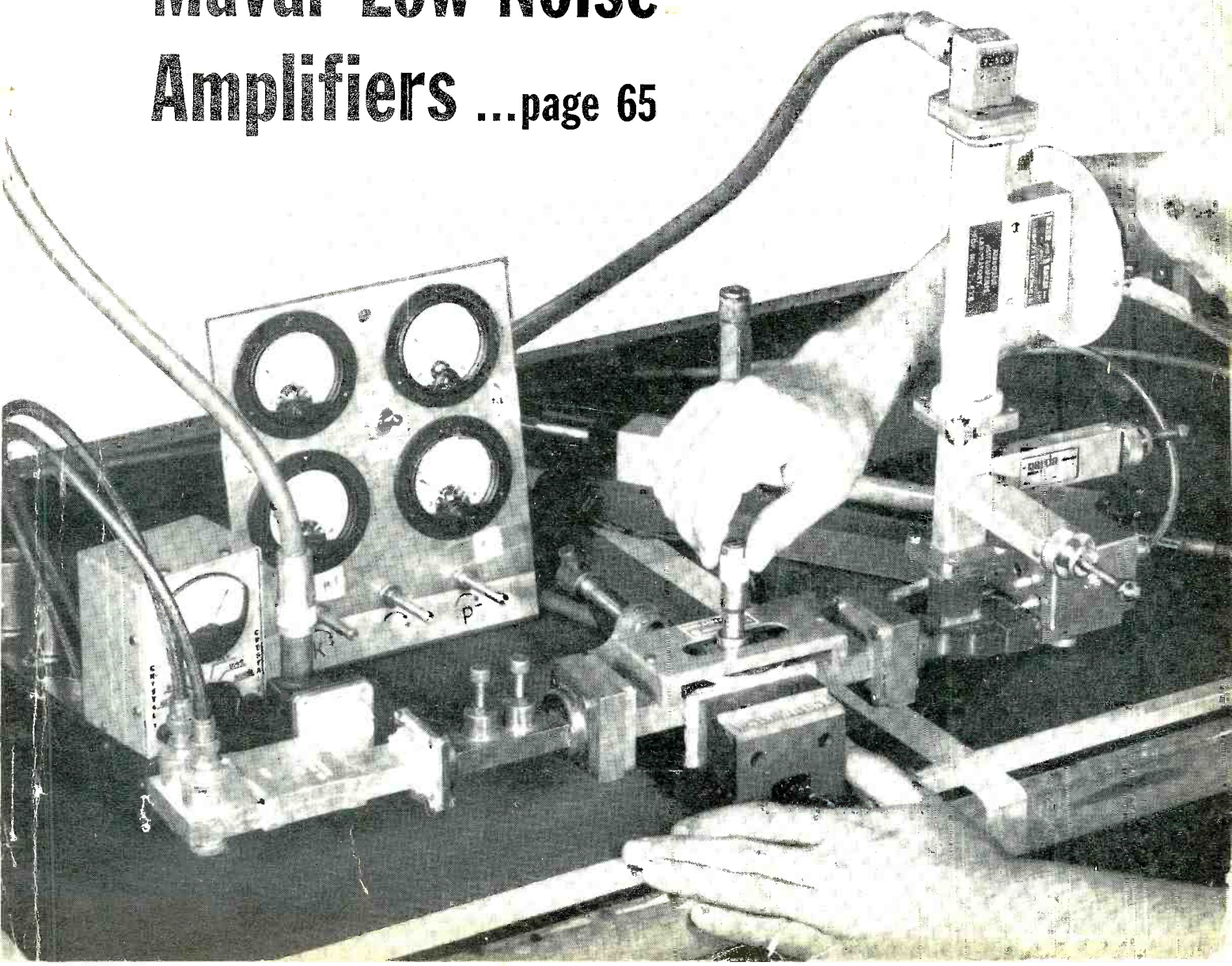
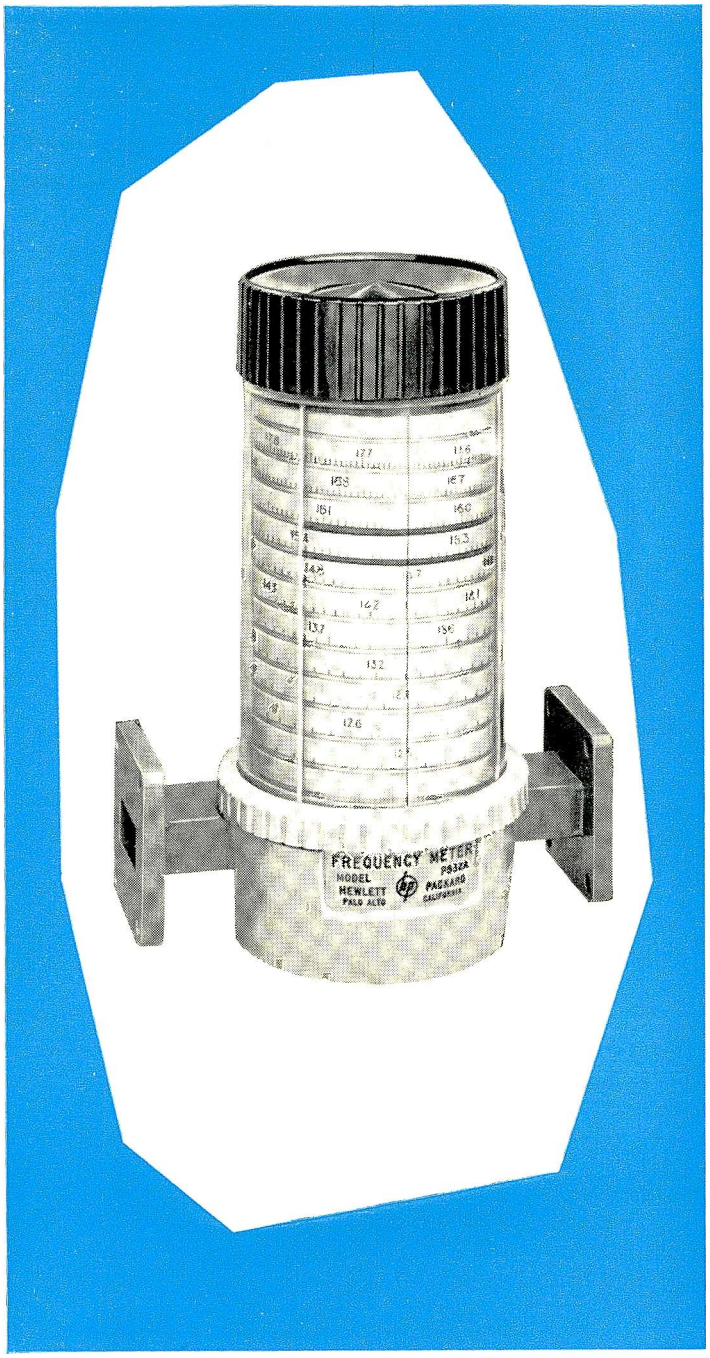
A McGRAW-HILL PUBLICATION • PRICE ONE DOLLAR SEPTEMBER 26, 1958

electronics

engineering issue

Mavar Low-Noise Amplifiers ...page 65





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FREQUENCY METERS

8.2 to 40.0 KMC

A completely new engineering approach enables the new -*hp*- 532A series Frequency Meters to provide you with low cost, direct-reading convenience and dependability not previously available in a microwave frequency meter.

These new general-purpose test instruments avoid the out-moded and error-prone sliding contact design. Instead, the 532A series employs a high Q resonant cavity (TE_{111} mode) tuned by a choke plunger. The cavity is mounted on a special wave-guide section designed so that a very small amount of power is reflected at resonance, while the major portion is transmitted. Reaction at resonance is virtually constant full range; there are no spurious modes or resonances; resonance is indicated by a dip of approximately 1.5 db in output. Scale divisions 5 MC apart insure a high order of resolution. Tuning is by a precision lead screw springloaded to eliminate backlash. Four separate models covering the X, P, K and R bands (see table) are offered.

HEWLETT-PACKARD COMPANY
4871A PAGE MILL ROAD • PALO ALTO, CALIFORNIA, U.S.A.
CABLE "HEWPACK" • DAVENPORT 5-4451
FIELD REPRESENTATIVES IN ALL PRINCIPAL AREAS

SPECIFICATIONS

	X532A	P532A	K532A	R532A
Accuracy:	0.08%	0.1%	0.1%	0.2%
Frequency range, KMC:	8.2 to 12.4	12.4 to 18.0	18.0 to 26.5	26.5 to 40.0
Waveguide size, inches:	1" x ½"	0.702" x 0.391"	0.5" x 0.25"	0.36" x 0.22"
Resetability:	0.01%	0.01%	0.01%	0.01%
SWR at resonance (approximate):	1.3:1	1.3:1	1.3:1	1.3:1
Price:	$150.00	$210.00	$230.00	$250.00

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

4871

electronics engineering issue

A McGRAW-HILL PUBLICATION • VOL. 31, NO. 39 • SEPTEMBER 26, 1958

Issue at a Glance

Low-Noise Mavar. Junction diode is used as a nonlinear capacitance to achieve wide-band, low-noise microwave amplification. This is one of three types of experimental devices using the principles of parametric or reactance amplification. See p 65 ..... **COVER**

DIGEST CONTINUED ON NEXT PAGE

DIGEST continued

electronics

Sept. 26, 1958 Vol. 31, No. 39

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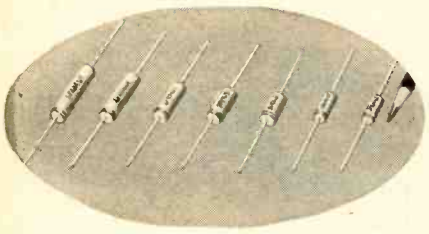
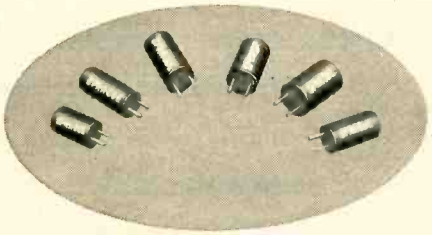


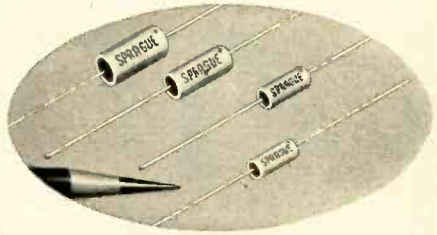
LITTL-LYTIC* CAPACITORS

Sprague's new Type 30D hermetically-sealed aluminum-encased capacitors are the *tiniest* electrolytic capacitors made to date . . . and their performance is better than ever. Their remarkable reliability is the result of a new manufacturing technique in which *all the terminal connections are welded. No pressure joints . . . no "open circuits" with the passage of time.* And check this for ultra-low leakage current: for a 2 μf, 6 volt capacitor . . . only 1.0 μa max.; for a 300 μf, 6 volt capacitor . . . 3.5 μa max.! Engineering Bulletin No. 3110 gives the complete story. 85°C standard.



VERTI-LYTIC* CAPACITORS

These space-saving Type 89D 'lytics are designed for easy manual upright mounting on printed wiring boards. Keyed terminals assure fast mounting and correct polarity. No reworking on the assembly line. Sturdy pre-molded phenolic shell with resin end-fill gives excellent protection against drying-out of the electrolyte or the entry of external moisture. The phenolic case eliminates the necessity for additional insulation. Reasonably priced for mass production receivers. Engineering Bulletin No. 3060 lists standard ratings with performance data.



Cera-lytic* CAPACITORS

The ideal capacitor for applications where low cost is the primary consideration is Sprague's new Type 31D. Capacitor sections are housed in a dense steatite tube with resin end-fill to provide protection against mechanical damage and atmospheric humidity. This construction results in excellent capacitor performance for all miniature electronic circuits. Size for size, they're the smallest the industry has produced in a ceramic-cased aluminum electrolytic. Engineering Bulletin No. 3010 details standard ratings and gives performance data.

*Trademark

FOR ENGINEERING BULLETINS on the industry's first complete line of subminiature aluminum electrolytic capacitors, write Technical Literature Section, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts.

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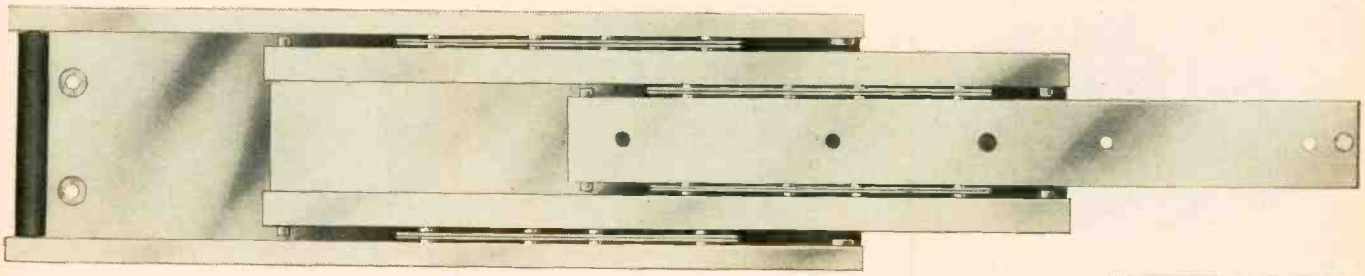
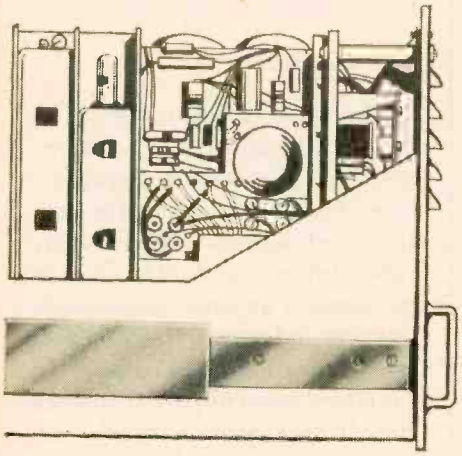
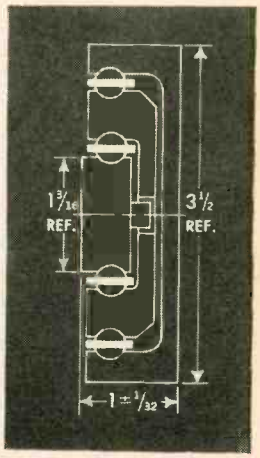
GRANT'S NEW 4000 SLIDE



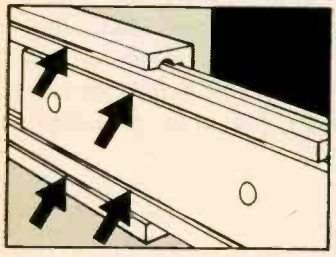


Newest of the Grant Industrial Slides. With reasons to specify a'plenty! The 4000 Slide has been subjected to the most rigorous shock, vibration, spray and life tests — and more than qualified in each category.

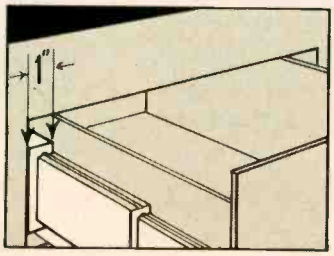
If you need a clear anodized aluminum, ball bearing slide, which is corrosion-resistant, and requires only 1" side space for up to 350 lb. load capacities yet is lightweight and structurally rigid and available in lengths from 10" to 40" — you'd do well to investigate Grant's 4000 Slide — latest product of the nation's leading slide manufacturer.



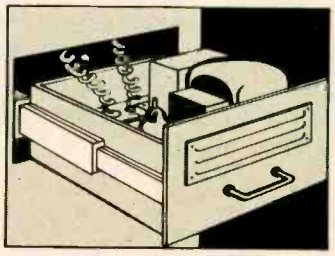
HALF SIZE SECTION



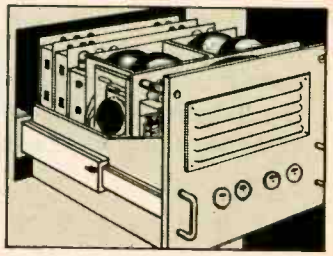
Precision-broached aluminum channels, with stainless steel balls results in smooth, silent action.



Only 1" of side-space required yet 350 lb. load carried efficiently and safely.



Full extension of sliding unit — all parts exposed for immediate servicing and maintenance.



Light, yet strong and durable, Grant 4000 slides can appreciably help your servicing and maintenance job.

Grant Industrial Slides are equipped with patented self-retaining ball spacers

We'll be happy to send you full data on the new 4000 Slide.

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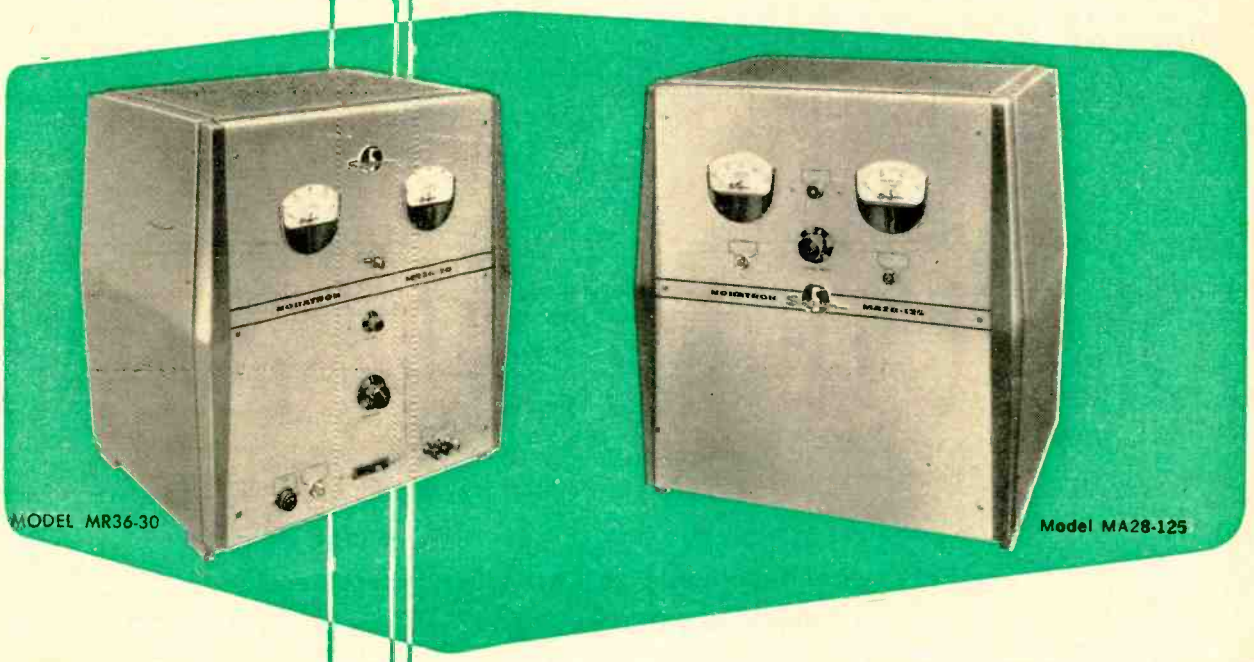

Fast Response...High Amps...External Sensing

Model MA28-125
Output: 28 VDC nominal at 125 amps.
Regulation accuracy of ± 0.2%.
Ripple: < 1% RMS.
Response time: < 0.1 second.
Choice of input voltage: 208, 230, or 460 VAC, 3-phase.
Weight: 225 pounds.
$1160 in cabinet.*

Model MR36-30
Output current, 0-30 amps, output voltage, 5 to 36 VDC continuously adjustable with regulation ± 0.25% against line or load change.
Response time of 0.2 second.
Input voltage: 105 to 125 VAC, single-phase.
Weight: 175 pounds.
$890 in cabinet.

Also supplied, as Model MR36-15, with output current 0-15 amps, otherwise similar.
Weight: 100 pounds.
$495 in cabinet.

*250 AND 500 AMP. MODELS NOW AVAILABLE

Two new high output power-packs—with response time ranging from 0.2 second down, and with transistorized power reference and magnetic amplifier power control circuits for trouble-free performance—that's just part of the story on these Sorensen DC power supplies.

One model supplies an output of *18 to 36 VDC at 125 amperes;* the other provides 5 to 36 VDC at 0 to 30 amps.

Zener diode reference circuit assures sharper regulation, and the external sensing provision puts this precise control at the load. Silicon power rectifiers and complete tubeless design increase durability with reduction in weight—and greater saving in size.

Get the full story from your Sorensen representative. Or write for technical data.

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YOUR COMPUTERS PERFORM BETTER
when you draw from this comprehensive
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RAYTHEON RELIABLE COMPUTER TRANSISTORS

Raytheon PNP Germanium Fusion-Alloy Computer Transistors are approved for military applications. They provide:

- H_{FE} control at high currents
- High voltage ratings
- Fast switching speed
- Low saturation resistance
- Temperature range −65°C to +85°C

ONE AMPERE, HIGH FREQUENCY, HIGH GAIN SWITCH

JEDEC-30 Type	Punch through Voltage min.	$f_{\alpha b}$ ave. Mc	H_{FE_1} ave. $I_B = 1$ mA $V_{CE} = -0.25$v	H_{FE_2} ave. $I_B = 10$mA $V_{CE} = -0.35$v	I_{CO} at −12v μA	r_b' $I_C = -1$mA ohms	C_{ob} $V_{CB} = -6$v μμf
2N658	−24	5	50	40	2.5	60	12
2N659	−20	10	70	55	2.5	65	12
2N660	−16	15	90	65	2.5	70	12
2N661	−12	20	120	75	2.5	75	12
2N662	−16	8	30 min	50	2.5	65	12

MEDIUM CURRENT, HIGH FREQUENCY, HIGH GAIN SWITCH

JETEC-30 Type	V_{CE} max. volts	$f_{\alpha b}$ ave. Mc	H_{FE_1} ave. $I_B = 1$ ma $V_{CE} = -0.25$V	H_{FE_2} ave. $I_B = 10$ ma $V_{CE} = -0.35$V	Rise Time* max. μsec
2N404	−24	12	30 min.	—	—
2N425	−20	4	30	18	1.0
2N426	−18	6	40	24	0.55
2N427	−15	11	55	30	0.44
2N428	−12	17	80	40	0.33

*I_C = 50 ma; I_{B_1} = 5 ma; R_L = 200 Ω; I_{B_2} = 5 ma; Grounded Emitter Circuit

SUBMIN Type	V_{CE} max. volts	$f_{\alpha b}$ ave. Mc	H_{FE_1} ave. $I_B = 1$ ma $V_{CE} = -0.25$V	H_{FE_2} ave. $I_B = 10$ ma $V_{CE} = -0.35$V	Rise Time* max. μsec
CK25	−20	4	30	18	1.0
CK26	−18	6	40	24	0.55
CK27	−15	11	55	30	0.44
CK28	−12	17	80	40	0.33

designed for computer service
made for computer service
tested for computer service
proved dependable in computer service
PREFERRED by computer designers

Ratings at 25°C unless otherwise indicated — Illustrations actual size
Dissipation Coefficients: For 1 Amp types, in air 0.35°C/mW; infinite sink 0.18°C/mW
For med. current types, in air 0.40°C/mW; infinite sink 0.18°C /mW
For submin types, in air 0.75°C/mW; infinite sink 0.35°C/mW

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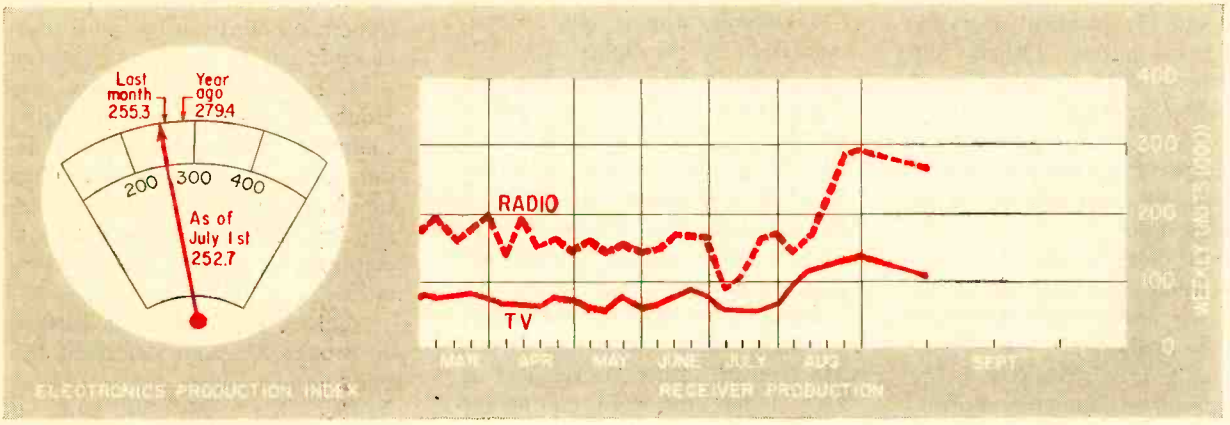
ELECTRONICS NEWSLETTER

COURSES IN RADIOISOTOPE TECHNIQUES will be given by the Atomic Energy Commission next year for industrial scientists and engineers. Six-week courses will start Feb. 9 and Apr. 6 at the Oak Ridge Institute of Nuclear Studies (ORINS). AEC says U.S. business is estimated to be saving millions of dollars a year by using radioisotopes, but that "less than one percent of the manufacturing and mining concerns in the nation now are using these materials." Commission expects increases in these industrial uses in the next few years. New courses will stress plant applications of radioisotopes, including standard techniques of wear measurement, thickness measurements and radiography, plus other techniques applicable in industry.

STEREOPHONIC RADIO BROADCAST system using a single channel is being tested in Britain by the BBC and Electric and Musical Industries, the developer. EMI's Percival system, said to have undergone preliminary tests successfully, sends out a composite signal. A small part of the channel is used to convey direction information which routes the sound signal at the receiving end. Most of the channel is used to carry the regular broadcast signal. One additional unit is used along with standard transmitter. Firm says range of the transmitter is not appreciably reduced and that stereo receiver would be "only slightly more complex" than an ordinary set. System is compatible, allowing normal reception on an ordinary home radio set. Declares EMI: "Should the BBC after further tests decide to adopt the system, it is envisaged that suitable receiving sets may be on sale to the public in about a year's time."

MOON POWER STATION elements were recently demonstrated by Westinghouse Electric's Astronautics Institute in Baltimore. Proposed lunar power plant would take advantage of the 6,000 kw per acre that the sun at zenith pours onto the moon. It would consist of acres of thin plastic sheets coated with about one micron of photoemissive material. A thin wire mesh is placed parallel to the sheet, slightly separated and insulated from it. Load would complete the circuit between emitter and mesh. Westinghouse says weight of the plant is about three pounds per kilowatt, hopes to reach solar conversion efficiencies of 25 percent. Moon's lack of atmosphere makes possible such a grand-scale solar cell, since elements don't have to be bottled up in a tube envelope. Internal impedances of cells now being demonstrated have been cut from a megohm to about 3,000 ohms, with new structures showing promise of reductions to 0.1 ohm.



FIGURES OF THE WEEK

RECEIVER PRODUCTION

(Source: EIA)	Sept. 5, '58	Aug. 29, '58	Sept. 6, '57
Television sets, total	112,992	134,921	146,288
Radio sets, total	274,604	293,771	256,292
Auto sets	91,738	68,928	58,451

STOCK PRICE AVERAGES

(Source: Standard & Poor's)	Sept. 10, '58	Sept. 3, '58	Sept. 11, '57
Radio-tv & electronics	56.64	54.62	46.81
Radio broadcasters	68.71	67.86	58.06

FIGURES OF THE YEAR

Totals for first six months

	1958	1957	Percent Change
Receiving tube sales	190,406,000	221,175,000	—13.9
Transistor production	18,452,324	11,199,000	+64.5
Cathode-ray tube sales	3,689,587	4,814,659	—23.4
Television set production	2,167,930	2,722,139	—20.4
Radio set production	4,961,293	7,187,294	—31.0
TV set sales	2,177,652	2,810,403	—22.5
Radio set sales (excl. auto)	2,964,338	3,638,969	—18.5

MORE FIGURES NEXT PAGE

Electronics stars in ISA exhibits and tech sessions, looking towards . . .

More Process Controls

Instrument Society conference speakers delve into advantages of electronic aids

HEAVY EMPHASIS on application of electronics to process control was the feature of Instrument Society of America's annual conference and trade show in Philadelphia last week.

Speaker after speaker underlined the growing use of electronics in the automatic-control field, or pointed out ways to make electronic equipment better.

There seemed to be general agreement that computers are the handiest answer yet for optimizing processes.

Some reports, particularly on analysis of huge masses of data, pointed out the practical necessity of using computers. Others felt that instruments themselves are not the problem so much as industry's acute need for a large, semiprofessional corps of trained instrument technicians to keep the new gear in working order.

A bright note in the show, for computermen, was evidence of increasing use and greater perfection of gas chromatography. Its ready analysis of process streams is assisting adoption of automatic control. The ISA devoted one of the largest all-day workshops to computers. It covered subjects from basic circuits to advanced applications.

There was little cause for complaining about the business climate. To the customers, instruments are a way of reducing some manufacturing costs and stretching the utility of equipment.

Prior to the show, Business and Defense Services Administration predicted a $1.5 billion second half in 1958. Sales had slipped to $1.3 billion in the first half after a $3 billion annual rate in 1957. BDSA expects an average annual gain of 15 percent a year.

Conference theme was "Instrumentation in the Space Age." It was carried out by such exhibits as a model of the Navy's rocket test facilities at Lake Denmark, N. J. The Navy also showed its carrier flight-deck communications system: transceiver helmets for personnel and a tv-coordinated network of controls.

Of the more than 400 exhibitors, a fourth were electronics firms. Most of the other booths had at least a few tubes in equipment shown. There were 11 computers on the Convention Hall floor. Exhibit space totaled 84,000 square feet. Attendance was estimated at 30,000 persons.

Numbers Run New System

DETROIT—350 MEMBERS of IRE and AIEE, here for the seventh annual conference on Industrial Electronics, heard panelists discuss new developments ranging from a numerically controlled manufacturing system to electronic inspection of beer.

The manufacturing system, described by Bendix's Fred E. Booth, includes a computer group that tapes in binary code the geometry and cutting requirements of the piece to be made. The tape then generates pulse trains, coordinated to represent cutter path in three-dimensional space. They control the machine tool.

N. W. Schubring of GM's research staff detailed a multichannel swept-frequency casting tester used in the company's foundries. It can handle more complicated castings because swept frequency, continuous wave, forced vibration obviates mode interaction to permit evaluation by comparison of sonic energy absorption spectra.

H. L. Shoemaker showed how Hughes Products' elementary digital computer building blocks, first designed to control a small-lot production line, are suitable for constructing any special or general purpose computer of 130 to 160 kc clock rate.

Another paper by Kurt Enslein of Brooks Research described the building of a pulse-train controlled scanner that reads 500 pairs of

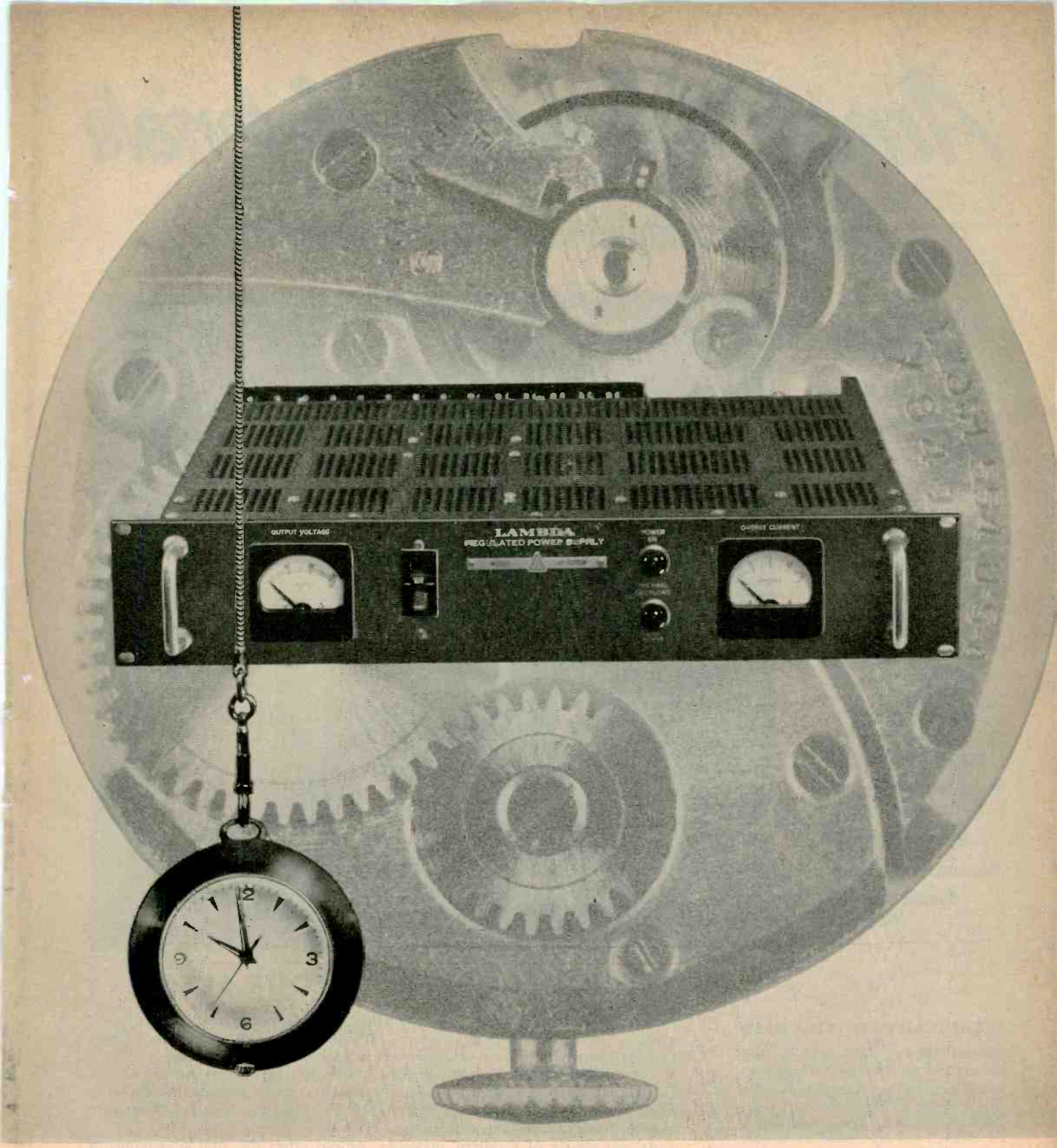
(Continued on p 12)

TRANSISTOR AND TUBE SALES, MONTHLY

(Source: EIA)	June, '58	May, '58	June, '57
Transistors, units	3,558,094	2,999,198	2,245,000
Transistors, value	$8,232,343	$7,250,824	$6,121,000
Receiving tubes, units	36,270,000	36,540,000	35,328,000
Receiving tubes, value	$31,445,000	$31,406,000	$31,314,000
Picture tubes, units	725,846	560,559	1,104,013
Picture tubes, value	$14,203,381	$11,237,147	$19,981,319

EMPLOYMENT AND EARNINGS

(Source: Bur. Labor Statistics)	July, '58	June, '58	July, '57
Prod. workers, comm. equip.	339,400	339,700	395,600
Av. wkly. earnings, comm.	$81.35	$82.39	$75.85
Av. wkly. earnings, radio	$80.99	$81.60	$75.05
Av. wkly. hours, comm.	39.3	39.8	39.1
Av. wkly. hours, radio	39.7	40.0	39.5



Guaranteed: around-the-clock performance for five years

Freedom from worry about major maintenance or extensive replacement for *five full years.* That's the guarantee given with every Lambda power supply—the first such guarantee in the electronics industry. It proves the point engineers keep making in preference studies: When operating conditions make dependability a "must," they specify Lambda...
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LAMBDA POWER SUPPLIES

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Arnold Magnetic Materials

. . . the most complete line in the industry

PERMANENT MAGNET MATERIALS

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Sintered Alnico

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HIGH PERMEABILITY MATERIALS

Tape Wound Cores of Deltamax, Supermalloy, Permalloy or Supermendur

"C" and "E" Cores of Silectron

Bobbin Wound Cores

Molybdenum Permalloy Powder Cores

Iron Powder Cores

Sendust Powder Cores

Special Magnetic Materials

Write for the

TECHNICAL DATA YOU NEED

Bulletin TC-101 A . . . Properties, standard sizes, etc. of Arnold Tape Wound Cores.

Bulletin PC-104 B . . . Complete data on Mo-Permalloy Powder Cores.

Bulletin GC-106 C . . . General information on Magnets and other Arnold products.

Bulletin SC-107 . . . Covers the complete range of Arnold Silectron Cores.

Bulletin TC-108 A . . . Describes properties, etc. of Arnold Bobbin Cores.

Bulletin PC-109 . . . Essential data on Arnold Iron Powder Cores.

Bulletin SDC-110 . . . Information on properties, etc. of Sendust Powder Cores.

Bulletin TC-113 A . . . Technical data on Arnold Supermendur Tape Cores.

ADDRESS DEPT. E-89

PRECISION-TESTED TO YOUR SPECS . . .

Arnold can answer all your requirements from the most complete line of magnetic materials in the industry. In addition, Arnold maintains complete control over every production step from raw materials to final performance testing.

Typical test facilities for Mo-Permalloy Powder cores are illustrated above. Precision equipment and methods such as these accurately measure the properties of all Arnold magnetic materials before shipment, insuring ultimate performance in accordance with your specifications.

As *your* source of magnetic materials, Arnold offers the vital advantages of long experience, undivided responsibility, and unequalled facilities for quality control throughout production. ● *Let us supply your needs!*

WSW 6781 B

THE ARNOLD ENGINEERING COMPANY

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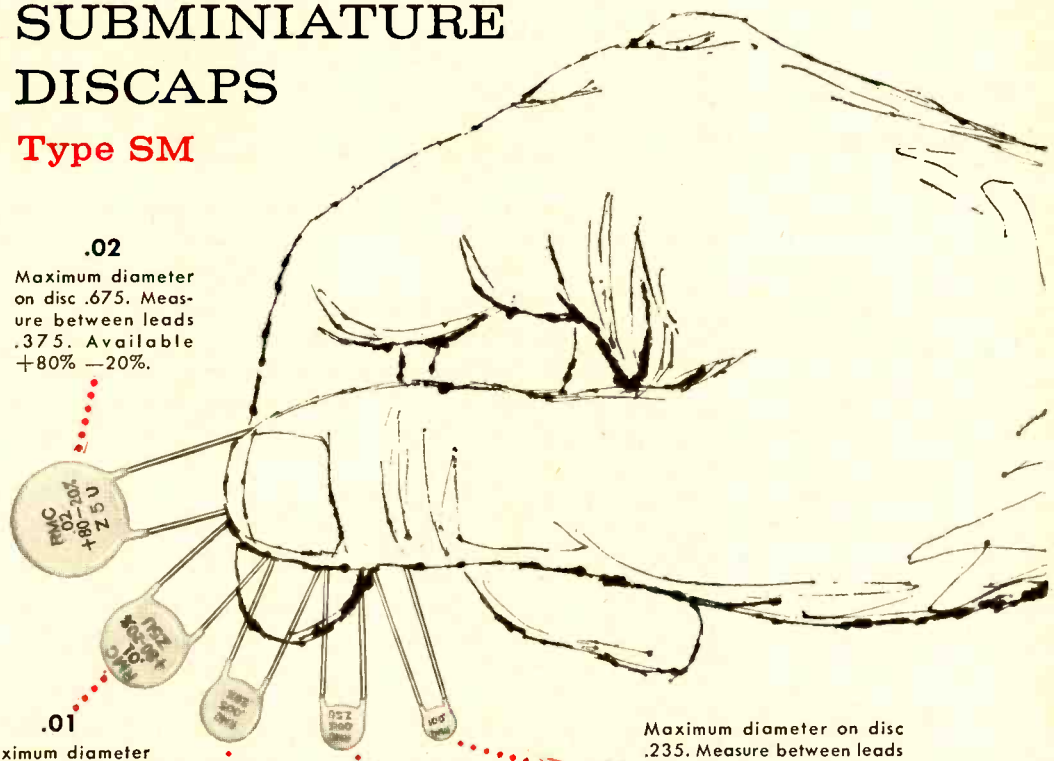
New York: 350 Fifth Ave. *Washington, D.C.:* 1001-15th St., N.W.

...where space and quality are at a premium

SUBMINIATURE DISCAPS

Type SM



.02
Maximum diameter on disc .675. Measure between leads .375. Available +80% —20%.

.01
Maximum diameter on disc .510. Measure between leads .375. Available +80% —20% or ±20%.

.005
Maximum diameter on disc .390. Measure between leads. .250. Tolerance ±20%.

.0015
Maximum diameter on disc .290. Measure between leads .250. Tolerance GMV.

.001
Maximum diameter on disc .235. Measure between leads .150. Capacities available are 800 and .001. Tolerance GMV.

Type SM DISCAPS answer the need for ceramic capacitors in the small sizes required in many applications. These miniature capacitors are manufactured without sacrifice of quality, dependability, or electrical characteristics built in all DISCAPS.

Write for information.

SPECIFICATIONS

POWER FACTOR: 1.5% Max. @ 1 KC (initial)

WORKING VOLTAGE: 500 V.D.C.

TEST VOLTAGE (FLASH): 1000 V.D.C.

LEADS: No. 22 tinned copper (.026 dia.)

INSULATION: Durez phenolic (⅛" max. on leads) —vacuum waxed

STAMPING: RMC—Capacity—Z5U

INITIAL LEAKAGE RESISTANCE: Guaranteed higher than 7500 megohms

AFTER HUMIDITY LEAKAGE RESISTANCE: Guaranteed higher than 1000 megohms

DISCAP CERAMIC CAPACITORS

RMC

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

strain gage inputs at a repetition rate of 50 per second. Output is connected to a digital voltmeter which feeds an IBM 727 tape unit. Data is processed by IBM 704.

And, oh yes, the beer. RCA's soft drink inspection system was modified to double-channel, suppressed carrier for stability to meet the additional problems inherent in beer inspection.

Railroads Laud Electronics Uses

PUBLICATION this Fall of *Proceedings* of the 34th annual session of the Communications Section of the Association of American Railroads indicates the considerable amount of electronics activity involved in running a railroad.

Statement by the association's vice president of Operations and Maintenance indicates that "capital expenditures since WW II have averaged over $1 billion a year for modern equipment, improved signaling, automation of yards and . . . communications."

Other statements indicate that electronics is proving useful in stretching railroad dollars under present conditions of increased costs and lower revenues.

Data-processing is pointed to as

Wavy Whiskers

Air jet blowing on metal whisker formation in potentiometer causes whiskers to wave and shimmer in the backlight, allowing Boeing Airplane Co. technician to view them with stereomicroscope. Whiskers are thin crystals which grow from metal surfaces

WASHINGTON OUTLOOK

THE ADMINISTRATION'S official forecast of a $12.2-billion Federal budget deficit this year—and its policy of sweating the deficit down as much as possible—lies behind all the talk you hear about a new hold-down on defense expenditures and other big spending programs.

Washington expects an upturn in corporate tax receipts and other revenues. It's firmly believed here that the recession is over and a general economic recovery is underway. But the key to a future balanced budget still lies in the administration's ability to trim its expenditures.

So the decision has been made to spend little, if any, of the extra $950 million Congress appropriated to the Defense Dept. this year for military production and development.

Included in this sum are funds for: extra Army procurement of equipment and missiles; speeding up construction of three nuclear-powered Regulus submarines; adding four nuclear-powered Polaris IRBM subs to the fleet; construction of two destroyer-escort vessels; accelerating development of the Polaris missile; expanding the Air Force's Minuteman and Hound Dog missile projects; production of additional KC-135 jet tankers and troop-carrier planes; increasing the Defense Dept.'s share of costs for VORTAC.

Just because these additional funds are not committed this year doesn't mean that the money goes down the drain. The funds could be spent next year.

- **The still-increasing role of electronics producers is evident in the Pentagon's latest listing of leading defense prime contractors.**

  Of the 15 top companies awarded contracts during 1957, 11 are either primarily electronics manufacturers or are firms heavily involved in electronics work.

  During the Pentagon's previous reporting period (January 1955 to June 1957) eight of the top 15 companies were in electronics production and development.

  The top electronics makers—and their ranking: General Dynamics, no. 1, $1.1 billion worth of new orders in 1957; GE, no. 2, $916.4 million; AT&T, no. 5, $471 million; North American Aviation, no. 6, $456.1 million; Hughes Aircraft, no. 7, $369.2 million; Martin Co., no. 9, $322.1 million; G.M., no. 10, $308.7 million; Northrop Aircraft, no. 12, $263.5 million; IBM, no. 13, $255.4 million; Sperry Rand, no. 14, $246 million; Bendix, no. 15, $223.5 million. (These figures include the companies' nonelectronic projects.)

- **Recent Congressional overhaul of Federal excise tax legislation eliminates the knotty problem of defining what is "entertainment type" electronic consumer equipment.**

  All radios, tv sets and phonographs are now subject to 10 percent excise tax. Exemptions are specifically permitted for sets which are components of any articles exported or sold to state or local governments or nonprofit educational organizations. Senate committee struck out all reference to magnetic recorders, tape or wire, thus exempting them from the tax.

VERSATILE, RELIABLE DIGITAL INSTRUMENTS

DC digital voltmeter offers maximum reliability... 0.01% accuracy... single-plane readout... and many other advanced features

The Model 401 offers four-digit display with automatic polarity indication and decimal placement... Measures .0001 to 999.9 volts with 0.01% ±1 digit accuracy... Adjustable least digit sensitivities of .1, 1, 10 mv... Average reading time of one second... Continuous, automatic standard cell calibration... 10 megohms input impedance... Built-in printer drive... 10 times longer readout bulb life... No circuitry in readout for easy remote mounting... Extra long relay life assured by DC drive. Price: $2100.

KIN TEL manufactures an exceptionally complete line of digital instruments. These "digital building blocks" permit measurement of AC, ohms, ratios, and automatic scanning of multiple inputs. Preamplifiers increase digital voltmeter sensitivity to 1 microvolt DC and 10 microvolts AC. Buffers permit driving typewriters, tape punches and printers. Complete digital systems for data logging, missile checkout and production testing are also available. The reliability and accuracy of these precision instruments are assured by KIN TEL's experience in designing and manufacturing more than 10,000 "standard cell accuracy" DC instruments. Sales and service are available nationwide. KIN TEL Engineering Representatives in all major cities.

All-electronic digital voltmeter measures millivolt to kilovolt with 0.1% accuracy ...costs only $960

Four ranges: 0.000 to 1.599; 00.00 to 15.99; 000.0 to 159.9; 0000. to 1000 volts (manual ranging and polarity)... No moving parts... Digital in-line readout... 70 millisecond conversion time... Adjustable display time... Input completely floating and isolated... 0.1% of full scale accuracy ... Direct voltage conversion circuit... Wide range of models.

KIN TEL's Model 801A all-electronic digital voltmeter measures DC from 0.001 to 1000 volts with 0.1% of full scale accuracy... and in less than 1/10 second, presents the measured voltage clearly on an in-line digital readout that even unskilled personnel can read with ease. *Direct* voltage measurement by successive approximation provides accuracy and sensitivity previously obtainable only in delicate, complex and expensive instruments. Extremely stable operation – continuous calibration against an internal reference. (Input impedance of the Model 801A is 20,000 ohms per volt. The Model 802A, priced at $1190, has an input impedance of 10 megohms on all ranges. In other models, the binary coded decimal and decimal outputs are externally available to permit driving printers and tape punches.)

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ELECTRONICS, INC.

Write today for descriptive literature or demonstration. 5725 Kearny Villa Road, San Diego 11, California

one area where intelligent use of existing equipment can effect substantial savings.

In addition to coverage of policy talks and speeches, the publication also contains papers presented to the session on such subjects as dataphone service, microwave transmission, automatic switching and transceiver operation.

Costs of R&D Increase 4%

RESEARCH and development costs continue to take an ever-increasing share of industry's dollar.

An American Management Association survey released early this month discloses that the 1958 all-industry average for budgeted R&D expenditures is up 4 percent over 1957. AMA uses the Census Bureau breakdown of industry, which does not consider electronics a separate industry group; but the several categories which include electronics firms give a fair indication of money spent for R&D by electronics.

Electrical machinery firms are spending 4.0 percent more this year than last—right on the all-industry mean. Last year the 62 firms in this group who responded to the survey budgeted an average amount equivalent to 4.8 percent of sales, compared to the all-industry average of 2.8 percent. AMA made a "horseback estimate" for ELECTRONICS that electronics firms included in this category are budgeting 4.5 to 5.0 percent more this year, and that last year's expenditure was more than 5.0 percent of sales.

Instrumentmakers are budgeting only one percent ahead of last year, but the 1957 average for the 73 firms responding was 5.2 percent of 1957 sales. This is the highest average R&D percentage reported by the AMA analysis.

Office machinery R&D is costing 5.2 percent more this year than last. Last year's average for 18 firms surveyed was 3.2 percent of sales.

According to AMA's factfinders, most R&D managers are still tying their budgets to near-term income expectations and emphasizing developments close to the shipping-room door.

MILITARY ELECTRONICS

• **Hound Dog's aerial launching** pads—pylons suspended below the left and right wing of the B-52—will carry individual star trackers for precise, on-the-spot, heading information prior to launching. Using the heading from the astro compass inside the fuselage—18 ft away—would give the missile's inertial guidance a slightly erroneous start.

Position information is fed to the missile's computer from the bomb-nav system in the plane (ELECTRONICS, p 15, Feb. 21).

Successor to the Rascal and forerunner of the air-launched ballistic missile, North American's Hound Dog is currently in fabrication. Pure inertial guidance, by North American's Autonetics, is a miniaturized and adapted version of the system used in the cancelled Navaho missile. (Modification of the same system navigated submarines *USS Nautilus* and *Skate* on their transpolar cruise. ELECTRONICS, p 8, Aug. 29). The pylon star tracker, KS-120, is produced by Kollsman, as is the KS-150 astro compass in the B-52.

• **New instrument** for measuring speeds of guided missiles, rockets, projectiles, aircraft and ground vehicles with accuracies of ±1 fps will be produced by Marconi of England.

EVA (electronic velocity analyzer) is small, portable and operates in the X-band. Range is up to nine miles. Data are obtained on moving Teledeltos paper and consist of a continuous graphical representation of events, recorded against a reference of calibration pips which occur every 0.1 sec. EVA records instantaneous changes in velocity.

From vantage point atop 35-story McGraw-Hill building, officer (lower right) uses portable 2-way f-m radio unit as . . .

Radio Eases Tunnel Traffic

NEW YORK's Port Authority is using electronics to combat traffic congestion at the heavily traveled Lincoln Tunnel.

During the Labor Day holiday weekend, portable 2-way f-m radio units worn by strategically deployed Port Authority patrolmen were initiated into regular service to report changing traffic patterns and dispatch police to trouble spots.

Traffic authorities reported a

FROM OUR GALLERY OF "DOUBTING THOMASES"

redoubtable doubter, Thomas Chulbb

COULDN'T "SEE" THE ELECTRIC BULB!

. . . nor could his present-day counterparts see the Elco Varicon connector principle when it was first introduced. These unhappy souls may now be selling electric bulbs in a 5-and-10 for all we know; while you are specifying more and more Varicons with each passing day.

If, by some chance, you do not as yet have our Varicon V-2 Catalog in your library, nor information concerning Elco's most complete and reliable quality line of printed circuitry, tube-sockets and shields, we'll be happy to correct that omission if you will drop us a note on your company letterhead immediately. The same applies to Elco's new products pictured below.

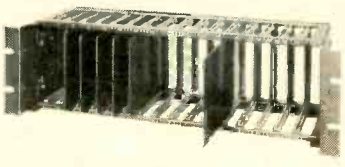
IF IT'S NEW... IF IT'S NEWS... IT'S FROM

ELCO CORPORATION

"M" St. below Erie Ave., Phila. 24, Pa., CU 9-5500

Elco-Pacific: 3260 Motor Ave., Los Angeles, Cal., TExas 0-3000

ELCO'S "VARIPAK"

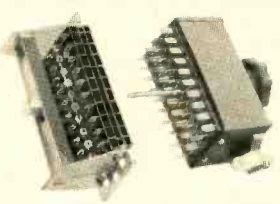


Printed circuit board enclosure for printed or etched circuitry. 78 parts may be retained with only 8 screws. For standard relay rack or standard electronic enclosure mounting. Bulletin A-1.

ELCO-PACIFIC EL SERIES

3 or 4 contact audio connector. Also available, our light-duty "B" Series. Both series are completely interchangeable with comparable units. Immediate delivery. Write for data.

ELCO'S SCREW-TYPE VARICON



Provides vibration-proof locking feature for mated connectors. Guarantees parallel insertion and withdrawal of contacts, with absolute avoidance of contact overstress. Write for complete data.

steady flow of traffic during peak periods and the rapid elimination of bottlenecks caused by breakdowns.

The Port Authority's two-way system consists of six transistorized transmitters and receivers operating in conjunction with a fixed repeater station. The units, designed by RCA, transmit and receive in the 150-mc band.

During peak periods, one officer is stationed atop the 35-story McGraw-Hill Building, home of ELECTRONICS. An unobstructed view of the tunnel approaches enables the officer to relay reports of traffic conditions almost instantaneously.

Electronics Probes Missile's Fluids

CAMBRIDGE, MASS.—Electronic method of detecting cavitation in liquid oxygen and other cryogenic fluids gave promise this week of pinpointing one source of trouble in missile propulsion systems.

Method stems from claim that cavitation in various liquids coincidentally produces omnidirectional magnetic field which may be observed and recorded with electronic instrumentation.

Preliminary report on the phenomenon was made here recently at MIT to nearly 600 attending the Fourth Cryogenic Engineering Conference.

James Clark of the Garrett Corp.'s AiResearch Manufacturing Div. in Phoenix told the conference that general field of magnetohydrodynamics is also expected to benefit from discovery that a local magnetic field is generated around certain molecules subjected to displacement relative to each other.

Varying magnetic field generated in region subject to dynamic or changing density gradients, he reported, can be picked up as an a-c voltage by sensing grids and transistorized electronic circuits.

Study of cavitation in cryogenic fluids and various hydrocarbons is also being applied to research in centrifugal pumps, turbines, marine propellers.

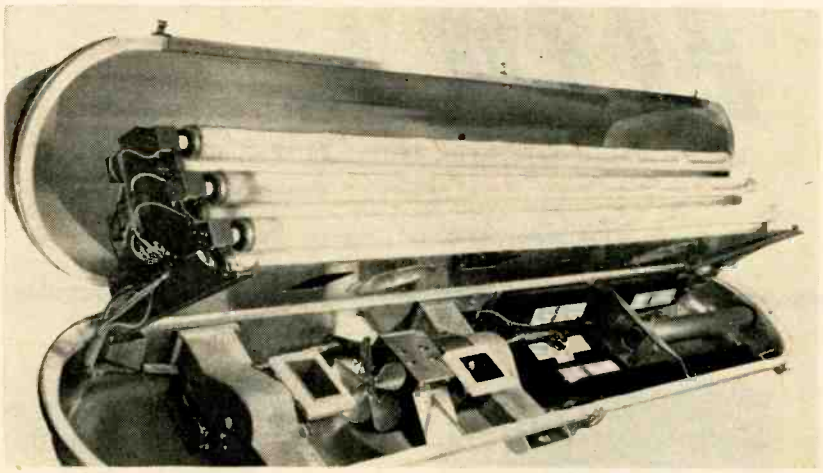
FINANCIAL ROUNDUP

• **Marquardt Aircraft**, Van Nuys, Calif., and **Applied Radiation Corp.**, of Walnut Creek, Calif., enter into agreement for joint efforts in developing ion and other electrical propulsion systems for space flight applications. Marquardt's **ASTRO Division**, which will work with ARCO on electrical propulsion systems, already has several programs underway on propulsion systems for satellite-boost and other hypersonic applications.

• **Mack Truck** discontinues manufacturing electronic equipment. Machinery and equipment of former Mack unit in Plainfield, N. J., has been acquired by **Electronics Assistance Corp.** of Red Bank, N. J. **Di An Controls** of Boston, Mass., has taken over the assets of Mack's Boston unit. Both firms are headed by the former Mack electronic unit general managers. It has been reported that Mack got out of the electronics business because it felt that it could more profitably devote its efforts to making trucks. Plainfield unit made electronic counters, radar sets and computer parts. Boston unit had been engaged in military contract work. Di An Controls, in addition to completing Mack contracts, is making magnetic cores and doing R&D work.

• **Servomechanisms**, Hawthorne, Calif., has been awarded $101,672 of additional funding by Douglas Aircraft. Additional money is for continued research into the field of solid state physics by Servomechanism's research laboratory.

• **Fairchild Camera & Instrument**, Syosset, N. Y., acquires the assets of **Acme Teletronix Division of NEA Service, Inc.**, of Cleveland, Ohio. Fairchild says Acme makes telephoto and facsimile transmitters used by United Press International and NEA Service and produces similar equipment for military and general industry use. The acquisition makes possible the combining of progress made by both companies in the field of color scanning in recent years. NEA already has a color scanner in operation. Fairchild Graphic Equipment Division, which developed several black and white electronic engraving machines earlier this year, has a color engraving machine under development.



Inside look at Chicago's new State Street radio-controlled lights shows "air conditioning" system (note fan, center), used when . . .

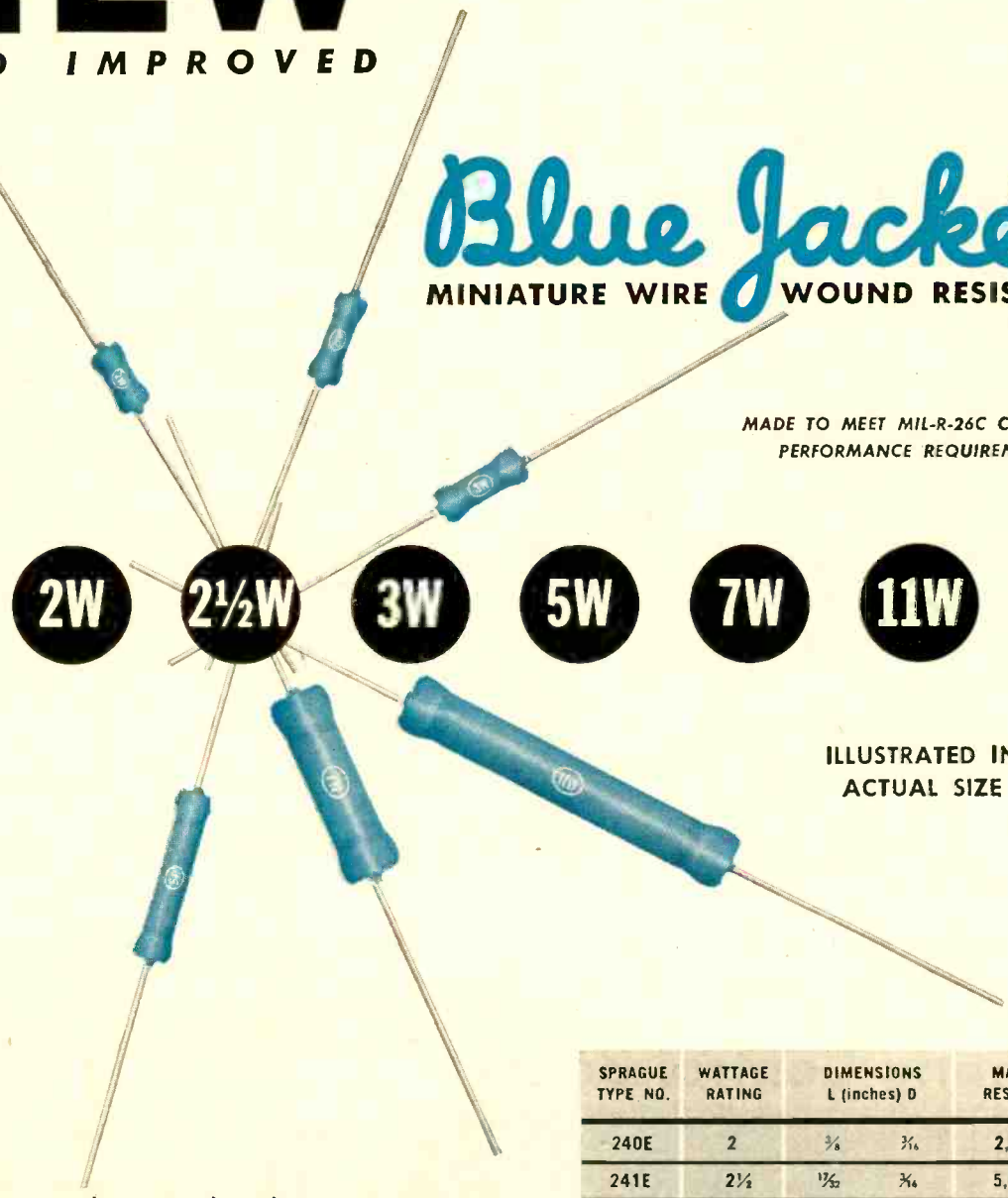
F-M Controls Street Lights

CHICAGO—A HALF-MILLION DOLLAR street lighting system featuring a central f-m radio transmitter unit and 70 receiver units, one each in the base of 70 fluorescent light poles, will soon be brightening

NEW
AND IMPROVED

Blue Jacket®
MINIATURE WIRE WOUND RESISTORS

MADE TO MEET MIL-R-26C CHAR. "V" PERFORMANCE REQUIREMENTS



ILLUSTRATED IN ACTUAL SIZE

SPRAGUE TYPE NO.	WATTAGE RATING	DIMENSIONS L (inches)	D	MAXIMUM RESISTANCE
240E	2	3/8	3/16	2,700 Ω
241E	2½	13/32	3/4	5,000 Ω
242E	3	17/32	13/64	10,000 Ω
243E	5	15/16	13/64	30,000 Ω
244E	7	1 1/8	5/16	30,000 Ω
245E	11	1 7/8	5/16	50,000 Ω

Now a new improved construction gives even greater reliability and higher wattage ratings to Sprague's famous Blue Jacket miniature axial lead resistors.

Look at the small sizes shown in the illustrations above and you will recognize how ideal they are for use in miniature electronic equipment with either conventional wiring or printed wiring boards.

For the full technical story on these dependable miniaturized resistors, write for Engineering Bulletin 7410.

SPRAGUE ELECTRIC COMPANY • 35 MARSHALL STREET • NORTH ADAMS, MASS.

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THE MARK OF RELIABILITY

SPRAGUE COMPONENTS: RESISTORS • CAPACITORS • MAGNETIC COMPONENTS • TRANSISTORS
INTERFERENCE FILTERS • PULSE NETWORKS • HIGH TEMPERATURE MAGNET WIRE • PRINTED CIRCUITS

State Street here.

The new poles in Chicago's loop will produce 15,624,000 lumens of light, or 225,672 lumens per pole. The electronics equipment will be "a sizable proportion" of the total cost, said General Electric, which is supplying the radio equipment.

This will be the first major lighting system to utilize radio for control, according to the State Street Council. Each pole's receiving set will automatically perform the following functions: turn on all lights at dusk, turn off portion of lights at midnight, turn off all lights at dawn and control festoon lighting.

Automatically controlled Calrod heating units installed at the base of each pole will maintain correct operating temperatures for the receivers so they will function properly in snow. The 70 receivers are mobile-type sets operating on a-c power. The 27-mc carrier is frequency-modulated with pulse tones to fulfill the various lighting requirements.

Each receiver is a crystal controlled double conversion superhet whose sensitivity runs 0.4 of a micro-volt, with frequency stability of 0.002 percent. A simple whip antenna will serve for the transmitter and short whip antennas will be placed on each light pole.

The input voltage of the transmitter is 117 volts a-c and the power output is 30 w, plus or minus 10 percent. Modulation on the wide band is a plus or minus 15 kc swing with instantaneous modulation limiting. The narrow band uses a plus or minus 5 kc swing with instantaneous modulation limiting. The crystal multiplication factor is 12, and ambient temperature is minus 30 C to plus 60 C.

The audio frequency characteristics are between plus 1 to minus 3 db of a 6 db octave with preemphasis from 300 to 3,000 cps, reference 1,000 cps. Spurious and harmonic radiation is at least 80 db below rated power output at any frequency. Size of the unit is 6 in. high by 4 in. wide by 13½ in. long. Weight is 3½ lb.

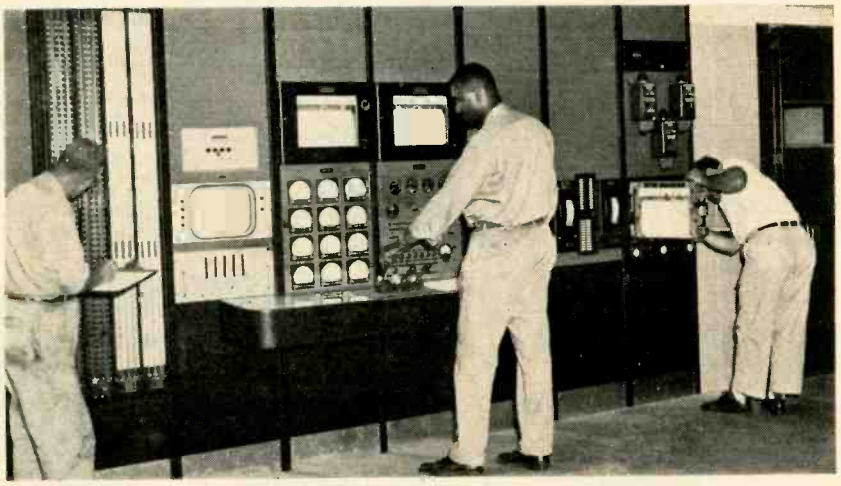
Buy 1,385 New Players for Blind

THIS WEEK saw sale of 1,385 Talking Book players to Library of Congress Division for the Blind to be distributed throughout the country.

The record players are portables especially designed for operation by the blind. They play 16⅔ rpm recordings of narrated books. An average size volume can be recorded on five or six 12-inch records.

The units sold this week are manufactured by Stromberg-Carlson. Player has a three-stage amplifier with 1½-w output, crystal pickup and speaker. In addition to volume and tone controls, a jack for headphones is provided.

Floating Control Booth



Windowless control room of Wright Air Development Center's new jet engine test stand floats on noise insulation. Technicians use tv and instruments to observe engine tests

MEETINGS AHEAD

Sept. 26-27: Broadcast Transmission Systems, Annual Symposium, IRE Prof. Group, Willard Hotel, Wash., D. C.

Sept. 28-Oct. 2: Electrochemical Society, 114th Meeting, Chateau Laurier, Ottawa, Canada.

Sept. 29-Oct. 3: Audio Engineering Society, 10th Annual Conv., Hotel New Yorker, N. Y. C.

Oct. 1-2: Radio-Interference Reduction, U. S. Army Signal Engineering Labs, IRE, Armour Research Foundation, Chicago, Ill.

Oct. 6-8: Symposium on Extended Range and Space Communications, IRE and George Washington Univ., Lisner Auditorium, Washington, D. C.

Oct. 8-10: IRE Canadian Convention and Exposition, Electronics and Nucleonics, Exhibition Park, Toronto, Canada.

Oct. 13-15: National Electronics Conf., 14th Annual, Hotel Sherman, Chicago, Ill.

Oct. 14-15: Institute of Printed Circuits, Fall Meeting, Chicago, Ill.

Oct. 20-21: Aero Communications Symposium, Fourth National, PGCS, Hotel Utica, Utica, N. Y.

Oct. 20-21: USA National Committee, URSI Fall Meeting, Penn State Univ., University Park, Pa.

Oct. 20-24: Society of Motion Picture and Television Engineers, 84th Convention, Sheraton-Cadillac Hotel, Detroit, Mich.

Oct. 26-31: American Institute of Electrical Engineers, Fall Meeting, Penn-Sheraton Hotel, Pittsburgh, Pennsylvania.

Oct. 29-30: Fifth Annual Computer Applications Symposium, sponsored by Armour Research Foundation, Morrison Hotel, Chicago, Ill.

Oct. 30-31; Nov. 1: Electron Devices Meeting, PGED, IRE, Shoreham Hotel, Wash., D. C.

Oct. 30-31: Aircraft Electrical Society, Pan Pacific Auditorium, Los Angeles, Calif.

Nov. 6-7: Prof. Group on Nuclear Science, IRE, Fifth Annual Meeting, Villa Hotel, San Mateo, Calif.

Nov. 17-20: Magnetism and Magnetic Materials, Fourth Annual Conf., AIEE, APS, IRE, AIME, OHR, Sheraton Hotel, Phila., Pa.

.....RELIABILITY

of electronic components, however small, is vital in controlling a rocket, however large . . .

RELIABILITY

of electronic components *you* use is vital, whatever their type, size or function . . .

RELIABILITY

of electronic components is the vital advantage, unconditionally guaranteed, in any quantity you order from . . .

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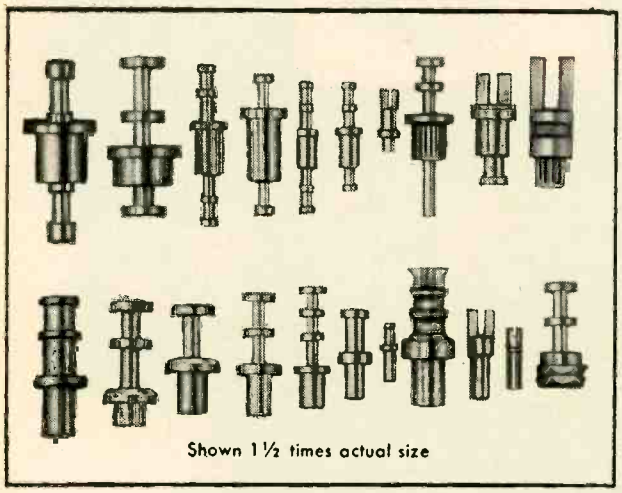
multiplied by millions

CAMBION® electronic components . . . countless in quantity, broad in variety . . . are quality-controlled, thoroughly tested and unconditionally guaranteed.



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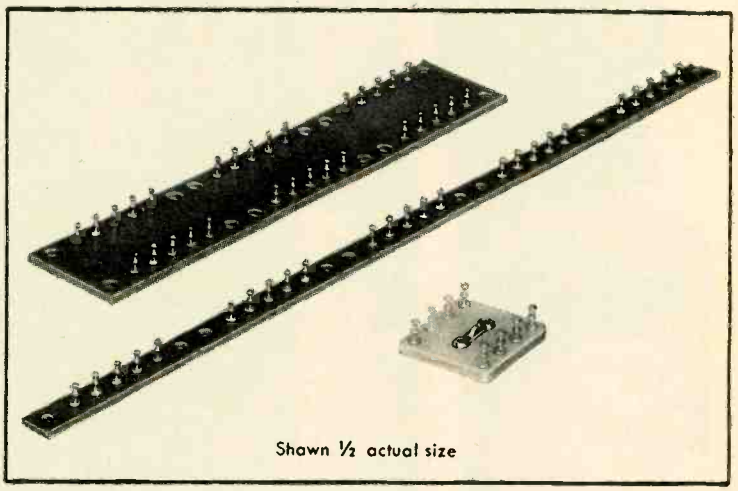
Terminals



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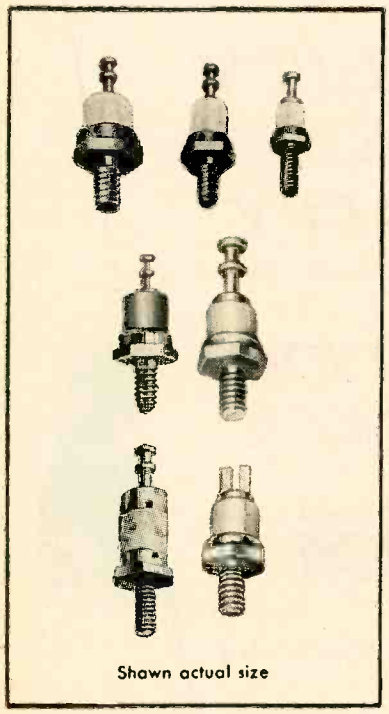
Terminal Boards



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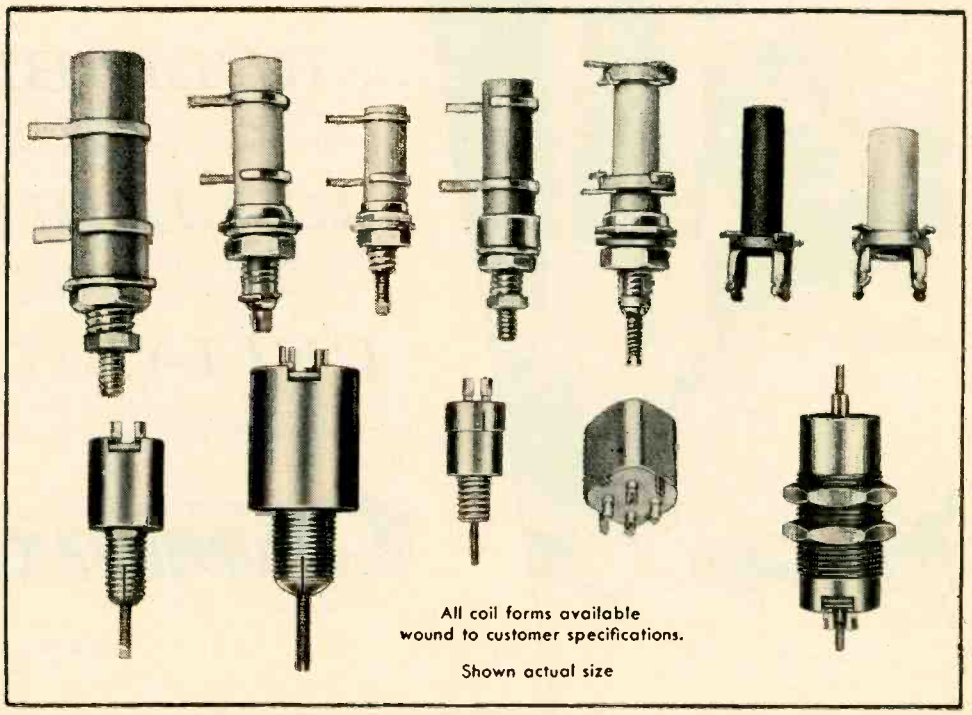
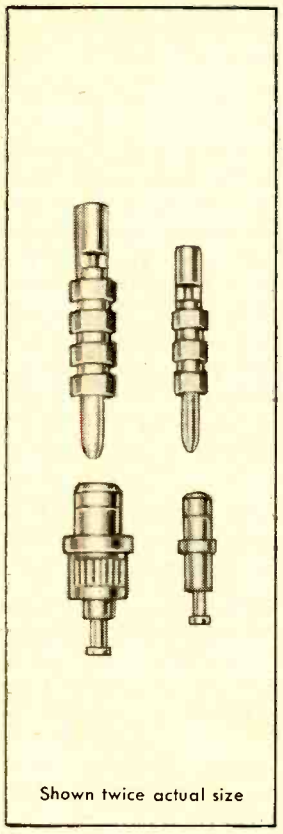
Insulated Terminals



All coil forms available wound to customer specifications.

Shown actual size

Coil Forms and Coils



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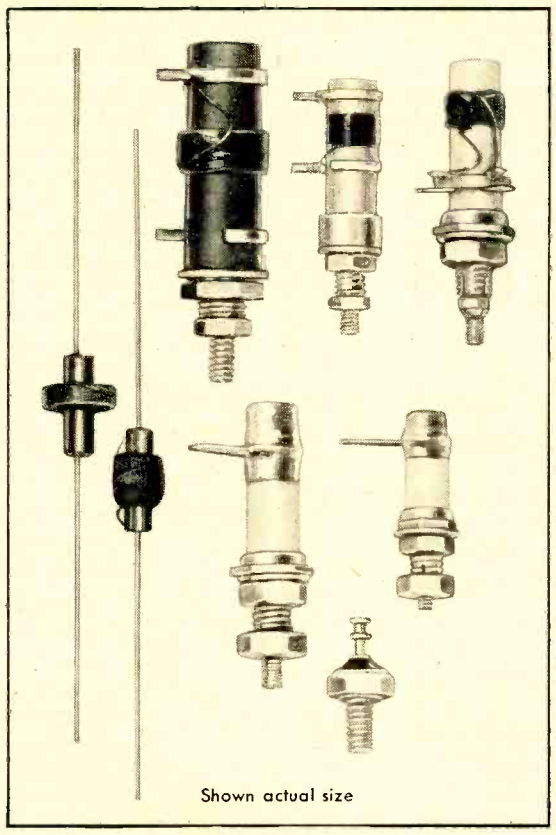
Miniature Connectors



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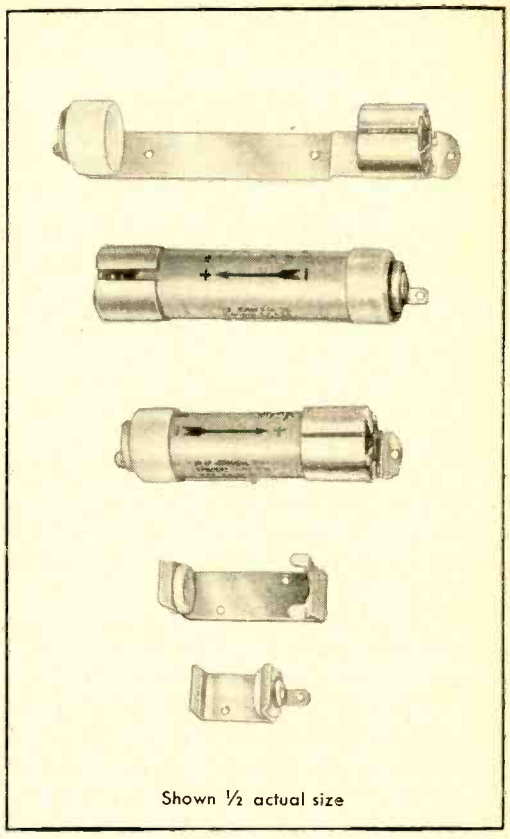
Chokes and Capacitors



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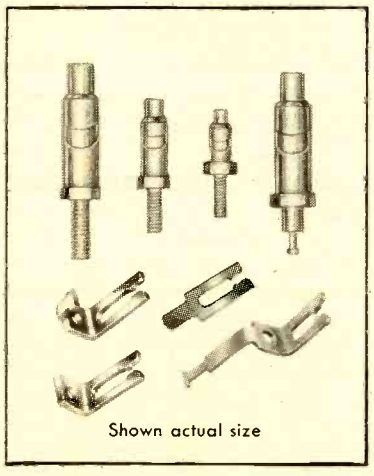
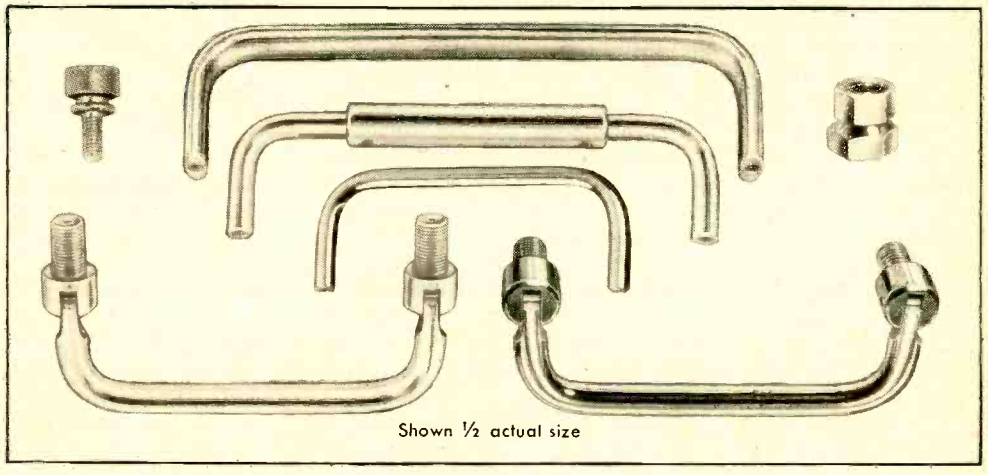
Battery Holders



Shown actual size

Diode Clips



Shown ½ actual size

Handles and Hardware

Any part, regardless of size, may be the most efficient, most reliable feature in an assembled product.

That's why CAMBION components, small as they are, are indispensable in many electronically equipped products — and can be equally valuable in your own. The reason is exceptional reliability — so carefully maintained that it will pay you to investigate how CAMBION components can benefit your own industry.

QUESTIONS YOU OUGHT TO ASK about these highly important little essentials are: How high in quality are their raw materials? . . . What advancements in design, and in manufacturing equipment and methods are evident in their production? . . . During and after manufacture, how much inspection and testing are they given? . . . How closely do they conform to government specifications? . . . How widespread is their reputation for reliability? . . . How is this reliability guaranteed — fully and convincingly?

FOR CAMBION ANSWERS to your questions, with facts that may help you to more successful, more profitable production . . .

Turn To The Next Page

CAMBRIDGE THERMIONIC CORPORATION

CAMBION®

Makers of guaranteed electronic components, custom or standard

RELIABILITY

100% Engineered
100% Guaranteed

On two previous pages you've seen some of the more prominent CAMBION electronic components. The entire family is huge, with many different types and sizes. Yet all share one family trait — *reliability*. Here are the reasons why:

CAMBION QUALITY CONTROL — Modern methods based on MIL-Q-5923C are carefully adhered to by CAMBION quality control engineers.

CAMBION RAW MATERIALS must be certified to meet CAMBION requirements. For example, grade L5 silicone-impregnated ceramic, used in coils and coil forms, is purchased only from government certified sources and must meet specification JAN-I-10.

CAMBION SPECIAL EQUIPMENT AND FACILITIES include an up-to-date precision tool and die shop, manufacturing all needed tools and dies to standards assuring highest product quality. In addition, all plating is done in a CAMBION-approved plant, with a laboratory for checking all solutions.

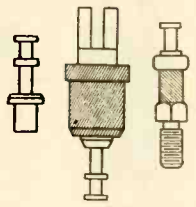
In the laboratory a Kocour electronic plating thickness tester is used. Other CAMBION testing equipment includes special electrical devices, some of them registering such delicate accuracies that they are seldom used by electronic component manufacturers. These devices cover such units as impedance, inductance and capacitance bridges to accuracies of .1%. Also included are standard oscilloscopes, synchroscopes, pulse and trigger generators; signal generators to 3,000 megacycles; sealed inductor standards; precision voltmeters; vacuum devices evacuating to microns.

Environmental testing equipment includes new electrodynamic shaker equipment, mechanical low frequencies table, humidity, temperature and salt spray chambers. Testing per MIL-E-5272A, MIL-STD-202 and MIL-E-5422 is regularly performed using this equipment.

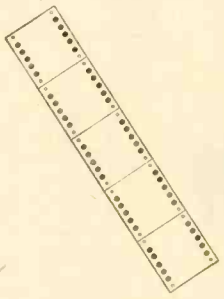
Among CAMBION standard production equipment are optical comparators and protractors; precision microscopes; monochromatic light sources for high precision measuring to millionths of an inch; gage blocks; supermicrometers; wire systems for measuring thread pitch diameters; and Tri-Roll thread comparators.

To speed and improve its own production, Cambridge Thermionic has developed unique equipment such as the Hopper staking machines. This machine fits terminals into terminal boards with precise proper handling and eliminates cracking the boards. It is available to customers.

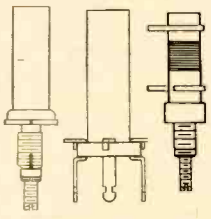
CAMBION TESTS — AT EVERY STEP OF THE WAY are too many to be completely described here. Let's take just a few, on some of the components, as listed below.



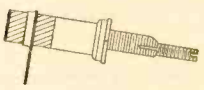
Terminals. On standard terminals a cross-sectional analysis of plating is made; dimensional and visual quality control checks are made as per MIL-Q-5923C; a salt spray test is performed and terminals are packaged in sulphur-free paper to avoid tarnishing. Insulated terminals, which get the same tests on the metallic component, are also subjected to a voltage breakdown, a humidity and insulation resistance test and a pull test — to find the strength of the insulation when tension is exerted on the terminal.



Terminal Boards. These receive all checks on terminals described above, plus pulling and twisting tests.



Coil Forms and Coils. When completed, these are checked for mechanical stability. Pull tests are also made, to assure the form is seated in the mechanical mounting. Where required, tests conforming to MIL-C-15305A are made, covering inductance, distributed capacity and other pertinent parameters.



Capacitors. Checked for vibration, temperature coefficient and tested for corona at reduced pressures equivalent to high altitudes.

Handles and Hardware. Life-tested for all movable parts, together with salt spray and general testing as per MIL-Q-5923C.

CAMBION QUALITY, RELIABILITY AND GUARANTEE form a combination unequalled for your guidance in choosing electronic components. In manufacture, CAMBION components meet or better government specifications. In testing, Cambridge Thermionic makes sure that keeping quality at its highest level is standard practice. And quality like this means CAMBION reliability is on the biggest scale *two ways:* first, because of the great breadth of the line; second, because of its nation-wide acceptance by leading manufacturers.

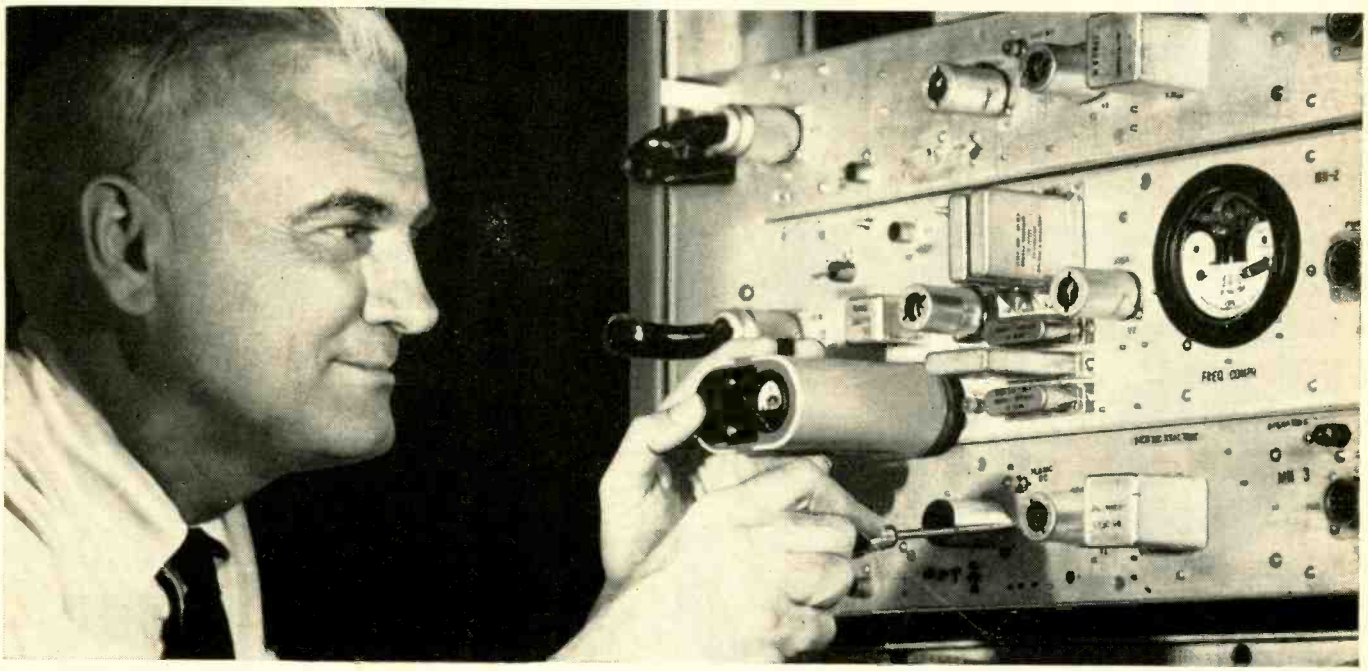
That's how Cambridge Thermionic provides the quality and reliability *you must have* — to help your products perform as you design them to perform. And these valuable advantages are guaranteed. That's on the biggest scale, too, because it applies *unconditionally* to all CAMBION components, in any quantity you order, from one to millions.

Get more details on CAMBION components. Send for samples or blueprints you need, or for the just-published Catalog Supplement. Write to Sales Engineering Dept., Cambridge Thermionic Corporation, 437 Concord Ave., Cambridge 38, Mass. In Canada, Cambridge Thermionic of Canada (Ltd.), 2425 Grand Blvd., Montreal 28, P. Q. For your convenience CAMBION components are available from Authorized CAMBION Distributors throughout the United States and Canada.

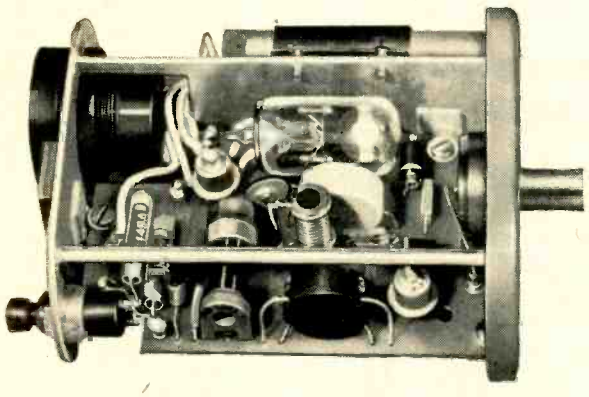
CAMBRIDGE THERMIONIC CORPORATION

CAMBION®

Bell Laboratories Announces Pocket-Sized Frequency Standard for Microwave Systems



Lawrence Koerner, who developed the portable frequency standard, demonstrates how the device can be plugged in at a radio relay station to supply a checking frequency. Battery-powered, the device maintains precision calibration for several months.



Inside the portable frequency standard. Four Laboratories-developed devices make it possible: (1) transistor, which converts the power from a battery to radio frequency oscillations; (2) voltage reference diode, which maintains constant voltage; (3) piezoelectric crystal unit of superlative stability; (4) thermistor, which corrects for temperature variations.

Microwave radio relay systems depend critically on the accuracy of their "carrier" frequencies. At scores of relay stations along a route, carrier frequency oscillators must be checked periodically against a signal from a precise standard.

In the past, the maintenance man has had to obtain his checking frequency by picking up a standard radio signal from a government station. This operation takes time—and requires elaborate equipment.

With a new *portable* frequency standard developed by Bell Laboratories engineers, the job is much simplified. To check an oscillator, the portable standard is plugged in, and a button is pressed. In seconds, it supplies a checking frequency accurate to one part in a million.

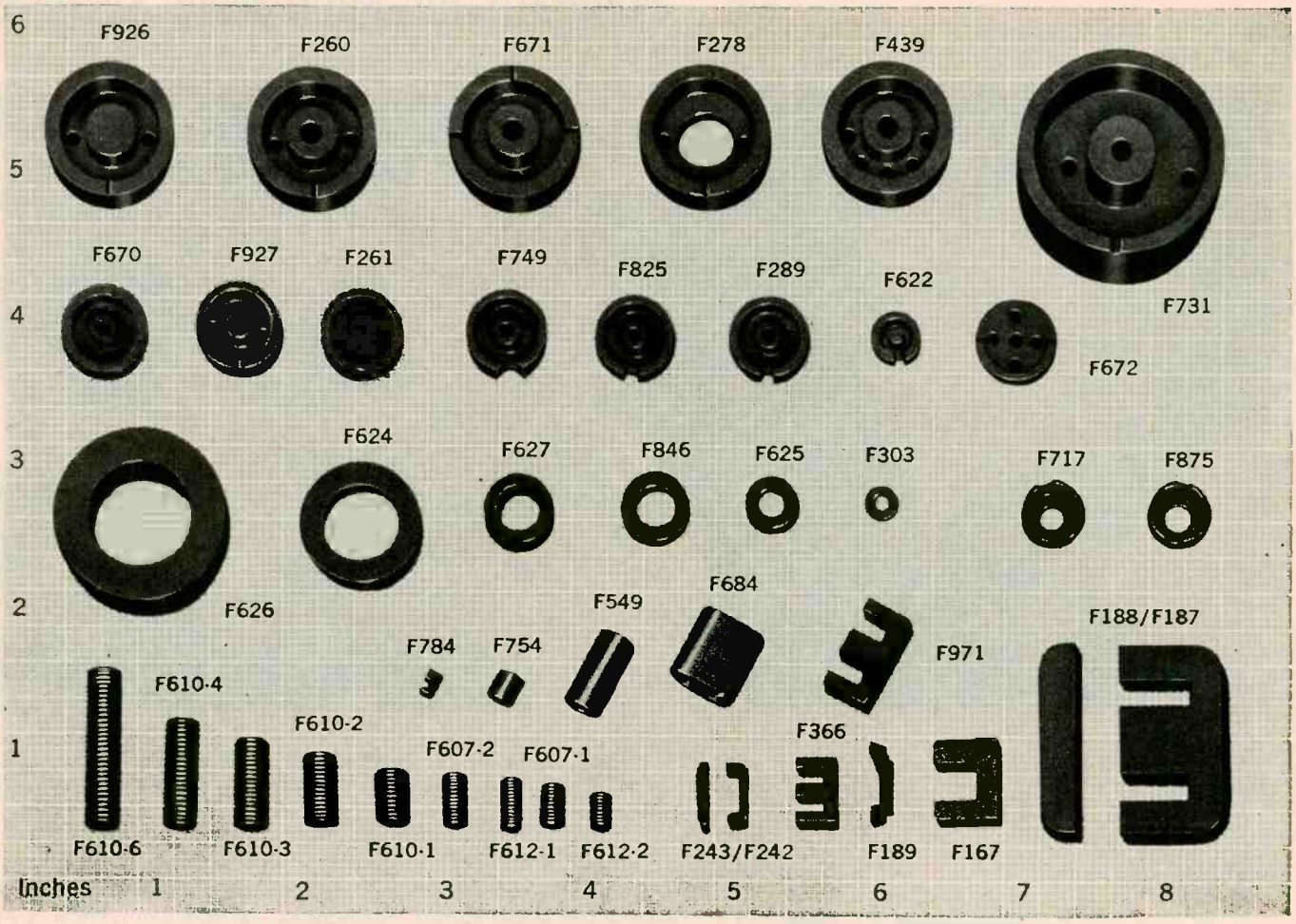
Until now, such precision in a frequency standard has been obtainable only in a laboratory. The new portable standard makes it available for routine use in the Bell System. First use of the standard will be to maintain frequency control in a new microwave system for telephone and TV, now under development at Bell Laboratories.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

Now, Immediate Delivery from Stock on

GENERAL CERAMICS SPECIAL PURPOSE FERRITE CORES



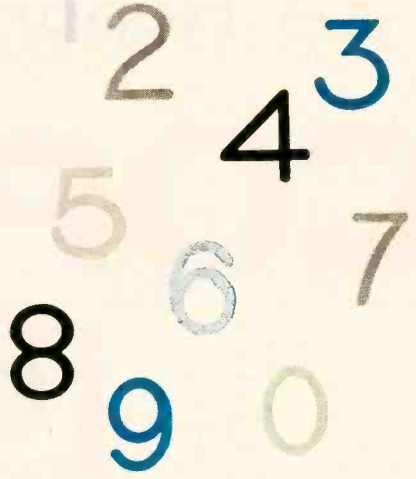
Rush service for designers – use this handy materials selector chart

Ferrite Cores available in various materials for development and design engineers to cover specific frequency bands of operation from 1 KC to 50 megacycles. General Ceramics provides extra-fast service on sample quantities for development and will make prompt delivery on production parts in reasonable quantities. Call, wire or write General Ceramics Corporation, Keasbey, New Jersey. Please direct inquiries to Dept. E.

APPLICATION	DESIRED PROPERTIES	FREQUENCY	FERRAMIC BODY	SHAPES
Filter Inductors	High μQ, magnetic stability, sometimes adjustable	up to 200 kcs 200 kcs-10 mcs 10 mcs-80 mcs	"O-3", "T-1" "Q-1" "Q-2"	Cup cores, toroids, C-cores, E-cores, slugs
IF Transformers	Moderate Q, high μ, magnetic stability, adjustable	465 mcs 40 mcs other	"Q-1" "Q-2" Materials for filter inductors apply	Cup cores, threaded cores, toroids
Antennae Cores	Moderate Q, high μ, magnetic stability	.5-10 mcs 10.50 mcs	"Q-1" "Q-2"	Rods, flat strips
Wide Band Transformers	High μ, moderately low loss	1 kc-400 kcs 1 kc-1 mc 200 kcs-30 mcs 10 mcs-100 mcs	"O-3", "T-1" "H" "Q-1" "Q-2"	Cup cores, toroids, C-cores, E-cores
Adjustable Inductors	High μ, moderately low loss	Same as Wide Band Transformers	Same as Wide Band Transformers	Rods, threaded cores, tunable cup cores
Tuners	High μ, moderate to high Q, magnetic stability, as much as 10 to 1 adjustability with mechanical or biasing methods	Up to 100 mcs	For high Q selective circuits, materials under filter inductors apply. For others, materials under wide band transformers apply	Threaded cores or rods for mechanical tuning. Toroids, C-cores, E-cores for biasing methods
Pulse Transformers	High μ, low loss, high saturation	Pulse	Materials under wide band transformers apply	Cup cores, toroids, C-cores, E-cores
Recording Heads	High μ, low loss, high saturation, resistance to wear	Audio, pulse	"H" "O-3", "T-1"	

GENERAL CERAMICS

Industrial Ceramics for Industrial Progress... Since 1906



Presenting hp *524D Electronic Counter*

New 8-decade numerical readout!

New $5/10^8$ per week stability!

SPECIFICATIONS

(Basic 524D without plug-ins)

Frequency:

Range: 10 cps to 10.1 MC

Gate Time: 0.001, 0.01, 0.1, 1, 10 secs or manual

Accuracy: ± 1 count ± 0.000005%

Reads in: KC. Automatic decimal

Period:

Range: 0 cps to 10 KC

Gate Time: 1 or 10 cycles of unknown

Accuracy: ± 0.3% (1 period)
± 0.03% (10 period average)

Stan. Freq. Counted: 10 cps, 1 KC, 100 KC, or 10 MC, or external

Reads in: Secs, msec, μsec

General:

Registration: 8 places (99,999,999 max.)

Stability: 5/100,000,000. May be standardized with WWV or external 100 KC or 1 MC primary standard.

Display Time: Variable 0.1 to 10 secs; or "Hold"

Input Voltage: 1 v min, 1.5 v peak. Rise time 0.2 seconds max.

Input Impedance: Approx. 1 megohm; 40 μμf shunt.

Price: $2,150.00 f.o.b. factory.

Data subject to change without notice

plus all these frequency and time measuring advantages!

Direct, instantaneous, automatic readings

Frequency coverage 10 cps to 220 MC*

Time interval 1 μsec to 100 days

Resolution 0.1 μsec

High sensitivity, high impedance

No calculation or interpolation

New convenience of uniform 8-decade numerical readout without meters — new 5 parts in 10^8 stability simplifying standards and other microwave measurements — this is the capsule story of the new *-hp-* 524D Electronic Counter.

Electrically similar to the widely used *-hp-* 524B Counter, the new 524D provides for full frequency measurements from 10 cps to 10 MC and period measurements from 0 cps to 10 MC. Low cost plug-in units extend frequency measuring range to 220 MC, permit period measurements of over 10,000 periods, and increase sensitivity for precise measurement of weak signals. Still another plug-in provides for time measurements from 1 μsec to 100 days with 0.1 μsec resolution. When used with *-hp-* 540A Transfer Oscillator, the 524D will measure accurately to 12 KMC. For complete details, write or call your *-hp-* representative; or write direct.

HEWLETT-PACKARD COMPANY

5022A PAGE MILL ROAD • PALO ALTO, CALIFORNIA, U.S.A.
CABLE "HEWPACK" • DAVENPORT 5-4451
FIELD REPRESENTATIVES IN ALL PRINCIPAL AREAS

*with plug-ins

hp world's most complete line of electronic counters

A Report On

COPPER and 8 points to consider

Today, with copper readily available, a new direction in electrical and electronic design is becoming apparent. There is a growing acceptance that many of the important new design requirements *besides* conductivity can be met by copper itself — as alloys, as laminates and as the pure metal. Sometimes it is merely the method of use which is changed to achieve optimum performance. But this is not just a rediscovery of copper — it is also the creative development of new alloys and new usages.

Here are just eight of the more important design requirements, besides conductivity, which are currently being met by some form of copper:

Conductivity plus Strength and Reliability

The flexibility, resiliency and fatigue strength of certain copper alloys have long dictated their use wherever reliability was important. Some of these alloys have excellent mechanical qualities while still maintaining high conductivity. Cadmium bronze, for example, is 99% copper with tensile strengths, for hard-drawn wire, up to 90,000 psi. Excellent spring qualities with fatigue strength and wear resistance, even at high temperatures, can be obtained with beryllium copper. Superfine-grain phosphor bronze is a relatively new development useful in applications where enduring contact-point pressure is most important.

The reliability of the copper operative parts of electromechanical choppers is a basic reason for the return to these in place of electronic types in a number of missile applications.

Conductivity plus Heat Dissipation and Hot Strength

Heat conductivity, of course, usually parallels electrical conductivity. In addition to the obvious uses of this property in heat exchange apparatus and appliances, many current applications are taking advantage of copper's heat conductivity, plus its good joining properties, to conduct heat away from more delicate components by means of cooling vanes and heat sinks.

Chromium copper's greater strength at elevated temperatures is finding new uses in mechanical-electrical parts such as commutator segments and resistance-welding electrodes. At 200C, for example, its tensile strength is about twice that of tough-pitch copper.

Conductivity plus Corrosion Resistance

Commercially pure copper affords excellent resistance to industrial, marine and rural atmospheres, and to water, steam, alcohol, fuel oil, gasoline and sewage. Alloys have been developed to withstand many of the more active reagents. Recognition of this property has led to non-electrical uses in electrical equipment.

Conductivity plus Forming Facility

The hot and cold workability of copper itself is excellent. In addition, coppers containing small amounts of tellurium have good machining properties while still retaining high conductivity. And extruded shapes can often be used to minimize the amount of forming needed.

Interesting new examples of copper's workability include cold rolling to thicknesses less than .0005 inches (for missile computer applications, foil coil transformers and flexible printed circuits). Another new development is the cold hobbing of solid copper, maintaining extremely close tolerances. With this process it is possible to produce *one-piece* magnetron cavities.

its ALLOYS

besides conductivity

Conductivity plus Joining Facility

Copper is, of course, easily and firmly soldered. Many of its alloys also lend themselves well to brazing and to oxyacetylene or gas-shielded arc welding. New methods of inert-gas metal-arc welding make it easy to weld pure copper.

Conductivity plus Bonding Facility

Copper's affinity for plating has made possible, for the first time, a really good bond with titanium, by flash coating the base metal with copper before plating with titanium. New developments in printed commutator-type circuits can take advantage of the exceptional wear resistance of rhodium because of the good bond it will form with the copper conductive layer. Continuing research is also being done on laminates of copper with other metals and plastics.

Conductivity plus Finish

Copper and most of its alloys, particularly the nickel silvers and low-zinc brasses, are useful for ornamentation and housings because of their cold-working properties and their ease of plating and finishing. The new fine-grain brasses provide a surface ideal for high finish.

Conductivity plus Availability

The copper industry's mine reserves and productive capacity are at a new high. Copper and copper alloys are now available in more shapes, sizes and material specifications than ever before. The long-range prospects are so good as to completely dispel any reservations lingering from the post-war years when stock-piling gave a surface appearance of short supply. Domestic mine capacity is scheduled to increase at an average rate of well over 20,000 tons per year. Free-world capacity, allowing for depletions, shows a projected 15% increase during the next five years.

And a word about conductivity itself. Even this classic property of copper merits a new examination. For example — silver-bearing copper, containing only 8 to 30 ounces of silver per ton, retains the high conductivity of copper, but has higher softening temperatures—and at commercially practical prices. Speaking of price, have you compared copper lately on a cost-per-mho basis with any other conductive metal you might be considering? You will find that this cost of conductance now makes it particularly economical to take advantage of copper's other properties.

The Copper & Brass Research Association is anxious to cooperate with you in finding a better way to solve your problems with copper. Write CABRA, 420 Lexington Avenue, New York 17, New York.

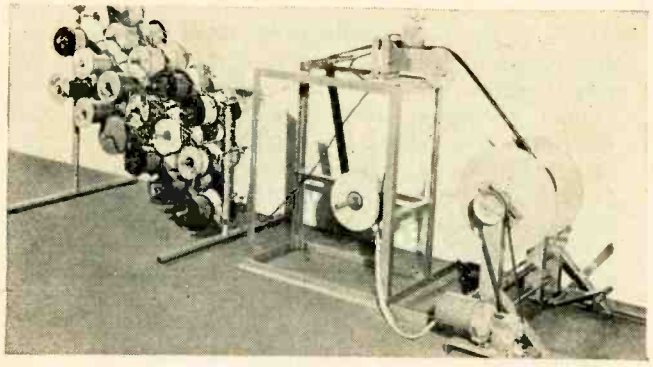
There's a new frontier in...

COPPER
BRASS
BRONZE

NEW Automatic Electronic Cable-making Machine Announced

(Los Angeles, California) After years of development, The Zippertubing Company announces production of a machine which automatically makes cables at speeds up to 900 feet per hour. This machine, occupying only 24 square feet of floor space, produces cables with up to 108 conductors and is so simple to operate that inexperienced personnel can make cables to any specification.

This new equipment utilizes the revolutionary Zippertubing cable jacketing, which is fed into the machine along with the required number of conductors. The Zippertubing then is automatically wrapped around the conductors, zipped closed and, if required, permanently fused with a chemical sealer. The completed cable automatically is wound on the take-up reel for storage or shipping. The machine will produce cable from ⅜" to 2½" O.D. with larger sizes on special order.



Complete unit with wire reels in place.

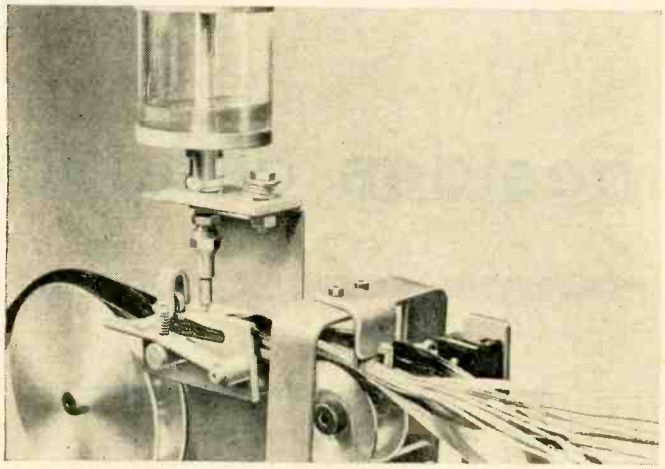
MULTI-JACKETED CABLES IN ONE STEP

By using Zippertubing laminated materials, cables which require jackets of several different materials can be made in one step without costly re-handling. Available jackets include copper, aluminum or Co-netic steel in combination with such materials as vinyl, Mylar,* or fiber glass. Other laminates for high temperature exposure, abrasion protection, etc., also may be used in the machine.

SUBSTANTIAL SAVINGS

Up to 90% of the labor costs formerly involved in fabricating cables are eliminated through the use of the Zippertubing Cable Machine. Only limited floor space is necessary for long-run continuous lengths, and material waste, skilled labor investment and expensive extruding equipment no longer are required. Expensive "minimum" orders for custom extruded cabling as well as delay in deliveries also are eliminated. Because of the flexibility of Zippertubing, small cable runs for R & D work are economically feasible. Zippertubing cables can be re-opened for additional work on conductors, virtually eliminating the great costs formerly incurred in correcting mistakes in prototype development.

**Trademark of duPont.*



Close-up of head showing Zippertubing jacketing and conductors being formed into cable and automatically sealed.

MEET MIL SPECS

Cables produced on this new equipment meet all necessary MIL specs, depending on the jacketing material and the purpose for which it is to be used.

CABLE MACHINE FREE

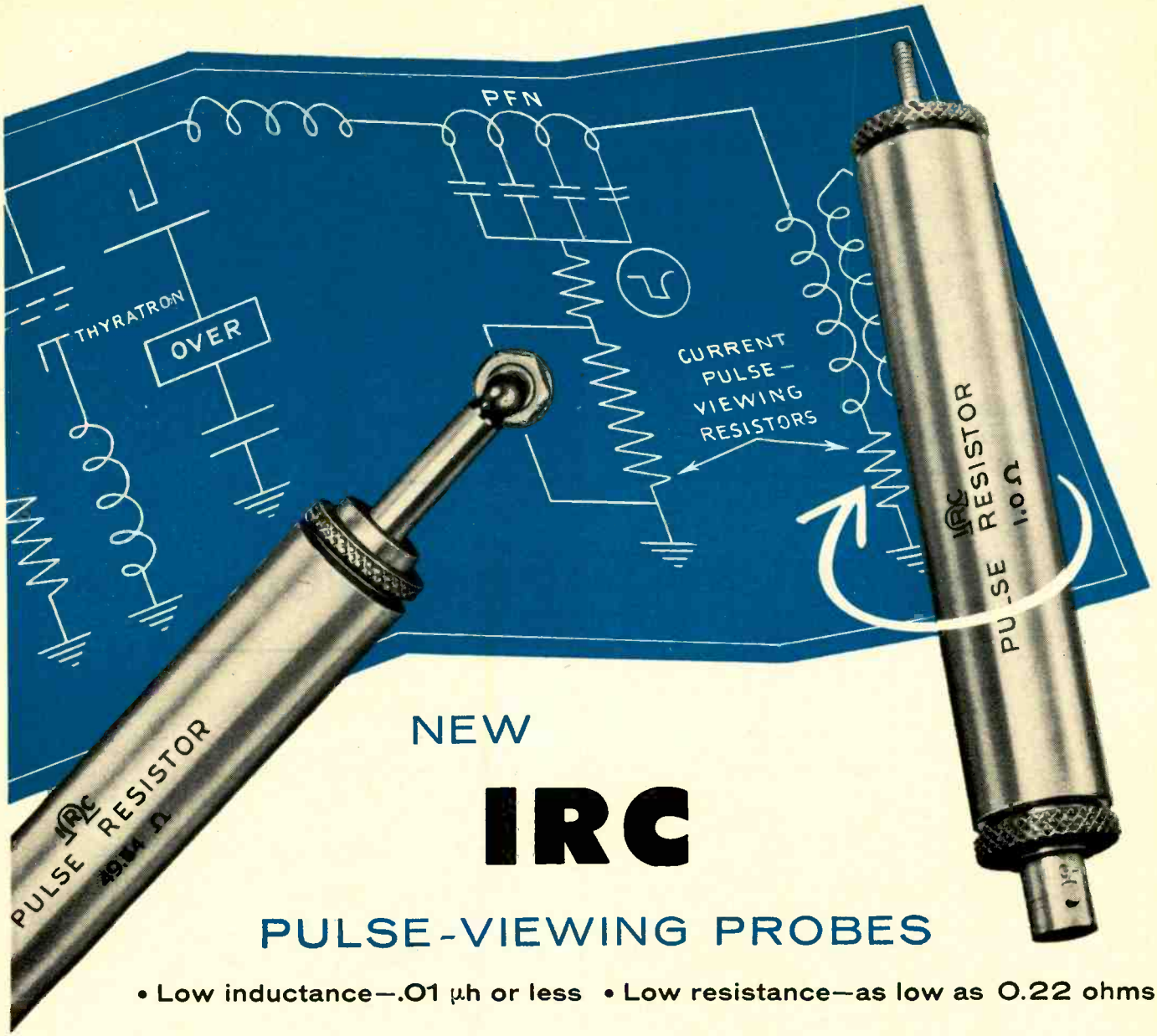
One of the purposes of this new machine is to help manufacturers reduce their capital investment and inventory in electronic cables. A special plan has been developed whereby manufacturers who use 10,000 feet or more of Zippertubing jacketing per month will be provided with one of these machines at no cost. For those with more modest requirements, the machine may be leased very inexpensively with option to buy, or it may be purchased outright. A 100% lifetime guarantee is available under all plans. When ordering, allow three weeks for delivery.

AVAILABLE IN THREE PARTS

The Zippertubing cable machine may be ordered in three units: basic unit, which includes the head and sealing device; wire payoff unit, which contains the "tree" and spindles for holding the wire reels; power unit, which has the take-up reel spindle, frame and 115 V AC/DC motor that pulls the cable through the complete process.

For complete catalog information or field engineering service, write to the manufacturer: The Zippertubing Company, 752 So. San Pedro St., Los Angeles 14, California. TWX LA 840. Sales offices and warehouses are located in all principal cities.

(advertisement)



NEW

IRC

PULSE-VIEWING PROBES

• Low inductance—.01 μh or less • Low resistance—as low as 0.22 ohms

Why bother with a makeshift resistor network when you want to look at pulse shapes? Especially when you can use the new convenient IRC Pulse-Viewing Resistors. Available with a phone plug which can be inserted into a standard phone jack, or a choice of coaxial connectors, both can be inserted right into the circuit . . . thereby saving engineering and test time.

END TRANSIENTS OR RINGING—Transient or ringing are eliminated by a special construction which reduces inductance to .01 μh or less.

18 STANDARD RESISTANCE RANGES—Resistance values from 0.22 to 150 ohms in 15-watt or 75-watt sizes (DC continuous duty rating) make it easy to test a wide variety of pulse radar and similar magnetron circuits. Resistor elements are of the highly-stable film type.

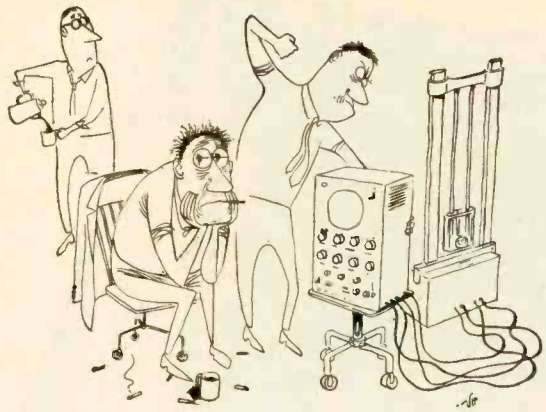
INTERCHANGEABLE CONNECTORS AND ELEMENTS—IRC Pulse-Viewing Resistors are so designed that resistance values and connectors can be quickly interchanged through use of a kit containing 4 sets of resistors, 4 sets of connectors (BNC-coaxial, UHF, Phone Plug, and 6-32 Stud), tools for assembly and necessary hardware.

WRITE FOR
NEW BULLETIN S-4A

IRC

INTERNATIONAL RESISTANCE COMPANY
COMPUTER COMPONENTS DIVISION
Dept. 376, 401 N. Broad St., Philadelphia 8, Pa
In Canada: International Resistance Co., Ltd., Toronto, Licensee

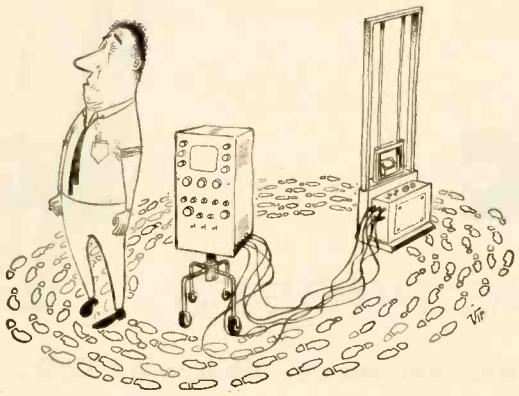
CIRCLE 21 READERS SERVICE CARD



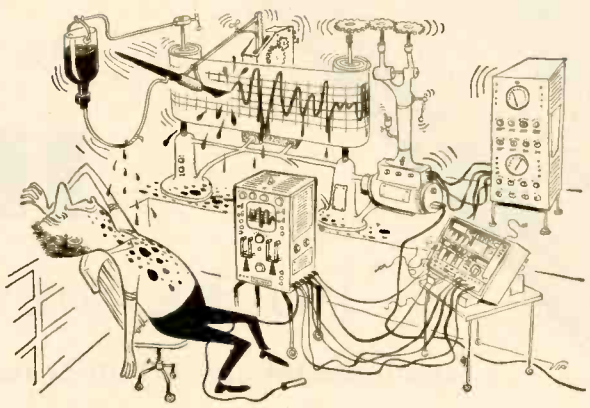
PROBLEM:
Wasted Effort in Capturing Transients

PROBLEM:
Wave-form Photography

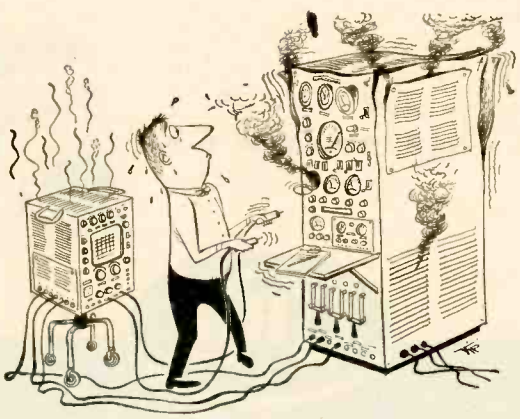
six not-so-funny problems...



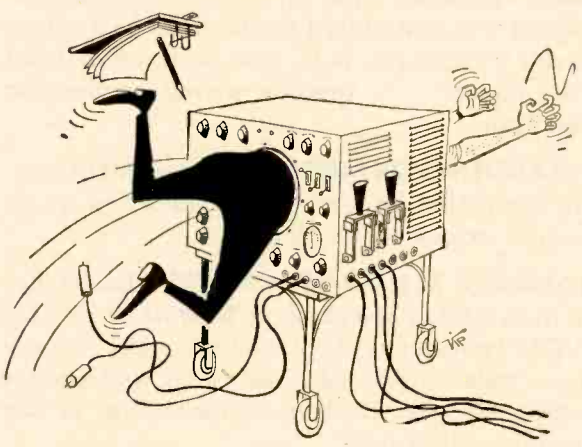
PROBLEM:
Duplication of Research Effort



PROBLEM:
Transient Analysis



PROBLEM:
Trouble Shooting

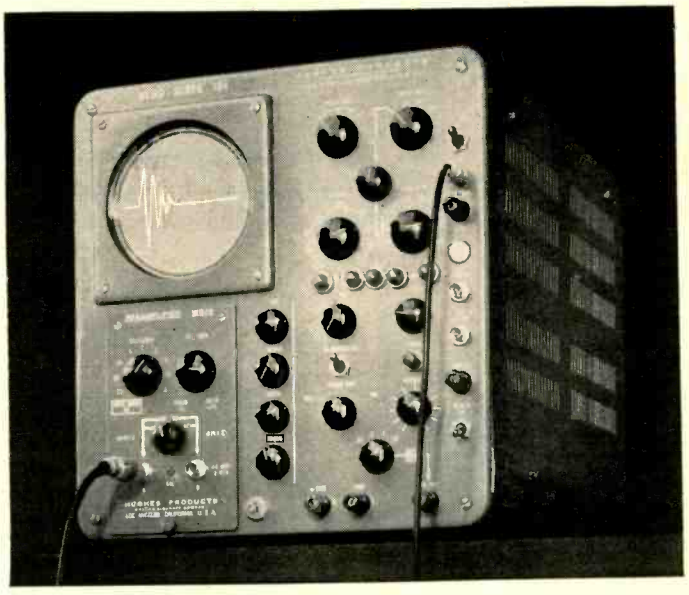


PROBLEM:
How to Capture Elusive Transients

...one happy solution

Has the analysis of non-recurring transients presented a perplexing problem to you? Are you using a conventional scope or recorder, which wastes time, money, and research dollars?

SOLUTION: The Hughes MEMO-SCOPE ® oscilloscope freezes wave forms until intentionally erased. Selected transient information may be triggered externally or internally and retained for viewing. Successive wave forms may be written above, below, or directly upon the original information.



HUGHES MEMO-SCOPE OSCILLOSCOPE

SWEEP SPEED FOR STORAGE:
10 microseconds to 10 seconds per division (0.33").

FREQUENCY RESPONSE: DC to 250 KC down 3 db.

SENSITIVITY:
10 millivolts to 50 volts per division or with optional high sensitivity preamplifier 1 millivolt to 50 volts per division.

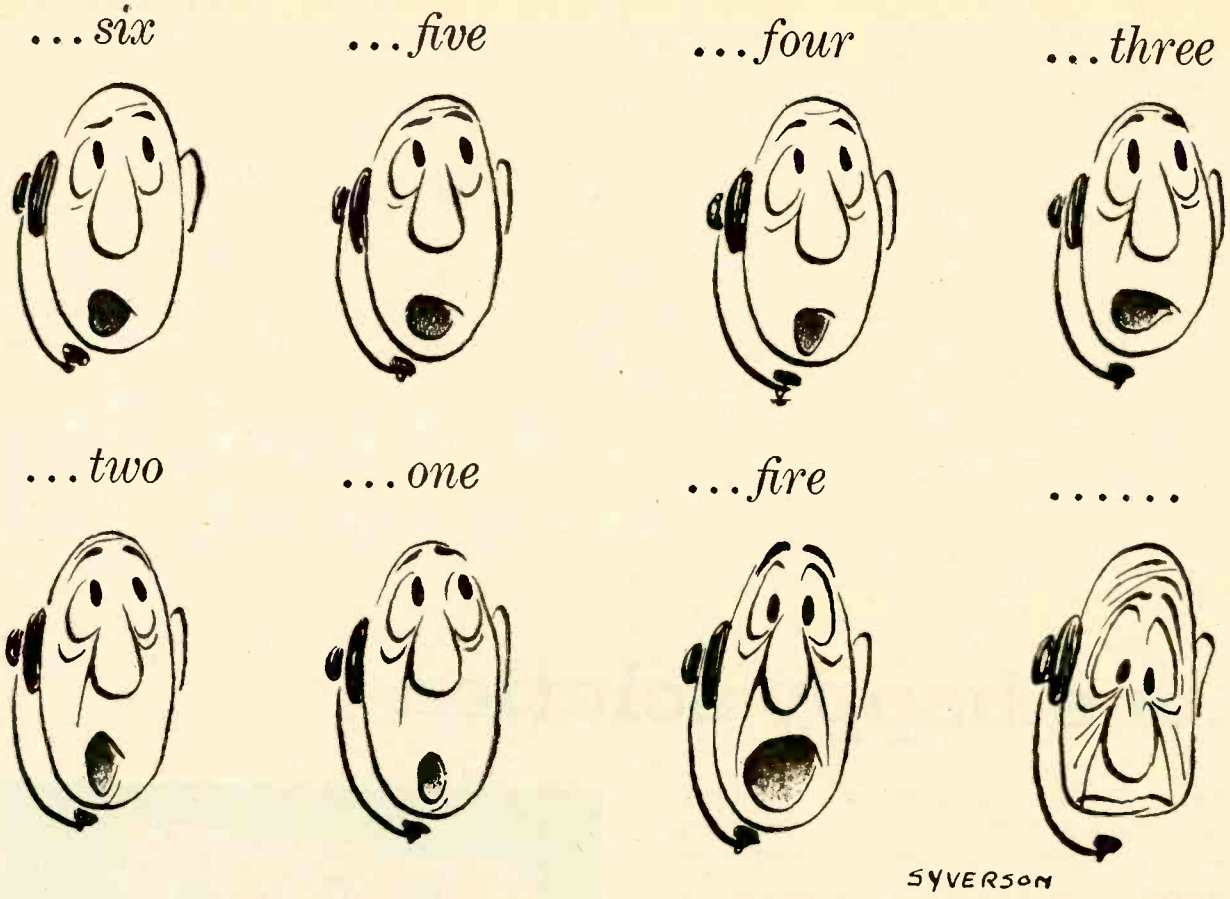
APPLICATIONS:
Trouble shooting data reduction equipment...switch and relay contact study... ballistics and explosives research... ultrasonic flaw detection... physical testing—shock—stress—strain.

If you haven't yet seen a demonstration of the MEMO-SCOPE oscilloscope, ask a Hughes representative to arrange one. He'll quickly do so—at your convenience—in your area. Please write to:

HUGHES PRODUCTS
MEMO-SCOPE Oscilloscope
International Airport Station, Los Angeles 45, California

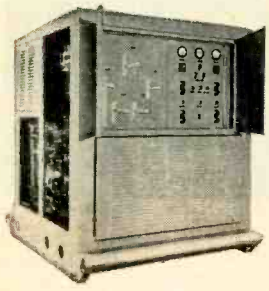
Creating a new world with ELECTRONICS

HUGHES PRODUCTS



When the target is space and a million dollars' worth of missile rests idly on the ground—not even a long countdown helps. In a showdown situation, the successful shoot depends on the "go, no-go" type of test that pinpoints the trouble.

NEXT TIME...LOOK TO INET FOR PRECISE GROUND POWER



This INET 400-cycle ground power unit was tailor-made for the Atlas. In meeting all of Convair's specifications for pre-flight calibration of electrical systems, the unit operates in parallel with the missile's power system and provides remote control regulation. Frequency regulation is ±0.2%. With shock load equal to a third of rated output, frequency recovers to ±0.2% in 0.15 seconds. Voltage regulation is ±0.5% with recovery time at 0.30 seconds.

Missile men desiring a special reprint of the above cartoon should write to "Count-down", c/o Inet Division of Leach.

INET DIVISION LEACH CORPORATION

18435 SUSANA ROAD, COMPTON, CALIFORNIA

DISTRICT OFFICES AND REPRESENTATIVES IN PRINCIPAL CITIES OF U. S. AND CANADA

NLS Model 481

Four-Digit Digital Voltmeter

- Measures DC Voltages from 1 Millivolt to 1,000 Volts
- Displays Measurements on Illuminated Numerical Readout
- Scale Factor and Linearity Accurate to 0.01%
- 10 Megohm Input Impedance
- Automatic Range Changing, Decimal Placement, and Polarity Indication
- New Snap-In Readout Assembly
- Furnished Complete; No Extras to Buy

NEW LOW-COST INDUSTRIAL VOLTMETER

Here is the greatest value ever offered in a precision instrument! Look at the features listed above . . . features that assure higher performance, reliability, and accuracy than provided by any other voltmeter. And look at the price . . . less than one-half the price of competitive instruments.
As originator of the digital voltmeter, NLS has led the way in developing new manufacturing techniques. Now, NLS is the first to mass produce digital voltmeters and make possible the unique combination of high performance and low cost in the NLS 481. See this rugged new industrial voltmeter demonstrated, and discover why electronic and servo-type digital voltmeters — as well as the most precise moving-coil voltmeters — are made obsolete by the NLS 481!
Write today for complete specifications and the name of the nearest demonstrator-equipped NLS field engineer!

INSTRUMENTS TO MEET EVERY APPLICATION
NLS manufactures the most complete line of three, four, five, and six digit instruments for automatically measuring DC and AC voltages, voltage ratio, and resistance. Complete catalog available upon request.

FULL PRICE

$985

F.O.B. Del Mar, California

Originators of the Digital Voltmeter

non-linear systems, inc.
SAN DIEGO COUNTY AIRPORT,
DEL MAR, CALIFORNIA

CIRCLE 25 READERS SERVICE CARD

Here's why you get the safest, most dependable electrical protection . . . *when you specify BUSS or Fusetron Fuses*

Each BUSS and FUSETRON fuse is designed and made to meet the highest standard of dependability. Every fuse is then tested in a sensitive electronic device that automatically rejects any fuse not correctly calibrated, properly constructed and right in all physical dimensions.

The dependability of BUSS and FUSETRON fuses provides equipment with maximum protection against damage due to electrical faults and — prevents useless shutdowns caused by faulty fuses blowing needlessly.

By operating as intended, BUSS and FUSETRON fuses help safeguard the reputation of your equipment for service and reliability.

To meet your needs, — there's a complete line of BUSS and FUSETRON fuses in all sizes and types, . . . plus a companion line of fuse clips, blocks and holders.

If you have an unusual or difficult electrical protection problem . . .

. . . the BUSS fuse research laboratory and its staff of engineers are at your service. In many cases, our engineers can help you save engineering time. Whenever possible, a fuse will be selected that is readily available in local wholesalers' stocks so that your equipment can easily be serviced.

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

BUSSMANN MFG. DIVISION, McGraw-Edison Co., University at Jefferson, St. Louis 7, Mo.

BUSS fuses are made to protect — not to blow needlessly

FUSETRON
TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION
BUSS

A COMPLETE LINE OF FUSES FOR HOME, FARM, COMMERCIAL, ELECTRONIC, AUTOMOTIVE AND INDUSTRIAL USE.

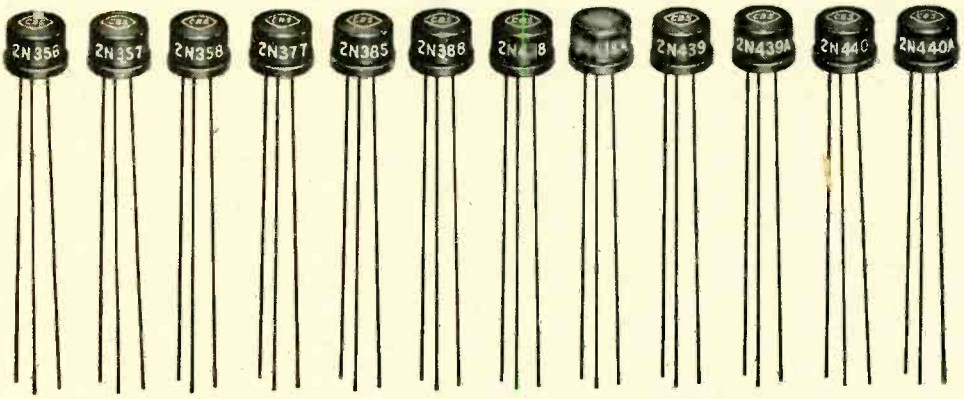
958

*now...

most comprehensive line of NPN high-speed switching transistors

12 RELIABLE COMPUTER TYPES FEATURING:

- Faster switching
- Higher voltage
- Lower cutoff current
- Lower saturation resistance



CBS-HYTRON was first with the most flexible selection of over 100 PNP power transistors. Now, it offers the most comprehensive line of mass-produced NPN transistors for high-speed switching and high-frequency amplification.

They are NPN alloy-junction germanium for greater uniformity, higher voltage and current, flatter gain, and lower saturation resistance. They employ the JETEC TO-9 package welded for reliability. They offer *high* frequency response, switching speed, operating voltage, current amplification factor, and dissipation rating. And *low* leakage current and collector capacitance.

The handy tables let you select for application, dissipation and frequency the types you need. Call or write your regional sales office or the Lowell general sales office for technical bulletin E-293-302 and for application and delivery information . . .today.

TYPES AVAILABLE

FOR LOGIC CIRCUIT

Typical Frequency in Megacycles		
12	2N440	2N440A
8	2N439	2N439A
4	2N438	2N438A

100 150
Maximum Dissipation in Milliwatts

FOR CORE DRIVER

Typical Frequency in Megacycles		
9	2N358	2N388
6	2N357	2N385
3	2N356	2N377

100 150
Maximum Dissipation in Milliwatts

*More reliable products through Advanced-Engineering

CBS® semiconductors

CBS-HYTRON, Semiconductor Operations
A Division of Columbia Broadcasting System, Inc.

Sales Offices: **Lowell, Mass.,** 900 Chelmsford Street, Glenview 4-0446 • **Newark, N. J.,** 32 Green Street, Market 3-5832
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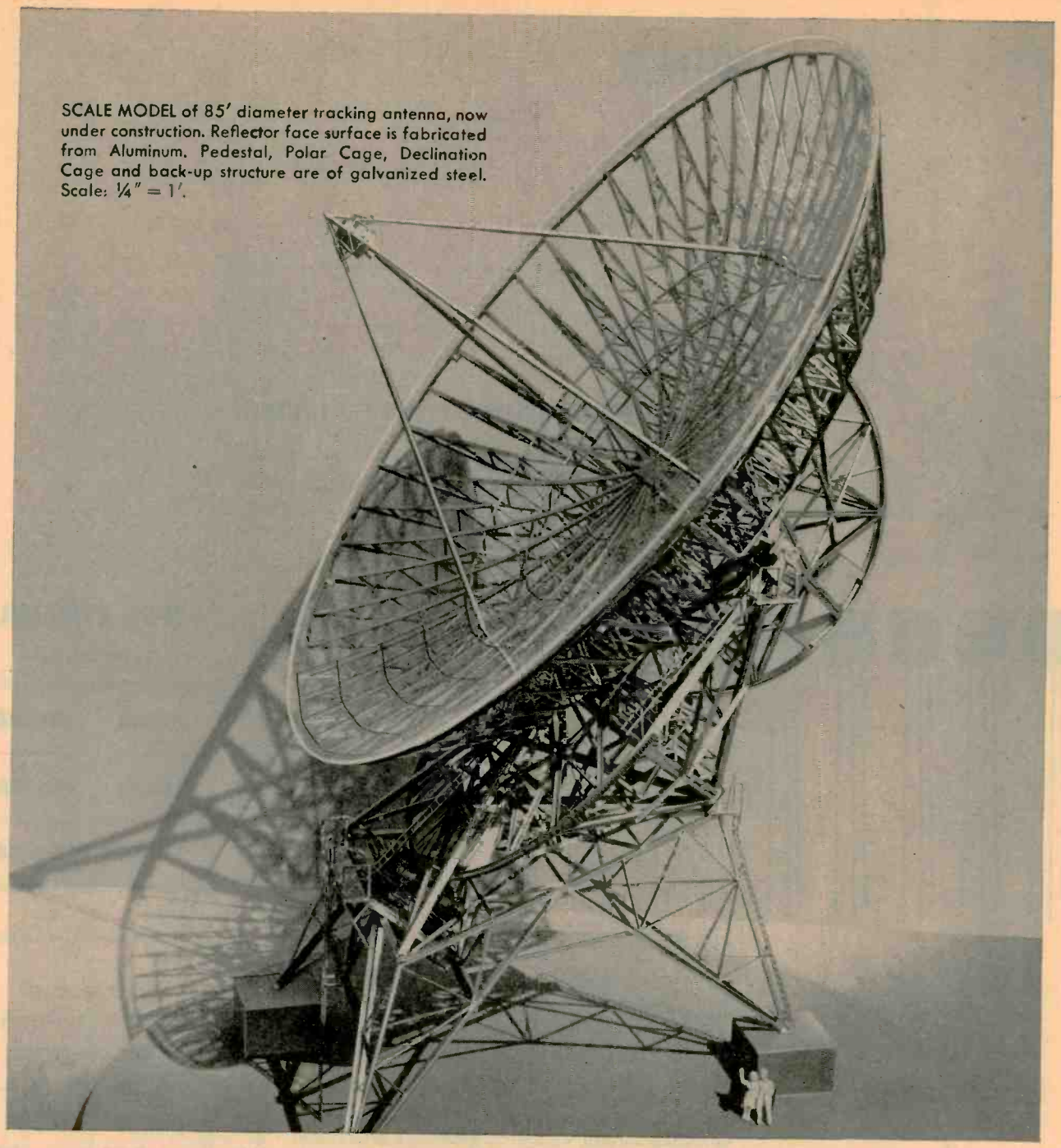


SCALE MODEL of 85′ diameter tracking antenna, now under construction. Reflector face surface is fabricated from Aluminum. Pedestal, Polar Cage, Declination Cage and back-up structure are of galvanized steel. Scale: ¼″ = 1′.

New Blaw-Knox 85′ Diameter Tracking Antenna

This newest Blaw-Knox 85′ Diameter Tracking Antenna will be part of a telemetering operation connected with missile and satellite development.

Its design is fully determinate. All structural members of the assembly are analyzed for stress and deflection before fabrication. Coupled with shop fabrication and field erection to rigidly accurate tolerances, it is capable of the highest gain, with a minimum of distortions or aberrations.

The entire drive system embodies such critical design requirements as infinitely variable movement with negligible creep or overrun for tracking. The slewing drives are capable of the extremely rapid acceleration and deceleration necessary to focus on supersonic targets.

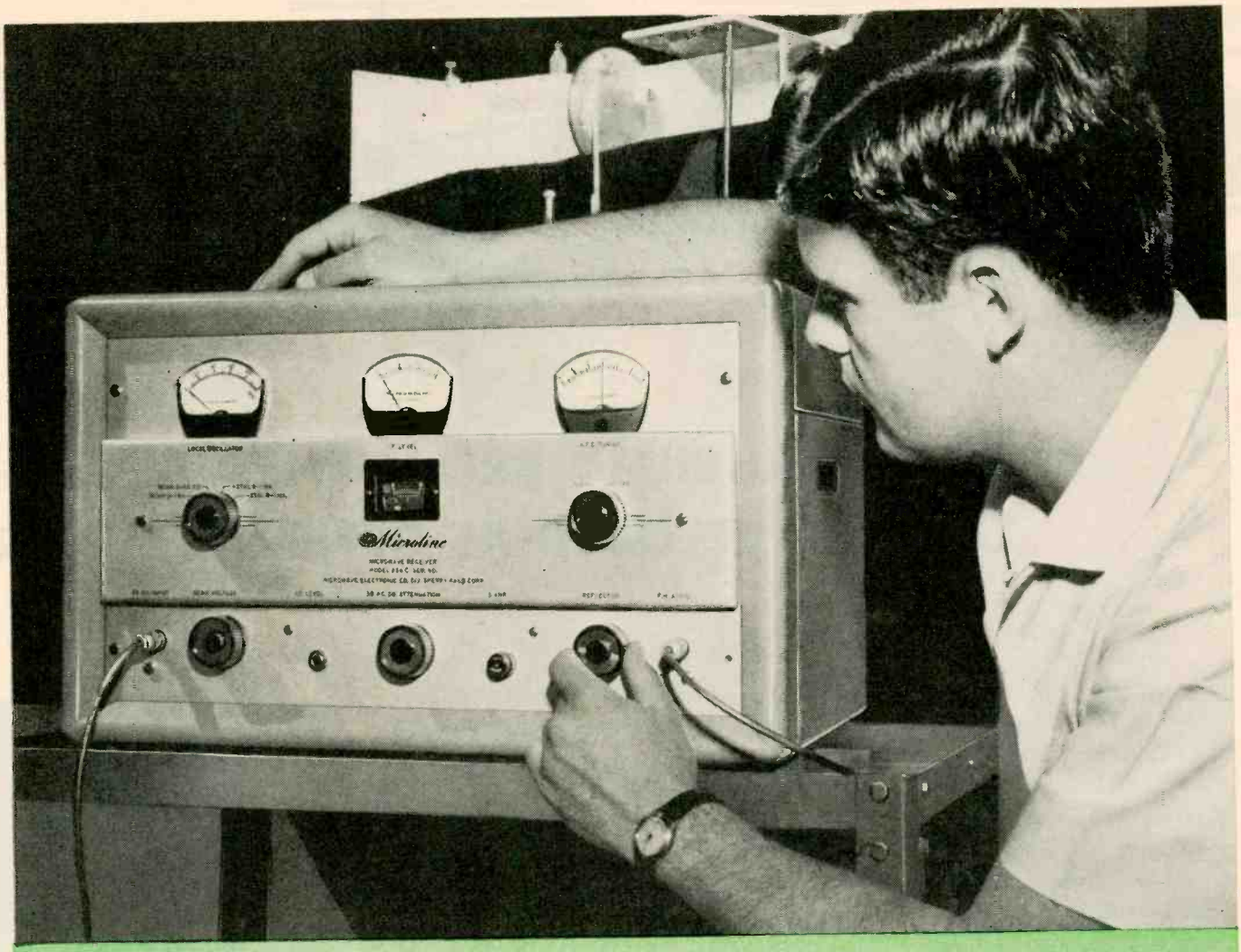
Pioneering like this is the latest step in a long series of Blaw-Knox developments. Such milestones as the Guyed Vertical Radiator design in AM radio, the first radar antenna used to bounce signals off the moon, and the Tropospheric Scatter Antenna for over-the-horizon television have marked Blaw-Knox as a world leader in advanced design, fabrication and erection techniques.

Blaw-Knox welcomes the opportunity to translate your most advanced concepts into highly reliable operating equipment. Contact the Antenna Group.

Antennas—Rotating, Radio Telescopes, Radar, Tropospheric and Ionospheric Scatter,

BLAW-KNOX

BLAW-KNOX COMPANY
Blaw-Knox Equipment Division
Pittsburgh 38, Pennsylvania



MODEL 296C MICROWAVE RECEIVER

IF frequency 30 mc

Bandwidth (overall) 1.3 mc at 3 db points

Gain IF amplifier 65 db min.
Pre-amplifier 30 db min.

Attenuation range, calibrated 0-80 db ± 0.2 db above 5 db at 30 mc

Self-contained local osc. power supply 600-800v at 50 ma., beam supply

Self-contained AFC System. Constant IF type with a time constant of about 0.2 sec.

For highly accurate measurements
at all microwave and UHF frequencies...

SPERRY'S MODEL 296C MICROWAVE RECEIVER

This Sperry Microline* Receiver is a precision instrument of great accuracy enabling measurements at all microwave and UHF frequencies.

Model 296C can be used for measuring coupling and directivity of directional couplers, relative field strength, very high and very low VSWR, antenna patterns and as a general-purpose microwave laboratory receiver. In addition, this receiver was designed for use as a good secondary standard of attenuation.

A completely self-contained unit, it includes a 30-mc pre-amplifier, 30-mc IF amplifier, 30-mc calibrated attenuator, local oscillator power supply and AFC circuits. The 296C requires only the use of a local oscillator and an appropriate mixer for operation at any microwave or UHF frequency.

*TM Reg. U. S. Pat. Off.

SPERRY MICROWAVE ELECTRONICS COMPANY
CLEARWATER, FLORIDA
Division of Sperry Rand Corporation

ADDRESS ALL INQUIRIES *to Clearwater, Florida or Sperry Gyroscope offices in New York, Cleveland, New Orleans, Los Angeles, San Francisco, Seattle.*

CIRCLE 29 READERS SERVICE CARD

CIRCLE 30 READERS SERVICE CARD→

The G-E Power Tube Microwave Laboratory is located at Stanford Industrial Park, Palo Alto, California where it was one of the Park's pioneer installations. Its staff of scientists and engineers has the advantage of technical exchange with Stanford University faculty and research staffs, as well as with General Electric's own Research and General Engineering Laboratories.

RADAR CAPABILITY BROADENED BY HIGH-TUBES DEVELOPED AT GENERAL ELECTRIC

DEVELOPMENT of advanced high-power, pulsed traveling-wave tubes at the Power Tube Department's Microwave Laboratory at Palo Alto, California, is contributing substantially to the broadening of radar frequency ranges. Vital accomplishments provided are: high pulse powers over wide instantaneous bandwidths; periodic permanent-magnet focusing; novel, light-weight, rugged tube structures. In addition to systems-oriented work at X band, developments are progressing at L, S, C, and K bands.

Traveling-wave tube pioneering is only one of a broad range of microwave activities being conducted at the G-E Microwave Laboratory. The Laboratory's fields of activities are applied research, advanced development, and product design in microwave tubes and microwave techniques. All development work is done with an eye to practical, economical manufacture – thus minimizing the time lapse between prototype development and quantity production–and to the realistic tube needs of future microwave equipment. Technical inquiries pertaining to advanced microwave tube development invited. *Power Tube Department, General Electric Company, Schenectady, New York.*

* * *

Professional opportunities available for engineering and scientific personnel. Inquiries invited.

Progress Is Our Most Important Product

GENERAL ELECTRIC

9545-8481-15

Extensive development work in the following classes of tubes is a continuing activity of the G-E Microwave Laboratory's staff of scientists, engineers and technical personnel.

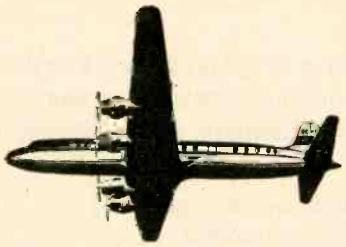
Pulse klystron power amplifiers
CW klystron amplifiers
High-power pulsed TWT amplifiers
Medium-power CW TWT amplifiers
Low-noise, broadband TWT amplifiers
Super-power klystrons
Voltage-tunable oscillators
High-power duplexers
Microwave filters
Frequency multiplier TWT amplifiers

POWER TRAVELING-WAVE MICROWAVE LABORATORY

Typical of traveling-wave tubes being developed at the G-E Microwave Laboratory is this S-band tube which has operated successfully at the 2-megawatt pulse output level with 30 db gain.

Effects of high-average power tests on a multi-megawatt traveling-wave tube are described by Project Engineer K. Zublin (center). Other members of the project team (left to right): E. J. Nalos, R. M. Phillips, R. A. Craig and R. P. Borghi.

AEROCOM'S 1046 H.F. TRANSMITTER



POWER + STABILITY

1000 WATTS WITH .003% STABILITY

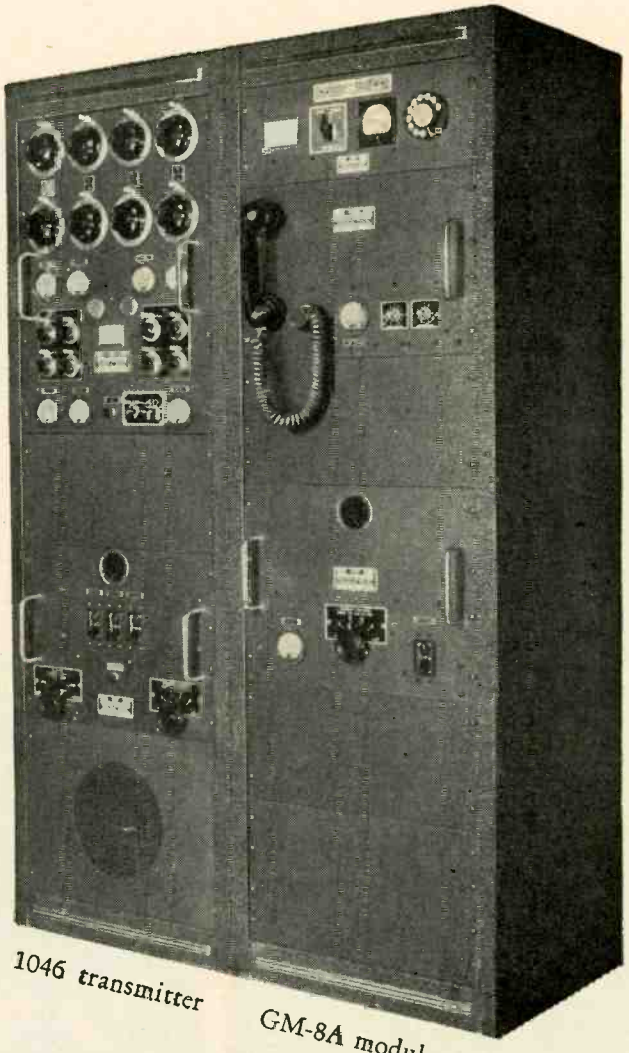
Rugged, versatile general purpose H.F. transmitter—Aerocom's 1046 packs 1000 watts of power and high .003% stability under normal operating conditions (0°to+50°C.). Excellent for point-to-point or ground-to-air communications.

Multi-channel operation on telegraph A1, or telephone A3 with GM-8A modulator... new Aerocom 1046 can be *remotely controlled* with TMC-R at control position and uses only one pair of telephone lines. In A3 operation, the local dial control panel is located in modulator cabinet.

Transmitter cabinet has 8¾ inch panel space available for either local dial control panel or frequency shift keyer.

Model 1046 operates on 4 crystal-controlled frequencies (plus 2 closely spaced frequencies) in the band 2.0—24 Mcs. Operates on one frequency at a time; channeling time 2 seconds. Operates into either balanced or unbalanced loads. Operates in ambient -35° to+50° C. Power supply: nominal 220 volts, 50-60 cycles, single phase.

Complete technical data on request



1046 transmitter GM-8A modulator

Now! Complete-package, 192 channel, H.F., 75 pound airborne communications equipment by Aer-O-Com! Write us today for details!

AER-O-COM

109

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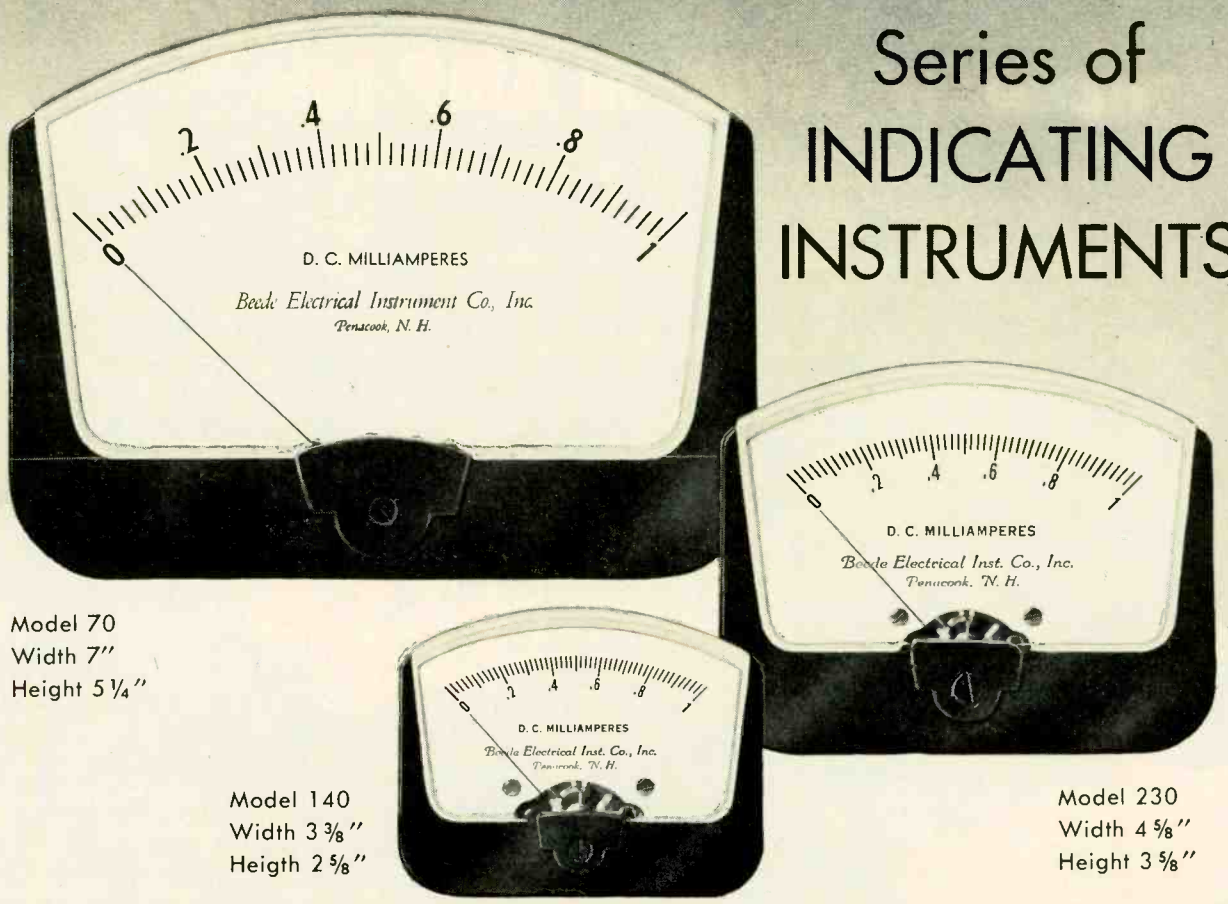
←CIRCLE 31 READERS SERVICE CARD

CIRCLE 32 READERS SERVICE CARD

BEEDE *Presents* the PANORAMA

Series of INDICATING INSTRUMENTS



Model 70
Width 7"
Height 5 1/4"

Model 140
Width 3 3/8"
Heigth 2 5/8"

Model 230
Width 4 5/8"
Height 3 5/8"

The PANORAMA gives you better, clearer vision and longer scales, with easier readability.

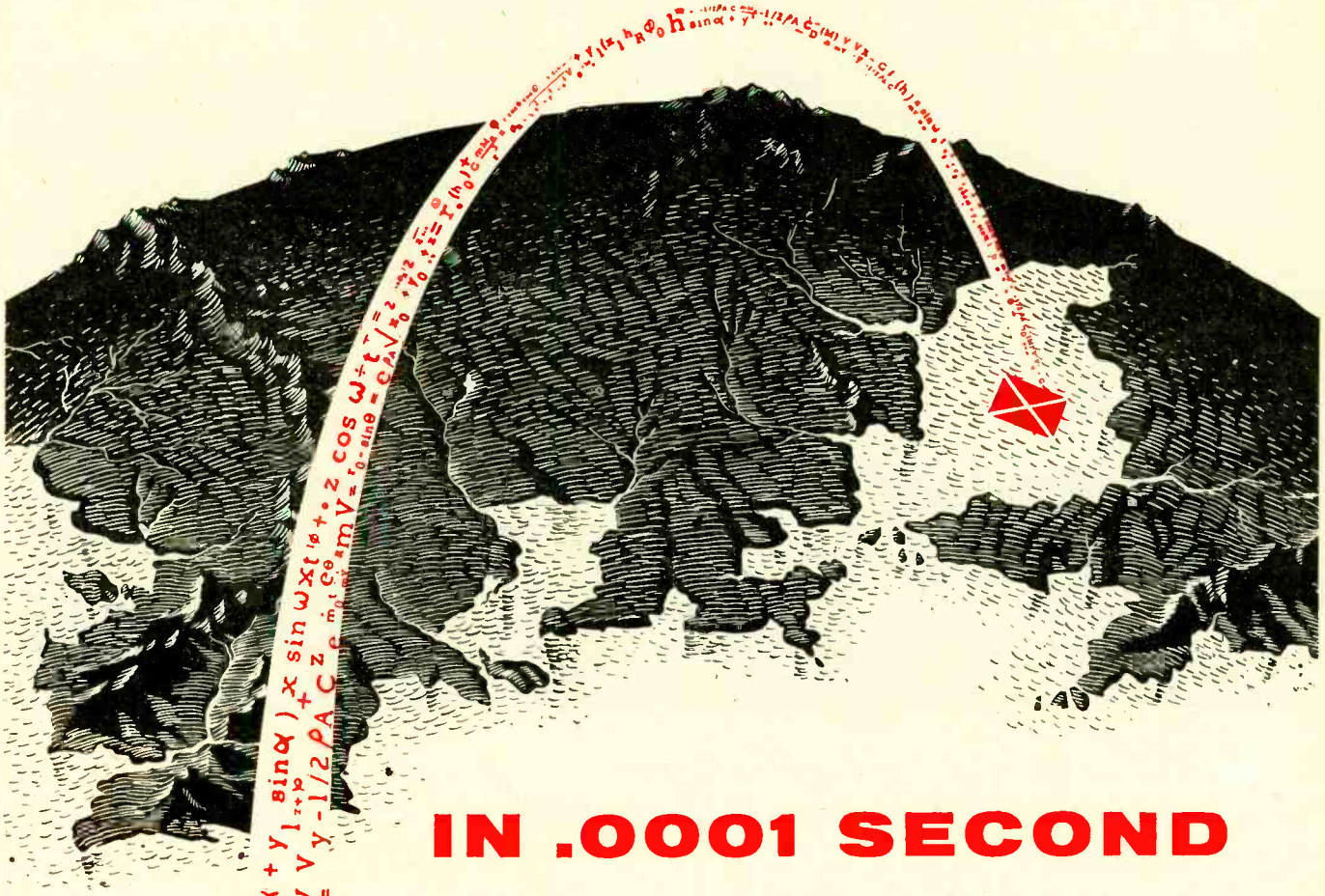
The plastic panel provides excellent natural illumination, top, sides and front.

Available with frosted portion or color of your choice.

The ultra modern beauty of the PANORAMA will add much to your product.

BEEDE ELECTRICAL INSTRUMENT CO., INC.
PENACOOK, NEW HAMPSHIRE

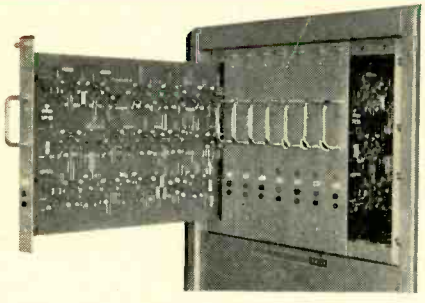
MISSILE IMPACT PREDICTION



IN .0001 SECOND

TRICE, the world's most advanced computer, saves many minutes over time currently required for ballistic missile impact prediction. TRICE modules (Integrators, Multipliers, etc.) can be assembled as a special purpose computer for dynamic systems or as a digital differential analyzer. Its incredible speed of 100,000 iterations per second *in parallel* is unaffected by the size of the problem. The first model is in operation at the U.S. Army Ordnance Missile Command, Huntsville, Ala.

Write for literature describing TRICE and its many uses: aerodynamic stability, control system stability, impact prediction, stable platform calculations, satellite orbit predictors and others.



ENGINEERING BEYOND THE EXPECTED

TRICE (Transistorized Realtime Incremental Computer, Expandable) is the first computer to combine the accuracy and repeatability of a digital computer with the speed, flexibility and ease of programming of an analog computer.

PACKARD-BELL COMPUTER CORP.

a subsidiary of

PACKARD BELL ELECTRONICS

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Los Angeles 64, Calif. BR. 2-2171

PHALO

WIRES, CABLES & CORD SETS

Announce the Proudest Moment In Their History!

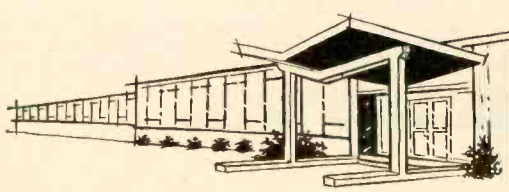
As histories go, ours is not ancient. This is only our fifteenth year, but we have had a progressive, action-packed fifteen years.

In July of this year, the doors of our fine new plant opened for the first time and provided our proudest moment.

This new plant of ours is a model of modern wire and cable production. From raw materials to finished product, efficiency and economy of manufacturing is the key-note. Equipment matches the skill of our people in this broad expanse of floor space . . . providing a perfect setting for the new product developments which have marked our growth from the firm's inception.

We are looking forward to providing you with a superior brand of service from the expansive new home of Phalo.

Visit us when you can . . . we'll be happy to show you our model plant from one end to the other.



PHALO

530 BOSTON TURNPIKE
PLASTICS CORPORATION
SHREWSBURY, MASS.

Plant Construction By Lilly Construction Company, Allston, Mass.

317-8

6528 medium mu, high current, twin power triode for series regulator service!

Volume output makes Tung-Sol/Chatham 6528 available for widespread use!

Enthusiastic acceptance of the 6528 Twin Power Triode forced rapid expansion of production quotas, in turn resulting in lower manufacturing costs. These savings are reflected in lower prices to the user making Type 6528 economically practical for a vast number of new industrial and military applications.

Type 6528 requires fewer passing tube sections . . . permits lower range control circuits . . . and combines low internal tube drop with top control sensitivity — a definite advantage over previous series regulators. Also, 6528 triodes may be used in parallel or separately. This simplifies circuitry . . . saves space.

DESIGN FEATURES OF TUNG-SOL/CHATHAM TYPE 6528!

1. Hard glass envelope permits full out-gassing . . . takes higher temperatures without gas evolution . . . increases thermal shock resistance.
2. Zirconium-coated graphite anodes assure excellent gettering. Graphite virtually unaffected by heat.
3. Oversize cathodes provide adequate emission reserve . . . eliminate standby deterioration.
4. Extra-rugged grids. Sturdy chrome-copper side rods support gold-plated molybdenum lateral wires.
5. Overall ruggedness. Metal snubbers and ceramic insulators support mount. Heavy button-stem has rigid support leads.

Tung-Sol Electric Inc. specializes in special-purpose tube development . . . can match any design requirement you have. For full data on Type 6528 . . . to fill any power tube socket . . . contact: Tung-Sol Electric Inc., Newark 4, N. J. Commercial Engineering Offices: Bloomfield and Livingston, N. J.; Culver City, Calif.; Melrose Park, Ill.

TYPE 6528 RATINGS

Max. plate dissipation per tube	60 watts
Max. plate dissipation per section	30 watts
Max. steady plate current per section	300 ma.
Max. plate voltage	400 volts
Max. heater cathode voltage	300 volts
Amplification factor*	9
Transconductance per section*	37,000 μmhos

**Average characteristics at $E_b = 100v$, $E_c = -4v$, $I_b = 185$ ma.*

TUNG-SOL®

CIRCLE 37 READERS SERVICE CARD

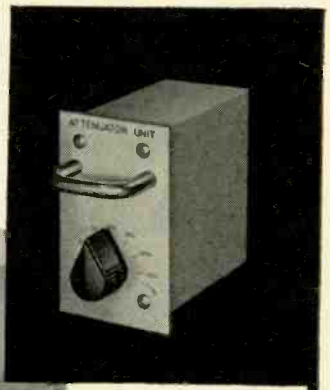
New Electro Instruments A-12 DC amplifier totally transistorized

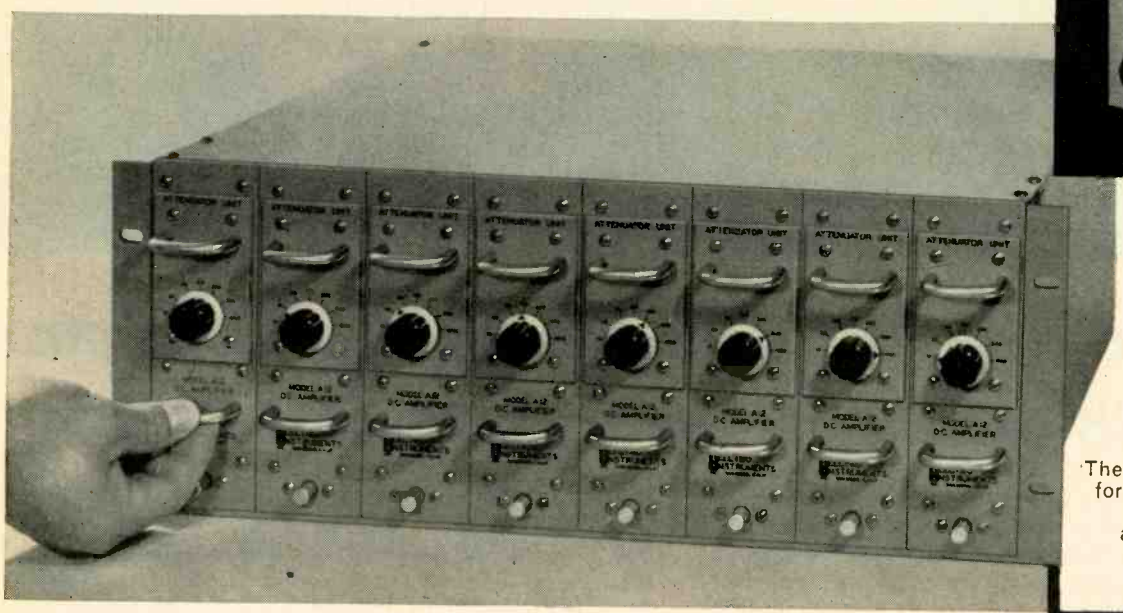
equal to or better than the best vacuum tube instruments!

The new Model A-12 DC Amplifier is the preferred systems link for amplification, normalization and impedence transformation. Use of solid state elements assures maximum reliability; power dissipation is only seven watts. Mil-type components are mounted on coated plug-in printed circuit boards for protection against vibration and corrosion.

versatility plus economy

Electro Instruments produces a series of plug-in mode selectors and attenuators for the A-12: single ended, differential and operational, fixed and variable gain.





Eight to a rack
The A-12 is packaged for high density use; mounts eight across in 19" relay rack panels.

SPECIFICATION SUMMARY

Single Ended Input

Gain:	Fixed gain set to any value from 10 to 1000 inclusive by front panel plug-in units. Gain switching plug-in attenuator available with gains of 0, 10, 20, 50, 100, 200, 500 and 1,000. Adjustable upward 6db from setting with potentiometer.
Input Impedance:	100 megohms shunted by 0.001 mfd (typical).
Source Impedance:	5K or less (to meet noise specification).
Drift:	Less than 2 microvolts in 200 hours at constant ambient temperature. Less than 0.4 microvolt per degree centigrade.
Ambient Temperature:	0° to 50°C.
Noise (Referred to input):	0-3 cps 5 microvolts peak to peak 0-750 cps 4 microvolts rms. 0-50 kc 8 microvolts rms.
Frequency Response:	±3db to 50 kc (typical); ±1.0% to 2 kc
Output Capability:	±10 volts at ±100 ma DC or peak AC to 10 kc

Write today for complete specifications on single-ended, differential and operational models.

Electro Instruments, Inc.
3540 Aero Court
San Diego 11, California

extremely pure, 'Baker Analyzed' *REAGENT*

HYDROFLUORIC ACID

in your choice of

3 CONTAINER SIZES

6½ GALLON POLYETHYLENE **CARBOYS**

10-LB. or 1-LB. POLYETHYLENE **BOTTLES**

...functional, labor-saving packaging for your

SAFETY · CONVENIENCE · ECONOMY

HYDROFLUORIC ACID is a key processing chemical.

To meet the sharply rising demand for Hydrofluoric Acid manufactured to J. T. Baker's exceptional standards of quality, Baker has once more expanded production facilities. In addition to dependable, on-time deliveries, Baker offers you:

YOUR CHOICE OF CONTAINER SIZES: 6½ gallon polyethylene carboys, 10-lb. and 1-lb. polyethylene bottles.

SAFE, CONVENIENT, LABOR-SAVING PACKAGING: Carboys and 10-lb. bottles expedite convenient handling of large quantities of acid. The Baker 1-lb. bottle makes possible more rapid pouring than competitive 1-lb. containers and with an added safety factor: There's no diaphragm to puncture—no danger of "acid-spurt."

PURITY: Baker manufactures in conformance with extremely high standards of purity. Specifications assure that copper and nickel each will not exceed ½ part per million.

ACTUAL LOT ANALYSIS: Each container is labeled with the actual lot analysis defining copper, nickel and eight other significant impurities.

ACTUAL LOT ASSAY: You'll appreciate this "J. T. Baker extra" especially important for your use.

FULL AVAILABILITY AND FAST SERVICE—from expanded production facilities.

FOR PRICES AND ADDITIONAL INFORMATION, WRITE OR PHONE

J.T.Baker CHEMICAL

J. T. Baker Chemical Co.

Phillipsburg, New Jersey

CIRCLE 39 READERS SERVICE CARD

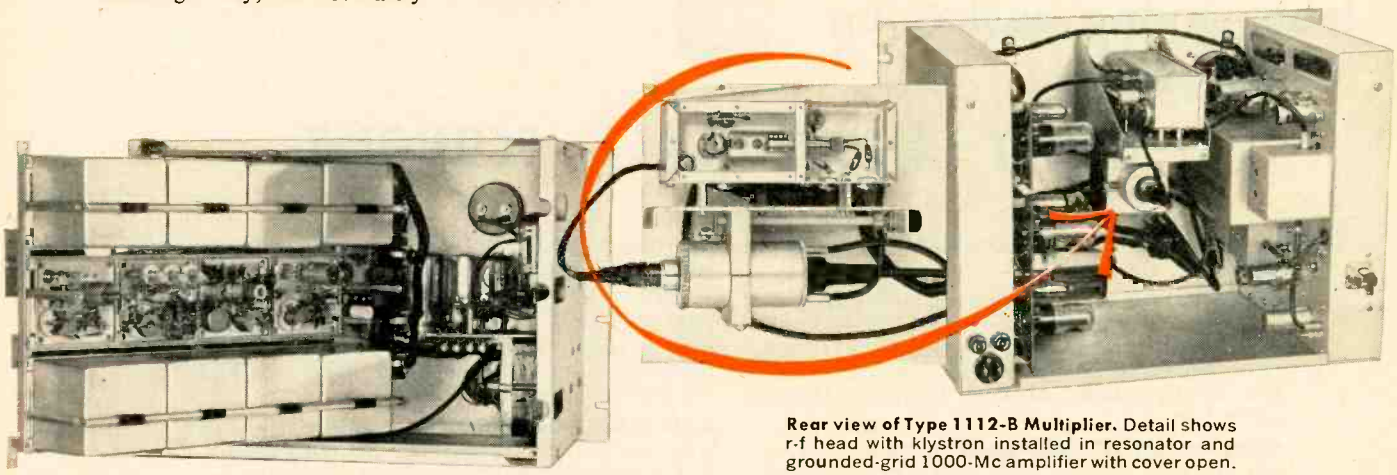
now microwave from NEW GR DECADE

Two new Standard Frequency Multipliers, the Types 1112-A and 1112-B, extend the range of General Radio's line of frequency-measuring equipment to well beyond the X band.

Extremely low noise characteristics and high stability, primary objectives in the development of these instruments, permit their use for precise measuring applications. Telemetering, guided-missile tracking, spectroscopy and atomic-resonance investigations, radar and navigation-systems work are but a few of the areas where signals of this quality are needed.

Submultiples of output frequencies are missing — all spurious signals other than harmonics of the desired output are more than 100 db below the nominal output signal. Long-term frequency stability is dependent only upon the driving source. Short-term stability is actually so much better than that of other types of frequency multipliers that measurement of performance is difficult — data will be available later.

The new Multipliers are versatile and convenient in use: for example, accurate measurements of microwave frequencies may be made by using a simple distorting and mixing diode to produce higher frequency harmonics for comparison against an unknown signal. For such work, a "picket fence" of standard-frequency markers can be generated (with suitable adding network), against which the unknown can be located quickly, unambiguously, and accurately.



Rear view of Type 1112-B Multiplier. Detail shows r-f head with klystron installed in resonator and grounded-grid 1000-Mc amplifier with cover open.

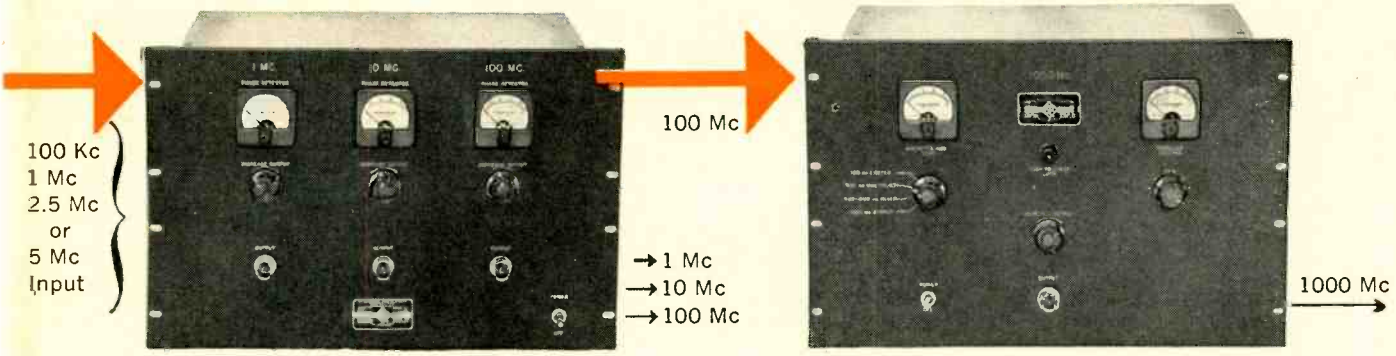
Rear view of Type 1112-A Multiplier with chassis assembly swung open. Covers are removed from 1 to 10-Mc multiplier stages.

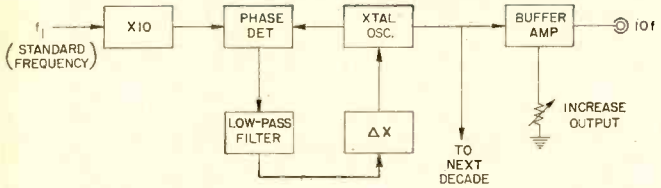
WE SELL DIRECT. Our District Sales Offices are staffed by engineers especially trained to help you in the selection of instruments and measuring systems best suited to your needs. We welcome your inquiries — will help solve your problems.

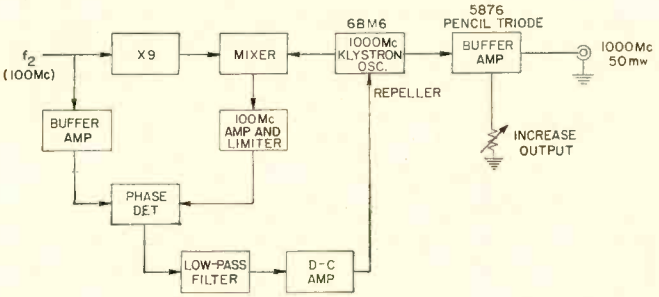
GR 2-Year Warranty on every Product

standard frequencies

MULTIPLIERS







Type 1112-A
STANDARD FREQUENCY MULTIPLIER

1-Mc, 10-Mc, and 100-Mc output frequencies are generated by separate *crystal* oscillators that are *phase locked* to the input frequency to insure extremely low f-m and a-m noise levels. (See diagram for typical decade.) Use of quartz-crystal resonators in each of these oscillators provides the highest possible Q for stabilizing amplitude and phase. With this technique, it is possible to avoid much of the noise commonly associated with multipliers that do not have such high-Q filters, and consequently, to actually improve the S/N ratio of the output signal.

INPUT: 1-volt, 100-kc sine wave from G-R Type 1100-A Frequency Standard or equivalent. Can be driven by 1-Mc, 2.5-Mc, or 5-Mc standard-frequency signal as well.

OUTPUT: 1-Mc, 10-Mc, and 100-Mc sine-wave signals; output level of each independently adjustable with maximum of 20mw into 50 ohms.

STABILITY: Long-term stability dependent only upon driving source.

PRICE: $1450.

Type 1112-B
STANDARD FREQUENCY MULTIPLIER

1000-Mc output is generated directly by a 6BM6 klystron that is phase-locked to the 100-Mc input. Input is multiplied to 900 Mc and mixed with the 1000-Mc output from the klystron oscillator to produce a 100-Mc beat. The difference frequency is amplified and limited to reduce a-m noise, and then compared to the 100-Mc input in a balanced phase detector. The output from the phase detector controls klystron frequency by varying repeller voltage. Phase-modulated noise normally produced by a klystron is greatly reduced by a wide-band, or fast-acting automatic-phase control.

INPUT: 100-Mc sine wave from Type 1112-A or equivalent; input impedance is 50 ohms.

OUTPUT: 1000-Mc sine wave; at least 50mw into 50-ohm load.

STABILITY: Long-term stability dependent upon driving source.

PRICE: $1360.

Write for Complete Information on G-R Frequency Standards.

GENERAL RADIO COMPANY

275 Massachusetts Avenue, Cambridge 39, Massachusetts, U. S. A.

NEW YORK AREA: Tel. N. Y. WOrth 4-2722, N. J. WHitney 3-3140 **CHICAGO:** Tel. VIllage 8-9400
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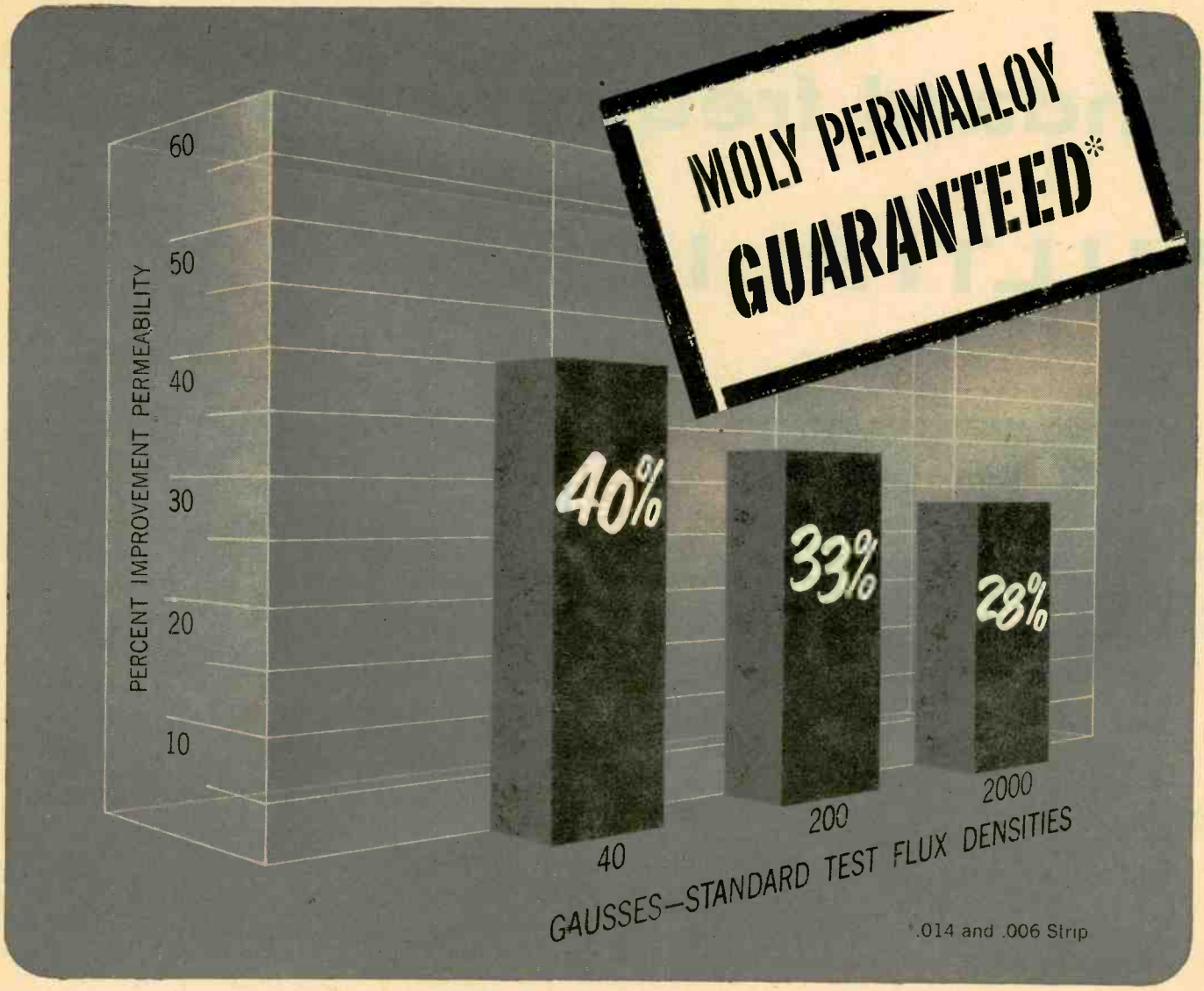
Experience**—the added alloy in **A-L Stainless, Electrical and Tool Steels



GUARANTEED PERMEABILITY OF MOLY PERMALLOY...

at values higher than old average specifications

Molybdenum Permalloy nickel-iron strip is now available from Allegheny Ludlum with *guaranteed* permeability values. And the new guarantees are much higher than the old typical values. This exceptionally high quality means absolute uniformity for the user—new consistency and predictability for magnetic core performance.

Improved permeability of A-L Moly Permalloy is the result of Allegheny's program of production research on nickel-bearing electrical alloys. A similar improvement has been made in AL-4750 strip steel. Research is continuing on silicon steels including A-L's famous Silectron (grain oriented silicon steel), plus other magnetic alloys.

Another plus in dealing with Allegheny Ludlum is the operation of complete lamination fabrication and heat treatment facilities. A-L's years of experience in producing quality laminations result in practical know-how in solving problems common to core materials.

This working knowledge is available to all. Give us a call for prompt technical assistance on *any* problem involving electrical steels, laminations, or magnetic materials. Write for more information on A-L Moly Permalloy. *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. Address Dept. E-9.*

WSW 7273

ALLEGHENY LUDLUM

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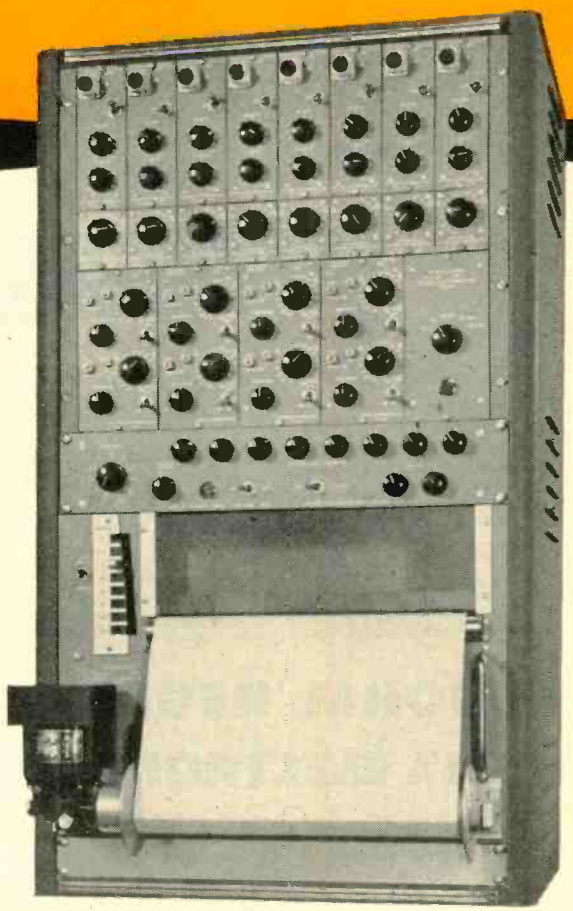
←CIRCLE 41 READERS SERVICE CARD

CIRCLE 42 READERS SERVICE CARD

OFFNER ALL TRANSISTOR TYPE R DYNOGRAPH

the most versatile...most sensitive direct writing unit available

Combining all these features...



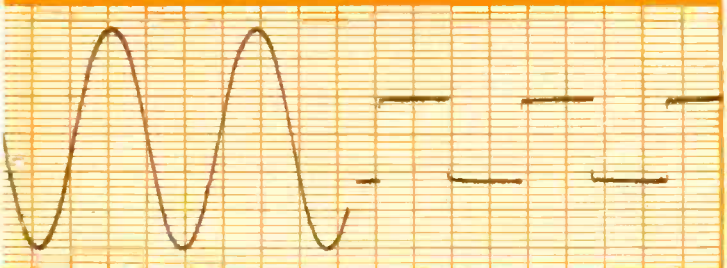
- ☆ stable d-c sensitivity of one microvolt per mm
- ☆ true differential input
- ☆ high input impedance
- ☆ response to beyond 150 cps.
- ☆ reluctance, differential transformer, strain gage with a-c or d-c excitation, thermocouples, etc., used with all amplifiers
- ☆ deflection time less than 2 milliseconds
- ☆ fixed precision calibration
- ☆ instant warm-up
- ☆ precision source for d-c and 400 cycle excitation, self-contained
- ☆ zero suppression, twenty times full scale, both directions

all these features...plus 8 channels in only 33¼″ of rack space

Whatever your application for direct writing recorders . . . you should investigate the ability of the Offner Type R Dynograph to do the job *better* and more *simply*. Using transistor circuits* developed and tested for over two years in hundreds of channels of Offner medical equipment, the Type R Dynograph is, we believe, superior in practically every respect to *any other* direct writing oscillograph. Write on your company letterhead for literature giving details and specifications.

*Patents granted and pending

FULL SCALE, UNRETOUCHED CHARTS PRODUCED ON THE TYPE R DYNOGRAPH



EXTREME SENSITIVITY—

10 Microvolt RMS Sine Wave — **Ten Microvolt D-C Square Wave**

Four recording media. Heat or electric rectilinear — ink or electric curvilinear. Readily convertible.

OFFNER ELECTRONICS INC.

3906 River Road, Schiller Park, Ill.
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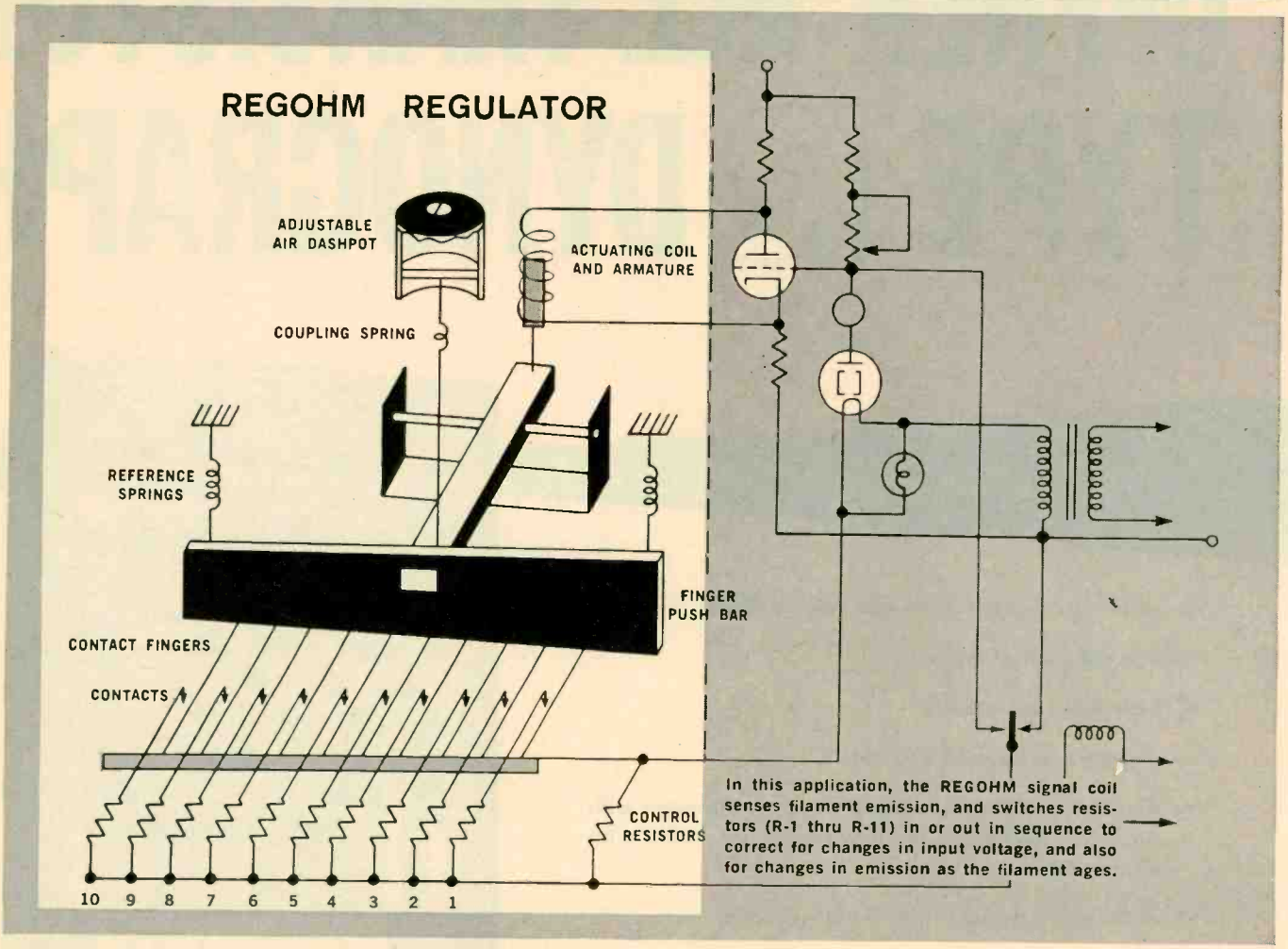
CIRCLE 43 READERS SERVICE CARD

REGOHM SOLVES Another Electronics Control Problem



REGOHM REGULATOR MAINTAINS CRITICAL 0.05% ELECTRONIC EMISSION IN DIATRON CIRCUIT

"The final design was made possible by the Electric Regulator Corporation's ten step contact finger regulator . . ." That is the tribute paid to REGOHM'S multi-contact voltage control by Consolidated Electrodynamics' engineers in speaking of their Type 24-210 Leak Detector.

The REGOHM regulator is used to provide an accurately controlled voltage to the tungsten filament in the Diatron mass spectrometer tube. It is this filament that produces the electron bombardment of the sampled gases passing through a magnetic field — causing each gas ion to assume a distinctly different path. This selective action affords the means for detection, and quantitative measurement, of the specific gas concerned.

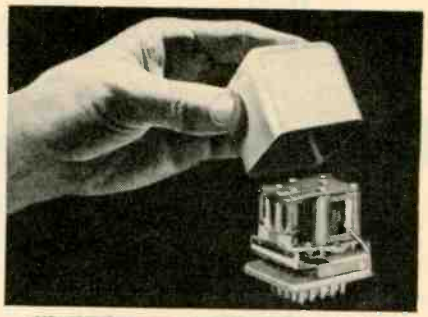
Tests with other regulating devices, such as thyratrons or mercury-wetted contact relays, were unsatisfactory — either because of poor performance or excessive costs.

The following distinct advantages were acclaimed for REGOHM by Consolidated Electrodynamics . . .

1. *The enormous power gain provided through flat compounding; the current needed to operate all ten contacts being only 5% more than that required for the first stage.*
2. *Relatively low power dissipation in the parallel resistors in ratio to the power fed into the filament.*
3. *Adjustable dashpot to check oscillation tendency in the circuit.*
4. *A compensating relay by-pass provision for holding voltage in the regulator tube when relays are open — to prevent destructive surging when filament is switched on.*

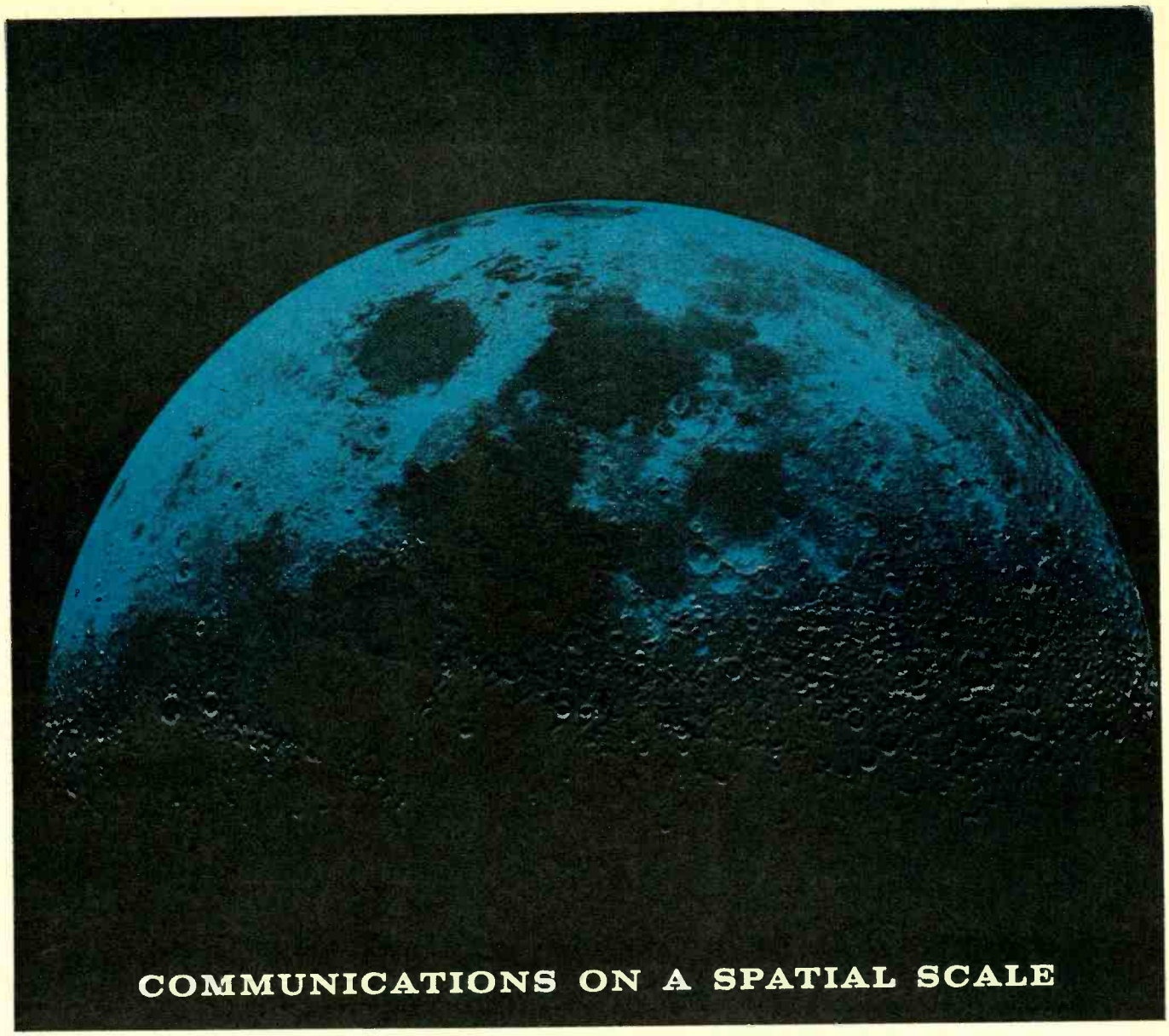
The REGOHM'S unique combination of advantages — flexibility, plug-in design, compact size, outstanding reliability, and *low cost* — is providing the answer to difficult regulation problems in many types of circuit. Why not consult our engineering staff to see how well it can fit your application? Please contact Electric Regulator Corporation, Norwalk, Connecticut.

Please write for design data and performance specs on REGOHM multi-stage regulators in applications similar to this.



REGOHM

ELECTRIC REGULATOR CORPORATION
NORWALK CONNECTICUT



COMMUNICATIONS ON A SPATIAL SCALE

"SHOOTING FOR THE MOON" at the Hughes Communications Systems Laboratories is more than just a figure of speech—it's an actual goal.

The Communications Laboratories have as one long-range objective the development of communications systems capable of deflecting their signals from meteors, artificial satellites and even the moon. Yet another is the development of systems which transmit intelligence through media impervious to radio frequencies by modulating frequencies far up in the electromagnetic spectrum—light, even gamma rays.

An example of advanced Hughes methodology is the use of digital techniques to overcome the multipath phenomenon—the tendency of radiations to be resolved by different layers of the ionosphere or other reflectors into two or more signal paths. Under certain circumstances, this situation in the past has produced a confused signal.

To extend its projects into advanced new areas, the Hughes Communications Laboratories must be staffed with engineers and physicists of high professional stature. Openings now exist for such personnel, and the salary structure will reflect the exceptional background required. Your inquiry is invited. Please apply directly to:

Dr. Allen Puckett, Associate Director,
Systems Development Laboratories.

the West's leader in advanced electronics

HUGHES

Hughes Aircraft Co., Culver City 32, Calif.

NAVTAC: "Pipeline" to a happy landing

The uniqueness of the new NAVTAC en route navigation and instrument landing system by Stromberg-Carlson is in its *combination* of functional modules.

The NAVTAC equipment is an assembly designed to provide high-performance aircraft with the TACAN navigational aid, plus marker beacon receiver, glide slope and runway localizer for instrument landing situations.

The entire system is packaged in a compact unit only 5" high, 10½" wide, 22" deep, and weighing only 47.5 lbs. Individual modules can be separated up to distances of several feet without any adverse effect on performance.

The equipment is designed to meet the rigorous environment of the high-performance aircraft of today and tomorrow. Its operating ambient temperature range is −60 to +125 degrees C. at altitudes up to 70,000 feet. Widespread use of semiconductors in the ILS receivers and TACAN circuitry means high reliability, small size and low power consumption.

Included in the design is the capability of performing complete preflight confidence tests with the use of a small auxiliary test set.

Complete technical details on the NAVTAC system are available on request.

There is nothing finer than a Stromberg-Carlson®

S-C

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RELIABILITY is the word

El-Menco *Dur-Micas* are the CAPACITORS with BUILT-IN RELIABILITY.

TWO WAYS . . .
- Highest-Grade INDIA RUBY Mica Films . . .
- TOTAL DEBUGGING . . . Guarantee Super Dependability*

the finest of materials...

superior engineering know-how . . . combine to build in El-Menco Dur-Mica Capacitors the highest reliability . . . to give long, ever-ready, powerful service in electronic equipment — from lightning-fast giant brains to tiny transistor receivers.

* unique features in El-Menco *Dur-Micas*

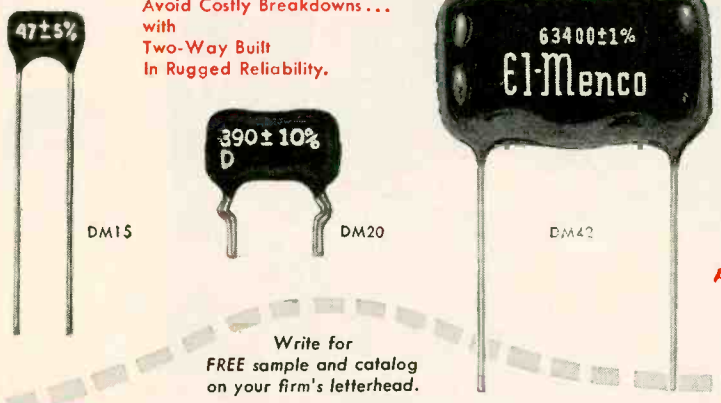
- Specially-selected, highest-grade India Ruby mica films . . . pre-tested to have highest insulation resistance . . . greatest dielectric strength . . . lowest dissipation factor. Specially developed dipped coating retains the superior properties of India Ruby mica.
- Debugging — the removal of early failures by subjecting mica capacitors to short life tests at elevated voltages and temperatures . . . THE SCORE . . . DM30, 10,000 MMF, "Debugged" El-Menco Dur-Mica Capacitors . . . subjected to 257,000 hours of life at 85°C with 100% of the rated DC voltage applied . . . turned in a record computed reliability performance — APPROX. 0.6% CUMULATIVE FAILURES OR ONLY 1 FAILURE PER 43 MILLION UNIT-HOURS.

El Menco "Dur-Micas"

have proved their tremendous power and ability under accelerated conditions of 1½ times rated voltage at ambient temperatures of 125°C and 150°C, winning out over all others in longest life, most powerful performance, smallest size, greatest stability.

DM15, DM16, DM19, DM20, DM30, DM40, DM42, DM43 . . . perfect for extreme miniaturization; ideal for new miniatured designs and printed wiring circuits. New "hairpin" parallel leads insure easy applications in radio, television, guided missiles. El-Menco Dur-Micas meet all humidity, temperature and electronic requirements, including military specs.

Avoid Costly Breakdowns . . . with Two-Way Built In Rugged Reliability.



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GENISCO CENTRIFUGES

with 10 times greater accuracy, larger centrifugal capacities, maximum flexibility...*and priced lower than any other centrifuges now available!*

The low-cost answer to fast, accurate testing of components under simulated operational g-forces as required by MIL-E-5272A.

These new precision centrifuges feature a unique, high-torque ball-disc integrator drive system which provides accuracies you would expect only from a rate-of-turn table. Constancy of boom rotation, including wow and long-term drift, is better than .05% at any speed setting—approximately 10 times more accurate than currently available machines. Boom speed is infinitely variable and is measured by an electronic counter built into the console.

The building block design concept gives the new centrifuges exceptional flexibility. Machines are assembled from six basic off-the-shelf components; drive system, drive motor, boom, test compartment, console and accessories. You simply select components which provide features needed to meet your specific requirements. Interchangeability of the components permits easy modification as requirements change. Kits are available for modification by the customer.

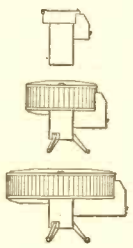
This new design concept also results in manufacturing economies which are reflected in the cost of the machines. *The new machines are the lowest priced centrifuges now available—in spite of their greater accuracy, flexibility and capacity.* Ask your Genisco representative for complete information today.

There are more than 400 Genisco centrifuges now in operation.

Genisco
INCORPORATED

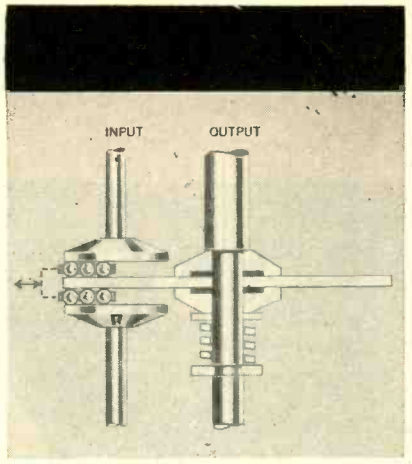
2233 Federal Avenue, Los Angeles 64, California

brief performance specifications



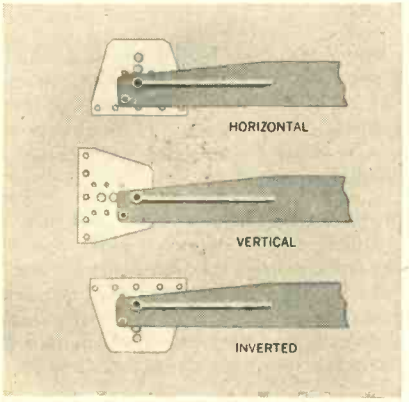
Model No.	Diameter	Test Object Weight	Capacity G-pounds	RPM Max.	G-Range Max.	Test Object Dimensions
A-1010	30" table	50 lbs. dead weight	2,500	800	.1 to 200 g's	
A-1020	60" arm	100 lb. dead weight	10,000	600	.1 to 250 g's	12" cube
A-1030	96" arm	100 lb. dead weight	10,000	400	.1 to 175 g's	18" cube

Large custom centrifuges: Genisco centrifuge experience includes the design, manufacture and installation of large custom-built machines. We invite your inquiry.



Entirely new, more efficient drive system—An integral variable speed transmission based on the new *Rouverol* *ball-galaxy principle achieves, for the first time in rotating machinery, high torque characteristics while maintaining the inherent accuracies of a hardened steel-to-steel ball-disc integrator. A novel choice of geometry among the drive elements results in a virtually linear handwheel vs rpm relationship, thus facilitating the presetting, programming and servo-controlling of output speeds. A built-in torque-limiter clutch protects the transmission from damage resulting from abuse or high inertia conditions.

*Pat. Pending

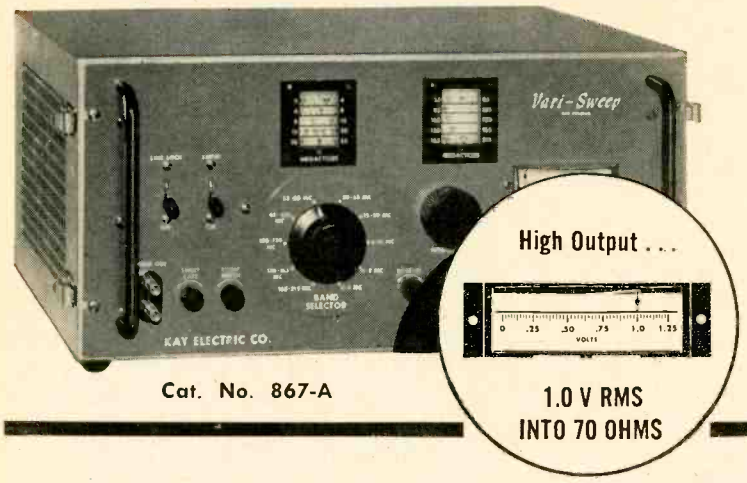


Basket-type mounting platforms, available on Model A-1020 and A-1030, may be oriented from the horizontal to the vertical or to the inverted attitude for multiple-axis testing without demounting the test object. Baskets may be raised or lowered to achieve an optimum dynamic balance and minimum angular deflections when extreme accuracies are required. When the basket is inverted the outside surface of the platform may be used to mount bulky, lightweight packages.

Available accessories include additional slip rings, servo control, microwave joints, high pressure air and hydraulic systems, TV viewing systems. Any accessory can be added *at any time* by the user. The mounting base is standard equipment.

NEW KAY *Vari-Sweep*

MODEL 400



Cat. No. 867-A

Wider Range, All-Electronic SWEEPING OSCILLATOR, or *(with sweep off)* Continuously Tuned CW Signal Source

HIGH Output—1.0 V rms into 70 ohms

WIDE Range—15-470 mc all at Fundamental Frequency

CONSTANT Output—fast-acting AGC circuit

- New Wider Range—15-470 mc in 10 Bands
- Fundamental Frequency—Stable Narrow Band Sweeps
- Direct Reading Frequency Dial
- Highly Accurate Attenuators
- Sweep Repetition Rates Down to 10 cps

The new *Vari-Sweep Model 400* is a highly versatile laboratory sweeping oscillator and signal generator. Its wide range of continuous frequency coverage from 15 to 470 mc is combined with a measure of accuracy and level of performance previously associated with limited, fixed-frequency-band oscillators only.

It provides frequency sweeps that are flat, wide, and linear. The RF output voltage is high enough for testing lossy networks without using additional amplifiers. Over the entire range, the RF output is a fundamental frequency held constant by a fast-acting AGC circuit to assure a high degree of frequency stability and the absence of spurious beat signals. The variable sweep rate goes down to 10 cps for checking high-Q circuits.

In addition, the *Vari-Sweep Model 400* is a source of accurately calibrated CW signal with the same high-level output AGC'd to be constant over the frequency band. This eliminates the need for readjusting output voltage when changing frequency, and permits the rapid testing of diverse frequency circuit elements under CW conditions.

SPECIFICATIONS

Frequency Range (CW or Sweeping Operation): Fundamental frequency, 15-470-mc, continuously variable in 10 switched, overlapping bands with direct-reading frequency dial.

Sweep Width: 60% of center frequency to 50 mc; at least 30 mc max from 50-400 mc; approx. 20 mc max above 400 mc.

Sweep Rate: Continuously variable, 10 to 40 cps; locks to line frequency.

RF Output: 1.0 V rms (metered) into nom 70 ohms (50 ohms on request) to 220 mc; 0.5 V rms to 470 mc. Output held constant to within ±0.5 db over widest sweep and frequency range by AGC circuit.

Attenuators: Switched 20, 20, 10, 6 and 3 db, plus continuously variable 6 db.

Sweep Output: Regular sawtooth, synchronized with sweeping oscillator. Amplitude 7.0 V approx.

Power Supply: Input approx. 100 watts, 117-V (±10%), 50-60 cps ac. B+ electronically regulated.

Dimensions: 9⅛" x 19½" x 13".

Weight: 34 lbs.

Price: $795.00, f.o.b. factory.

Cat. No. 386

NEW KAY *Rada-Sweep 300*

Single Unit Sweeping Oscillator in 10 Switched Bands For Sweeping Radar IF's Between 1 and 350 mc Center

SPECIFICATIONS

Frequency Range: Any 10 fixed center frequencies set to customer specification between 1 and 350 mc. Ten switched bands; fundamental frequency; all-electronic sweep.
Sweep Width: 70% of center frequencies selected between 1 and 100 mc; 60 to 70 mc for frequencies between 100 and 350 mc.
Sweep Rate: Variable around 60 cps. Locks to line frequency.
RF Output: 0.5 V rms into nom 70 or 50 ohms, higher for lower frequency units. Output held constant to within ±0.5 db over widest sweep by AGC circuit.

Zero Reference: A true zero-base line is produced on oscilloscope during retrace time.
Attenuators: Switched 20, 20, 10, 6 and 3 db plus continuously variable 6 db.
Markers: Up to 30 crystal-controlled positive pulse markers at customer-specified frequencies. Accurate to ±0.05%. Up to three markers per band (more at lower frequencies) are available; no individual switches on markers.

Marker Amplitude: Continuously variable, zero to 10 V approx.
Sweep Output: Regular sawtooth synchronized with sweeping oscillator.
Power Supply: Input approx. 150 watts, 117 V (±10%) 50-60 cps ac. B+ electronically regulated.
Dimensions: 8¾" x 19" rack panel, 13" deep. Supplied with cabinet; suitable for rack mount.
Weight: 34 lbs. approx.
Price: $695.00, f.o.b. factory. Add $15.00 per crystal marker ordered.

Write for 1958 Kay Catalog

KAY ELECTRIC COMPANY

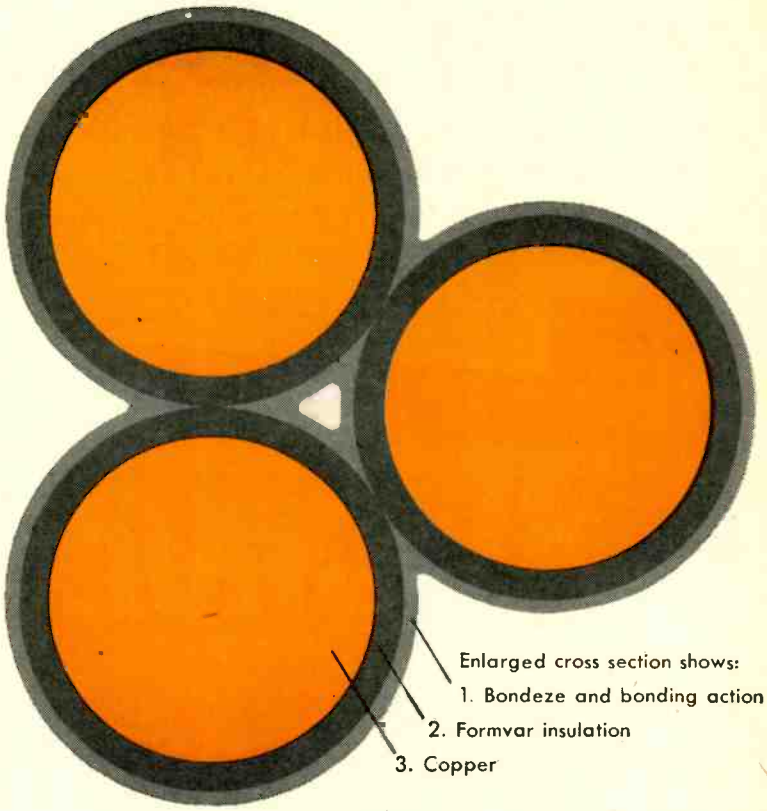
Dept. E-9 — **Maple Avenue, Pine Brook, N. J.** — **CApital 6-4000**

For quick bonding, turn to turn, with a single application of heat or solvent . . .

Specify

PHELPS DODGE BONDEZE®

MAGNET WIRE



These successful uses of Bondeze suggest unlimited new redesign possibilities, often at overall savings.

COILS Random-wound, layer, paper-section and solenoid coils for brakes and clutches, instruments, television, radio and other applications.

TRANSFORMERS Paper-section, random-wound, oil-filled, air-cooled and high voltage for distribution, current, X-ray, television, radio and other applications.

MOTORS Windings for shaded pole, series fields, instruments, induction and others.

Any time your problem is magnet wire, consult Phelps Dodge for the quickest, easiest answer!

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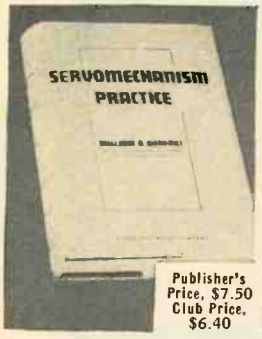
GIVEN TO YOU WITH A CHARTER MEMBERSHIP AND SENT WITH YOUR FIRST SELECTION

VALUES FROM $6.00 to $18.00



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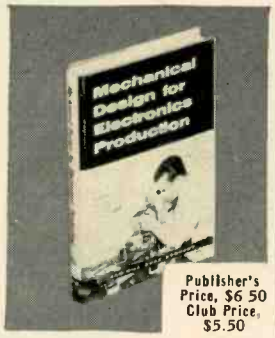
Servomechanism Practice by W. H. Ahrendt. How to solve problems of servo design, manufacture, test, and adjustment.



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Mechanical Design for Electronics Production by J. M. Carroll. Vital mechanical factors in building electronic equipment.

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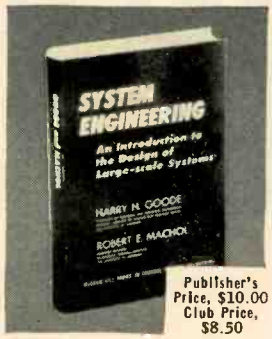
Television Engineering Handbook by D. G. Fink. Full reference of modern data needed to design and operate TV equipment.



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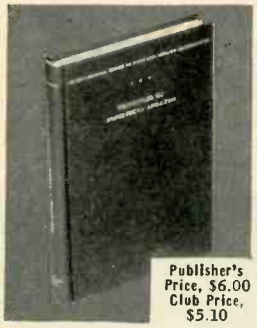

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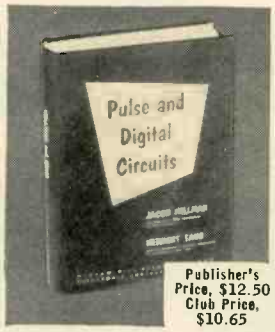

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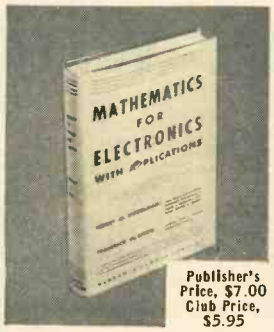

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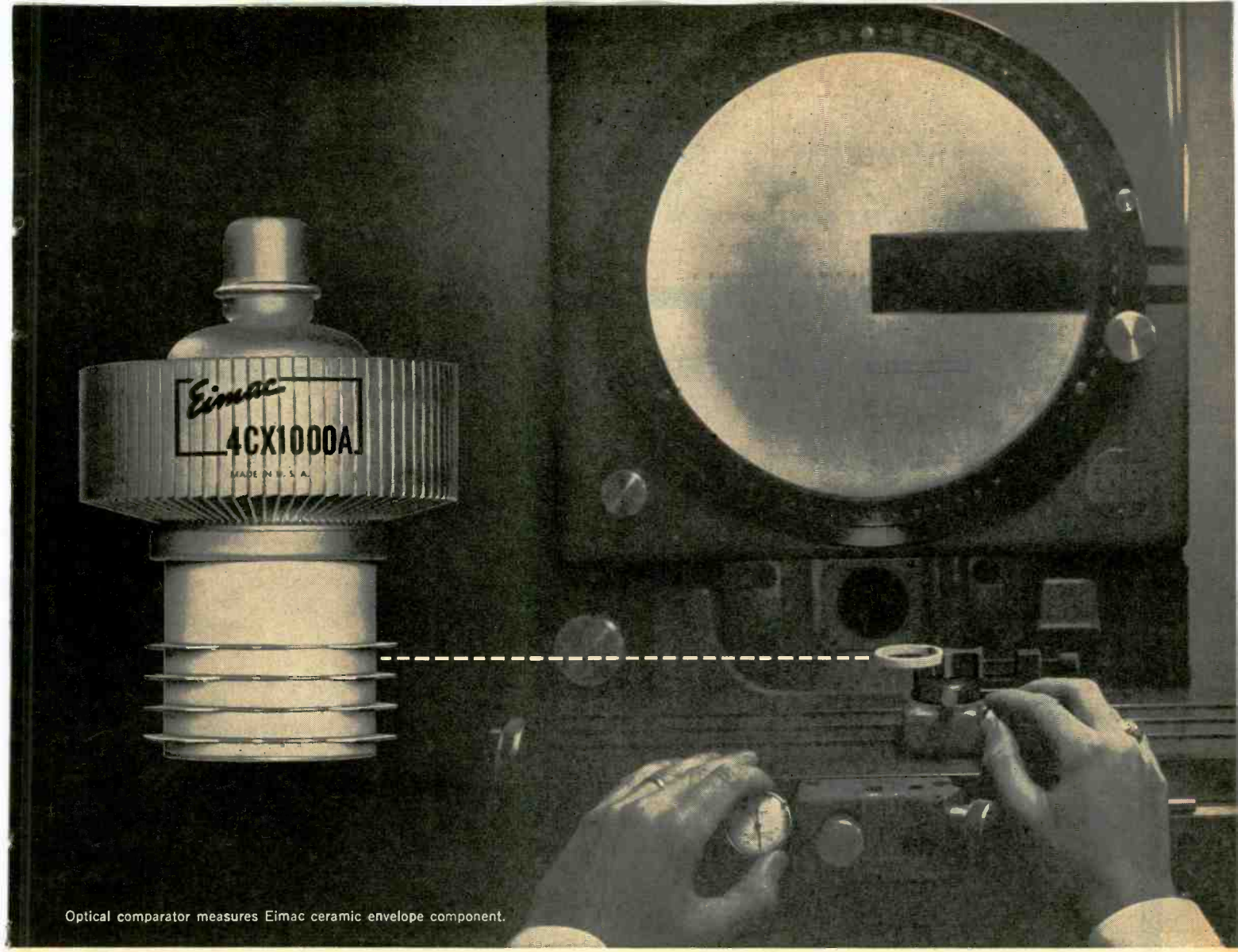

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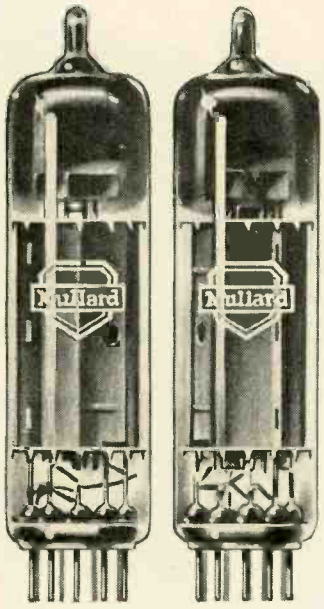

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V_a	300	V
V_{g2}	300	V
$I_{k(o)}$	2×40	mA
I_k (max. sig.)	2×45	mA
R_k (per valve)	270	Ω
$V_{in\ (g1\text{-}g1)r.m.s.}$	16	V
$R_{a\text{-}a}$	8.0	kΩ
P_{out}	11	W
D_{tot}	0.7	%

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R_k	130	Ω
$R_{a\text{-}a}$	8.0	kΩ
$I_{a(o)}$	2×36	mA
I_a (mag. sig.)	2×46	mA
$I_{g2(o)}$	2×4.0	mA
I_{g2} (max. sig.)	2×11	mA
$V_{in(g1\text{-}g1)r.m.s}$	20	V
P_{out}	17	W
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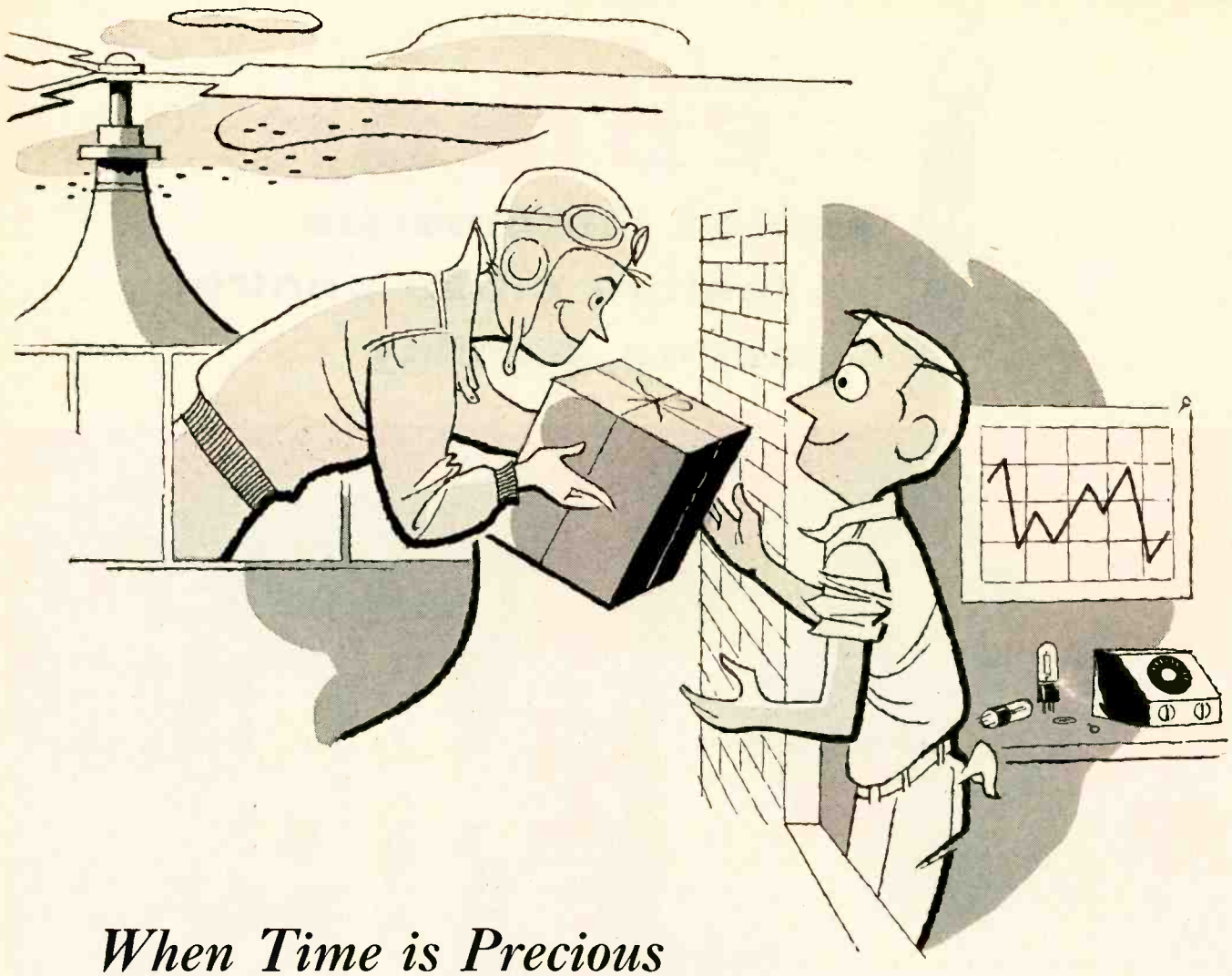

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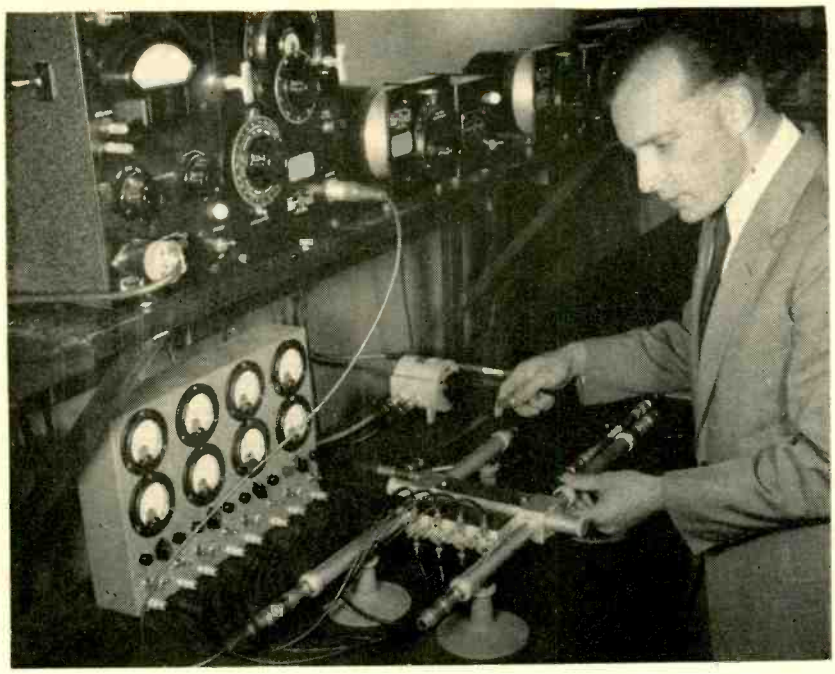


electronics
engineering issue

SEPTEMBER 26, 1958

A traveling wave version of a diode mavar. It consists of four semiconductor diodes arranged to produce a growing wave as signal travels down successive stages

The Mavar: A Low-Noise Microwave Amplifier

In the quest for methods of low-noise amplification at microwave frequencies, the principles of parametric or reactance amplifiers are being exploited in increasing measure. Investigation of these principles has resulted in the development of three major types of mavar which rival the supercooled maser in low-noise performance. Unlike the maser, the mavar requires no cooling, is capable of wide bandwidths at substantial gain

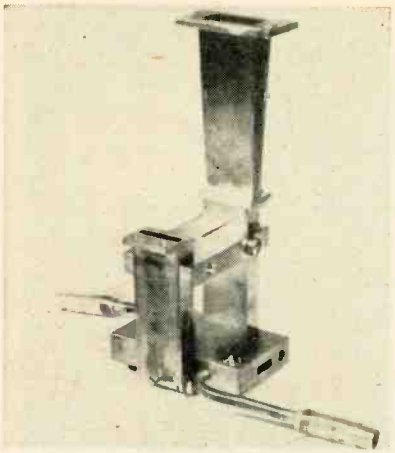
By **SAMUEL WEBER** Associate Editor, ELECTRONICS

MICROWAVE AMPLIFIERS using variable nonlinear reactances as the active elements constitute a significant trend in electronics research. Recent intensive activity in the development of these devices has revealed an unlimited potential in applications requiring extremely low noise at room temperatures. Such fields as radar, radio astronomy, microwave relay and uhf television will be major beneficiaries of the new amplifiers.

Reactance or parametric amplifiers, as they are popularly called, derive their name from the fact that the differential equation governing their behavior has one or more reactive parameters varying with time. More descriptive perhaps, is a recently coined acronym MAVAR (Mixer Amplification by Variable Reactance) which is gaining accepted usage.

The mavar bears a superficial resemblance to the solid-state maser (ELECTRONICS, Apr. 25, 1958) in that it requires an r-f energy source or pump, but unlike the supercooled maser, the mavar achieves low-noise amplification at room temperature.

Operation of the mavar depends upon the fact that a lossless nonlinear reactance exhibits a negative resistance characteristic under certain conditions, or can perform as an up-converter with gain under other conditions. Because the reactance is lossless, no thermal noise is generated. Consider the circuit shown in Fig. 1A. This is a modulator circuit in which a low-frequency source V_s and a higher frequency source V_p drive a nonlinear reactance represented in this case by the inductance L. Its nonlinearity might be in the form of a flux



Bell Labs scientists Suhl and Weiss examine development model of a ferromagnetic mavar. Device was built by Weiss (right) after theoretical investigation by Suhl showed feasibility. At far right, closeup of ferromagnetic mavar assembled to waveguide

density which is a quadratic function of the current through the coil. The reactance might also be represented by a capacitor whose charge is a nonlinear function of the voltage across it. The analysis is essentially the same.

Because of the nonlinearity, many upper and lower sideband frequencies are generated. In this circuit it is assumed that power at only four frequencies is permitted to flow through reactor L. These frequencies are f_p the pump frequency, f_s the signal frequency, and the first upper and lower sidebands which are $f_h = f_p + f_s$ and $f_l = f_p - f_s$, respectively. To all other frequencies the reactor represents a short circuit.

Power Relationships

Under these conditions, analysis of the power relationships in the reactor[1] for the frequencies involved shows that the following expressions are valid:

$$\frac{P_p}{f_p} = -\frac{P_h}{f_h} - \frac{P_l}{f_l} \qquad (1)$$

$$\frac{P_s}{f_s} = -\frac{P_h}{f_h} + \frac{P_l}{f_l} \qquad (2)$$

where positive P represents power leaving the reactor at the frequency denoted by the subscript, and negative P represents power absorbed. From these equations, it is apparent that the reactance always absorbs pump power, but under proper conditions, signal power can be emitted from the reactance.

To illustrate, if only the upper sideband is permitted to exist in the circuit, then Eq. 2 becomes $P_h = -f_h P_s / f_s$. Hence power flows from the reactor at the upper sideband frequency and is amplified by a factor f_h/f_s, as long as signal power is supplied. This is the up-converter type of operation which may be employed in both amplifier and modulator applications.

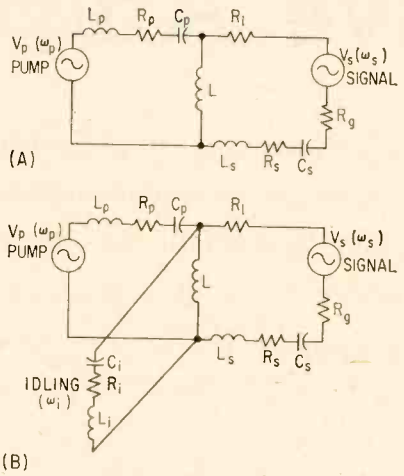


FIG. 1—Equivalent circuit of reactance amplifier (A). Idler circuit added in (B) absorbs difference frequency

On the other hand, if the upper sideband is completely suppressed, Eq. 2 becomes $P_s = f_s P_l / f_l$. Since both P_s and P_l are positive, power is emitted from the reactance at both the signal frequency and the lower sideband. Amplification of the signal is obtained directly without demodulation, with a gain limited only by the circuit configuration and with a constant gain-bandwidth product.

Idler Circuit

Because of the necessary condition that the difference frequency f_l be sustained for power to flow at the signal frequency, an idler circuit capable of absorbing power at f_l is required in this type of operation. This is illustrated in Fig. 1B.

Gain in this type of mavar is equivalent to a negative resistance being introduced into the signal circuit. It can be shown that the equivalent negative resistance is a function of the applied pump power and hence is controllable.

Application of these general principles has resulted in the successful development of three major types of mavars. These differ mainly in the form taken by the nonlinear element. Mavars yielding promising performance, at least in the laboratory, have been built using ferrites, reverse biased semiconductor diodes, and modulated electron beams.

I—Ferromagnetic Mavar

To understand how a ferrite is used as the nonlinear reactance element in a reactance amplifier, it is necessary to discuss the concept of magnetostatic modes.

In a ferrite crystal, unpaired electrons are spinning about their own axes with angular velocity ω_s. The spinning motion of the electron gives rise to an angular momentum and a magnetic moment along the axis of rotation. If the ferrite is subjected to a d-c magnetic field, the axis of the electron spin tries to line up with the applied field, since this is the position of minimum potential energy. Because the electron has finite mass, it cannot move to this position instantaneously, but begins to precess with an

Table I—Pump Power Required For Ferromagnetic Mavar

Mode of Operation	Approx. Pump Power
Electromagnetic	15 kw
Semistatic	10 w
Magnetostatic	100 mw

angular velocity ω_p as shown in Fig. 2A. The angular velocity with which the precession takes place is given by the expression $\omega_p = \gamma H_{dc}$ where γ is a quantity known as the gyromagnetic ratio of the electron, and H_{dc} is the effective value of the applied magnetic field.

Energy Absorbed

Because of damping factors in the material, the electron spin axis gradually aligns itself with the d-c field. If now a small uniform r-f field is applied to the system so that the resultant field oscillates between points P_1 and P_2 as shown in Fig. 2B, the electron is perturbed and precession takes place again. If the rate of oscillation of the field just equals the frequency corresponding to the precession rate, energy is absorbed by the ferrite.

This absorption manifests itself as a single symmetrical peak which takes place at a particular frequency for a given value of d-c field. A typical plot of absorption as a function of field is shown in Fig. 3A. For a long time this single resonance peak was the only one observed by experimenters. More recently, it has been found that if the ferrite is placed in an r-f field which is nonhomogeneous throughout the ferrite region, a multiple series of less intense resonant absorption peaks occur. Two such series are typified in Fig. 3B. The new absorption peaks are caused by the fact that the axes of the electron spins are no longer precessing in synchronism throughout the ferrite region, but are out of phase in various parts of the sample because of the uneven distribution of magnetic flux.

Magnetostatic Modes

With each resonant peak is associated a particular spatial configuration of the r-f field within the ferrite known as a magnetostatic mode. Magnetostatic modes are distributed in an almost continuous frequency spectrum. Their frequencies depend only on the shape of the sample and the applied d-c magnetic field, but are always greater than, or equal to $\gamma(H_{dc} - 4\pi M)$ where γ is the gyromagnetic ratio, H_{dc} is the applied field, and M is the saturation magnetization of the ferrite. One of the magnetostatic modes is the uniform precession with frequency $\omega_p = \gamma H_{dc}$.

Theoretical investigations suggested that magnetostatic modes could be utilized in the construction of a parametric amplifier[3, 5] and three possible types of operation were found to be feasible with such a device.

Energy can be coupled between the uniform precession mode and the other magnetostatic modes. If the pump frequency is selected to equal the uniform precession frequency f_p and two additional magnetostatic modes whose frequencies are f_s and $f_p - f_s = f_i$ are excited, the necessary conditions for parametric amplification are fulfilled. This type of operation is called "magnetostatic" because it depends only upon resonances characteristic of the ferrite and the field, independent of the external structure.

Practical use of magnetostatic operation is made difficult by the large number of pairs of modes adding up to the uniform precession frequency, resulting in dissipation of pumping power in those modes which are uncoupled to the load.

Semistatic Operation

A second mode of operation, known as "semistatic", is more practical. In this mode, the ferrite sample is placed in a cavity made resonant to f_s or f_i. The other required frequency is derived by establishing a magnetostatic mode in the ferrite at f_i or f_s. The applied magnetic field H_{dc} is adjusted so that no two magnetostatic modes add up to the pump frequency f_p.

In the third mode of operation, known as "electromagnetic", a doubly resonant microwave structure is tuned to both f_s and f_i. The only magnetostatic mode present is that of the uniform precession frequency f_p.

Based upon the theoretical proposals an amplifier utilizing the electromagnetic mode of operation was constructed at Bell Labs. This approach was used because electromagnetic modes are easily excited

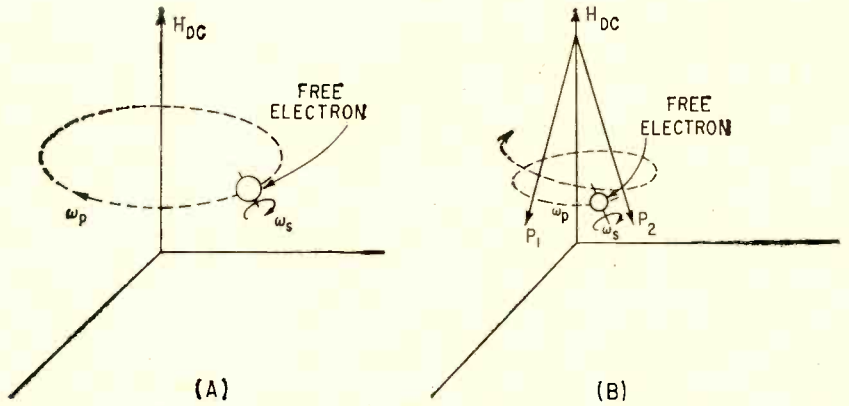


FIG. 2—Precessional path of electron spin axis under influence of (A) d-c magnetic field and (B) uniform r-f field

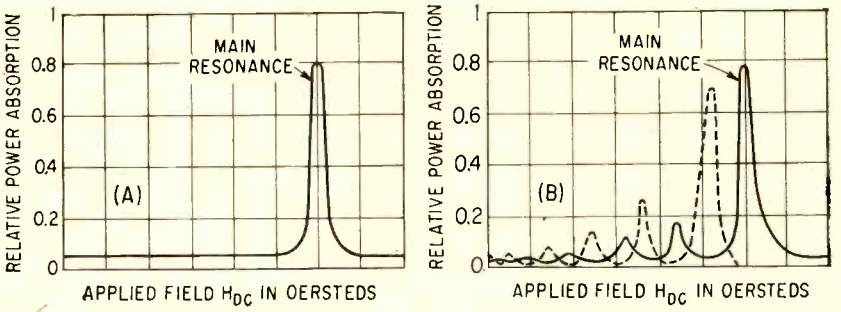


FIG. 3—Typical plot of power absorption as a function of magnetic field in a ferrite crystal. Single resonance peak as in (A) occurs when ferrite is uniformly magnetized. In (B) series of smaller peaks is manifestation of magnetostatic modes

and measured, and the microwave structures necessary to sustain them are readily constructed.[4]

Experimental Amplifier

Figure 4 is a sketch showing the construction of the experimental ferromagnetic amplifier. In this system, the pumping oscillator frequency is 9,000 mc.

Both f_s and f_i are made equal to 4,500 mc. The microwave structure consists of a shielded stripline, a half-wavelength long with a Q of 500.

A coaxial probe couples the signal to the cavity. The ferrite sample consists of two disks of single-crystal manganese ferrite, 0.125 in. in diam. and 0.050-in. thick. These are placed at the center of the stripline, one on top and bottom. The pumping power enters the device through a TE_{10} mode waveguide orthogonal to the stripline.

With a d-c magnetic field applied at a 45-deg angle to the stripline, and 3-μsec pulses of 20-kw peak pumping power, oscillations at 4,500 mc are observed having an output power of 100 w. When the pumping

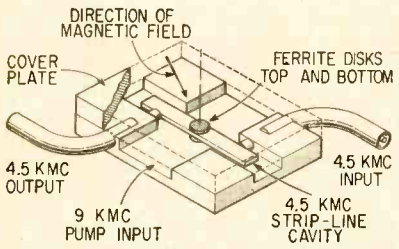
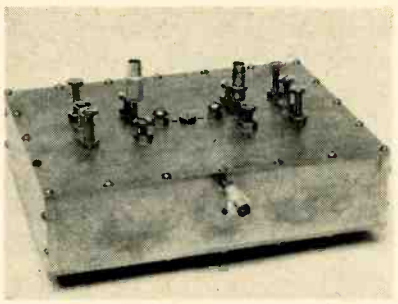
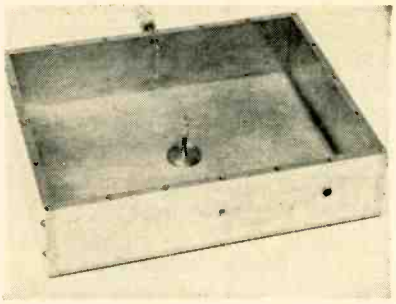


FIG. 4—Sketch of ferromagnetic mavar operating in the electromagnetic mode

power is reduced below the threshhold level, amplification of the 4,500 mc signal may be observed. When the pump oscillator output is reduced about 1 db below the value required for sustaining oscillation, a gain of 8 db is realized. The high level of pump power required for electromagnetic operation seems to preclude it from practical application. Further experiments with semistatic and magnetostatic operation indicate that successful development of the ferrite mavar lies in this direction. Table I is a chart of the various modes of operation and the order of magnitude of the pumping power required for each, as derived from laboratory experiments.





Deceptive simplicity of this "diode-in-a-box" is revealed by these views of a mavar developed at Stanford University. Tuning screws in cavity lid provide multiple resonance, essential if mavar operation is to take place

II—Variable Capacitance Mavar

It has long been known that a *pn* junction exhibits the characteristics of a nonlinear capacitance when biased in the reverse direction.[6]

At the junction there is a region known as the depletion layer, in which there are few holes or electrons. Within the depletion layer, the net fixed charge is not neutralized by mobile carriers, whereas outside the region, there are enough holes and electrons present to neutralize the fixed charges. This situation, pictured in Fig. 5A, is analogous to a parallel-plate capacitor with plates oppositely charged.

When the reverse bias of the junction is increased, the depletion layer widens. This corresponds to separating the plates of the capacitor with an accompanying decrease in capacitance. Hence the *pn* junction may be represented as a variable capacitor whose value depends on the voltage applied. Figure 5B is a graphical representation of the depletion layer capacitance as a function of the back voltage. A typical dynamic capacitance characteristic for a germanium pn junction is a 3:1 change in capacitance for a 15-v change in bias.

An equivalent circuit of a back-biased junction or point contact diode is shown in Fig. 5C. The depletion layer capacitance C_d is shown in series with a constant spreading resistance R_s and C_o is the junction static capacitance.

Diode Amplifier

The variable reactance represented by the depletion layer capacitance is the mechanism which can be utilized in mavar construction.

Figure 6 shows a block diagram of a negative resistance type experimentally set up at Bell Telephone Laboratories.[7] Here the diodes employed are silicon and germanium diffused junction types or welded contact gold-bonded germanium types mounted in a suitable waveguide structure. A circulator is used to isolate the input from the output signals and also prevents thermal noise from the load from being amplified. Pump power is supplied at 12 kmc and stable power gain of 45 db is measured at the signal frequency of 6 kmc. As predicted by theory, constant gain-bandwidth product is achieved. With gain adjusted to about 18 db, a bandwidth of 8 mc is possible at a noise figure of about 5 db. Pump power is 50 to 500 mw.

In a negative resistance type mavar constructed at Stanford Uni-

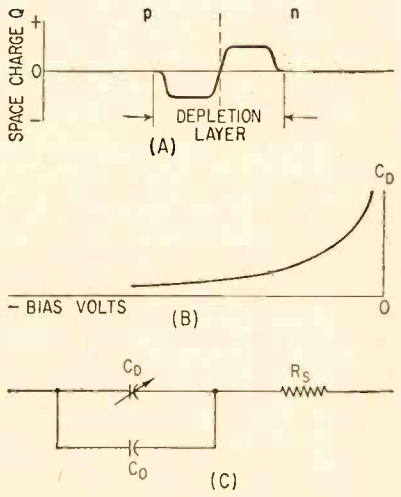


FIG. 5—Space charge distribution at a *pn* junction (A) results in a nonlinear capacitance which varies with reverse bias (B). Equivalent circuit of diode is shown in (C)

versity,[8] a cavity is made simultaneously resonant to frequencies of 3,500, 2,300 and 1,200 mc. The diode, a special type with a low frequency zero-bias capacitance of 1 $\mu\mu$f and a spreading resistance of about 5 ohms is placed within the cavity. Pump power of about 100 mw at 3,500 mc causes oscillations to occur at both lower frequencies. When pump power is reduced slightly below this level, amplification at either 1,200 or 2,300 mc is obtained. Bandwidth at 19 db gain is 1 mc, at a power output of 1.5 mw. Preliminary noise figure is less than 4.8 db.

Disadvantages

The negative resistance mode of operation suffers from the disadvantage that by its very nature it is difficult to achieve stability. In some cases, adjustment of the threshold pump power is critical, and the device is sensitive to load variations unless a circulator or other isolation device is used. Furthermore, placing a negative resistance in the signal circuit is equivalent to raising the Q. This results in a limitation of the bandwidth capable of being achieved at substantial gains.

The up-converter mode of operation overcomes some of these disadvantages although at the expense of requiring a demodulator to recover the signal frequency f_s from the amplified sum frequency f_u. Scientists at Airborne Instrument Lab, have successfully developed a low frequency amplifier of this type with a view to extending the technique to higher frequencies.[9] Figure 7 illustrates the method.

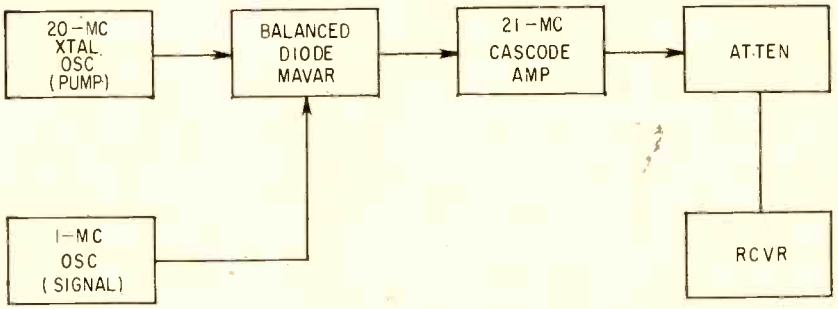


FIG. 7—Setup for up-converter low frequency mavar. This type is generally more stable, capable of greater bandwidth than negative resistance type

In this system, a balanced mixer arrangement using two identical 1N470 silicon diodes constitutes the mavar section. The balanced configuration provides ease of tuning, eliminates local oscillator noise and cancels the local oscillator current through the input and output circuits. Available power gain is 10 db with a 10 percent bandwidth at the signal frequency. The overall effective input noise temperature is 40 K, which corresponds to a startling noise figure of 0.5 db.

Traveling Wave

Many variations of these basic circuits have been devised. One of these is an experimental traveling-wave amplifier using four stages of diodes arranged in tandem and in such a phase relationship that a growing wave is generated as the signal travels down the line of successive stages. The advantage of such an arrangement is an increase in the available bandwidth. R. S. Engelbrecht of Bell Labs has obtained a 100-mc bandwidth at a signal frequency of 400 mc. The pump power of 10 mw was at 900 mc. Gain of 10 db at a noise figure of only 3.5 db was achieved.

The implication of the properties of diodes in mavar applications are clear. The cost is potentially low, reliability high. No external magnetic fields or refrigeration are required. One basic type covers a wide frequency range since there are no abrupt internal resonances in the properties of a *pn* junction. Probably it is the diode type mavar that will have the most immediate impact on communications.

III—Electron Beam Mavar

Parametric amplification of a signals may also be achieved by using the properties of a modulated electron beam as the variable reactance.

One method varies the reactance of a microwave cavity with a pump oscillator.[10] Figure 8 illustrates the system. A beam of electrons is produced by the electron gun and accelerated toward the collector. The signal cavity has two equal gaps separated by a drift space L. As the electron beam passes through the cavity, it enters the field-free drift region. An effective impedance is produced by the beam across the cavity which is a function of the drift angle α as plotted in Fig. 8. As seen in the figure, if L is adjusted so that α is $n\pi$ radians, where n is any integer, then the impedance across the cavity becomes a pure reactance.

To produce mavar action, the

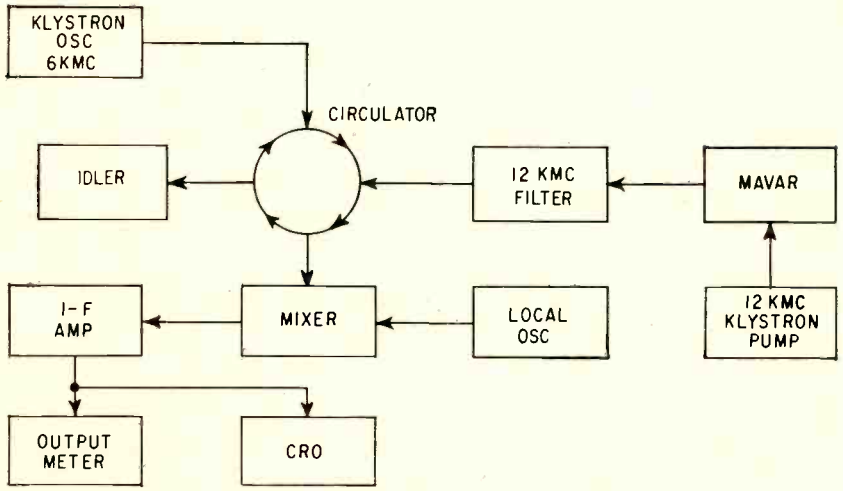


FIG. 6—Block diagram of negative resistance mavar setup. Diodes employed are silicon and germanium diffused junction types or welded contact gold-bonded germanium

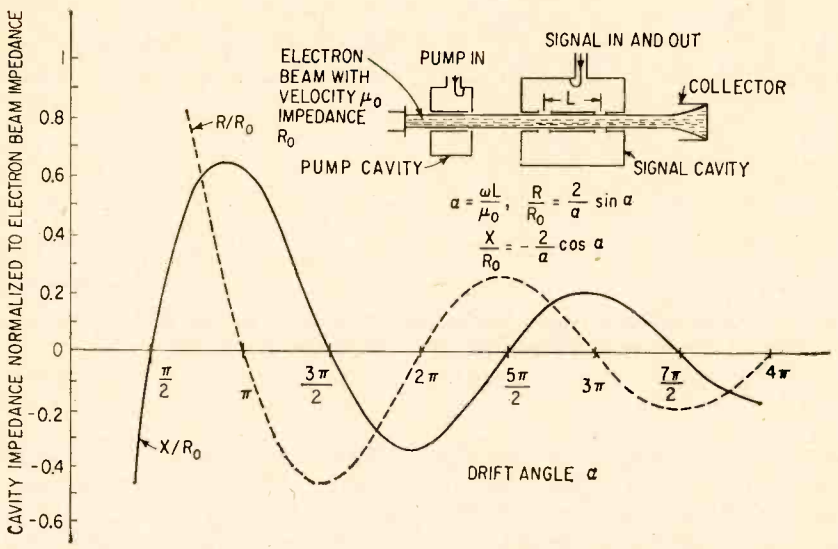


FIG. 8—Resistive and reactive components of impedance across cavity as a function of drift angle. Pure reactance is obtained when $\alpha = n\pi$ radians

electron beam, and hence the reactance, is modulated by injecting pump power into another cavity resonant to the pump frequency. For simplicity the pump frequency is made equal to twice the signal frequency.

If the drift angle is $(2n + 1)\pi$ radians, corresponding to a positive reactance, any noise currents of signal frequency coupled onto the beam at the cathode will cancel at the signal cavity by virtue of their being equal in amplitude but out of phase at the two gaps.

An experimental tube based on this principle was successfully operated, although no noise figures are as yet available. With a pump frequency of 8,300 mc at a power level of 140 mw, 20-db gain was observed at the signal frequency of 4,150 mc.

Space Charge Waves

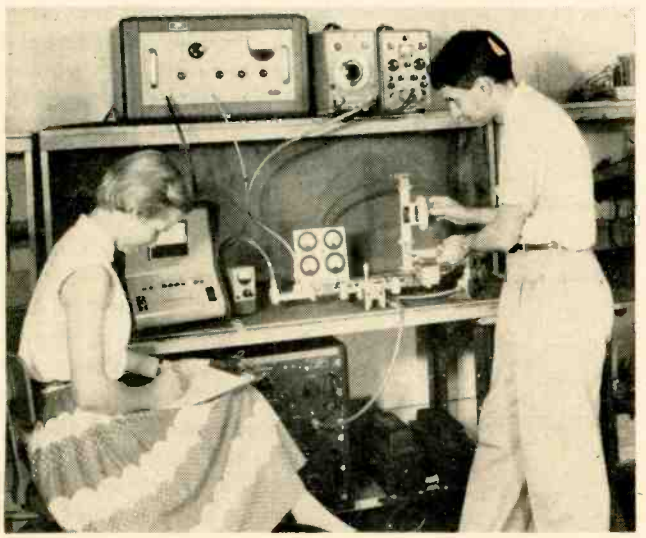
Another mavar employs space charge waves imposed on a modulated electron beam. When a beam is modulated by an r-f signal, either of two traveling waves of space charge can propagate along the beam. One wave, called the "slow" wave travels at a velocity less than the d-c velocity of the beam, and the other "fast" wave travels at a greater velocity. Hence the slow wave may be thought of as representing a negative power with respect to the d-c beam power, and the fast wave may be considered as positive power. Therefore, to excite the slow wave, r-f power must be extracted from the beam, while the fast wave is excited by adding power to the beam.

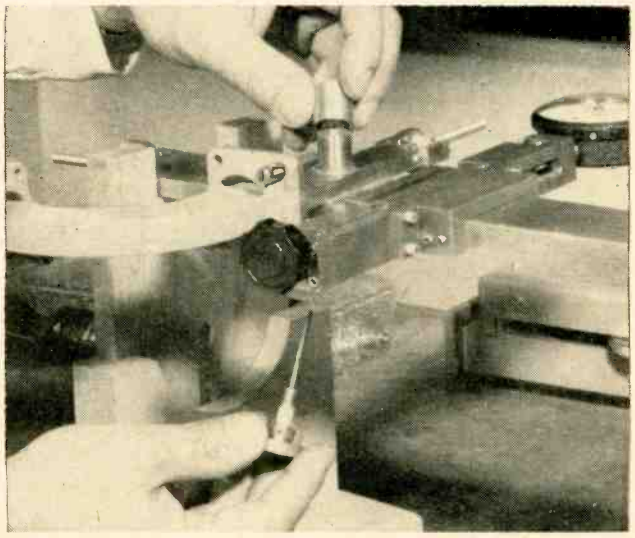
In a conventional traveling wave tube, gain is achieved by amplification of the slow wave. This is accomplished by a slow-wave structure such as a helix which extracts r-f power from the beam at the expense of the d-c power. Noise imposed on a slow wave at the cathode would require for its removal the addition of r-f power to the beam of proper phase and amplitude to cancel it out. Because of the random nature of noise, this is clearly impossible. On the other hand, noise imposed on a fast wave represents an excess of power on the beam that need merely be extracted and absorbed.

The fast wave, once launched on the beam, can be amplified by parametric action if the beam is modulated by a pump oscillator. Under these conditions the fast wave grows exponentially with distance along the beam at the expense of the pump power.

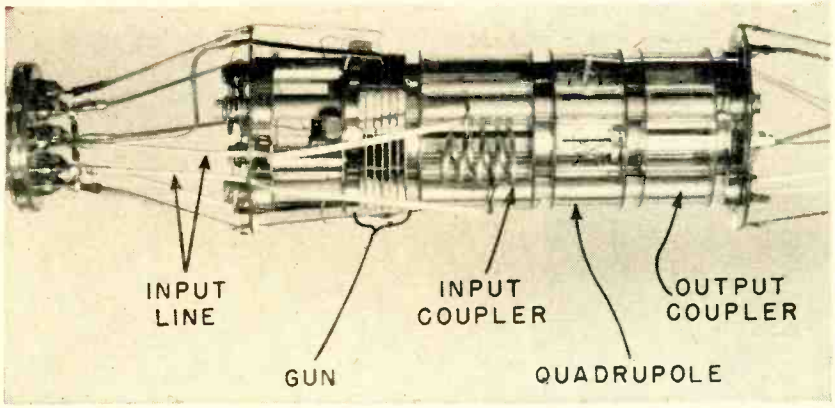
Practical Version

A low-noise tube embodying these principles was first developed at Zenith Radio Corporation. The latest version of this tube (see cut)





Technicians at Airborne Instruments Lab (left) measure noise in up-converter mavar. Special techniques are required to measure such low levels of noise accurately. At right, closeup of semiconductor diode being inserted in waveguide structure in a negative-resistance mavar application



Electron beam mavar developed at Zenith Radio Corporation. This is an experimental model, made demountable for ease of component adjustment

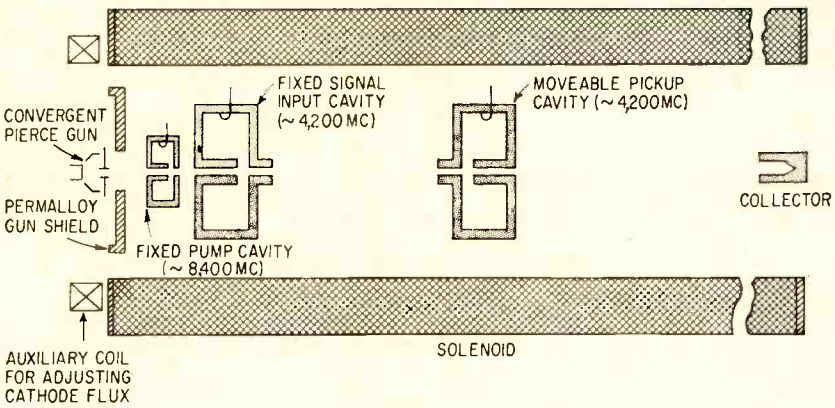


FIG. 9—Cross-section of experimental fast-wave parametric amplifier under development at Bell Labs. Solenoid is used to focus beam to desired width

uses an electron gun which generates an electron beam of about 35 μA. The beam drifts at a low velocity along the lines of a magnetic field of about 200 gauss. Input and output couplers are pairs of deflection plates tuned to the signal frequency of 560 mc by built-in coils.

At the input coupler, signal power is transformed into spiraling electron motion. The beam absorbs power from the signal and carries it in the form of a transverse fast wave. At the same time, the input coupler is designed to absorb the fast wave component of noise which is already present on the beam. Thus beam noise and input signal are interchanged.

Parametric amplification of the fast wave is accomplished during passage of the beam through a nonhomogeneous transverse electric field produced by a structure resembling the stator of a 4-pole generator. The structure, called a quadrupole, is excited by pump power of about 10 mw at a frequency of 1,120 mc. The alternating field thus produced causes the radius of the orbits of the spiraling electrons to increase or decrease exponentially. On averaging, exponential growth always exceeds exponential decay, resulting in gain. At the output coupler, the electrons spiral inward, giving up their kinetic energy in the form of amplified signal to the load circuit.

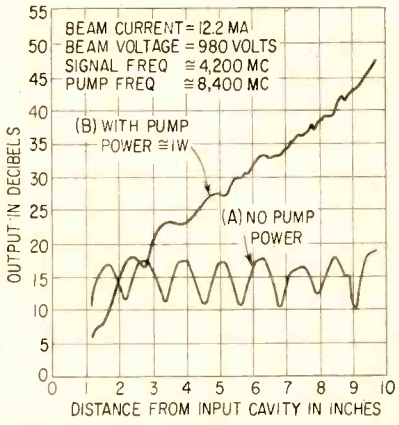


FIG. 10—Plot of signal amplitude measured as a function of distance from input cavity. Growth of signal is evident when pump is applied

Typical performance data for this tube are: bandwith of 50 mc at a center frequency of 560 mc; gain of up to 30 db at an approximate noise figure of 1 db. The tube is unconditionally stable and gain is controlled by adjusting the pump power.

Cavity Coupling

A demountable tube similar in principle to that just described has been built and operated at Bell Laboratories.[12] The setup is sketched in Fig. 9. Here the input and output coupling as well as modulation of the beam by the pump is accomplished by resonant cavities.

In this tube, the pump cavity is resonant at 8,400 mc. The signal cavity is tuned to half the pump frequency and excites a fast wave of space charge on the beam. Simultaneously noise is coupled out and absorbed.

The third cavity is tuned to the signal frequency and can be moved axially so as to measure the variation of space charge with distance along the beam. Figure 10 shows the variations when approximately 1 w of pump power is used. In this case a parametric gain of about 41 db was achieved with the tube, but internal losses cut this figure to a realizable 21 db. Although noise performance data is unavailable, the figure should be well below that of conventional twt's which is limited to about 4 db.

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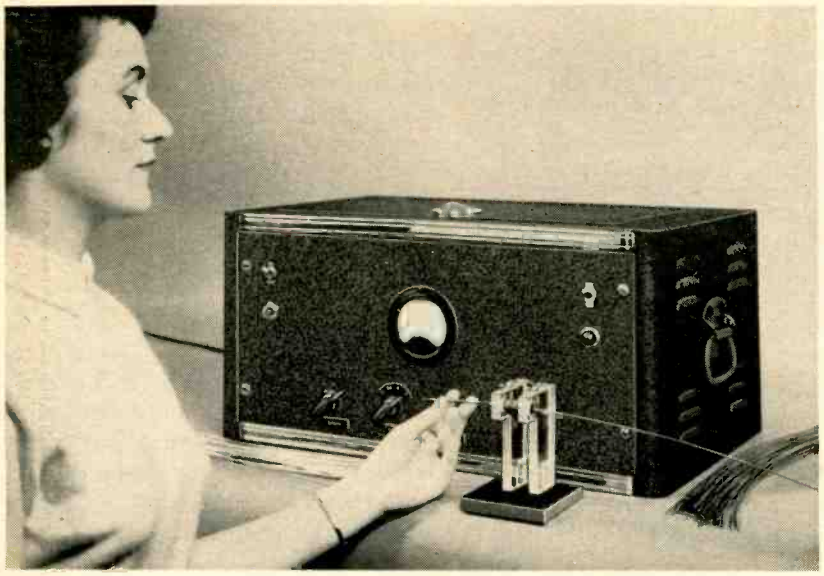

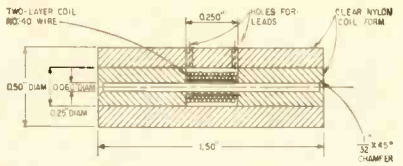

FIG. 1—Probe dimensions for 0.055-inch diameter wire under test

FRONT COVER—When wire is pulled through probe coil mounted on clear plastic stand, meter on panel indicates size of each flaw. Meter reads full-scale for perfect wire

Detecting Invisible

ONE CRITICAL NUCLEAR reactor application called for a large quantity of 0.055-inch-diameter-zirconium wire having exceptionally high quality. Cracks or internal voids less than 0.001 inch in depth or length were sufficient cause for rejection. The instrument described here reliably detected these defects. Speed of inspection is limited by the band width of the recording system used to make a permanent record of the wire quality; however, if a permanent record is not necessary, an electronic relay circuit can be used to indicate flaws in the wire. Inspection speeds of many feet per second then become possible. Both paramagnetic and ferromagnetic wire can be inspected.

Theory of Operation

The wire to be tested is run through a small probe coil which establishes an a-c magnetic field that induces eddy currents in the wire. Flaws cause a change in the magnitude and direction of the eddy currents, thereby causing changes in the impedance of the probe coil. Measurement of the change in impedance can thus provide information on wire quality.

To obtain a maximum change in coil impedance for a given flaw, the probe coil must fit tightly around the wire. Coil length should be the minimum that will still give an adequate coil impedance. For testing zirconium wire 0.055 inch in diameter the optimum coil geometry as determined experimentally is shown in Fig. 1.

Factors Affecting Accuracy

Wire defects are usually cracks and internal voids, the size of which determine the magnitude of the change in coil impedance. The impedance value also depends on the electrical properties of the wire. With zirconium wire, however, the conductivity and permeability were sufficiently uniform so they did not interfere with flaw detection.

Variations in coil-to-wire spacing change the impedance of the coil. To minimize this change, the diameter of the center hole of the coil form was made only 0.005 inch

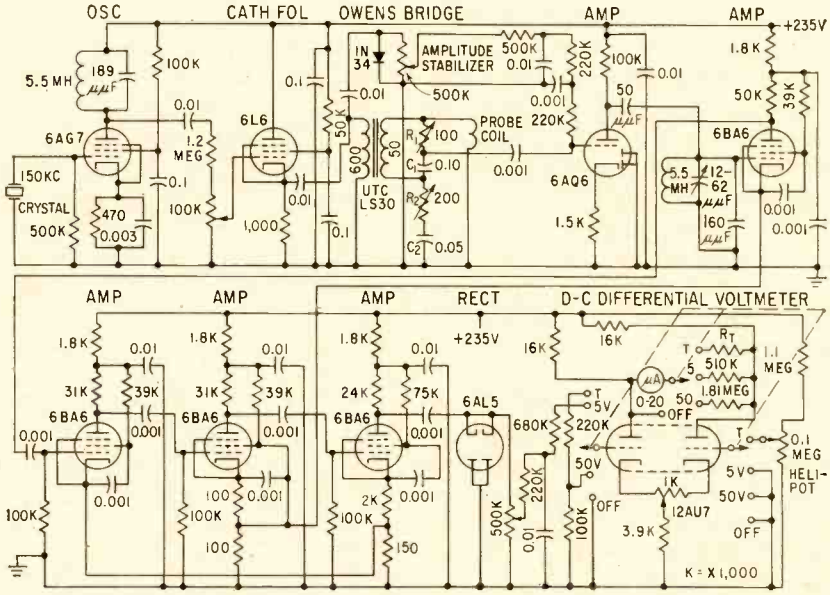

FIG. 2—Circuit of instrument. Electronic relay or recorder may be connected across microammeter in d-c differential voltmeter circuit if desired

Zirconium wire for positioning fuel elements of nuclear reactors is run through probe coil of high-sensitivity eddy-current instrument that gives permanent record of surface or internal cracks and voids smaller than 0.001 inch. Result is measure of integrated wire quality because several small cracks give same indication as one large crack. Instrument is readily calibrated for other kinds of wire. With meter or relay in place of recorder, speeds of several hundred feet per minute can be achieved for production

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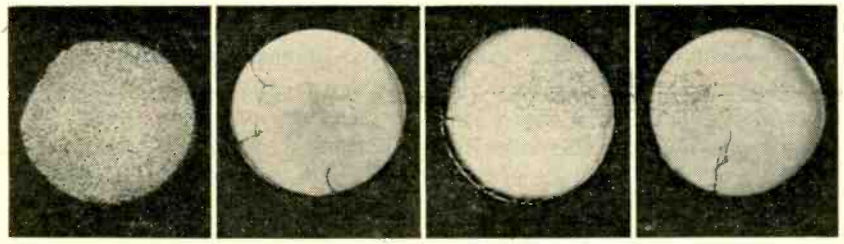
Flaws in Wire



Cross-sections of 0.055-inch zirconium wire used for calibrating instrument. Output was adjusted so meter gave reading of 5 for standard acceptable wire at left. Next sample, with at least four major flaw areas, gave reading of 0.0, third sample gave 0.5, and sample at right with only one surface crack gave 2. For nuclear reactor application, acceptable wire had to read over 4.25 at all points

greater than the nominal wire diameter. Wire diameter varied only ±0.003 inch, which was not enough to interfere with detection of flaws.

Changes in the operating temperature of the coil vary its impedance. If these temperature changes are too drastic, the calibration of the instrument will be affected. These changes in temperature may come from changes in the ambient temperature or from excess coil current.

The operating frequency is not critical, hence a wide range of frequencies can be used for detecting flaws in wire. This range can be determined theoretically or experimentally, and varies with the permeability, conductivity and diameter of the wire to be tested.

The circuit diagram is shown in Fig. 2. The impedance of the probe coil is measured with a modified Owens bridge circuit consisting of R_1, R_2, C_1 and C_2. The crystal-controlled oscillator supplies a 150-kc, 20-volt peak-to-peak sinusoidal voltage to the primary of the audio transformer through a cathode follower. Probe coil heating is negligible with this voltage. An amplitude-stabilizing circuit practically eliminates the effects of oscillator voltage drift.

Output Voltage

Bridge output voltage is amplified in five stages, then rectified for measurement by a d-c differential voltmeter. A tuned circuit connected from the grid of the second amplifier stage to ground eliminates undesirable harmonics. Degenerative feedback loops in the last amplifier stages assure high stability.

To calibrate the instrument, several wires were tested at many points, the wires were sectioned at these points, and wire quality was determined by microscopic inspection. This gave output voltages of 0 to 4.25 v for unacceptable wire.

To set up the instrument for operation, the bridge is first balanced without a wire in the coil by adjusting R_1 and R_2 for zero output voltage, using first the 50-v range and then the 5-v range. With the meter on the 5-v scale, the standard flawless wire is placed in the probe coil and the 500,000-ohm potentiometer across the 6AL5 rectifier output is adjusted until the meter reads 5 v. The meter is then switched to the test scale and the 0.1-megohm meter balance potentiometer is adjusted to obtain a full-scale deflection. The instrument is then ready.

When the meter is set on the test position, the variable resistance in the grid circuit of the 12AU7 balances out a portion of the d-c voltage. This allows the remaining d-c voltage to cover the entire meter range and increases the sensitivity of the meter to defects. To obtain a full-scale reading for 2.5 v, a 0.2-megohm resistor is used for R_7.

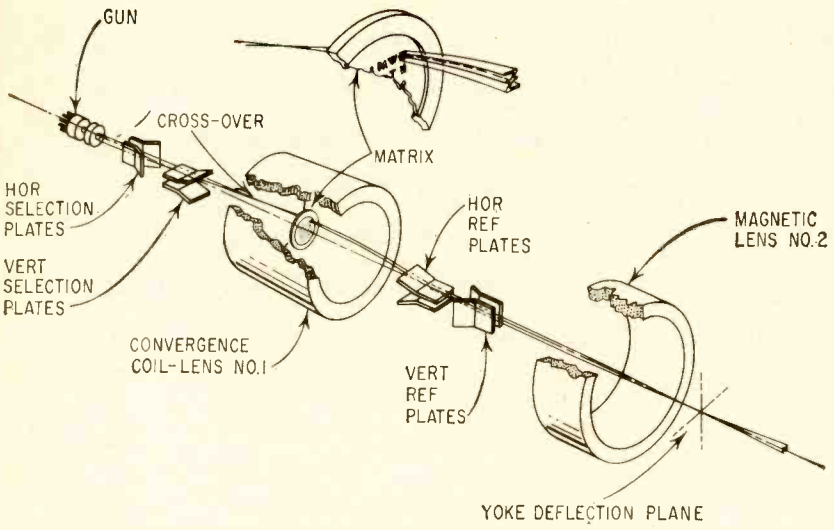
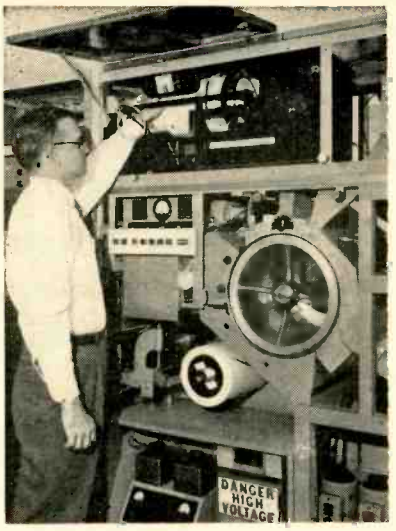


FIG. 1—Diagram illustrates how the electron beam is shaped to select individual characters from the matrix. The shaped-beam tube, part of the computer readout, represents a method of writing on a cathode-ray screen. Selection plates direct the beam at the desired character in the matrix whence it is deflected to face of crt



Operator is shown checking final adjustments prior to actual operation of the high-speed electronic printer. The character-forming tube is in the top panel

Electron Gun Operates

SUCCESSFUL MARRIAGE of the Charactron computer readout, employing the shaped-beam tube for code conversion and character display, with the Copyflow Xerographic printer, now makes it possible to record one-million typewritten characters per minute.

Pulse-code data of electronic processors can be converted to printed records in the form of letters, numerals, charts and graphs on ordinary untreated paper.

The shaped-beam tube effects code conversion and character display by first transforming pulse-codes into light rays of predetermined configurations. The printer transforms these light rays into printed records. Each system is unique in its respective method of operation and in combination they are expected to make worthwhile contributions to the growing read-out speed requirements of data processors.

Electron Optics

Shaped-beam tube C7C11 is used as the code converter. A simplified diagram of the electron optical system of this tube is shown in Fig. 1. The optics are similar to that of the C19K, developed for use in aircraft surveillance systems, except that a second magnetic lens has been added to the C7C11 tube. This lens is located betwen the deflection yoke and the reference plate system.

Characters are formed by directing a beam from the electron gun at a thin metal disk which may have as many as 64 different characters arranged in an 8-by 8-character matrix, cut out like a stencil. Beam diameter is sufficient to cover the largest character in the matrix. Selection plates, located between the electron gun and the matrix, are supplied with d-c control voltages which direct the beam at the desired character.

The characters and their matrix alignment conform with the common language of the computer. There is, therefore, a direct relationship between a given set of identifying codes, the type and arrangement of characters in the matrix and the characters displayed on the screen of the tube.

Magnetic lens No. 2 in Fig. 1 permits the characters displayed on the screen of the tube to be varied in height from 0.035 in. to 0.07 in. in accordance with instructions from the data-processing equipment. The 0.035 in. character-display dimensions permit an information density (characters-per-unit-area) of more than 10,000 characters within the 4½ in. sq area of a 6-in. useful screen diameter of the tube. This is nine times the information density possible when employing, for example, 0.1-in. high characters on the 19-in. diam screen of the C19K tube. The use of 0.035-in. high characters in many computer read-out applications vastly reduces the number of pictures needed in the conversion of output data to permanent records. In line-at-a-time printing of the output of data processors, there is ample room to display 128 or more 0.035-in. characters in a single line across the useful screen diameter of the tube.

A simplified diagram of the computer readout and printer, is shown in Fig. 2. The control elements of the shaped-beam tube are shown as block diagrams. Figure 3 shows the actual physical layout of the components.

Xerography

Operation of the printer is centered around an aluminum drum having a photoconductive surface of vitreous selenium which has

Electronic printer converts pulse-code data from shaped-beam crt into printed records on ordinary untreated paper at the rate of one-million characters per minute. Characters are formed by passing a magnetically controlled electron beam through a thin metal stencil-cutout matrix which contains alphabetic and numeric characters. High-speed printed readout is solved by using xerographic electronic dry-printing technique

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High-Speed Printer

been deposited by vacuum evaporation. There are five processing steps involving this drum: Uniform charging of the drum's photoconductive surface renders it light sensitive; Exposure of the uniformly-charged drum surface to light images from the shaped-beam tube; Development of exposed areas by allowing them to collect oppositely charged and finely-divided powder particles; Transfer of the powder image to a record medium, such as untreated paper; Removal of any remaining powder particles prior to the succeeding charging cycle.

After the powder is transferred to the paper, the characters are heat-fused to the paper and are available immediately as a permanent record.

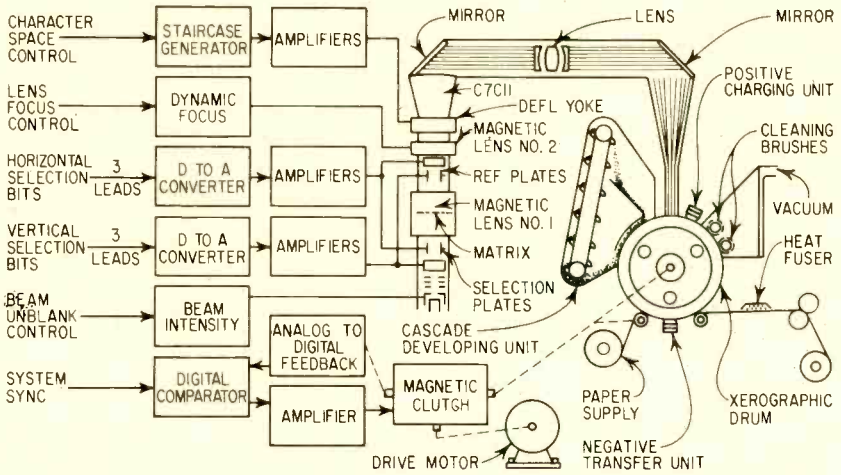

FIG. 2—Simplified diagram of the computer readout circuitry and the printer. Much of the circuitry is of conventional design. Message displays on the screen of the shaped-beam tube are focused on the light-sensitive surface of the drum through an optical system of surface-reflecting mirrors and lenses

The photoconductor surface of the drum is charged by spraying the surface with positive ions formed by corona discharge. A corona-charging unit consists of two sets of fine wires, supported adjacent to the surface of the drum and at right angles to the direction of drum rotation. A flat plate conductor is supported on the opposite side of the wires. To generate corona discharge, the upper and lower wire sets are connected respectively to positive potentials of a few thousand volts and several hundred volts with respect to the drum and plate which are at ground potential. These potentials cause air molecules to become ionized and positive ions deposited on the surface of the drum, thereby, charging the photoconductor to a potential of several hundred volts.

Exposure

After the surface of the drum has been charged, the potential difference between the surface of the photoconductor and the aluminum base may be neutralized by exposing the surface to visible light rays. When exposed to character shapes having the blue light illumination of the fluorescent screen of a C7C11

tube, only those areas of the photoconductor which have been exposed will decay to the ground potential.

When the charged photoconductor is exposed to light, electron-hole pairs will be generated near the surface of the selenium layer when incident photons are absorbed and, thereby, produce sufficient excitation to raise electrons from the valence band to the conduction band. The positive holes, thus created, are then free to migrate through the selenium lattice toward the base and so contribute to discharging the illuminated area. Electrons can move only the short distance to the surface, hence their contribution to the discharge of the plate is negligible.

Perhaps the most important characteristic of the selenium photoconductor, which allows the process to resolve the character presentations of the C7C11 tube, is the absence of lateral conduction. This is due to the fact that the lateral electric field component is small compared to the strong perpendicular component within the photoconductive layer.

Development

To develop the latent images on the surface of the drum, a finely-ground pigmented resinous powder known as toner, combined with a relatively large granular material which acts as a carrier, is cascaded over the exposed surface. The carrier adds mass to the developer as it cascades over the drum and also charges the powder particles to the correct polarity by frictional electrification. This phenomenon, also called triboelectrification, is responsible for the electrical bond which exists between the carrier and the toner.

As the toner-laden carrier particle passes over an electrical discontinuity of the drum's surface, the vertical component of the fringing field exerts a sufficiently large force on the toner particles to overcome the carrier-to-toner bond. Thus the toner particles attach themselves to the drum within the image area.

Image Transfer

After the images have been developed on the surface of the drum the toner is transferred to the record medium, such as paper, and made permanent by heat fixing.

The paper is fed past the transfer unit at the surface speed of the drum and in actual contact with the drum's surface. The ion charge which is deposited on the paper by the corona unit sets up an electric field of sufficient magnitude to overcome the attraction between the toner and the discharged surface areas of the drum. Thus, the positively charged toner is drawn from the drum and attracted onto the paper which is then subjected to heat that melts the resinous toner and fixes it to the paper. The pigmented image is permanently bonded to the paper by this process, making printed copy available for immediate viewing.

Pulse Code Data

In the simplified diagram of the high-speed readout device shown in Fig. 2, message displays on the screen of the shaped-beam tube are focused on the light-sensitive surface of the drum through an optical system of surface reflecting mirrors and lenses. Illuminations appearing on the screen are in accordance with pulse-code data coupled to control circuitry of the shaped-beam tube. These data may be derived from a variety of information sources such as scientific electronic computers, automatic data processors, central filing systems and telecommunication networks.

The staircase generator, which is a 7-stage binary counter and a 7-bit digital to analog converter, controls the horizontal spacing of symbolic data across the 11-inch wide paper, while a servo-controlled paper drive regulates the vertical spacing of data on the paper as it is fed through the printer. The staircase generator provides a maximum of 128 display positions across the paper which, as in the mechanical typewriter, may be referred to as character spacing. In each of these display positions symbolic data from the matrix may be printed corresponding to letters, numerals, symbols, or horizontal and vertical line making data. Line making data is programmed to print the desired business form along with the recorded message. Larger type size of the fixed form is controlled from the input equipment by coupling the necessary control signals to the dynamic focus circuitry of the printer.

Forming Characters

The character matrix of the shaped-beam tube is positioned along the axis of the tube, normal to the direction of electron flow,

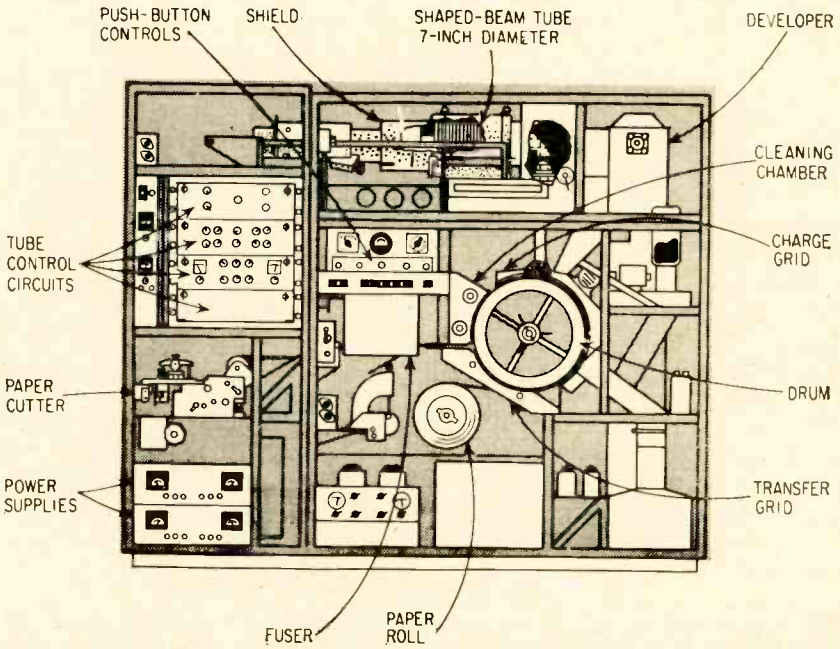

FIG. 3—Cross sectional view of the high-speed electronic printer shows the physical configuration of the complete system

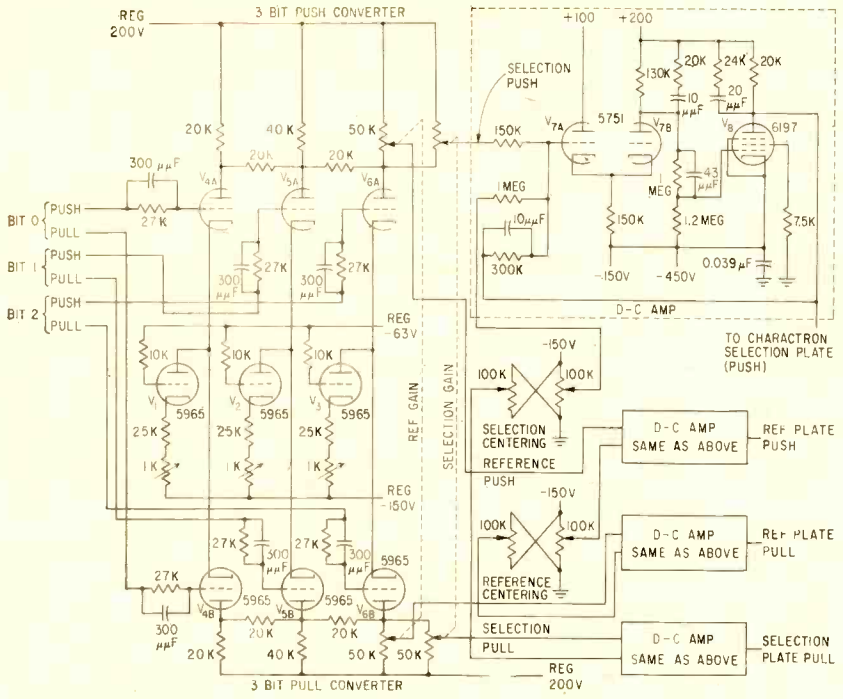

FIG. 4—Circuit diagram of the 3-bit digital-to-analog converter, used to select any one of the 64 matrix positions

and about midway of the field of the magnetic lens. A beam of electrons from the electron gun is directed at the matrix upon the excitation of an intensity circuit by a beam unblank control signal. Before the application of an unblank signal and prior to the display of a character, the three horizontal selection bits and the three vertical selection bits are coupled to their respective digital to analog converters and d-c voltages derived from the converters are amplified and applied to the reference and selection plates of the tube.

Upon the application of a beam unblank signal, the selection plates will direct the beam toward the desired character in the matrix, and, after the No. 1 magnetic lens has returned the shaped beam to a cross-over point on the axis of the tube, the reference plates will redirect the beam back onto the axis. A 6-bit code permits the cross-section of the beam to assume the shape of as many as 64 different characters which are engraved in less than a 0.25-sq in. area of the matrix.

The size of the displayed character may then be controlled in height by the No. 2 magnetic lens just prior to final deflection.

It is not necessarily a requirement to regulate drum rotation and paper feed in accordance with control data from a computer or data processor except in those applications where data coupled to the printer is subject to variations in the character-per-second display rate. In such cases a special servo-regulated drive mechanism is incorporated in the printer.

Selection Bits

The selection of any one of the 64 matrix positions is accomplished by two 3-bit digital to analog converters: three bits for vertical selection and three for horizontal selection. The two function identically. Three bits are channeled to each converter, where they are decoded (or converted) in two current ladders that provide push-pull signals.

Each converter functions on the principle of three equal currents being electronically switched in and out of a network of precision resistors. These resistors weight the inputs according to the significance of the bits so that one current causes a voltage change of E, the second a change of $\frac{1}{2}E$, the third a change of $\frac{1}{4}E$.

If the current through the plate load resistance of V_{6A} in Fig. 4 is assigned a value of I, then the current through this same load as a result of V_{5A} conducting will be $\frac{1}{2}I$, and the current through this same load as a result of V_{4A} conduction will be $\frac{1}{4}I$.

A constant voltage on the grid of V_1 causes the cathode of V_1 to rise to the same voltage plus the tube bias voltage; thus a constant voltage on the cathode is established. The cathode bias resistor of V_1 is a precision resistor. Current flowing through V_1 must flow through either V_{1A} or V_{1B} to reach plus 200 v.

Assuming an input signal of 111 hence all three tubes are conducting, the voltage developed across the plate load resistance of V_{6A} is 1.75 IR. With an input condition of V_{5A} and V_{6A} conducting and V_{4A} nonconducting, the voltage developed across the output will be 1.5 IR v. Thus binary combinations of the 3-bit information (23) can be converted into 8 different voltage levels at the output of the ladder.

Final Amplifiers

Two d-c amplifiers are used to amplify the decoded push-pull signals from the decoder. The resulting amplifier push-pull signals are then applied to the selection plates of the display tube for correct character selection. The output signals from the horizontal and vertical decoders are also fed into four additional amplifiers, these are reference amplifiers used to amplify the push-pull signals before the signals are applied to the reference plates of the display tube to reference the shaped electron beams back onto the axis of the tube. Each set of amplifiers, both selection and reference, are provided with an independent signal gain control and centering adjustment.

These potentiometer adjustments provide compensatory control for variations in tube sensitivity and computer readout circuitry.

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Designing Transistor

Transistorized, saturable-core relaxation oscillators are finding increased application as d-c to a-c converters. This article presents a rapid means for determination of necessary circuit parameters. The technique is applicable to many variations of the basic, two-transistor symmetrical circuit

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DETERMINATION of circuit parameters in transistorized d-c to a-c converters is simplified greatly by use of the accompanying nomographs.

A symmetrical form of converter[1] is shown in Fig. 1. It consists of transistors Q_1 and Q_2 operating as controlled switches, a battery E, and a core with square-loop characteristics.

Circuit Operation

Assume that Q_1 begins conducting. Current flowing into the top or dot end of L_1 causes all windings to be positive at the dotted end. The voltage across L_3 increases conduction still further, causing regeneration until Q_1 saturates. This switching occurs rapidly. The induced voltage across L_4 keeps Q_2 cut off.

When Q_1 saturates, almost all of the battery voltage appears across L_1. The core flux, ϕ, increases linearly with time until positive core saturation is reached. At core saturation, the transistor current increases rapidly in an attempt to maintain constant $d\phi/dt$, but the transistor current is limited by the base voltage developed by L_3.

When the current and the resultant flux can no longer increase, the induced voltages drop to zero and Q_1 is cut off. Cessation of current in L_1 allows the flux to decrease toward its remanance value, inducing voltages of the opposite polarity in all windings. This action holds Q_1 off and turns Q_2 on. The battery is now connected across L_2 and the flux builds up linearly to its negative saturation level.

The core oscillates between positive and negative saturation. If Q_1 and Q_2 are similar and $L_1=L_2$ and $L_3=L_4$, a square wave is induced in the output.

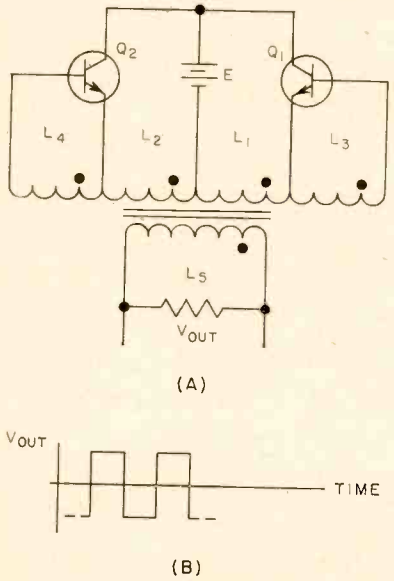


FIG. 1—Symmetrical converter circuit (A) and ideal output waveform (B).

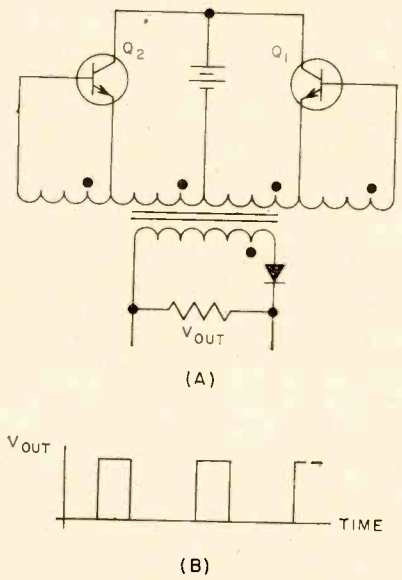


FIG. 2—Assymetrical circuit (A) and its ideal output waveform (B)

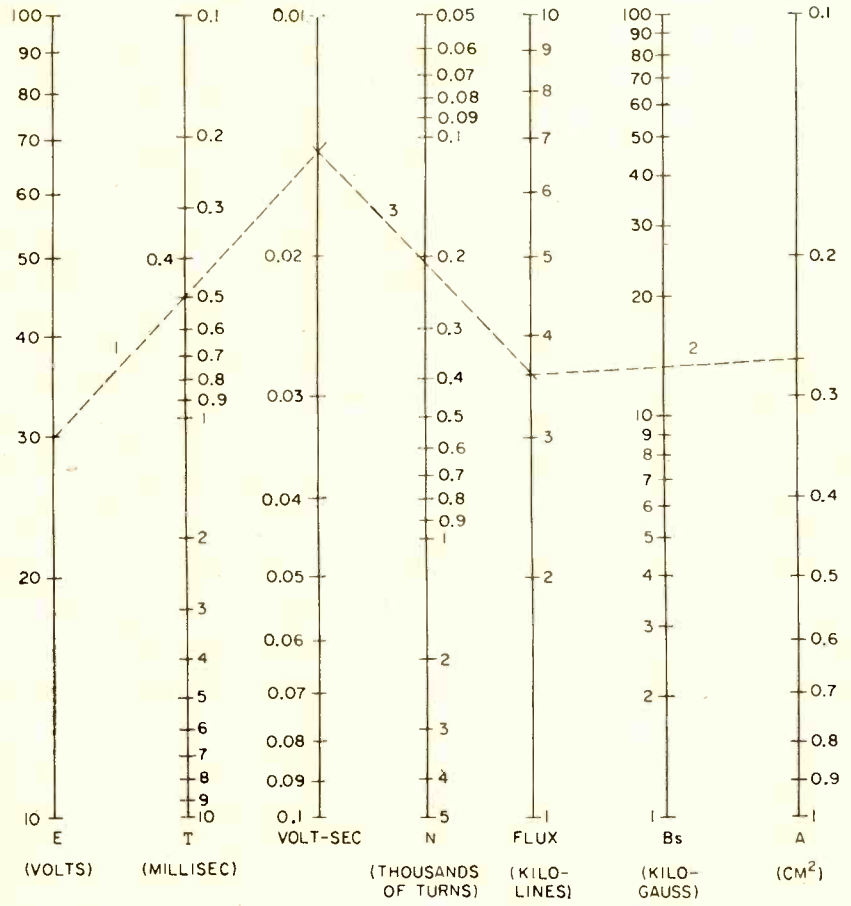
Design Procedure

Usual design procedures involve initial-core selection, completion of necessary design calculations, and a check to make certain that the required windings fit into the available area. The designer may then accept the initial core size or repeat the procedure with a larger or smaller core as influenced by his preceding calculations.

Core size may be dictated by factors such as window area available for windings, cost, weight, and overall size. Cores wound from thin tape and with high ratios of inside to outside diameter, give fast switching and steep waveforms.

Core materials such as Orthonol and Hymu "80", with narrow rectangular hysteresis loops, contribute to frequency stability and low core losses. Unfortunately, all desirable features are not available simultaneously. The narrower the loop, the lower the saturation flux density and the less rectangular the

D-C to A-C Converters



Timing Nomograph

loop. The material selected must be a compromise of all factors.

Timing Nomograph

With a trial core in mind, the number of turns for L_1 and L_2 may be found from the timing nomograph. This is based on the relation governing the change in core flux:

$$N = \frac{ET}{2B_sA}\,10^8 \qquad (1)$$

where T is time in seconds during which battery voltage is applied to the core winding; E is the battery voltage; N is the number of turns on the core; A is cross-sectional area of the core in sq cm; and B_s is saturation flux density in gauss. The factor of 2 is necessary because the core change from negative to positive saturation, or vice versa, is a change of $2B$.

For a specified load voltage, the number of output turns resulting from application of the ideal transformer equation must be increased by ten percent. This increase is necessary to compensate for leakage impedances and the transistor saturation voltage. The latter is normally less than one volt for germanium transistors but may be higher for silicon units. The voltage nomograph for output turns assumes that this ten percent factor is sufficient. The equation is

$$N_{out} = 1.1\,N\,\frac{V_{out}}{E} \qquad (2)$$

where V_{out} is the peak output voltage during one-half cycle.

At this point, the transistor may be selected. Although it must supply one-half the required load power and core and copper losses, its operating point passes through the high dissipation region quickly. As long as switching time occupies a negligible portion of the cycle, the transistor may be assumed 95-percent efficient. Copper and core losses total about 15 percent. Overall conversion efficiency is 0.95×0.85 or about 81 percent.

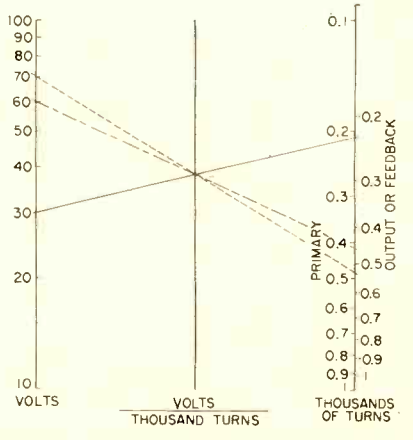
The transistor must deliver current to a fictitious load whose resistance is about 85-percent of the reflected converter load. In addition, the transistor must deliver about 130 percent of the current required by the fictitious load. This value is necessary to insure that the core is driven well into saturation.

Peak voltage appears across the transistor when it is cut off. Assume zero saturation voltage for the transistors and ideal windings. Peak inverse voltage from collector to emitter of Q_1 is then the battery voltage plus the voltage induced in L_1 by current in L_2. In this case, peak inverse voltage is $E + E$ or $2E$ volts.

Feedback

Feedback turns of L_3 may be determined from the voltage nomograph once the required base voltage is found from the transistor output and input characteristics. The applicable formula is similar to Eq. 2 with the feedback voltage substituted for V_{out} and the number of turns on L_3 and L_1 for N_{out}.

Design now continues as in stand-



Voltage Nomograph

ard transformer practice. Appropriate wire sizes are picked and the fit of the windings checked. It is important to employ a winding sequence that will result in close coupling between L_1 and L_2. Close coupling minimizes ringing caused by interprimary leakage reactance.

Regulation and internal heating are affected by the same factors that apply in standard transformer design. However the converter is one device that cannot be damaged by overload. Overloading causes the oscillation to cease and not resume until the overload is removed.

Example

As an example, assume a 1,000-cps symmetrical converter operating from a 30-v source is to deliver 120 v to a resistive load of 200 ohms.

Duration of each pulse is half the period of the 1,000-cps wave or 0.5 millisec. Using the timing nomograph, connect $E = 30$ and $T = 0.5$ with a straight line. Extend the line until it intersects the volt-sec axis.

As an initial core selection, try a 2-mil Orthonol core, Magnetics Inc., type 50018-2A. Cross-sectional area for this core is 0.257 sq cm. Saturation flux density is 14 kilogauss.

Connect $A = 0.257$ and $B_s = 14$ with a straight line that intersects the flux axis. Connect this intersection with that previously found on the volt-sec axis. This results in an intersection with the N axis at 0.21. Both L_1 and L_2 of Fig. 1, therefore, should have 210 turns.

To determine the number of turns for L_5 for an output of 60-v peak (120 v peak-to-peak), use the voltage nomograph. Connect battery voltage E = 30 with the primary

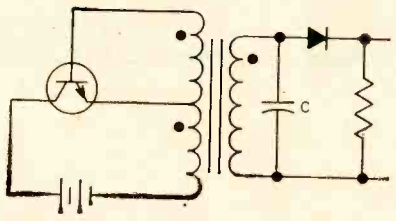


FIG. 3—Simple converter circuit using a single transistor

turns, $N_1 = 210$, as read on the left scale. Note the intersection with the volts-per-thousand-turns axis. Connect this intersection with the peak output voltage (60 v) and extend the line until it intersects the turns axis. Read the value of N_5, the number of output turns, from the right scale as 460.

The fictitious reflected load to each transistor is $0.85 \times (210/460)^2 \times 200$ or 35.6 ohms. Transistor current during the pulse is 30/35.6 or 0.845 amp. Peak transistor current must be 1.3×0.845 or 1.1 amp.

Voltage and current requirements may be met by the type H-7 transistor. As determined from the transistor output characteristics, a base voltage of 0.7 v is necessary for an output current of 1.1 amp.

Bias Windings

Return to the voltage nomograph and connect the 70-v point with the intersection on the volts-per-thousand-turns axis found previously. Extend the line until it intersects the turns axis. The value 540 turns is read from the right scale. Since 0.7 v rather than 70 v is required, L_3 and L_4 should each have 5.4 or say 6 turns.

Wire sizes may now be selected and the winding fit checked. Table I shows the wire selection and required winding area for the coils.

Window area of the type 50018-2A core is 1.82 sq in. but space must be allowed for the winding-machine shuttle. The RW II toroidal-core winding machine uses a 13/16-in. diam shuttle for number 22 wire. Shuttle area is 0.518 sq in. Utilizing a 70-percent space factor, effective window area is $0.7 \times (1.82 - 0.518)$ or 0.9114 sq in. This value leaves ample room for winding and insulation.

Admittedly, a generous amount of hindsight was used in formulating this example. In general, a few tries are necessary before a satisfactory design is achieved.

Circuit Variations

Two important variations of the basic circuit are shown in Figs. 2 and 3. In the circuit of Fig. 2,[2] power is delivered to the load only when the power transistor Q_1 conducts. Transistor Q_2 resets the core by driving it to negative saturation. During reset, the induced voltage in the output winding is such that the diode is cut off and no power is delivered to the load. Transistor Q_2 may be a low-power unit. It need only supply the core saturation current and any current required by the diode's finite back resistance.

Figure 3 shows the circuit for a single transistor converter.[3] Here, resetting action is caused by the capacitor. Again, the diode isolates the load during the reset interval and power is delivered to the load only when the transistor conducts. Value of the capacitor is chosen experimently to provide a waveform with any degree of symmetry.

It has been assumed that the circuits under discussion are self-starting. At room temperature, germanium transistors usually have sufficient leakage current to start oscillation. This is not always true, however, and auxiliary starting circuits may be required.

Table I—Wire Selection and Required Winding Area

Coil	Turns	RMS Current	Wire Size (Awg)	Coil Area (sq in.)
L_1	210	423	22	0.17
L_2	210	423	22	0.17
L_3	6	15	38	0.000156
L_4	6	15	38	0.000156
L_5	460	600	22	0.355
Winding area required = 0.6953 sq. in.				

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(2) D. A. Paynter, An Unsymmetrical Square-Wave Power Oscillator, *IRE Trans.* CT-3, p 64, Mar. 1956.

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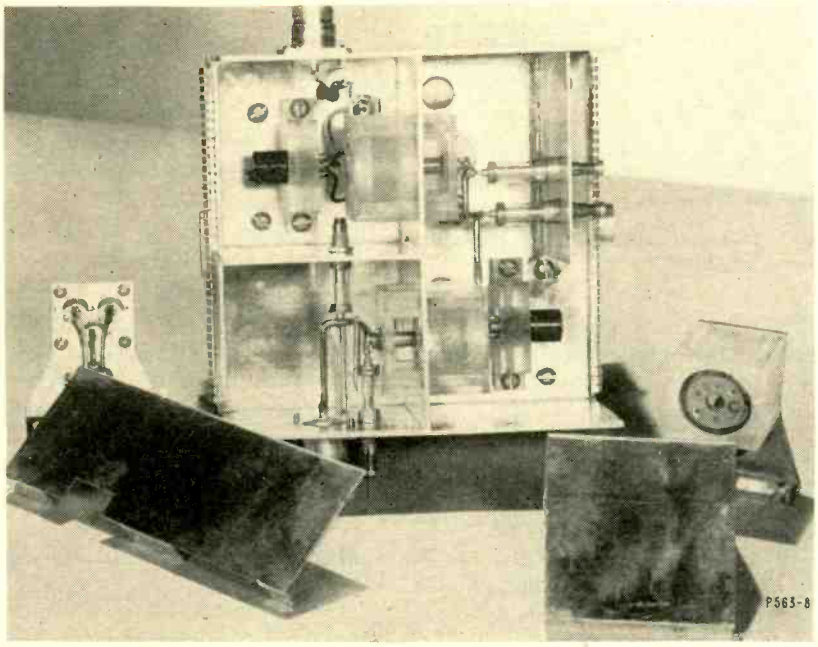
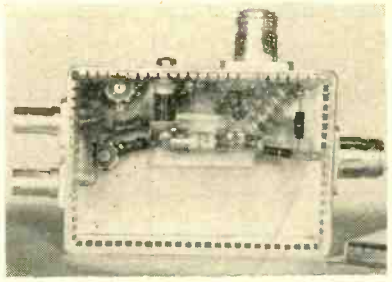


Broad-band amplifier developed for the 400- to 450-mc band



Mixer is constructed as a separate unit to simplify alignment and trouble shooting in the field

Broad-Band Amplifier for Radar and Scatter

Low-noise two-stage broad-band amplifier and mixer covers 400 to 450 mc and can be designed for 200 to 300 mc or 700 to 800 mc. Amplifier uses tubes in cascaded grounded-grid circuit. Overall power gain is 29 db with noise figures ranging from 3.6 to 4.5 db at band center and 4.5 to 5.5 db at edges

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DESIGN OF UHF amplifiers and mixers can become critical owing to the circuit tolerances involved. To produce circuits that are inherently low in noise adds even more of a design burden. The two-stage broad-band amplifier and mixer design described here shows one way to design low-noise uhf circuits using the 6280 electron tube.

Circuit construction is a mixture of lumped and distributed elements. In preferred form, the interstage and output coupling networks are double-tuned circuits that give good flat-top response. Where a single-tuned band-pass characteristic is acceptable, simpler single-tuned circuits may be used.

Overall power gain is 29 db. With one group of 16 tubes, noise figures ranging from 3.6 db to 4.5 db were obtained at band center and from 4.5 to 5.5 db at band edges. In obtaining these data, the input circuit was retuned for each tube. Without individual tuning, the noise figure might be degraded as much as 0.5 db.

Input noise of an n-stage amplifier is expressed by the equation

$$F = F_1 + \frac{F_2 - 1}{W_1} + \cdots + \frac{F_n - 1}{W_{n-1}},$$

where F is the overall noise figure, F_n is the nth stage noise figure, and W_n is the gain of the first n stages.

With two 6280 stages, at least 27 db of gain may be realized with a 50-mc bandwidth, and consequently the overall noise figure depends little on the mixer noise figure. It is desirable to pad the mixer with from 3 to 10 db, to make sure that the amplifier output looks into a

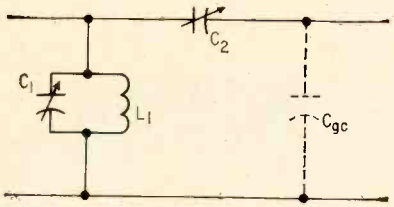

FIG. 1—Input network used to determine optimum source impedance

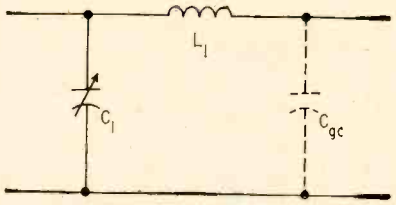

FIG. 2—Input network used in broad-band amplifier

load flat with respect to frequency. This prevents degradation of the overall band-pass characteristic of the receiver because of improper mixer impedance at any point in the passband.

The design of the input network is crucial in any low-noise uhf amplifier. A minimum noise figure is obtained only when the source impedance is optimum and this optimum source impedance must be preserved throughout the entire band.

Optimum Source

If the circuit losses and the tube cold losses are assumed to be zero, the optimum source admittance is[1]

$$G_{e\ \text{optimum}} = \sqrt{\frac{\beta G_e}{R_{eq}}}$$

where β is a constant depending on the cathode material and construction, R_{eq} is the equivalent noise resistance of the tube, and G_e is the transit-time conductance loading.

The noise figure (ratio) obtained using this optimum value of the source conductance is[1]

$$F_{\text{optimum}} = 1 + 2\sqrt{\beta G_e R_{eq}}$$

The factor β is generally taken equal to 5 for oxide-coated cathodes[2]. Quantity G_e may be calculated from the following equation, derived for plane-parallel geometry[3]:

$$\frac{G_e}{G_m} = \frac{45 \times 10^6 (a/\lambda)^2}{V_1}\left[1 + \frac{3.3b/a}{1+(V_a/V_1)}\right]$$

where λ is the wavelength, G_m is the transconductance, V_1 equals $5.69 \times 10^3\ a^{4/3}\ J_c^{2/3}$, a is the grid-to-cathode spacing, b is the grid-to-anode spacing, V_a is the cathode voltage, and J_c is the cathode current density. Quantity G_e for the 6280 tube is calculated to be 0.915×10^{-3} mho. Using this value at 425 mc, 0.01 mho is obtained for $G_{s\ \text{optimum}}$ and 3 db for F_{optimum}.

Verification

The correctness of this approach is verified by simple tests. A narrow-band amplifier was constructed using the input circuit of Fig. 1, which was designed to transform a source impedance of 50 ohms up to the calculated 100 ohms. With this arrangement, the noise figure was in excess of the calculated figure. The network transformation ratio was then varied systematically until the minimum noise figure was obtained which occurred with a transformed source impedance of 67 ohms. The noise figure was then measured as 4 db.

This noise figure is in reasonable agreement with the calculation, since circuit losses and tube cold losses are not zero, as assumed, and the value of 5 taken for β is merely an approximation. With selected tubes, noise figures as low as 3.6 db have been observed.

The input circuit of Fig. 2 was used for the broad-band amplifiers. The Q of this network is low and impedance transfer is fairly constant across the band. Capacitor C_1 is tuned to accommodate various values of G_e. The physical construction is shown in Fig. 3A.

Interstage and Output Networks

The interstage and output networks may be regarded as double-tuned band-pass circuits. The physical form of these networks approximates a pair of coupled transmission lines. Amplifier construction, arrived at largely by an empirical process, is shown in Figs. 3B, 3C and 4.

The interstage is capacitively coupled and the output network is inductively coupled. In both cases the load is heavily coupled to the plate of the 6280 tube to achieve the required 50-mc bandwidth. As a consequence, the output impedance of the amplifier represents a mismatch of about three or four to one with respect to the 50-ohm mixer load. This property must be kept in mind when designing the mixer.

The amplifier has a center gain of 29 db and a bandwidth somewhat greater than 50 mc between

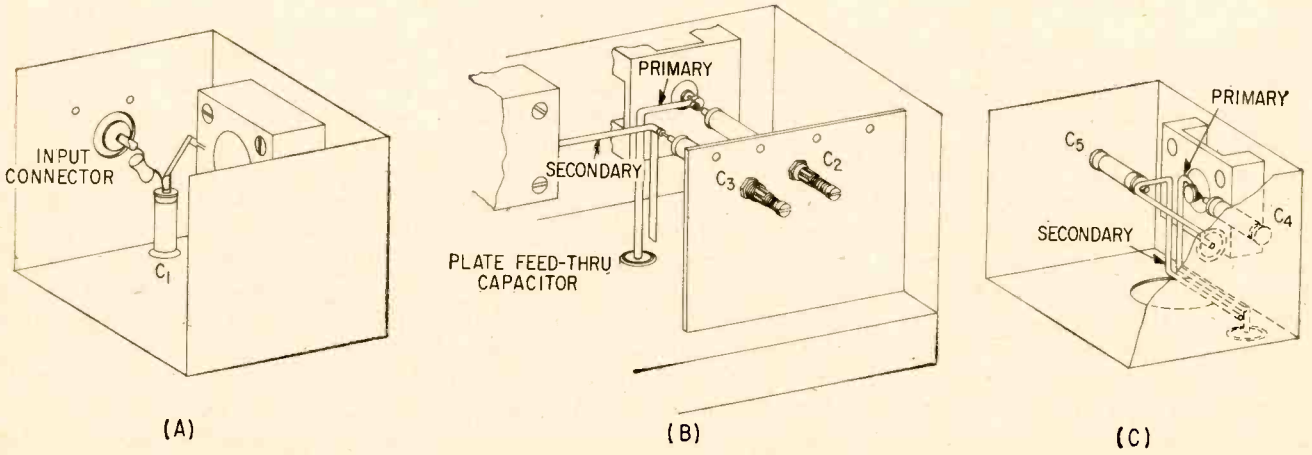

FIG. 3—Physical construction of input (A), interstage coupling (B) and output network (C)

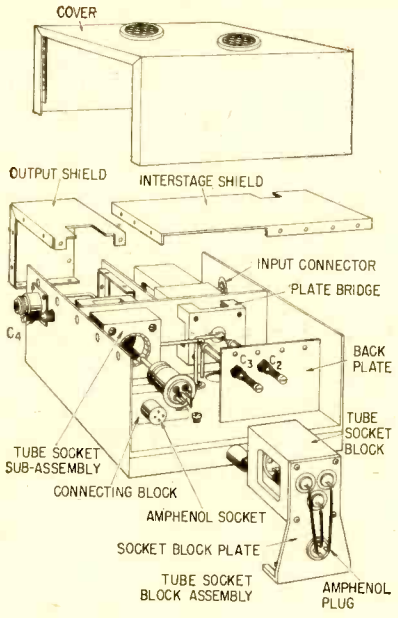

FIG. 4—Exploded view of broad-band amplifier derived empirically

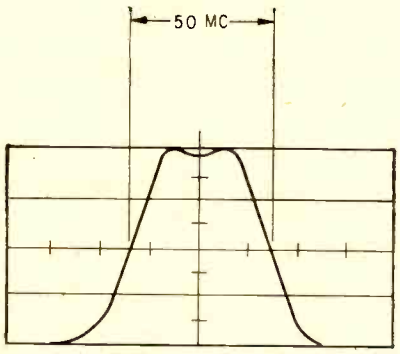

FIG. 5—Response curve of broad-band amplifier shows slight overcoupling

the 3-db points. A typical plot of the gain-bandwidth characteristic is shown in Fig. 5. In Fig. 6, the noise figure is plotted as a function of frequency. This characteristic was measured with a low-noise receiver following the amplifier. With a gain of 29 db, the noise figure of the mixer that follows the amplifier is not critical.

Figures 7 and 8 show this type of amplifier construction schematically.

Mixer Circuit

To simplify both alignment and trouble shooting, the mixer was constructed as a separate unit with a nominal 50-ohm input and operated at 1-ma crystal current. Mixers have been designed to work with both 60-mc and 104-mc intermediate-frequency amplifiers.

The mixer circuit for a 60-mc i-f amplifier, given in Fig. 9, uses either a 1N21E or 1N25 crystal. The local-oscillator is terminated and is loosely coupled to the crystal by a resistive L-pad. The signal input is tapped on the inductance at a point selected to give an approximate match.

A resistive pad, not shown, is used in front of the mixer. This pad maintains a constant load impedance and avoids irregularities in the band-pass characteristic which might otherwise arise because of interactions between the mismatched output impedance of the amplifier circuit and the mixer.

Using a 1N21E crystal, as much as 10 db padding will not seriously affect the overall receiver noise figure. If there is no rejection of image noise, a 9-db noise figure is obtained. The overall noise figure is deteriorated by about 0.2 db, with 10 db padding, but this results in a smooth passband and provides additional crystal protection.

Noise Figure Life

Best noise-figure life is obtained with 6280 tubes if no cathode current is drawn during the warmup process. Accordingly the power supply is designed such that the tube is initially cut off. Bias is removed after the heater power has been applied for about one minute. When the power is turned off, cut-off bias is applied again until the tube has cooled, and then both the bias and the plate voltage are removed.

Because of the uncertainty of diode noise sources, a gas discharge device is used to make noise measurements in this frequency range[1]. The noise generated in an argon discharge is coupled to the output by a matched helical winding. These noise generators are calibrated by comparing their outputs against a calibrated hot source. Accuracy to measurements is estimated to be 0.2 db.

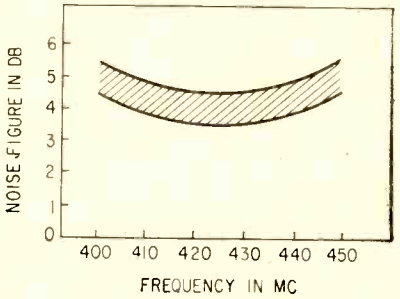

FIG. 6—Amplifier noise figure plotted against frequency

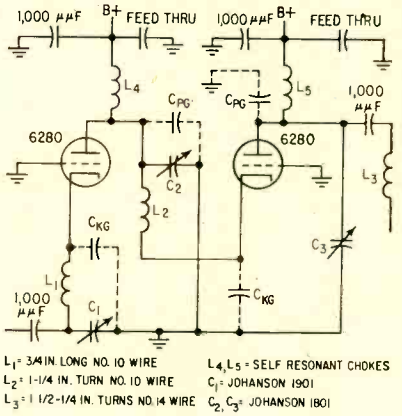

FIG. 7—Single-tuned low-noise amplifier schematic

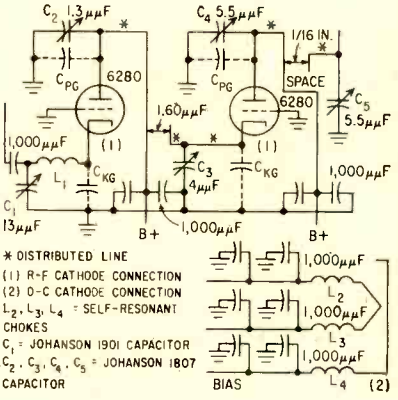

FIG. 8—Double-tuned low-noise amplifier schematic

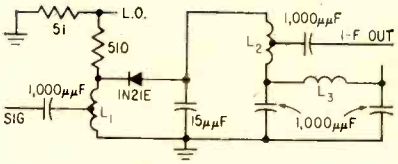

FIG. 9—Mixer circuit for a 60-mc i-f amplifier used in many radars

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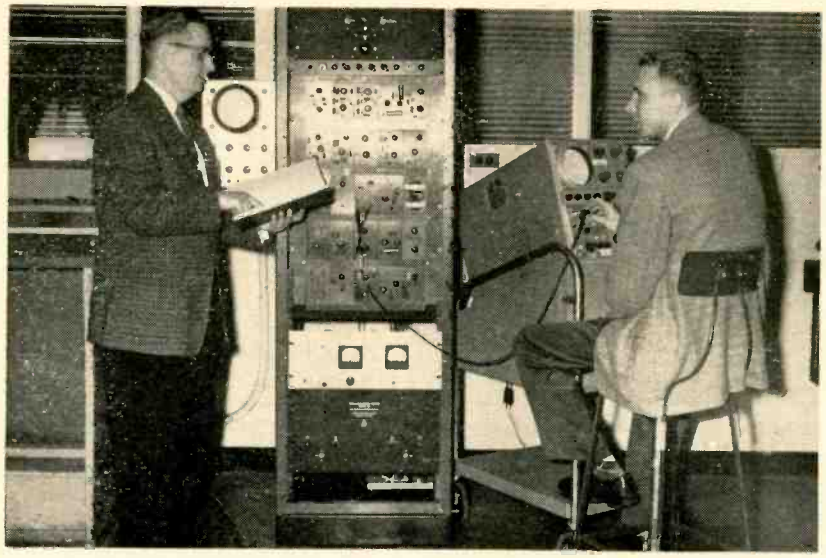
(1) G. E. Valley Jr. and H. Wallman, "Vacuum Tube Amplifiers," *Rad Lab Ser*, **18**, p 640, McGraw-Hill Book Co., Inc., N. Y., 1948.

(2) Ibid., p 625.

(3) L. J. Giacoletto and H. Johnson, *Proc IRE*, **41**, p 51, 1953.

(4) E. Maxwell and B. J. Leon, Absolute Measurement of Receiver Noise Figures at UHF, *IRE Trans.*, **MTT-4**, No. 2, Apr., 1956.



Entire bandwidth-saving system is rack-mounted as shown

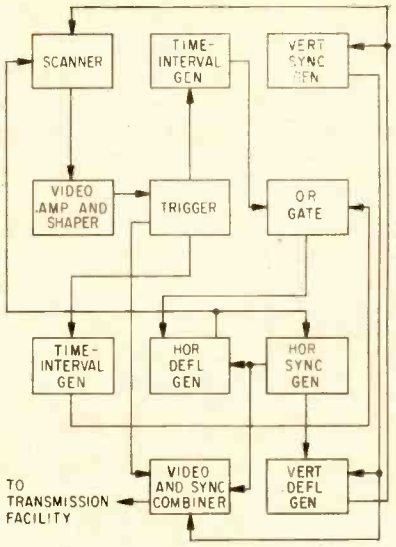


FIG. 1—Major circuits of the transmitter

Stop-Go Scanning Saves

MOST INFORMATION SOURCES occupy more bandwidth than is represented by their true information rate or average number of bits of information produced each second. According to the Shannon-Hartley Law[1], the information capacity of a channel is fixed if bandwidth and signal-to-noise ratio do not vary with time. A coding system can make it possible for the output of a source to represent a more uniform rate of information flow and use the fixed information capacity of the channel more fully.

In the case of image transmission, storage already exists in the space domain and useful statistical coding can be carried out by nonuniform scanning velocity. In the type of application in which the time consumed in transmitting an image is not restricted except that for any given image it is a minimum, a nonuniform scanning technique is applicable.

In the system to be described, a nonuniform scanning system suitable for facsimile-type transmission is used where frame rate need not be constant. Only black and white brightness levels are considered. Line-raster scanning is used.

Picture areas of uniform black or white contain no information except that represented by the locations of their boundaries. For this reason, it is permissible to scan rapidly in uniform areas and slowly in the vicinity of transitions. In a stop-go system, the slow speed is zero; that is, the scanning is halted at transitions. The fast rate is chosen on the basis of available signal-to-noise ratio since system vulnerability to noise is a function of this speed. In the system described, velocity chosen was about 10 times greater than that which the particular channel could have handled with conventional scanning.

System Operation

System operation is as follows: A scanning spot travels at its fast uniform rate until a boundary is en-

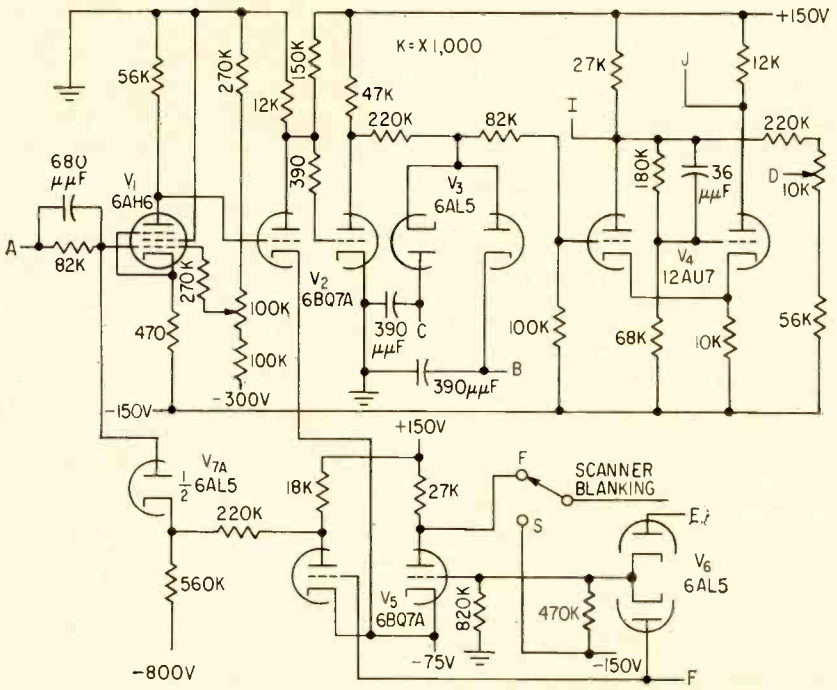


FIG. 2—Detailed schematic of the transmitter video generator

For facsimile-type transmission, where graduations between black and white are not vital, spectrum utilization can be increased by use of stop-go scanning. Scanning is halted at transitions from black to white and white to black. Scanning velocity for nontransition portions is determined by available signal-to-noise ratio of the transmission channel

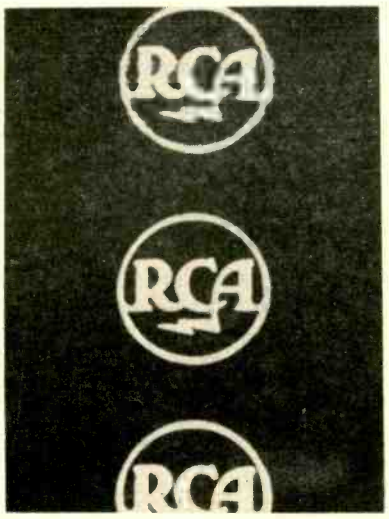
By HAROLD E. HAYNES,
Development Engineer, Industrial Electronic Products,

and DONALD T. HOGER,
Development Engineer, Defense Electronic Products, Radio Corp. of America, Camden, N. J.

Spectrum Space

countered. It then stops within a distance which is a small fraction of its own diameter. The spot remains stopped for a precisely controlled time interval. The interval is such that the response of the channel to a step function will reach substantially steady-state within the interval. The exact relationship depends on the cutoff characteristic of the channel. With the simulated channel used, a single T-section low-pass filter, a value of $0.8/f_c$ for the stop interval was found suitable where f_c is the three-db point. At the end of the interval, the spot just as abruptly resumes its fixed scanning speed and proceeds to the next transition. The process is repeated.

Basic waveform transmitted is a series of step functions of alternating directions, each associated with the beginning of a stop interval. At the receiver, the stop interval is initiated by the received signal. It is terminated by a timing circuit in the receiver precisely adjusted to duplicate the stop interval of the transmitter. With this system, terminations of the stop intervals are not transmitted. This leaves a minimum time spacing of transmitted steps. The spacing is always greater than the stop interval itself, regardless of the closeness of transitions to each other in the image. The channel is never called upon to handle information faster than its capabilities.



Effect of random noise upon transmission of a simple image. From top to bottom, two signal-to-noise ratios of 10 db and 20 db are depicted as well as essentially noise-free operation

Medallion as it appears when the kinescope beam is modulated with type of signal shown in Fig 3D (top). At bottom, medallion appears as shown when intensity modulation is disconnected

Transmitter

Figure 1 shows the transmitter deflection and video generator circuit arrangement. The scanner could have been any type that lent itself to having the scanning process halted whenever a transition in the scanned material is encountered. Actually, a simple flying-spot scanner for transparencies was employed. Electrostatic deflection was used in the scanner as well as the monitor. In later work, magnetic deflection was used successfully.

The signal derived from the scanner appears at point *A*, Fig. 2. It is amplified and shaped to operate a trigger circuit, V_4, which reconstructs the video signal into two waveforms which are pulse trains of opposite polarities (points *I* and *J*). The trigger output also acti-

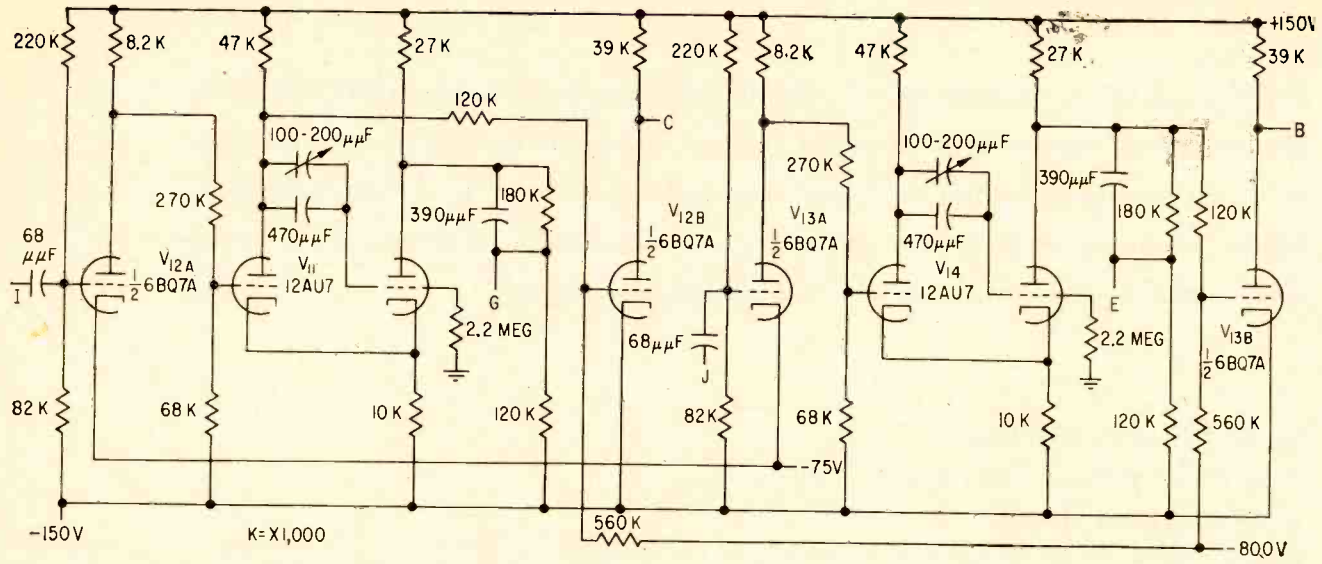


FIG. 3—Time-interval-generator circuits for the transmitter

vates the identical one-shot multivibrator time-interval generators of Fig. 3, which function at alternate transitions to stop the horizontal deflection. Length of the time interval is specified by the characteristics of the transmission channel as explained previously.

Noise and spurious signals in the video waveform that rise above the trigger threshold would be capable of activating the transmitter scanning circuits. This action would create pulses too narrow to be transmitted and would cause the receiver to lose synchronism with the transmitter until the next horizontal sync pulse occurred. For this reason, it is necessary to insure that once trigger V_4 (Fig. 2) goes from one stable to the other it does not return until a pulse of minimum transmittable duration has been generated.

Timing generators supply signals through diode V_3 in Fig. 2 that activate clamp circuits which produce synthetic inputs to the trigger. In effect, this mechanism is a regenerative circuit. It operates rapidly as soon as the trigger changes state and continues to supply a constant trigger input so that input is maintained for the minimum duration.

To prevent signals generated during flyback from operating the timing circuits, the scanning beam is switched off by V_5, Fig. 2, during this interval. The beam is blanked also during all stop intervals to avoid burning of the phosphor. The input signal to the video circuits is clamped to black artificially through diode V_{7A} (Fig. 2) so that noise and spurious signals generated during retrace cannot operate the timing generators.

Horizontal deflection is produced by a sawtooth generator consisting of a simple R-C circuit—R_1, R_2, and C_1 in Fig. 4. The gate made up of V_{19} and V_{21A} interrupts the generator whenever a transition is encountered. When the sawtooth voltage reaches a predetermined value, representing the end of a scanning line, it is returned rapidly to its zero value. Amplitude is sensed by V_{22} which also generates a pulse at point F to produce horizontal fly-

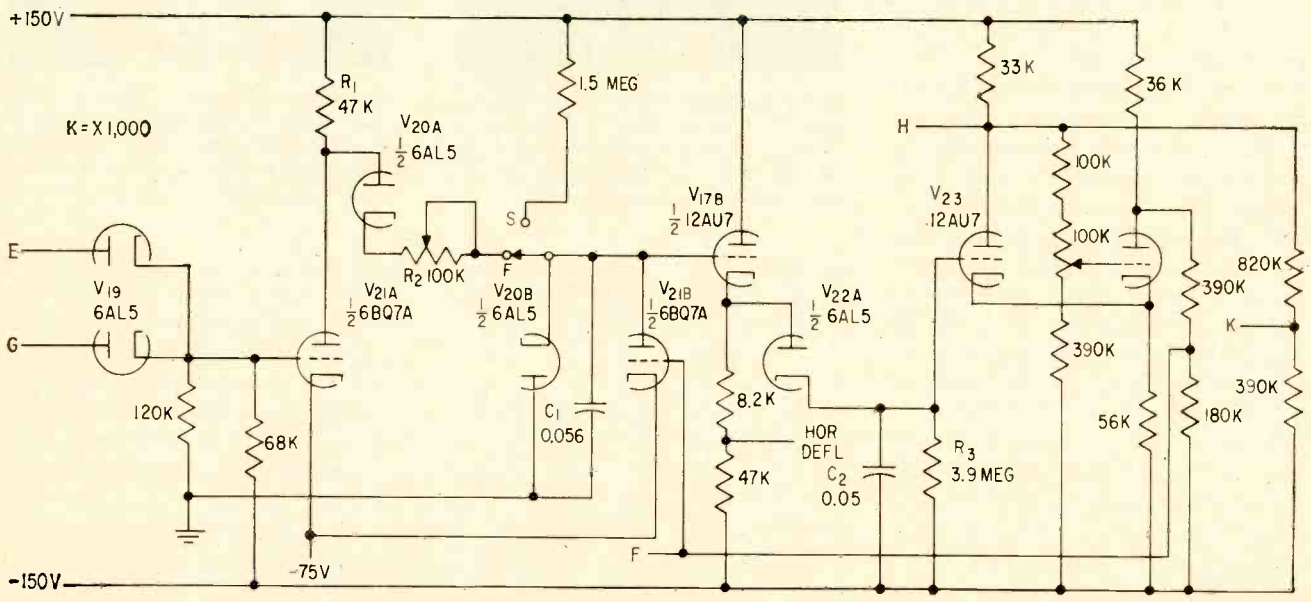


FIG. 4—Horizontal deflection and sync circuits of the transmitter

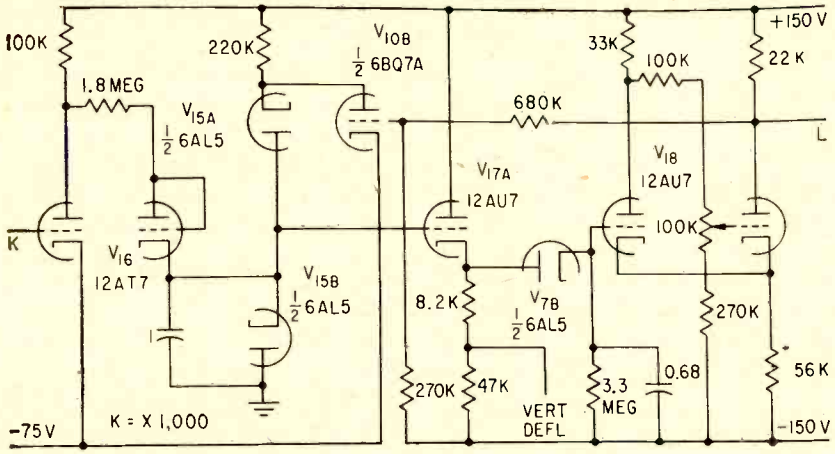


FIG. 5—Vertical deflection and sync circuits for the transmitter

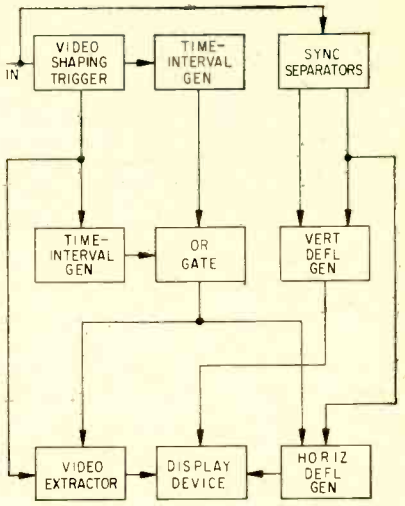


FIG. 6—Deflection and video-generator circuits of the receiver

back and synchronizing information for the receiver.

Operation of the circuit consisting of V_{23}, V_{22A} and associated components in Fig. 4 is as follows. Schmitt trigger circuit V_{23} is designed to trigger when the input signal reaches a fixed potential. It does not return to its original state until a fixed duration after the input signal has been removed.

Capacitor C_2 is charged from a low-impedance source through V_{22A}. When the charge reaches a fixed value, V_{23} triggers and the potential at the plate of V_{22A} is removed by application of the trigger signal through V_{21B} and V_{17B}. Capacitor C_2 is left to discharge slowly through R_3. When the potential across C_2 reaches the triggering level of V_{23}, the trigger circuit returns to its original state of conduction.

Pulses at K, Fig. 4, serve to operate the stairstep generator for vertical deflection, Fig. 5. Since horizontal scanning time is a function of the number of transitions contained in a line, it is not necessarily constant. The vertical syn-

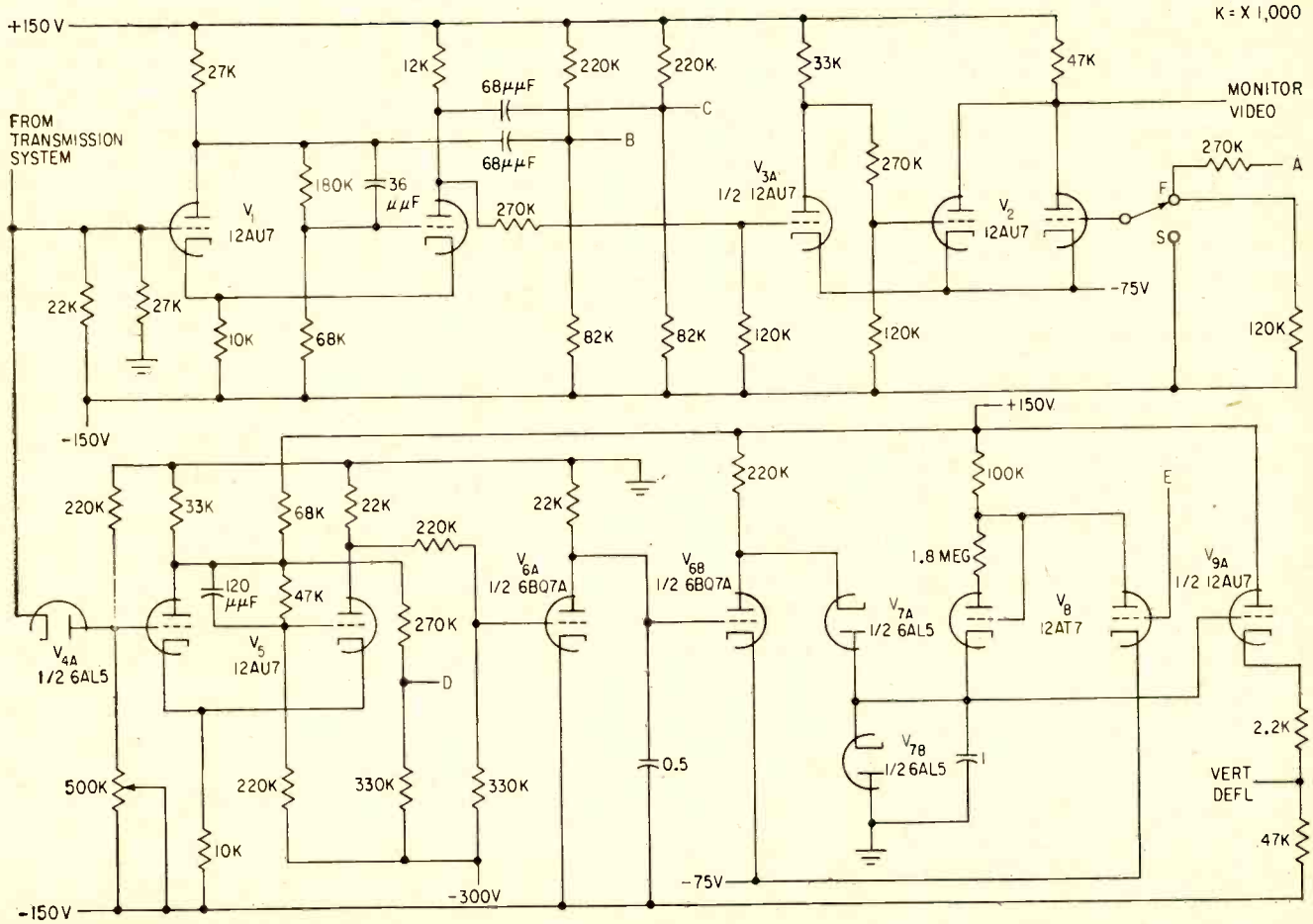
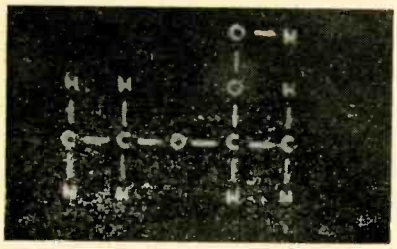


FIG. 7—Video, sync-separator, vertical-deflection and sync circuits for the receiver



Sample of reproduced copy as shown on display screen

chronizing generator, Fig. 5, operates in the same manner as the horizontal sync generator.

Horizontal and vertical sync pulses are added to the video and timing information to form a composite waveform. The signal can then be sent over the transmission channel if d-c transmission is available or used to modulate a carrier if it is not.

Receiver

In Fig. 6, the received video signal is sent into a Schmitt trigger circuit to reshape the band-limited signal. This circuit also limits the effects of noise so that positive operation of the timing generator may be accomplished.

Negative sync signals are coupled through diode V_{4A} of Fig. 7 to the Schmitt trigger, V_3. This circuit ignores the positive video signals and reshapes the horizontal and vertical sync pulses for use in the receiver. Vertical sync pulses, which are more than 10 times the duration of the horizontal sync pulses, are separated by filtering at the plate of V_{6A}.

Operation of the receiver horizontal deflection system is identical to that of the transmitter except that termination of scan at the receiver is determined by the sync pulses sent out by the transmitter. Horizontal sync pulses serve also to operate the vertical stairstep generator. Vertical sync is derived from the received waveform.

Output of the trigger contains timing as well as video information. To intensity-modulate the display device, video must be extracted from the signal. This action is accomplished by subtracting the output of the time-interval generators from the composite waveform with the Rossi gate V_{3A} and V_2 of Fig. 7. A signal at the input of V_{3A}, indicating white, keeps V_{3A} cut off and holds V_{2A} in conduction. Negative voltage appearing at the plates of V_2 is sufficient to cut off the display device. When the signal at V_{3A} indicates black, the plates at V_2 will rise to turn on the monitor video (provided no signal indicating that deflection is halted appears at point A). If a signal appears at point A, then conduction of V_{2A} will keep the common plates of V_2 at a low potential to keep the video signal cut off.

Accuracy

Accuracy with which an image may be reproduced by the system depends upon several factors. If the system transmits the fundamental components of the signal

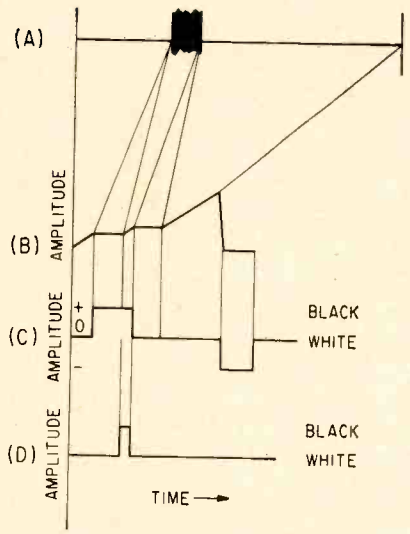


FIG. 8—Some important waveforms in system are shown here

undistorted and has a suitable signal-to-noise ratio, reproduction depends upon the combined resolution of the pickup and display devices and the electrical circuits in the transmitter and receiver.

The most critical circuits are the time-interval generators. If the transmitter and receiver stop times are not identical, there will be an error in placement for each transition of the receiver. Magnitude of this error is a function both of the error in timing and the velocity of scanning. Errors for a given line are cumulative for that line but are erased when the horizontal sync pulse is received. In practice, it was found desirable to use two timing operations at the transmitter and two at the receiver. This resulted from the particular circuits used. It stemmed from the fact that the circuits did not have sufficiently fast recovery time to generate the time intervals for two closely spaced transitions. Actually, from the standpoint of maintaining identical time intervals at both transmitter and receiver, it would be preferable to use only one generator in each place.

Figure 8B shows a typical horizontal scanning line deflection waveform for the single black bar on a white background shown in Fig. 8A. Sloping portions of the waveform represent the times when the scanner is scanning rapidly while seeking a transition. Flat sections correspond to the stop intervals at the transitions.

The waveform of Fig. 8C depicts the type of signal that is derived from the trigger circuits for transmission. The first positive step indicates that a transition from white to black has been sensed. Length of the pulse is equal to the stop time plus the time required to scan to the next transition. Zero level indicates that the scanner is looking at white areas in the copy. The negative pulse is the horizontal sync pulse indicating the end of the scanning line.

After the sync has been separated from the video waveform, the stop interval must be subtracted from the signal to give the waveform of Fig. 8D. This waveform is used to key the writing operation of the display device.

Results

In operation with a simulated narrow-band transmission channel (values of 1 to 3 kc were used), the system has demonstrated time reductions approaching 10 to 1 for simple images. This figure decreases to about three to one for highly detailed images such as printed matter or a moderately complex map. The time ratio cannot exceed the ratio of the fast scan speed to that constant scan speed which would be suitable for the bandwidth involved.

REFERENCE

(1) C. E. Shannon, A Mathematical Theory of Communication, *BSTJ*, July and Aug. 1948.

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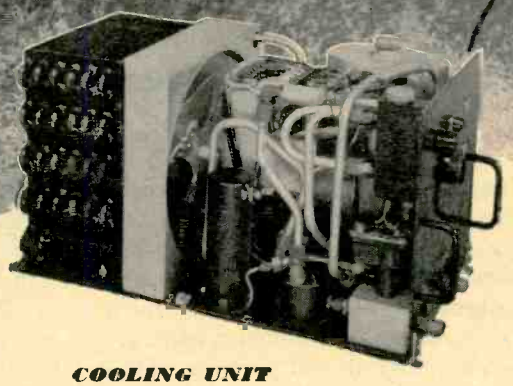

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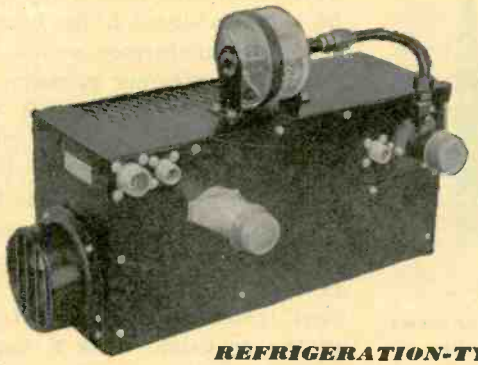

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Night Vision Unit Uses Starlight

TROOPS may be able to see military objectives at night with a new type light intensifier. Extension of the range and sensitivity of astronomical telescopes, low radiation level X-rays and viewing minute light flashes emitted by nuclear particles are other expected uses.

Called a cascaded photosensitive image intensifier, the device was developed by the U. S. Army Engineer Research and Development Laboratories and RCA.

The new development differs from other night vision devices. No artificial sources of radiation such as radar or infrared are required. It is also said to be much less complex than low-level light intensifier tv systems.

This unit gathers reflected starlight and diffused light from skyglow falling on the objective. The intensity of light furnished by the stars is so low that it is of limited value to the unaided eye in seeing military objectives at night. With the new intensifier, however, it will be possible to see objects at greatly increased ranges.

Heart of the instrument is a cascaded image tube—actually two tubes. They operate through an optical system that focuses the light reflected from objects in the field. The first tube acts as a preamplifier. The second tube further amplifies the light and presents the image on a viewing surface.

The image tube operates at approximately 25,000 volts. A six-volt battery is the primary power source with transformers and transistors used to step it up.

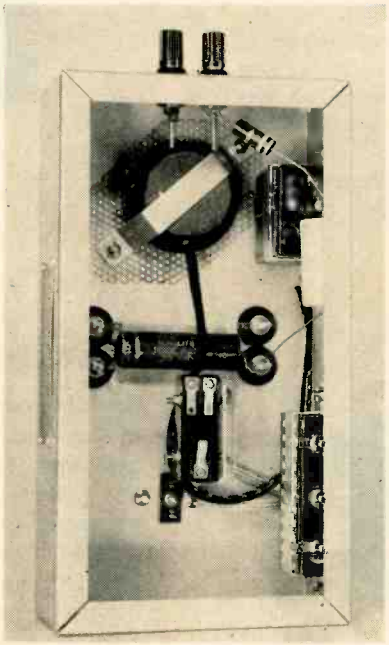
Transistor Tester Predicts Failures

By J. M. TEWKSBURY Bendix Aviation Corp., Baltimore, Md.

TRANSISTOR failure can be expensive, time-consuming and irritating. Greater knowledge of transistor characteristics enables the designer to select a transistor for a particular application with more assurance that it will perform satisfactorily.

A tester is described that provides audible and visual indications of variations in characteristics of transistors of the same type. Prior knowledge of the circuit in which the transistor will be used coupled with information gained from the tester enable the designer to predict very closely the voltage at which a given transistor will be subject to failure.

In typical transistor circuits, the collector-base junction is reverse biased. The mobile carriers are swept away from the collector-base junction, forming a depletion region. The ionized impurity atoms left behind are locked in the crystal lattice and are therefore immovable. As collector voltage is increased, the depletion region extends in the direction of the emitter-base junction. When it reaches the junction, punch-through occurs.



Bottom view of breakdown tester shows how earphone is used as speaker

A plot of collector current versus collector-emitter voltage for a typical transistor is shown in Fig. 1. These curves show that circuits with low resistance between base and emitter have a negative-resistance characteristic that becomes evident near the initial breakdown point. This characteristic varies in magnitude among transistors, and some transistors do not have it under any circumstances. Lack of the negative-resistance effect can usually be attributed to the geometry of the particular transistor.

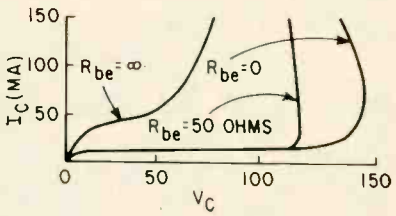


FIG. 1—Collector current versus collector-emitter voltage show negative-resistance characteristic when resistance between base and emitter is low

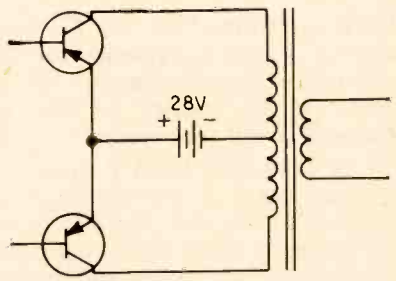


FIG. 2—Negative-resistance characteristics in transistors used in audio output stage can cause oscillations that can destroy the transistors

A class B power output stage is shown in Fig. 2. Assuming a power supply potential of 28 volts, collector-emitter potential approaches 56 volts on signal peaks because of the autotransformer action in the output transformer primary.

If this voltage exceeds punch-through, large reverse currents flow, impairing efficiency. Current flow after punch-through is limited by the resistance of the associated circuitry, and in many circuits there is enough built-in resistance to prevent transistor damage. However, if the transistor has a negative-resistance characteristic, oscillation will result, and the attendant high currents will destroy the transistor.

Transistors without a negative-resistance characteristic should therefore be selected for operation

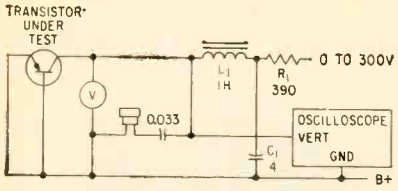


FIG. 3—Oscillations are heard from earphone when collector voltage is increased to breakdown point if transistor has negative-resistance characteristic

at voltages close to punch-through. A transistor breakdown tester for selecting such transistors is shown in Fig. 3.

Collector voltage of the transistor under test is increased slowly until the point of breakdown is reached. If the transistor has a negative-resistance characteristic, an oscillation will be heard in the earphones. An oscilloscope connected to the collector permits analysis of the type audio voltage present.

Inductor L_1 limits current flow out of capacitor C_1 into the collector circuit after breakdown. However, L_1 and C_1 also constitute a tuned circuit that is resonant at an audible frequency. Transistors with a pronounced negative-resistance characteristic break into an interrupted sine-wave oscillation. The frequency of interruption is a function of the R_1-C_1 time constant. Transistors not highly active but with a negative-resistance characteristic produce a triangular wave with a frequency dependent on the degree of activity.

Transistors that do not oscillate produce breakdown noise that is random in nature and of relatively low intensity. It can be heard in the earphone and is readily identified on an oscilloscope.

A voltmeter connected between collector and ground indicates punch-through voltage directly. Voltage during oscillation is an indication of transistor activity and is a direct measure of the negative-resistance characteristic.

Rate-of-Rise Control for Filaments

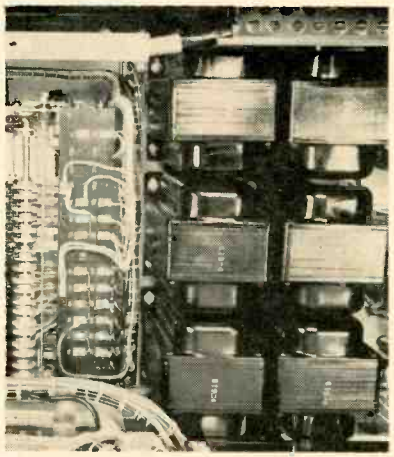
By JOHN T. KEEFE
Sola Electric Co., Div. of Basic Products Corp., Chicago, Ill.

PROTECTION of cold tube filaments against excessive inrush currents during the warm-up period is necessary for maximum tube life and equipment reliability. Ideally, initial filament current and power should be held substantially below rated values.

As the filaments warm and their resistance increases, current and power should be gradually increased to full rating. During warm-up, protection against surges caused by line voltage changes is also desirable.

A simple method will be described for using special-type constant-voltage transformers for both controlled warm-up and regulation against line changes. The basic system is shown in the block diagram in Fig. 1.

Constant-voltage transformers T_1 through T_6 are identical. They are similar to standard constant-voltage transformers except that output is 40 volts a-c. The constant-voltage transformers are connected with the primaries in parallel but with individual switch contacts for each primary. The secondaries are connected in series. Since total output is 240 volts, a standard 240 to 6.3 or 240 to 12.6-volt filament transformer is required to provide the correct filament voltage.



Constant-voltage transformers and stepping switch are installed in computer power supply to increase tube life

All primaries are initially open. Contacts in the motor-driven stepping switch energize the primaries

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The acceleration switching servo valves provide positive control of spool velocity, thereby achieving greater resolution, reliability and response even at extreme temperatures.

Easily installed and removed as a complete, interchangeable unit, acceptance testing of this compact system can be accomplished prior to missile installation. Suggested applications are: missile surface controls, jetavator controls, and vector and nozzle steering controls. Your inquiries are invited.

Specifications

Actuator load (range)	*90 to 150 in. lbs.*
Electrical input (nominal)	*28 volts DC—10 Milliamperes*
Pressure range	*500 to 3000 psi*
Rated flow	*½ to 2 gpm*
Mounting	*Manifold*
External leakage	*None*
Proof Pressure	*4500 psi*
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of each transformer individually starting with T_1. Output is applied to the filament transformer. However, the secondary of T_1 is also in series with the secondaries of the remaining transformers.

Since the primaries of the other transformers are open, their secondaries act as high reactance chokes. Total impedance is so high that current is limited to approximately 23 percent of full load. The 40-volt output is only 16 percent of rated voltage, and power delivered to the filaments is less than 4 percent of rated filament power.

After equal predetermined time intervals, the stepping switch energizes the remaining transformers individually. With each succeeding step, total output voltage increases 16 percent, series impedance decreases and filament resistance increases. The net result is a progressive increase of filament current and power until all the constant-voltage transformers are energized and full-load current is delivered.

Output voltage at any step is held to one percent against a 15-percent change in line voltage, since the transformers regulate as constant-voltage transformers individually and collectively. The reactance in the circuit controls steady-state current during each step and also prevents current surges during switching of the primaries.

Power is removed from the fila-

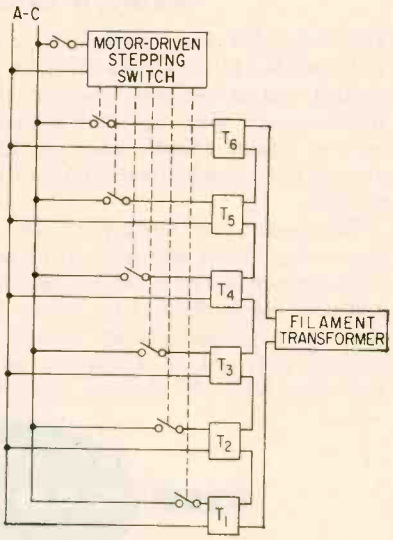

FIG. 1—Stepping switch energizes constant-voltage transformer primaries in sequence. Secondaries of unenergized transformers provide high reactance to limit current in filament transformer

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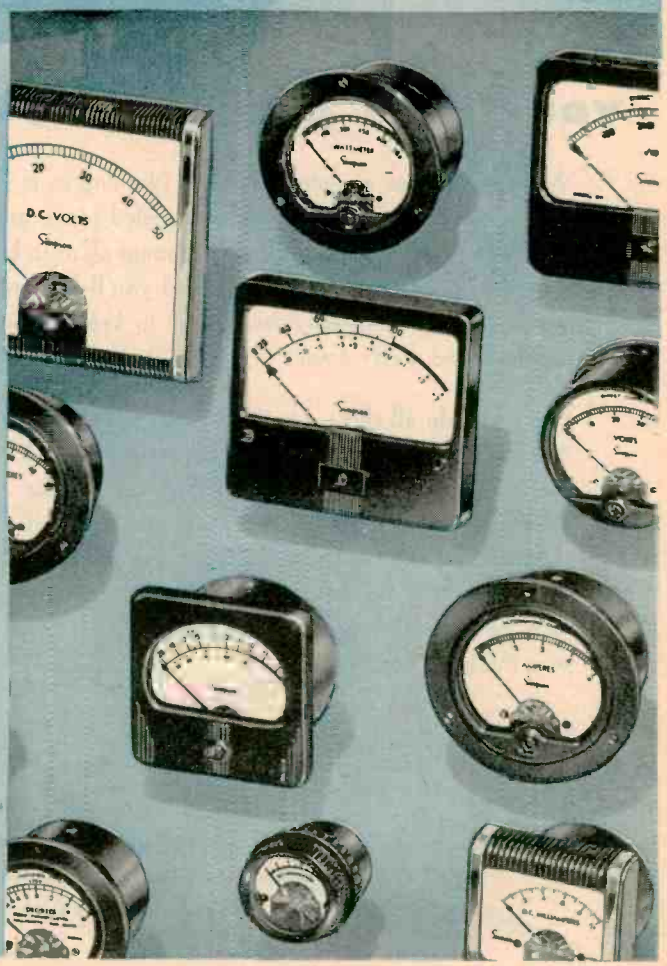


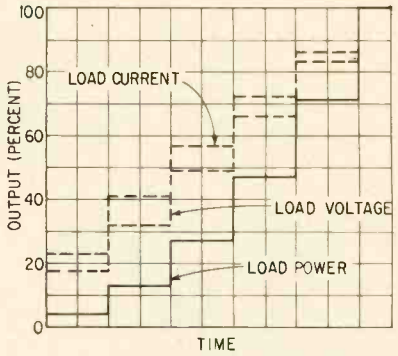


FIG. 2—Plot shows percentage of full current, voltage and power provided to filaments as each of six constant-voltage transformers is switched into circuit

ments in a similar manner.

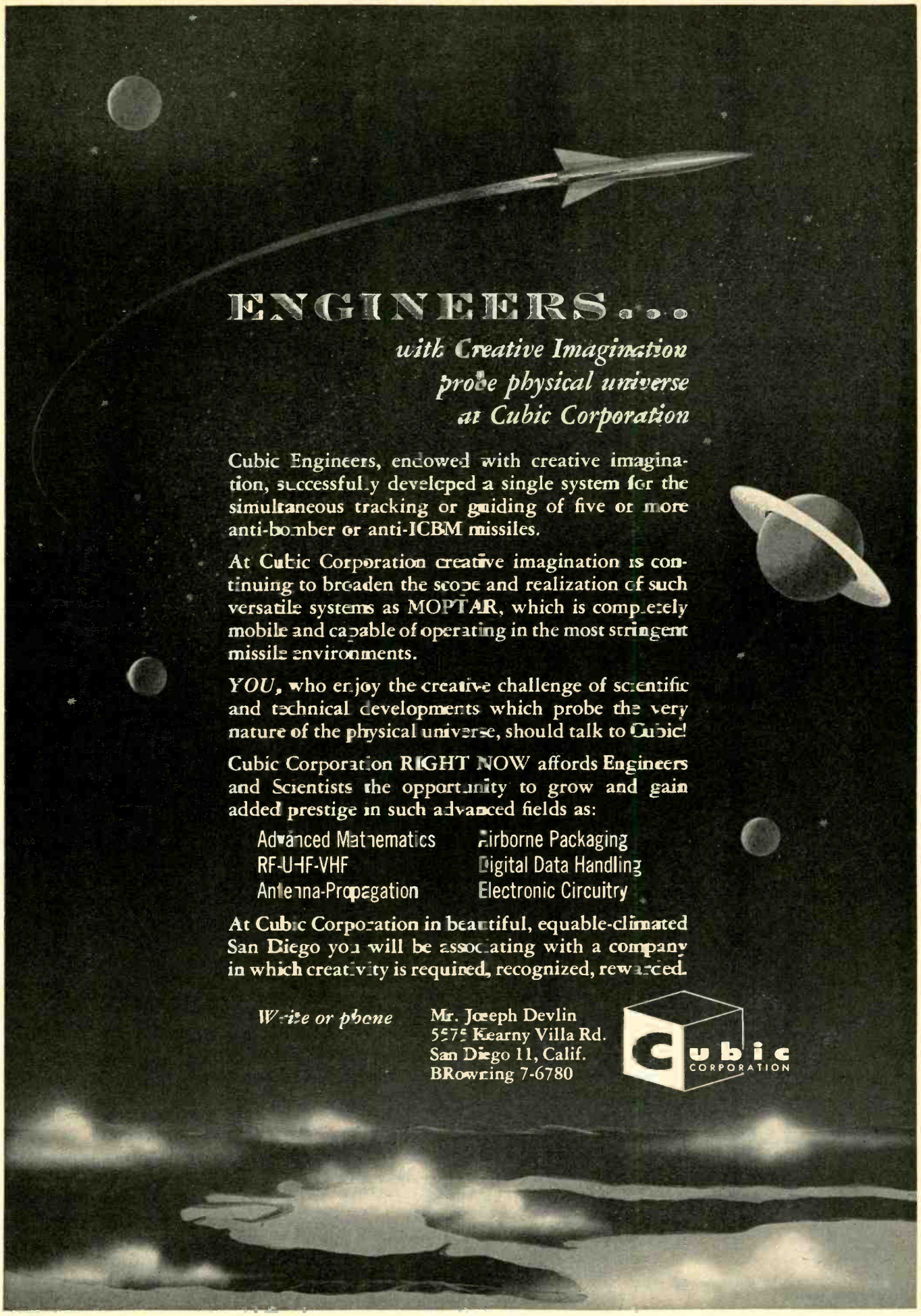
Typical results are shown in Fig. 2. The plot is for a system of six standard 500 v-a constant-voltage transformers. Total load was 2,400 watts, and percentages were computed on this basis.

The number of transformers in a system can be varied to suit requirements. The duration of each step can also be changed easily.

In the installation described, the motorized switch had a spring mechanism to open all constant-voltage transformer primaries in the event of a power failure.

System Gives Pilots Sky Path Display

Sky path on tv screen provides airplane pilots with integrated display of flight-orientation information. Kaiser Aircraft & Electronics has been awarded prime contract for developing system incorporating display by Naval Air Development Center, Johnsville, Pa. Forward, vertical and lateral motion and aircraft attitude are some of the variables used in creating the display.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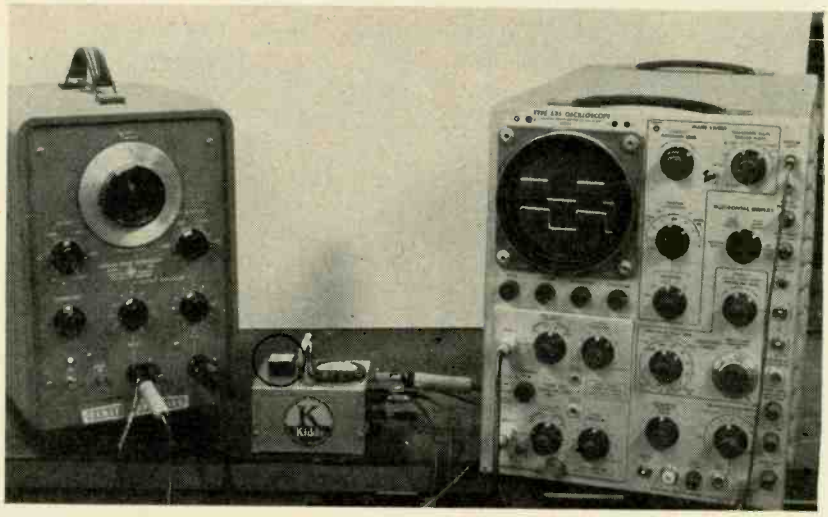
Static Relay Is Actuated in Three Microsec



Test setup with relay (circle) in operation

CONSTRUCTED ENTIRELY of semiconductor and magnetic devices, a new static relay developed by Walter Kidde and Co., Inc., Belleville, N. J., has a life expectancy of 10,000 hours or one billion operations. Actuation time is measured in microsec and the unit is virtually insensitive to shock and vibration.

A schematic diagram of the relay is shown in Fig. 1. Functionally, it consists of an actuating circuit and one or more contact circuits. The actuating circuit is a blocking oscillator normally turned off. When the signal voltage exceeds the Zener diode rating, the base of Q_1 is taken into the conducting region and the blocking oscillator operates.

Output of the high-frequency oscillator is coupled to the contact circuit through a pulse transformer. The circuit rectifies, filters and applies the oscillator output power to the base circuit of the contact transistor. This action keeps transistor Q_2 in a saturated condition as long as the signal voltage is applied. When this voltage is reduced slightly below the Zener voltage (about one volt), oscillation stops abruptly and the contact opens.

The relay requires 24 mw of power to actuate and can switch 600 mw at speeds up to 50 kc. Since no power other than the signal power is required, it can be incorporated in equipment with the same utility as an electromechanical relay.

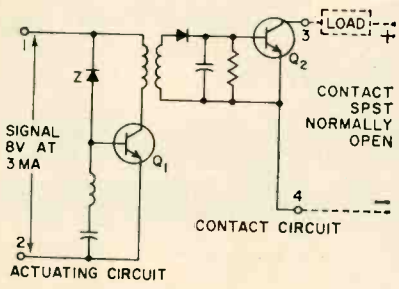


FIG. 1—Schematic diagram of static switching relay

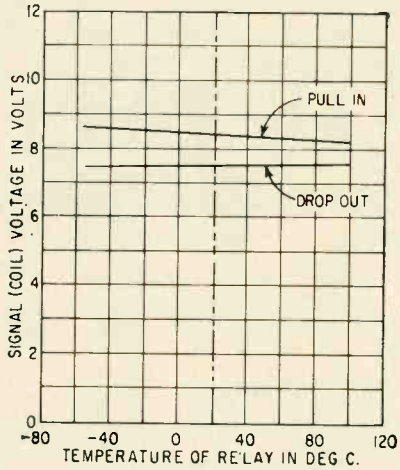


FIG. 2—Nominal performance of relay with change in temperature

When utilized properly, the relay is highly reliable. But it is not always a perfect substitute for a mechanical relay. Inherent characteristics of semiconductor devices differ from coils and metal contacts. Both the control circuit and the actuation circuit are susceptible to burnout with overvoltage and/or overcurrent. Contact ratings given in Table I, together with other pertinent characteristics, are maximum ratings and should not be exceeded. Current in the actuation circuit is determined by the signal voltage and the source impedance.

Although the original model WK-BYN-4XA is a d-c unit, the relay can be modified for a-c loads utilizing a bridge rectifier around the contact. Higher-temperature operation (above 100 C) can be achieved if the specification on contact leakage is relaxed.

Stability of pull-in and drop-out voltages with ambient temperature is evidenced in Fig. 2.

Table I—Relay Specifications

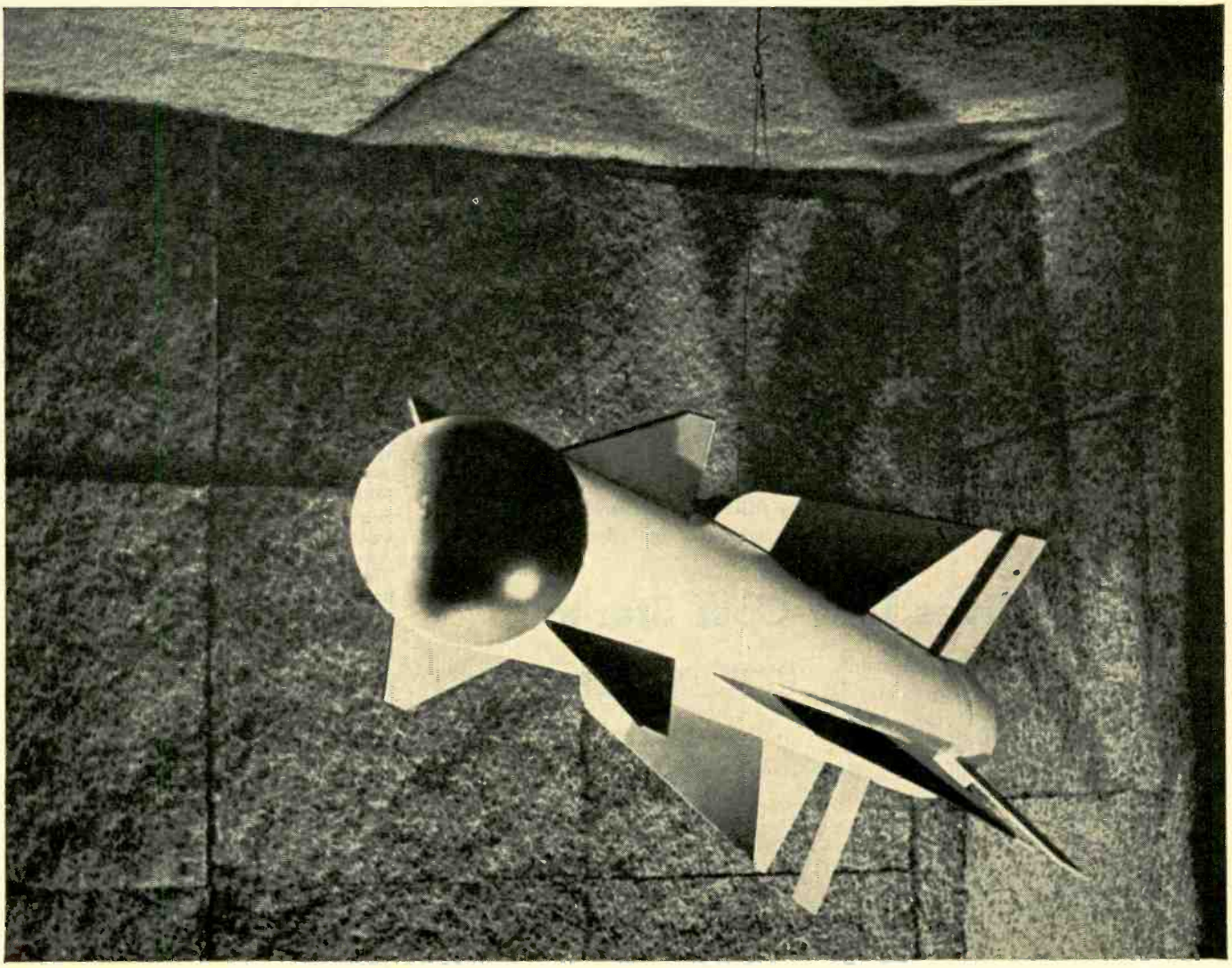
Pickup time	— 3 μsec
Dropout time	— 6 μsec
Contacts	— spst, normally open
Contact rating	— 30 v, 20 ma d-c
Pickup volts	— 8–9 v at 3 ma
Dropout volts	— 6.5 v
Contact resistance	— 150 ohms, closed 10 megohms, open
Shock	— 150 g
Vibration	— 25 g to 2,000 cps
Temperature	— −55 to +100 C
Weight	— 1.1 oz
Epoxy encapsulation	

Artificial Dielectrics for Microwave Lenses

IN MICROWAVE WORK, it is often necessary to change phase velocity of electromagnetic waves by transmission through a medium with a permittivity and/or a permeability different from that of air. Need for a light-weight material with a controllable refractive index led to development of artificial dielectrics. This development was described in a 1958 WESCON paper by Ming-Kuei Hu and David K. Cheng of Syracuse University.

Basic design approach used is random arrangement of identical artificial-dielectric elements with

B.F.Goodrich



New low reflective absorbents makes free space tests more reliable

Ten times *lower* reflection is now available with all B. F. Goodrich Microwave Absorbents. This 0.1% material gives reliability to measurements previously unattainable for testing of guided missiles in a free space chamber.

You can now be sure, by selecting the proper B. F. Goodrich material, that you will get this 0.1% performance at any point on the microwave frequency spectrum.

In addition to this outstanding quality, the B. F. Goodrich absorbent is light-weight, fire-retardant, easy to install. It will not deteriorate in performance when walked upon and has excellent water and weather resistant properties. For darkroom use, a special white compound can be applied to the surface of the pads to increase light reflectance.

When you're investing thousands, start right—specify B. F. Goodrich—the company with the longest experience and record for *consistently* high quality microwave material. For new booklet on these absorbents write The B. F. Goodrich Company, 486 Derby Place, Shelton, Connecticut.

List of B. F. Goodrich Broadband Absorbents

Designation	Lowest Frequency*	Thickness	Maximum Reflection
12 CM	2500 mc	1½"-2"	2%
12 CM – 1%	2500 mc	1½"-2"	1%
12 CM – 30db	2500 mc	1½"-2"	0.1% at X-band. 2% elsewhere.
6 CM	5000 mc	1"	2%
30 CM	1000 mc	3½"-4"	2%
30 CM – 1%	1000 mc	3½"-4"	1%
60 CM	500 mc	7"-8"	2%
60 CM – 1%	500 mc	7"-8"	1%
100 CM	300 mc	10"-11"	2%
200 CM	150 mc	26"	2%
600 CM	50 mc	69"	2%
8 CM–glass fiber	3600 mc	1"-1½"	2%
4 CM–glass fiber	7500 mc	¾"	2%

Most of the above absorbents can be furnished with 0.1% maximum reflection at selected points in the frequency band.

*All perform up to 30,000 mc

B.F.Goodrich
microwave absorbents

each element in direct contact with a number of adjacent ones. The elements are supported by one another.

Figure 1*A* shows a basic construction technique—two thin shells with one completely enclosing the other. Spherical shape for the shells, as shown, is generally preferred to any other. Thickness of the outer shell is determined mainly by strength of the dielectric material used and by maximum mechanical load that may occur on a single element in the final assembled structure.

The inner shells control the refractive index by change in their size or shape. Thickness of the inner shells is determined by required refractive index, allowable loss of the resulting dielectric and properties of the conductive material used.

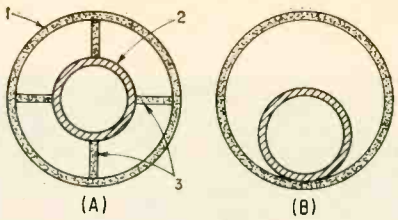


FIG. 1—Basic concentric double-shell element (A) has outer dielectric shell (1); inner conducting-material or non-conducting - material - with - conductive - coating shell (2) and supporting devices (3). Double-shell element with freely enclosed inner shell is shown in (B)

In a variation of the basic design, as shown in Fig. 1*B*, the inner shells can be enclosed freely within the outer shells.

An artificial dielectric of any given size and of a specified refractive index can be assembled easily by filling the volume with shell-type elements as described.

Crystal Gives Low-Cost Stereo

IN PRODUCTION at the Electronic Components Div., Clevite Corp., is a new twister-bender crystal, the 1LK35-S, designed for stereo applications using unscrambling circuits.

The shear plate (twister), Fig. 1,

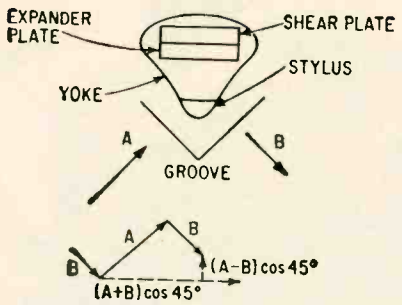
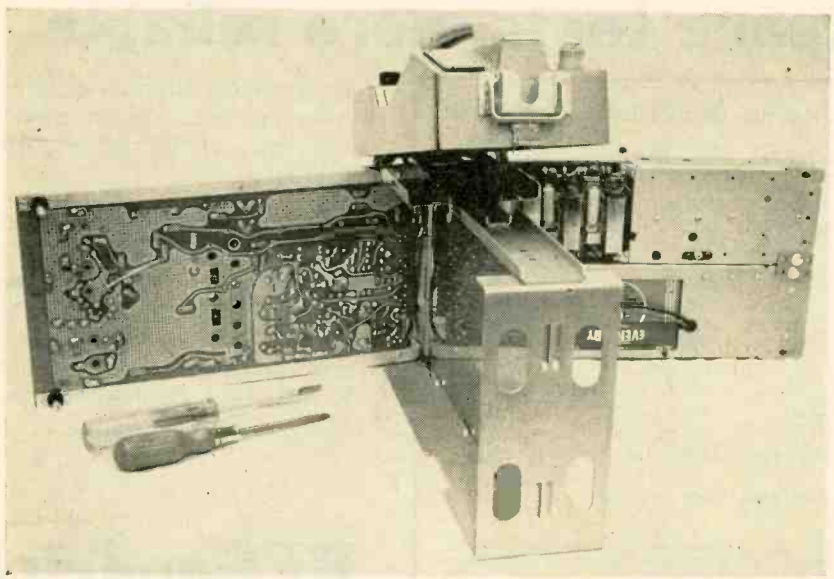


FIG. 1—Shear and expander plates react to horizontal and vertical components of groove motion

Radio Has Fan-Type Design



Servicing is no problem because of the unique swing-out chassis employed in this transistorized, portable two-way radio by General Electric

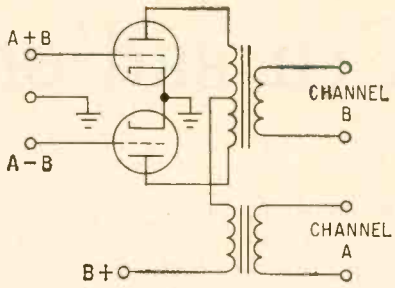
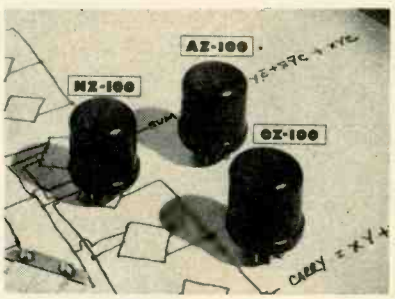


FIG. 2—Typical unscrambling circuit for use with crystal pickup

generates a voltage proportional to the horizontal components of groove motion. The length expander (bender) generates a voltage proportional to the vertical components. Components of both channels are present in each crystal plate as sums and differences. The circuit shown in Fig. 2 represents a simple method for unscrambling.

Basic Logic Modules Speed Programming

THREE BASIC seven-pin plug-in modules, energized by a 100-kc r-f power supply, have been developed by the Semiconductor Division, Hoffman Electronics Corp., Evanston, Ill. The new units make it possible to go directly to logic programming without necessity for individual circuit design.



Three logic-system modules are seven-pin miniature units

First of the three modules in the Magnalog system, Type NZ100, is a NOT unit consisting of a series-type pulse magnetic amplifier. The second, Type OZ100, is an OR unit containing three silicon, double-anode Zener diodes with appropriate Zener breakdown voltages. The third, Type AZ100, is an AND unit also containing three Zener diodes but with different breakdown voltages than those used in the Type

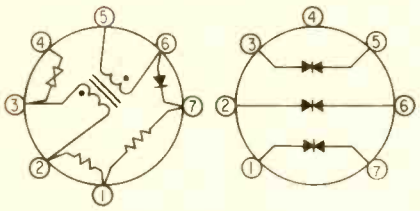


FIG. 1—Wiring of NZ100 module (left) and AZ100 and OZ100 modules (right)

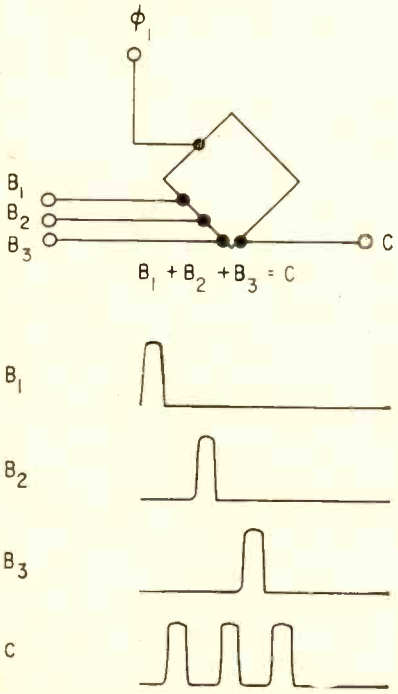


FIG. 2—Configuration for an OR circuit with waveshapes for Boolean expression illustrated

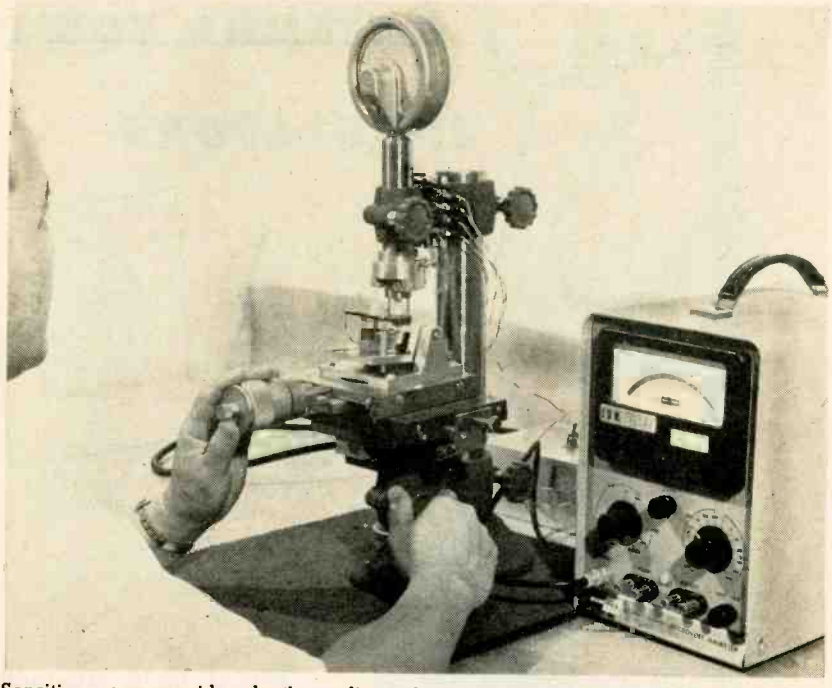
OZ100 module. Figure 1 shows wiring diagrams of the internal structures of the modules. Figure 2 illustrates an OR circuit made up from an NZ100 and an OZ100 module. The three Zener diodes of the OZ100 module are connected to pin 2 of an NZ100 module. Waveshapes illustrate the Boolean expression, $B_1 + B_2 + B_3 = C$ for the circuit operation.

Papers Wanted for Components Meeting

PROSPECTIVE AUTHORS are invited to submit titles of papers and 150 to 200 words abstracts to the Program Committee of the 1959 Electronic Components Conference. Deadline is October 15, 1958. Address: Brig. Gen. Edwin R. Petzing, AGEP, Secretariat, University of Pennsylvania, 200 S. 33rd St., Philadelphia 4, Pa. Deadline for completed papers will be February 15, 1959.

Hot Probe Measures Germanium Diffusion Depth

By M. BELIVEAU, International Business Machines Corp., Poughkeepsie, N. Y.



Sensitive gage provides depth reading when zero-point on meter indicates junction

METAL DIFFUSION depth in germanium may be measured within a few millionths of an inch by using the thermoelectric effect in semiconductors to detect the change in impurity type and level. Sample preparation takes only a few minutes time.

Apparatus consists of a sensitive height gage, a hot stylus mounted on the gage's spindle, a sample mounting block, a microscopic cross slide and a zero-center millivoltmeter or microammeter.

Variable reluctance or capacitor type gages with light actuating forces are suitable. In this case, a Johansson Mikrokator was modified to give a force of 20-30 grams for its entire range. A small permanent magnet is mounted to the barrel and an armature mounted to the spindle. Fine adjustment of the clearance between them, a few thousandths of an inch, gives the desired force.

The hot probe is rigid and constructed to avoid heat-caused dimensional changes. The heater coil, of thin resistance wire, is powered with a filament transformer to produce 125 F to 150 F temperature at the probe shank. A large gap is left between the coil's top and the spindle. Insulating material in the gap is beneficial.

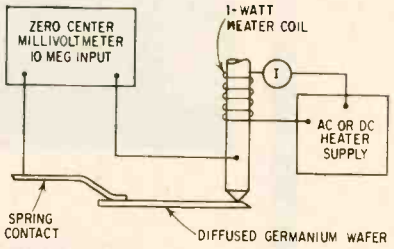


Diagram of probe and meter arrangement

Fuzed quartz tubing is used for heater and probe support. The stylus holder is Invar. The stylus has an Invar shank and tungsten carbide tip, or may be all-carbide if shorter than ½ inch. Tip radius is 0.004 inch.

The mounting block is steel and matches the size of the wafer used. A bevel cut in one edge extends into the mounting face for an inch or more. The bevel face guides the beveling of the wafer edge.

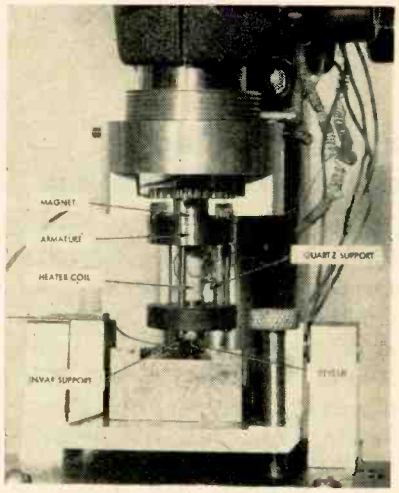
The leveling platform, permanently mounted to the micrometer-equipped cross slide, assures the wafer surface is parallel to the slide ways. The ways are perpendicular to stylus motion. The platform pivots are in line with the top surface of the germanium near the beveled edge.

Thermal output of the probe is read with the meter. Electrical connections are made to the hot probe and to a pressure contact anywhere on the germanium surface.

The germanium sample is placed on the metal block, which has a built-in guide for lapping a small-angle bevel (5 degrees) on one edge of the sample. Since only vertical distance will be measured, it is not necessary to know the exact angle or starting point of the bevel.

The block with sample is placed on the levelling platform. Contact between sample and probe is made and the depth gage read. Cross slide and block are moved and the platform adjusted to level the top surface of the sample so that the gage shows little or no variation. The reading is recorded.

As the cross slide is moved so that the stylus starts down the bevel, thermal output is observed, or plotted, against depth. When output changes from negative to positive, or vice-versa, a junction has been located. To obtain junction depth, the depth reading obtained as the thermal output crosses the



Hot probe assembly is mounted on gage spindle over sample block

DUAL HIGH DIRECTIVITY COUPLERS

Narda Dual High Directivity Directional Couplers are designed for reflectometer measurements in waveguide systems, and exhibit the same flat response (± 0.4) and high directivity (40 db min.) as Narda's single units. Primary line VSWR: 1.05 max. (1.10 for M1027); secondary line VSWR: 1.15 max.

Coupling structures are on opposite broad walls of the primary line; secondary output arms are on the same side. Detector mounts can be attached readily to facilitate connecting detector mounts.

BAND	FREQUENCY (kmc)	WAVEGUIDE O.D. (in.)	NARDA Model	PRICE
S	2.60-3.95	3 x 1½	1034	$650.
C	3.95-5.85	2 x 1	1033	400.
XN	5.40-8.20	1½ x ¾	1032	255.
XB	7.05-10.0	1¼ x ⅝	1031	220.
X	8.20-12.4	1 x ½	1030	175.
KU	12.4-18.0	.702 x .391	1029	180.
K	18.0-26.5	½ x ¼	1028	295.
V	26.5-40.0	.360 x .220	V1027	330.
M	50.0-75.0	.228 x .154	M1027	900.

3, 6, 10 and 20 DB

40 DB HIGH POWER

HIGH DIRECTIVITY COUPLERS

The 40 db High Power Coupler is another exclusive Narda product. Similar to standard types, except that coupling irises are in the narrow wall, it may be used at full rated power of the waveguide size. Nominal coupling value is 40 db; directivity 40 db. Directivity for 3, 6, 10 and 20 db couplers is also 40 db. Standard cover flanges on primary line; low VSWR termination and standard cover flange on secondary. All bands—2600 to 90,000 mc.

STANDARD REFLECTIONS

Narda offers five values of reflections for each of six different waveguide sizes . . . the most complete choice we know of! Provides calibrated reflections or VSWR's for use in standardizing reflectometers or calibrating slotted line impedance meters.

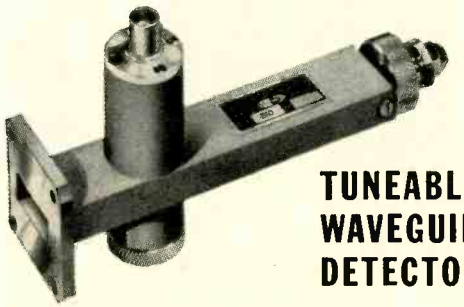
SPECIFICATIONS

Reflection Coefficient	0.00	0.05	0.10	0.15	0.20
Accuracy	0.002	0.0025	0.0035	0.0045	0.007
VSWR Equivalent	1.00	1.105	1.222	1.353	1.50

Models for 2.60 to 18.0 kmc, from $125 to $300

Microwave engineers—

Where can you use these exclusive features offered by NARDA?



TUNEABLE WAVEGUIDE DETECTORS

Narda's tuneable waveguide detectors are designed for broadband operation with small reflections and maximum versatility. Detected output is from a standard BNC female fitting, and the detectors may be used with a variety of crystal, bolometer, or thermistor elements, for absolute power measurements, as well as detection of relative power levels.

Although VSWR is low, impedance match can be improved by means of additional tuning such as E-H or slide-screw tuners. All models are designed for optimum VSWR with Narda model N610B bolometers, but good impedance matches can frequently be obtained with other bolometers and thermistors.

Data on VSWR with various elements is available from Narda, as well as a wide range of suitable detecting elements and crystals.

BAND	FREQUENCY (kmc)	WAVEGUIDE O.D. (in.)	NARDA MODEL	DETECTING ELEMENTS					MAX. VSWR WITH N610B	CRYSTALS	PRICE
				BOLOMETERS			THERMISTORS				
C	3.95-5.85	2 x 1	513	N610B	N821B	N605	N333D or N333	N334	1.25	IN21 or IN23	$95.
XN	5.30-8.20	1½ x ¾	512	N610B	N821B	N605	N333D or N333	N334	1.25	IN23	90.
XB	7.05-10.0	1¼ x ⅝	511	N610B	N821B	N605	N333D or N333	N334	1.25	IN23	85.
X	8.20-12.4	1 x ½	510	N610B	N821B	N605	N333D or N333	N334	1.25	IN23	75.
KU	12.4-18.0	.702 x .391	509	N610B		N605	N333D or N333		2.00	IN78 or IN23	110.

Tuneable Detectors for use with crystals only, available for millimeter bands 18,000 to 90,000 mc., from $125

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zero point is subtracted from the first or reference gage reading.

The bevel angle selected, while not critical, is a function of surface waviness, diffusion depth and accuracy desired. Deep diffusions (0.001 inch) and wavy surfaces require larger angles. Figure 1 shows how errors due to waviness and inaccurate leveling are reduced by a greater bevel angle B, perhaps 8 degrees.

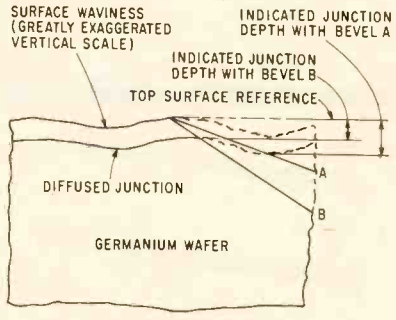
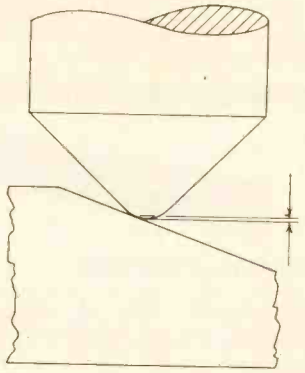


Fig. 1—Deeper bevel avoids errors due to irregular sample surface



BEVEL ANGLE (DEGREES)	TIP RADIUS	
	.003 IN.	.004 IN.
4	7.3	9.8
5	11.4	15.2
6	16.4	21.9
7	22.4	29.7
8	29.2	38.9

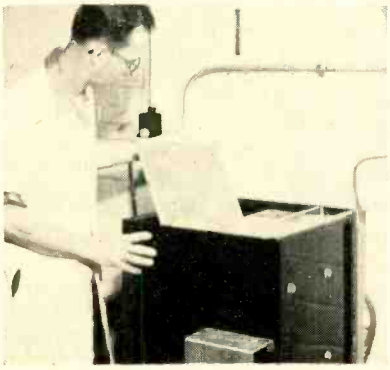
Fig. 2—Correction (in millionths inch) for tip radius and bevel angle

The wavy surface technique is as follows: Level the block until the gage pointer oscillates about a point on the scale. Take a reference reading at the jump-off point to the beveled surface. Subtract from the reference reading the reading at the junction and a correction for tip radius and bevel angle (Figure 2).

There are 3 checks for the apparatus. For thermal stability: warm up the probe for ½ hour. When probe temperature is 140 F, contact the germanium and allow ½ minute for stabilization. The change in depth

reading must not exceed 10-millionths per minute. Mechanical stability: readings must not be erratic when the probe is moved left to right over a level sample or polished surface. Probe contact force and radius: a variation in junction depth readings, after the probe has been moved several times over the bevel in the same trace, indicates the germanium is being scored. The scoring can be observed with a metallurgical microscope.

One Etchant Handles Several Metal Plates



Unetched board is inserted in paddle etcher

RECENTLY introduced process for etching printed copper circuits employs an aqueous solution of ammonium persulfate as the etchant, rather than ferric chloride or chromic acid.

Advantages claimed for the process by Becco Chemical Division, Food Machinery and Chemical Corp., Buffalo, N. Y., are: plain, solder-plated and plated circuits may be etched in one system, the etchant is relatively non-corrosive, does not produce fumes, does not form sludge, produces only water-soluble reaction products, allows copper recovery and sewering of wastes.

Comparative costs per gallon of etching solution, according to Becco, 36 to 42 cents for ammonium persulfate, 50 to 75 cents for ferric chloride and $1 to $1.25 for chromic acid. Overall process time for all three are reported as comparable.

Conventional tank, paddle or spray etchers may be used. The ammonium persulfate solution requires activation by operating at

temperature of about 130°F, or by using catalytic activation at room temperature. Tank etching requires agitation by board motion or air bubbling.

The bath is prepared by mixing 2 to 2.5 pounds of stable ammonium persulfate powder to each gallon of hot water. This 25% solution may be stored 8 to 10 days. A 50 to 60% head tank solution may be stored 2 to 3 days. All vessels must be thoroughly cleaned of residues left by other processes.

Etched board is washed in rinse tank

Copper capacity of the 25% solution is 8 ounces of copper per gallon. Typical etching time in a paddle etcher is 7 to 8 minutes, 2 ounce copper; 5 to 6 minutes, 1.5 ounce copper, and 3 to 4 minutes, 1 ounce copper in heat activated solution is about half these times in catalyst activated solution. Etching time will be approximately double over the useful life of the solution. No precipitate or sludge will form in the etching tank.

Water rinse, rather than water wash or scrubbing, will clean the water soluble residues left on etched boards. Lead sulfate will form on solder-plated boards, but may be removed by buffing, hot water or chemical dip.

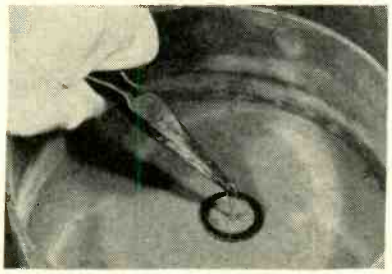
Spent solution will contain essentially only ammonium sulfate, copper sulfate and a trace of sulfuric acid. Copper may be recovered practically by plating it out electrolytically. If copper is not to be recovered, liming the waste solution in a settling tank will precipitate a copper-bearing sludge. In either case, the remaining solution can be sewered in most localities after dilution.

The process can be used with all

conventional resists. With modifications, it can be used to clean copper or remove copper flash.

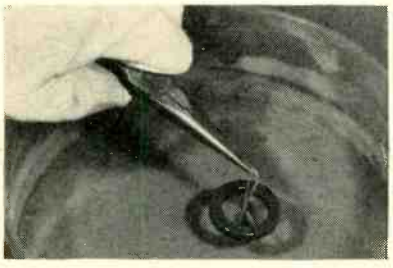
Fluidized Resin Coats Hot Parts

SMALL PARTS may be readily encapsulated by plunging them when hot in dry resin. The photos illustrate a technique recommended by Minnesota Mining & Manufacturing Co. for encapsulating toroids.



Pliers serve to plunge hot part in powdered resin

The toroid, held by a wire spring, is heated to 350 F. It is dipped into powdered epoxy resin until completely submerged and kept submerged for 2 or 3 seconds. The heat of the part causes the powder to melt and adhere to its surface in an even coating. On withdrawal, the part will show a slightly granular surface until the internal heat of the toroid melts the resin grains clinging to its surface.



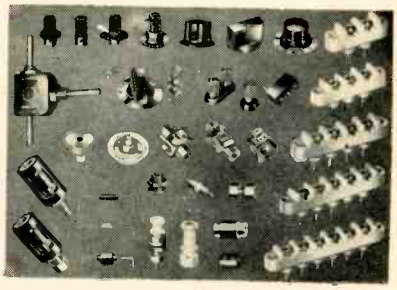
Melting resin grains give a smooth, shiny coating

The resin is held in a container which fluidizes, or aerates, it by compressed air so that it has the properties of a simmering liquid. The air enters through a membrane of glass, cloth and paper under the resin. One foot of resin was used under about ½ to 1 pound of air pressure.

NEW PRODUCTS

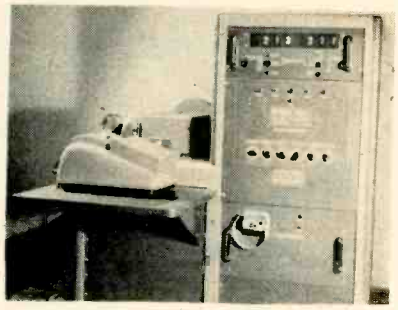
Tiny Components
wide variety

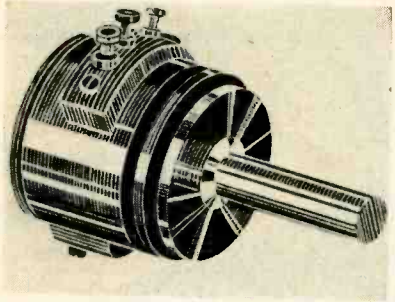
THE JAMES MILLEN MFG. CO., Malden, Mass., announces a complete line of miniature components approximately ⅔ the size of the standard units. Such components include i-f transformers, dials, knobs, dial locks, shaft locks, flexible couplings (in 7 types), ceramic terminal strips, binding posts, gear drives, insulated potentiometer mountings and all other components in the company's standard line that lend themselves to miniaturization. **Circle 300 on Reader Service Card.**



Cable Evaluator
self programming

JAMES CUNNINGHAM, SON & CO., INC., 33 Litchfield St., Rochester 8, N. Y. The self-programming automatic cable evaluator (SPACE) is a console-mounted testing instrument which automatically checks for leakage (hi-pot) and continuity between any and all wire ends or terminations of a cable harness or device being tested. SPACE, employing a computer type memory, progresses through a series of tests in a logical manner at a maximum rate of 10 tests per second and has a capability of generating its own tape program. **Circle 301 on Reader Service Card.**



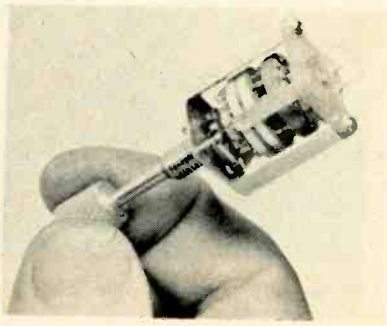


Miniature Pot
two voltage outputs

WATERS MFG., INC., Wayland, Mass. Type WPSC is a miniature nonlinear sine-cosine precision pot that provides two accurate and entirely separate 360 deg sinusoidal voltage outputs. The two output signals are displaced 90 deg in phase and represent the sine and cosine of the shaft rotation angle. Standard servo-type mounting is provided, but tapped hole mounting can be specified in this precision-wound unit. The new potentiometer is particularly useful in radar ppi displays and for various types of computers. **Circle 302 on Reader Service Card.**

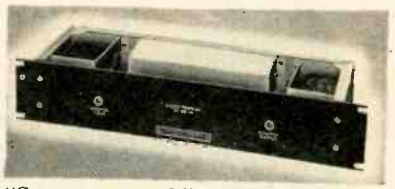
Attenuator
two switch sections

THE DAVEN CO., Livingston, N. J., has a subminiature attenuator whose dimensions are only ¾ in. square by 1¼ in. long. Diameter of the shaft is ⅛ in. with ¼ in.-28 mounting bushing. Inside the unit are two switch sections with slip rings and 22 fixed resistors. It is designed to surpass applicable MIL specifications such as MIL-STD-202A by temperature cycling, moisture resistance, vibration up to 2,000 cps at 15 G, and 50 G acceleration. The unit is available as an 11-position bridged T, 20-position ladder, or 20-position pot. **Circle 303 on Reader Service Card.**



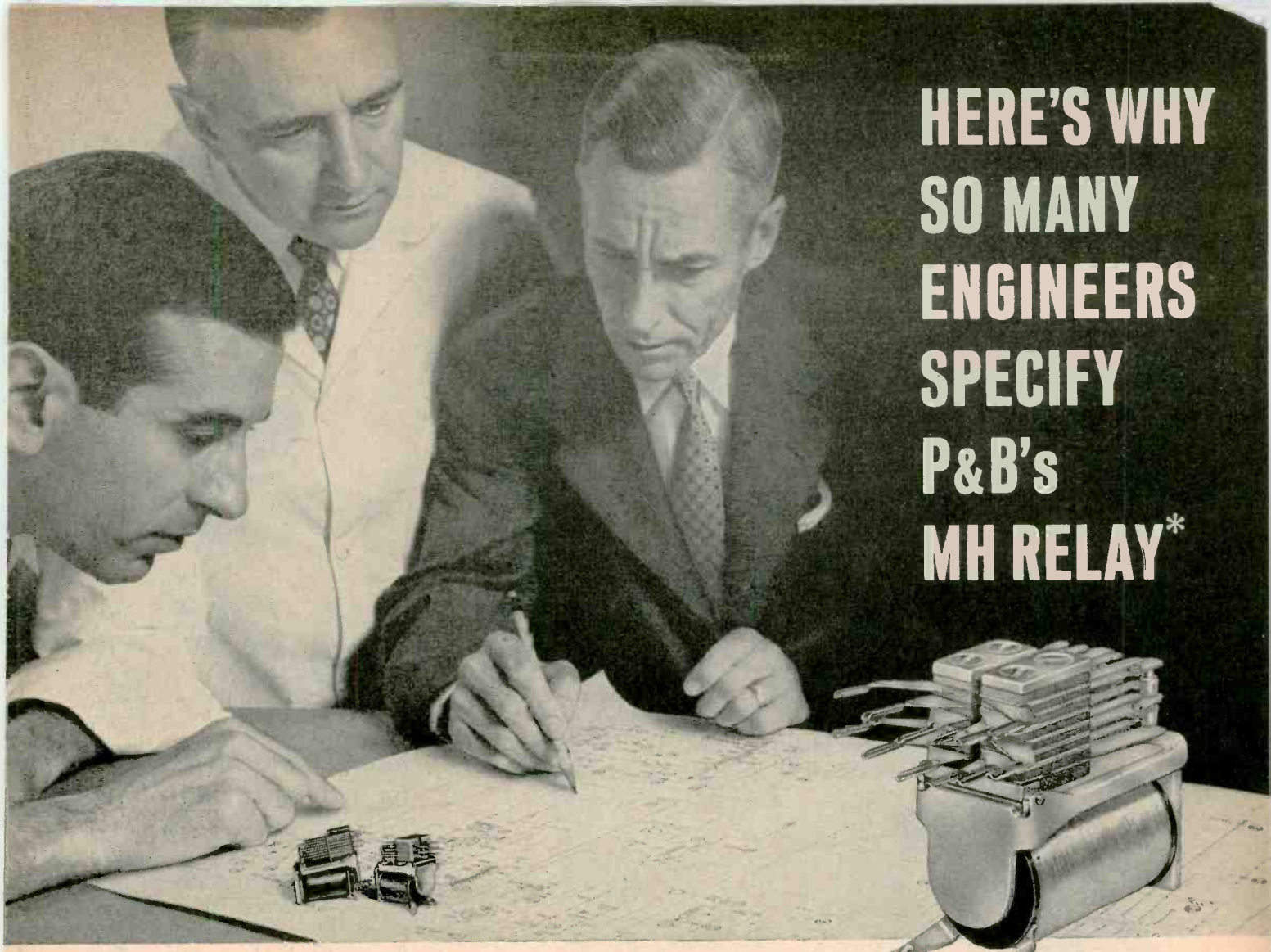
Unique Network
improves a-m/f-m power

KAHN RESEARCH LABORATORIES, INC., 22 Pine St., Freeport, N. Y. Specifically designed for a-m, f-m, tv audio, and h-f communications transmitters, the model SP-58-1A



"Symmetra-peak" network redistributes unequal positive or negative peak energy of audio waves symmetrically about the zero axis. Thus, any asymmetry resulting from certain voice characteristics, improperly phased microphones, or switching between local and distant program sources is eliminated. With peak energy considerably re-

CIRCLE 75 READERS SERVICE CARD →



HERE'S WHY SO MANY ENGINEERS SPECIFY P&B's MH RELAY*

*AND VARIATIONS OF THIS BASIC STRUCTURE SHOWN BELOW

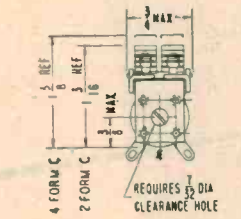
Shown with printed circuit terminals

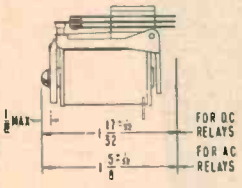
VERSATILITY and adaptability

are prime reasons why designers have made the MH a P&B best seller. This relay series, for example, does yeoman duty in such diverse applications as jet aircraft, street lighting equipment, computers and missile ground controls.

When multiple switching is required...when size, weight, long life and reliability are critical ...our MH relay can usually fill the bill. It's RIGHT for countless jobs, often at countable savings.

Let us send you complete information about this miniature telephone-type relay and the variations we've evolved for special applications. Write or call today.





ENGINEERING DATA/MH RELAY

Insulation: Laminated phenolic.

Insulation Resistance: 100 megohms minimum.

Breakdown Voltage: 500 volts RMS between all elements.

Shock: Up to 30g.

Vibration: Up to 10g from 55 to 500 cps.; .065" max. excursions from 10 to 55 cps.

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

Weight: 2½ oz. max. (open relay)

Pull-In: Approx. 75% of nominal voltage.

Pull-In Speed: Approx. 15 ms.

Drop-Out Speed: Approx. 10 ms.

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

CONTACTS:

Arrangements: Up to 9 springs per stack.

Material: ⅛" silver; also Palladium or gold alloy.

Load: Dry circuits to 5 amps @115V AC resistive.

COILS:

Resistance: 22,000 ohms max.

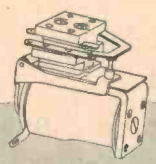
Power: 100 milliwatts per movable minimum to 4 watts at 25°C. max. (200 mw. min. to meet max. shock/vibration spec.)

Duty: DC: Continuous. AC: Intermittent (2 pole relay max.)

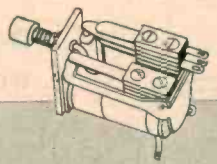
Voltages: DC: Up to 110 volts. AC: Up to 230 v. 60 cycles.

Current: 2.5 ma to 10 amps DC.

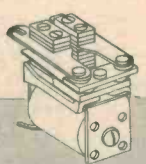
P&B STANDARD RELAYS AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR



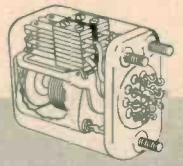
MC FOR RF SWITCHING
For RF switching where intercontact capacitance losses must be minimized. Ceramic contact spacers.



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



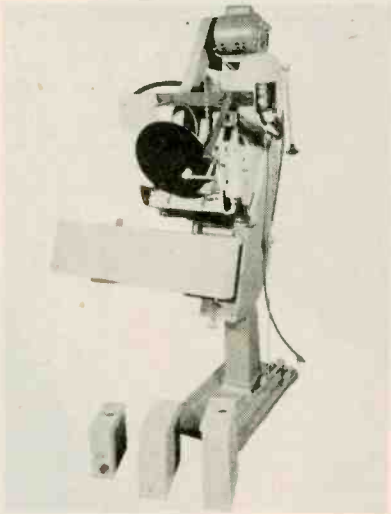
MB CONTACTOR
Contacts rated 60 amp. 28 volts DC non-inductive. Will carry 150 amp. surge for a duration of 0.3 seconds.



MH SEAL-TEMP
Features sealed coil to minimize contact contamination. Available as hermetically sealed relay only.

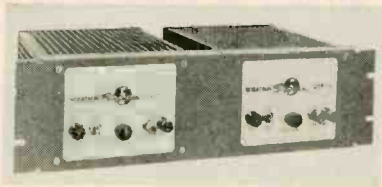
POTTER & BRUMFIELD INC.
PRINCETON, INDIANA • SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY

duced, average modulation level can be increased, permitting potential power improvement of up to 4 db on voice transmission. Circle 304 on Reader Service Card.



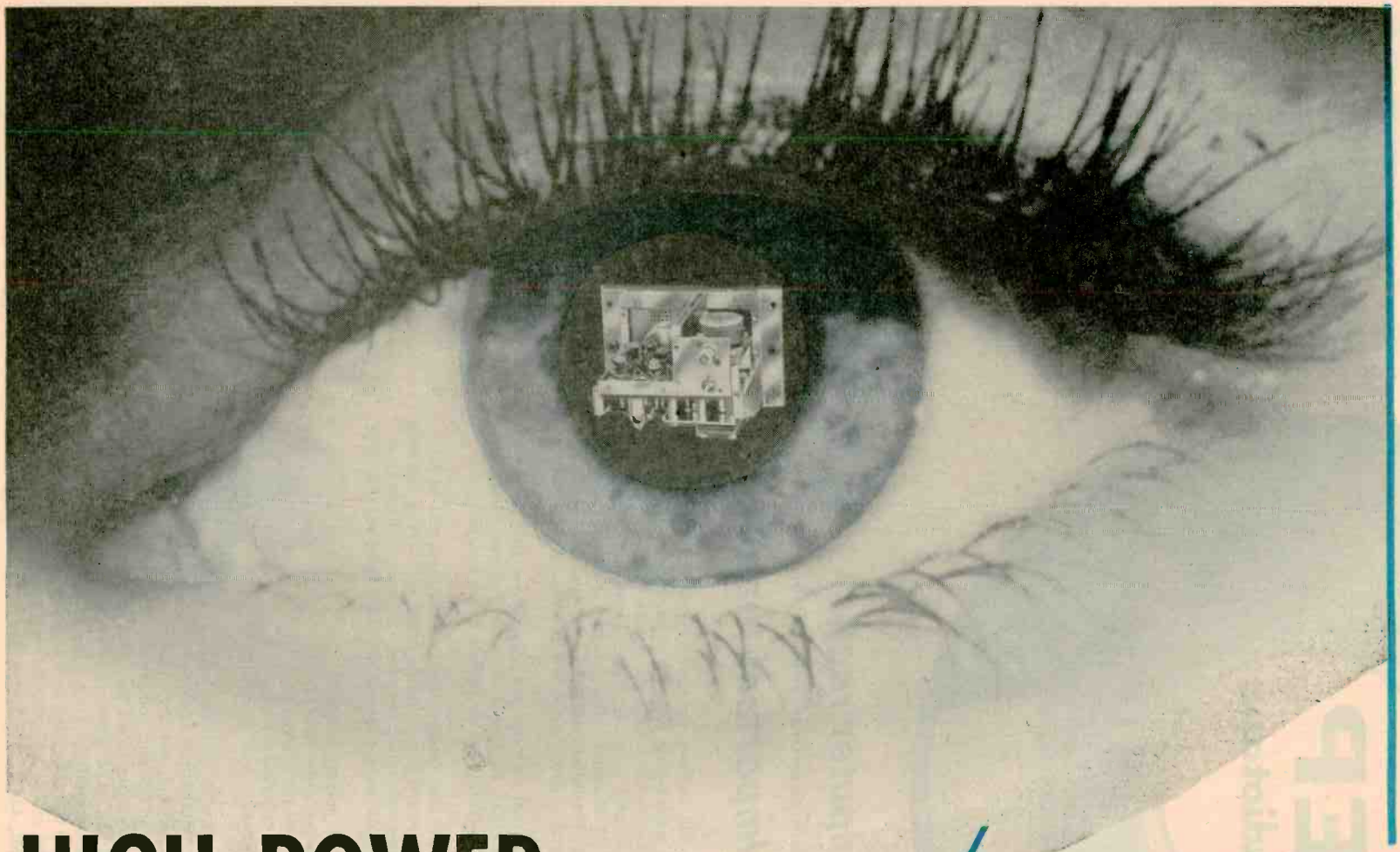
Marking Machine for flat items

Markem Machine Co., Keene 55, N. H. Flat or rectangular meter sockets and similar flat items may be marked directly with UL approval seal and issue number by the model 25AU machine. The machine uses a sealed, recording, non-reset counter mechanism and manifest printing plates purchased from and issued through Underwriters Laboratories, Inc. Speeds up to 60 imprints per minute may be achieved on a full range of sizes of meter sockets, with rapid change-over from size to size. Imprint size of the UL label section is 2½ in. by 3 in. Circle 305 on Reader Service Card.



D-C Supplies transistorized

Sorensen & Co., Inc., Richards Ave., South Norwalk, Conn. Added to the Q-Nobatron line of transistorized low-voltage high-current d-c supplies is the model Q28-5, with



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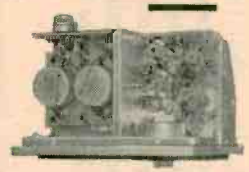
Direct FM Transmitters Crystal controlled 215-235 megacycles. 125kc deviation.



Model 1462

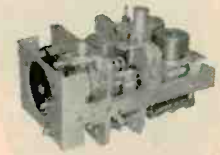
6" x 4¼" x 3¾" 50 to 80 Watts

Model 1463

5 19/32" x 3 13/16" x 4" 15 to 30 Watts

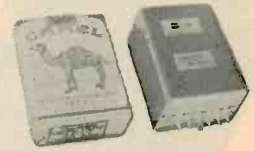
Model 1472

4" x 1.5" x 2.7" 2 Watts



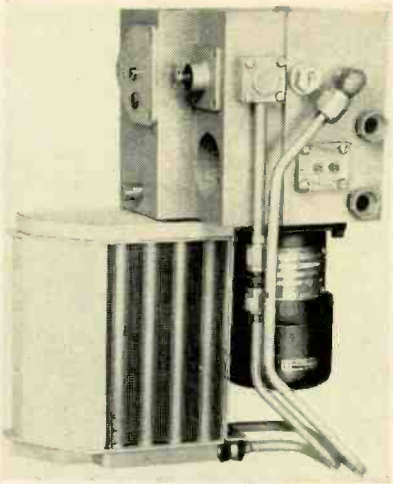
Model 1466A
6.5" x 4" x 3.25" RF Amplifier
2 watts in — 100 watts out

SUB-CARRIER OSCILLATOR.



Model 800C — 1.5" x 1.9" x 2.45"
Deviation stability ±1% of band width. Deviation linearity less than 1% of band width under all conditions measured from a straight line drawn between end points.

an output range of 18-36 v d-c at 0-0.05 ampere. It is ideal for use in such applications as computer circuits or strain gage bridges. Unit is available in single or dual rack mounting models or in cabinets. **Circle 306 on Reader Service Card.**



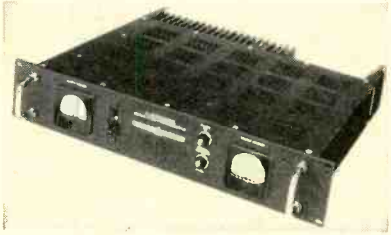
Tube Cooler for missile use

EASTERN INDUSTRIES, INC., 100 Skiff St., Hamden, Conn., produces a unit for cooling high powered electronic tubes in the guidance systems of missiles. Model E/HT-200, type 204, is a complete assembly, weighing 10 lb and with dimensions of only 10½ in. by 6 in. by 7¾ in. It has an operating temperature range from – 65 F to + 160 F. It has a capacity of 1,600 w and operates on 28 v, d-c power supply. Coolant is ethylene glycol-water solution delivered at 0.6 gpm flow rate and 35 psi pressure at maximum temperature. **Circle 307 on Reader Service Card.**

Resistance Bridge high precision

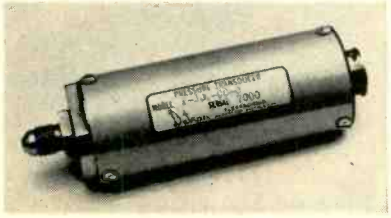
ELECTRO-MEASUREMENTS, INC., 7524 S.W. Macadam Ave., Portland 1, Ore. Model 230-R Wheatstone resistance bridge offers a

combination of accuracy, speed and convenience for precise resistor checking, temperature coefficient measurements, strain gage calibration and other critical resistance measurements. It features an accuracy of better than 0.02 percent for most measurements from 0 to 12,000 megohms. The lowest range has a resolution of 10 microohms per dial division. **Circle 308 on Reader Service Card.**



Power Supplies transistorized

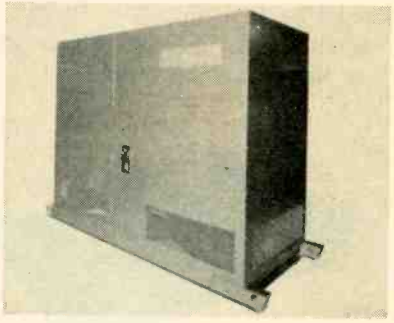
Lambda Electronics Corp., 11-11 131st St., College Point 56, N. Y. The L-T series transistorized power supplies feature convection cooling. They are designed to operate at maximum rating of 50 C ambient temperature without internal blowers or other moving parts. First two models in the series, LT2095 and LT2095M (metered), are priced at $365 and $395, respectively. Ranges are 0-32 v d-c, 0-2 amperes. Input rating is 105-125 v a-c at 50-400 cps. **Circle 309 on Reader Service Card.**



Pressure Transducer good repeatability

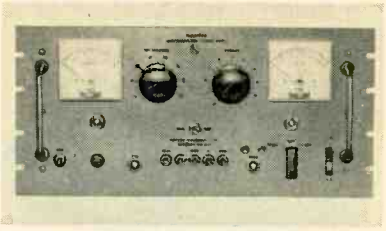
Datran Electronics, 1836 Roscrans Ave., Manhattan Beach, Calif. A new pressure to frequency transducer is completely self-contained with only d-c current required as input power. The basic pressure sensing is accomplished by a variable inductance a-c transducer, the transducer coil being

part of an integral oscillator tank circuit. The instrument therefore has infinite resolution and provides repeatability of 1 percent or better. Unit measures 1½ in. in diameter by 3¾ in. long and weighs 8½ oz. Circle 310 on Reader Service Card.



Silicon Power Supply heavy duty unit

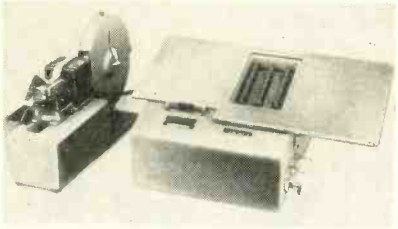
PERKIN ENGINEERING CORP., 345 Kansas St., El Segundo, Calif. A new heavy duty silicon rectifier type d-c power supply has an output of 75 to 750 v at 200 kw. Regulation accuracy is 1 percent and ripple 2 percent rms. The unit is controlled remotely by a self saturating magnetic power amplifier which permits smooth continuous adjustment between 75 and 750 v. Complete description is given in bulletin MS708 available on letterhead request.



Power Supplies transistorized

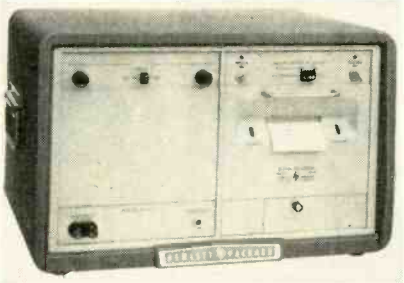
ELECTRONIC MEASUREMENTS CO., INC., Eatontown, N. J. A new series of transistorized power supplies feature three-way short circuit protection, including a high-speed, all-electronic circuit breaker. Additional features are remote control and remote sensing. The remote sensing provision eliminates voltage changes at the load due to voltage drops in the leads. This

feature is of special value when leads are long or the load draws high currents. Regulation is 0.1 percent or 0.01 v for extremes of line and load. Ripple is less than 0.001 v. **Circle 311 on Reader Service Card.**



Data Processor
desk-top type

TALLER & COOPER INC., 75 Front St., Brooklyn 1, N. Y. A new data processor for use with tabulating equipment and systems, and computers, cuts tabulating card files by 50 percent and increases productivity by 100 percent. The device accepts fixed data from tabulating or edge-punched cards and variable data through its simple keyboard. The two data inputs are automatically combined and punched out on tape. The tape output can be fed directly to a computer, or to a tape-to-card converter for use in tabulating machines and systems. **Circle 312 on Reader Service Card.**



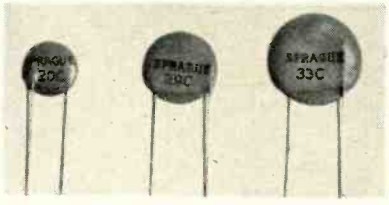
Digital Recorder
11 column entry

HEWLETT-PACKARD CO., 275 Page Mill Road, Palo Alto, Calif. Model 560A digital recorder prints 11 column digital information at rates to five prints per sec. Although primarily designed to make a permanent record of electronic counter read-outs, it can be used with two or more counters simultaneously, digital voltmeters, time recorders,

flowmetering equipment and systems, such as telemetering installations and engine test stands. In addition to the printed tape record, model 560A provides an analog current or voltage output to drive a galvanometer or potentiometer strip chart recorder or to provide a servo control. Circle 313 on Reader Service Card.

Power Supply transistorized

Quan-Tech Laboratories, Morristown, N. J. Model 104 is a dependable d-c power supply for all applications requiring excellent regulation and low ripple. It is completely transistorized and has a low internal impedance of less than 0.03 ohm, d-c to 10 kc. The three voltage and current ranges are accurately metered. Overload protection is provided for the current meter, with automatic reset. Coarse and fine voltage controls facilitate precision settings. Circle 314 on Reader Service Card.



Ceramic Capacitors for p-c boards

Sprague Electric Co., North Adams, Mass. Snug-mount Ceramite capacitors are designed so that there is no coating material on the leads below the final encapsulation. Since the final coating is always a minimum of 1/32 in. above the bottom tangent line of the disk, these capacitors can be used on two-sided or plated-through boards. At the same time, this technique

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electronics' READER SERVICE

it's free–it's easy–it's for your convenience

Each Advertisement and New Product item is numbered.

For more information, simply . . .

(1) Circle number on postpaid card below that corresponds to number at the bottom of Advertisement, or New Product item.

(2) Print your name, title, address, and firm name carefully. It is impossible to process cards that are not readable.

*** FOR SPECIFIC ITEMS IN MULTI-PRODUCT ADVERTISEMENT**

Certain multi-product advertisements contain Reader Service numbers for each product.

For multi-product advertisements that are not keyed for Reader Service, indicate in box on postcard marked with asterisk (*) ad circle number(s) and specific product(s) on which you want more information.

Additional postage MUST be added to cards for all FOREIGN MAILINGS

An occasional Advertisement cannot be numbered for the READER SERVICE CARD due to lack of space and must be indicated by writing the Advertisers' name in the space at the bottom of the card...

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(NAME) _____ (POSITION) _____

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CIRCLE THESE NUMBERS ONLY WHEN YOU ARE INTERESTED IN ALL ITEMS SHOWN OR DESCRIBED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
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INSIDE FRONT COVER — INSIDE BACK COVER

An occasional Advertisement cannot be numbered for the READER SERVICE CARD due to lack of space and must be indicated by writing the Advertisers' name in the space at the bottom of the card...

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Circle No.	Product	*

INSIDE FRONT COVER — INS·DE BACK COVER

MEMO:

NEW PRODUCTS RELEASES

TO: ALL MANUFACTURERS

FROM: electronics

electronics publishes all new product items of interest to makers and users of electronic and allied equipment.

The reverse side of this card provides a service to subscribers by facilitating the flow of additional information between manufacturers and our readers.

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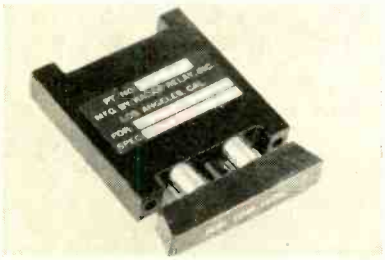
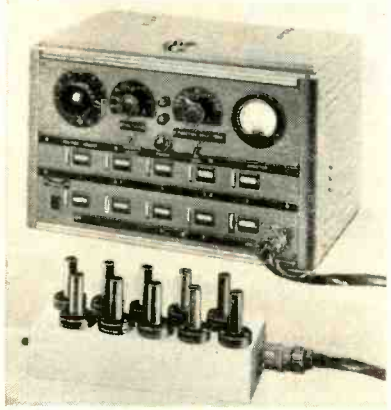
avoids lead breakage under severe mechanical vibration which has occurred with the hooked-lead capacitors used on printed wiring boards. Snug-mount Cera-mites do not have any exposed electrode or ceramic. Circle 315 on Reader Service Card.



Lighted Push-Bar magnetic hold-in

RADAR RELAYS, INC., 2120 Pontius Ave., Los Angeles 25, Calif., has developed a lighted-nomenclature push-bar with magnetic hold-in provisions. When lamps in the switch are lighted, they may be de-energized by depressing the bar which is then held in position magnetically. The bar returns to its original position by spring action when the circuit is de-energized. The magnetic hold-in provision may be manually overriden if desired. Circle 316 on Reader Service Card.



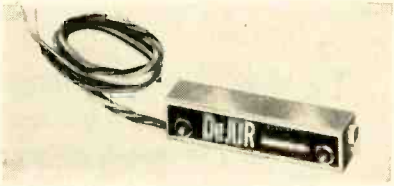
Test Set for timing relays

G-V CONTROLS INC., Hollywood Plaza, East Orange, N. J. A timing relay test set testing up to ten relays simultaneously is designed for users who make receiving inspection or lab tests in moderate

or high volume. Tests of normal operate time, saturate release time, or release time after predetermined heating can be made on either normally open or normally closed timing relays. The test, once started, proceeds automatically and the operator is released for other duties. Circle 317 on Reader Service Card.

Panel Meter
antiparallax scale

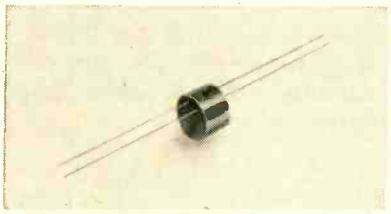
MARION ELECTRICAL INSTRUMENT CO., Grenier Field, Manchester, N. H. A new antiparallax scale that places dial markings in the same plane as the pointer has been designed for use with the MM-3 3½ in. Medalist meters. The calibrated portion of the scale is raised from the dial face and is in the same plane as the pointer. The pointer tip swings under the scale so that calibration marks, from any angle, appear to be a continuation of the pointer, thereby eliminating any errors due to parallax. Circle 318 on Reader Service Card.



Rectilinear Pot
small, compact

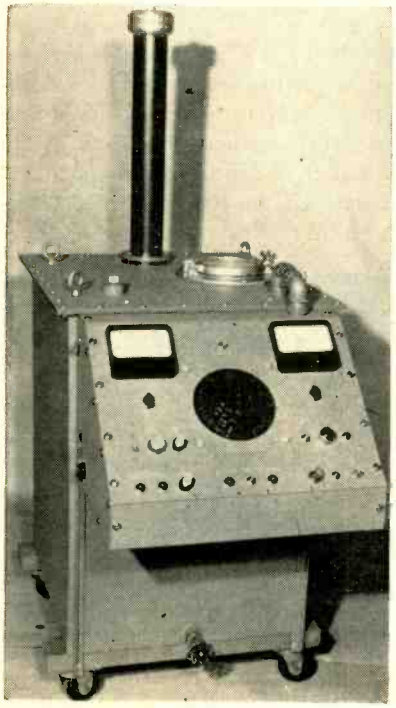
DEJUR-AMSCO CORP., 45-01 Northern Blvd., Long Island City 1, N. Y. Series RP-125 miniature trimming pot meets environmental specifications of MIL-R-19. It measures only 1¼ in. in length and is available in a complete range of resistances. A multifinger contact brush travels along the wirewound resistance element which is permanently bonded to the card to eliminate loose turns or shifting

wires. Insulation on wire is removed by a unique process without altering cross-section or winding resistance. Circle 319 on Reader Service Card.



Pulse Transformer miniaturized

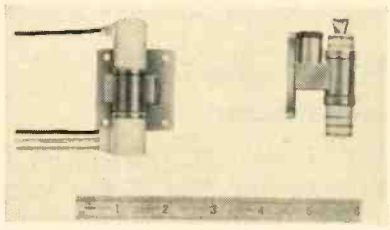
ESC Corp., 534 Bergen Blvd., Palisades Park, N. J. A new series of miniature pulse transformers are only $\frac{3}{8}$ in. long with an o.d. of $\frac{1}{2}$ in. They are available as blocking oscillator pulse transformers covering a range of pulse widths from 0.05 μsec to 2.0 μsec, and pulse coupling transformers covering a wide range of impedance ratios and pulse widths. Circle 320 on Reader Service Card.



Insulation Tester completely mobile

Peschel Electronics, Inc., R.F.D. No. 1, Patterson, N. Y., announces a 120 kv high voltage d-c test set, a completely mobile one

piece unit which can be rolled to the job, for lab or production dielectric testing of insulation on large motors, generators, transformers, bushings, cable. It is used for nondestructive evaluation of insulation quality—for quantitative tests to determine nature and degree of fault and possible life expectancy of insulation. **Circle 321 on Reader Service Card.**



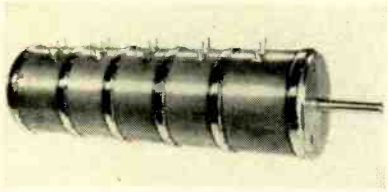
Reflex Klystrons for X and K band

EITEL-MCCULLOUGH, INC., San Bruno, Calif. The 1K20 series of ceramic-metal X-and K-band reflex klystrons consists of four lightweight, ruggedized tubes that cover the 8,500 to 11,700 mc range at output power levels to 50 mw. They will withstand vibration levels of 15 g in any reference plane, with less than 100 kc frequency deviation. Rated for use at any altitude they are conservatively rated at + 250 C seal temperature. **Circle 322 on Reader Service Card.**

Bobbin Cores new type cap

MAGNETICS, INC., Butler, Pa., has available tape wound bobbin cores capped with a tough glass polyester which offers complete core protection. "Poly Cap" bobbin cores offer economies in handling and pro-

duction since the rigid structure of the cap, which will not distort with temperature changes, allows complete freedom of handling on the assembly line without the use of tweezers or special tools. High permeability, along with the small core's ability to switch from positive to negative saturation in a very few microseconds, makes the cores highly suitable for use in pulse applications in electronic computers. Circle 323 on Reader Service Card.



Precision Pot
low-capacitance

PRECISION LINE INC., 63 Main St., Maynard, Mass. Model RP20 precision pot has been designed especially to reduce the element-to-ground and element-to-element capacitance to the minimum. Isolation of the slip ring and resistance winding by design and the use of phenolics where metal is normally used has resulted in interelement capacitance and capacitance-to-ground of approximately 11 $\mu\mu$f with low inductance. The pot is available in linear and 3 to 1 taper and resistance to 100,000 ohms. It may be ganged up to 5 units. Circle 324 on Reader Service Card.

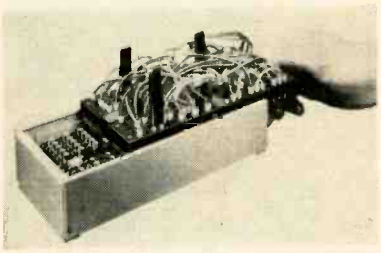
Moisture Monitor
0-20,000 ppm range

CONSOLIDATED ELECTRODYNAMICS CORP., 300 N. Sierra Madre Villa, Pasadena, Calif. Type 26-302 moisture monitor will measure water content accurately down to 10 ppm full-scale and permit precise

meter readings over the range of 0-20,000 ppm, by means of a 6-position attenuator. The output of the analyzer can be telemetered to a remote recorder for monitoring or control. The new instrument can help solve many problems in research, quality control, and process efficiency studies. Circle 325 on Reader Service Card.

Electric Counter with six digits

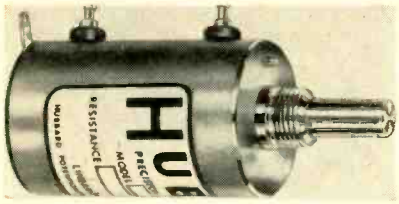
General Controls Co., 8070 McCormick Blvd., Skokie, Ill. Two hundred million count life, full wave rectification for a-c operation and complete dustproof enclosure are featured in the new CE-800 electric counter. A built-in silicone diode full wave bridge rectifier with capacitor makes possible maximum reliability and service life through all a-c voltages to 230 with 25, 40 and 60 cycle frequencies. Rated at 1,000 counts per minute, the new Wizard operates reliably at much higher speeds with electronic actuation. Circle 326 on Reader Service Card.



Programming System light-weight

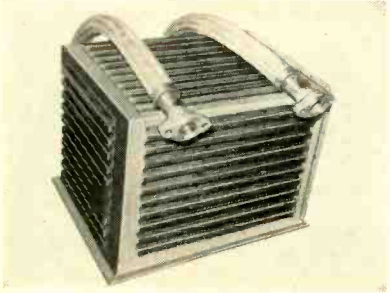
AMP Inc., Harrisburg, Pa., has released a new light-weight patchcord programming system designed for split second reprogramming of air-

borne circuitry. The A-MP240 weighs 3¾ lb and is miniaturized to conserve space. Removable, pre-patched boards make complete circuitry reprogramming possible in a matter of seconds. Seating of patch-cord pins are designed for shock resistance. Patented wiping action assures pre-cleaning of contact springs and taper pins. Circle 327 on Reader Service Card.



Miniature Pot
15-turn unit

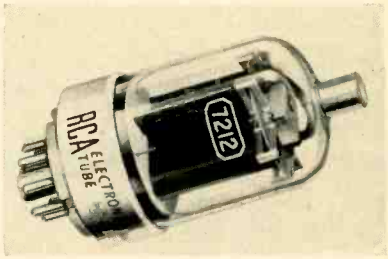
Hub-Pot Inc., 1242 E. Transit St., Pomona, Calif. Model HP-151 15-turn miniature pot is 1 in. in diameter with a case 1 39/64 in. long and with a ⅛ in. or ¼ in. slotted shaft that is 11/16 in. long. It features low torque and better resolutions. Standard resistance values are from 50 ohms to 150 K ohms. Unit will dissipate 4 w at 40 C and will perform perfectly under shock, vibration, acceleration and temperatures, from −65 to +85 C. Circle 328 on Reader Service Card.



Heat Exchangers
high capacity

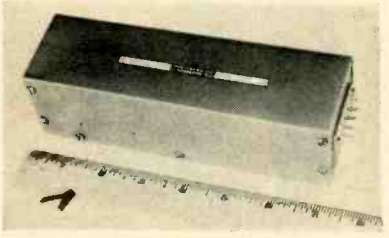
Tenney Engineering, Inc., 1090 Springfield Rd., Union, N. J., has developed a new line of high capacity heat transfer surfaces. They are designed to operate under reduced pressure with a high degree of heat exchange for cooling and heating purposes. Units are

expected to find increased utility in a wide range of industrial and military applications as oil and fuel coolers, air to air exchangers, liquid to air exchangers, liquid to liquid exchangers, saturated vapor to air exchangers, and as evaporators and condensers for compartment cooling. Circle 329 on Reader Service Card.



Beam Power Tube small in size

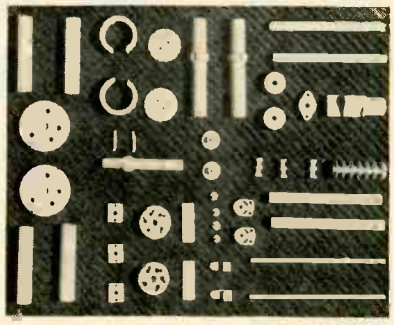
Radio Corp. of America, Harrison, N. J. The 7212 is a small beam power tube designed specifically for applications where dependable performance under severe shock and vibration is essential. It is useful as an r-f power amplifier as well as an a-f power amplifier and modulator. Maximum plate dissipation is 25 w under ICAS conditions in modulator service and in c-w service. In the latter service, it can be operated with full input to 60 mc and with reduced input to 175 mc. Circle 330 on Reader Service Card.



Power Supply high temperature

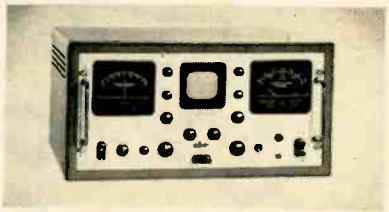
The Daven Co., Livingston, N. J., has developed a new high-temperature, regulated transistor power supply, series 60A, for missile and aircraft applications. Units have been proven during lengthy test procedures ideally suited to provide the power required for highly sensitive command, guidance and

destruction receivers; or for any other electronic gear. The units permit continuous operation at full load in an ambient temperature of 85 C without heat sink. Circle 331 on Reader Service Card.



Steatite Ceramic low loss

D. M. STEWARD MFG. Co., Chattanooga, Tenn., announces production of a new steatite, S-500 material classed as L-5, Jan Specs 1-10. It is an extremely dense, low loss, steatite ceramic which can be fabricated to close tolerance in pressed or extruded machined shapes. Glazing can be very easily added and grinding facilities are available to achieve tolerances of ±0.0005. Circle 332 on Reader Service Card.



Flutter Meter wide-band unit

D&R, LTD., 402 E. Gutierrez St., Santa Barbara, Calif. Model FL-4B wideband flutter meter is designed for precision measurement of flutter and wow components on high speed tape transports. Features include improved linearity, input band-pass filters, built in oscilloscope for visual flutter presentation, internal band-pass filters, drift and rms flutter meters, and provisions for external recording of flutter information. Circle 333 on Reader Service Card.

Literature of

MATERIALS

Epoxy Glass Laminate. The Mica Corp., 4031 Elenda St., Culver City, Calif., has issued a 21-page technical data manual containing test values and curves, plus specification data, on high reliability epoxy glass copper clad and unclad laminates. **Circle 350 on Reader Service Card.**

Nuclear Fuel Elements. Sylvania-Corning Nuclear Corp., Bayside, L. I., N. Y. A 64-page bibliography contains 306 references on problems concerning solid fuel elements, such as fabrication and properties. Copies, limited to one per company, may be obtained by writing on company letterhead.

Making Magnetic Tracks Visible. Reeves Soundcraft Corp., 10 E. 52nd St., New York 22, N. Y., announces a technical bulletin describing Magna-See, a non-toxic chemical solution which makes visible the sound track recorded on magnetic tape and can be used for editing and splicing video recording tape. **Circle 351 on Reader Service Card.**

COMPONENTS

Chokes. National Co., Inc., 61 Sherman St., Malden, 48, Mass. A four-page folder describes a full line of chokes. It contains illustrations and complete specifications on 17 types including ferrite bead chokes, ferrite core chokes, MIL-inductance chokes and r-f chokes. **Circle 352 on Reader Service Card.**

Subminiature Delay Lines. NYT Electronics, Inc., 2979 N. Ontario St., Burbank, Calif. Bulletin 140 describes a small-size new series of standard delay lines which meet requirements of MIL-C-15305A, grade 1, class B. **Circle 353 on Reader Service Card.**

Deflection Systems and Components. Radio Corp. of America, Camden, N. J. A full line of precision deflection systems, and components designed for itv and broadcast cameras and other crt applications are described and illus-

the Week

trated in a six-page brochure, Form 3R-3295. **Circle 354 on Reader Service Card.**

EQUIPMENT

Power Supplies. Kepco Laboratories, Inc., 131-38 Sanford Ave., Flushing 55, N. Y. Catalog B587 describes a complete line of voltage and current regulated power supplies including transistorized, magnetic and vacuum tube types. **Circle 355 on Reader Service Card.**

Electronic Apparatus Racks. Par-Metal Products Corp., 32-62 49th St., Long Island City 3, N. Y. Catalog No. 58 lists and illustrates a complete line of relay racks, cabinets, panels and other accessories. **Circle 356 on Reader Service Card.**

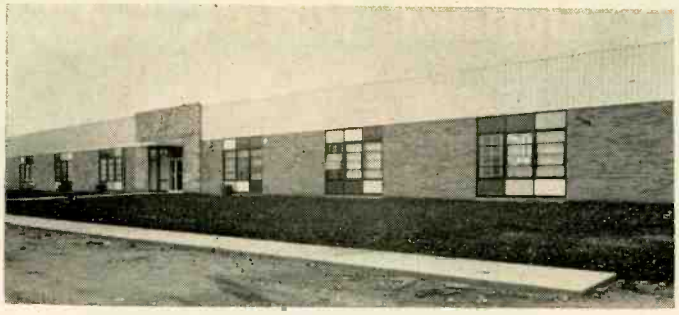
Particle Accelerators. High Voltage Engineering Corp., Burlington, Mass. A 12-page booklet describes the many known and potential applications of both Van de Graaff and linear accelerators, utilizing photographs and line drawings to point up significant design and performance features. **Circle 357 on Reader Service Card.**

Military Power Supplies. General Electric Co., Schenectady 5, N. Y. Bulletin GEC-1496 provides information on a 28-v, 200-ampere, ground support d-c power supply. **Circle 358 on Reader Service Card.**

FACILITIES

Coil Windings. The Dano Electric Co., 93 Main St., Winsted, Conn., has available a 2-color catalog covering its various coil departments and facilities. Incorporated into the catalog is a handy 9-page reference section dealing with technical coil designing data. **Circle 359 on Reader Service Card.**

Forced Air Cooling. McLean Engineering Laboratories, P. O. Box 228, Princeton, N. J. Purpose of a recent 6-page technical booklet is to supply engineering information on thermal design and to survey methods of cooling electronic components. **Circle 360 on Reader Service Card.**



IFI Settles in New Plant

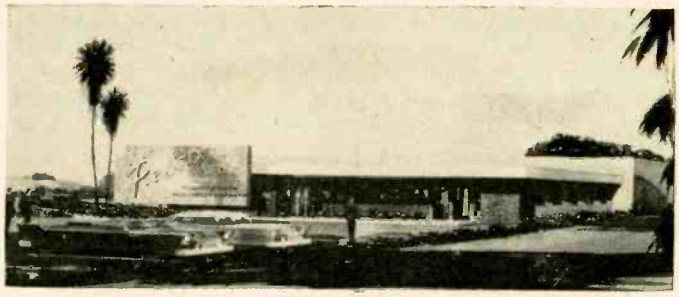
AFTER busting out of its old shell in Mineola, N. Y., Instruments for Industry is now settling into a new plant in the Hicksville, L. I., industrial park.

The ultramodern 38,000-sq ft building is equipped to comfortably house IFI's research and engineering activities, and at the same time phase in an increasing volume of equipment production.

IFI was founded in 1951 by Elston H. Swanson around a nucleus of engineers and administrators. The firm is largely devoted to countermeasures work, with prime contracts in this area from all three services. IFI worked in the development of the repeater type of active countermeasure, in which hostile radar signals are received, delayed and retransmitted to give the appearance of many targets instead of only one.

Engineering work on this and other systems was IFI's major endeavor for some time. Now, with the systems phasing into production, the firm was pushed into expanding to make room for the assembly benches.

Commercial proprietary products outgrowing from the government work are a line of wideband amplifiers using traveling-wave tubes. The firm has also developed a novel—but still classified—delay-line storage device. Director of engineering for the young company is Eugene B. Novikoff.



New Pesco Branch in Action

VOLUME production of precision generators and inverters for aircraft and missiles is already under way in the new $1 million plant of Western Branch, Pesco Products Division, Borg-Warner Corp.

Situated on a large expandable site in Burbank, California, the new plant, with Allen T. Puder as operations manager, will house offices, engineering laboratory and manufacturing facilities. Important products now in manufacture include the Pesco permanent magnet alternator and rotary inverters used in many of the major missiles and supersonic aircraft. As a result of extensive development work, static inverters, meeting rigid space age requirements, will be in production by the end of the year.

The new facility brings together, in one location, the three segments of the company previously situated in Sherman Oaks, North Hollywood, and Azusa, California, and will permit the closely integrated production operation required by governmental and commercial precision standards.

Name Patterson Chief Engineer

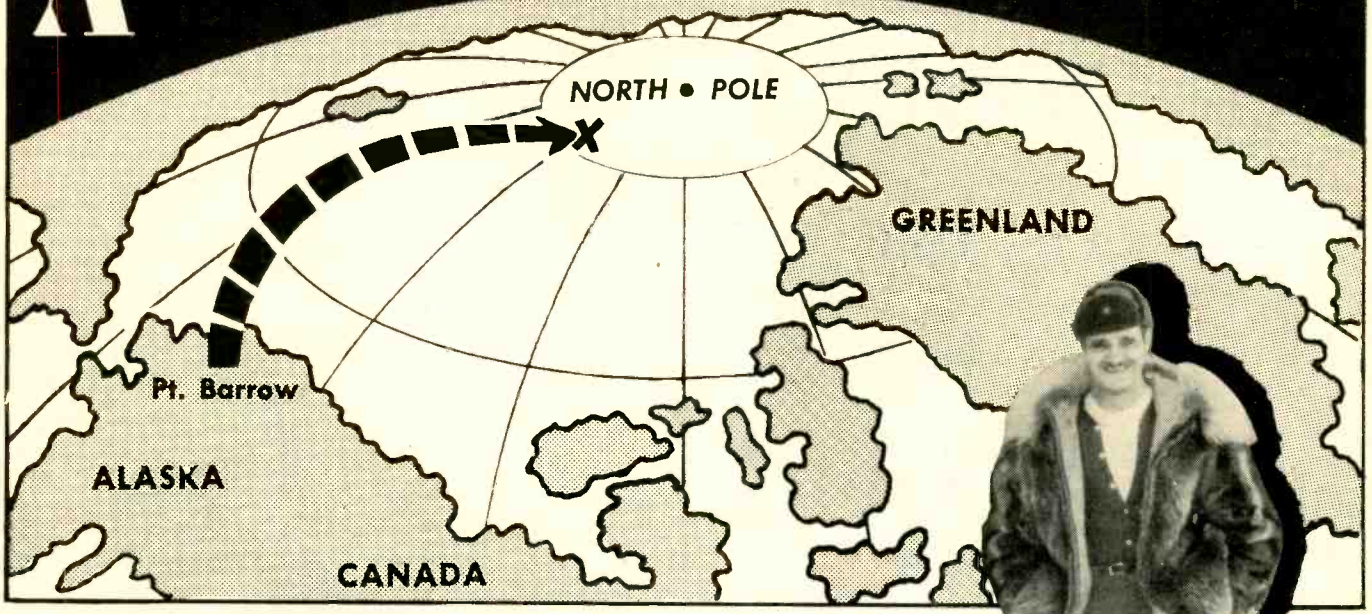
THE newly-created post of chief engineer of Sierra Electronic Corp., Menlo Park, Calif., goes to Guy K. Patterson. He will direct Sierra's engineering and laboratory programs, including product development. He previously was a project engineer with the company.

Prior to joining Sierra in 1948, Patterson was on the engineering staff of the Federal Telecommunication Laboratories in New York City.

Hock Advances At Technitrol

APPOINTMENT of Roy Hock as chief engineer is announced by Technitrol Engineering Company, Philadelphia, manufacturer of

ADVENTURES *in* ELECTRONICS



AT THE TOP OF THE WORLD ON AN ISLAND OF ICE

"TechRep" Floats 8 Months On Arctic Ocean Ice Floe

by C. F. Graebe

Mike Swiercz, well-traveled Philco Field Engineer, is a veteran of 6 years in Japan and Alaska. He is now in Tripoli, North Africa.

Seven men adrift on an island of ice twelve feet thick, a mile above the Arctic Ocean floor, floating just 450 miles from the North Pole in bone-chilling minus-40-degree temperatures: that was the hazardous setting for Project Ice Skate — one of America's significant contributions to the International Geophysical Year.

On this isolated team of adventurous volunteers was Field Engineer Mike Swiercz — the group's communications expert and only civilian. With him were three Army polar specialists, two Eskimos, and a Jesuit priest who doubled as an Arctic veteran.

Flown from Pt. Barrow, Alaska, to their wind-whipped ice floe on April 5th last year, this hand picked crew was left to observe and measure Arctic phenomena. With special instruments they studied Arctic conditions of geomagnetism, gravity, oceanography, meteorology and seismology. For eight months their sole contact with the outside world was by radio.

"Radio communication was better than anyone had thought possible," reported Mike. "I had an antenna up four days after we landed on the ice, and that same day we were talking to the men at the South Pole and later listened to Sputnik's 'beep-beep' as it passed overhead."

Asked if the dangers of the icy wilderness and the fight against endless cold didn't grate on the men's nerves, Mike replied, "No, that's Hollywood stuff; we all got on just fine. Remember, there was plenty of interesting work to be done, and the food was very good. I'm glad I asked for the assignment."

We, at the Philco TechRep Division in Philadelphia, are proud of Mike Swiercz's contribution to the IGY. His experience as a Philco TechRep doing an exciting job is, however, only the first of a series profiling the fascinating and unique adventures of our TechRep engineers and technicians to be published here in the months ahead.

pulse transformers, delay lines and computer systems.

Joining Technitrol in 1956, Hock became a senior supervisory engineer responsible for the complete design and construction of data processing systems and digital control mechanisms. In his new position as chief engineer he will assume the technical direction of all engineering projects.

Taylor Assumes New Position

PROMOTION of Ray Taylor to chief engineer of Varo Mfg. Co., Garland, Texas, is announced. During his three years with the company as project engineer he has designed communications equipment, both airborne and ground power conversion equipment, and frequency meters and standards.

Tube Plant Opens

LITTON Industries recently opened the first unit of its new 60,000 sq ft tube plant in Salt Lake City, Utah.

The plant, newest production arm of the company's Electron Tube Division with headquarters

in San Carlos, Calif., will be managed locally by Vinton D. Carver. It is located on a ten-acre site opposite the Salt Lake airport. It will ultimately employ more than 600 persons manufacturing magnetrons, klystrons and other microwave tubes.

Creighton Heads Motorola Group

A Combat Surveillance Group has been established in Phoenix, Ariz., by Motorola's Western Military Electronics Center. Purpose is to focus increased R&D efforts on the rapidly expanding airborne surveillance field.

Selected to manage the new organization is Allen M. Creighton, former head of the communications section of W.M.E.C. The new group, which is responsible directly to R. E. Samuelson, manager of engineering, has a two-fold function—to exercise systems planning and coordination over all Motorola Military Electronics Division airborne surveillance projects, and to carry out projects directly assigned to the group.

Before appointment to his present position, Creighton was in charge of all Signal Corps communications projects at Motorola's Phoenix laboratories.

Burroughs Fills Three New Jobs

Three new positions at Burroughs Research Center, Paoli, Pa., were recently announced by R. V. D. Campbell, deputy director.

U. C. S. Dilks, formerly man-

ager, research division, is new associate director-commercial products; while Edward Lohse, former manager, ballistic missile division, is new associate director-defense products, a parallel position.

The positions, established to strengthen commercial and military technical planning, will be directed by Campbell.

At the same time Campbell announced the promotion of J. H. Howard, with Burroughs since 1950, to manager, research and development division. The new division is a merger of all commercial research and development efforts.

Rixon Hires J. A. Elliott

JAMES A. ELLIOTT has joined Rixon Electronics, Inc., as engineer in charge of quality control at its plant in Silver Spring, Md. He was formerly with Collins Radio Co., Cedar Rapids, Iowa, where he was engaged in design, component testing and component application.

Plant Briefs

Don Romine Associates, Westbury, N. Y., has been organized to design and construct environmental simulation equipment for testing space vehicles and components according to specifications.

Cushman Precision Industries, Princeton Junction, N. J., is a new company formed for the development, test and manufacture of electromechanical precision rotat-

ing components for the electronic, missile and aircraft industries.

Delta-f Inc., Batavia, Ill., manufacturer of frequency control systems and equipments, has been introduced to the electronics field by recently elected president John A. Cunningham, formerly division manager of Hamilton Watch Co.

News of Reps

SALES rep organizations recently appointed by Chester Cable Corp. are **Robert W. Gray, Inc.**, of New England, and **Ringland M. Krueger Co.** for Illinois and Wisconsin.

DeMornay-Bonardi, Pasadena, Calif., manufacturers of microwave test instruments, appoint **Instrument Dynamics, Inc.** as their new sales and engineering representatives in New England.

The Columbus Electric Mfg. Co., Columbus, Ohio, makers of precision snap switches, name **Kahant Associates** as exclusive reps for eastern New York State and northern New Jersey.

Bach Sales Co., a new rep organization in Old Bethpage, L. I., N. Y., will handle the high fidelity component line of Fairchild Recording Equipment Corp. in the N. Y. area.

Aero Sales Co. of Caldwell, N. J., now handles cooling and ventilating fans for electronic equipment cabinets for Kooltronic Fan Co., Princeton, N. J.

Industrial Test Equipment Co. appoints the **Broger Instrument Sales Co., Inc.**, to handle the sales of its Phazor and Iteco product lines of electronic test equipment in the New England area.

Penta Laboratories, Inc., Santa Barbara, Calif., names three new sales reps to handle its line of power tubes. **T. J. Ray Co.** will cover Oklahoma; **L. F. Florence Co.**, western Iowa and the states of Nebraska, Kansas and Missouri; and **Nortel Engineering Service Co.**, Ontario, Quebec and the Maritime Provinces.

Atmospheric Explorations

By HENRY G. HOUGHTON.

Technology Press of the Massachusetts Institute of Technology and John Wiley and Sons, 1958, 125 p, $6.50.

THE lectures which comprise the five chapters of this entertaining book were given in 1956 by leaders of research in their respective fields to commemorate the 250th anniversary of the birth of Benjamin Franklin. All chapters are written in semitechnical language both understandable and meaningful to readers of ELECTRONICS. All chapters have good bibliographies.

Dr. Ross Gunn, for years the Director of Physical Research for the U. S. Weather Bureau, known to electronic engineers for his work on precipitation static and for his fabulous 28-page paper on thunderstorm electrification in the *Proceedings of the Institute of Radio Engineers* last October, describes some of his many researches on the electrification of cloud and raindrops.

Dr. J. P. Kuettner, of the Geophysical Research Directorate, Air Force Cambridge Research Center, one of the country's leading glider pilots, discusses the Electrification of Thunderstorms with emphasis on his unmasking theory of charge separation.

Professor L. B. Loeb, who has had a lifetime of research in gaseous electronics and probably has written more on the subject than any man alive, contributes an excellent summary including very recent work on the positive streamer spark and its relation to lightning. Radar engineers may be interested to read how millimicrosecond techniques have been applied to the study of spark discharge.

Dr. Harry Wexler, Director of Meteorological Research for the U. S. Weather Bureau, "Looks at the Upper Atmosphere" from the ionosphere on down and discusses the physical processes such as absorption of solar radiation, that have such an important but not immediately obvious relationship to

our weather at the ground.

Professor Henry Booker of Cornell University discusses some currently interesting phenomena of radio scattering in the ionosphere. Should there be an electronics engineer (perhaps a computer man) who does not have an understanding of ionospheric echoes, meteor echoes, auroral echoes, vhf scatter, spread F and sporadic E phenomena, this chapter with its very good summary of these effects is one to read.—SEVILLE CHAPMAN, *Director, Physics Division, Cornell Aeronautical Laboratory, Buffalo, N. Y.*

The Ultra High Frequency Performance of Receiving Tubes

By W. E. BENHAM AND I. A. HARRIS.
McGraw-Hill Book Company, Inc., New York, 1957, 173 p, $6.50.

ONE purpose of this book is to present the theory of operation of uhf receiving tubes with emphasis on the equivalent circuits valid for small signal operation. A second purpose is to give a simple, detailed account of the electronic processes occurring in the tube which will provide the mathematical background required for the investigation of new problems in this field.

The book should appeal to engineers interested in the applications of receiving tubes at uhf and to engineers engaged in uhf vacuum tube research and development. The authors have carefully selected portions of the works of such leaders in this field as Muller, Llewellyn, Bakker, Devries, North as well as that of their own excellent research. The result is a particularly good, high level and concise book.

Scope and Special Features—The book starts with a general survey of space-charge control tubes including the internal action of a tube, the interaction between the tube and the circuit, and the high-frequency equivalent circuit of practical tubes.

The next three chapters deal with current in an interelectrode space, the small-signal high-fre-

quency characteristics of idealized basic diodes and the small-signal high-frequency characteristics of ideal triodes and tetrodes. These chapters start with a discussion of fundamental concepts of the tube theory. A basic equation describing the motion of an electron in the presence of space-charge is then developed. At this point the small-signal admittance of the parallel-plane diode is derived. By considering gridded tubes as a series of planar diodes, the parallel plane triode and tetrode characteristic are determined. Equivalent circuits for these tubes are discussed.

A very interesting chapter follows on the differences between actual and ideal tubes in which effects of initial electron velocity, nonuniform cathode fields and secondary anode emission are discussed. The characteristics of tubes operating in retarding fields are then discussed in the two chapters that follow.

The chapter on the tube as a linear active two-terminal-pair circuit element is of particular interest to engineers interested in tube applications. Analysis of the grounded cathode and grid triodes are discussed. A chapter on large signal theory is mostly qualitative as much work remains in developing a satisfactory large signal theory.

The final chapter, and one of the most interesting, is on calculation of noise factor. The fundamental principles are discussed including the high-frequency shot-noise reduction factor, the calculation of noise factor and the effect of reflected electrons on the induced noise currents. An excellent discussion on the agreement of theory with experimental result is included.

Analysis—The authors have prepared a very readable book on uhf tubes. Development of the text material is very good and excellent use of the seven mathematical appendices is made to supplement the text material. For the purposes intended by the authors, the degree of completeness of the material appears to be about right. While there are other books avail-

able on vacuum tubes, this one includes more detail on the high-frequency performance of receiving tubes. An excellent feature of the book is that it provides the reader not only with an authoritative source of information but with a state of the art review.

This reviewer is pleased to endorse this book as an excellent up-to-date reference on uhf tubes. It should be of particular interest to persons engaged in active networks using vacuum tubes, to engineers interested in perfecting the tubes themselves and to graduate students engaged in research in ultra high frequency tubes and circuits.—G. C. DALMAN, *School of Electrical Engineering, Cornell University, Ithaca, N. Y.*

THUMBNAIL REVIEWS

Better Report Writing. By W. H. Waldo, Reinhold Pub. Corp., New York, 1957, 231 p, $4.75. This desk guide presents facts on the details of composition, style, dimension of reports, tables, illustrations and use of words in a format calculated to provide the engineer with a quick reference to turn to for answers to his impromptu questions concerning writing.

Aeronautical Electronics Conference Proceedings. The National Conference on Aeronautical Electronics, 53 Park Ave., Dayton 9, Ohio, $4.00. Complete texts and illustrations of 10 papers on equipment applications, 18 on component parts, 10 on navigation, six on communications, six on electronic equipment, nine on management research and production, 15 on environment and six on air safety given at 1957 conference in Dayton.

Design of Free-Air Ionization Chambers. By H. O. Wyckoff and F. H. Attix, Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., 1957, 16 p. $.20 (paper). This National Bureau of Standards publication presents general design characteristics for standard free-air type ionization chambers for X-rays from 50 to 500 kv. Accuracy of free-air chamber measurements is given in a table which lists the estimated maximum error for each experimental factor.

Programs for an Electronic Digital Computer. By M. V. Wilkes, D. J. Wheeler and S. Gill, Addison-Wesley Publishing Co., Inc., Second Edition 1957, 238 p, $7.50. A general introduction to programming for any machine of the stored-program type. Emphasis is placed, however, on the single-address binary machine.

COMMENT

The Solid-State Switch

We just saw the Aug. 1 issue of ELECTRONICS, which contained (p 108) your note on our solid-state switch, including the two photographs . . .

While we appreciate the publication of that note, we are quite disappointed that you have failed to mention the name of the organization where the new device originated.

The solid-state switch was developed by Kurt O. Otley, Robert F. Shoemaker and Philip J. Franklin of the Diamond Ordnance Fuze Laboratories in Washington, D. C. You might also want to add the information that the switch is described in somewhat greater detail in the *1958 Conference Proceedings of the 2d National Convention on Military Electronics*, June 16-18, 1958.

PHILIP J. FRANKLIN
DIAMOND ORDNANCE FUZE LABORATORIES
WASHINGTON, D. C.

So many questions have come in from readers asking about the rugged solid-state switch that uses the operating principles of an electrolytic capacitor that we're delighted to be able to provide this additional information.

Spikes

The comments by Messrs. Simmons and Todd (Comment, p 190, Sept. 12) on the mechanism by which spikes are formed in the transistor inverters described in my recent article ("Magnetic Inverter Uses Tubes or Transistors," p 158, Mar. 14) are very interesting. My main concern was with the salient features of the differential common-base type of inverter, as compared with the common-emitter inverter. No very detailed investigation of the cause of the spikes was conducted by me.

Tight coupling between the various windings is obviously desirable even if only the gross features of circuit operation are considered. For this reason the magnetic cores used in the circuits described in the article were of toroidal form and

of high-permeability magnetic material. The windings were placed one on top of the other and uniformly distributed around the whole core periphery as shown in the illustrations in the article. Further improvement in coupling would certainly be obtained by using twisted pair, and of course spacing the windings at discrete intervals around the core periphery would loosen the coupling.

Whether it is desirable to use only a small portion of the core periphery for the windings is open to question, however. This measure does not greatly tighten the coupling and, besides making uneconomical use of the winding space available, it has the effect of lowering somewhat the permeability of the magnetic circuit as a whole since more flux will escape to the air. In some cases the use of twisted pair may be open to objection on the grounds of voltage stress in the windings, since the voltage across the nonconducting element may be appreciable when high-voltage transistors or vacuum tubes are used.

The comments by Messrs. Simmons and Todd do show, however, that the transformer coupling is intimately connected with the nature and magnitude of the spikes, and even more conclusively . . . show the effect of load upon the damping of these transients. Nevertheless the measures suggested do not eliminate completely the spikes from the no-load output waveform.

There is probably more to be learned about the switching process. Many earlier articles on the subject have ignored the matter. Little or no mention of spikes in the output waveform has appeared, and the absence of waveform photographs in many cases does little to give assurance that they have not been present. In the writer's experience the spikes in some cases are of extremely short duration compared with the period of the square wave and are likely to be missed altogether if waveforms are observed with anything but a wideband oscilloscope.

C. H. R. CAMPLING
DEPT. OF ELECTRICAL ENGINEERING
QUEEN'S UNIVERSITY
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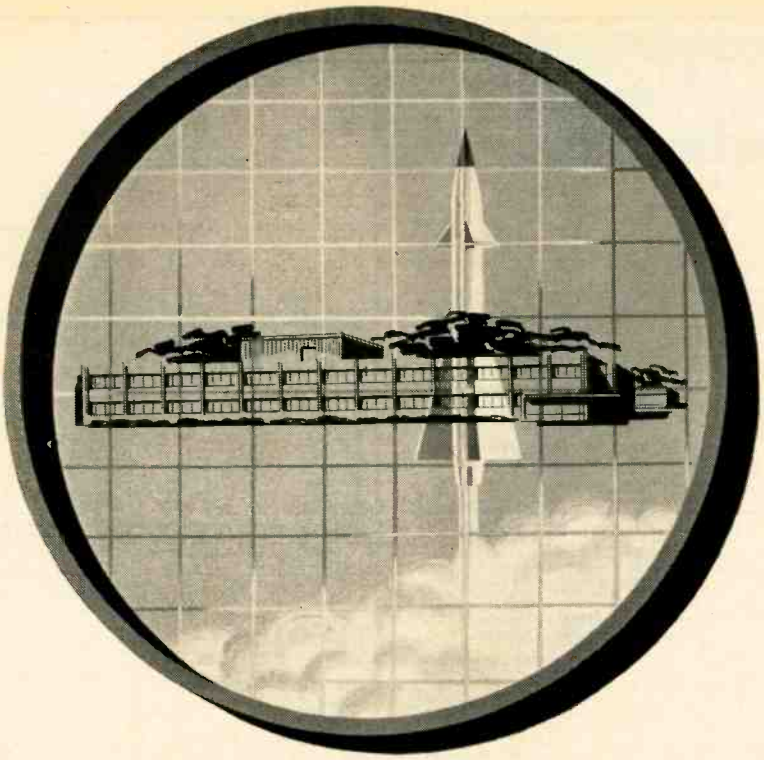

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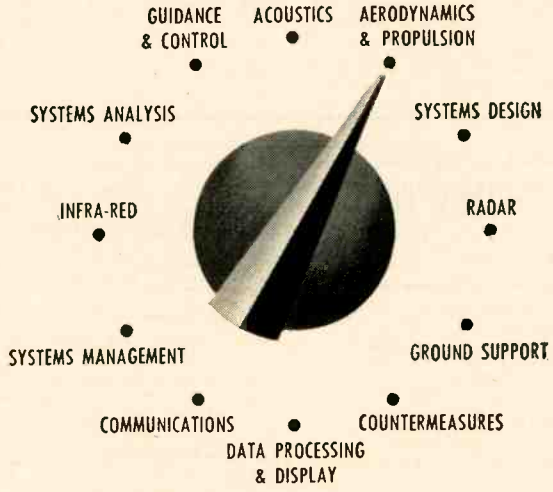

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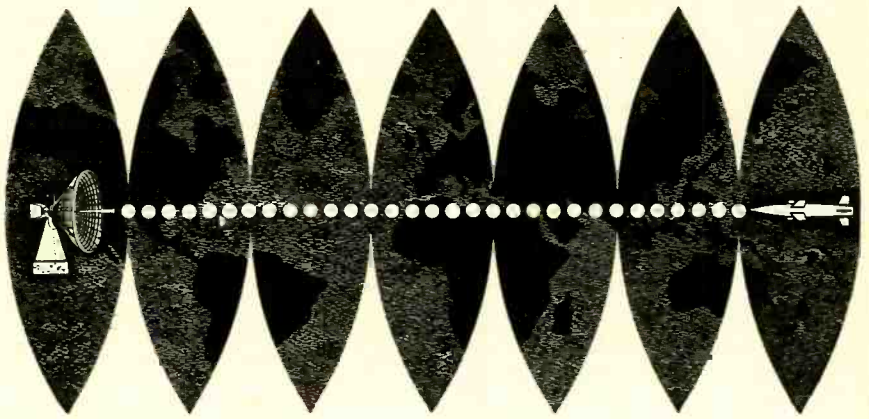

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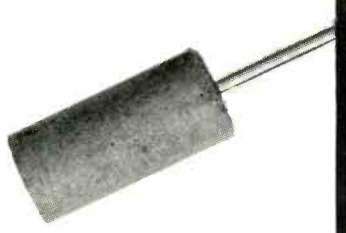

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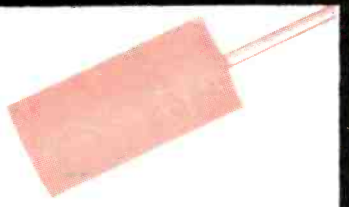

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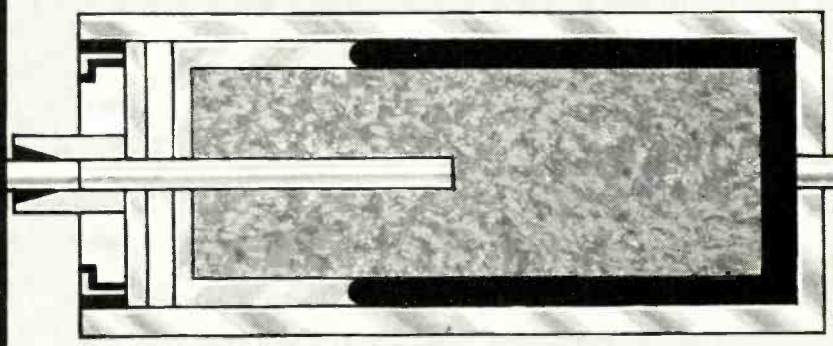

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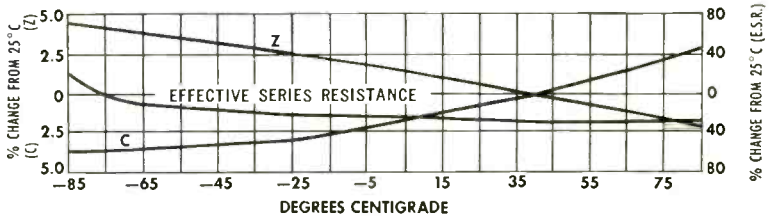

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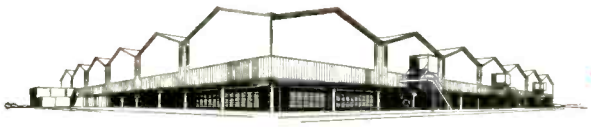

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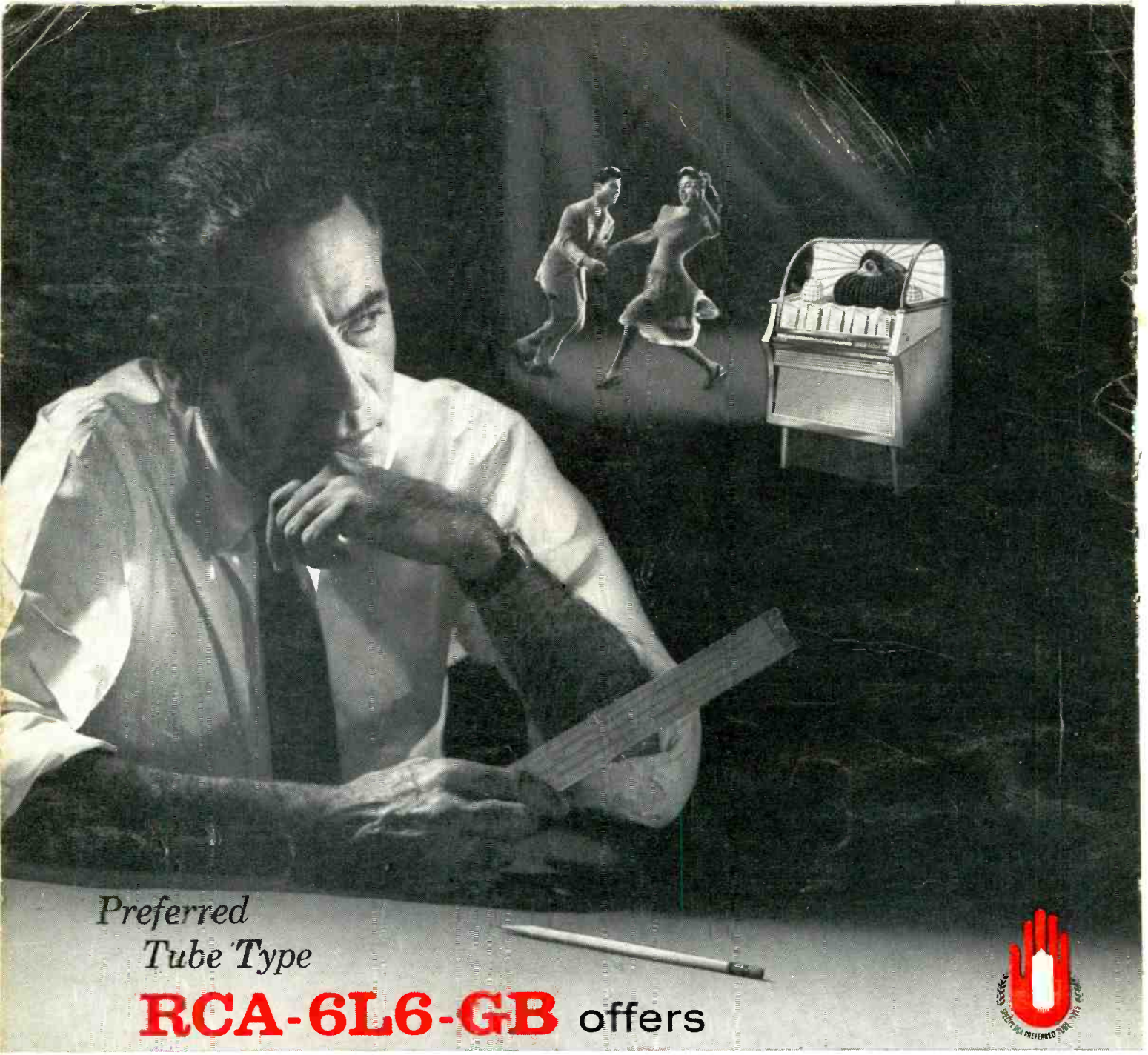

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