phase errors which contribute only to ϕ can be corrected by an equal and opposite phase shift at i-f between sum and difference signal. However, this means of correction is not recommended since r-f phase errors are generally frequency sensitive while, for a properly tuned local oscillator, the i-f errors will be independent of frequency, thus, ϕ would be zero at only certain points in frequency.

Characteristics typical of a precision monopulse instrumentation radar have been given.[7] For a 20 mil antenna beamwidth (1.25 deg), overall absolute rms tracking accuracies of 0.1 mil (0.0057 deg) in angle are obtained. This figure includes all system biases and rms errors. The precision or angular difference in positions of a target that can be measured by the radar is less than 0.01 mil. As an example, in the tracking of a balloon-borne 6-inch sphere, a 1.5-inch wobble of the sphere inside the supporting balloon gives the major source of tracking deviation about the balloon center (measured with a boresight camera) out to approximately 2 miles where the variation of index of refraction of the atmosphere becomes the most significant source of error.

In precision radar tracking it is occasionally desired to make real time correction of angle tracking data. The amount of lag that is present with any tracking antenna, when there are angular rates, is always accompanied by a corresponding voltage output from the angle error detector circuits. Therefore, if the radar is calibrated in volts-per-unit angle error, the angle error detector output can be read in terms of angle lag providing data for real time correction of target position information from the antenna mount.

Calibration can be accomplished in monopulse with a beacon by measuring the open loop angle error voltage for given values of angle error. A conical scan radar whose sensitivity depends in part upon its scan on transmit may require boresight balloon runs with optical measurements for given bias errors introduced into the servo system.

One further point on the capability of monopulse tracking radars is that they can passively track a noise source such as the radiation from the sun.

ADVANTAGES OF MONOPULSE—The monopulse radar is the only tracking radar which utilizes the full gain capability of its secondary aperture. With present microwave techniques the amplitude of the sum signal of the monopulse radar, obtained by using all four horns in phase, is as great as if a single feed horn of optimum dimensions were used. The difference signals do not reduce the normal sum signal energy because the energy received in the difference channels is only that energy which would normally be reflected back into space if an optimum single horn feed were used.

The conical scan tracking radar has an average beamwidth (averaged over the scan cycle) which is considerably spread with respect to the optimum by the lobing process (Fig. 4). The resultant two-way antenna gain or received signal for range tracking, when using optimum squint angle for tracking, is about 3 db below that obtainable with a monopulse. In addition, the rotary joints involved in lobing may cause additional losses which, although small in reduced signal power, can seriously limit the minimum system noise temperature for use with low-noise receivers.

Sequential-lobing radars transmit an optimum beam pattern with the four horns fed in phase, but on reception the energy output from the horns which are not being observed is dumped into a load. Since the energy is divided equally between the four horns (when the target is on axis) the power in each horn will be one fourth or 6 db down from the total. Therefore, if one horn is sampled at a time the total on axis signal will be 6 db down from optimum or if it is sampled in pairs it will be 3 db down. Thus, the superiority of the monopulse is demonstrated in terms of antenna gain.

The relative capability of tracking radars to resolve multiple target and the associated angular sensitivity has been discussed in some detail[8] where the monopulse is shown to have both superior angular sensitivity and resolving capability. This is indicated (Fig. 5) by the d-c error voltages out of the angle error detectors as a function of pointing angle, for the three types of tracking radar. The sensitivity or the slopes of curves of Fig. 5 taken on axis are: (normalized to monopulse) monopulse—1.00, sequential lobing—0.72, paired lobing—0.67 (paired lobing is a form of sequential lobing where the horns are sampled in pairs), conical scan—0.59, thus indicating the superior angle sensitivity of monopulse.

The resolving capability of the radar systems is summarized[8] by the figures on the separation of two point echo sources required for resolution of the sources normalized to the separation expresses as a fraction of one way antenna beamwidth: monopulse —1.3, paired lobing—1.4, conical scan—1.7 and sequential lobing—1.8. Thus, the monopulse radar demonstrates superiority in resolution capability.

The monopulse is the only tracking radar which has no tracking noise caused by amplitude noise or amplitude scintillation[9]. This immunity to amplitude noise results because complete tracking information is obtained from each pulse on the basis of ratios of the portions of the energy of the pulse which is received in each of the horns of the feed. The echo amplitude does not affect these ratios or the electrical axis of the radar.

The sequential lobing and conical scan radar also take ratios, in a sense, but the ratios are of signals received at different times. Thus, any echo amplitude change which occurs at the rate at which the sampling or scanning takes place causes false information in the output of the angle error detector. For example, when a constant level point echo source is on axis of a conical scan radar there is no modulation of the received r-f signal. However, if the echo amplitude fluctuates up and down during a full scan, this modulation will appear to the radar as if it had a tracking error. In closed-loop tracking the radar would move off the true target position as a result of the false information. The rms tracking noise, σ_{amp}, caused in a scanning radar by amplitude scintillation[9] is $\sigma_{amp} = (0.0085)\ B\ A_{amp} \sqrt{\beta}$, where B is the two-way antenna beamwidth (the units of B determine the units of σ_{amp}), A_{amp} is the percent-noise-modulation density in the vicinity of the lobing rate in units of percent modulation per $\sqrt{\text{cps}}$, and β is the servo bandwidth in cps. The constant (0.0085) was computed assuming a parabolic-shaped pattern and takes into account the frequencies both above and below the lobing rate. For significantly different antenna patterns a new constant must be derived.

The amplitude scintillation has its highest density in the frequency range below 50 cps although there is background modulation and propeller modulation up to a few hundred cps. Therefore, since the tracking noise in scanning radars is a function of the amplitude scintillation density, it was desired to raise the lobing rate as high as possible where the amplitude scintillation density is the least. This was one of the major reasons for development of the sequential lobing radar which can be lobed electronically where the limit is the pulse repetition rate pulse-to-pulse lobing.

One further point of interest is that very-low-frequency amplitude fluctuations in the vicinity of the servo passband, although not a direct source of tracking noise, do affect the contribution target angle scintillation to tracking noise, dependent on the agc characteristics[10]. However, this effect contributes equally to all tracking systems.

A further advantage of monopulse, which is also an advantage of sequential lobing radars, is the complete elimination of mechanical moving parts from the error sensing process. This advantage is becoming increasing significant with the present and future demands for high precision tracking. The mechanical scanning not only places a limit on boresight accuracy but adds rotary joints which can seriously limit the minimum noise temperature of a low-noise system.

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APPENDIX

Derivation of the Angle Error Detector Output As A Function of R-F and I-F Phase errors.

Analysis of the effect of phase errors on the tracking boresight will be made in the azimuth plane only for simplicity. The error detector output is the smoothed output of a product detector which multiplies the sum and difference signals. These signals are derived in azimuth by hybrid 3 of Fig. 4 which takes the sum and difference of the signals from the left and right pairs of horns of the monopulse feed.

As described in the text, when using a lens or parabola, the signals in these feeds will be in-phase but their amplitudes will vary as the antenna azimuth pointing angle θ_o moves through the target such that they are equal when θ_o is equal to the target angle θ_t. Assuming the antenna patterns are linear in the region where $(\theta_o - \theta_t)$ is small, the signal is left pair of horns, e_l, and the right pair of horns, e_r, will have the functions

$$e_l = A\ 1 - k\ (\theta_o - \theta_t) \cos (\omega t)$$
$$e_r = A\ 1 + k\ (\theta_o - \theta_t) \cos (\omega t)$$

where A is the signal amplitude of the horn pairs when the antenna is on target, ω is the angular r-f frequency, and k is an antenna gain constant.

First, e_l will have a phase error τ added to the argument of the cos to simulate a phase error occurring before the difference network. Also, for simplicity, θ_t will be set to zero reference angle such that when θ_o is zero the antenna is pointing at the target. Hybrid 3 has a sum output e_s and a difference output e_d which are the sum and difference of e_l and e_r such that

$$e_s = A\ (1 + k\ \theta_o) \cos \omega t + A\ (1 - k\ \theta_o) \cos (\omega t + \tau) \text{ and}$$
$$e_d = A\ (1 + k\ \theta_o) \cos \omega t - A\ (1 - k\ \theta_o) \cos (\omega t + \tau)$$

by taking the vector sum and difference of the two vectors in e_s and e_d,

$$e_s = \sqrt{2}\, A\ (1 + k^2\theta_o^2 + (1 - k^2\theta_o^2) \cos \tau)^{1/2}$$
$$\cos \left[\omega t + \tan^{-1} \frac{(1 - k\theta_o) \sin \tau}{(1 + k\theta_o) + (1 - k\theta_o) \cos \tau} \right]$$

$$e_d = \sqrt{2}\, A\ (1 + k^2\theta_o^2 - (1 - k^2\theta_o^2) \cos \tau)^{1/2}$$
$$\cos \left[\omega t + \tan^{-1} \frac{-(1 - k\theta_o) \sin \tau}{(1 + k\theta_o) - (1 - k\theta_o) \cos \tau} \right]$$

The next source of phase error can occur at r-f or i-f between hybrid 3 and the product detector. This phase error ϕ is accounted for by addition to the argument of the cos of e_d. The product detector output smoothed, e_o, is the d-c voltage

$$e_o = A^2\ (1 + 2k^2\theta_o^2 + k^4\theta_o^4 - (1 - k^2\theta_o^2)^2 \cos^2 \tau)^{1/2}$$
$$\cos \left[-\phi + \tan^{-1} \frac{(1 + k\theta_o) \sin \tau}{(1 + k\theta_o) + (1 - k\theta_o) \cos \tau} + \tan^{-1} \frac{(1 - k\rho_o) \sin \tau}{(1 + k\theta_o) - (1 - k\theta_o) \cos \tau} \right]$$

One condition to be examined is where there is no phase errors ($\phi = \tau = 0$) giving

$$e_o = A^2 k\ \theta_o.$$

Here there is no boresight error since $e_o = 0$ when $\theta_o = 0$ and $\phi = \tau = 0$.

The next condition is where $\tau = 0$ and ϕ is finite giving

$$e_o = A^2\ k\ \theta_o \cos \phi. \quad (\text{where } \phi = 0)$$

This condition shows no boresight error but loss of sensitivity for finite values of ϕ. (see discussion in text)

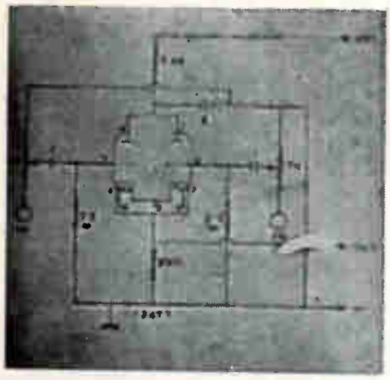
When both ϕ and τ are finite, the error voltage is e_o. By analysis of the magnitude of the cos function it is found that there is no real zero. The electrical zero, $e_o = 0$, occurs only when the argument of the cos function is $\pm \pi/2$. Solving for θ_o

$$\theta_o = \frac{1}{k} \left[\frac{-1 + \sqrt{\sin^2 \tau \tan^2 \phi + 1}}{\sin \tau \tan \phi} \right]$$

and where τ is small as in the usual case

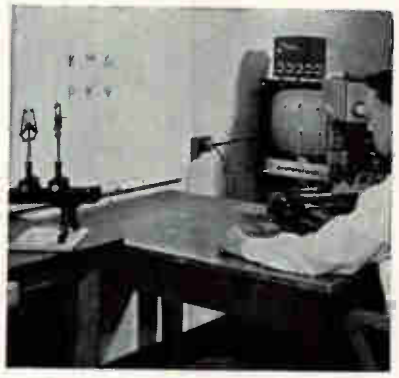
$$\theta_o \cong \frac{1}{k}\ \frac{\tau \tan \phi}{2}$$

Thus, there is a boresight shift when τ and ϕ are both finite which is the value of θ_o required for $e_o = 0$



Televised view of scene with bright spot showing point of eye fixation

Bite bar steadies subject's head in conjunction with neck rest



Matrix of photocells on monitor screen surface encodes positional data

Tv Tracker Records Eye Focus Points

Light reflection from the eye indicates direction of view. One tv camera monitors the scene, a second camera picks up eye light-reflection. Camera outputs are mixed, and eye focus point is displayed as a bright spot superimposed on televised picture of the scene. Photocells on monitor screen convert bright-spot position-data to digital form

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HOW A MAN moves his eyes, and where he actually looks while he is studying a fixed or moving scene are questions arising in many areas of applied science. Such questions are of increasing importance to engineers because the equipment they are designing is, despite wider use of automatic control systems, making greater demands upon the human operator. For example, although the pilot of a jet aircraft may be relieved of much routine flying by automatic equipment, he must nevertheless be ready to act with speed and decision during take-off and landing. As the speed of aircraft increases, this demand upon the man becomes greater. Advancing technology, while releasing man from many routine operations, is at the same time making more exacting demands upon him during those periods when his judgment is indispensable.

The same holds true for many other man-machine situations in which information is conveyed to the brain chiefly by the eyes.

One way of reducing the time delay in this human portion of the servo loop is to present the information to the man in a way that helps him to understand it as quickly as possible. For example, the layout of instruments in an aircraft cockpit has often been governed mainly by engineering expediency, little or no consideration being given to the capabilities or limitations of the pilot. As soon as we try to redesign such things as cockpit layout, to present information in the best possible way, we are faced with the problem of finding out how people actually do look at the displays before them.

Television Eye Marker

There are various ways in which movements of the human eye can be examined. One method is to use the reflection of light from the front surface of the eye. This is called the corneal reflection, and can be seen as a bright spot if an eye is viewed when a light falls on it. The spot moves as the eyeball moves. Within about 15 degrees on either side of the central axes, the movements of this corneal reflection, and the direction of gaze, have a direct correlation. The corneal reflection was originally used in 1907 by Dodge to study eye movements.

In the device to be described, Fig. 1, this corneal reflection is viewed by a television camera. A second television camera is used to survey the scene that the subject is studying, and the two camera outputs are mixed electronically. The result is a composite television picture which shows the scene with a bright spot of light superimposed upon it. This spot of light indicates the subject's position of gaze from instant to instant.

The camera viewing the corneal reflection is mounted with its lens close to the eye, and the subject's head is kept still by a bite bar and neck support. The television camera is at 45 degrees to the right of the line of regard, with the lens at eye level and approximately 2 inches away from the eye. The light source is 45 degrees to the left, and is focused to cast an image at the surface of the cornea. The beam is very narrow and although it falls directly on the eye it is surprising how little it interferes with vision; presumably because only a small part of the light enters the eye, the rest being reflected by its surface.

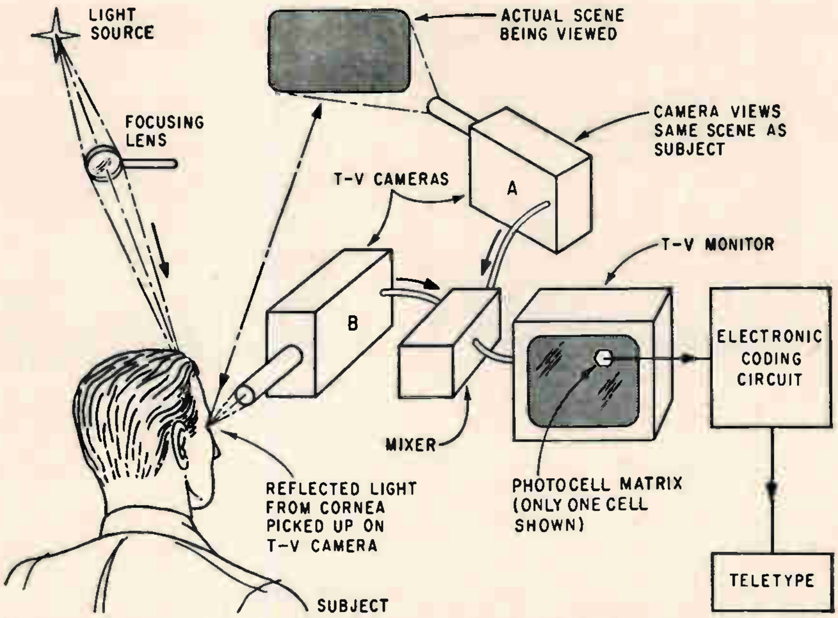

FIG. 1—Subject and camera A view same scene; camera B picks up light reflected from subject's eye. Camera outputs are mixed and presented on monitor screen

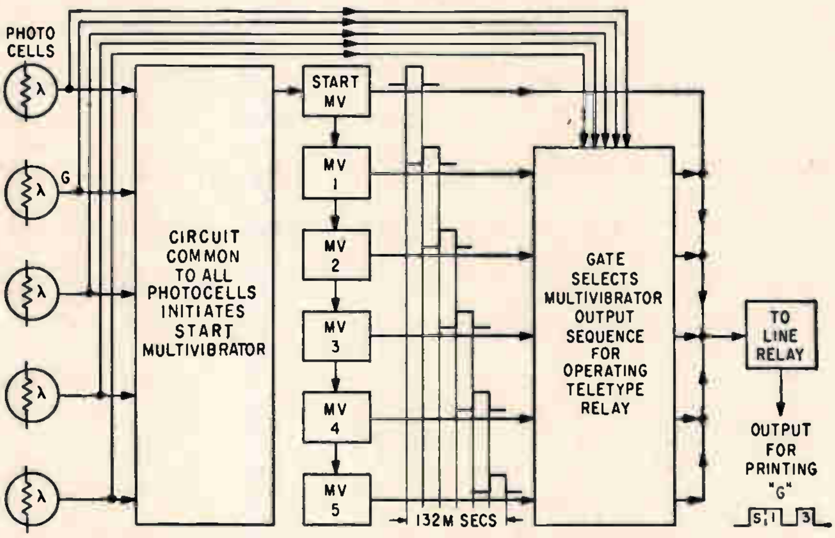

FIG. 2—Illuminated photocell triggers mv chain. Same photocell operates a gating relay to pass correct pulse sequence to teleprinter control

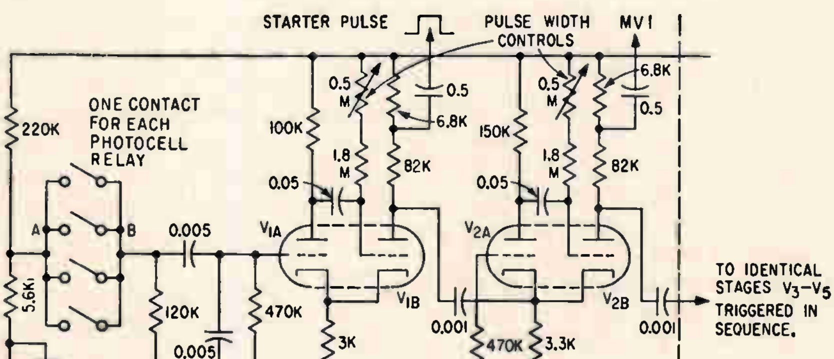

FIG. 3—Starter mv is grid-triggered, the rest are initiated by pulses fed to their cathodes

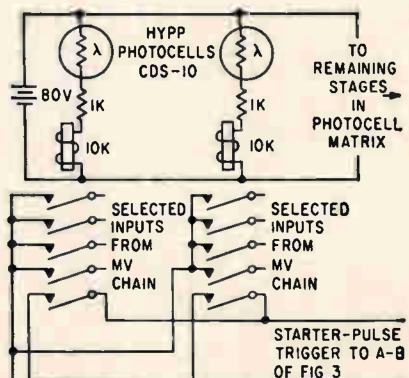

FIG. 4—In addition to starting-pulse, transmission of coded G requires outputs from multivibrators 1 and 3 to be fed to grid of line relay circuit

Magnifications of the order of 100 are required since the corneal reflection moves only about 2 mm for a horizontal movement of the eye through 20 degrees of arc.

The second television camera provides the visual scene, and the outputs of the two cameras are mixed in an electronic mixing unit so that the images from each of the two cameras are fed to the same recording screen. This combined eye-scene picture can then be viewed directly by the investigator and recorded by a motion picture camera.

The eye spot and the visual scene are calibrated by asking the subject to look at known points within the scene.

Recording and Evaluation

Successive eye fixations are shown as bright spots of light on a screen, but to extract the maximum information it is necessary to analyze the sequence in which they occur. This can be done by examining the film frame-by-frame and noting the successive positions of fixation, but it is more convenient to record the position-data in coded form on punched paper tape.

Since the eye spot appears as a bright spot of light it can be used to activate photocells mounted on the monitor screen surface. Each cell will be energized only when the eye spot is focused on it, permitting a coded output as the spot moves about the screen.

Outputs from the photocells are used to drive a coding circuit. This coding circuit gives an output consisting of direct current signals in the teletype code. Teletype signals are then used to operate a teletype printer perforator whose output is a paper-tape with both typed characters and punched holes.

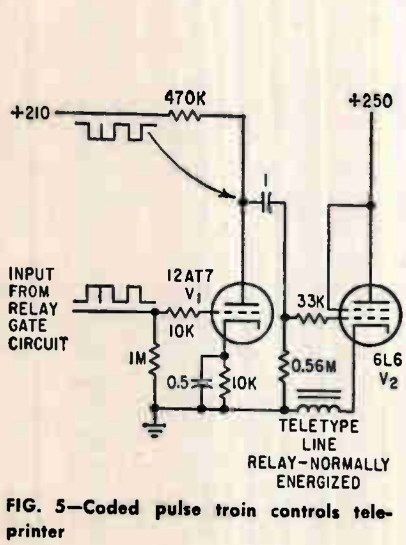

FIG. 5—Coded pulse train controls teleprinter

Coding Circuit

The block diagram of this circuit is shown in Fig. 2. It consists of six cascaded one-shot multivibrators, each of which gives a square wave output of twenty-two milliseconds duration—the duration of an element in the teletype code. The first multivibrator, the starter, is triggered every time the light spot excites a different photocell. The remaining multivibrators are connected so that the end of the differentiated square wave from the starter triggers number 1 multivibrator, the end of the differentiated square wave from number 1 triggers number 2, and so on down the chain. There are thus available six 22 millisecond square waves, each one following immediately after the other.

When energized, each photocell operates a gating circuit, to select those square wave pulses which are equivalent to the coding of the symbol for that particular photocell. Thus, when the photocell at position *G* on the screen is illuminated, the starting pulse plus pulses from multivibrators 1 and 3 will be passed through the gates, and the line relay will transmit the teletype code for *G*. The correct time delay between pulses 1 and 3 is maintained because of the 22 millisecond delay while miltivibrator 2 is generating its square wave.

The output signal to line therefore consists of d-c signals in the teletype code, each equivalent to one position of eye fixation.

Multivibrator circuits, Fig. 3, are conventional and differ only in that the starter-multivibrator is triggered by a positive pulse on the grid of V_{14} while the remainder are triggered by a negative pulse on the cathode. The output pulses are taken from across the 6,800 ohm resistor and a-c coupled to the gate circuit.

Gate Circuits

Gating can be accomplished by diode gates or relays. Diode gates have been used and are very suitable in some applications. However the comparatively slow movement of the eye marker, and the long response of the photocells used when recording normal eye movements often gives a slow voltage rise and difficulty in obtaining a positive trigger. Therefore sensitive relays have been employed, Fig. 4. These relays close on 1.3 ma and open on 0.4 ma.

The resistance of each photocell changes from about 1.5 megohms, when no eye spot is present, to about 2000 ohms when an eye spot falls upon it. The relays are five-pole single-throw and are normally open. The first contacts of all relays are connected in parallel and used for initiating the start-multivibrator as shown in Fig. 3. The remaining four poles of each relay are used to select the desired pulses from multivibrators 1 through 5. Since each relay is set up for only one symbol, it it quite possible that some poles of the relay will not be used. For example the letter *K* requires only the fifth multivibrator pulse to be passed through the relay, consequently only one of the four available sets of contacts need be used. It should be noted that the starter pulse by-passes the photocell relays, as every code symbol requires this initiating signal.

The outputs from the photocell relays are connected together and passed on to V_1 of Fig. 5. They are then amplified, inverted and fed to V_2, which is connected as a cathode follower. The line relay of the teletype printer is connected directly to the cathode circuit of V_2 and is normally in a closed position. When negative pulses are applied to the grid of V_2, the line relays open corresponding to the pulse pattern. As there is only one eye spot, only one relay should be closed at any one time. If a second relay closes before the initial relay opens, the starter multivibrator will not be retriggered as the starter relay contacts will have remained closed. This method prevents erratic pulse patterns from passing through the gate circuit. It was found that the pulse width of 22 milliseconds was quite critical, consequently a width adjustment control was used in all multivibrators.

Inductive Elements for Solid-State Circuits

Coilless L-C resonant tank circuit can be constructed with inductive negative-resistance diode. Germanium diffused-base transistor with open-circuit base connection serves as diode

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A STUMBLING BLOCK in the development of microminiaturized circuits is presented by inductance coils that defy miniaturization efforts and occupy volumes orders of magnitude larger than those of other passive and active components fabricated either in thin-film form or as small chips of solid-state materials.[1,2,3] One way of circumventing this problem is to design all inductances out of conventional circuits before constructing the integrated analogs. For example, transistor oscillators with resonant L-C circuits have been replaced by R-C phase-shift oscillators. This procedure is not satisfactory in all cases; therefore, various effects are being investigated that exhibit inductive behavior in small volumes of semiconductor material.

Semiconductor Inductances

Study of carrier motion in semiconductors, including diffusion, drift, quantum-mechanical tunneling, avalanche multiplication and internal field emission under various impurity concentrations, and current and voltage-dependent recombination mechanisms, has revealed that several of these effects or combinations thereof show inductive behavior. Research conducted at the U.S. Army Signal Research and Development Laboratory has led to design theories for solid-state inductances that should operate up to the microwave range.

The disadvantage of some of these so-called inductive diodes is the accompanying high-loss resistance that may be compensated by a solid-state negative resistance in series.[4] Utilizing the fact that the operating-point variation of a solid-state negative-resistance element usually changes the magnitude of the differential negative resistance, circuits have been built whose Q and bandwidth are voltage-tunable over a wide range. More desirable, however, are inductive diodes that have a small loss resistance or even exhibit a negative-resistance region. The latter case occurs in transistor-like three-layer structures if the emitter-to-collector current gain increases with increasing current through, and voltage across, the diode.

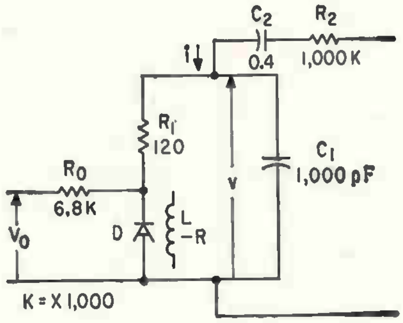
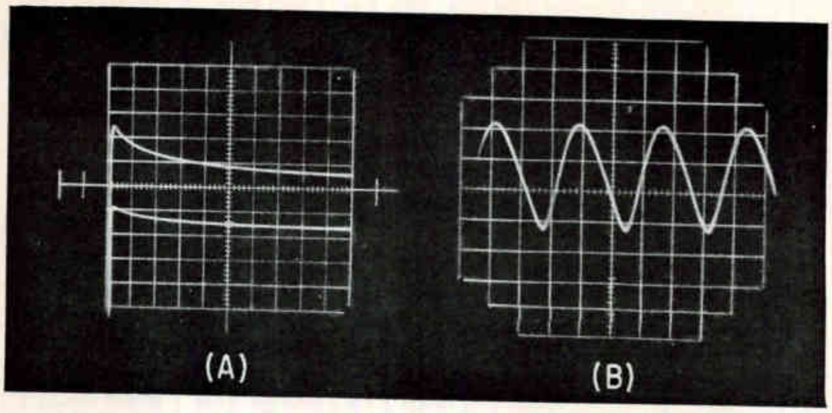


FIG. 1—Coilless L-C tank circuit uses inductive negative-resistance diode

The numerous mechanisms that may produce this phenomenon are being studied in many semiconductor laboratories. These investigations will result in negative-resistance diodes that may compete with the tunnel diode. Discussion of this work is not included here. Certain commercially available transistors, however, exhibit the inductive effect coupled with negative resistance, usually with the base open or shorted to the emitter and biased close to or just into avalanche multiplication. A circuit is described that uses such a three-layer inductive diode instead of a customary inductance coil.

Coilless Tank Circuit

Figure 1 shows the coilless tank circuit. This circuit consists of inductive negative-resistance diode D, tank capacitance C_1, damping resistance R_1 (which prevents the circuit from oscillating by itself unless so desired), d-c bias voltage source V_o (to keep the diode in the negative-resistance region) and bias resistance R_o which stabilizes the bias current and prevents the alternating current from bypassing the inductive diode. Capacitance C_2 and resistance R_2 are included for measurement and do not form an essential part of the circuit. Resistance R_2 provides an alternating current of constant and frequency-inde-



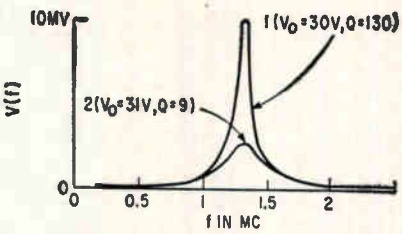


FIG. 3—Frequency response of coilless tank circuit is shown for two values of bias voltage, V_o

FIG. 2—Negative-resistance characteristic of inductive diode is shown with 0.5 ma/div vertical scale and 5 v/div lower curve, 2 v/div upper curve (A); output from self-oscillating coilless L-C resonant circuit is shown with 0.3μsec/div horizontal scale and 0.2 v/div vertical scale (B)

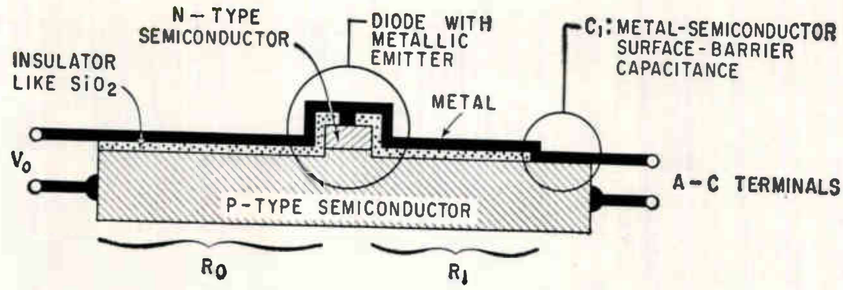


FIG. 4—Coilless L-C resonant circuit can be fabricated as microelectronic function block

pendent amplitude, and C_2 prevents any d-c bypass of the bias supply.

The negative-resistance diode used in these experiments consisted of a germanium diffused-base transistor with an open-circuit base connection. The negative-resistance characteristic of the diode is shown in Fig. 2A. Negative resistances of this type have been explained as being due to avalanche multiplication in the collector junction coupled with an emitter efficiency that increases with increasing current.[5]

The resulting resonance frequency, f_o, was 1.3 Mc, indicating an effective inductance of 15 μh. The bandwidth is a function of the circuit losses that may be varied by changing the bias of the negative-resistance element, thus compensating more or less of damping resistance R_2 by varying amounts of differential negative resistance.

Figure 3 shows the measured frequency response of the tank circuit, obtained by sweeping the frequency of a constant-current generator (R_2) and measuring the voltage, v, across the tank. When the magnitude of the differential negative resistance becomes equal to the positive loss resistances in the circuit, the bandwidth reaches zero and the tuned circuit begins to oscillate by itself. Figure 2B shows the output voltage of such a self-oscillating coilless L-C circuit. The amplitude of the oscillations may again be modulated by varying the bias voltage on the diode.

One difficulty was encountered with the diode used. In the negative-resistance mode of operation, the diode exhibits a considerable amount of low-frequency noise of the flicker type. This is believed due to the fact that avalanche multiplication in most junctions (at the present time) does not occur uniformly but in localized areas, which are not stationary themselves but wander over the cross-section of the junction. Research at the present time is directed toward producing small stable regions of avalanche multiplication—so-called microplasmas which should exhibit only the usual high-frequency shot noise. The large-scale application of avalanche-type devices for small-signal circuits seems to depend on the success of these studies. Some success in this direction has been reported recently.[6]

Outlook

Development of such inductance diodes appears promising. Their active volume is of the order of 10^{-5} cm^3 which compares favorably with the volume occupied by a coil with the same inductance and Q values.

Research on these devices is proceeding in various directions. One is the reduction of avalanche noise; others deal with the design of three-layer negative-resistance and inductance diodes. These studies indicate a wide variety of effects, all of which yield negative resistance and/or inductance. Once these are fully understood, it will be possible to incorporate the inductive effect, together with the bulk resistances, junction capacitances and transistor-like regions, into a single semiconductor wafer to produce a true microminiaturized or molectronic function block. The schematic view of such a structure is shown in Fig. 4.

In further developments of such all-semiconductor function blocks, some of which have already been breadboarded, junction capacitance C_1 is made voltage-tunable to control the resonance frequency of the circuit.

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Conversion of analog inputs into digital form using shaft-position encoders is receiving wide acceptance in computer and data logging applications. Unfortunately, small changes in analog variables can introduce positional ambiguity. This problem is eliminated with the disk pattern designs described here

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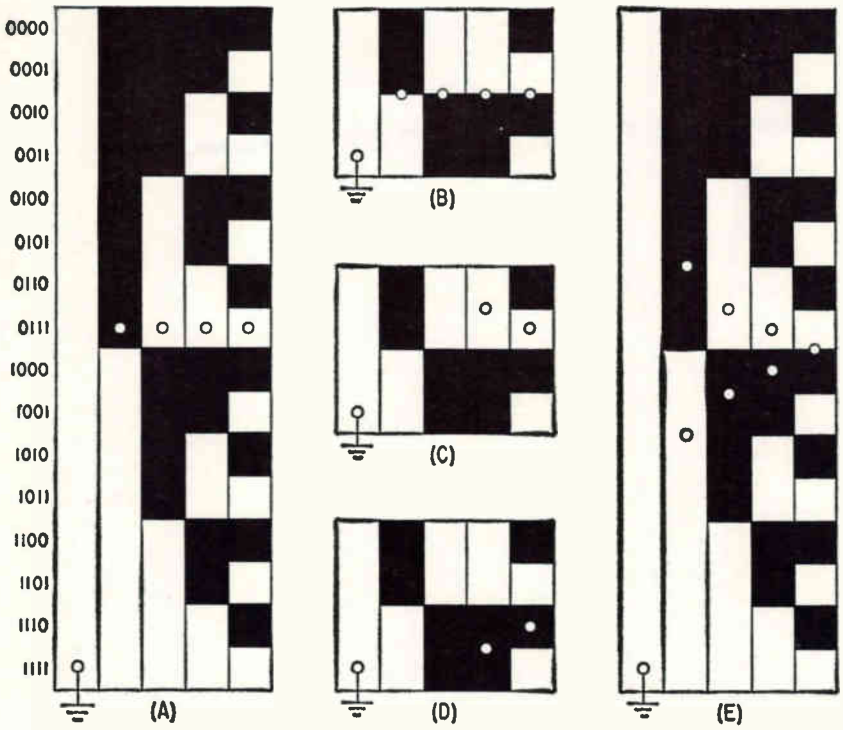

FIG. 1—Binary progression and equivalent printed circuit representation (A); segments 0110 to 1001 with reading brushes on dividing line between segments 0111 and 1000 (B), and with more significant digit brush lagging (C) and leading (D) the LSD brush; and V-brush configuration (E)

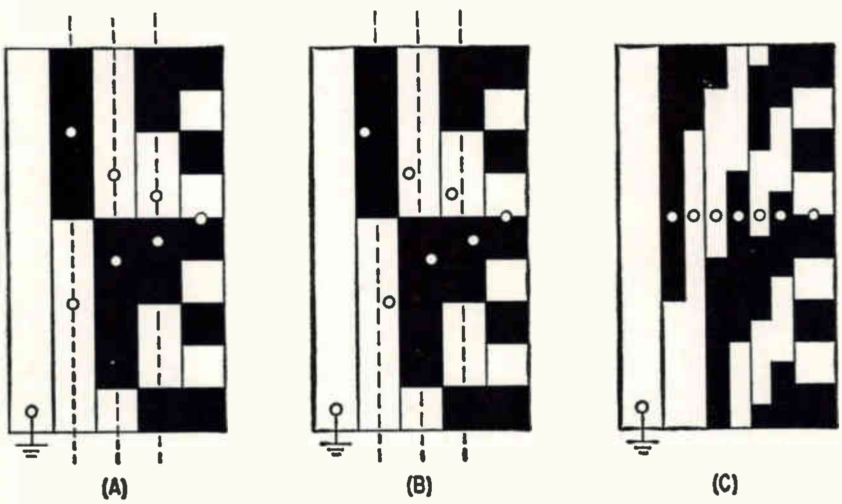

FIG. 2—V-pattern for segments 0100 to 1100 (Fig. 1A) with brushes in conventional (A) and radially displaced (B) positions, and brush alignment for V-disk encoder (C)

ANALOG-TO-DIGITAL encoders can be constructed to provide literally any type of output—linear, nonlinear, pure binary, coded binary, and even random as a function of shaft rotation. Indeed the possibility of using an encoder not only as a translator, but as a medium for converting the digital information to a desired format is a factor which adds tremendously to the value of the device.

It is easy to take a sheet of graph paper and represent a function digitally in any desired format, but it is quite another story to construct an encoder that does the same thing and yet has no ambiguous points. This article describes some measures through which positional ambiguities are avoided while preserving the integrity of the pure binary progression or one of its natural variants. Accordingly, the adoption (for nonambiguous readings) of cyclic codes requiring translation to computable form will not be discussed.

Binary Coded Printed Circuits

In the left column of Fig. 1A is shown a binary progression; in the right column appears the same presentation, but transformed into a printed circuit substituting for each 0 a solid segment representing insulation and for each 1 a blank segment representing conducting material. Also shown is a common track of conducting material with a brush riding on it and connected to a power supply. Through application of electrical current to the common track all conducting segments are energized.

As shown in Fig. 1A, each of the four reading brushes rides in a separate digit track. A check of their positions reveals that the brush on the most significant digit track lies on an insulated segment and will read no voltage while the remaining three are on conducting segments and have voltage applied

Disk Encoder Design Avoids Ambiguities

to them. Substituting figure 0 for no voltage and figure 1 for voltage, the reading is 0111 (binary 7). This is the true reading for brush positions in this progression.

Disk Encoding

The preceding describes a printed circuit in linear form. To simplify the discussion, modifications will be shown in this same form. It should be noted, however, that if the binary progression is represented on a disk with a shaft through the center and the brushes in a fixed position, rotation of the shaft will provide a change in the binary count either up or down.

If the shaft is turned to provide an increasing count, the progression will continue to the maximum provided in the pattern (a function of the number of digit tracks) and then begin again at zero. By utilizing a disk on which the code pattern appears, the angle of the shaft through its rotation is actually measured and a direct indication of the shaft position is available in pure binary code.

In the usual type of brush and disk encoder, the generally accepted count in a pure binary code is 2^7 or 128 counts per shaft rotation on a disk with a diameter of about 1⅜ inches. This size disk fits conveniently into a size 18 synchro mount. Considerable progress is being made in miniaturization.

Positional Ambiguity

Presence or absence of voltage on the various brushes gives a true binary reading of the shaft as long as the brush does not fall on the dividing line between insulated and conducting segments. The following discussion will consider the situation when a brush does fall on the dividing line.

Figure 1B shows the segments from the binary equivalents of 6 (0110) to 9 (1001) of Fig. 1A. The reading brushes lie along the dividing line between 7 (0111) and 8 (1000). Note that the most significant brush is making contact with the conducting segment indicative of the 8 (1000) position while the remaining three brushes are still in contact with the conducting segments indicative of the 7 (0111) position. The result is a reading of 1111 which is the binary equivalent of 15 or an intolerable error of almost 100 percent. This condition is known as a positional ambiguity.

Detents, both mechanical and electrical, have been used to avoid this error, but the key to a better solution was provided by two characteristics of the binary progression. First, in any vertical column any change from a 1 to a 0 in an increasing count is accompanied by a change in the state of the next more significant digit. Second, in any vertical column any change from a 0 to a 1 in an increasing count is never accompanied by a change in the next more significant digit.

Change of State

On investigating the first consideration and its application to the segments from the binary equivalents of 6 to 9 beginning with the least significant digit (LSD), the position will indicate that the number with the brushes in a horizontal line would be 7 (0111). In going from a 1 to a 0 in an increasing count, there will always be a change in the next more significant digit column. The LSD brush is in a 1 zone and thus is preparing to change to a 0 with a consequent change in the next higher digit.

Accordingly, if a brush is placed in the next more significant digit track in a position behind or lagging the LSD brush by a distance equal to ½ the width of an LSD segment (Fig. 1C), it can be assured that the newly added brush will not cross the reading line at the same time as the LSD brush. As long as the LSD brush is in a 1 or conducting zone and the succeeding brush is ½ an LSD's width behind, the presentation will always be correct for the binary number indicated by the position of the LSD brush.

No Change of State

The presentation just described will be correct only when the LSD brush is on a 1 or conducting zone. This condition exists because advantage has been taken of only one of the two characteristics previously noted. Consider again the 6 through 9 pattern, but this time place the LSD brush in the insulated or 0 segment indicative of number 8 (1000). As stated previously, in going from a 0 to a 1 there will never be a change in the next more significant digit column. Thus, the LSD brush is in a 0 zone preparing to change to a 1 with no change expected in the next higher order digit.

Accordingly, if a brush is placed in the next more significant digit track in a position ahead of or leading the LSD brush by a distance equal to ½ the width of an LSD segment (Fig. 1D), it can be assured that the newly added brush will not cross the reading line at the same time as the LSD brush. What has been done, in essence, is to create an ideal brush incapable of an ambiguous reading.

V-Scan Logic

Through the use of two brushes in each successive digit track which are spaced a distance apart equal to one preceding digit's width, an ideal series of brushes has been created. By electrically interrogating each brush and selecting the proper brush in the next higher order digit track, it is possible to guarantee a nonambiguous reading.

The brush configuration shown in Fig. 1E has earned this method of brush positioning the title V-brush or V-scan logic. The V-scan

Experimental work on extremely small disks indicates that more than 10,000,000 revolutions of life can be achieved

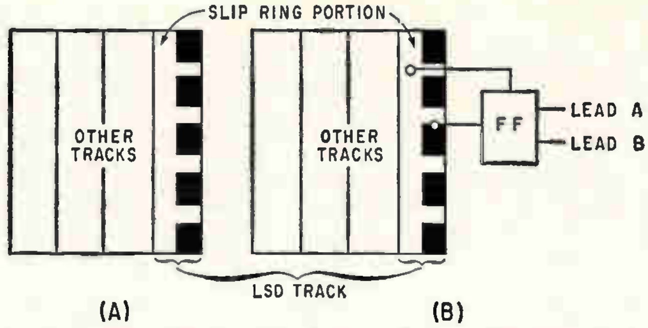

FIG. 3—Alternate insulating (solid), conducting (blank) segments and slip ring portion of LSD track (A) and brushes in place (B) flip-flop plus spst action

principle, as described previously, need not be strictly a position pattern of the brushes, but rather a relationship between the position of the brushes and the precision pattern on the code disk.

A linear binary pattern from 4 (0100) to 12 (1100) with the brushes placed in the conventional V-pattern is shown in Fig. 2A. Figure 2B shows these brushes displaced radially while being kept in the same digit track. To accentuate the effect of this displacement, each digit track is split with a dotted line except for the LSD track. Note that in Fig. 2A this line intercepts both brushes in each digit track while in Fig. 2B it serves to separate them.

If the brushes can be displaced radially, it is also possible to split each digit track circumferentially (vertically in the sketches), precisely as was done with the dotted line in Fig. 2B. Once this is done, the entire code pattern can be skewed thereby moving the outer (right-hand) half of each digit track counter-clockwise (up). The inner (left-hand) half of each digit track can also be moved clockwise (down). To preserve the integrity of the relationship between brush positions and the precision pattern on the disk, the brushes will then have to be moved an equal distance in the same direction.

V-Disk Encoder

If the distance the pattern was moved in each track is equal to ½ the width of a segment in the preceding digit track and if the brushes are moved an equal distance in the same direction, the relationship displayed in Fig. 2C will have been achieved. In effect, the V-brush logic has been transferred to the disk pattern and thus a device so equipped can be referred to as a V-disk encoder. Note that the brushes are now in a straight line.

The complex geometry of the V is now accurately reproduced on the disk by photographic techniques with a repeatability and tolerance difficult to achieve by any other method. One important consideration is that although the encoder is so modified as to render precise brush positioning a simpler operation, the V-disk encoder is electrically interchangeable with the standard V-brush type described earlier.

Electrical interchangeability implies operation is handicapped by using this type of shaft-position encoder in that external brush selection logic circuitry is still necessary. Elimination of this requirement, that is development of an encoder capable of automatic internal selection of the proper brush in successive digit tracks, would be most desirable.

Self-Selecting Encoders

Inventive techniques have created self-selecting encoders requiring a minimum of external circuits. One of these will be described. It may be well to stress the physical differences between this type of encoder and those previously described, beginning with the precision pattern on the disk.

First, it will be established taht there is no longer a common track and that each digit track is isolated from its neighboring digit tracks by a narrow strip of insulation. The LSD track resembles the LSD track of the V-brush and V-disk encoders except that, in addition to the al-

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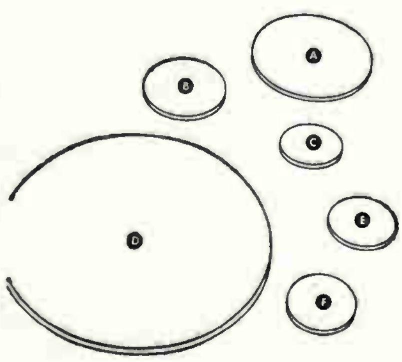
THE FRONT COVER



Disks shown on the front cover have a great many uses; only a few applications are described here as examples.

(A) Self-selecting, natural binary disk type ADC-ST8P-BNRY gives 512 counts per turn or 256 counts per turn with parity check. Used in data link computer.

(B) Self-selecting, 8-4-2-1 binary-coded decimal disk type ADC-ST2-BCD gives 100 counts per turn. Used for machine tool control applications.

(C) Non-selecting, natural binary disk type ADC-ST7-BNRY-X gives 128 counts per turn. Used in Hound Dog air-to-ground missile and in Polaris program.

(D) Self-selecting, 8-4-2-1 binary-coded decimal disk type ADC-ST3-BCD gives 1,000 counts per turn. Used in film reader for Wilson cloud chamber.

(E) Nonself-selecting, Gray code disk type ADC-ST8-GRAY gives 256 counts per turn. Used in an air-to-ground missile and in a satellite program.

(F) Self-selecting, natural binary disk type ADC-ST7-BNRY gives 128 counts per turn. Used in navigation and fire control system of Convair's F106 fighter.

ternate insulating and conducting segments, there is a slip ring included within the confines of this track providing a common for all LSD conducting segments (Fig. 3A). An encoder requiring a minimum of external circuits will now be investigated.

After placing the usual LSD reading brush in the 7 (0111)—8 (1000) position (Fig. 3B), it is then connected on an external circuit which is essentially a flip flop. A second brush is introduced in the LSD track which rides in a slip ring supplying voltage. The physical position of the brush has no significance except that it must be wholly within the slip ring portion of the LSD track.

When the reading brush in the LSD track is on an insulating (0) segment there will be no circuit between the two brushes in the LSD track. Conversely, when the reading brush is on a conducting 1 zone, there will be a circuit established between the two brushes in the LSD track. This functions as a spst switch. The closed or open circuit changes the state of the flip flop so that an output is available at lead *A* or lead *B*—never both and never neither.

Advantages

Shifting of load current is of practical value. Returning to the brush selection logic system, it can be seen that a reading (short circuit between the two LSD brushes) will cause a voltage to exist on lead *A* which is connected to the lagging brush in the next higher order digit track. If we have 0 reading (no circuit between the LSD brushes), a voltage will exist on lead *B* which is connected to the leading brush in the next higher order digit track.

If the remainder of the disk pattern were to duplicate the V-brush or V-disk types, the initial brush selection would be complicated since external circuits would be required for all higher order digits. The question then is how to change the pattern to render the encoder, from this point onward, entirely self-selecting yet wholly free of any possible ambiguity.

Eliminating Ambiguities

To study the differences that must be introduced to eliminate ambiguities in contrast to the encoders previously studied refer to Fig. 4A. As has already been pointed out, each digit track is isolated by insulation boundaries on its inner and outer circumference. If the second digit track is studied, it will be seen that a gear-tooth type of insulation barrier separates the two interlocking conducting zones from each other. This configuration has the appearance of a slip ring at the inner and the outer circumference of the track and a series of blocks between.

If the structure of these blocks is examined, it will be noted that those positions where the widest conducting portion lies toward the outer circumference of the digit track correspond with the insulating (zero) segments in the regular binary pattern. Also, those positions where the widest conducting portion lies toward the inner circumference of the digit track correspond with the conducting segments in the regular pattern.

An inference from this fact is that every digit track except the LSD track, the conducting zone of which lies above the gear-tooth insulation barrier (toward the outer circumference of the digit track), is a 0 zone and that the conducting zone which lies below the gear-tooth insulation barrier (toward the inner circumference of the digit track) is a 1 zone. Additional brushes required are shown in Fig. 4B.

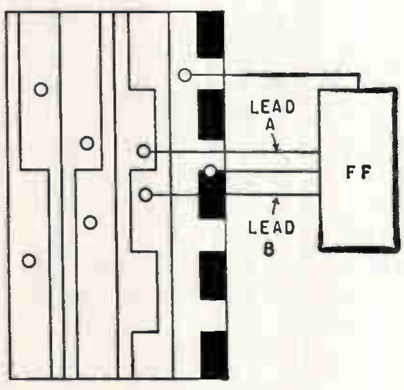
Assume the LSD commutating brush is on the conducting zone indication of position 7 (0111). A circuit is established between this brush and the slip ring brush in the LSD track and, logically, load current is directed to the lagging brush in the second digit track (when reading a 1, select a lag brush in the next higher order digit track).

The lag brush in the second digit track is then in a 1 zone, that is below the gear tooth insulation barrier. The logic then causes the lag brush to be read since as the pattern moves beneath the brushes, the second digit lag brush will be in the 0 zone of the second digit track as frequently as it is in the 1 zone.

To offset this condition, a 1 zone slip ring brush can be installed in each digit track directly connected to the lag brush in the next higher order digit track. It will be seen then that whenever the current-carrying brush in any digit track is in a 1 zone it is, in effect, directly coupled to the lag brush in the next higher order digit track.

A lag brush is chosen in the second digit track. This brush is in a 1 zone and is connected through the 1 zone slip-ring brush to a lag brush in the third digit track. The brush is in a 1 zone and, following the logic, is again connected to a lag brush in the fourth digit track. At this point, the picture changes. The logis brush in the fourth digit track is in a zone thus separated from the 1 zone slip-ring brush in this track by the gear-tooth insulation. Accordingly, since the logic brush is in a zone, a lag brush will not be read in the next higher order (fifth) digit track.

Before investigating the manner in which the higher order digits are read in this configuration, the output signals (readout) will be derived for the portion of the technique thus far described (see Fig. 5A). In the LSD track, there are



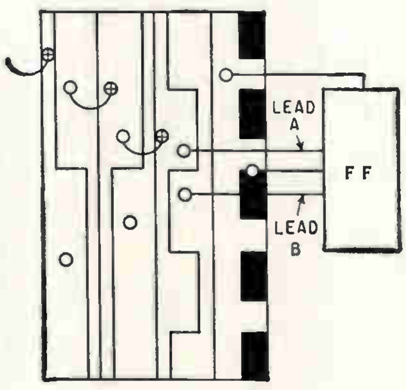


FIG. 4—Gear-tooth insulation separates interlocking conducting zones from each other (A). Additional brushes required to prevent ambiguity (B) are shown in circled crosses

two brushes which are connected and disconnected as the commutating brush passes from insulator to conductor. In theory, the reading could be taken from this circuit but in practice this is not feasible because a small signal (5 to 8 v and 0.2 to 0.5 ma) is used. This signal is sufficient to change the state of the flip-flop but remains within the work function of the metals used thus minimizing electrical wear.

However, in the state pictured in Fig. 5A the load current is directed to the lag brush. That the load current is so directed is indicative of the fact that a 1 reading has occurred in the LSD track. A reading from the lead which is carrying the current to the lag brush in the second digit track will tell that the LSD brush is reading a 1. A dotted line brought out to a terminal is shown as the source of the reading. It will be noted that subsequent readings are taken from the 1 zone slip-ring brushes. Hence, with the LSD brush on a conducting or 1 zone, a reading of voltage (or 1) from each terminal through the first three digit tracks can be made but no voltage (or 0) is available from the fourth digit track thus giving 7 (0111).

The foregoing describes one half of the internal circuits necessary to accomplish the aim of self-contained or self-selecting logic. A discussion of the remaining circuits can best be begun by assuming that the LSD brush was on the insulation segment at the position indicating an 8 (1000).

The load current now shifts to the lead brush in the second digit track. Since this lead brush is in a 0 zone, a lead brush in the next higher order digit should be selected. Once again, these two brushes cannot be directly coupled since the reading brush in the second digit track will be in the 0 zone only one half the time. A solution is to provide slip-ring brushes in the 0 zone of each digit track, directly coupled to the lead brush in the next higher order digit track. Then the 0 zone slip-ring brushes can be connected to external terminals. The complete wiring is illustrated in Fig. 5B.

Moving Patterns

Effect of moving the pattern beneath the brushes so as to occasion a transfer of the LSD brush from 7 (0111) to 8 (1000) will now be reviewed. Assuming in position 7 (0111) the LSD brush is conducting and current is directed to the lag brush in the second digit track, the logic brush in the second digit track is in a 1 zone. Therefore, the 1 zone slip-ring brush carries current to the lag brush in the third digit track. The logic brush in the third digit track is also in a 1 zone; thus, the 1 zone slip-ring brush carries current to the 1 zone logic brush in the fourth digit track.

The logic brush in the fourth digit track is in a 0 zone, thus the 0 zone slip-ring brush is energized. This arrangement would carry current to the lead brush in the next higher order digit track if one were shown and would give a voltage reading in the fourth digit position on the lower terminal. Readings on upper and lower terminal strips will be 0111 and 1000, respectively.

Assuming position 8 (1000) the LSD brush is nonconducting and load current is directed to the lead brush in the second digit track. The logic brush in the second digit track is in a 0 zone; therefore, the 0 zone slip-ring brush carries current to the lead brush in the third digit track. The logic brush in the third digit track is also in a 0 zone; therefore, the 0 zone slip-ring brush carries current to the lead brush in the fourth digit track.

The logic brush in the fourth digit track is in a 1 zone, thus the 1 zone slip-ring brush is energized. This arrangement which would carry current to the lag brush in the next higher order digit track if one were shown and would give a voltage reading in the fourth digit position on the upper terminal. Complete readings on upper and lower terminal strips will be 1000 and 0111, respectively.

In each of the cases described, the proper reading of the shaft position is taken from the upper terminal strip. Consideration of the possible positions in which the brushes will be placed as the disk moves indicates that the readings will always be exact opposites—that is, wherever there is a 1 reading for a given digit track on one terminal strip, there will be a 0 reading for the same digit track on the other terminal strip. As a result, the encoder provides not only a digital presentation of shaft position in binary form but also the one's complement of this number.

It can be seen that in any digit track, both logic brushes can and will find themselves periodically in the same zone. To prevent sneak circuits, diodes are introduced in the position shown in Fig. 5B.

The internal circuits appear to be and may actually be more complex than the ordinary V-scan encoder; however, it is only slightly so while replacing extensive, cumbersome and costly external brush selection logic circuits.

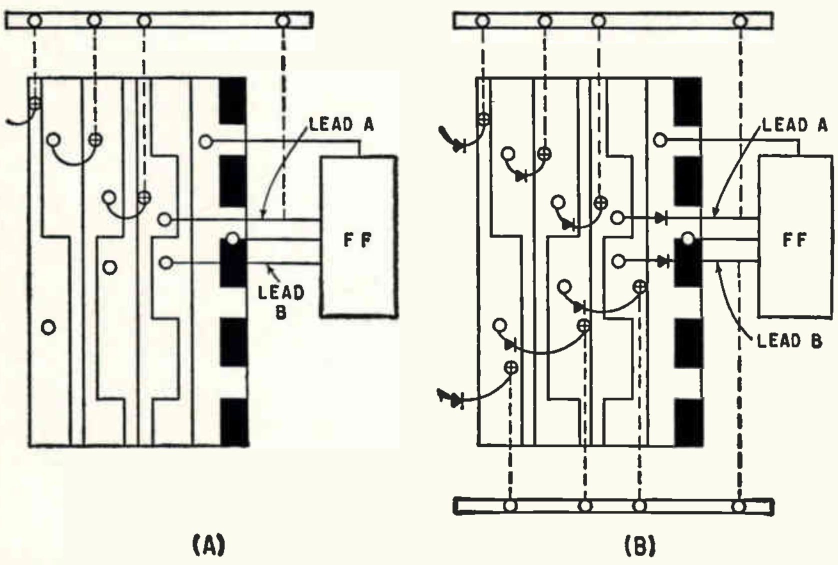


FIG. 5—Technique of obtaining output signal (A) and complete wiring diagram (B) of nonambiguous encoder

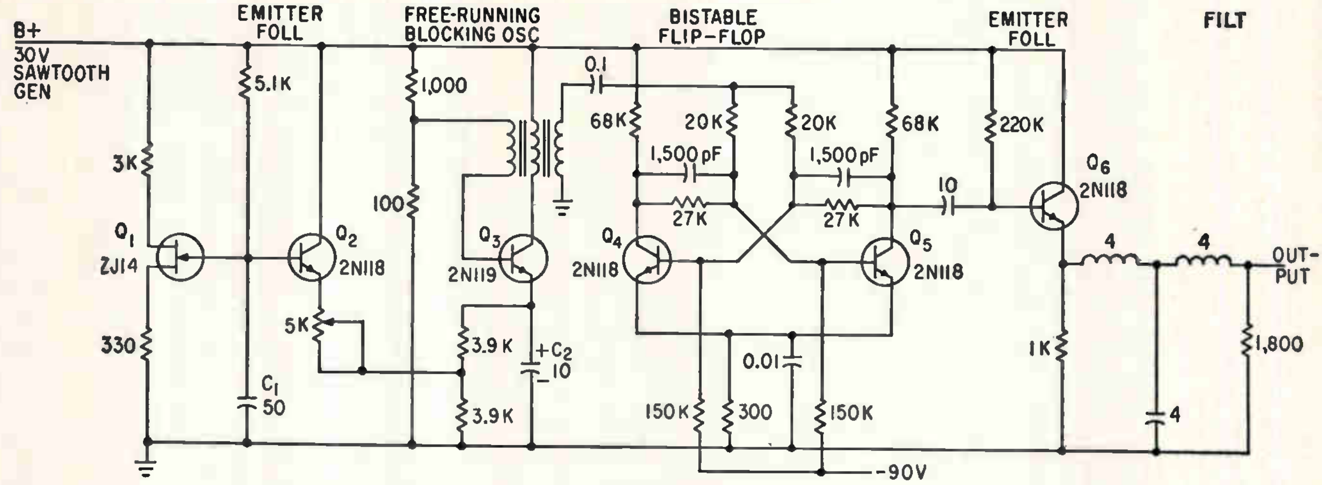


FIG. 1—Complete circuit of the swept frequency generator with a low-pass filter at the output. If desired, the distortion in the output can be decreased with more filtering

Subaudio Swept Signal Generator

Operating in the frequency range from 20 to 40 cps, this relatively simple generator can be used to test servos and related equipment and components. Sawtooth waveform developed by unijunction transistor circuit is used to key blocking oscillator

By **M. ROSEN,** Airborne Instruments Laboratory, Deer Park, L. I., New York

MOST EXISTING variable-sweep audio-frequency waveform generators are comparatively complex. The device described is simple and inexpensive to build, yet meets the requirement of checking the response of servo systems, circuit components, audio equipment, and other devices operating in the audio and subaudio frequency ranges. The characteristics are listed in Table 1.

Circuit Operation

Figure 1 shows the circuit. A transistorized sawtooth generator provides a waveform whose amplitude increases linearly with time. This waveform is applied to the timing circuits of a blocking oscillator. The period of the pulses generated by the blocking oscillator varies with the sawtooth voltage. Pulses generated by the blocking oscillator are fed to a flip-flop bistable circuit whose state reverses upon receipt of each pulse. The output of the bistable circuit consists of a series of rectangular waves of nonuniform duration whose period is twice that of the pulses at the blocking oscillator. Rectangular waveforms generated by the bistable circuit are fed to a low-pass filter through an emitter follower. A low-pass filter removes the higher-order harmonics and passes the fundamental frequency components of the rectangular waveforms. The low-pass filter output is substantially sinusoidal in shape. The emitter follower provides an output signal having a low source impedance. The heart of the timing system is a blocking oscillator operating in a free-running state.

Table I—Characteristics of Sweep Frequency Generator

Frequency range	20 to 40 cps
Sweep period	0.3 sec
Retrace time	<0.033 sec
Output	2 v peak-to-peak
Output impedance	<1,000 ohms

The blocking oscillator contains a regenerative feedback loop. The base circuit of the transistor is biased so that the transistor is virtually at cutoff. A sawtooth modulation waveform, introduced at the emitter portion of the transistor circuit, provides a variable

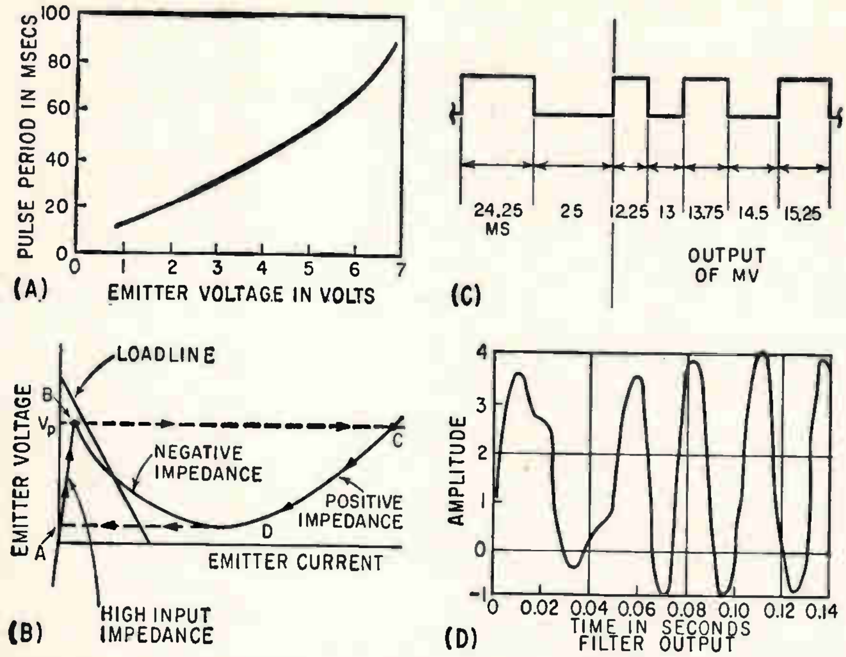


FIG. 2—Rate of pulses from the blocking oscillator is a function of the voltage on the emitter (A). In (B) is the path of operation of the unijunction sawtooth generator. The rectangular wave generated by the multivibrator (C), and the filtered output (D)

pulse repetition rate. The free-running period of the blocking oscillator is a function of the rate of decay of charge of capacitor C_2 and the absolute value of the emitter potential when the transistor is in saturation condition. Figure 2A shows pulse repetition period as a function of applied d-c voltage at the emitter junction.

A unijunction transistor is the active element of the sawtooth oscillator. The negative resistance characteristics are ideal for switching applications.

Figure 2B shows the transfer characteristics of the emitter circuit. The input impedance remains high because the emitter is back-biased in the cutoff region; the only current flowing is a few μa of leakage.

With 25 μa of emitter current flowing, the base 1 to base 2 resistance drops to about 800 ohms, with the major portion of the resistance located in the region from base 2 to the emitter. This portion of the semiconductor is only slightly affected by the minority carriers injected by the emitter. A current-limiting resistor is placed in base 2 to prevent overdissipation. The sawtooth oscillator operates similarly to a thyratron gas-tube oscillator.

By properly selecting the emitter load line, it is possible to have the unijunction operate as a monostable, bistable, or stable device. For a free-running sawtooth oscillator, the load line might intersect the emitter transfer curve above the peak point. Figure 3 is a schematic diagram of the sawtooth oscillator where R_1 represents the input impedance of a conventional transistor emitter follower nominally having a 5,000-ohm impedance in the emitter circuit. For the components used, R_1 has a value of 200,000 ohms.

The sawtooth generator oscillates when the emitter load line satisfies two conditions. First, the load line must intersect the ordinate axis (zero emitter current) at a value exceeding V_P. Second, the load line must intersect the emitter transfer characteristic line. Because the value of R_2 must be in the negative resistance region, its value was chosen to be 5,100 ohms. The unijunction transistor emitter load line satisfies both conditions.

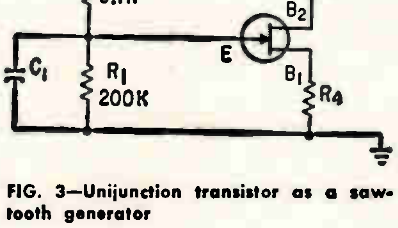


FIG. 3—Unijunction transistor as a sawtooth generator

The sawtooth generator operates in the following manner. When capacitor C_1 is fully discharged, the diode is in the OFF condition, with little current flowing into the emitter and through the base circuit. The emitter voltage at C_1 begins to rise until it reaches the peak point voltage corresponding to point *B* in Fig. 2B. At that point the emitter to base diode begins to conduct heavily. Because the input voltage is retained by the capacitor, the transistor operating point moves to point *C* (Fig. 2B). As the capacitor discharges through the unijunction transistor, the transistor operating point moves along the input characteristic curve, *C-D*, until the valley point is reached at *D*. At point *D* the transistor again becomes unstable, and the transistor current decreases until the operating point reaches point *A*. The cycle then repeats and the output is a sawtooth wave.

Multivibrator Design

The bistable device is a conventional transistor flip-flop circuit. When one transistor is conducting the other transistor is in the nonconducting state.

The transistor bistable multivibrator reverses state upon receipt of each pulse and a rectangular waveform appears at the collector of Q_5. This rectangular waveform, whose duration changes constantly, is fed to an emitter follower that presents a low source impedance to the low-pass filter. The pulse waveform is shown in Fig. 2C.

A single low-pass filter was used with this instrument. An analysis of the filter's response to the rectangular waveform was made using the *z* transform method and the results are shown in Fig. 2D. The curve shows distortion in the lower frequencies—also evident when the output waveform was displayed on an oscilloscope. There was also a slight variation in amplitude. Distortion can be reduced by using a filter with more sections.

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Radiation Effects On Electronic Systems

Designing electronic systems for nuclear-powered aircraft requires knowing response of system components and materials to irradiation

By **J. H. LEVINE**, Senior Nuclear Engineer,
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INDUCED NUCLEAR RADIATION is an environmental factor of concern to the electronics engineer designing electronic systems for nuclear-powered aircraft. Eliminating radiation-sensitive materials and components in design is vital for reliable system operation.

Radiation effects which have been observed in electronic materials and components are categorized as transient, permanent and secondary. Transient effects are changes in the properties of a material or component which occur during irradiation and disappear at some time after. Permanent effects are changes in electrical and mechanical properties which occur during irradiation and are irreversible. Permanent effects may depend either on the total amount of radiation received (dose effect) or on the intensity of the radiation (dose-rate effect).

Secondary effects include such radiation-induced phenomena as liberation of gas from organic materials and fluids, nuclear heating, air ionization and electromagnetic wave attenuation.

CONDUCTIVITY INCREASE—One example of a transient effect is the increase in conductivity of dielectrics as a function of gamma dose rate, as shown in Fig. 1. Recovery time after irradiation varies with the dielectric material, but, in general, 10 to 12 hours at room temperature is required for the conductivity to return to its pre-irradiation level.[1]

Permanent radiation damage has been observed in electrical insulations, electron tubes, semiconductors, potting compounds, capacitors, resistors, radomes, frequency control crystals, transducers, transformers, electrical connectors, flotation fluids, lubricating greases, and many other materials and components.

It is generally accepted that inorganic materials are more radiation-resistant than organic materials, a notable exception being the semiconductor class (ELECTRONICS, p 55, Nov. 27, and p 38, Dec. 25, 1959). Nuclear radiation produces changes in the various properties of organic materials by ionization and excitation processes which cause chain scission, cross-linking, free radical formation, and polymerization of the molecules. Gamma rays are the ionizing radiation of primary concern in organic damage work. Inorganic material damage, such as lattice structure dis-

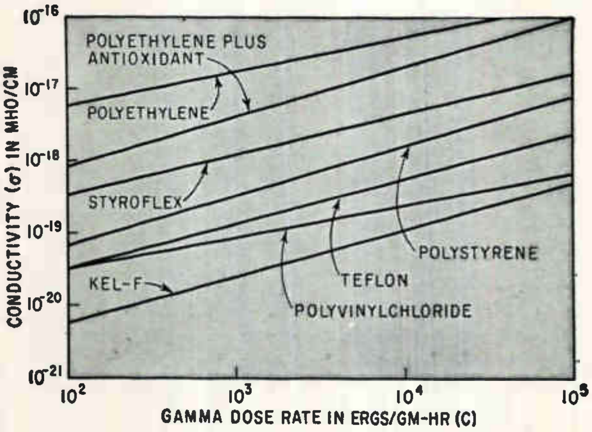


FIG. 1—Dielectric conductivity (σ) is related to dose rate by the expression $\sigma = I^n$, where I is the gamma-ray intensity and n is a constant depending on the specific dielectric (averaging approximately 0.5)

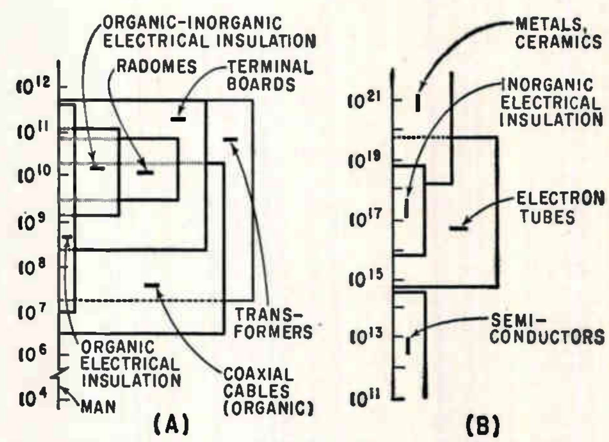


FIG. 2—Relative radiation resistance of organic materials (A) is based on energy absorbed in carbon by gamma rays and is given in ergs/gm; radiation resistance of inorganic materials (B) is based on fast neutrons/cm^2

placements in ionic-and-metallic-bonded materials, is primarily caused by heavy, energetic particles such as neutrons. Figure 2 illustrates the relative radiation resistance of several electronic materials and components.

In a reactor environment, the radiation field is mixed, containing predominantly neutron and gamma rays of various energies. Consequently, material or component damage must be analyzed with respect to the irradiation-component primarily responsible for the damage.

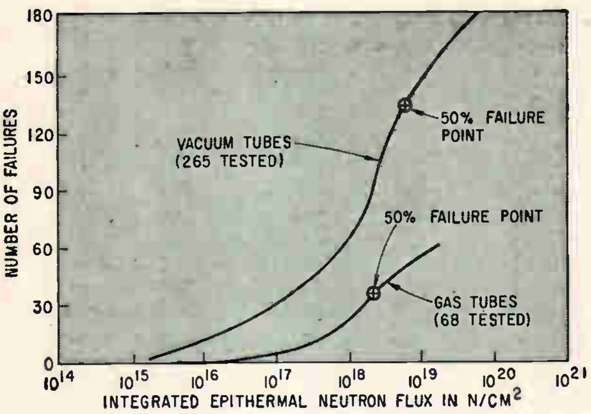


FIG. 3—Radiation damage to electron tubes is caused largely by fracture of the metal-to-glass seal, particularly in tubes using borosilicated glass

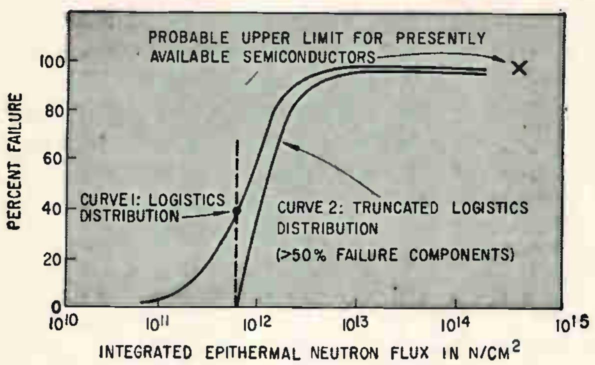


FIG. 4—Failure distribution of irradiated low-frequency transistors

Table I—System Analysis Summary

Material or Comp.	Type	Life[a]	Possible Modification	Replace. Life[b]
Electron Tubes	Vacuum	160	Addit. Test. or Devel.	>1,000
	Gas	2,500	———	———
	Photo	[c]		———
Transistors	Low Freq.	<1	Selection, Addit. Test, Devel. or Redesign to Elim. Transistors	>1,000
Capacitors	Mica	1.1×10^5	———	———
Elect. Insul.	Teflon	11	Formval Elect. Insulation	>1,000
Resistors	Deposited Film (Boron)	770	Deposited Film (No Boron)	>1,000

(a) Predicted nuclear life in hrs (b) Replacement predicted life in hrs (c) No transient radiation effects problem

The effect of sample size must also be considered in the evaluation. This relates to the surface area exposed to a particular environment and the radiation attenuation afforded by the material under consideration. For example, very thin specimens will allow secondary particle capture and multiple scattering to be neglected when calculating energy absorbed within the specimens. Since radiation damage is related to energy absorbed, specimen life in a radiation environment is lengthened.

RADIATION EFFECTS ANALYSIS—In the preliminary design of electronic systems for nuclear-powered aircraft, it is necessary to evaluate the materials and components using functional thresholds. A functional threshold is defined as the minimum amount of nuclear radiation required to change the properties of a material or functioning component to values outside the specification limits. Present thresholds are usually derived from general specifications and are, therefore, generally conservative.

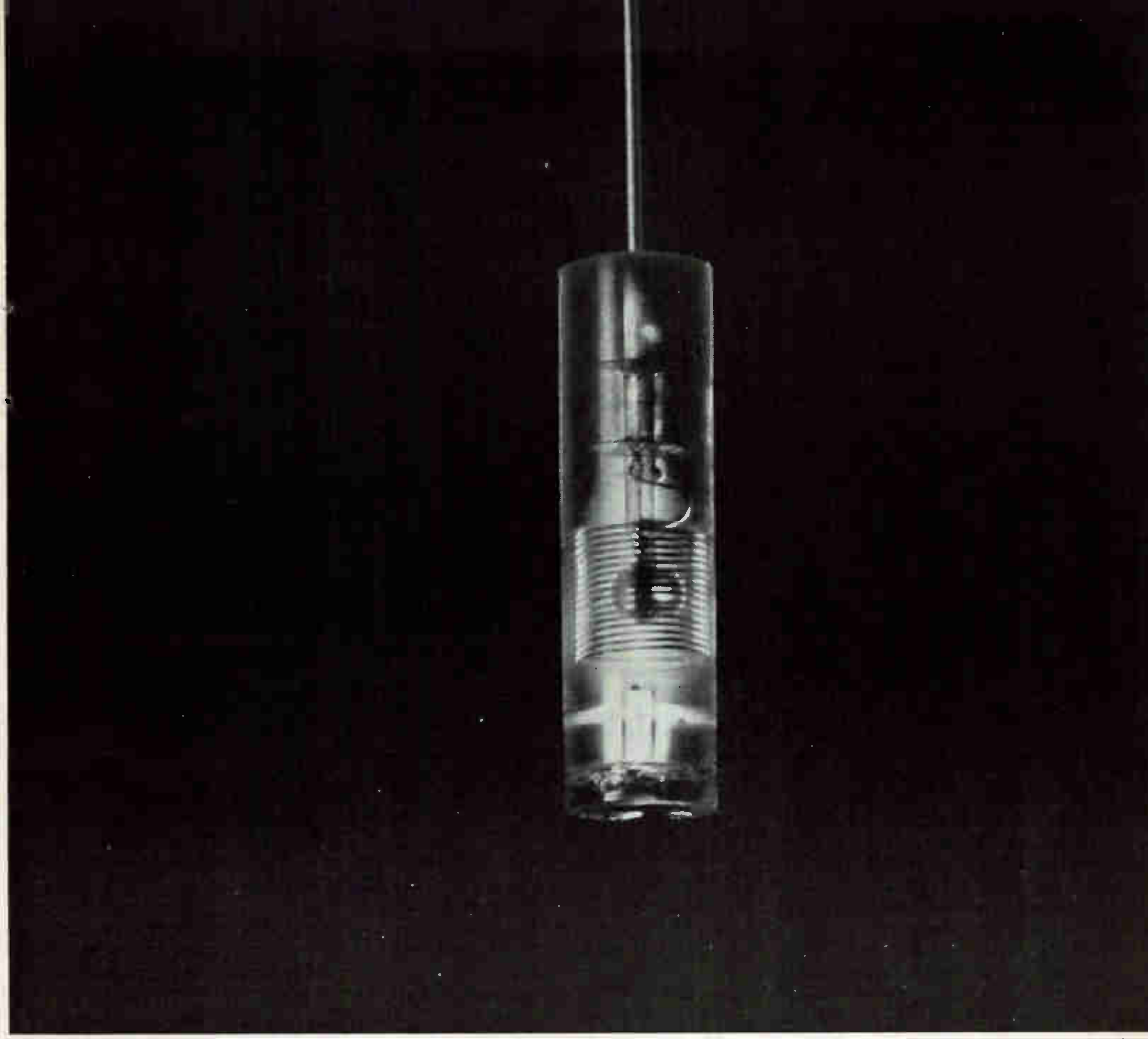
Where radiation data permit, a failure distribution can be obtained with statistical techniques. The logistics distribution is a distribution commonly used in analyzing electronic components. It is similar to a normal distribution but simpler to apply. Figure 3 illustrates the failure distribution of vacuum and gas tubes as a function of integrated neutron flux. The data used in plotting the curves are specification failures in some instances and catastrophic failures in others.

Figure 4 illustrates the failure distribution for low-frequency transistors. Curve 1 is the logistics distribution. Curve 2 is known as a truncated distribution[2]. The data used in plotting the curves are functional threshold points based on the integrated neutron flux when manufacturer tolerances are exceeded for particular types of low-frequency transistors.

Test data indicate that low-frequency transistors capable of operating in excess of the 50 percent point plotted in curve 1 are available. The procedure is then to select and test in a nuclear environment, low-frequency semiconductors whose specification-allowables are not exceeded prior to the 50 percent point. The truncated distribution curve illustrates the improvement trend which may be expected. Based on the 50 percent failure point, the functional thresholds for low-frequency transistors, high-frequency transistors, point-contact diodes and *pn* junction diodes are 6.5×10^{11} n/cm^2, 8×10^{12} n/cm^2, 8×10^{13} n/cm^2 and 1.6×10^{13} n/cm^2, respectively.

SYSTEM ANALYSIS—After the material and component evaluation, the radiation effects analysis of the system may be initiated. Two methods are currently employed. These include the weakest link concept and the computer simulation technique.

The weakest link concept is based on the premise that a system is no better than the component most sensitive to irradiation. Table 1 indicates the critical components in a system operating in a Grade E environment set forth in WADC specification WCRE 56-lb[3]. The limiting component or weakest link in the system is the low-frequency transistor with a



Sample cell used at the IBM Watson Laboratory for studies of the self-diffusion of quantum liquids.

Studying Quantum Liquids to Observe Nuclear Theory

Atomic nuclei are dense systems composed of identical particles which obey Fermi-Dirac statistics. Using these statistics, scientists have computed the theoretical behavior of the particles which compose heavy nuclei.

Helium³, a quantum liquid, provides scientists with an extremely convenient model of this nuclear matter – a model readily accessible to research. A cryogenic liquid, He^3 permits the investigation of quantum effects. This makes it possible to compare nuclear behavior with theoretical predictions.

Research in quantum liquids is being done at the IBM Watson Laboratory at Columbia University. Direct spin-echo measurements of diffusion and nuclear relaxation were made on He^3 atoms in the pure liquid, and also in dilute solutions of He^3 in He^4. Measurements were made in the temperature range 0.5°K to 4.2°K, at pressures up to 67 atmospheres.

Experiments on the pure quantum liquid revealed diffusion persisting to the lowest temperatures. However, it was apparent that the diffusion was not thermally activated as in an ordinary liquid, or in a gas. Diffusion persisted for two reasons: (1) because of the zero-point energy of the atoms, and (2), because of the atoms' long wave length as compared with the thickness of the potential barriers which inhibited their motion. The results of the experiments on dilute solutions of He^3 in He^4, in accord with expectations, showed that the He^3 diffusion coefficient increased rapidly with decreasing temperature.

This study will help to increase our understanding of quantum systems, and consequently, help to increase our familiarity with nuclear matter.

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predicted nuclear life of less than one hour. This lifetime is based upon consideration of the more radiation-resistant low-frequency transistor types and a low failure rate.

The computer simulation analysis technique uses an analog computer to simulate the system under consideration. The characteristics of the components making up the system are varied according to changes which have been observed during the irradiation. System response is then studied as a function of these changes which are, in turn, related to various radiation exposures.

IRRADIATED COMMUNICATION SYSTEMS—Two System Panels tests have been conducted with the Ground Test Reactor as a radiation source[4, 5]. B-36-type systems as well as more recently developed systems were irradiated.

Table II is a compilation of the irradiation results of communication-type systems irradiated during these tests. It is noted that the AN/ARN-14 omnidirectional receiver and the AN/ARC-34 communication set operated without failure to integrated neutron fluxes in excess of the functional threshold of 1.6×10^{13} nvt for *pn* junction diodes. The diodes used in these electronic systems were not selected for their radiation resistance. The point to be made here is that there are off-the-shelf semiconductors whose radiation resistance tends to verify the truncated distribution procedure discussed previously. It should be emphasized however, that additional testing is necessary to select the more radiation-resistant semiconductors with a high degree of statistical confidence.

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Table II—Irradiation Data on Communication-Type Systems

System[6]	Irradiation Gamma (ergs/gm-C)	Irradiation Neutron (n/cm²)	Results	Critical Component
Radio Receiving Set AN/ARN-18 (Glide Slope Receiver)	1.5×10^8	2.1×10^{13}	No change in performance	
Radio Receiving Set AN/ARN-14 (Omni-directional Receiver)	1.2×10^8	1.7×10^{13}	No change in performance	1N43 Germanium Diodes
Marker Beacon Receiving Set AN/ARN-12	1.5×10^8	2.1×10^{13}	No change in performance	
Radar Identification Set AN/APX-6 (IFF)	8.7×10^8	1.2×10^{14}	No failure but drop in efficiency observed	Unknown
Radio Receiving and Transmitting Set AN/ARC/27 (UHF)	6.8×10^8	1×10^{14}	No appreciable radiation damage	
Receiver Transmitter AN/ARC-27	8×10^8	2×10^{14}	No change in performance	
IFF Transponder AN/APX-6	9×10^8	2×10^{14}	Radiation induced damage not detectable	
UHF Communication Set AN/ARC-34	3×10^8	3×10^{13}	System operated within specs throughout test	
UHF Communication Set AN/ARC-34	4.7×10^{8a}	5.4×10^{12a}	System failed at indicated dose level	1N69 Germanium Diodes
Intercommunication Set AN/AIC-10	9×10^8	2×10^{14}	Radiation caused damage was not detectable	
Marker Beacon Receiving Set AN/ARN-12	3×10^9	1.2×10^{14}	No appreciable radiation damage	
Marker Beacon Receiving Set AN/ARN-32	3×10^8	1.2×10^{14}	No appreciable radiation damage	
Marker Beacon Receiving Set AN/ARN-12	1.3×10^9	1.2×10^{14}	System did not fail as result of irradiation	
Radio Receiving Set AN/ARN-18 (Glide Slope Receiver)	3.4×10^{6a} 1.8×10^9	5.6×10^{11a} 1.2×10^{14}	System failed after 89 hrs of irradiation	1N69 Germanium Diodes
Radio Receiving Set AN/ARN-14 (Omni-directional Receiver)	6.5×10^8	8×10^{13a}	System failed after 165 hrs of irradiation	1N43 Germanium Diodes

(a) Dose at time of malfunction

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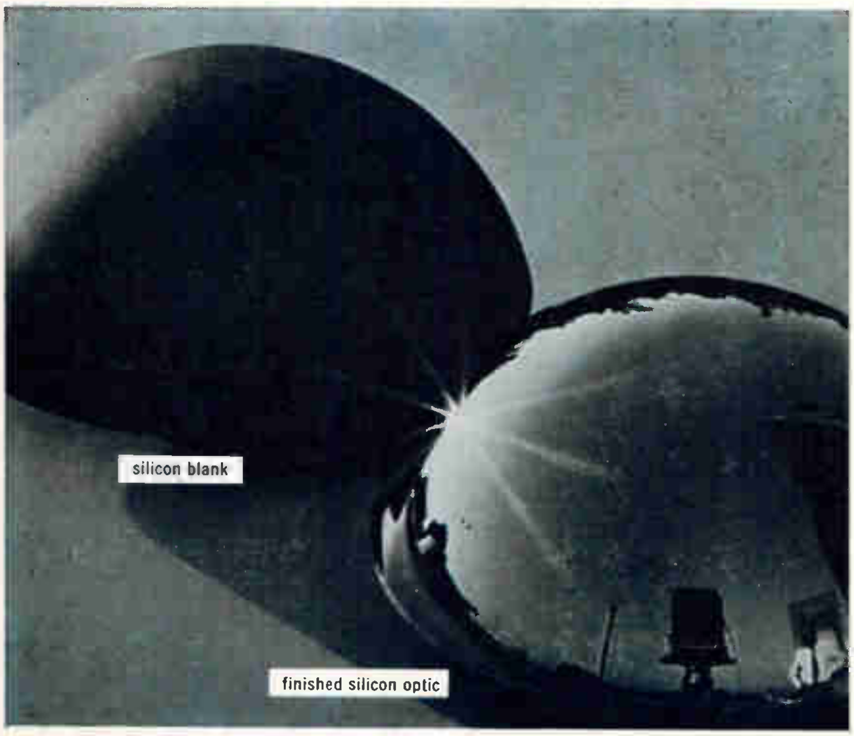

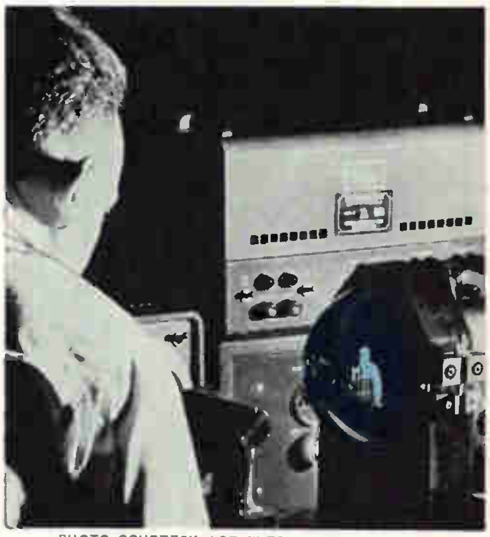

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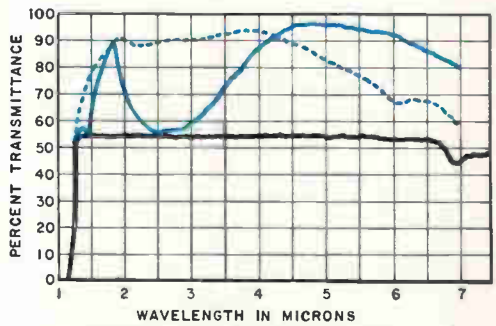

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The black line indicates the percent of transmittance for silicon is relatively constant from 1.3 to 6.7 microns. Blue lines show how transmission is increased by coating. Single coating provides maximum transmission on a narrow band; several coatings, dotted blue line, give maximum transmission on a broad band.

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Silicon Junctions Detect Particles

SILICON *pn* junction particle detectors were made in a program sponsored by the U. S. Atomic Energy Commission and Bell Telephone Laboratories. The work was described at the 7th Scintillation Counter Symposium in a paper by G. L. Miller of Brookhaven National Laboratory and W. L. Brown, P. F. Donovan and I. M. Mackintosh of Bell Labs.

Ionizing particles incident on the depletion layer of a reverse-biased junction create hole-electron pairs. About 3.5 $\pm$0.07 ev of incident particle energy, ϵ, produces one hole-electron pair. Experimental evidence indicates that ϵ is independent of particle type. Any particle losing ϵ Mev of energy in the depletion layer produces N hole-electron pairs, where $N = \epsilon/3.5 \times 10^6$. These carriers are the basic signal. With independence in carrier production process, Gaussian distribution should occur with resolution limited by $N^{½}$ fluctuations.

Total charge liberated is $Q_L = 1.6\ N \times 10^{-19}$ coulumbs. If carriers cross a fraction f of total potential across the device, charge collected is $Q_C = f\ Q_L$, as in an ion chamber.

The depletion layer is the sensitive region since it has voltage across it. Depletion layer thickness in microns is about $d = \rho\ v^{½}/3$, where ρ is resistivity of the p region in ohm-cm and v is applied reverse bias voltage. The ρv product should be maximum to detect high-energy particles and reduce capacitance.

Capacitance is that of a parallel plate capacitor d microns thick and is proportional to $v^{-½}$. If detector and stray capacitance in parallel is C_t farads, signal energy is $E_s = Q_C^2/2C_t$ joules. Increasing C_t reduces signal energy and S/N

Detector reverse leakage current also affects S/N. This current flows in C_t and circuit shunt resistance. Leakage fluctuations produce noise at the amplifier input.

Collection by diffusion also affects depth sensitivity. Carriers produced outside the depletion region may diffuse to the boundary of that region. The minority carrier is swept across contributing to total signal. Time for a carrier to diffuse L microns is about $t = L^2$ nsec. Hence this method of collection is slow over a reasonable distance. Also carrier life time must exceed it for efficient collection.

Dead Layer

The diffusion process can produce an essentially zero dead layer even for heavily ionizing particles. If L is small enough (n region thin enough) only a short life time is needed for carriers to reach the junction and be collected.

A 1.0-μ device had a dead layer of about 0.5 μ, so that collection took place from about half the n region by diffusion. A much thinner diffusion might achieve 100 percent collection. A more sensitive test was made with fission fragments. Because of their high initial charge state, fission fragments lose most of their energy in the extreme surface of a detector.

A Cf^{252} fission spectrum was obtained with a 0.1-μ n layer. Results agree with time-of-flight data within the accuracy limits of both methods. Thus ϵ for fission fragments is the same as ϵ for other particles. Also the device must have negligible dead layer or absolute energies would be lower.

Results show that these detectors do not exhibit the ionization defect of gaseous ion chambers. Also there is negligible columnar recombining along the track of the fission fragment even though peak carrier density must be about 10^{20} cc^{-1}.

Electronics

Detector output is voltage Q_C/C_t, but total charge is the quantity of interest. Therefore a charge-sensitive amplifier was used. Rise time of 20 nsec was used because device leakage in general is not white noise. It has an f^{-a} dependence on frequency, with a close to unity.

Total grid impedance also behaves like f^{-1} since it is essentially a capacitance. Hence noise voltage varies as $1/f$ to a large power. However, because of the fast detector signals, short clipping time far from the high noise region is possible. Thus noise line widths of about 20 Kev were obtained even from devices with about 1 μa leakage current. If high-energy particles are to be detected, thick depletion layers must be used, contributing to leakage current by space-charge generation in the depletion layer.

The thickest depletion layers used (700 μ) can stop a 10-Mev proton. Volume-generated leakage current is proportional to depletion layer thickness. At high bias voltages it is the dominant source of leakage current.

Space-charge generated leakage current is inversely proportional to carrier life time. Therefore initial long life of the starting material (hundreds of microseconds) should be preserved. Unfortunately high-temperature diffusion reduces life time. Results indicate a life time of about 10 μsec, a fifty-fold reduction of starting value. However, only diffusion techniques seem capable of producing the thick depletion layers.

Edge Protection

Surface-generated currents often contribute to leakage. They may also contribute disproportionately to noise because of their far from white spectrum. Degradation was often noted over periods of days. An oxide layer was tried to protect the junction with promising results for 1.0-μ diffusions. Difficulties arose with thinner diffusions.

Since leakage current decreases monotonically with decreasing bias voltage, good resolution might be achieved by operating high-resistivity devices with small biases. Device area would be small to limit capacitance. However, resolution was much worse than expected because at low bias voltages, collection efficiency is poor. Statistical uncertainties in the fraction of

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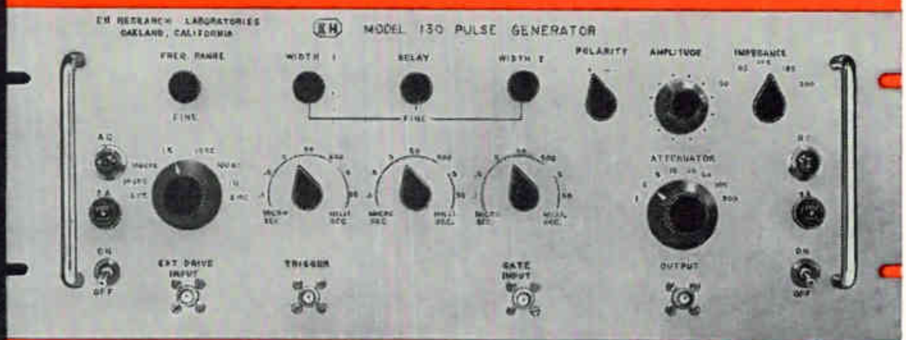

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JITTER (Pulse widths, relative delay, rep rate)
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TRIGGER OUTPUT
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EXTERNAL DRIVE
3 volts rms required (0.1 volt or 2 mμsec equivalent jitter referenced to Pulse Output)

ELECTRONIC GATE
10 volts required

OUTPUTS
Two Pulses at one output connector, independently variable in width and relative delay

PULSE WIDTHS
100 millimicroseconds to 50 milliseconds

PULSE AMPLITUDE
0 to 50 volts maximum
0 to 500 ma maximum

POLARITY
Positive or Negative Pulses available

DUTY FACTOR
50 percent

OUTPUT IMPEDANCE
50, 93, 125, 185 or 200 ohms available (selected by front panel switch)

OUTPUT ATTENUATOR
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Here at last is a pulse generator which can shoulder a broad range of applications . . . a flexible, reliable pulser whose fast rise and low jitter features make it the most advanced instrument of its kind. With its provisions for external drive and electronic gating, its enormous range in pulse widths and delays, and the arbitrary cable impedance feature, you'll find the E-H 130 indispensable for almost any pulser job. Call, write or wire E-H for more information today.

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carriers collected limit resolution.

With the high carrier mobilities and high limiting velocities of carriers in silicon, fast charge collection was expected in the detectors. To check this, fission fragments were counted in a 1,000 ohm-cm *pn* device. Fission fragments provided the large signal required to trigger the sampling oscilloscope used.

Expected rise time was about 2 nsec, and actual system rise time was 1.5 nsec. Rise time from the fission fragments was 10 nsec, well beyond experimental error.

The diffused silicon *pn* junction detectors were made up to 1 cm^2 in area and with depletion thicknesses up to 0.7 mm. They had negligible dead layers and exhibited line widths down to 20 Kev.

Semiconducting Diamonds Made

INDUSTRIAL diamonds may prove valuable for highly sensitive thermometers, as transistors and as small Geiger probes. A high-voltage electron accelerator has been installed at Diamond Research Laboratory, Johannesburg, to study these and other possible applications of diamond. The research is sponsored by De Beers Consolidated Mines, Ltd., and Industrial Distributors, Ltd.

The cascade electron generator can be operated for 24 hours a day if necessary. The accelerator will permit study of diamond under the effects of both electron beams and gamma rays, which alter hardness, electrical conductivity, surface structure and other characteristics of diamond.

Applications

Diamonds have potential applications in medicine and electronics. The electrical resistance of some types of semiconducting diamonds varies with slight changes in temperature. A recorder connected to one will register changes in temperature as small as 0.05 C.

Highly sensitive thermometers using these semiconducting diamonds could be important in medicine to record minute temperature changes in the skin and other body parts. Some areas of industry also need very sensitive thermometers. Some semiconducting diamonds

ging Concepts of the Cosmos

Reproduction of one of the finest, current drawings of Mars, showing the visible markings of the planet, and a dust storm sweeping across its surface. The original is by Dr. de Vaucouleurs of Harvard College Obser

about Mars. It rotates on its axis with a day of 24 hours, 37 minutes. It has changing seasons, and a diameter about half that of the earth.

Through a large telescope Mars looks reddish-yellow with patches of grey or grey-green. What are these patches? Oceans, said early astronomers. Vegetation, we believe today.

We can see the polar caps of Mars: most likely thin layers of frozen water, for they vanish in summer and return in winter.

On Mars, you would find the atmosphere thin and probably composed of carbon dioxide and water vapor. There would be very little water. The Martian sky would be nearly black, and dotted with high-floating blue or violet clouds of fine ice powder.

You would face storms at times. And strong winds that sweep up large clouds of yellow dust as they drift across the planet.

Some observers have said they see a complex web of fine lines on Mars. Other, equally reliable observers have seen nothing. Most astronomers now agree that these controversial "canals" may be only an optical illusion. But they are surely not artificial waterways.

Where vegetation exists—and we believe it does on Mars—animal life is possible, too, though it is not likely that human-like life will be found. But here we have no relevant observations. Only exploration of the planet—first by probes and then by manned expeditions—can answer this question in a final way.

Because we believe that cosmography—the geography of the cosmos—will play a vital role in the future, McDonnell Aircraft has instituted important basic research in astronomy, solid-state physics, chemical kinetics and mathematics.

These research programs are oriented toward a fuller understanding of the universe: That men—men of all nations—may cooperate in the exploration of space, the moon, the sun, and the planets. That, through such adventure, men may better understand themselves and one another.

McDONNELL *Aircraft* St. Louis 66, Missouri

VE INVITE INQUIRIES FROM ENGINEERS & SCIENTISTS INTERESTED IN PARTICIPATING IN CURRENT SPACE PROGRAMS AT McDONNELL could also serve efficiently as point-contact transistors that can be subjected to large fluctuations in temperature without damage or loss of efficiency. These transistors may be valuable in extraterrestrial devices that encounter extreme temperature changes.

Some diamonds function as counters of radioactivity. A likely application of this property is in detecting radioactivity in deep-earth drilling where the small size of the diamond would be an advantage. Another use may be in medicine for small Geiger probes to trace radioactive materials introduced into patients for diagnostic purposes.

The research program may also reveal heretofore unknown properties of diamond.

Flowmeter Cancels Temperature Effect

ULTRASONIC flowmeter uses two crystal transducers that direct beams along a common path to eliminate temperature errors. They are mounted at an angle outside the measuring section of pipe, creating no flow disturbance and therefore no pressure drop. The instrument was developed by the British Scientific Instrument Research Association, Chislehurst, Kent, England.

Each transducer operates simultaneously as both a transmitter and receiver, transmitting ultrasonic beams that are received by the other transducer. Since they are in line along the pipe, one beam is directed upstream and the other downstream. If there is no flow, beam travel times will be equal. With flow, upstream time will exceed downstream time, with the time difference proportional to flow rate.

A continuous wave of 5 Mc is used, with phase difference between the two received signals indicating time difference. Since it would be difficult to measure phase difference between two 5-Mc signals, it is extracted at lower frequency.

Phase difference is fed in pulse form to a bistable multivibrator that generates an output pulse of duration proportional to flow rate. Flow rate is also integrated with respect to time to indicate quantity.

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silicon diodes

IN ANY COMBINATION OF CHARACTERISTICS

high speed • high conductance • high temperature
high voltage • high back resistance
complete reliability

General Instrument semiconductor engineering has made possible these silicon diodes with a range of characteristics never before available to the industry.

The types listed here are just a small sampling of the complete line which can be supplied in volume quantities for prompt delivery. General Instrument also makes a complete line of medium and high power silicon rectifiers. Write today for full information.

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1N456	1N461	1N625	1N482	1N484A
1N457•	1N462	1N626	1N482A	1N484B
1N458•	1N463	1N627	1N482B	1N485
1N459•	1N464	1N628	1N483	1N485A
		1N629	1N483A	1N485B
		1N662†	1N483B	1N486
		1N663†	1N484	1N486A

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PLUS a large group of special DR numbers developed by General Instrument Corporation with characteristics that far exceed any of the standard types listed above!

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Answers to Printed-Motor Questions

IN THE SUMMER of 1958, Photocircuits Inc., of Glen Cove, New York heard about a French technique for incorporating a two-sided printed circuit armature in a d-c motor. They were quick to see that this development held an answer to the problem of obtaining excellent speed of response and smooth torque directly from a motor shaft.

The technique was invented by a research and development firm in Paris, the Societe d'Electronique et d'Automatisme. After investigation and negotiation, Photocircuits introduced the printed circuit motor into this country at the 1959 IRE show (ELECTRONICS, 20 Mar. 1959, p 70). However at that time the American company was experimenting with prototype models.

During the past year, Photocircuits has reduced techniques to practicality, and at this year's IRE show their production models of printed machines got a lot of attention.

Engineers who visited the Photocircuit booth at the New York IRE show last month asked a lot of questions about these motors. And ELECTRONICS stayed around long enough to hear the answers:

Question: What is the PMI printed machine?

Answer: It is a new type of permanent magnet d-c servo motor. Printed Motors Inc., Glen Cove, New York holds the patents in this country and Photocircuits is handling manufacturing and distribution.

Q: What are the advantages of its printed armature?

A: The disc-type armature contains *no iron*, resulting in unusually low inertia and negligible inductance. The uninsulated conductor pattern of the flat armature produces greater exposed surfaces for cooling. As a result, higher current pulses can be applied, effecting very high pulse torque values.

Q: What about the commutator?

A: No special commutator is needed, since commutation is accomplished directly on the conductors.

Q: Then does this mean that the absence of rotating iron eliminates preferred armature position and cogging?

A: Yes. This fact plus the large number of conductor (commutator) bars. As a result, remarkably smooth torque over the entire speed range is obtained.

Q: Then this means that gearless drives are now possible?

A: Yes.

Q: Can the printed motor be used under high temperature and radiation environments?

A: Studies are now being conducted to determine the feasibility of high temperature and radiation exposure operation of a printed motor which incorporates an armature printed on a high alumina ceramic base and high-temperature dry bearings. Initial experiments have been successful.

Q: What is the smallest size motor that can be produced with present day techniques?

A: It appears that the smallest size producible with present day techniques is about 4 in. diam and 2 in. long.

Q: Can printed motors be produced in large sizes?

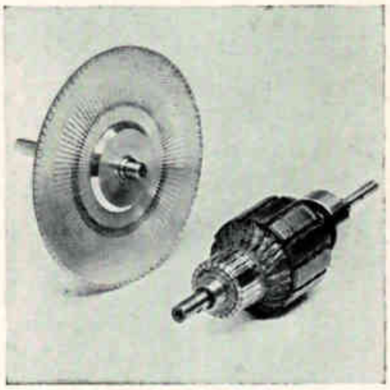
A: Experience with an experimental three-horsepower machine which has been produced indicates superior performance in larger sizes. There seems to be no mechanical limitation in the production of large diameter pancake-shaped printed motors.

Q: Can printed motors be used as tachometer generators?

A: The basic fact that there is no rotating iron in these machines indicates good performance as tachometer generators. Developmental work is being done in this field at present.

Q: Where are printed motors now being used?

A: The largest production use is

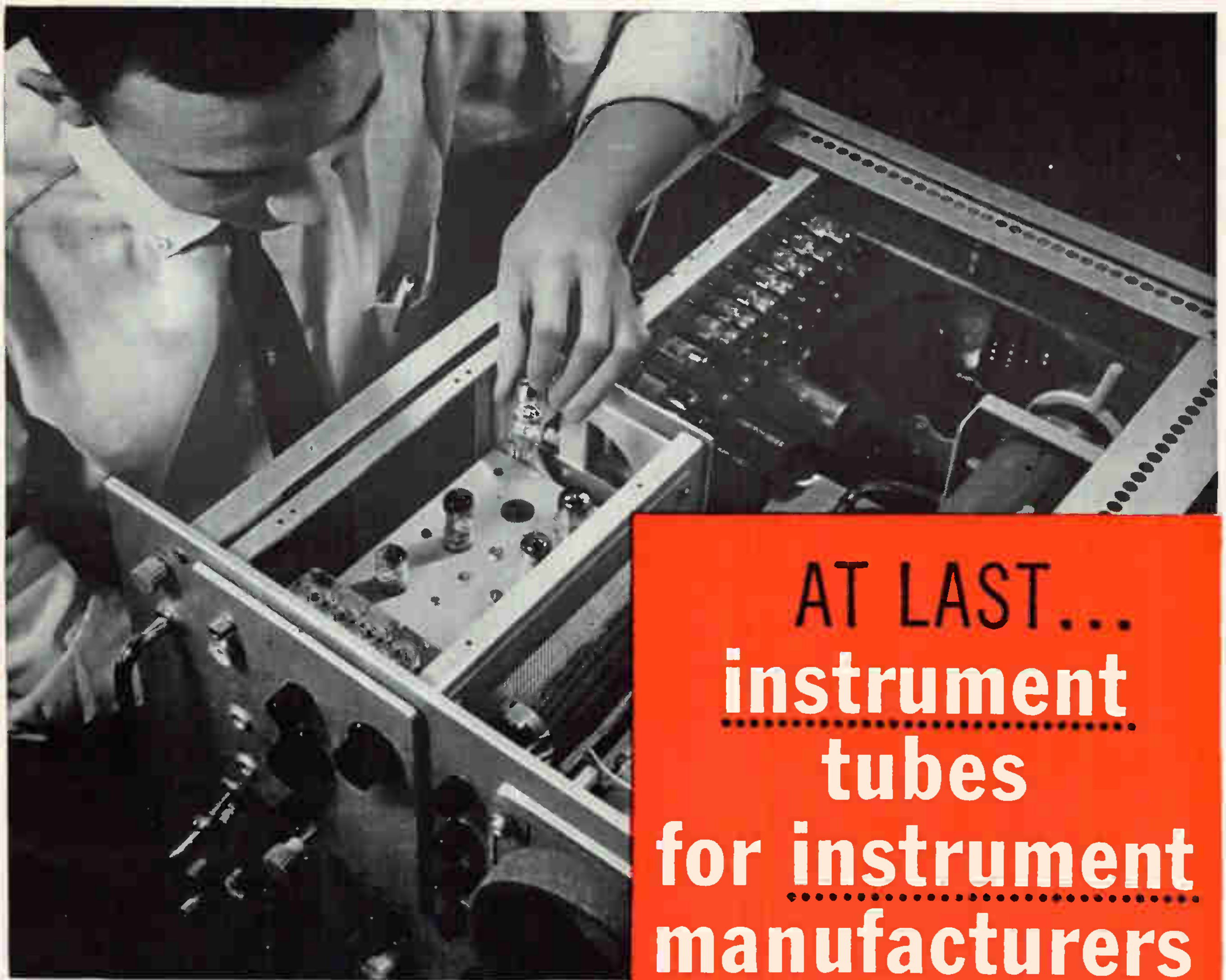


Concept of the flat-disc armature (left), utilizing printed circuit techniques, opens up exciting possibilities for practical d-c motor drives. Here the standard armature is compared with the disc-type version

Table I—Direct Drive Printed D-C Servo Motors

Characteristics	Model 368	Model 488
Rated Torque, Continuous Duty, (oz in)	12	42.5
Max Pulse Torque Capability, Intermittent (oz in)	150	375
Armature Inertia, Including Hub & Shaft (oz in sec²)	0.005	0.018
Mechanical Time Constant (sec)	0.025	0.025
Armature Inductance (μH)	<200	<200
Rated Speed, Continuous Duty (rpm)	3,500	3,000
Rated Current for 70 C Rise, Cont. (amps)	6.5	7.5
Rated Voltage (v)	12	24
Power Output (w)	30	95
Magnetic Field (Alnico)	8 pole	8 pole
Number of Commutation Segments	97	121
Armature Resistance (ohms)	0.37	0.57
Maximum Friction Torque (oz in)	2	2.2
Back EMF per 1,000 rpm (v)	2.22	5.55
Average Torque per Amp (oz in)	3	7.5
Weight (lbs)	3	6.5

Models with shaft modification and internal damping also available



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- **Stable Characteristics**
Degradation of characteristics is controlled through special stabilization (48-hour) and life tests for plate (and screen) currents, insulation and interface resistance, spurious grid currents, etc.

- **Minimized Undesirable Characteristics**
Spurious grid currents, microphonism, hiss noise, interface impedance, and heater-cathode leakage (e.g., as low as 5 μamps max.) are minimized. Satisfactory operation at low and high line voltages is assured by controlled cathode activity.

FEATURES

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- 100-hour early life assurance test
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- Customer-specified AQL values

MOST COMPREHENSIVE LINE

- Instrument versions of standards
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The "new-concept" CBS Instrument Tube line is fast becoming the most comprehensive in the industry.

CBS Electronics meets an industry challenge by producing a new line of Instrument Tubes. Especially designed, manufactured and tested for instrument and test equipment manufacturers, they make it unnecessary for you to screen or "burn in" tubes to achieve instrumentation reliability.

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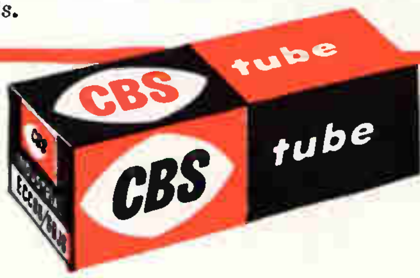
Call your Manufacturers Warehousing Distributor, your local sales office . . . or write direct for technical data sheets.



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CIRCLE 81 ON READER SERVICE CARD

in Photocircuits own photoelectric tape reader. Here the low armature inertia allows step-by-step reading without introducing noisy clutches or brakes to stop the perforated tape. Other uses include magnetic tape reel and capstan drives, as well as positioning devices for the machine tool industry. There is a lot of interest coming from the servo people, and in automotive and traction applications. The speed of response and smooth torque obtainable directly from the motor shaft enable engineers to design servomechanisms having superior performance. In addition, the low impedance feature makes the printed motor especially suitable for semiconductor circuits.

Q: What are the characteristics of the two models now available?

A: See Table I, p 80.

Combined Transistor Simplifies Circuitry

IN CONVENTIONAL transistor radios only limited automatic-gain-control can be applied to a conventional converter stage. And a combination oscillator mixer capable of being gain-controlled would simplify the designs of portable and automobile transistor radios.

A new developmental double-emitter multi-purpose transistor, re-

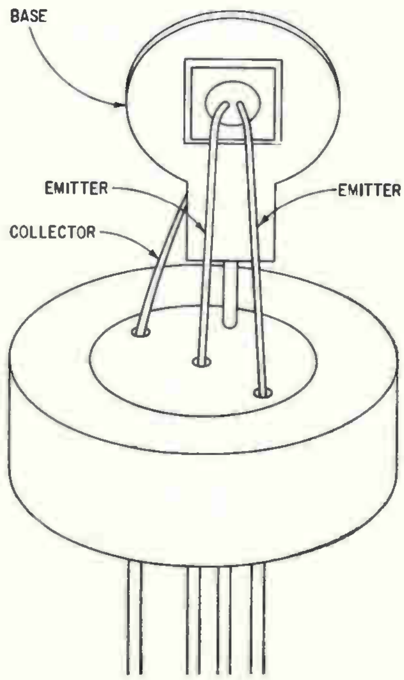


FIG. 1—Oscillator-mixer device

cently described by L. Plus and R. A. Santilli of RCA promises to apply agc directly to the mixer portion of the circuit without affecting the oscillator portion, and combines two functions which are normally accomplished by two transistors. Another technical advantage of the double-emitter transistor is the freedom from oscillator blocking under strong signal conditions.

Construction

The RCA multi-junction drift-field transistor, Fig. 1, has two alloyed p-type emitters, an n-type base, and one alloyed p-type collector. The two emitters are processed so they can function independently of one another.

Plus and Santilli describe several methods for obtaining improved agc with the new device in oscillator-mixer circuits. They showed complete circuit diagrams for a developmental four-transistor automobile receiver and a developmental portable broadcast-band receiver using a double-emitter transistor as a mixer oscillator and having sensitivities of 18 microvolts and of 500 microvolts per meter.

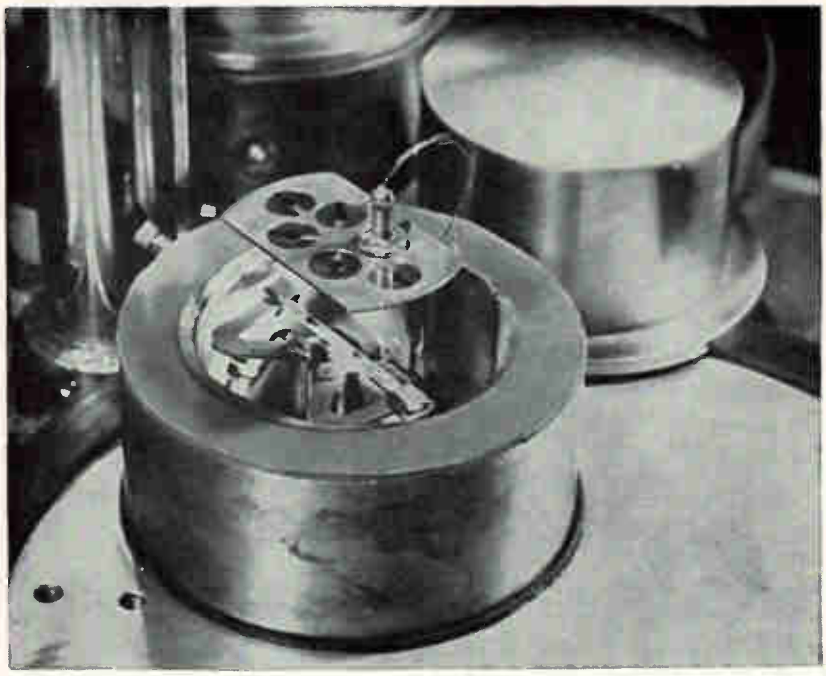
Technical feasibility of the device and its application as a combination oscillator-mixer capable of being gain controlled have been demonstrated. Among the first significant results expected of this developmental transistor will be the design of broadcast-band receivers exhibiting excellent agc performance with only a frequency converter stage without an overload or clamping diode.

Color Code Standards

TYPE NUMBERS assigned to semiconductor diodes and rectifiers may be indicated on the device by color bands coded in accordance with EIA-NEMA standards formulated by JEDEC (Joint Device Engineering Council), according to a recent bulletin.

Last month Electronic Industries Association also issued standards to be employed with traveling-wave tubes that are equipped with flying leads.

Recommended standards are adopted in the public interest.



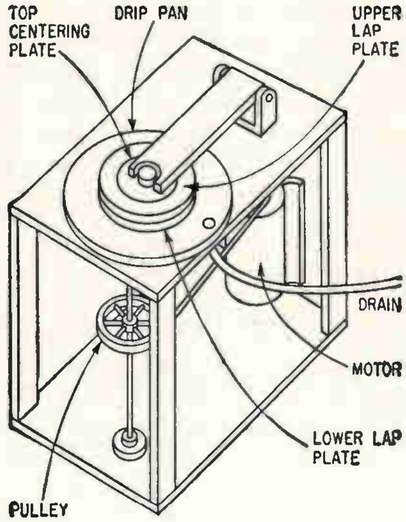


FIG. 1—Crystal polisher

Closeup of plating chamber. Plating is monitored by button electrode on crystal

Monitor Crystal Base-Plating

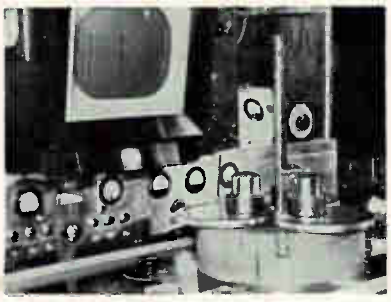
By **GEORGE F. FISHER**, Midland Manufacturing Co., Inc., Kansas City, Kansas

INCREASING familiarity with the production of VHF quartz crystal units has resulted in improved lapping, polishing and base-plating techniques, as well as improved design and a rise in the upper frequency limit.

Acceptable yield rates are obtained at frequencies up to 140 mc, in production, and up to 190 mc in small lots. Crystal blank size has been reduced from 0.5 inch to 0.3 inch, facilitating transition from HC-6/U to HC-18/U type holders.

The extension of the frequency range necessitated additional work on very thin AT quartz plates and processing for fifth and higher overtones. The manufacturing techniques are described below.

Conventional methods are used during crystal orientation, mounting, sawing, x-raying, dicing and rounding. However, units requiring tolerances tighter than ± 0.005 percent are x-rayed again after intermediate lapping. Blanks are x-rayed when at a fundamental frequency of 7 mc to 10 mc. The primary purpose is not selection, but obtaining thinner plates and closer process control. After blanks are lapped with 5-micron abrasive, they are cleaned and optically polished.



Base-plating equipment, showing arrangement of plating chambers (foreground) and frequency scanning monitor

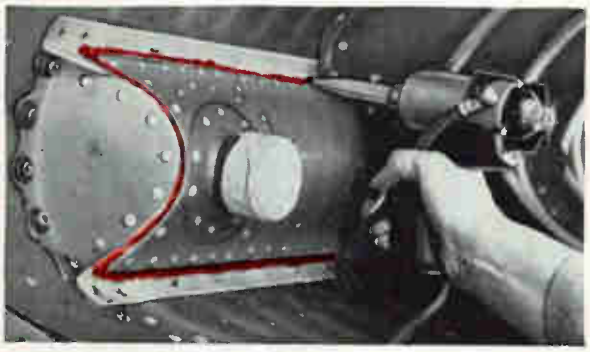
Polishing equipment. Operator uses squeeze bulb to apply polish compound

The amount of polish applied to the 100 mc, fifth overtone crystals, for example, adds approximately 500 kc as measured on the fundamental frequency of 20 mc. The polisher (Fig. 1) is similar to the familiar Allied type of equipment, but includes some recent innovations. Lapping plates have a 4.5-inch outside diameter. The top plate is supported by an annular ring pivot. Spindle speed is 640 rpm. The carriers are Mylar.

Faces of the lapping plates are 0.1-inch vinyl. Each has a scroll groove pressed into the major surface to assure adequate delivery of cerium oxide polishing compound to the major surfaces of the quartz plates. After the groove is formed, the plates are conditioned on equip-

General Electric RTV silicone rubber

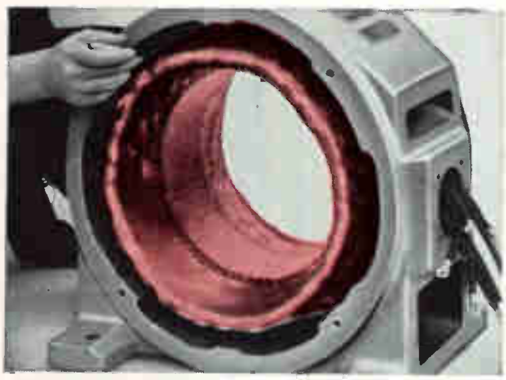
New <u>liquid rubber</u> cures without heat, useful from — 70 F to + 600 F, ideal for sealing, electrical insulation and flexible molds.



HEAT RESISTANT SEALING, such as shown on this Douglas DC-8 Jetliner, is made possible with RTV (room temperature vulcanizing) silicone rubber. RTV cures without application of heat; won't shrink (no solvents); forms no voids. It has excellent bond strength, plus resistance to high temperatures, moisture, weathering, ozone, aircraft fuels and solvents.

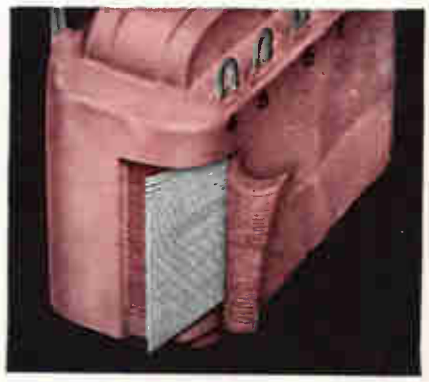
PRECISION MOLDING of prototype and engineering models and replacement parts is simplified and improved with RTV flexible mold material. G-E RTV's low shrinkage permits close tolerances and fine surface detail.

LOW-COST TOOLING with flexible RTV mold material offers added savings in time and expense. RTV's "built-in" release agent provides easy removal of this epoxy coil-winding form from mold. Total cost reduced 81%, delivery time 90%.



ENCAPSULATION OF STATOR WINDINGS, introduced by General Electric motor departments, extends service life of motors. RTV's resistance to moisture and other contaminants enables these dripproof motors to meet certain applications formerly requiring enclosed units.

POTTING OF AIRBORNE EQUIPMENT provides protection from high altitude arc-over and corona as well as vibration and moisture. RTV silicone rubber protects this cathode ray tube up to 70,000 feet.



RTV COIL IMPREGNATION enables this Hughes Aircraft Co. transformer to provide top performance at 250°. Unlike other insulations tried, G-E RTV compounds proved successful both for coil impregnation and full encapsulation.

For application data and samples of General Electric RTV silicone rubber write Section N414, General Electric Company, Silicone Products Department, Waterford, New York

GENERAL ELECTRIC

ment similar to the Lap Master and checked with an optical flat. Optical flat control of the lapping plates magnifies by 15-to-1 flatness effects on the crystals. Accuracy is further maintained by proper control of the polisher's throw, or break. Ultrasonic washing follows polishing.

Plating processes are unusual in that crystal frequency is monitored during base plating as well as during final plating. Monitoring base plating minimizes the amount of final plating and final calibration difficulties. A Constantin type plater with a frequency scanning monitor is used.

The base plating masks hold 6 large crystals or 12 miniature crystals. In each load, 1 crystal is monitored through a simple button electrode. The tungsten filament which evaporates the plating metal, usually aluminum, is located immediately beneath the mask. Half the optimum amount of plating is applied to the crystals on the first side. The second side is then plated by the same method to bring the crystals into audio range at the fundamental frequency.

After crystals are mounted in the holder base and the conductive cement has cured, they are final-plated with gold, calibrated, sealed and tested. Ruggedized units are made by using the HC-6/U base originally designed for the 1 mc CR-18/U. Its heavy, claw-type mount uprights are soldered to the crystal after the crystal has been spotted with silver, fired and tinned.

Production Area Gets Glass Walls

GLASS WALLS are used in the manufacturing area of a new plant built by C. P. Clare & Co., Chicago, Ill., for the production of sealed contact reed relays. The glass wall facing has only vertical seams. The remainder of the area also follows clean room design and the air supply is filtered.

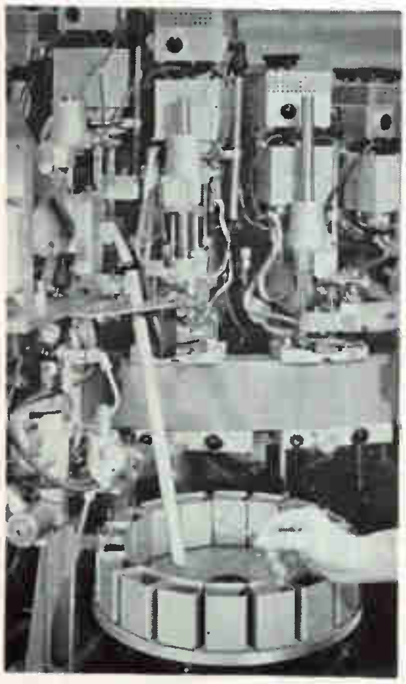
The assembly machine is an 18-headed turntable. Each head has 3 chucking devices which hold and position the reeds and glass case. Parts are loaded while top and

Assembly machine operates in clean room

center chucks are raised.

The heads are closed to the sealing position and an inert forming gas is introduced in and around the glass tube. The reeds are moved to a touching position and locked. The upper chuck is released, leaving the upper reed supported and positioned by the lower reed. The upper seal is made by a heating coil. After the top seal is cooled, the contact gap is adjusted by moving the lower reed and the lower seal is made.

The reeds produced on each head are released into a container corresponding to that head. If inspection of the reeds indicates adjustments are required, the head needing adjustment is quickly identified.



Relays released into separate containers to pinpoint adjustments needed

On The Market

Medium-Price Computer: 6,000 Operations a Sec
features automatic correction of magnetic tape

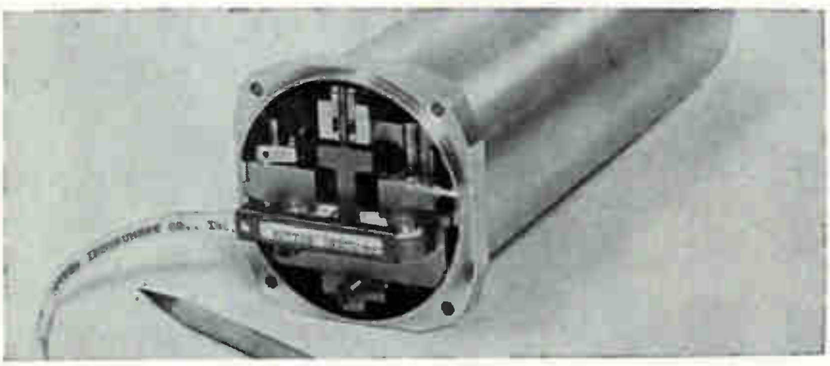
A NEW medium-price computer expected to find a market among some 6,000 of the top 10,000 top companies in the U. S. has been introduced by Minneapolis-Honeywell Regulator Co., Datamatic Division, Wellesley Hills 81, Mass. The computer is able to perform 6,000 operations a second. It is designed for a broad range of business applications including storage and high-speed manipulation of large volumes of data. Known as the Honeywell model 400, the computer with central processor, four magnetic tape units, printer and card reader rents for $8,660 a month. It will be available in summer 1961.

The central data processor of the computer will have an internal speed of 6,000 operations a second. Its core memory capacity will be 1,024 words of 48 bits each.

Transfer rate of information to or from the magnetic tapes will be 64,000 characters or 96,000 decimal digits a second. Orthotronic control will automatically detect and correct any errors in or damage to information recorded on the tapes.

The printer will operate at 900 lines a minute. The card reader will handle 650 cards a minute. In addition to the basic computer described above, one or two additional tape handlers can be added.

CIRCLE 301 ON READER SERVICE CARD



Miniature Printout Device
prints 30 characters a second

MORE THAN 30 characters a second are printed on $\frac{1}{16}$-in. tape by a miniature printer developed by Potter Instrument Co., Plainview, N. Y. The device is $9\frac{1}{4}$ in. long and fits a standard 3-in. instrument case. Paper supply is self-contained.

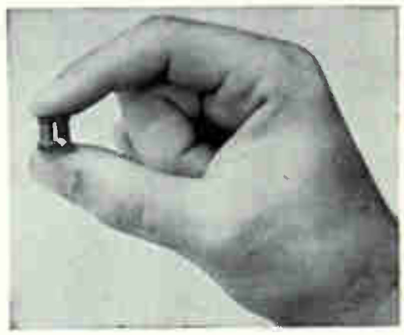
The instrument is useful as a printer for computer output and for weapons-system checking. It is also used in burst communications systems to conserve bandwidth of a radio transmission link. The unit is to sell for less than $500.

CIRCLE 302 ON READER SERVICE CARD

Thermoelectric Modules
cool 4 cu ft

A NEW bismuth telluride alloy now makes possible thermoelectric cooling of volumes up to four cu ft. The material is produced by Materials Electronic Products Corp., 990 Spruce St., Trenton, N. J. The firm produces n and p-type alloy as crystals up to 18 in. long and also thermoelectric modules made from the rods.

The BiTe crystals are said to be 60 percent as efficient as a mechanical compressor for cooling. The p-type alloys have a figure of merit of 4 to 4.5 $\times$ 10^{-3} and the n-type



2.7 to 3 $\times$ 10^{-3}. At 100 deg C this gives the modules a temperature difference of 105 deg. Cold temperature is reached seconds after current is applied.

The module pictured consists of p-n couples in series with copper electrodes and projecting leads. Thickness of the matrix can be varied for different heat loads. A single couple or module gives 75 to 80 deg difference in temperature drop from 27 deg C.

CIRCLE 303 ON READER SERVICE CARD

Handling Device
for minute parts

HANDLING MINUTE parts such as germanium or silicon bars can be accomplished with a pencil-shaped device that operates on direct pressure instead of a vacuum. The pickup is made by Penfield Manufacturing Co., Inc., 19 High School

To simplify your design problems—

COMPLETE ENGINEERING AND SAMPLE SERVICE PLUS A NATIONWIDE NETWORK OF FIELD ENGINEERS—

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2. SPECIAL SEALS—For unusual requirements, E-I engineers will design seals to specifications or modify standard types for your particular application. Complete engineering facilities available.

3. CUSTOM SEALING—Complete facilities for sealing components or assemblies of your own manufacture. Send samples or drawings for quotations. Fast service on reasonable quantities.

Patented in Canada, No. 523,390; In United Kingdom, No. 734,583; licensed in U.S. under No. 2561520

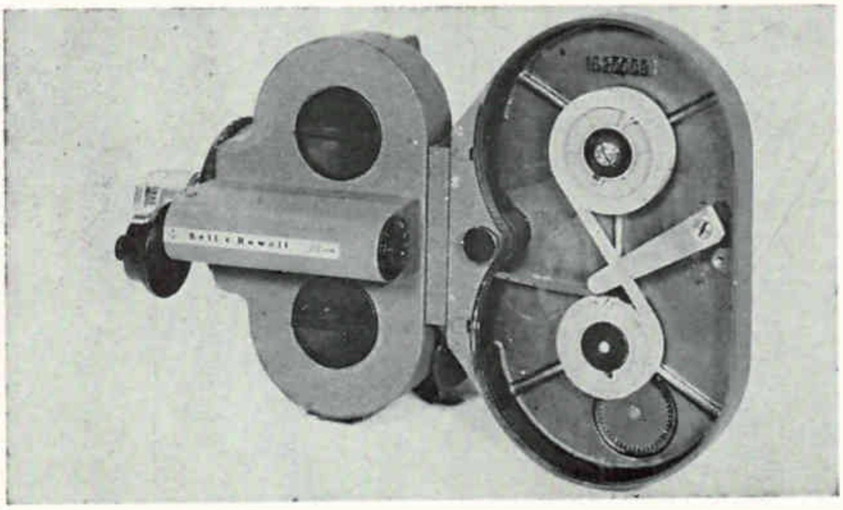
ELECTRICAL INDUSTRIES
A Division of Philips Electronics & Pharmaceutical Industries Corp.
MURRAY HILL, NEW JERSEY

CIRCLE 89 ON READER SERVICE CARD

Ave., Meriden, Conn.

Either air or nitrogen is forced through a specially channeled and orificed eductor tube at one to two psi pressure. Sufficient negative pressure (suction) is developed at the pickup point to attract and hold tiny parts. The pickup point is the unsharpened end of a conventional hypodermic needle. These needles can vary in diameter to accommodate particles of different size. To release the particle, the operator finger-stops an orifice on the face of the pickup to create a positive or repelling pressure.

CIRCLE 304 ON READER SERVICE CARD



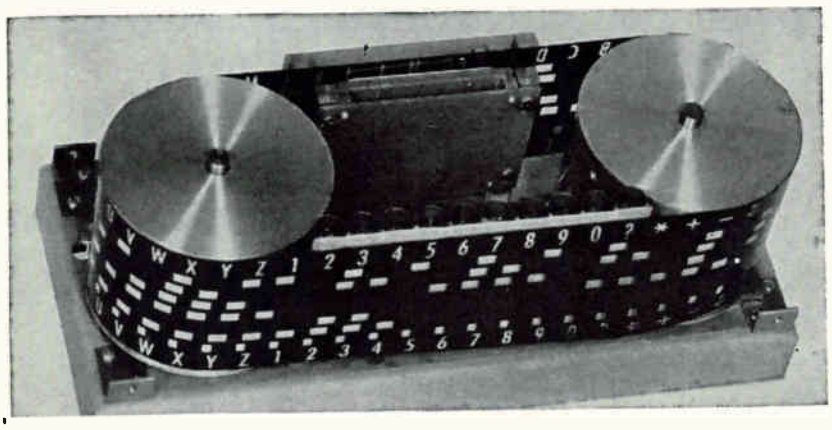
Sixty-Second Movies
camera for high-speed oscillography

IMMEDIATE ACCESS to photographed data when a motion picture camera is used for oscillography or instrumentation recording can be had with Rapromatic film processing developed by Specialties, Inc., Skunks Misery Road, Syosset, N. Y. The film can be projected on a screen within 60 seconds.

The process is a mechanical technique for applying a processing solution to an emulsion by sandwiching the photographic material with a paper web saturated with appropriate photochemicals. The web is called Raproroll.

In the magazine processor the web and exposed film or paper are pressed together in intimate contact under nominal pressure. The paper releases its liquid under pressure and the liquid is accepted by the emulsion.

CIRCLE 305 ON READER SERVICE CARD



Stroboscopic Display Device
binary code identifies characters

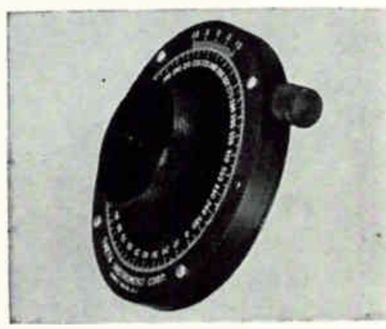
A NEW DATA display device in which characters or symbols may be selected by binary-coded input signals has been developed by Hazeltine Corp., Little Neck, N. Y. The device is known as Randid which stands for Rapid Alpha Numeric Digital Indicating Device. The characters are displayed photographically on a moving belt and appear as transparent characters on an opaque background. Applications are said to include aircraft panel display, digital tape transmission monitor, card or tape reader or verifier, visual decoder, information retrieval display, computer read-out, small tote board and test equipment read-out.

Code tracks on the belt provide binary coded identification of the characters. The code tracks are scanned with incandescent lamps and phototransistors to derive a code signal identifying each character. The generated code signal is compared with the input binary code signal. When the signals agree, a high-intensity neon lamp is fired stroboscopically to illuminate the character.

The belt speed, which determines the strobe repetition rate of the character is selected to give a flickerless display. Repetition rates vary from 30 to 60 strobes a second with motor speeds of from 1,800 to 3,600 rpm.

Change of characters or character style can be accomplished by changing the belt. Transistorized storage circuits enable the device to accept input information in either pulse binary-coded decimal form or d-c.

CIRCLE 306 ON READER SERVICE CARD



Dial Assembly
high resolution

A HIGH DEGREE of angular setability for synchros and potentiometers can be achieved with the model DR dial assembly by Theta Instrument Corp., 520 Victor St., Saddle Brook, N. J. One rotation of the dial's vernier knob turns the synchro shaft only 16 min. of arc. Movements as small as 10 sec of arc can be made comfortably be-

cause of the 1,350 to one ratio of the vernier knob. The knob assembly is intended for panel mounting. Each dial assembly accommodates one synchro size.

Rotation is continuous from zero to 360 deg; the dial is graduated in 1-deg intervals, the vernier in 0.1-deg intervals. Readability is 0.1 deg; ratio of coarse knob is one to one; ratio of vernier knob is 1,350 to one. Price is $170.

CIRCLE 307 ON READER SERVICE CARD

Frequency Standard
portable unit

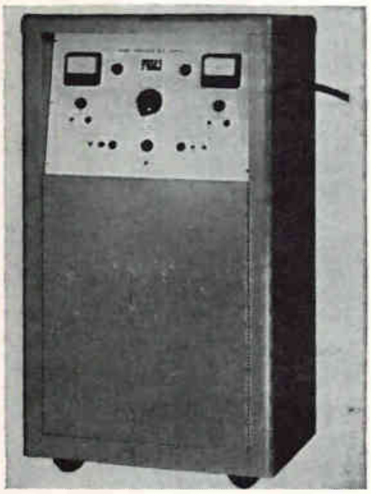
BULOVA WATCH CO., INC., Electronics Division, 40-26 62nd St., Woodside, N. Y. Portable frequency standard is fully transistorized and maintains a stability of $\pm$ 1 pp 10^8 in a range of 10 Kc through 20 Mc. The FS-100 series includes a special model with a stability of 1 pp 10^9. Input is 115 v a-c—a self-contained battery source is optional—and output is 1 volt p-to-p 1K sine or square wave. Size is 6 by 8 by 8 in., and weight is 12 lb.

CIRCLE 308 ON READER SERVICE CARD

Relay Analyzer
multipurpose

MOLECTRONICS CORP., 1717 No. Potrero Ave., S. El Monte, Calif. Model 708R relay analyzer tests all d-c and a-c (60 and 400 cps) relays up to 6 pdt. Test information presented on meter and on go-no-go lights. Automatic presentation of pull-in and drop-out voltages or currents, pull-in and release times, and coil resistance. Variable pulsing rates. Provisions for external oscilloscope monitoring.

CIRCLE 309 ON READER SERVICE CARD



D-C Power Supply
5 ma at 120 Kv

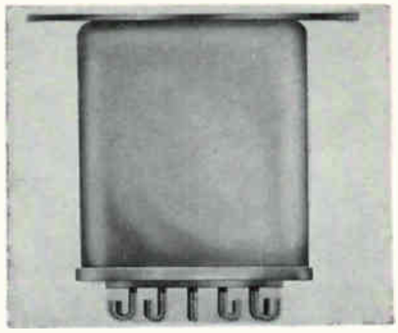
Del Electronics Corp., 521 Homestead Ave., Mt. Vernon, N. Y. Model PSC 120-5-2 d-c power supply, rated 5 ma at 120 Kv, is ideal for insulation testing, industrial, experimental and research applications. It is completely mobile. Either positive or negative polarity may be obtained by changing simple plug-in internal connections. Ripple is less than 2 percent rms. High quality selenium rectifiers are used for rectification. The high voltage output is delivered through a shielded polyethylene cable. Unit is housed in a steel cabinet measuring 32 in. by $21\frac{1}{2}$ in. by 59 in. high.

CIRCLE 310 ON READER SERVICE CARD

R-F Amplifier
compact unit

Telechrome Mfg. Corp., 28 Ranick Dr., Amityville, N. Y. Model 1460-M r-f amplifier is capable of supplying 8 w minimum of r-f power into a 50 ohm load over the frequency range of 200-250 Mc. The specified output power will be obtained with no more than 2 w of r-f input power. Small size and stable construction and performance make the unit suitable for a wide variety of telemetering applications. The circuit consists of a single grounded grid stage using a 2C39 tube. A filter box enclosing filters for each power input lead is provided to minimize r-f leakage.

CIRCLE 311 ON READER SERVICE CARD



Small Power Relay rugged device

WHEELOCK SIGNALS, INC., Long Branch, N. J. Model RX-1307 is contained in a hermetically sealed header, and will handle 17.5 amperes at 16.6 v to 100,000 operations under full load at ambient temperature of 100 C. It meets all requirements of Signal Corps Standard GS-4176-1, including shock resistance up to 75 g and temperature range from −55 C to 100 C. Dimensions are $1\frac{5}{8}$ in. by $1\frac{5}{8}$ in. by $2\frac{1}{8}$ in. high. It is especially adapted to ground power units used in checking out aircraft or rack mounted circuitry, and for modulators, power supplies, amplifiers, and process control equipment.

CIRCLE 312 ON READER SERVICE CARD

Recorder/Reproducer video band

MINCOM DIVISION, Minnesota Mining and Mfg. Co., 2049 S. Barrington Ave., Los Angeles 25, Calif. The CM-100 system records and reproduces both analog and pulse signals. Single, standard size rack contains 7-track system covering an overall bandwidth of 400 cycles to 1.0 Mc on each track. Unit provides greater bandwidths at lower speeds; for example, frequency response up to 1.0 Mc at 120 ips, 500 Kc at 60 ips. Instantaneous selection of six speeds ranging from 7½ ips to 120 ips on single ½-in. tape.

CIRCLE 313 ON READER SERVICE CARD

Signal Generator
low distortion

SOUTHWESTERN INDUSTRIAL ELECTRONICS CO., 10201 Westheimer Road, Houston 27, Texas. Model N-2 signal generator has a frequency range of 1 cps to 1 Mc and includes an output meter and attenuator (which permit output amplitude to be set precisely to any desired value). Unit also features low distortion (0.2 percent).

CIRCLE 314 ON READER SERVICE CARD

Current Supply
constant output

QUAN-TECH LABORATORIES, 60 Parsippany Blvd., Boonton, N. J. Model 151 constant current supply is particularly useful in requirements where d-c current is the independent variable and a well regulated constant current is a necessity. Output is 0.5 to 500 ma in three ranges—regulated to within 0.25

CIRCLE 97 ON READER SERVICE CARD

percent on 0 to 20 v load and 105 to 125 v a-c line. Ripple never exceeds 50 μa at peak output, and is as low as 1.5 μa on lower ranges. The open circuit output voltage can be read on the meter by a simple flip of a front panel switch. Unit is especially useful in such applications as semiconductor testing, in electrolytic work, as a supply for magnets, in strain gage systems and many other laboratory and industrial uses.

CIRCLE 315 ON READER SERVICE CARD

Phase Shifter
Ku-band

KEARFOTT DIVISION, General Precision Inc., 14844 Oxnard St., Van Nuys, Calif. Model No. 5106001 small size phase shifter is ideal for use in confined areas where equipment space is at a premium. A high degree of phase shift is offered and all ferromagnetic resonances are eliminated. Unit is temperature compensated and is not affected by environmental conditions. Features include: frequency range of 15,000-17,000 Mc ($f_0 \pm 10$ Mc); phase shift is indicated at 112 deg; insertion loss at 0.5 db maximum; input vswr is 1.12 maximum; peak power is 3 Kw; ambient temperature range, -10 C to $+100$ C; length, 2 in.

CIRCLE 316 ON READER SERVICE CARD

Varactor Diode
gallium arsenide

TEXAS INSTRUMENTS INC., Semiconductor-Components Division, P.O.

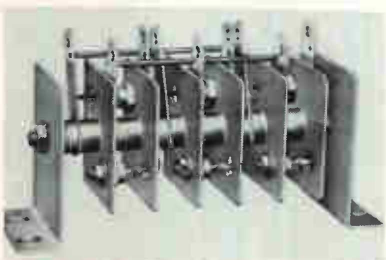
Box 312, Dallas, Texas. The TI XD500 gallium arsenide diffused junction varactor diode is encased in a reversible polarity, double ended, ceramic microwave package. It offers a junction capacitance of 0.1 $\mu\mu$f min. to 1.0 $\mu\mu$f max. at zero bias, a Q of 30 measured at 2,000 Mc at -2 v. When referenced to -6 v at 2,000 Mc, Q is typically 45. Cut-off frequency is 60,000 Mc at -2 v and 110,000 Mc or greater when measured at breakdown voltage. Shunt capacitance variation follows the minus ½ power law. Unit has a very low inductance with a 0.4 $\mu\mu$f package capacitance measured at 100 Kc.

CIRCLE 317 ON READER SERVICE CARD

Frequency Meter
solid state

MARSTAN ELECTRONICS CORP., 204 Babylon Turnpike, Roosevelt, L. I., N. Y. Solid state frequency meter is a low cost unit with an accuracy better than ± 1 percent. No hum or noise problems are encountered with the unit being completely shielded and battery operated in a case size approximately ⅛th the volume of existing frequency meters. It has switched cps ranges of 0-20, 100, 500, 2 K, 10 K, 50 K, and 200 K; E_i is from 0.2 to 300 v and Z is 250 K ohms minimum at 1 Kc.

CIRCLE 318 ON READER SERVICE CARD



Rectifier Stacks
silicon power units

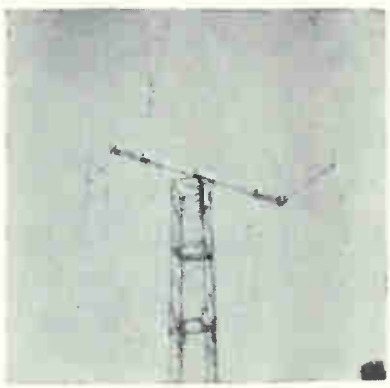
SYNTRON CO., Homer City, Pa., announces silicon power rectifier stacks. Standard assemblies are available employing the style 21 and style 33 diodes. Bridge assemblies using the style 21 diodes are rated up to 39 amperes single phase and 58 amperes three phase. Bridge assemblies using the style 33 diodes are rate up to 75 amperes single phase and 112 amperes three phase. All stacks are available with cell voltages to 600 piv. The assembly design permits rapid adaptation to any type of unit configuration. The assemblies are available in a variety of standard commercial finishes.

CIRCLE 319 ON READER SERVICE CARD

Broadband Diodes
two models

SYLVANIA ELECTRIC PRODUCTS INC., 100 Sylvan Road, Woburn, Mass. Two new broadband video detector microwave diodes covering the 10,000 to 20,000 Mc frequency band are available for use in countermeasures equipment, microwave link systems, and similar applications. Type D-4104 has a minimum tangential signal sensitivity of —40 dbm and a minimum figure of merit of 15. Type D-4104A has a minimum sensitivity of —45 dbm and a minimum figure of merit of 30. Both diodes use a non-tripolar coaxial package and have a maximum video impedance of 18,000 ohms.

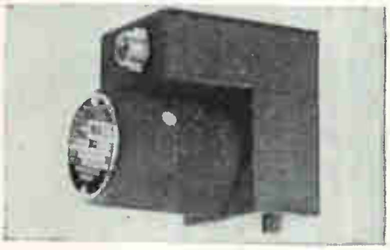
CIRCLE 320 ON READER SERVICE CARD



Yagi Antenna
30-50 Mc

ANDREW CORP., 363 E. 75th St., Chicago 19, Ill. Type 111 is a six element array providing directional coverage for the 30-50 Mc range. Minimum forward gain is 8.6 db over one-half wave dipole at 30 Mc. Average gain across the entire band is 9.1 db. The pattern provides wide angle coverage while maintaining a front-to-back ratio in excess of 14 db. At the 50 ohm type uhf connector input, the vswr of the array is tuned to less than 1.5 to 1 at the frequency of operation. Complete antenna weighs 100 lb and will withstand windloading of 30 lb per sq ft with ½ in. ice.

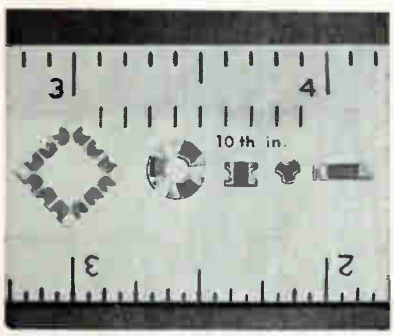
CIRCLE 321 ON READER SERVICE CARD



Rotary Actuator
miniaturized

BARBER-COLMAN CO., Rockford, Ill. The new NYLC actuator is 2⅞ in. long, 2¼ in. high, and 1⅝ in. wide; weight, with radio noise filter, is 0.65 lb. Breakaway torque is 35 lb in. Continuous load torque is 25 lb in., but can be increased to 100 lb in. over entire stroke by addition of ½ in. height and 0.2 lb weight. Switches are available for either internal or external adjustment with positive locking. A newly designed motor is used in this actuator to provide longer life and improved reliability. This motor uses a brush rigging which provides uniform pressure during the entire motor life.

CIRCLE 322 ON READER SERVICE CARD



Module Resistors
microminiature

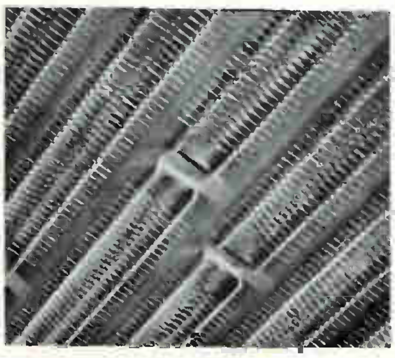
FILMOHM CORP., 48 W. 25th St., New York 10, N. Y. Microminiature module resistors can be supplied on substrates to most 3-dimensional configurations and physical size is limited only by the ability to handle parts. Common forms include rods, plates and semi-circular elements. Substrates may be of mica, glass, ceramic or quartz. Single or multi-element resistors can be deposited on a single substrate. Power rating and resistance values are a function of element size and shape. All units are designed and manufactured to customer specifications.

CIRCLE 323 ON READER SERVICE CARD

Sweep Resolver
for radar use

PLESSEY INTERNATIONAL LTD., Ilford, Essex, England. A new size 23 sweep resolver, the type 113D8H, for use in radar sweep circuits has been designed by Ketay Ltd. It has a flat frequency response extending into the 100 Kc range, peaking at 500 Kc. In many applications the output may be connected directly to the deflection coils of the crt in the ppi display system. A compensation or feed-back winding is included on the stator. Voltage range is 0-30 v. Operating temperature range is from − 55 C to 75 C and weight is 28 oz.

CIRCLE 324 ON READER SERVICE CARD



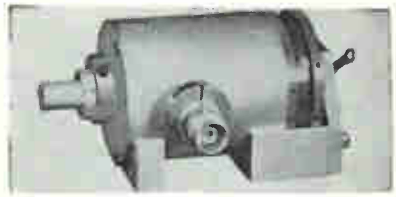
Silicon Diodes
ultra fast

RHEEM SEMICONDUCTOR CORP., 350 Ellis St., Mountain View, Calif. These ultra fast glass silicon diodes feature maximum recovery time of 4 nanosec together with extremely low capacitance, typically less than 1 $\mu\mu$f. Listed under type numbers 1N903 through 1N908, plus 1N914 and 1N916, the units give voltage ratings up to 100 v and average rectified current up to 75 ma. They are hermetically sealed in the

CIRCLE 101 ON READER SERVICE CARD

standard subminiature glass package and are designed to exceed the requirements of MIL-S-19500B. Average price is $4.25 at the 100 piece quantity level.

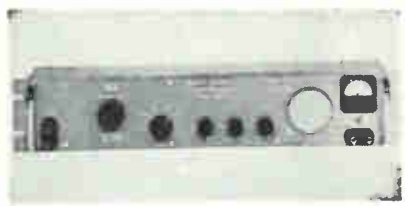
CIRCLE 325 ON READER SERVICE CARD



Pulse Oscillator
C-band

ACF Electronics Division, ACF Industries, Inc., 11 Park Place, Paramus, N. J. The C-band triode pulsed oscillator is designed specifically for transmitter service in missile and drone type radar beacons. It utilizes an easily replaceable planar triode tube which has the capability of operating into highly mismatched loads. Designated C-band range is covered with two units—one having a tuning range of 5,400 to 5,700 Mc; the other from 5,700 to 5,900 Mc. Output peak power is 100 w minimum with a maximum duty cycle of 0.002.

CIRCLE 326 ON READER SERVICE CARD



WWV Receiver
transistorized

Specific Products, 21051 Costanso St., Woodland Hills, Calif. Model WVTR is battery operated and requires only 3½ in. rack space. Instantaneous carrier frequency selectivity of 2.5, 5, 10, 15, 20 and 25 Mc is crystal controlled. Double conversion, 1990 Kc first i-f crystal converter to 90 Kc second i-f. Sensitivity is 2 μv, selectivity is 10 Kc at 20 db down. Hi-lo impedance antenna inputs, "S" meter, and phone jack and speaker are provided. Battery or a-c power pack available. Price is $725.

CIRCLE 327 ON READER SERVICE CARD

PRICES HAVE DROPPED!

on **high voltage** transistor regulated power supplies

- for critical commercial and military applications
- full five year warranty includes *all* components
- guaranteed to meet published specs.
- short circuit protected
- fit standard 19″ rack

Specifications	Model PS4221M	Model PS4231M	Model PS4222M	Model PS4232M
Voltage Range (VDC)	30-210	120-330	30-210	120-330
Current Range (Amps)	0-1	0-1	0-1.5	0-1.5
Regulation Against 20% Line change / 0 to full load	0.1% / 0.1%	0.1% / 0.1%	0.1% / 0.1%	0.1% / 0.1%
Impedance (Ohms) DC to 100KC	.4	.4	.2	.2
Ripple (RMS) in Millivolts	2	3	2	3
Panel Height	5¼″	5¼″	5¼″	5¼″
Price: (See Notes)	$555	$620	$580	$645

Note 1: If meters not desired deduct $30 and drop "M" from model number.
Note 2: If fixed output desired (±5 volts) deduct $40 and add "F" to model number followed by nominal output voltage desired.

Write for complete specifications

Specify POWER SOURCES BY

POWER SOURCES, INC.

Burlington, Massachusetts

CIRCLE 205 ON READER SERVICE CARD

SYSTRON ANNOUNCES.....

IN-LINE SOLID STATE 10 MC COUNTER-TIMER

ONLY $2900

MODEL 1039

• Fully Transistorized • Small Size-5¼″ Panel Ht. • Nixie In-Line Readout

EXCLUSIVE:
- In-line readout
- No time base adjustments
- 3 Amplifiers — 0.1 V RMS Sensitivity, 1 Megohm input impedance

Model 1039 is solid state . . .
- NO vacuum tubes
- Greater reliability
- Modular plug-in construction
- Low power — 50 watts
- Ease of maintenance

IT'S UNIVERSAL

frequency — 0 to 10 MC
Intervals / Period — .3 μsec 10^8 sec.
Ratio of 2 frequencies — 1 to 10^7
Phase Shift — Gated Counter
Compatible with all frequency extenders for measurements to 12,000 MC

SYSTRON CORPORATION

Write for complete specifications of Model 1039 and free copy of Short Form Catalog.

SYSTRON CORPORATION
950 Galindo Street • Concord, Calif.
Representatives - Principal Cities

CIRCLE 103 ON READER SERVICE CARD

Literature of

RADAR TRANSMISSION SYSTEM. Collins Radio Co., 2700 W. Olive Ave., Burbank, Calif. Operation of a radar data transmission system designed to provide accurate, real time missile impact predictions is covered in a new bulletin.

CIRCLE 380 ON READER SERVICE CARD

MULTIPOSITION SWITCH. Burroughs Corp., Electronic Tube Division, Plainfield, N. J. A 4-page folder describes the Beam-X switch, a decimal electronic device which is expected to effect a major change in basic electronic design logic from binary to decimal systems.

CIRCLE 381 ON READER SERVICE CARD

HEAT EXCHANGERS. Wakefield Engineering, Inc., 7 Broadway, Wakefield, Mass., has available technical bulletin No. 260 and price list on semiconductor heat exchangers, series 5000, for medium pressure forced air cooling systems using transistors, Zener diodes and rectifiers.

CIRCLE 382 ON READER SERVICE CARD

RELAYS. General Electric Co., Schnectady 5, N. Y. Bulletin GEA-7021, a 12-page publication, discusses a complete line of GE relays for all applications. Dimensions, ratings and ordering information are included.

CIRCLE 383 ON READER SERVICE CARD

TANTALUM CAPACITORS. Fansteel Metallurgical Corp., 2200 Sheridan Road, North Chicago, Ill. Complete information on tantalum electrolytic capacitors for elevated temperature applications is given in technical data bulletin 6.111-2.

CIRCLE 384 ON READER SERVICE CARD

TRANSFORMER WINDER. Geo. Stevens Mfg. Co., Inc., Pulaski Road at Peterson, Chicago 46, Ill. A catalog sheet illustrates and gives full technical details on two medium range multiple transformer/bobbin winders.

CIRCLE 385 ON READER SERVICE CARD

AIRCRAFT INSTRUMENTS. Weston Instruments Division of Daystrom, Inc., 614 Frelinghuysen

Ave., Newark 12, N. J. A 48-page manual enumerates and describes a complete line of aviation instruments and components manufactured by the company.

CIRCLE 386 ON READER SERVICE CARD

PRINTED CIRCUITS. Arthur Ansley Mfg. Co., New Hope, Pa. A 16-page illustrated booklet outlines the several functions that may be performed by the printed wiring board and describes the types of circuitry best adapted to this method of packaging as well as those where it shows up less favorably.

CIRCLE 387 ON READER SERVICE CARD

MICROWAVE CATALOG. Transco Products, Inc., 12210 Nebraska Ave., Los Angeles 25, Calif. A spiral bound, quick-reference catalog covers the company's line of microwave products—plus special charts and graphs for the microwave engineer.

CIRCLE 388 ON READER SERVICE CARD

SEMICONDUCTOR DATA SHEET. Alpha Metals, Inc., 56 Water St., Jersey City 4, N. J., has released a new group of technical data sheets describing the physical properties of alloys used in the manufacture of semiconductor devices. Properties of aluminum-silicon, lead-silver and indium-gallium alloys are shown.

CIRCLE 389 ON READER SERVICE CARD

OPERATIONAL AMPLIFIERS. Burr-Brown Research Corp., Box 6444, Tucson, Ariz., has available a product data sheet on the 130 series transistorized high gain d-c amplifiers which have differential inputs.

CIRCLE 390 ON READER SERVICE CARD

DELAY LINES. Allen Avionics, Inc., 255 E. 2nd St., Mineola, N. Y., recently published a new lumped constant delay line specification bulletin.

CIRCLE 391 ON READER SERVICE CARD

VARIABLE RESISTORS. Chicago Telephone Supply Corp., Elkhart, Ind., has published a data sheet on new ⅝ in. diameter compact miniature commercial controls.

CIRCLE 392 ON READER SERVICE CARD

CIRCLE 105 ON READER SERVICE CARD

Leeds & Rothschild: the hat shifts

WHEN A MANUFACTURERS' REP gives up a profitable and surefire business to dare the rigors of an untried manufacturing enterprise, it's news. But when Gerard G. Leeds (shown at left) and his partner Richard Rothschild did exactly that last June, it was a carefully calculated step on a path both men had been laying out for years.

It's impossible to talk about only one of these two executives. They think together, finish each other's sentences, plan everything jointly, and take turns wearing the president's hat of Lumatron Electronics (Leeds is president this year, Rothschild's turn is next).

Leeds, a German-born dynamo, came to the U. S. in 1939 (and speaks impeccable Californian). After wartime hitches at MIT's Radiation Lab and the old Evans Labs at Fort Monmouth, he set up his own business for a while, making electronic flash controls for cameras. Once the bug to be in business for himself had bitten, he embarked on a series of moves calculated to give him the experience he wanted.

He went to work for Berkeley Scientific Co. (now part of Beckman Instruments) as a sales engineer (they didn't even know they wanted one until he sold them on the idea), moved up to sales manager, set up Berkeley's rep organization, just incidentally pushed the firm into the digital-counter business. He came east in 1949.

He took a sales management job with Anton Electric, moved to an equivalent position at Electronic Products, and then in 1954 set up the G. G. Leeds Co., one of the middle-Atlantic's biggest rep organizations. The following year he hired Rothschild.

The younger partner—Rothschild was born in 1926, Leeds in 1922—is a quiet-spoken, serious-minded New Yorker who left college to serve as an electronics officer in the Navy during the war, then went back to take his BS in physics at Yale. He worked his way purposefully through several of DuMont's divisions, picking up experience in research and development, engineering, production and contracting. He went with Leeds to fill out his background by gaining marketing experience.

In March of 1958, one of the Leeds Co. salesmen got a customer request for a nanosecond oscilloscope. Leeds checked with his principals, found no one who could meet the request despite evident market demands. The two partners moved swiftly; in August of 1958 they decided to set up a laboratory to develop such a scope. With the approval of their principals, they engineered a working model, showed it at the Solid-State Circuits Conference in Philadelphia in February of 1959. The same month they moved into a small plant in Westbury, L. I. and started outgrowing it at once.

The interest generated at the conference convinced them: they incorporated in May, split up the rep business among their regional sales managers, and closed out their own part of the business at the end of June. Lumatron has been all their professional interest since. This week the firm is moving into a new plant in New Hyde Park, L. I.

ECI Engineering Appoints Ludwig

JOHN T. LUDWIG, until recently a senior research and development engineer with Minneapolis-Honeywell Regulator Co., has joined the Electronic Communications, Inc., Scientific Advisory Group as a principal engineering scientist.

With Honeywell from 1954 to 1960, Ludwig was responsible for electrical engineering research at the corporate research center. His personal research projects were in the fields of magnetic circuits, electrostatic motors, liquid-metal gyroscopes, and magnetic and electric support of gyroscopes.

Hazeltine Elects New Officers

DIRECTORS of Hazeltine Corp., Little Neck, N. Y., have elected James W. Evans (picture) a vice president of Hazeltine Electronics Division. He is director of the 36-year old firm's Advanced Planning Group.

Elected as assistant vice presidents of the division were Vernon A. Radom, Edward M. Tyler and John B. Winningham. Elsa T. Ramm was elected an assistant vice president of the corporation.

Evans joined Hazeltine in 1955 as a member of the Government & Commercial Department. Previously he was affiliated with the CAA, NRL and the U. S. Air Force.

Radom is manager of Army and Navy liaison in the Government &

Commercial Department. He joined Hazeltine in 1953 after serving with Bell Aircraft Corp., Bell and Howell, Inc., ITT Corp., and RCA.

In charge of the Test Engineering Department, Tyler joined Hazeltine in 1959 after serving as general manager of the Electronics Division of Gorham Mfg. Co. He also has been an engineer with the Western Electric Co., Bell Telephone Laboratories, Wired Radio, Inc., and Hogan Laboratories.

Winningham is presently deputy for operations in the office of the executive vice president for operations of Hazeltine Electronics Division.

Mrs. Ramm joined Hazeltine in 1945 and has been assistant secretary of the corporation since 1951.

Epsco-West Hires Gerhard

F. H. GERHARD has joined Epsco-West, Anaheim, Calif., as senior design specialist. He will be responsible for all analog circuit design.

A specialist in transistorized amplifier circuitry, Gerhard comes to Epsco-West from Autonetics Division of North American Aviation. He was a senior research engineer at Autonetics.

Organize New Company

ANTENNA SYSTEMS, INC., Hingham, Mass., is a new corporation formed by a group of veteran employees from D. S. Kennedy & Co. The financing has been provided entirely by the employees.

President of the new organization is Charles W. Creaser, Jr., and executive vice president, Walter W. VanderWolk, Jr.

The company is devoted exclusively to the design, manufacture and installation of reflectors, feeds, waveguide, rotary joints, towers, pedestals, and other related equipment.

Kuck Advances At Kinetics

KINETICS CORP., Solana Beach, Calif., manufacturer of electronic and electromechanical components for the aircraft and missile fields has appointed Burton M. Kuck senior project engineer. He joined Kinetics in January of this year.

Kuck was formerly with the Bell Telephone Laboratories in New Jersey, where he specialized in military communications system design and underwater sound development.

Jensen Takes New Position

E. WILLIAM JENSEN has joined Geoscience Instruments Corp., New York, N. Y., as sales manager. The company is marketing a new alumina abrasive, Corunda, designed for polishing semiconductor surfaces.

Until recently, Jensen headed the materials section at General Transistor's Research Division in New York.

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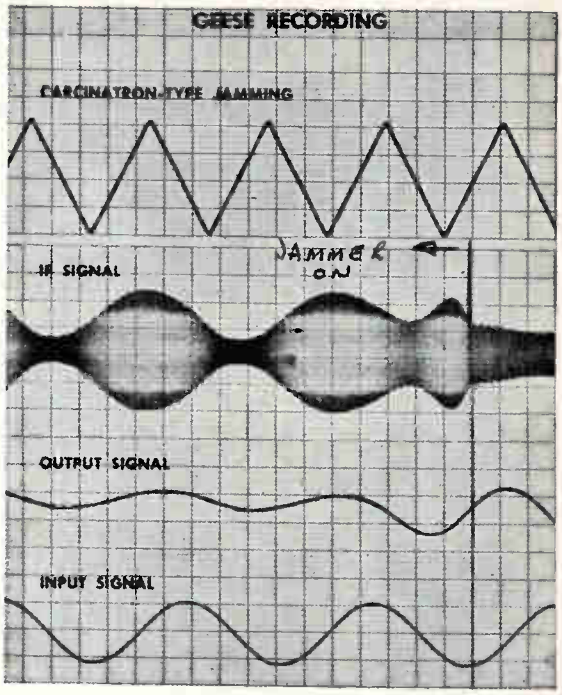

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Defense Systems Department is directing its technical capabilities toward the development of large-scale electronic systems. Inherent within this work program is the recognition, definition and solution of problems in every aspect of the systems technology.

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A recent contribution by Defense Systems Department in this technological area is GEESE (General Electric's Electronic System Evaluator). Utilizing advance computer techniques, it enables systems engineers to accurately predict, optimize and synthesize system performance prior to design.

GEESE is indicative of the scope of Defense Systems Department's involvement in the systems technology. Many programs offer systems-oriented engineers and scientists an opportunity to participate in new areas of long-term importance.

Senior members of our technical staff would welcome the occasion to discuss personally and in detail the career positions available with this growing organization. Address your inquiries in professional confidence to Mr. E. A. Smith, Box 4-E.

DSD DEFENSE SYSTEMS DEPARTMENT
A Department of the Defense Electronics Division

GENERAL ELECTRIC

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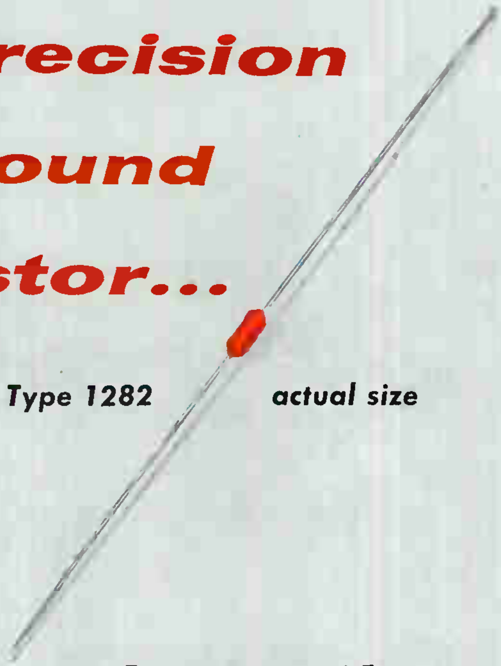
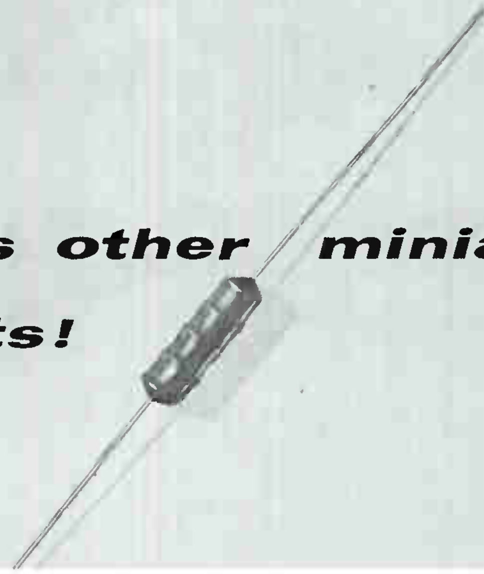


Type 1282 *actual size*



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