June 24, 1960

electronics

A McGraw-Hill Publication 75 Cents

SPECIAL REPORT *Multiple focal length honeycomb antenna for high-power radar is one of many advances revealed in roundup of modern microwave developments*

Audio, telemetry and low frequency oscillators

Pictured here are six of the most widely used oscillators in electronics. All employ the highly stable, dependable, accurate resistance-capacity circuit. They require no zero setting. Output is constant, distortion is low and frequency range is wide. Scales are logarithmic for easy reading; all are compact, rugged and broadly useful basic instruments. Brief specifications are given below; call your hp rep for demonstration or write direct for complete data on any instrument.

Model	Frequency Range	Calibration Accuracy	Output to 600 ohms	Recommended Load	Maximum Distortion	Max. Hum & Noise ¶	Input Power	Price
200AB	20 cps to 40KC (4 bands)	±2%	1 watt (24.5 v)	600 ohms	1% 20 cps to 20 KC 2% 20 KC to 40 KC	0.05%	70 watts	$150.00
200CD	5 cps to 600 KC (5 bands)	±2%	160 mw 10 volts	600 ohms*	0.5% below 500 KC 1% 500 KC and above	0.1%	75 watts	$170.00
200J	6 cps to 6 KC (6 bands)	±1%†	160 mw 10 volts	600 ohms*	0.5%	0.1%	110 watts	$300.00
200T	250 cps to 100 KC (5 bands)	±1%†	160 mw 10 volts	600 ohms*	0.5%	0.03%	160 watts	$450.00
201C	20 cps to 20 KC (3 bands)	±1%†	3 watts (42.5 v)	600 ohms**	0.5%‡	0.03%	75 watts	$225.00
202C	1 cps to 100 KC (5 bands)	±2%	160 mw 10 volts	600 ohms*	0.5%§	0.1%	75 watts	$300.00

*Internal impedance is 600 ohms. Frequency and distortion unaffected by load resistance. Balanced output with amplitude control at 100. Use line matching transformer for other control settings. **Internal impedance approximately 600 ohms with output attenuator at 10 db or more. Approximately 75 ohms below 5000 cps with attenuator at zero. †Internal, non-operating controls permit precise calibration of each band. ‡0.5%, 50 cps to 20 KC at 1 watt output. 1.0% over full range at 3 watts output. §0.5%, 10 cps to 100 KC. 1.0%, 5 to 10 cps. 2.0% at 2 cps. 3.0% at 1 cps. ¶Measured with respect to full rated output.

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6036

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hp 200J
Interpolation Oscillator

hp 200T
Telemetry Oscillator

hp 201C
Audio Oscillator

hp 202C
Low Frequency Oscillator

hp pioneered the world-famous resistance-capacity oscillator circuit

June 24, 1960

electronics

A McGraw-Hill Publication 75 Cents

W. W. MacDONALD, Editor

BUSINESS

ENGINEERING

DEPARTMENTS

3M COMPANY CHEMICALS THE RAW MATERIALS OF PROGRESS

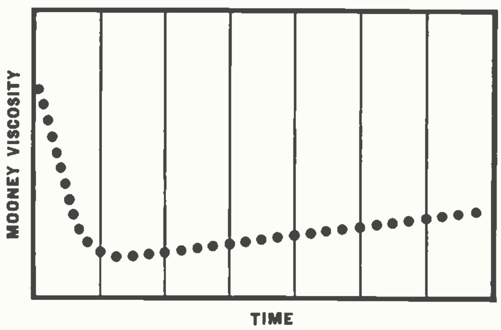
NEW FLUOREL® 2141

BRAND ELASTOMER

Its Mooney Scorch Rating is ideal for the fluorinated rubber processor because it makes possible fast, more economical cures with fewer defects, less scrap, fewer rejected parts. Material can be reprocessed with greater safety.

A SIGNIFICANT BREAKTHROUGH in elastomer processing has been made possible by 3M research through development of its new FLUOREL 2141 Elastomer.

This remarkable new product has a Mooney Scorch Rating

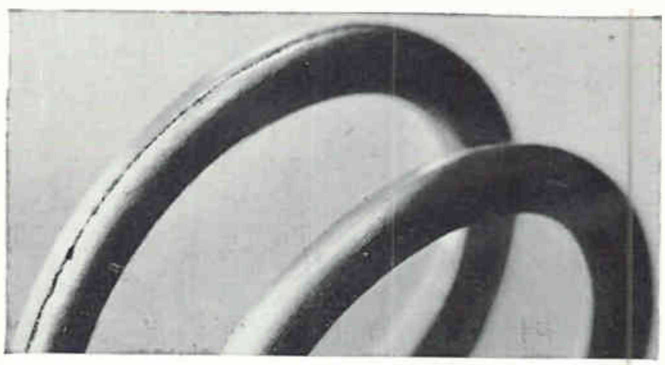


MOONEY SCORCH CURVE for FLUOREL 2141 Brand Elastomer.

outstanding among fluorinated elastomers. The range permits the rubber processor to achieve fast, more economical cures with fewer defects, less scrap and fewer rejected parts. The inherent safety of FLUOREL Elastomer 2141 allows repeated reprocessing to produce high quality parts that meet military specifications or other critical end uses.

At the same time, the outstanding physical qualities of the elastomer are retained. They include: non-combustibility, excellent resistance to corrosive chemicals, fuels, solvents and ozone, minimum compression set, rated for continuous service at 400° F., and the ability to tolerate 600° F. temperatures for reduced periods under certain service conditions.

If you use or work with elastomeric materials, it will pay you to examine the remarkable features of this new product. Examine, too, your present rubber products with an eye toward increasing their life and quality through use of FLUOREL 2141 Elastomer. For complete data, write today on your company letterhead to: 3M Chemical Division, Dept. KAX-60, St. Paul 6, Minnesota.



FLUOREL 2141 "O" ring, bottom. Note freedom from defects because of the improved scorch characteristics of FLUOREL Elastomer "O" ring as opposed to elastomer at top of photograph.

"FLUOREL" is a reg. T.M. of 3M Co.

CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

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3M COMPANY

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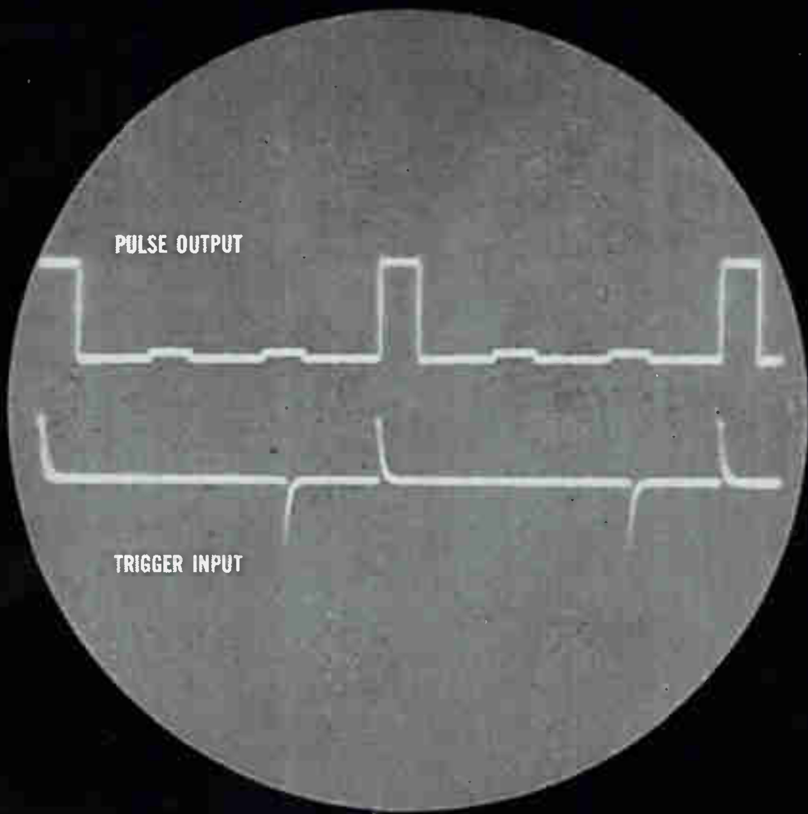
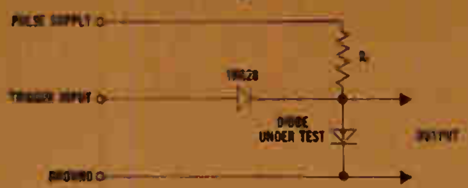
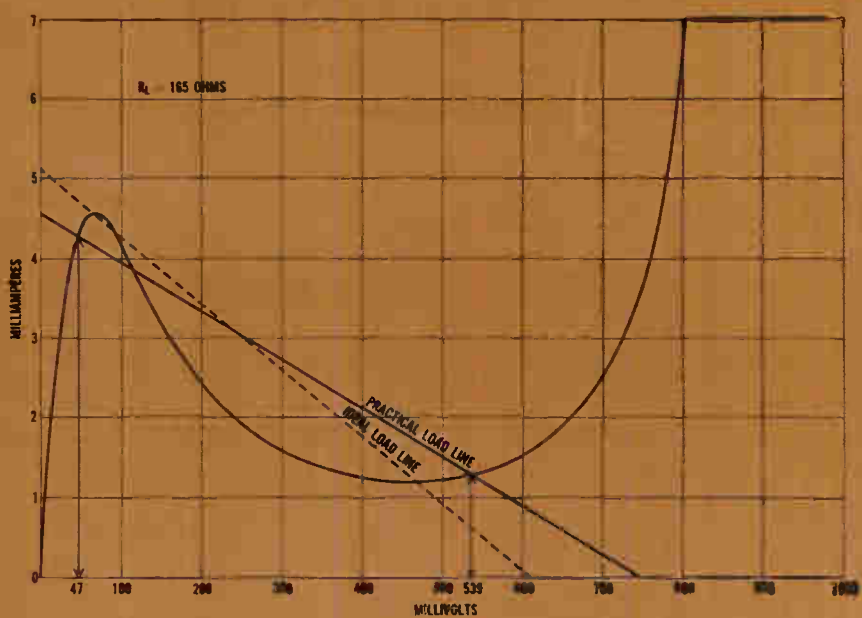


Input and output wave forms for circuit shown below

Switching circuit





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Hoffman silicon tunnel diode
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germanium tunnel diode
4.3-6.4**
gallium arsenide tunnel diode
3.8-4.5**
*By actual test, **As advertised

- **HIGH TEMPERATURE STABILITY** From –85°C to +200°C.
- **RUGGEDNESS** Made to withstand severe shock, vibration, acceleration, nuclear radiation.
- **UNIFORMITY** All characteristics carefully controlled by advanced manufacturing techniques.
- **RELIABILITY** Not only are these silicon devices, they are made by Hoffman—the world's leading specialist in silicon semiconductor technology.

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Audited Paid Circulation

CROSSTALK

MICROWAVES. Our Sept. 1935 issue carried a two-page report of a 10-cm "mystery ray" system developed by Telefunken in Berlin that was capable of locating aircraft through fog, smoke and clouds. "Rumor indicates," the article continued, "that U. S. and Italian armies are experimenting with similar system, declared to revolutionize war tactics".

Since this first brief discussion of the forerunner of radar, ELECTRONICS has kept its readers abreast of the growing microwave industry with reports of significant component and system developments. The Special Report by Associate Editors Carter and Solomon in this issue is intended to give you a picture of the state of the art and the trends in this dynamic field.

MOSCOW MEETING. Next Monday the first congress of the International Federation of Automatic Control gets underway in Moscow. The meeting will continue through July 7. Among those attending will be some 150 Americans. In all, 700 to 800 delegates from about 30 countries are expected.

A total of 285 papers will be presented, including 81 by Soviet Union delegates and 73 by United States experts. About half of all the reports will be devoted to the theory of automatic control, the rest to the technical means and methods of introduction of automatic devices. Ernest Conine, chief of the McGraw-Hill World News bureau in Moscow, is keeping a close reportorial eye on this major international event, as you can see from his story on p 34.

OCEANOGRAPHIC. Less is known about the bottom of the ocean than the surface of the moon. In order to learn more about the ocean floor, underwater camera systems like those described by H. E. Edgerton and S. O. Raymond in our April 8 issue (p 62) have been developed. In this week's issue, Edgerton describes the sonar pinger equipment used in positioning a camera at any distance from the bottom with a precision of approximately one meter. Edgerton, who is a professor of electrical measurements at MIT and vice president and chairman of the board of directors of Edgerton, Germeshausen & Grier, in Boston, has been concerned with the problem of underwater flash photography and stroboscopy for several years.

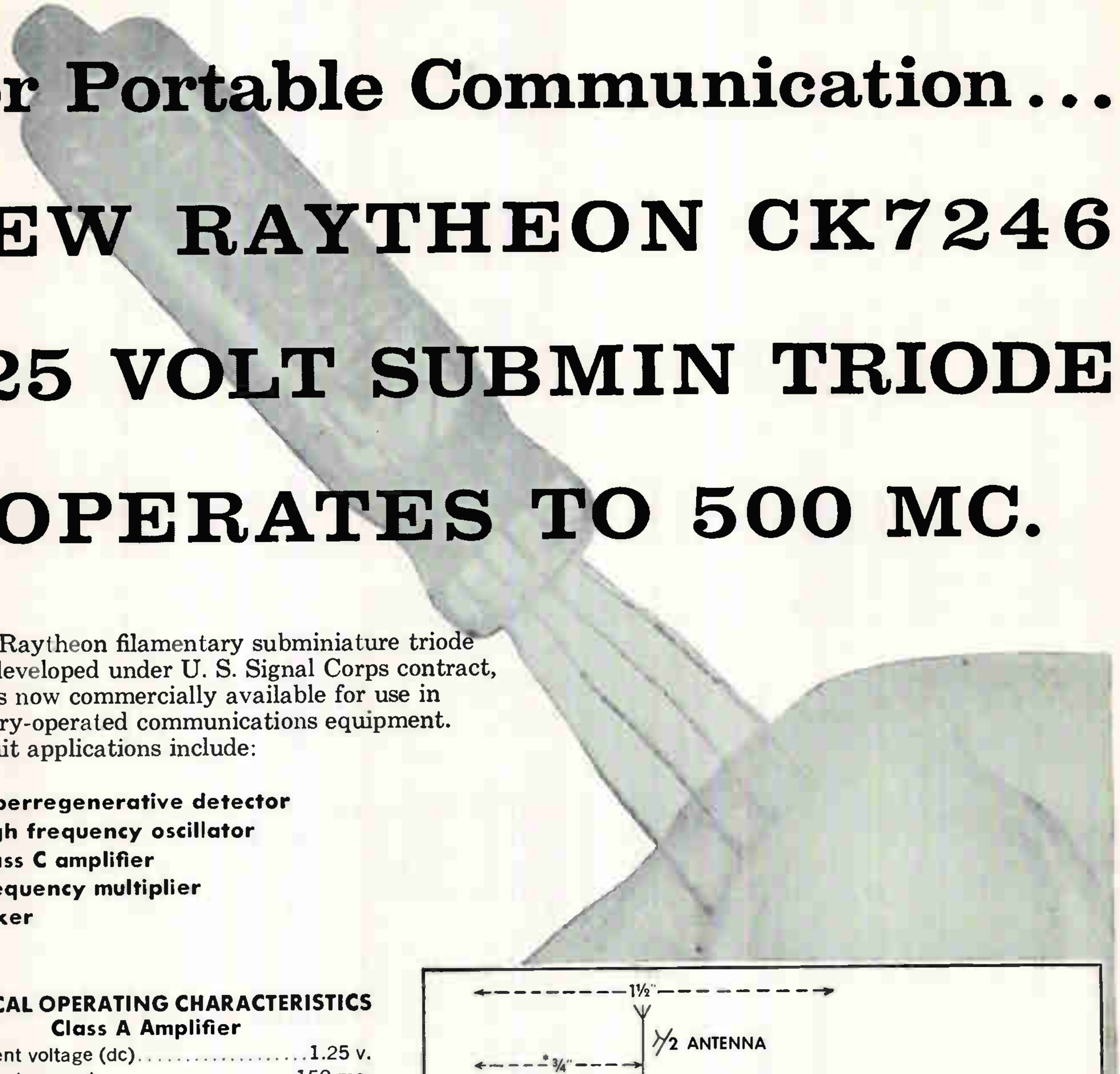
Coming In Our July 1 Issue

SEMI-ANNUAL INDEX. In its role of authoritative technical and industrial journal, ELECTRONICS publishes a huge amount of high-quality editorial matter each year. Most of this material is timely, yet it often retains its usefulness for months, even years after it appears. Until now, we've indexed it annually.

Beginning with the July 1 issue, as a new service to our readers, we are initiating a *semi*-annual index. We believe this will be an invaluable aid to researchers, busy engineers and industrialists, and we've tried to make it the most complete and comprehensive ELECTRONICS index ever.

Next week's index contains 136 topic headings and several thousand entries on articles that have appeared in our pages between January 1 and June 24, 1960. Some of the topic headings have never appeared before, giving graphic evidence of the dynamic growth of our industry. New headings such as Magnetohydrodynamics, Biophysics, Oceanography, Superconductors, Meteorology and Information Retrieval indicate how ELECTRONICS now ranges even farther afield to cover the industry in depth.

The second half-year index will appear in our December 23 issue.



For Portable Communication...

NEW RAYTHEON CK7246 1.25 VOLT SUBMIN TRIODE OPERATES TO 500 MC.

This Raytheon filamentary subminiature triode was developed under U. S. Signal Corps contract, and is now commercially available for use in battery-operated communications equipment. Circuit applications include:

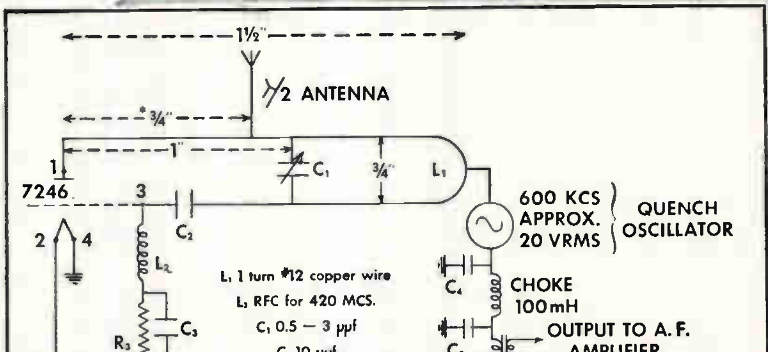
- **Superregenerative detector**
- **High frequency oscillator**
- **Class C amplifier**
- **Frequency multiplier**
- **Mixer**

TYPICAL OPERATING CHARACTERISTICS
Class A Amplifier

Filament voltage (dc)	1.25 v.
Filament current	150 ma.
Plate voltage	105 v.
Plate current	4.5 ma.
Grid voltage	−2.5 v.
Transconductance	2700 μmhos
Amplification factor	22

TYPICAL OPERATING CONDITIONS
420MC. Superregenerative Detector

Filament Voltage DC	1.25 v.
Filament Current	150 mA.
Plate Voltage (B+)	105 v.
Plate Current	4.5 mA.
Sensitivity	5 to 10 μV.



TYPE 7246 — 420MC. SUPERREGENERATIVE DETECTOR

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COMMENT

Ions and Health

Reference your article "Ions Affect Health, Behavior" (p 45, Feb. 26). These effects should be studied as a possible new tool in the field of medical electronics. With medical approval, the millions of hay-fever sufferers may soon have relief . . .

C. B. Heffron
Westinghouse Electric
Metuchen, N. J.

I, too, was pleased to read your article "Ions Affect Health, Behavior." It is the most recent report I had read since an internal RCA report by C. W. Hausell about 1951.

Your Comment column in the May 27 issue (p 6) convinced me that there are others also intrigued by this subject . . .

L. W. Ferber
Radio Corp. of America
Princeton, N. J.

There certainly are. We've had a minor-league flood of mail, all from research groups, all asking for references and sources. We've tried to help, because—as we commented on May 27—this subject, of such avid interest to so many, promises to be of positive benefit to mankind.

Communications in Korea

Appreciated . . . your most informative article, appearing in the May 20 issue of Electronics, p 40 and 41, on communications in Korea ("Korea: On Guard 10 Years After Invasion").

I was wire officer in Osan, Korea, five years ago, and your article does much to explain current conditions . . .

S. T. Thompson
Aerojet-General Corp.
Azusa, Calif.

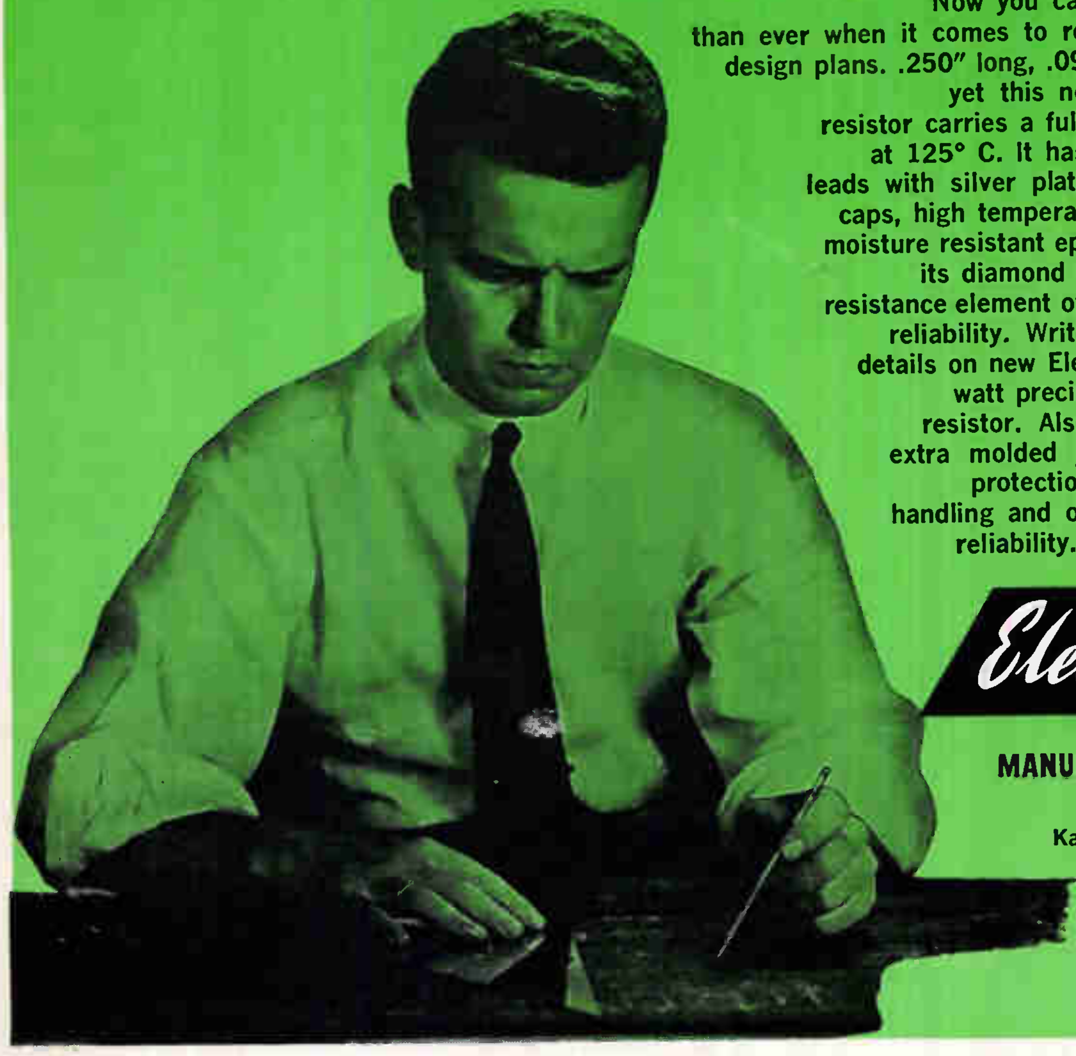
Active Filters

There appears to be an error (in "Selecting R-C Values for Active Filters," p 83, May 13), since the expanded form and the factored form for $n = 3$ in Table I do not correspond. It seems that the ex-

* NOW YOU CAN THINK SMALLER THAN EVER!

* 1/4 Inch to be Exact, that's the Length of this

NEW ELECTRA 1/10th WATT PRECISION FILM RESISTOR



Now you can think smaller than ever when it comes to resistors in your design plans. .250″ long, .093″ in diameter, yet this new 1/10th watt resistor carries a full wattage rating at 125° C. It has sturdy No. 22 leads with silver plated compression caps, high temperature impact and moisture resistant epoxy coating and its diamond spiralled carbon resistance element offers exceptional reliability. Write today for full details on new Electra DC 1/10th watt precision carbon film resistor. Also available with extra molded jacket for extra protection against rough handling and other enemies of reliability. Just write . . .

Electra

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panded form should read

$$\frac{E_0}{E_1} = \frac{K}{s^3 + 2Bs^2 + 2B^2s + B^3}.$$

1/Lt. Morris M. Williams
Marine Corps Base
29 Palms, Calif.

Reader Williams is right; of course the last term should be B^3 and not B^2.

Miniature Microphone

I have read the article about our miniature capacitor-microphone ("Miniature Capacitor Microphone," Research and Development, p 80, May 6) and found some errors in it.

On p 82, third line, you have written $(l/\omega)^{\frac{1}{2}}$, which has to be $(1/\omega)^{\frac{1}{2}}$.

The last sentence of the article: "The acoustical filter mounted inside the microphone acts like a damped resonant circuit, functioning like the slit filter" is perhaps not clear for the reader.

Better would have been: "The acoustical filter mounted inside the microphone acts like a damped resonant circuit, in order to give the proper phase change for those frequency regions where the slit filter alone is not sufficient . . ."

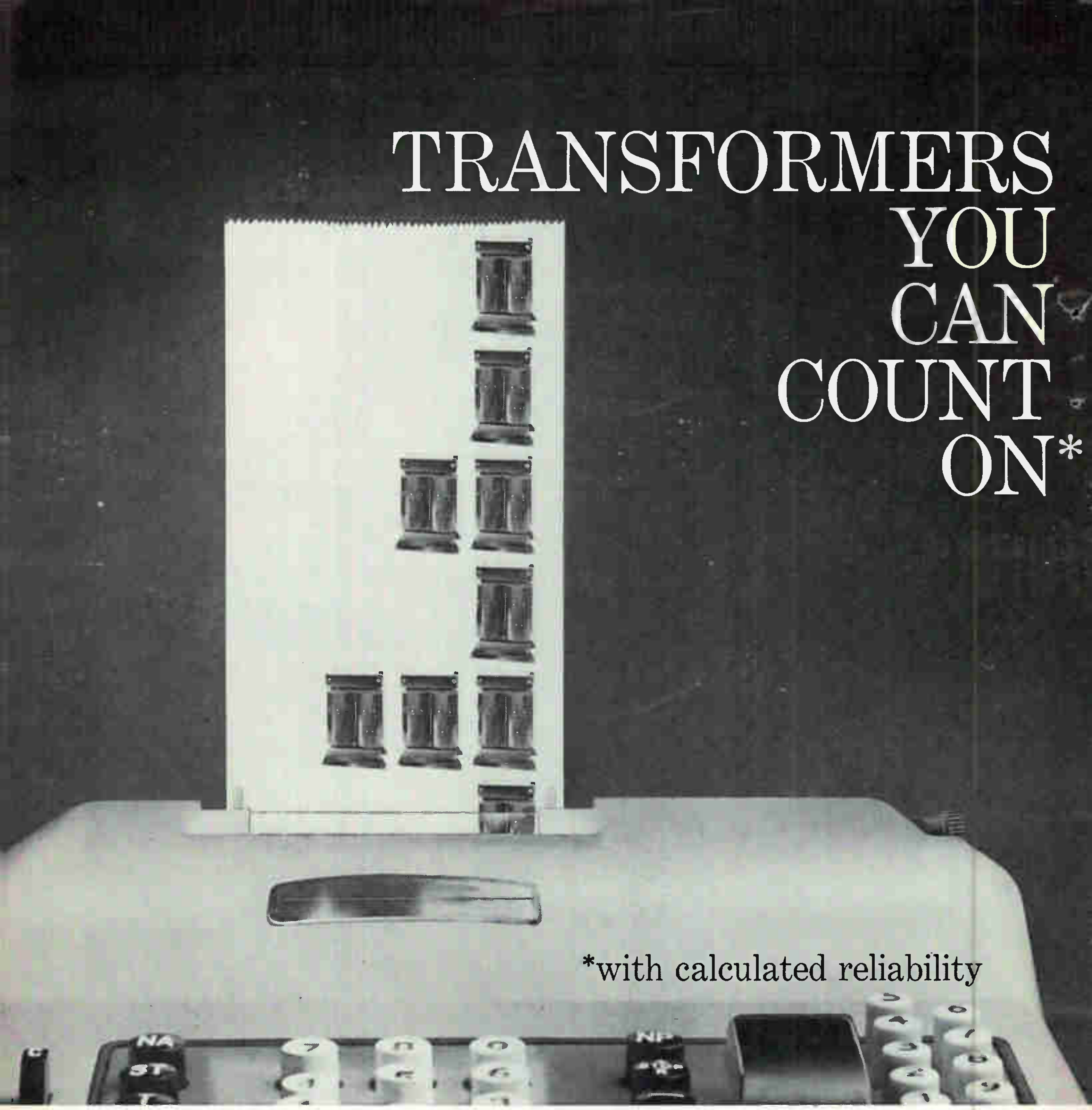
C. Wansdronk
Philips Research Laboratories
Eindhoven, Netherlands

The equations contained both el's and one's, which are the same on our typewriters, but not the same on reader Wansdronk's; our typesetter quessed wrong in this case. Also, we agree that reader Wansdronk's revised sentence is clearer than our original one.

Electronics in Japan

I am writing specifically to congratulate you for the excellent article "Electronics in Japan," which appeared in your May 27 issue (p 53). I was astounded at the breadth of coverage of the article . . .

Harper Q. North
Pacific Semiconductors Inc.
Culver City, Calif.



Reliability is much more than just a feature of Electro's transformers. It begins as an integral design consideration; and many bold design innovations have been pioneered by Electro to make transformers **inherently more reliable.** Among them: new developments in the use of **epoxy resins** for **encapsulation** and **coil protection; thinner coils** with greater exposed surface area for faster heat transfer; a **unique terminal design** that is much more rugged; **special filling compounds** for hermetically sealed transformers that eliminate the thermal expansion problem and provide better thermal conductivity. Reliability in Electro's transformers is also the result of pains-taking testing and **rigid quality control.** Electro's complete facilities include in-plant equipment approved for **qualification testing** in accordance with MIL-T-27A. **Environmental** tests are conducted to assure resistance to humidity, temperature, shock and vibration. Electro reliability begins with the design, continues through development, manufacture and qualification, and results in a better product. If you need a more reliable transformer—talk to the Electro people.

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ELECTRONICS NEWSLETTER

Japanese Push Color-Tv Production Plans

JAPAN'S electronics industry is concentrating on the color-tv business. Sparked in part by final government approval of NTSC color standards (ELECTRONICS, p 11, June 17), and in part by reduced radio-set revenue, nine big manufacturers are rushing to complete production lines—even at heavy financial loss—in order to start commercial production this summer.

Officials of Ministry of International Trade & Industry told ELECTRONICS last week that combined production will reach monthly level of 300 sets this summer, 1,000 by fall, 10,000 by yearend 1961. The sets—probably to be priced for the foreseeable future at about $1,400 for a 21-in. and $1,100 for a 17-in. set—are far out of reach of most Japanese consumers. Setmakers figure they can effectively compete in the export market, pick up domestic sales as a sideline for the time being.

Color-Tv System Uses Two Monochrome Tubes

PRINCIPLES of non-Newtonian color optics elucidated within the last year by E. Land and others are being applied to color television. Frank G. Back, president of Zoomar Inc., recently demonstrated a simplified color-reception system that uses two monochrome tubes before a regional meeting of the Society of Photographic Scientists and Engineers.

Back's set—based, in his words, "on experiments which indicate that the eye is basically a two-color mechanism, not a three-color one"—has a front end similar to conventional color sets, a middle equivalent to two monochrome sets. NTSC color is received, but the blue signal is dumped. Red and green chrominance signals are separately amplified and fed ultimately to two monochrome tubes. Scan in one tube is actuated by the red signal, and in the other by the green; "part of the blue signal," Back told ELECTRONICS, "is used for blanking."

The green tube is capped with a blue-green filter and the red with a yellow-red filter close to a deep blush-amber. The two tubes are arrayed vertically, one tilted 20 deg and the other 110 deg, so that they are at right angles to each other. A semitransparent mirror—similar to cathedral glass—is placed in the plane where the axes of the tubes cross, perpendicular to the bisector of the right angle.

RCA Prepares to Open Far East Research Lab

RESEARCH LABORATORY to conduct fundamental studies in the physics and chemistry of solids will be opened soon in Japan by Radio Corp. of America. The lab is the second to be established by RCA overseas; the first, in Zurich, has been operating since 1955. Labs take advantage of international climate and attitudes toward basic research, draw swiftly on local research breakthroughs.

Lab director at the Far Eastern site will be Martin C. Steele, who has been in Tokyo since early May formulating plans. Steele told ELECTRONICS that only basic studies in the general field of solid-state phenomena—including electrical, magnetic and optical properties—will be made. Initial staff will be "three or four" young Japanese fresh from the universities.

Epitaxial Technique Cuts Transistor Switching Time

TECHNIQUE for vapor-growing a high-resistivity collector film on a low-resistivity substrate, developed by Bell Telephone Laboratories and revealed last week at a joint IRE-AIEE conference in Pittsburgh, may have far-reaching implications for both fabricating semiconductor devices and applying them. Using the epitaxial technique, Bell has made silicon transistors with collector resistance and switching time both reduced by a factor of ten.

Diffused-base transistors need high-resistivity collector regions for low capacitance, high voltage-breakdown values; mechanical requirements force manufacturers to make the collectors 30 times as thick as electrically required (about 0.003 in.).

The epitaxial technique—which can be introduced at the beginning of existing diffused-base production facilities—starts with lapped wafers of heavily doped silicon or germanium. These are put in a furnace, into which is introduced a vaporized semiconductor compound with far fewer impurities. By gaseous deposition, a layer of correct resistivity forms on the base wafer as a film 0.0001 in. thick. The heavily doped wafer acts as a seed, and the lightly doped film grows onto it as an extension of the basic crystalline structure.

Silicon transistors already produced epitaxially are useful as switches in the 2-Gc region. Germanium epitaxials, according to a Bell Labs spokesman, will be usable at frequencies above 2 Gc as amplifiers.

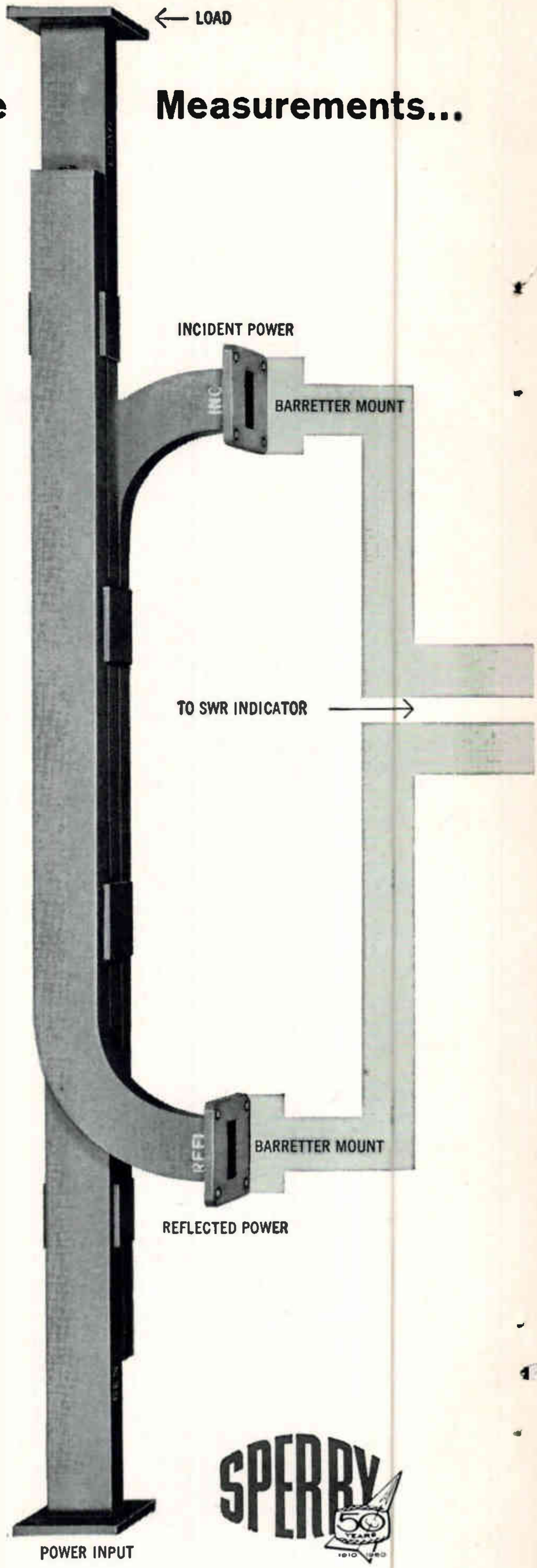
Advent Relay Satellite Should Hover by 1964

TIMETABLE for the Advent active communications satellite, ELECTRONICS learns, calls for the advanced space relay station to be in operation by the end of 1964. Test launches may be undertaken during 1962.

A 22,000-mile-high orbit is planned for Advent. The critical altitude will put the relay satellite in a synchronous 24-hr orbit, so that it will hover over a single point and eliminate doppler problems. Three such satellites should be able to reach all but 2 percent of the earth's populated surface.

Relay gear in the 2,000-Mc range is planned for the project, which is under control of the Advanced Research Projects Agency. Two configurations are under study, one a 625-lb repeater carrying 144 voice channels, the other a 4-ton station carrying 300 voice or 2 tv channels. Ground stations will beam 1,000-w signals at the repeater; the spaceborne gear will retransmit in real time at 20-w levels.

For direct, accurate Microwave Measurements...



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REFLECTOMETER COUPLERS

Microline Reflectometer Couplers provide a quick, simple and accurate means of measuring voltage standing wave ratios. Each is actually two couplers, and can do many of the jobs of two, yet is considerably more compact.

The outputs of the coupler at the barretter mounts are incident power and reflected power respectively. These outputs may be coupled to the Microline 29A1 SWR Indicator through a 29A2 Input Switch; by noting differences in db, VSWR may be simply calculated. The Input Switch provides convenient audio switching between the barretter mounts.

With one arm terminated (normally the "REFL" arm), the other can be coupled to a frequency meter, or to power measuring or other monitoring equipment, and used as any standard coupler. With both the "Load" and "REFL" arms terminated—using matched components such as Microline 42 or 43 series terminations—the coupler serves as an excellent fixed attenuation standard, unaffected by variations in temperature or humidity. Calibrated against primary attenuation standards, the coupling values of this circuit become the attenuation values at all frequencies over the range.

Available for immediate delivery from stock, the Reflectometer Couplers are another in the Microline family of high quality, matched microwave instruments . . . the most complete, most dependable, most advanced line for today's high precision microwave applications.

SPECIFICATIONS:

Frequency Range:	Waveguide Size:	Recommended Barretter Mount	Recommended Barretter
Mod. 24S1 . . 2.60-3.95 kmc	3" x 1½"	33S2	821
Mod. 24C1 . . 3.95-5.85 kmc	2" x 1"	33C2	560
Mod. 24X1 . . 8.2-12.4 kmc	1" x ½"	33X2	560

Nominal Coupling: 10db
VSWR of Primary Line: 1.05
Coupling Variation Over Range: ± 0.5
Tracking Between Arms: ± 0.05db
Minimum Effective Directivity: 40db

PRICES: Mod. 24S1, $600
Mod. 24C1, $350
Mod. 24X1, $175

CONTACT: LOUIS A. GARTEN & ASSOCIATES: WEST ORANGE, N. J. 645 Eagle Rock Ave., REdwood 1-1800; NEW YORK, N. Y. BOwling Green 9-4339; PHILADELPHIA, PA. 730 Washington Lane, Jenkintown, WAverly 7-1200.
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29A2

INPUT SWITCH

The Microline 29A2 Input Switch is an accessory for use with the SWR Indicator, providing audio switching between two inputs. In an appropriate circuit it will permit direct reading of insertion loss. A gain adjustment is provided on one of the inputs. This adjustment does not affect bolometer bias. Connected as illustrated, the SWR Indicator, 29A2 Input Switch and a Microline Reflectometer Coupler with barretter mounts form a versatile reflectometer for impedance measurement.

FROM REFLECTOMETER COUPLER ↓ $30

$200

29A1

SWR INDICATOR →

The ideal amplifier for measuring standing wave ratios and relative power in microwave systems . . . and the ideal indicator in frequency measurement. It is the only instrument providing two bandwidth selections: Wide Band, 300-5000 cps (fixed); or Narrow Band, 30-150 cps (variable), with resultant high stability, sensitivity, and freedom from modulator drift error.

The 29A1 incorporates an expanded scale and automatic compensation for increased accuracy in low VSWR measurement. A "Plus 5 db" gain step facilitates accurate upper-scale readout on the meter. Many other advantages, such as a push-button bolometer current reading . . . positive diode protection against bolometer burnout . . . "wide" position switching eliminating the tuned circuit . . . easy readability and operability . . . make the 29A1 the most desirable instrument of its kind. It is handsomely designed—a light blue case, brushed aluminum control panel, and contrasting gray sub-panel.

Available for immediate delivery from stock, the SWR Indicator is another in the Microline family of high quality, matched microwave instruments . . . the most complete, most dependable, most advanced line for today's high precision microwave applications.

SPECIFICATIONS:

Frequency:	1000 cps, ± 1%
Sensitivity:	0.1 uv at 200 ohm level for full scale deflection.
Noise Level:	Less than 0.03 uv referred to input, narrow-band position.
Amplifier Bandwidth:	Wide band position, 300-5000 cps; Narrow band position, continuously adjustable, 30-150 cps.
Calibration:	Meter reads SWR, db, bolometer current.
Range:	70 db. Input attenuator provides 60 db in 10 db steps. Accuracy 0.1 db per step.
Meter Scales:	SWR 1-4, SWR 3-10, Expanded SWR 1-1.3, db 0-10, expanded db 0-2, bolometer current 0-10 ma.
Gain Control:	30 db.
Input:	BNC female.
Input Positions:	High Bolo—8.4 ma bolometer position, 200 ohms. Low Bolo—4.3 ma bolometer position, 200 ohms. 200—200 ohms for crystal rectifier. Hi-Z—high impedance for crystal rectifier.
Output:	Jack provided for 0-1 ma recorder, 1 side grounded, 1500 ohm resistance. Jack for audio output.
Power:	115 230 volts, 50-60 cps.
Size:	Approx. 8 x 11 x 12.
Weight:	14 lbs.
Price:	$200.

CONTACT: LOUIS A. GARTEN & ASSOCIATES: WEST ORANGE, N. J. 645 Eagle Rock Ave., REdwood 1-1800; NEW YORK, N. Y. BOwling Green 9-4339; PHILAOELPHIA, PA. 730 Washington Lane, Jenkintown, WAverly 7-1200.

TECHNICAL INSTRUMENTS, INC.: REAOING, MASS. 90 Main St., REading 2-3930; LIVERPOOL, N. Y. 916 Liverpool Rd., OLdfield 2-2535; BRIOGEPORT, CONN. 1115 Main St., FOrest 8-4582.

SPERRY

SPERRY MICROWAVE ELECTRONICS COMPANY, *CLEARWATER, FLORIDA · DIVISION OF SPERRY RAND CORPORATION*

CIRCLE 13 ON READER SERVICE CARD

WASHINGTON OUTLOOK

CONGRESS THIS WEEK goes into the last lap of the debate over the new defense budget, now running at $40.4 billion. Outlook in electronics is for increased spending on a number of major projects. But the probability is great that the overall Congressional increase will be far below the $2- or $3-billion boost Senate leaders called for after the summit collapse.

The Senate Appropriations Committee has approved a measure hiking the appropriation slightly more than $1 billion; the House has passed an appropriation with a net increase of only $122 million over the administration's request.

Final sum will probably be about $750 million greater than the original request. But the specific projects to be favored are still in doubt since there are important differences between the House and Senate committee versions.

The Senate committee boosted the appropriations for B-70 development from $75 million to $360 million; the extra money would allow the Air Force to renew contract negotiations for major electronic subsystems.

The committee also restored $294 million for Bomarc B missiles that was killed by the House, failed to go along with the House's addition of $215 million for F-106 fighter-interceptor aircraft.

Among the other major Senate committee additions: $200 million for jet transport planes (the House added $250 million); $241 million for extra Polaris submarines (the same amount added by the House); $83.8 million for the Samos reconnaissance satellite (the House tacked on $54 million extra for all military satellites).

The Senate committee also restored $293 million for an aircraft carrier and $400 million for general procurement—sums previously knocked out by the House. It voted against the House's $20.7-million hike for the Minuteman ICBM and against the Air Force's post-summit proposal to jack up the Atlas program by two squadrons. It also trimmed back the increases voted by the House for antisubmarine warfare.

MORE AMMUNITION has been poured into the fight to consolidate military electronic procurement.

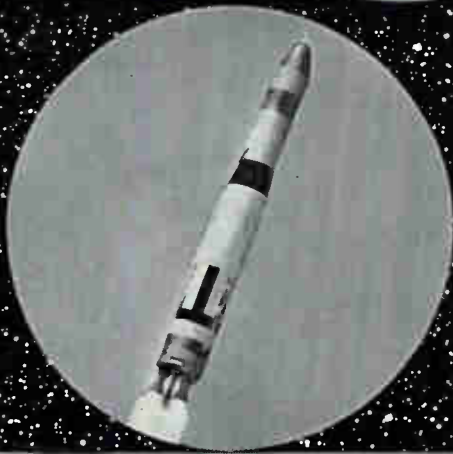
The General Accounting Office has released a critical report on its year-long investigation into military electronic supply matters (ELECTRONICS p 14, Apr. 29), recommends that the Pentagon unify electronic buying and other supply management functions.

This is GAO's chief finding: "Inadequate coordination of electronics supply management" among military agencies results in "unnecessary purchases;" "costly duplication and overlap" of functions and organizations; and "unnecessary administrative costs."

GAO claims it found a case where one service was about to buy $20-million worth of major equipment another service considered surplus, another case where $2.5-million worth of equipment was being repaired at high cost while similar equipment was available in another agency's surplus stocks.

The accounting agency wants a single military electronic bureau to do these things: (1) monitor entry of new equipment into the military supply system; (2) review, coordinate, and consolidate requirements; (3) do all buying; (4) determine "depth and range of initial supporting spare parts for new items;" (5) be in charge of "wholesale stocks including mobilization and production reserve stocks;" (6) control and manage maintenance programs; (7) store and distribute supplies; and (8) dispose of surplus equipment.

So far the Pentagon is cool to the establishment of a new agency with such broad and powerful authorities. But it is making its own review of electronic supply management, is expected to consolidate selected management functions for a limited number of electronic stock items.



Building Strength Upon Strength... the USAF Ballistic Missile Program

The strength and prestige of this nation depends upon many things . . . important among these are the successes of the Air Force Ballistic Missile Program and related advanced space projects. In turn, these programs depend upon the continuing flow of new ideas and inventions. All of these are part of a common pool of knowledge and know-how which are drawn upon for today's capability and tomorrow's advances.

In building strength upon strength in the race for space technology leadership, the knowledge and experience gained from Atlas, Thor, and Titan ballistic missile systems developement is being applied to advance Minuteman. For these programs, under the management of the Air Force Ballistic Missile Division, Space Technology Laboratories has had the direct responsibility for over-all systems engineering and technical direction. As these ballistic missile and related space programs go forward, STL continues to contribute technical leadership and scientific direction.

In this capacity STL offers unusual opportunities for creative work in the science and technology of space systems. To those scientists and engineers with capabilities in propulsion, electronics, thermodynamics, aerodynamics, structures, astrophysics, computer technology and other related fields and disciplines, STL now offers immediate opportunities. Please address your inquiries and/or resumes to:

STL

SPACE TECHNOLOGY LABORATORIES, INC.
P. O. Box 95004, Los Angeles 45, California

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MELABS-

Seasoned microwave designers and builders

Specialists in microwave receivers, researched and designed to individual specification, fabricated from Melabs-manufactured components, proved in laboratory and field operation.

Designers and manufacturers of microwave components—calorimeters, choppers, couplers, filters, isolators, mixers, multiplexers, radiometers, switches—offering maximum reliability and dependable performance.

R&D specialists in microwave physics—application of ferrites in microwave electronics, circuit development in countermeasures and radio reconnaissance.

In a new facility in Stanford Industrial Park, Melabs' 180-member staff daily ventures into new areas of microwave research. More than 75 qualified engineers and physicists supported by a large technical and manufacturing staff stand ready to solve unique electronic problems.

Employment opportunities at Melabs are exceptional for ambitious engineers and physicists; write in confidence.

Melabs

Youthful vigor in an academic climate of research and development has led Melabs to delivery, under military and private contract, of a unique array of advanced microwave instrumentation:

Model SGS-2 Swept Signal Generator, S-band BWO microwave signal source offering constant power output to within 1 db.

Model X-127 400 MC Circulator, compact three-port instrument with a 10% bandwidth at 400 MC.

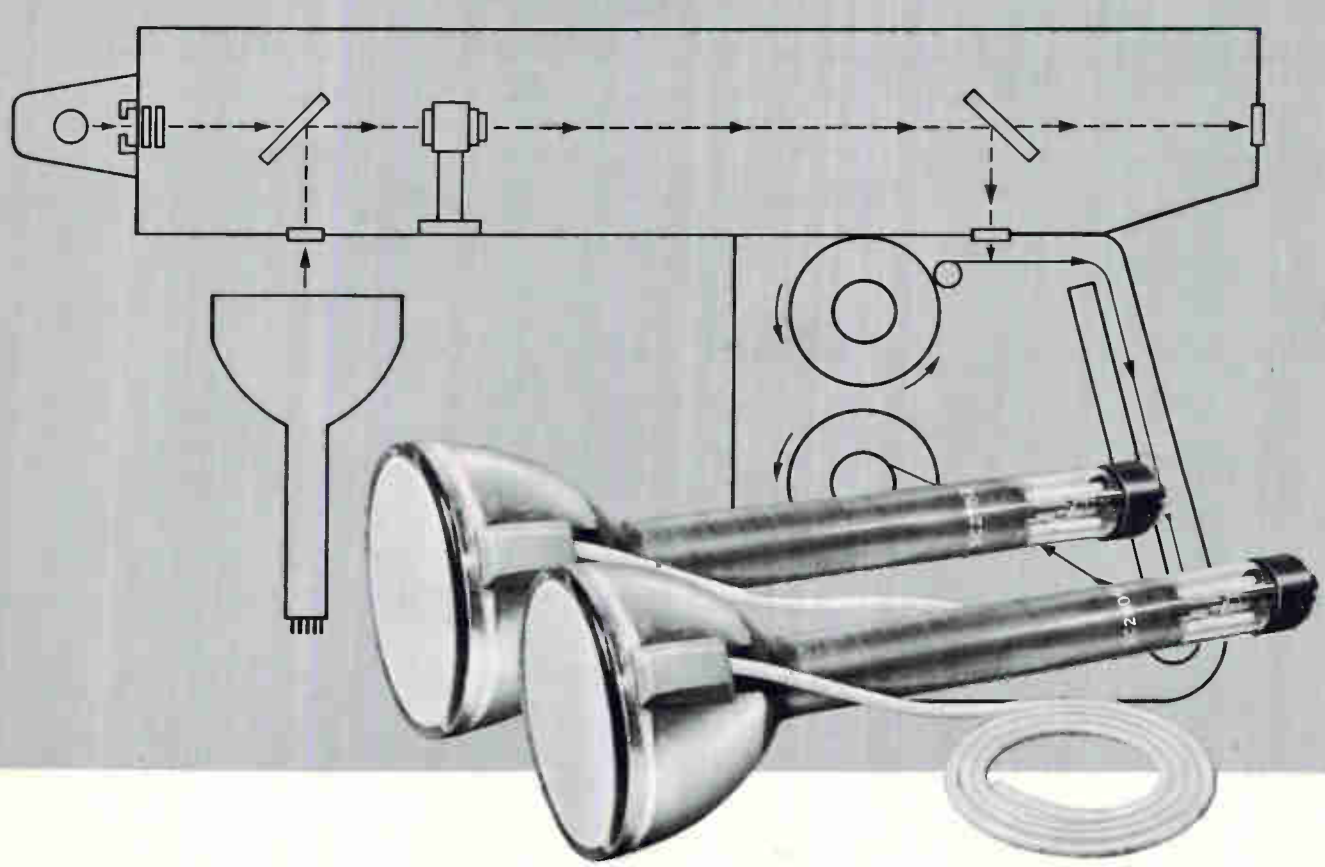
Model AN/GLA-10 memory-display group for use with radio reconnaissance receivers.

Model RSS-3 frequency-sweeping imageless superheterodyne receiving system, operating in the microwave region.

Model M-3 Broadband Mixer (0.5 to 11 KMC) untuned coaxial instrument, offering unusual conversion efficiencies.

MELABS (pronounced MEL-LABS) • Dept. E-6, 3300 Hillview Drive, Palo Alto, California • DAvenport 6-9500

ELECTRON TUBE NEWS
...from SYLVANIA



• HIGH RESOLUTION
• SIMPLIFIED CIRCUITRY
• IMAGE BRILLIANCE

with 2 new Sylvania C.R.T.'s for photo-recording applications

Sylvania SC-2809, SC-2782 utilize precision guns, fine grain P11 phosphor, aluminized screens, clear nonbrowning optical faceplates. Result: remarkably high resolution and excellent brilliance. SC-2809 has a line width of .0008″, a resolution of 6000 lines. SC-2782 has a .001″ line width and a 3000-line resolution. Both tube types feature conventional magnetic focusing and deflection, simple beam-centering magnets, no ion traps. They simplify external circuitry requirements, offer potential savings in equipment costs. Minimum useful screen area is 4¼″. Deflection angle is 50°. Use of an integral encapsulated high-voltage connector minimizes possibility of corona at high altitudes. Screens other than P11 are available if desired. For further information and complete technical data, contact the Sylvania Field Office nearest you.

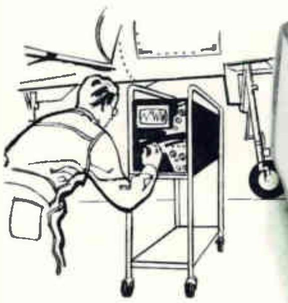
KEY CHARACTERISTICS	SC-2809	SC-2782
Anode Voltage	25,000 Volts dc*	25,000 Volts dc*
Anode Current ($E_{G1}=0$)	3 μA dc*	
Grid No. 2 Voltage	2,500 Volts dc*	2,500 Volts dc*
Grid No. 2 Current ($E_{G1}=0$)	2,000 μA dc*	
Screen Current	2 μA dc	5 μA dc
Line Width	0.0008″	0.001″
Face Diameter	5″	5″
Over-all Length	16⅜″	16″

*Absolute Max. Ratings

NEW SYLVANIA C.R.T.'s FEATURE

LOW HEATER POWER HIGH RELIABILITY "COOL" OPERATION

for battery-powered, portable 'scope applications



Sylvania 3BGP1, 3BGP2, 3BGP7, 3BGP11 . . . feature direct-view rectangular faces, electrostatic deflection and focus, high deflection sensitivity.

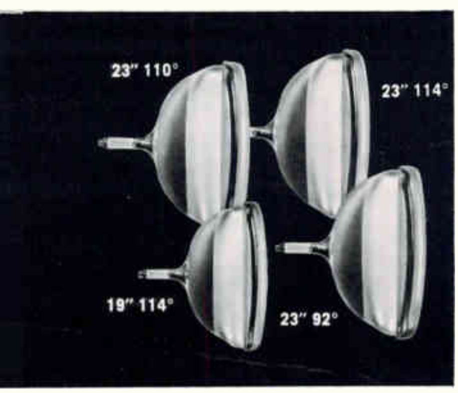
KEY CHARACTERISTICS	
Anode No. 2 Voltage	2,750 Volts dc*
Anode No. 2 Input	6 Watts*
Anode No. 1 Voltage (Focusing Electrode)	1,100 Volts dc*
Heater Ratings	1.5V/140mA
Line Width (Light output of 20 ft. Lamberts)	0.026"
Face Dimension	1½" x 3¼"
Useful Screen Area	1⅛" x 2¾"
Over-all Length	9¼"
*Absolute Max. Ratings	

The 3BGP-family of 'scope tubes is typical of the continuing work of Sylvania to advance the "state of the art." Combining modern C.R.T. technology and powder metallurgy techniques, Sylvania has produced a heater-cathode assembly requiring only 1.5V @ 140mA – less than 7% of the power normally needed. Reduced power demands result in much lower tube operating temperatures and low drain from battery or flyback heater supply. The heater-assembly has a relatively low mass which makes it virtually impervious to vibration of portable equipment. Clear, pressed faceplates are utilized for improved glass quality, greater uniformity of thickness resulting in minimized distortion. Complete information and technical data can be obtained from your local Sylvania Field Office.

The new Sylvania low power heater-cathode assembly holds vast promise for picture tubes for portable, battery-operated TV receivers. This concept is currently under investigation at Sylvania. Your inquiry is welcome.

4 NEW "BONDED SHIELD" TV PICTURE TUBES

all available with new reflection-diffusing, treated caps



Sylvania continues its leadership in "Bonded Shield" picture tubes with an expanded line to help you meet the demand for squared-corner TV. Now, you can offer *broad-angle* and *low-reflection* viewing with the specially treated laminated cap. The treated surface of the tube cap can diffuse up to 70% of reflected light without appreciable loss in resolution—eliminating the old problem of mirror images.

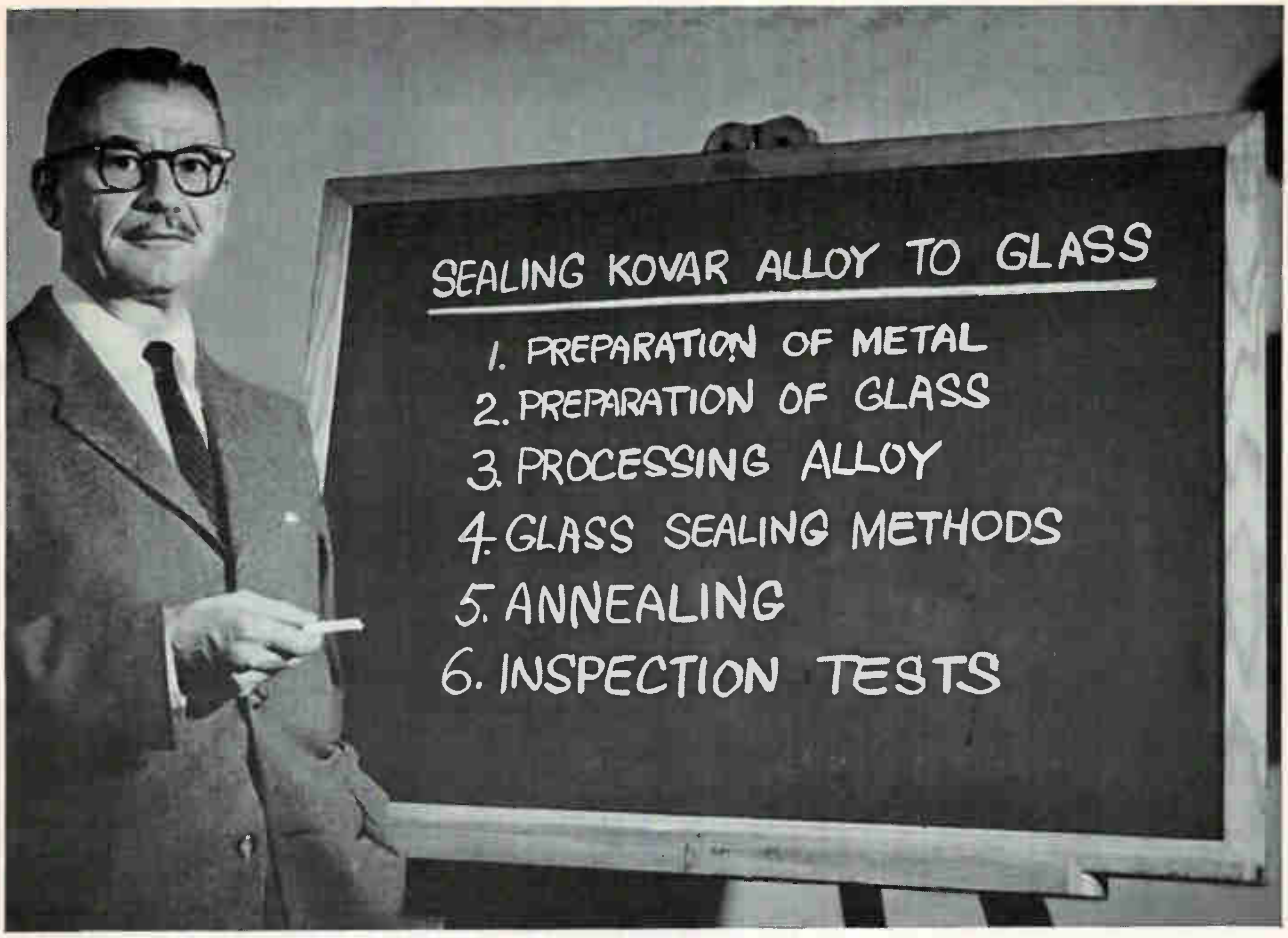
Bonded Shield eliminates front-of-the-cabinet safety glass • Reduces front-to-back cabinet dimensions • Reduces danger of implosion • Reduces production-line rejects significantly • Offers squared-corner screen • Simplifies mounting with integral mounting lugs • Offers potential savings in set manufacture.

Sylvania pioneered the quantity production techniques of bonding cover panels to the face of a picture tube. These same techniques hold excitiug possibilities for application in industrial and military cathode ray tubes. You may have a C.R.T. application that can benefit from Sylvania Bonded Shield "know-how." Sylvania Engineers will be pleased to work with you.

If your industrial or military design demands specialized Cathode Ray Tubes, call on the creative experience and production capabilities of Sylvania. Electronic Tubes Division, Sylvania Electric Products Inc., 1740 Broadway, New York 19, New York.

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**



Engineering hints from Carborundum

6 steps to better glass-to-metal seals with KOVAR® Alloy

KOVAR® is the original iron-nickel-cobalt alloy with correct thermal expansion characteristics for making seals with several hard glasses. Procedures for obtaining a satisfactory seal—with optimum production yields—will vary according to the nature of the end product. This may range from large electron tubes to the smallest semi-conductor devices. The following hints typify recommendations for the more critical electron tubes; they can be modified for other products according to need.

1. KOVAR should be scratch-free. Polish with 180-grit aluminum oxide cloth, followed by 260-grit—never emery or carbide. Round edges of edge-type seals with a radius of about half metal thickness. Sand-blasted matt finish, using pure alumina, is preferable for butt type seals.
2. REMOVE DUST FROM GLASS with lint-free cloth. Rinse in 10% hydrofluoric acid solution, then in running tap water, finally in distilled water. Dip in methanol and hot air dry.
3. CLEAN KOVAR prior to sealing by trichlorethylene vapor degreasing, immersion in concentrated HCl, followed by rinses in tap and distilled water. Methanol dip and hot air dry. Heat treat in wet hydrogen atmosphere.
4. SEALING EQUIPMENT includes gas-oxygen burner and glass lathe. Oxidize surfaces by heating metal and glass to 850° C in air. Bring parts together by pressure. For strong seal, glass edge should approach 90° angle where it meets KOVAR alloy.
5. ANNEAL SEAL using flame or furnace program, advancing to annealing temperature for 30 mins. Reduce to 50° C below strain point at 1° per minute, then 10° per minute to room temperature.
6. INSPECTION may include stress analysis by polariscope viewing or other method. Examination under 10x to 15x magnification should show that glass is free from excessive bubbles. Glass color should be grayish or mouse brown.

FIND OUT ABOUT KOVAR—WHERE IT IS USED AND WHY

Bulletin 5134 gives data on composition, properties and applications of KOVAR Alloy. For data on sealing procedures, ask also for Technical Data Bulletin 100-EB6. Write Dept. E-60, Latrobe Plant, Carborundum Co., Latrobe, Pa.

For permanent vacuum and pressure-tight sealing . . . count on

CARBORUNDUM®

CIRCLE 19 ON READER SERVICE CARD

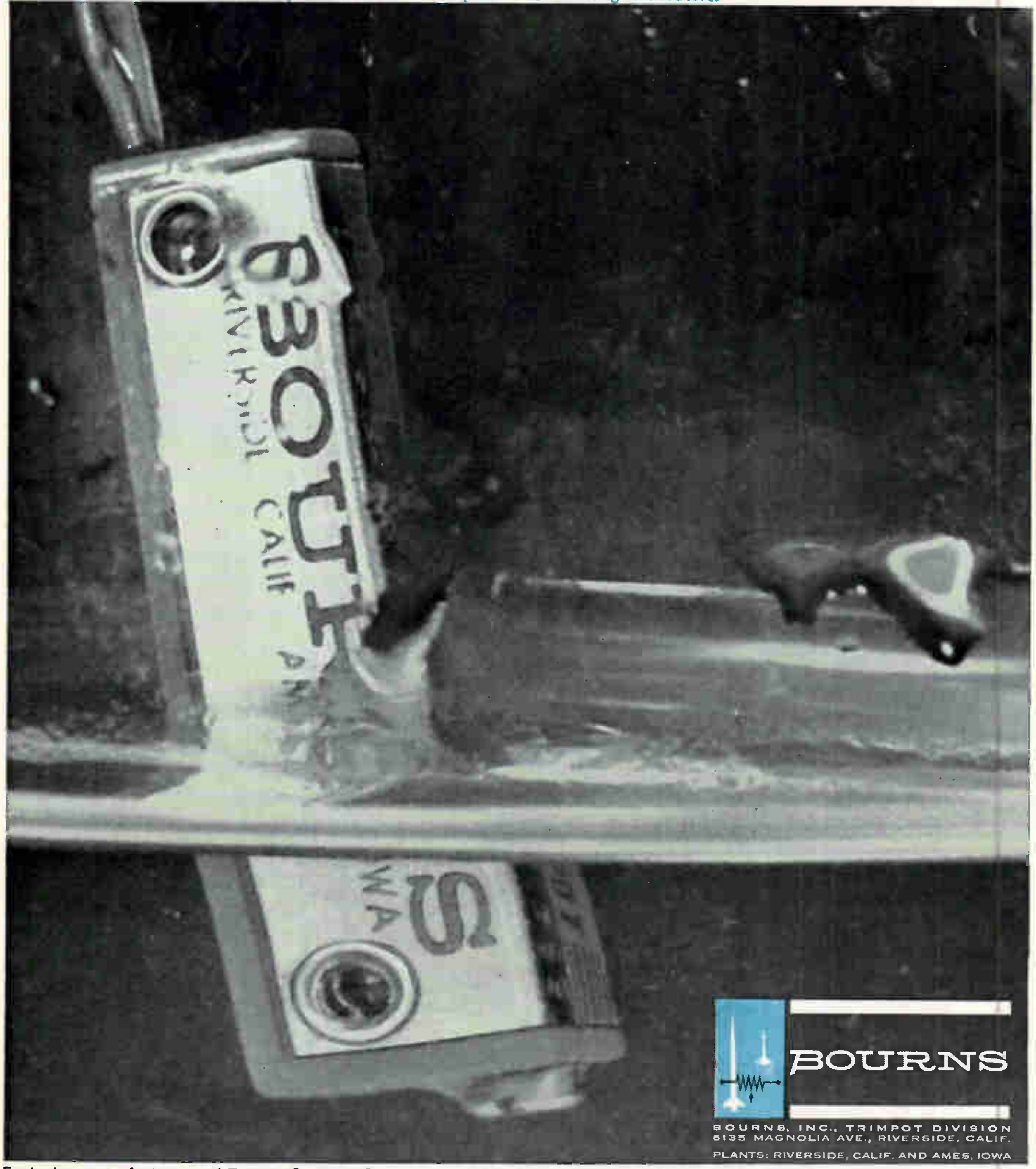
Bourns Trimpot® Puts the Proof in Humidity-Proof

Plunging a potentiometer into near-boiling water is just one of the ways Bourns puts the proof in humidity-proof. Every Trimpot unit made takes this 60-second bath with the water simmering at 90°C. Air expanded by the heat creates four pounds of pressure inside the potentiometer—enough to cause bubbles—if it leaks. Only if the unit is completely leak-free does it pass the test.

Bourns humidity proofing starts at the beginning—with original design and selection of materials. The plastic chosen for Trimpot cases, for example, displays the unusual properties of high insulation resistance and extremely low moisture absorption.

Further protection against humidity results from manufacturing procedures, such as internal potting of the resistance element and sub-components. Finally, Bourns samples all production for compliance to MIL-STD-202A, Method 106 as a routine part of a Reliability Assurance Program. As a result, Trimpot does more than "resist" moisture; it keeps moisture out.

For more information about the industry's largest selection of humidity-proof adjustment potentiometers—wirewound and carbon in a variety of sizes, power ratings, operating temperatures, etc.—write for new Trimpot summary brochure and list of stocking distributors.



Exclusive manufacturers of Trimpot®, Trimit®, and E-Z-Trim®. Pioneers in transducers for position, pressure and acceleration.

Accelerator Companies Merge

High Voltage Engineering Corp., Burlington, Mass., reports acquisition of all the stock of **Applied Radiation Corp.**, (ARCO), Walnut Creek, Calif. The transaction was made on the basis of one share of HVE stock for every 10¾ shares of ARCO. The California firm will continue to operate as a separate corporation under its present administration, but will have close management and technical affiliation with its new parent company. ARCO sales in the fiscal year ended Sept. 1959 were $1,648,516. HVE's 1959 sales were $7,087,916, with a Dec. 31 backlog of more than $9 million.

Diversa, Inc., Dallas, Tex., announces acquisition of 80 percent of the stock of **Texas Electronic Products Corp.** in the same city for an undisclosed amount. TEPC specializes in design and manufacture of automated equipment for the quality control field. Equipment presently being readied for market includes an automatic quality control computer and a system for production line control of package weights. Diversa has eight subsidiaries in the fields of banking, liquid petroleum, geophysical exploration and others.

United Control Corp., Seattle, Wash., reports acquisition of **Electro Development Corp.** in the same city, by a stock purchase for an undisclosed amount. Electro Development, employing about 115 persons, is presently working on contracts related to the Polaris and Minuteman projects. Its equipment is also used in the 707, DC-8 and 880 jet transports. Projected figures for the fiscal year to end Sept. 1960 indicate that sales will exceed $1 million. United Control, employing more than 800 persons, had sales of $11,680,000 in 1959, $5,847,000 during the first six months of this year.

Varian Associates, Palo Alto, Calif., announces plans to acquire **Semicon Associates, Inc.**, through an exchange of stock. Varian will acquire Semicon's outstanding shares in exchange for a maximum of 30,000 Varian shares. The smaller firm consists of two companies bearing its name in Lexington, Ky., and Watsonville, Calif.

Cain & Co., Los Angeles-based electronics sales engineering organization, announces acquisition of **Memo, Inc.**, New York, also an electronics sales organization, operating in New York.

25 MOST ACTIVE STOCKS

	WEEK ENDING JUNE 10			
	SHARES (IN 100's)	HIGH	LOW	CLOSE
Gen Tel & Elec	1,939	31¾	35⅝	30⅝
Int'l Tel & Tel	1,265	46⅛	42½	45⅞
Standard Coil	1,256	19¾	16½	18¾
Gen Electric	934	95¾	90⅜	95⅛
Du Mont Labs	867	10¼	9½	10
Collins Radio	812	65¼	62	63¼
Int'l Resistance	811	39⅜	34½	35¼
Ampex	754	36⅞	35⅛	35⅞
Lear Inc	717	20⅜	18⅝	18⅝
RCA	676	77⅜	74¾	77
Westinghouse	625	65	59⅝	65
Gen Inst	598	42	38¼	38⅜
Raytheon	586	44½	40⅜	43¼
Zenith	499	122¾	113	119
Avco	484	13⅜	12½	12⅞
Western Union Tel	467	50⅜	47¾	49
Cohu Electronics	445	12¼	11⅛	11⅜
Univ Controls	440	16¼	15⅜	15½
Varian Assoc	427	60	54⅝	60
Burroughs	420	39⅜	37¾	38⅜
Philco	401	33¼	31½	31⅞
Gen Precision Equip	346	61⅝	58	60
Barnes Engnr'g	343	52½	46	49
Transitron	325	50¼	47¾	50⅛
Amer Electronics	278	60⅜	14⅝	15¾

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

DIVIDEND ANNOUNCEMENTS

	Amount per Share	Date Payable
Barry Controls	.10	July 28
Collins Radio	4%	Aug. 15
Collins Radio 4% pfd	.50	July 1
Fisher Porter 5% pfd	.12½	July 1
RCA	.25	July 25
RCA pfd	.87½	Oct. 1

NEW ISSUES PLANNED

	No. Shares	Price per Share
Briggs Assoc	44,470	$5.00
Control Data Corp	125,000	*
Electronic Specialty	150,000	*
Franklin Corp	1,000,000	10.00
Garrett Corp	100,000	*
Pacotronics	150,000	4.00
Shaevitz Engineering	100,000	3.00
Vector Mfg.	25,000	*

* To be announced

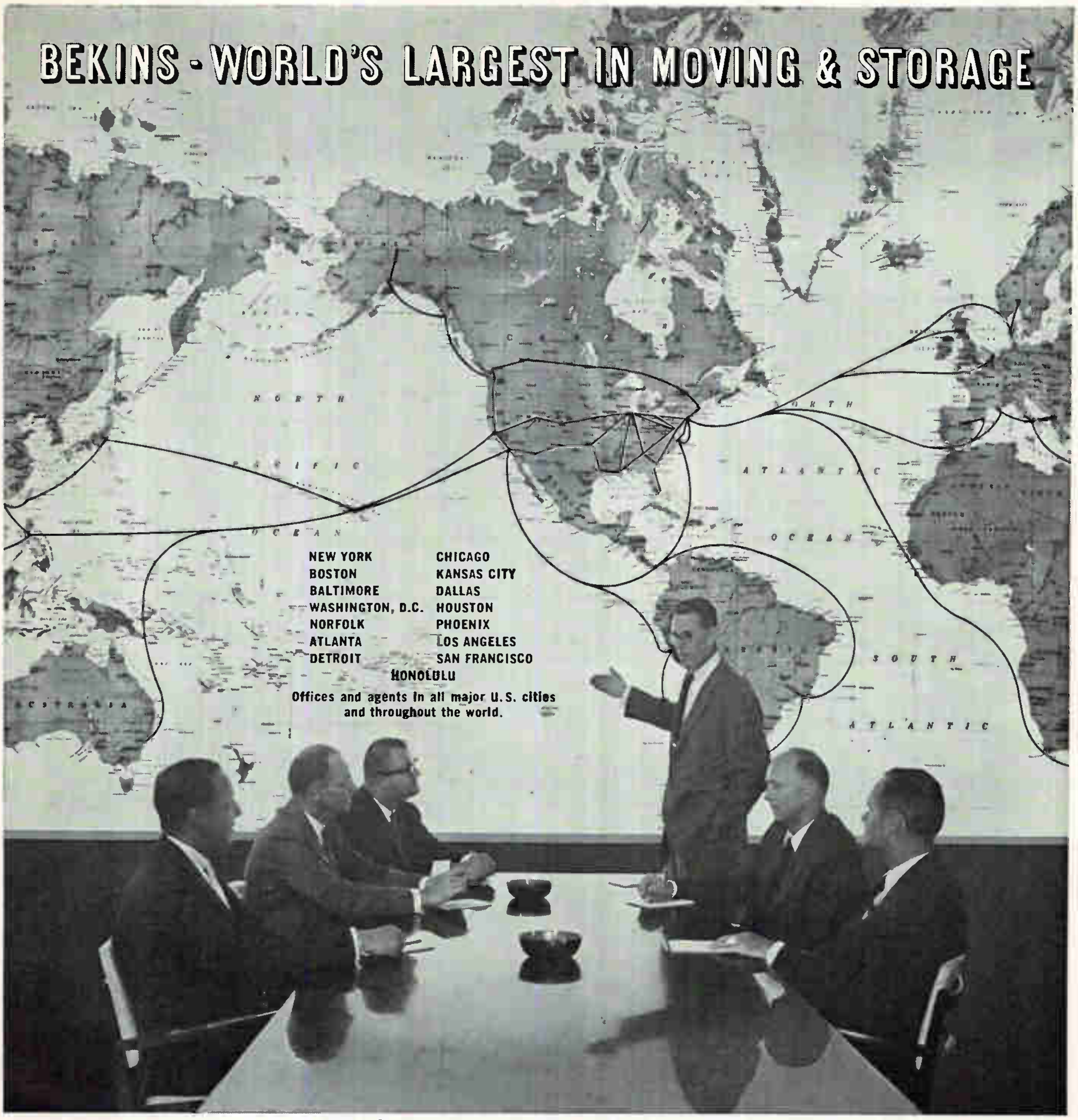
Chart new paths in printed circuits with Panelyte®

As new uses for printed circuits are developed, and new, more demanding designs are specified—count on Panelyte Copper-Clad Laminates for consistently superior quality.

At present, you can choose from a wide range of properties in four different grades. But St. Regis® Panelyte is working to perfect structural qualities which will meet your *future* needs, as well.

Whether you're looking for better machinability and adhesion, superior chemical resistance, closer thermal tolerances or any special combination of characteristics, bring your copper-clad laminate specifications to Panelyte. We can supply Panelyte in the following grades: Paper Phenolic Base—XP, XXP, XXXP; Glass Melamine—G5; Glass Silicone—G7; Glass Epoxy—G10, G11. For complete information and the address of your nearest Panelyte distributor, write Dept. EL-624, St. Regis Paper Co., 150 E. 42nd St., N.Y., N.Y.

St. Regis
PANELYTE®



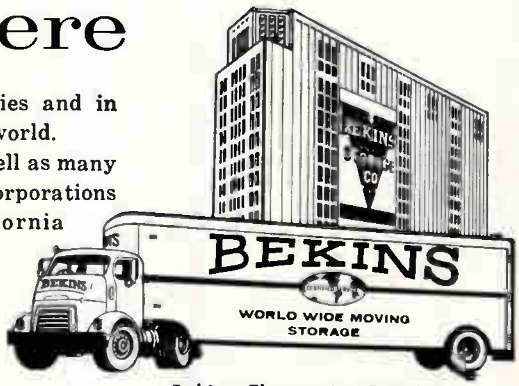
Daniel P. Bryant, President of Bekins, reviews global operations with company executives, Andreson, Holt, Robison, Shaw and Bekins.

Bekins is Everywhere

Across the United States from east to west and around the world, Bekins is keeping apace with the ever-increasing demand for family and for corporate moving services.

Certified Service, the modern concept which has made Bekins the largest moving and storage company in the world, is now available in more than 80 North American localities and in key cities throughout the world.

Today 2,000 families as well as many of the nation's greatest corporations from New York to California use Bekins every day for Certified Service. You'll find Bekins listed in the Yellow Pages.

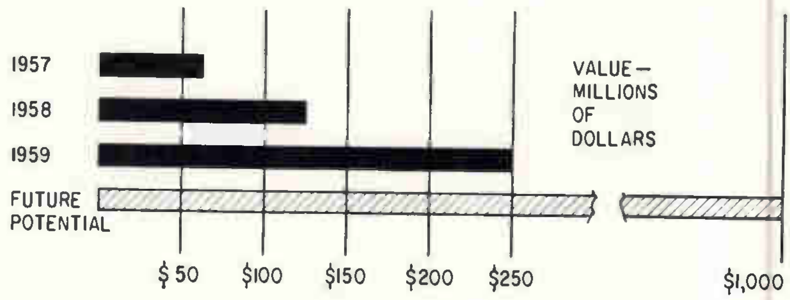


Certified Electronics Moving *Write for new free brochure which explains why leading U.S. manufacturers rely on Bekins for skilled handling of delicate equipment.*

Bekins Electronics Division
1335 South Figueroa Street
Los Angeles 15, California

MARKET RESEARCH

PLASTIC PARTS PRODUCTION BY ELECTRONICS INDUSTRY



Plastic Parts Production Doubles

PLASTIC PARTS produced by the electronics industry were worth $250 million in 1959, said Ralph L. Mondano, manager of Raytheon's plastic plant in Maynard, Mass., in a talk before The Society of the Plastics Industry.

Mondano says value of production doubled in each of the past three years, indicating approximate volumes of $125 million in 1958 and $63 million in 1957. Only 25 to 30 percent of the plastics potential for the electronics industry has been reached, he says, predicting a future annual volume of $1 billion.

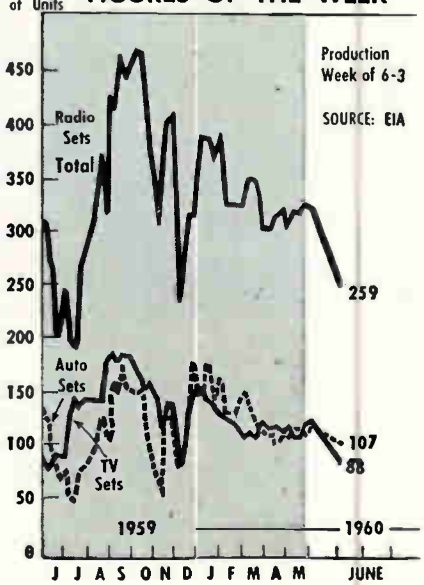
Rapid rate at which use of plastics has been growing has been largely influenced by military spending. The government has been the primary support of research which developed such applications as the all-plastic radar reflector, reliable miniature gyros and liquid therosetting resins with co-efficients of thermal expansion to match metal.

Growing use of plastics by our industry has resulted in parallel growth in importance of plastic specialists. Today, all sizeable electronics companies have competent plastic engineering and development sections, says Mondano.

Some electronics firms have seen that by merely expanding their present plastic departments they can sell to others and add a fast-growing product to their lines. Some have taken the step already, others are getting ready to do so.

Firms thinking of entering this field should bear in mind that the government is the big ultimate electronics customer, he adds, and they should have the following: Government contract negotiators, good quality control and inspection procedures, means of attaining and holding certificates of material compliances and bookkeeping procedures satisfactory to contracting agencies.

FIGURES OF THE WEEK

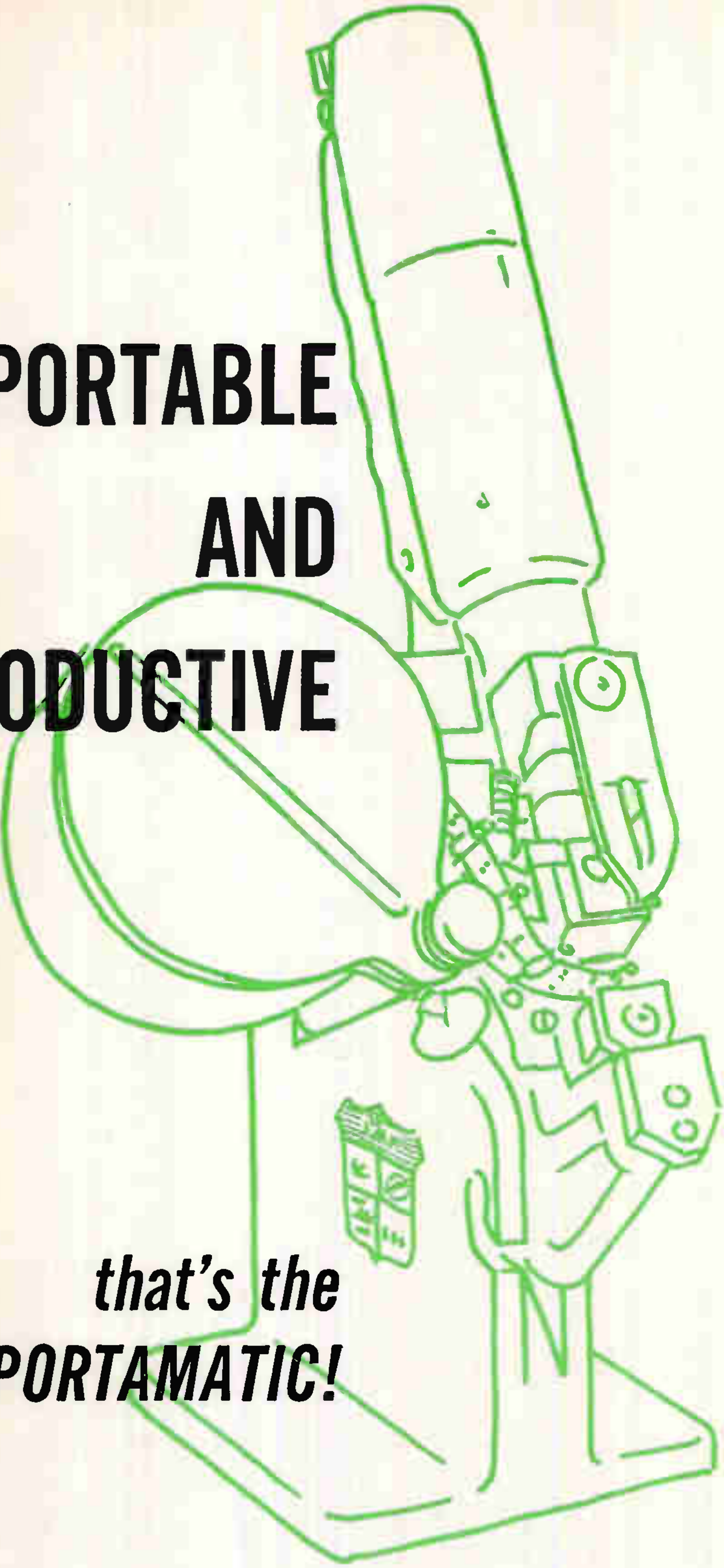


LATEST MONTHLY SALES TOTALS

(Source: EIA)
(Add 000)

	Mar. 1960	Feb. 1960	Change From One Year Ago
Rec. Tubes, Value	$31,751	$27,881	−10.0%
Rec. Tubes, Units	36,382	32,734	− 8.7%
Pic. Tubes, Value	$15,654	$14,495	+13.4%
Pic. Tubes, Units	794	741	+10.7%
Transistors, Value	$28,700	$24,832	+58.4%
Transistors, Units	12,022	9,528	+90.5%

PORTABLE AND PRODUCTIVE



that's the AMPORTAMATIC!

If your production problem puts you squarely in the middle of not ready and not yet—quotas too high for hand tool crimping yet not high enough to justify installation of AMP automatic machinery—you'll find a minimal investment, speed-up answer in the AMPORTAMATIC Tool.

The AMPORTAMATIC Tool is designed for continuous use to precision crimp a variety of AMP terminal types in a wide wire size range. For volume, bench production or for hard-to-reach locations—anywhere along the production line—the AMPORTAMATIC Tool delivers a single crimp or a fast series of crimps with complete reliability.

Think there's room for this versatile performer in your lineup? Then you'll want to know more about the portable AMPORTAMATIC Tool.

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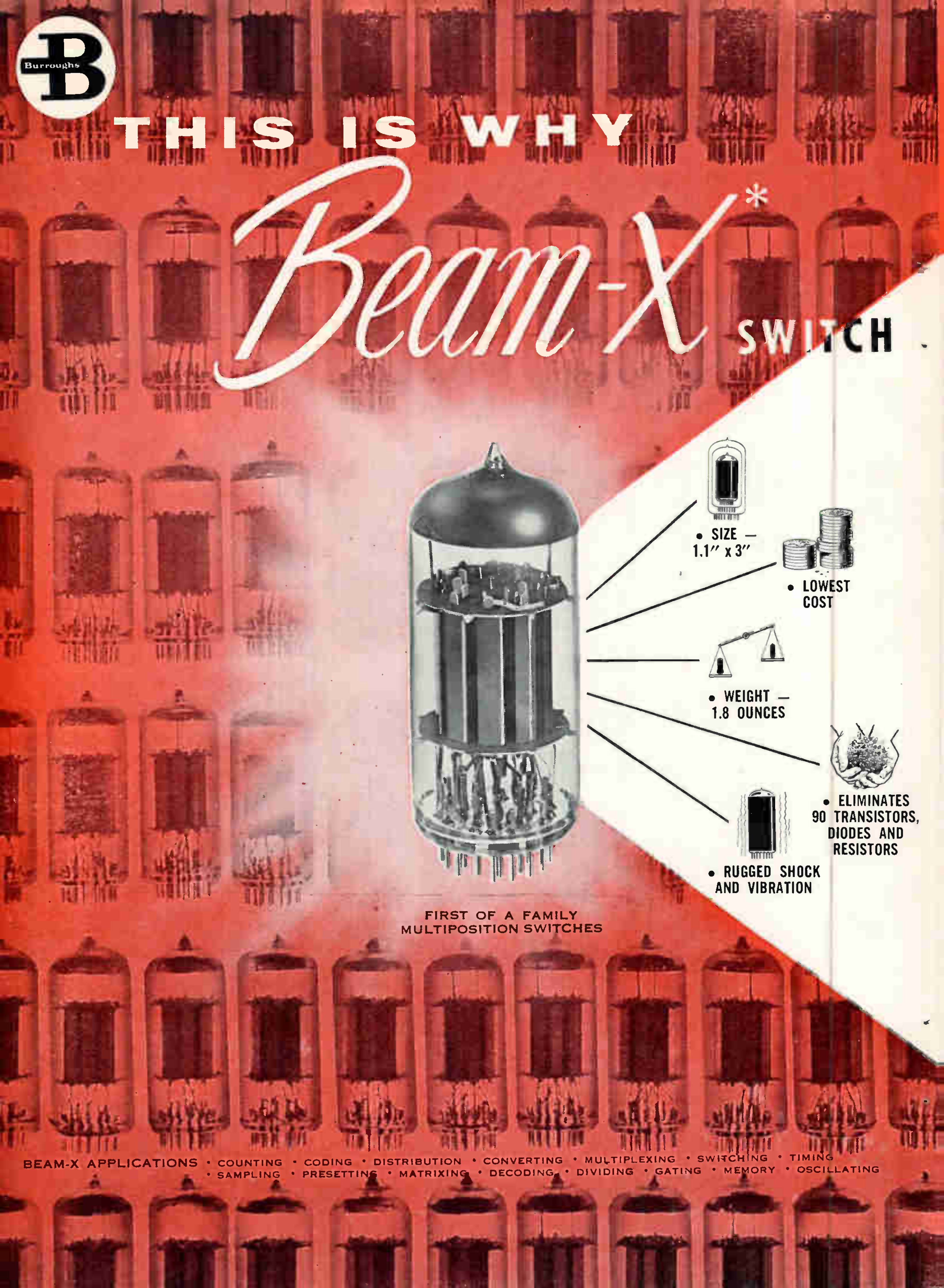
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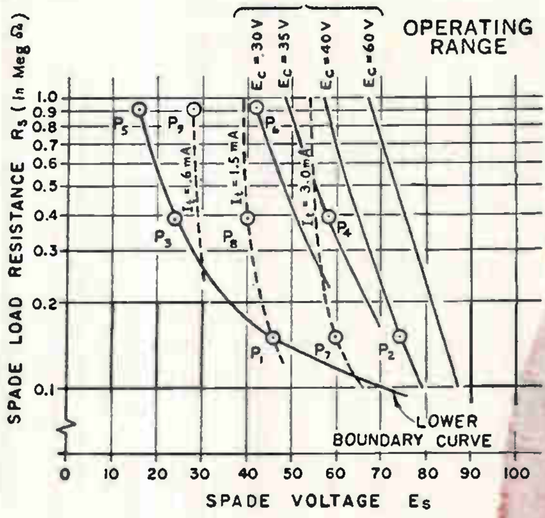

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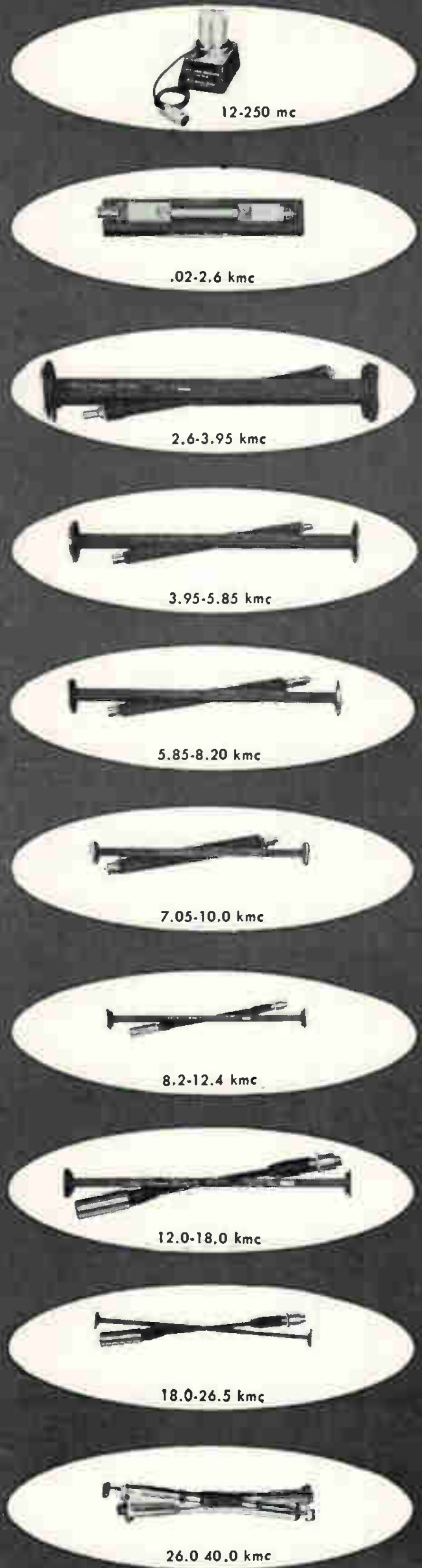

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- VSWR 1.1 max.
- Insertion loss 0.5 db max.

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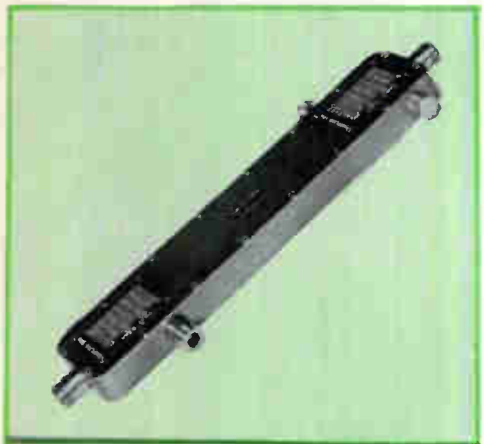
Model 175

- Operation over full waveguide frequency ranges.
- Full range of sizes from 2.6 to 40 KMc.
- Stability dependent only on locked mechanical setting.
- Frequency sensitivity ± 0.3 db to 20 db.
  ± 0.5 db 20 to 30 db.
- VSWR 1.15 max.
- Factory set values from 0.5 to 30 db.



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RCA's new Basic Micromodule Laboratory Kit provides a revolutionary new way to meet the challenge of microminiaturization. It places full facilities for building and encapsulating experimental Micromodules directly in the hands of your own design group. From breadboard to finished Micromodule, you can evaluate your own circuits, assemble and encapsulate to your own specifications.

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The new kit provides all of the tools and instructions needed to convert many of your existing electronic-circuit designs into Micromodule equivalents: encapsulants, encapsulating mold, curing oven, cleaning materials, special microscope, special jigs, special air-abrading tools and automatic-control equipment—all are supplied with your Basic Micromodule Laboratory Kit. The only additional equipment you need to build your own sample Micromodules in your own laboratory is a tank of nitrogen and ten feet of workbench.

STEP-BY-STEP INSTRUCTIONS

The Design Manual and Instruction Manual supplied with the kit give the step-by-step procedures for converting to Micromodular form and for building your own micromodules. The Design Manual shows, for example, how to divide circuits into units to suit Micromodule requirements—how to determine the positions of microelements in the assembled Micromodule—how to lay out the wiring for interconnections between Micromodules—how to make mechanical layouts. The Instruction Manual clearly explains and illustrates all of the techniques for building and testing experimental Micromodules. The stock of microelements and other components provided in the kit can be used for a wide range of circuit designs.

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Give your equipment designs the inherent advantages of microminiaturization now, with the RCA Basic Micromodule Laboratory Kit—component densities to several hundred thousand parts per cubic foot, greater reliability through redundancy, room to improve accuracy, precision, control, sensitivity, and selectivity.

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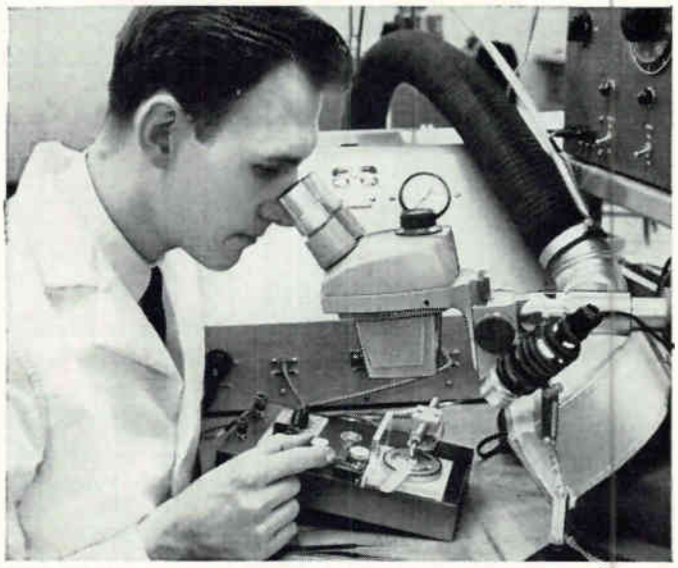
Your RCA Field Representative is ready to give you the details on the new RCA Basic Micromodule Laboratory Kit. He also has complete information on standard Micromodules available from stock for application in your new or existing designs. Remember, micromodularized end-equipment is probably your number one goal today—and it's ready for you now with RCA Micromodules. Give your local RCA office a call today!

For your copy of RCA's new, complete Micromodule Design Manual, send $2.00 today to RCA Semiconductor and Materials Division, Commercial Engineering Section F19-NN-Z, Somerville, N. J.



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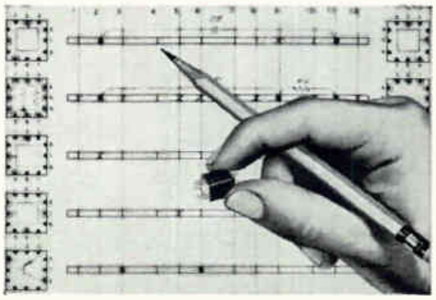

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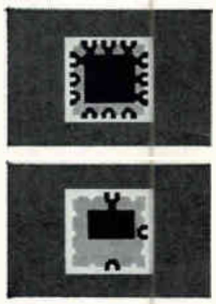

Microelement ceramic capacitor (magnified) with "universal" multiple terminations (top) can be abraded to give custom tailored capacitance values and provide the terminal arrangement you want (bottom).

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AUTOMATIC CONTROLS CONFERENCE OPENS IN MOSCOW NEXT WEEK

Some 150 Americans are among 700 experts gathering to exchange notes

Moscow University's main auditorium, where plenary sessions will be held. Control instruments will be exhibited in foyer outside

Night view of centuries old Kremlin. Excursions on Moscow River, shown here, are available

By ERNEST CONINE
McGraw-Hill World News

MOSCOW (McGraw-Hill World News)—Hundreds of automation experts from both the Communist and non-Communist worlds gather here next week to exchange notes—and get at least a limited look at the progress of automatic control in the Soviet Union.

The first congress of the International Federation of Automatic Control, founded in Paris in 1957, opens June 27 in the main auditorium of Moscow University's 32-story "wedding cake" skyscraper in the Lenin Hills section of the Soviet capital.

In addition to a "substantial number" of Soviets, the meeting is expected to be attended by 700 to 800 delegates from almost 30 other countries, including some 150 Americans.

The host committee, composed of prominent Soviet scientists, has been at work for months making arrangements for the congress and choosing the 285 papers to be presented.

Discuss Theory

To quote one Soviet scientist's joking remark: "We have been so busy preparing for this meeting that you Americans will pass us up in automation."

About half the reports will be devoted to the theory of automatic control, and the rest to the technical means and methods of introduction of automatic devices.

The greatest contributions, numerically speaking, will be made by Soviet and American delegates—presenting 81 and 73 papers, respectively.

In addition to contributions from western industrial powers, papers also will be presented by delegates from India, Red China, Poland, Rumania, Hungary, East Germany, Czechoslovakia, Yugoslavia and Japan.

The main sessions will be presented in English, Russian, French and German. English and Russian will predominate in the smaller technical sessions. All papers will be printed in these two languages.

Alexander M. Letov, Soviet automation theorist and president of

IFAC, thinks "the papers will contribute very valuable scientific information about modern problems of automatic control. They should give the participants a basis for good scientific discussions."

Letov expects nine technical sessions in the field of theory (his own pet field), five in components and six in applications.

Russian and English translations of all papers are being distributed in advance of the meeting.

About 100 scientists and engineers from different countries will preside at the sectional meetings, supply comments on and sum up the debates and prepare written reports on the results. A general report on the work of all sections will be read at the final plenary meeting.

The hosts also expect that systematic exchanges of automation information between federation members from different countries will be set up. This will be the province of scientific-technical committees, multinational in character, organized along the lines of theory, technical means, application, terminology, personnel training and bibliography.

The congress' program also includes exhibition of literature on problems of automation, remote control and computing machines; exhibition of automation instruments and techniques "of the latest type"; showing of some 30 scientific-technical films on automation produced in the Soviet Union, the U. S., Great Britain, France, Italy, Belgium and other countries; and visits to Soviet industrial establishments utilizing automatic control.

Industrial Excursions

The business sessions at Moscow University will last seven days; then, delegates who wish will make industrial excursions to Leningrad or Kiev. (Earlier excursions will be available in the Moscow area.)

Visits to the Institute of Automation and Telemechanics in Moscow, and the Ukrainian Institute of Automation at Kiev definitely are on the list. But the Soviets have been chary of specifying in advance what plants will be open for inspection.

"However," promises organization committee member Ivashin A. Grigorivich, "there will be enough of them, I assure you."

Demonstrations are expected to include automatic lines in the fields of metallurgy, chemical processing, machine building, and instrument construction; application of digital computers in controlled industrial processes and some self-adaptive control systems.

The Soviets have said that delegates may arrange individual industrial visits outside the framework of the IFAC congress.

Friendly Welcome Expected

The recent political troubles between the U. S. and the Soviet Union, climaxed by the failure of the summit conference at Paris, do not appear to have dampened the Soviet interest in technical exchange programs—programs from which they presumably have been getting a net benefit. Westerners living in Moscow can notice little or no change in Soviet citizens' attitude of friendliness to Americans.

Automation and mechanization are at the heart of the Soviet Union's plans to increase its workers' productivity (now only half that in America) and overtake U. S. industry within 10 or 12 years.

The Soviets plan to put at least 1,300 automatic lines into service during the current Seven Year Plan, which began with 1959. The Soviet press has told of automated copper mills, steel mills, oil fields, power stations and machine tools. But it has also told of problems: slowness of economic planners and factory managers to adapt automatic control techniques, a tendency to automate individual operations in a plant but not an integrated production process, etc.

Delegates to the IFAC meeting will have an opportunity to check their own impressions against those of Communist Party leaders within days after the congress ends—when the Central Committee of the party holds its meeting in Moscow in July.

High on the agenda is a review of progress in the effort to mechanize and automatic Soviet industry. If past history is a guide, the meeting will produce much praise for various jobs well done—and some very hard and specific criticism of abject failures.

'59 Parts Sales Up, Profit Margin Steady

COMPONENT manufacturers say 1959 was the best year in their history, according to the National Credit Office, which recently completed a survey of operating results among 31 large firms in the field.

Total sales of the group were up 23 percent for the year; profits 28 percent. Altogether, they racked up $633.5 million of sales and $24.8 million in profits.

But the profit picture was not as good as it looks at first glance. Despite big dollar increases in sales and profits during 1959—$129 million and $6 million respectively—profit margin (net profits as a percentage of sales) advanced only from 3.7 percent in 1958 to 3.9 percent in 1959.

Moreover, this slight improvement compares unfavorably with the 4.1 profit margin earned in 1957 on sales which were 18 percent less than 1959.

Increased labor, material and overhead costs in 1959 were the chief reasons for limiting profit margin growth, survey reports.

Computer Will Advance Submarine War Training

LARGE-SCALE digital computer is destined to be the core of a $3.6-million nuclear-submarine training center. The computer, a Honeywell 800, will permit the Navy facility to achieve a high degree of realism in waging mock undersea battles using modern tactics, weapons.

The trainer will be installed by Minneapolis Honeywell at the Navy's Submarine School in New London, Conn. Computer will be used to compute ship movements and performance, calculate damage, keep track of tactical situation.

Within the three-story trainer building, attack centers of three nuclear submarines will be accurately duplicated. Radar and sonar presentations will show trainee commanders the situation in detail.

Periscopes will be connected by closed-circuit tv to models of targets on a mock sea, automatically positioned for correct aspect and distance.

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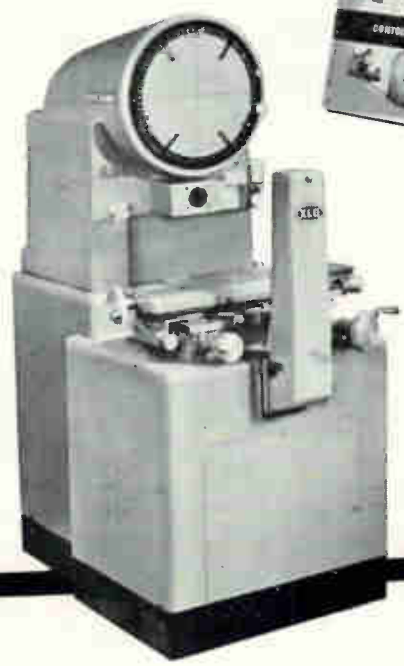

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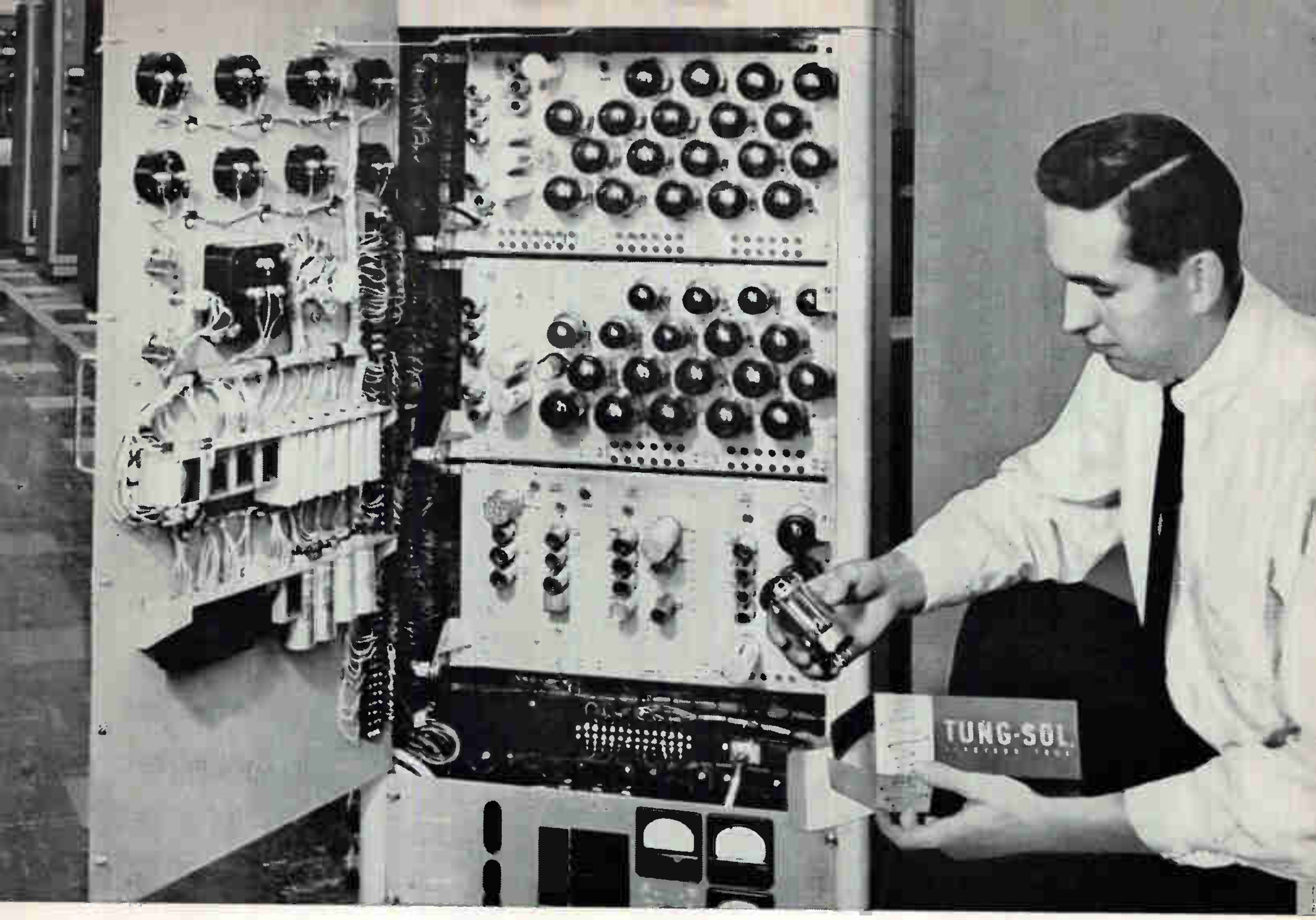

TUNG-SOL

FREQUENCY CONFERENCE:

Atomic Clocks and Quartz Crystals

Today atomic clocks are being packaged for industrial, laboratory and missile use; research continues on quartz crystals

By GEORGE J. FLYNN
Associate Editor

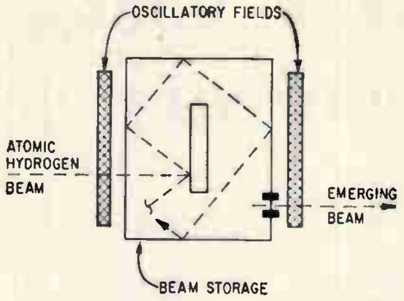
QUARTZ CRYSTALS and atomic clocks were the subjects of major interest at the fourteenth annual Frequency Control Symposium. The conference, attended by an estimated 500 engineers and scientists from industry and government, was held recently in Atlantic City and was sponsored by the U. S. Army Signal Research and Development Laboratory, Ft. Monmouth, N. J.

N. F. Ramsey of Harvard University reported on progress toward a stored beam atomic clock that will use atomic hydrogen. Hydrogen is directed into a chamber whose sides have been coated with a special paraffin. The hydrogen atoms are not allowed to emerge from the box directly but must bounce off the walls numerous times before they accidentally strike the small exit hole. The result is that the beam is stored inside the chamber for a longer time than is possible with typical beam clocks. The longer the beam can be stored, the greater the accuracy of the clock. The illustration shows how the beam is made to bounce around inside the chamber.

First tests were made with cesium—because of availability and ease of use—in a relatively small chamber. About 190 collisions were obtained between the walls and individual atoms and an emerging beam was formed. With the operating principle verified with cesium, experiments are being made with hydrogen in a chamber approximately 1 meter on a side. The number of bounces is expected to be on the order of 2,000. If the tests are successful, an atomic clock with an accuracy of 1 part in 10^{13} should be possible. This is approximately two orders of magnitude better than available clocks, would amount to 1 second in 320,000 years.

Quartz Crystals

Approximately half the conference papers were on quartz crystals. Significant data comes from tests being made by R. B. Belser and his associates at the University of Georgia. Under a contract from USASRDL, commercial grade, hermetically sealed crystals have been undergoing tests for several years. Shown in the table are the results of leak tests on almost 600 units. Leaks were found in 83 percent of the units tested. The most typical leak points were at the pinch-off tube, at the base seal, around the socket pins and where identification marks were stamped in the cover.



By holding the atoms for a longer time in the area between the two oscillatory fields, measurement of the precession rate can be done more accurately, thus allowing a more accurate clock

LEAK TEST OF HERMETICALLY SEALED CRYSTALS

Test Temperature, Degrees C	Number Tested	Small Leaks	Large Leaks	Total Leaks	No Leaks
25	230	158	23	181	49
85	196	150	19	169	27
125	143	87	35	122	21
Totals:	569	395	77	472	97
Percent:	100	69.5	13.6	83	17

The most significant parameters causing aging—evident as frequency drift—are various changes in the metal film on the quartz substrate. The film is affected by corrosion, diffusion, adsorption, alloying if overplating is used and stress relieving actions. Corrosion and adsorption are believed to be the major and most frequent cause of aging but these processes can be stopped by meticulous cleaning and true hermetic sealing. Glass seems at present to be in favor over metal as the crystal container, probably because it is easier to inspect for cleanliness.

A summary of the effects of nuclear radiation on quartz crystals was presented by J. M. Stanley of USASRDL. Tests are being conducted by Admiral and Bendix. Crystals are generally not greatly affected by radiation and units with a precision of 0.005 percent will probably not be harmed by radiation of the level found in the Van Allen belts in outer space. However, units projected for future use, with stability specifications of 3 parts in 10^7, may be affected. The tests are being continued, with particular attention directed at the transient effects of radiation.

Talking Grapefruit

Analog recorder at Florida Minitrack station translates signals 4 times a day from still-busy Vanguard I

Firms Plan to Hire 44% More New EEs

U. S. FIRMS plan to hire 44 percent more electrical engineer graduates this year than in 1959. Last year, 1,148 new EEs were hired. This year companies aim to obtain 1,656.

There will be more job offers in 1960 for college graduates in all fields and for engineers in general.

Information comes from the Department of Labor which has surveyed intentions of 211 firms who actively recruit university and college graduates, and who are considered representative of large and medium-sized firms active in recruiting.

Starting Salaries

Average monthly starting salaries this year for engineers is $504, survey shows, as against $489 in 1959. But separate salary information on electrical engineers was not obtained.

The average starting salaries are probably somewhat higher in actual practice because past experience has shown that salaries offered in the spring tended to be higher than intentions indicated in November, when poll was taken.

Companies report this year they will offer at least $80 a month more on the average to engineers than to general business graduates. This differential has been increasing in past five years. In 1955 it was $32.

New temperature controlled MICROSTACK® meets

-55°C to +85°C

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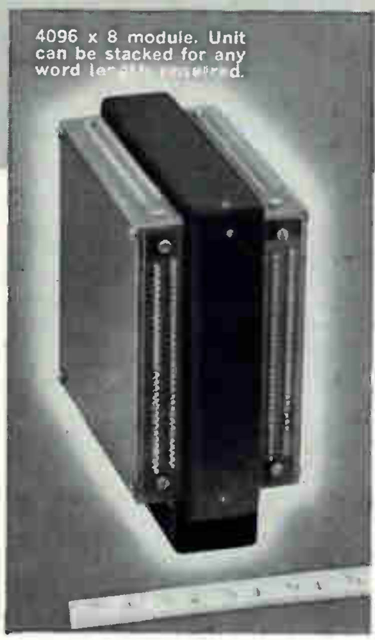

The General Ceramics MICROSTACK, one of the most important advances in memory core packaging, now operates in a temperature range of from —55°C to +85°C. Core characteristics remain constant. By maintaining temperature stability inside the MICROSTACK unit, General Ceramics engineers have developed a memory core package that is smaller, more rugged, requires no external cooling or heating, and meets MIL shock and vibration specifications.

For additional information, please write on company letterhead. Address inquiries to Section E.

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WORLD'S LARGEST STOCK FOR IMMEDIATE DELIVERY—Chances are Ohmite's huge stock of several million resistors in more than 2000 sizes and types contains a unit that fits your requirements. Many types are also available through Electronic Parts Distributors located across the Nation.

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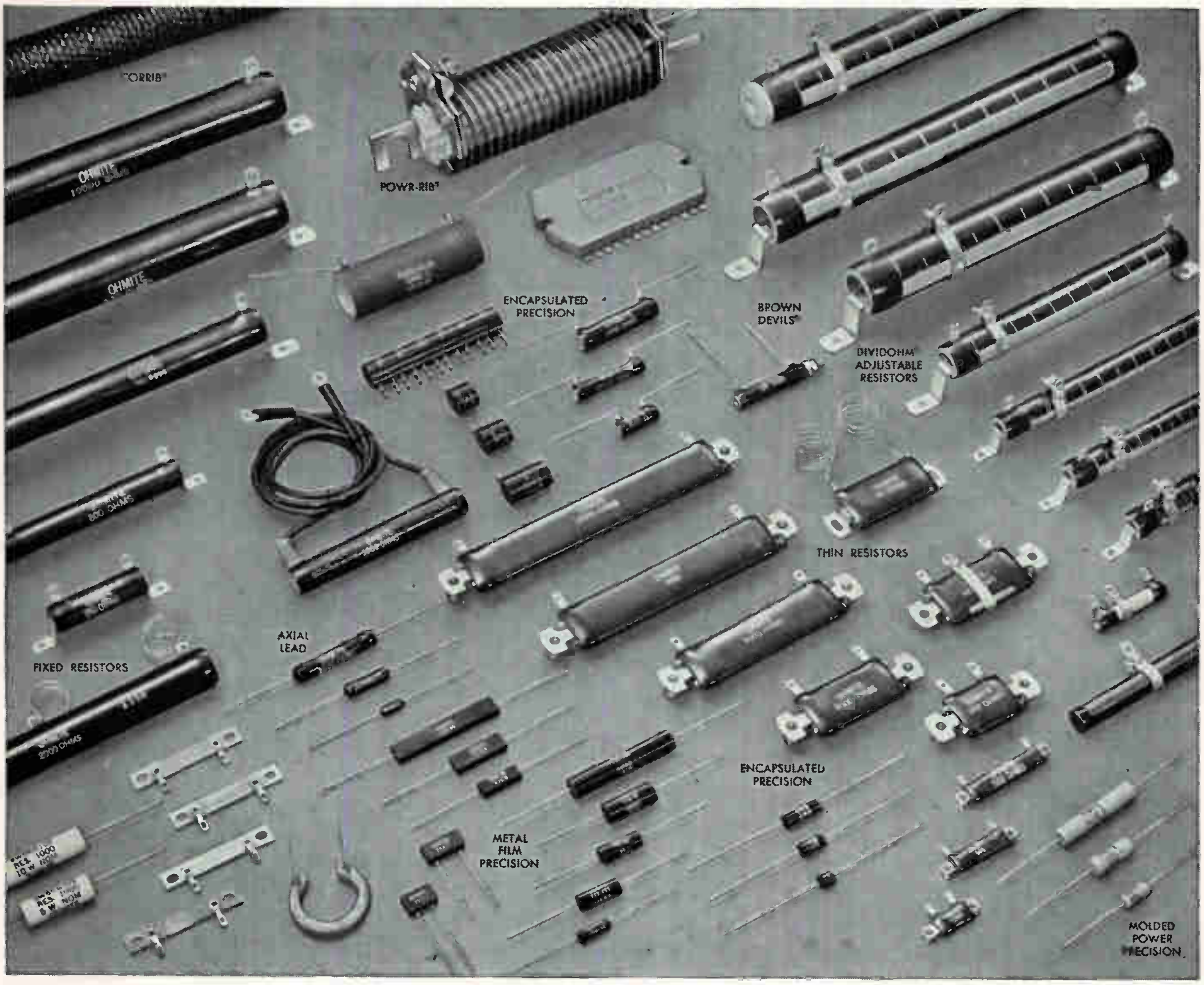

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CIRCLE 41 ON READER SERVICE CARD

Model Perceptron Makes Debut

Nondigital self-organizing machine identifies objects or patterns

By WILLIAM E. BUSHOR,
Associate Editor

A WORKING MODEL extension of the basic perceptron concept — previously simulated on high-speed digital computers—was publicly demonstrated for the first time this week by Cornell Aeronautical Laboratory.

This experimental nondigital self-organizing machine — dubbed Mark I—is capable of being trained to automatically identify objects or patterns, such as letters of the alphabet.

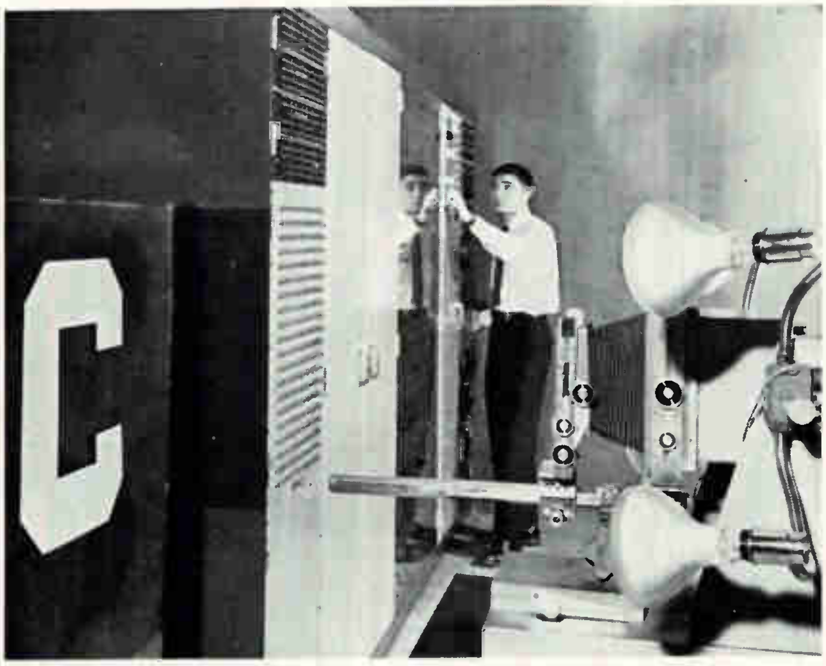
Sensory Units

Basically an electronic-electromechanical device, the machine consists of photocell sensory units which view the pattern, association units which contain the machine's memory and response units which visually display the machine's pattern recognition response.

During the demonstration, the alphabet from a single type face was shown to the machine and it correctly identified the letters without error. (A featured article describing the machine's operation and performance will appear in ELECTRONICS' July 22 issue.)

Dr. Frank Rosenblatt, who originated the perceptron theory, stressed that unlike some pattern recognition machines, the Mark I does not recognize forms by matching them against an inventory of stored images or by performing a mathematical analysis of characteristicts. He said the machine's recognition is direct and almost instantaneous since its memory is in the form of altered pathways through the system rather than a coded representation of the unique stimuli.

The perceptron research program, underway since 1956, is under sponsorship of the Information System Branch of the Office of Naval Research, with assistance of the Air Force's Research and Development Command.



Operator sets response unit on perceptron during forced-learning experiment

The machine is a limited capacity version of what eventually may become a family of efficient pattern recognition machines. CAL scientists emphasize that the present equipment is intended for research purposes only, and has not been designed for particular applications. Currently it performs only the simplest pattern recognition tasks and is of scientific interest because of its use of new principles, rather than its present level of performance.

Variety of Inputs

Perceptrons might eventually be used in many situations which now require human operators to differentiate between patterns. Such machines would be larger than the Mark I, although constructed on the same principles. A variety of inputs would be handled. For example, they would be able to receive audio as well as visual stimuli.

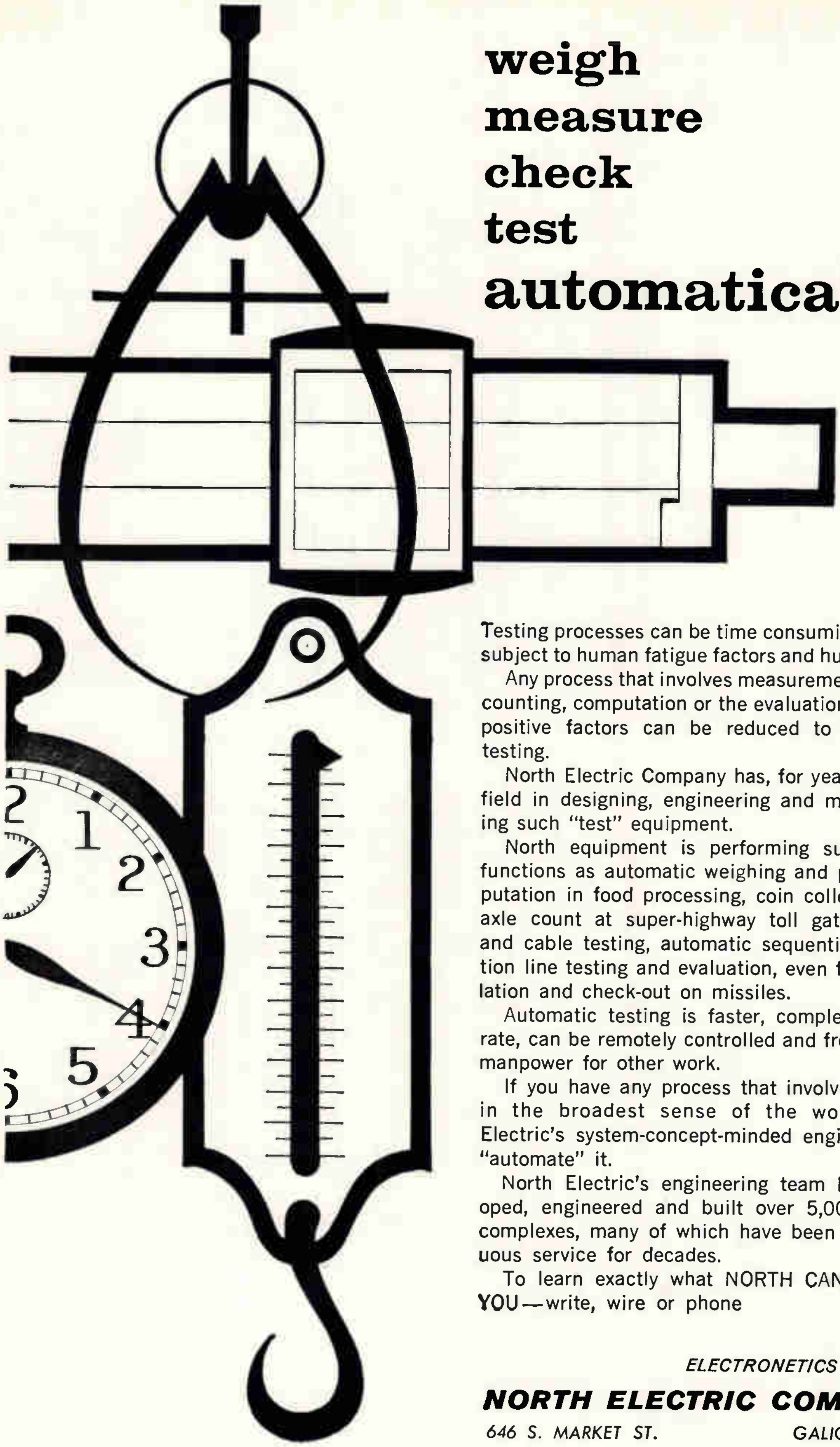
A CAL physicist thinks it is possible that future large-capacity perceptrons could be used to read print of various type faces and recognize spoken words. Similar machines might also be used to extract salient features from photographic information.

Considerable research and development effort lies ahead before perceptron-type machines can be designed for such applications, and it remains to be demonstrated that their use will prove economically feasible.

M. C. Yovitz, of ONR, points out that the fundamental significance of machines like the perceptron for eventual uses in the solution of many scientific, engineering and military problems is recognized by the military services, particularly for the processing of non-numerical information.

He also says that ONR and RADC are sponsoring a research program with Ford's Aeronutronic division to simplify the design of perceptron association units by using small magnetic components.

Warren Dunn, of RADC's Directorate of Intelligence and Electronic Warfare, commented that his people are convinced that developments such as the Mark I perceptron could represent a significant breakthrough in the field of intelligence data processing.



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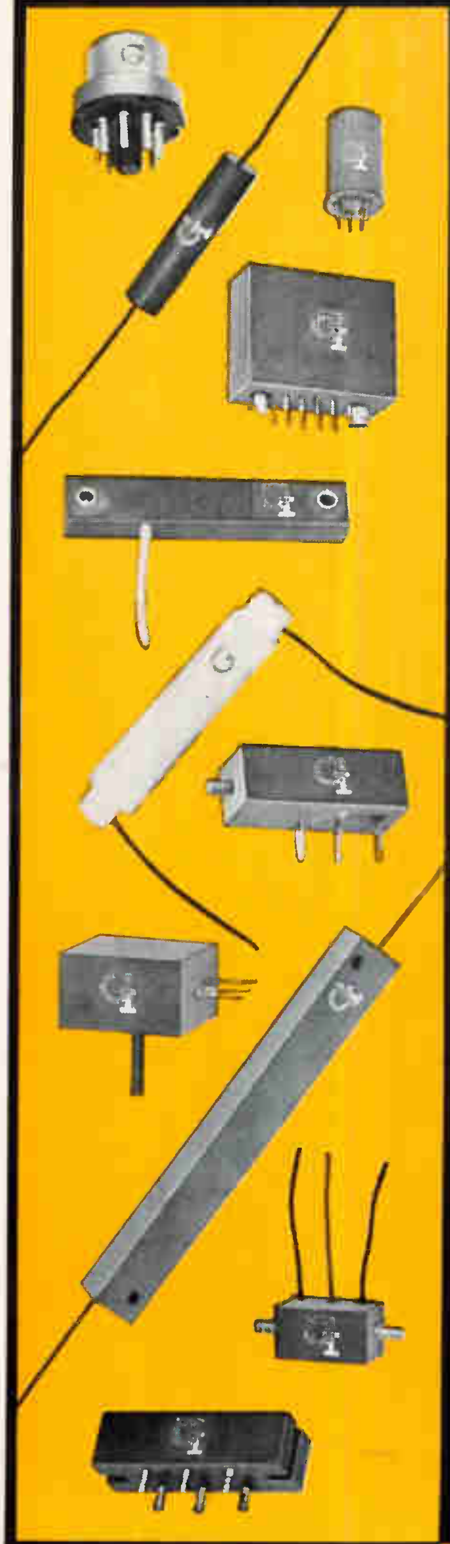

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CIRCLE 45 ON READER SERVICE CARD

British Show Industrial Gear

Instruments, controls, electron microscopes, advanced communications in New York exhibit

THE BRITISH EXHIBITION—still running this week at New York's Coliseum—contains a number of examples of advanced electronic design. Stress in British electronics as demonstrated at the big show is on commercial and industrial gear.

Item: Molins' Mark 8 cigarette-making machinery, which uses electronic weight-analyzing and recording equipment to ensure uniform filling of the cigarette and accurate unit weight. The system can be hooked up to as many as 35 machines, each capable of turning out 1,500 cigarettes a minute.

The Pye group's exhibit at the show lays stress on a 20-line all-electronic telephone switchboard being offered for export. In the tv field, Pye's exhibit includes a 3-D (stereoscopic) television system, a long-nosed closed-circuit tv camera specifically designed for internal inspection of nuclear reactors, and an underwater camera that has been proved out in various submarine salvage jobs.

Ferranti is showing a viscosity meter with automatic flow-curve recorder designed to study anomalous behavior in complex fluids. Other industrial instruments in the company's exhibit are a portable viscosity meter and a peak accelerometer.

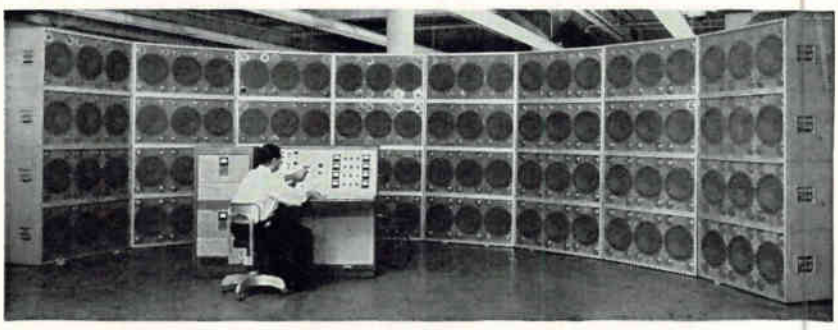
Kelvin & Hughes demonstrates a rapid-processing photographic projector designed to capture oscilloscope traces continuously on 35-mm film, produce a finished copy in six seconds, and project the images on an 18-ft screen in continuous sequence as rapidly as they are taken. Units similar to the one on display are already in use in this country's defense establishment, 48 of them in the SAGE system alone.

Associated Electrical Industries is conducting a series of demonstrations of the use of electron microscopy in physical and biological research. In the AEI exhibit, image-intensifier gear permits the passer-by to watch submicroscopic plant and animal activity, and see such phenomena as thin gold films evaporated on salt, on two large line-monitor sets. For tv transmission, the selenium plate on which the magnified image appears is scanned by an electron gun synchronized to the receiver raster.

ITT affiliate Standard Telephone & Cables is demonstrating a triangulation system that enables controllers on the ground to pinpoint aircraft position by direction-finding techniques from two or more points. D-f gear includes a stationary circular antenna array of 12, 18 or 24 antennas (depending on frequency band and accuracy requirements). Antennas are sampled in rapid sequence for 0.001 sec; relative amplitudes of received signal from each antenna are measured to derive bearing. Fix data are remoted for presentation on tv-type controllers' display.

STC is also exhibiting an all-electronic telegraph switching system dubbed STRAD (signal transmitting, receiving and distributing) which

Sound and Physiology Studied



Loudspeaker array made by Stromberg-Carlson is a keystone of Air Force studies of high intensity sound and its relation to human physiological reactions can take messages from a number of incoming circuits, store them temporarily on a magnetic drum, sort them by destination, and retransmit to correct outgoing circuit in order of time of arrival and priority. System can handle 83,000 words a minute.

Hi-fi and stereo gear are also on display at the exhibition, as are a broad spectrum of components. Components range from high-figure-of-merit tubes through semiconductor diodes and conventional transistor types to zener reference diodes, silicon photocells and double-diffused mesa transistors. Tape-handling equipment for computer systems is also on display.

The show concludes Sunday.

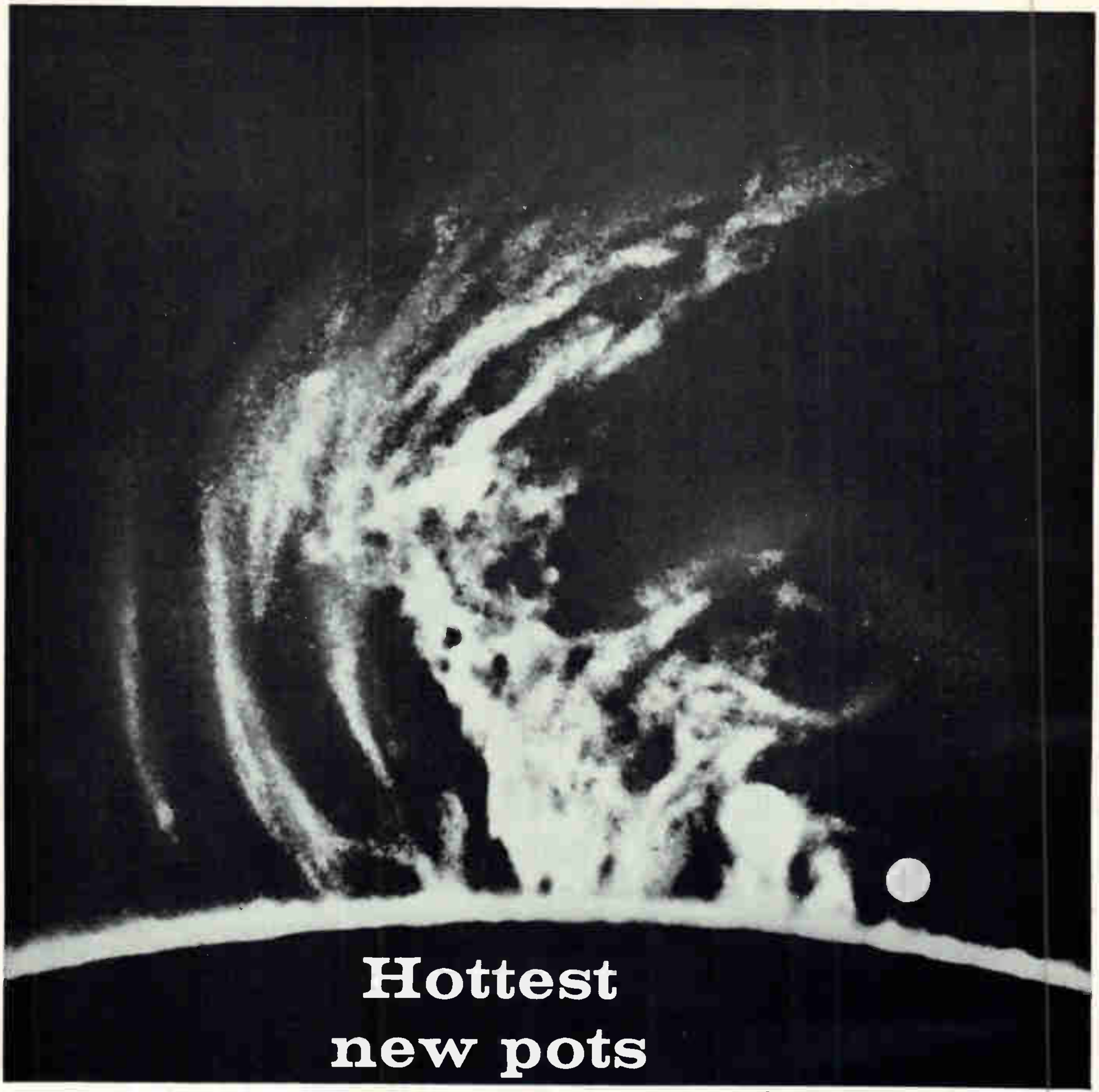
Gas Chromatography Highlights Meeting

MONTREAL (McGraw-Hill World News)—Instrument Society of America met in this city recently for a symposium on instrumental methods of analysis.

Featured topic of interest to industry was gas chromatography. As in the past, this continues to be main contribution of analytical instrument men to process control. New developments and broader applications of this approach were discussed in 14 papers, highest number devoted to any topic.

Two hot new developments appeared to be NMR (nuclear magnetic resonance) and EPR (electronic parametric resonance) as principles of analytical instrumentation. Said F. A. L. Anet, associate professor of chemistry of the University of Ottawa: "High-resolution NMR, particularly of protons . . . is assuming an importance rivaling that of ultraviolet and infrared spectroscopy."

Said of Herbert Rubin of Schumberger Well Surveying Corp.: "(NMR) is a form of radiofrequency spectroscopy in which a given nuclear isotope absorbs a characteristic electromagnetic radiation in the r-f band. The energy absorbed is converted to a signal which is proportional to the nuclear concentration. The instrument used . . . employs a permanent magnet, a square-wave modulated magnetic field, and an electronic integrator and strip chart recorder."



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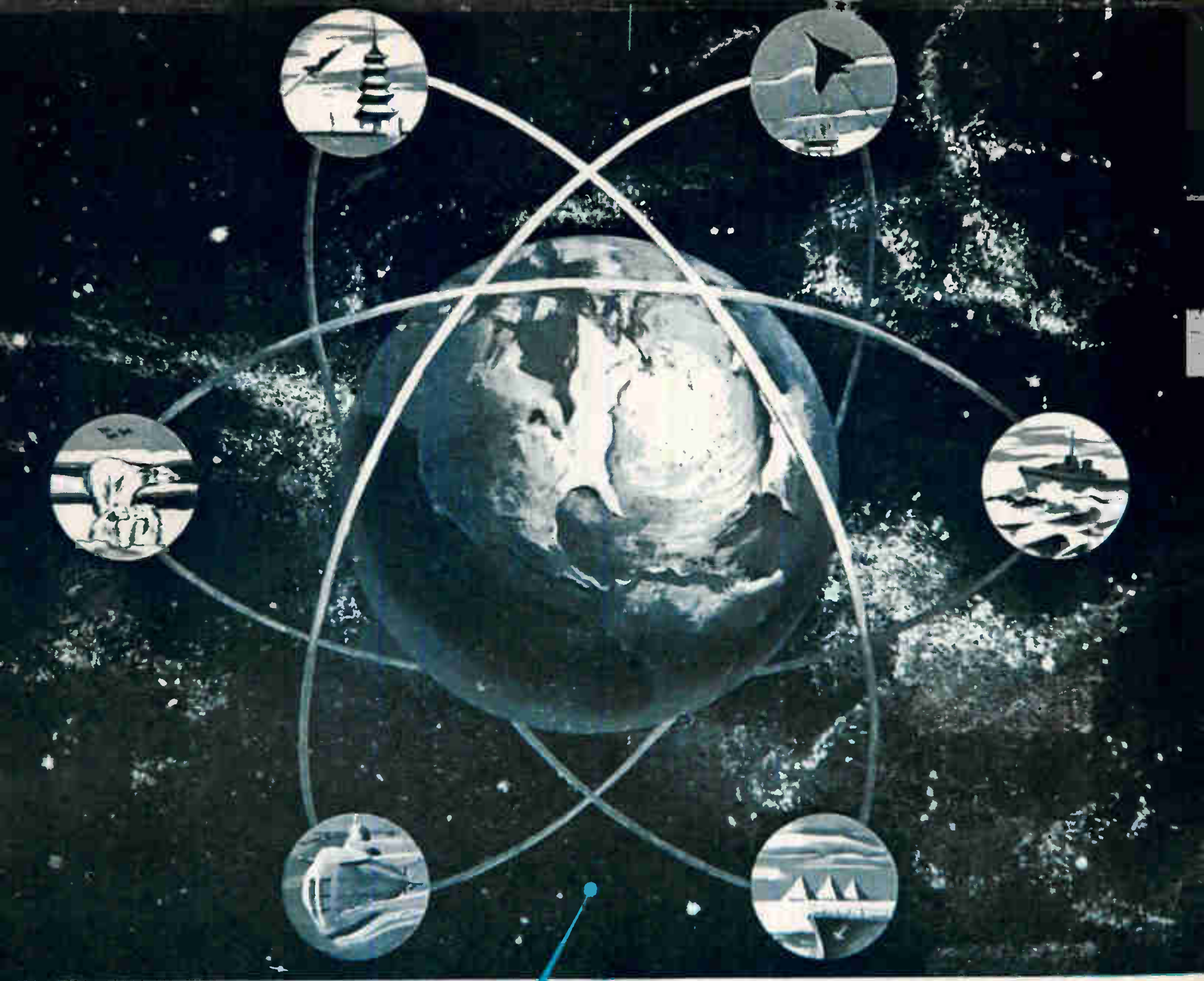
CIRCLE 49 ON READER SERVICE CARD→



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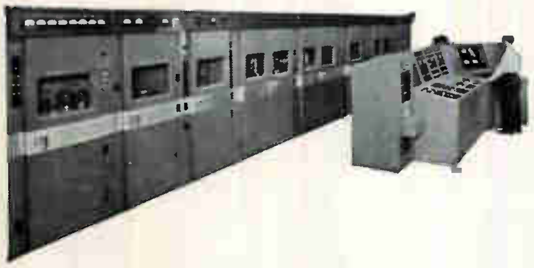

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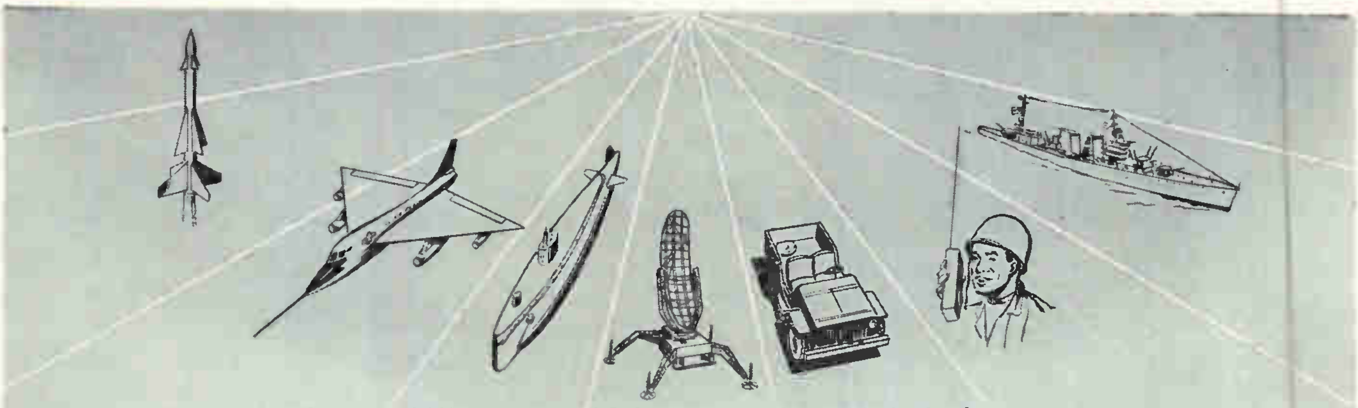

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					Volts	mA.	Volts	mA.		Volts	mA.		μmhos
SUBMINIATURE	**5639**	Video Amplifier Pentode	169C	100†	6.3	450	150	21	100Ω	100	4	—	9000
	5639WA	Video Amplifier Pentode	—	40† 250‖	6.3	450	150	21	100Ω	100	4	—	9000
	5643	Thyratron	757D	—	6.3	150	epx = 500 v max; ip = 100 ma max; I_p = 16 mAdc max.						
	5702WA	Video Amplifier Pentode	82C	50†	6.3	200	120	7.5	200Ω	120	2.6	—	5000
	5702WB	Video Amplifier Pentode	1069A	50† 240★	6.3	200	120	7.5	200Ω	120	2.6	—	5000
	5703WA	High Frequency Triode	293C	10†	6.3	200	120	9.4	220Ω	—	—	25.5	5100
	5703WB	High Frequency Triode	1070A	10† 50★	6.3	200	120	9.4	220Ω	—	—	25.5	5000
	5744WA	High Mu Triode	84C	25†	6.3	200	250	4.2	500Ω	—	—	70	4000
	5744WB	High Mu Triode	1073A	15† 75★	6.3	200	250	4.2	500Ω	—	—	70	4000
	5783WA	Voltage Reference	87C	20†	Operates at approximately 85 volts between 1.5 and 3.5 mA.								
	5784WA	RF Mixer Pentode	88D	100†	6.3	200	120	5.5	230Ω	120	4.1	—	3200
	5784WB	RF Mixer Pentode	1096A	75† 300★	6.3	200	120	5.5	230Ω	120	4.1	—	3200
	5787WA	Voltage Regulator	89B	20†	Operates at approximately 98 volts between 5 and 25 mA.								
	5829WA	Dual Diode	292A	—	6.3	150	Max. Io = 5.5 mA. per plate.						
	5902	Beam Pwr. Pentode	175C	100†	6.3	450	110	30	270Ω	110	2.2	—	4200
	5902WA	Beam Pwr. Pentode	—	30† 200‖	6.3	450	110	30	270Ω	110	2.2	—	4200
	6021	Medium Mu Dual Triode	188B	50†	6.3	300	100	6.5	150Ω	—	—	35	5400
	6021WA	Medium Mu Dual Triode	—	20† 125‖	6.3	300	100	6.5	150Ω	—	—	35	5400
	6088	Output Pentode	694A	—	1.25	20	45	0.65	−1.25	45	0.15	—	625
	6111	Medium Mu Dual Triode	189B	50†	6.3	300	100	8.5	220Ω	—	—	20	5000
	6111WA	Medium Mu Dual Triode	—	20† 125‖	6.3	300	100	8.5	220Ω	—	—	20	5000
	6112	High Mu Dual Triode	190C	25†	6.3	300	100	0.8	1500Ω	—	—	70	1800
	6112WA	High Mu Dual Triode	—	20† 75‖	6.3	300	100	0.8	1500Ω	—	—	70	1800
	6418	Power Pentode	—	—	1.25	10	22.5	.240	−1.2	22.5	.06	—	300
	6533	Low Microphonic Triode	975	1.0†	6.3	200	120	0.9	1500Ω	—	—	54	1750
	6533WA	High Mu Triode	1104A	15.0★	6.3	200	120	0.9	1500Ω	—	—	54	1750
	6611	High Freq. Pentode	1101 (S-C)	100†	1.25	20	30	1.0	0	30	.35	—	1000
	6612	High Freq. Pentode	1102 (S-C)	125†	1.25	80	30	3.0	0	30	1.0	—	3000
	7576	High Mu Triode	—	300†	6.3	450	200	15	150Ω	—	—	44	10,500
	6832	Medium Mu Dual Triode	1082B	10†	6.3	400	100	.8	3000Ω	—	—	26	1050
MINIATURE	**OA2WA**	Voltage Regulator	290B	100*	Operates at approximately 150 volts between 5 and 30 mA.								
	OB2WA	Voltage Regulator	940C	100*	Operates at approximately 108 volts between 5 and 30 mA.								
	6AH6WA	Video Pentode	1130A	100*	6.3	450	300	10	160Ω	150	2.5	—	9000
	6AN5WA	Power Pentode	839A	100*	6.3	450	120	33	125Ω	120	11	—	8500
	5517	Cold K Rectifier	690A	—	Peak Inverse = 2800 volts Io = 12mAdc.								
	5651WA	Voltage Reference	825A	5.0†	Operates at approximately 85 volts between 1.5 and 3.5 mA.								
	5654, 6AK5W	RF Ampl. Pentode	4C	200**	6.3	175	120	7.5	−2	120	2.5	—	5000
	5670	Medium Mu Dual Triode	5C	130‡**	6.3	350	150	8.2	240Ω	—	—	35	5500
	5687WA	Low Mu Dual Triode	779B	100*	6.3	880	120	36	−2	—	—	18.5	11,500
	5814A	Low Mu Dual Triode	12C	100‡**	6.3	350	250	10.5	−8.5	—	—	17	2200
	5842	Medium Mu Triode	466	500*	6.3	300	150	25	60Ω	—	—	43	25,000
	5847	RF Pentode	467	500*	6.3	300	150	13.5	110Ω	150	4.0	—	13,000
	6414	Medium Mu Dual Triode	1092	300*	6.3	450	180	8.0	−2.0	—	—	42.5	5550
	7044	Medium Mu Dual Triode	—	—	6.3	900	120	35	−2.0	—	—	21	12,500

*2.5g, 25 cps. fixed frequency ‡Sections in parallel All ratings for dual tubes are for each section †15g, 40 cps. fixed frequency

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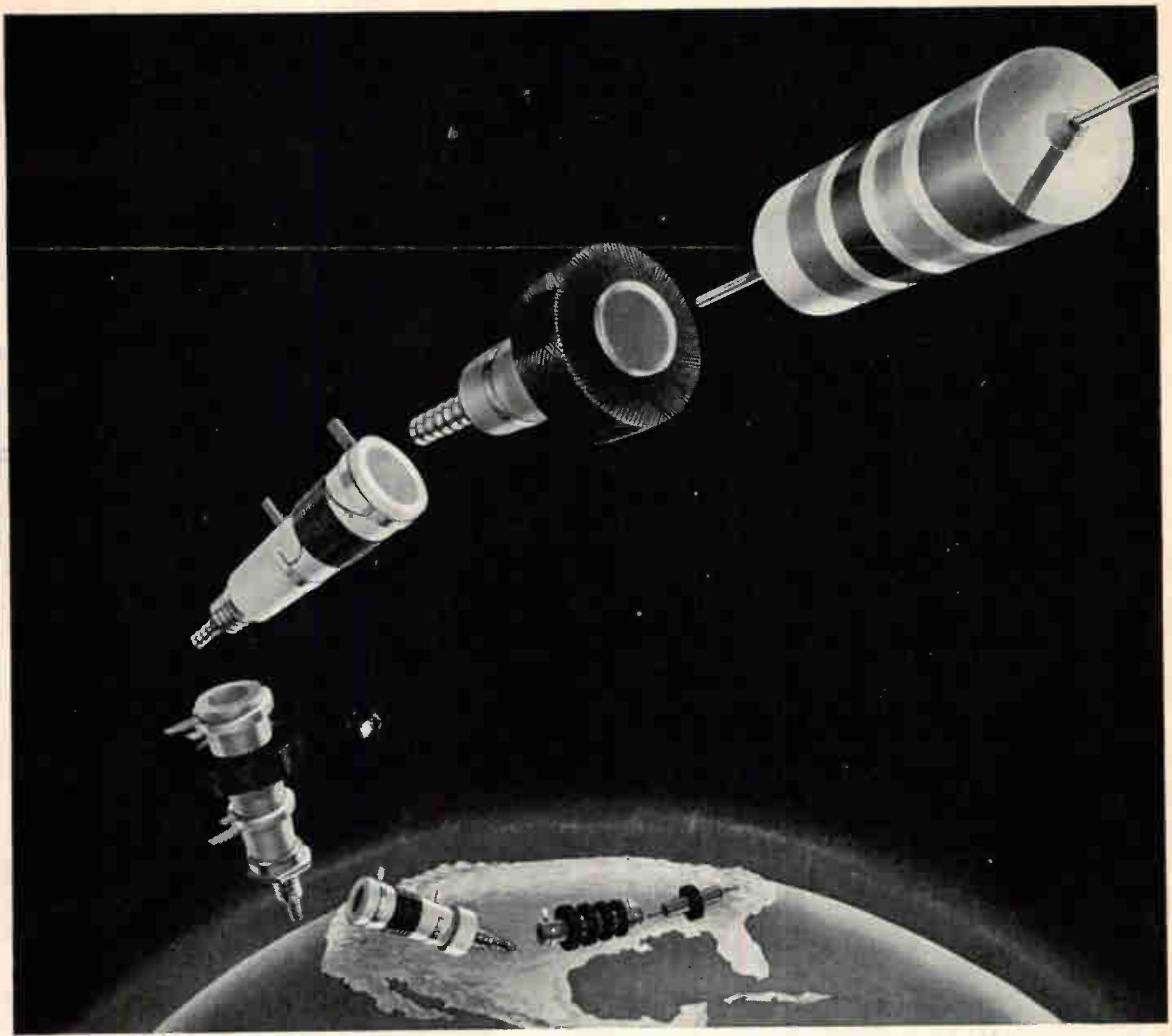

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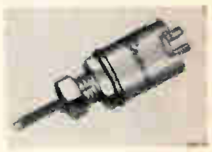

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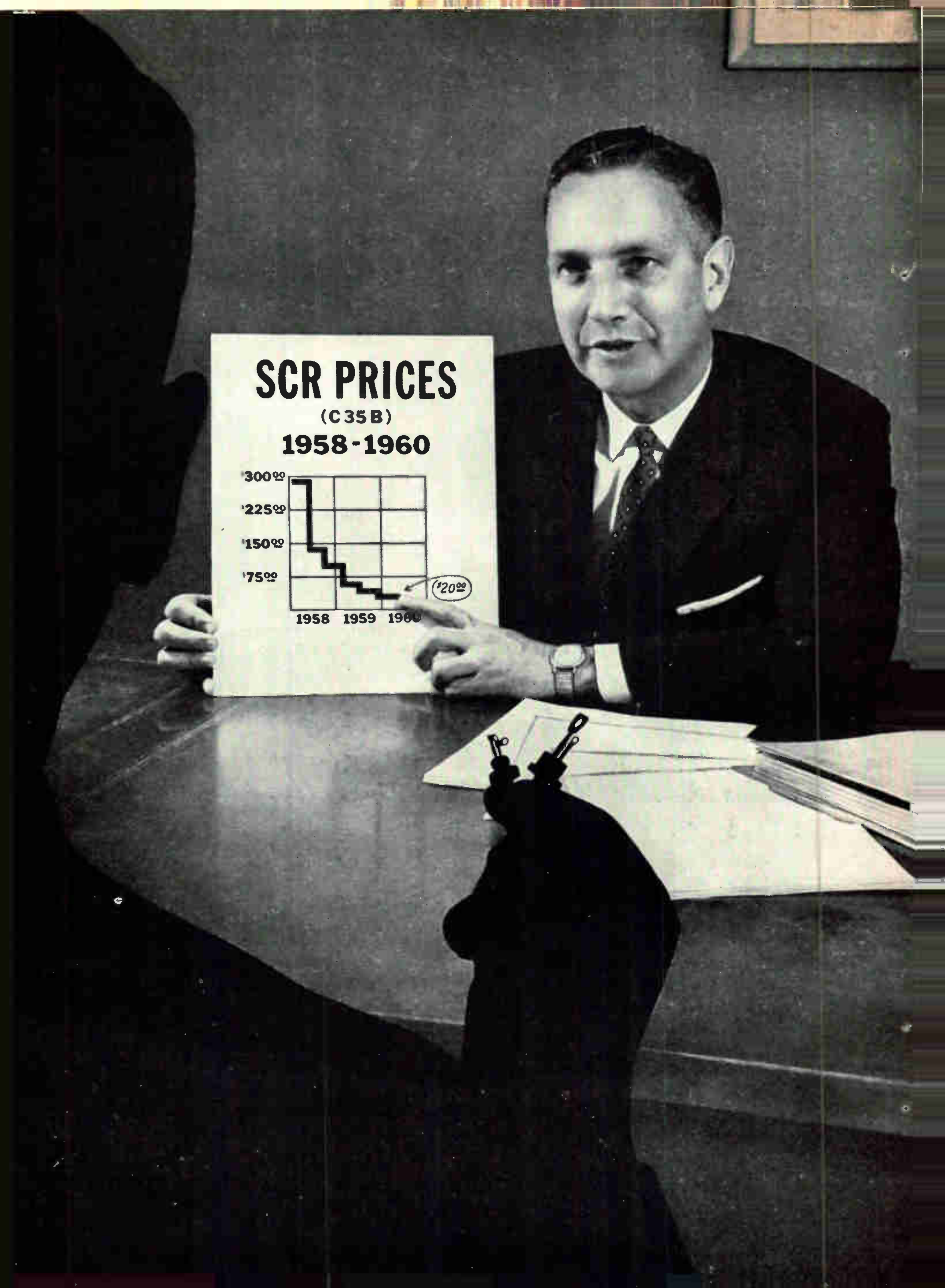
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 CIRCLE 51 ON READER SERVICE CARD

Mobile Unit to Check Interference

MOBILE UNIT from the Boulder Laboratories of National Bureau of Standards will travel across the country this summer to measure manmade interference caused by generators, power lines, sparkplugs and other electrical gear.

Goal is to get information that will lead to methods for cutting down noise that interferes with communication, radio navigation, missile control and so forth.

A panel truck will be equipped with antennas, recording instruments and the like, will carry two Boulder Labs noise experts. Measurements in particular areas will study noise in relation to population density, industrial activity, and power consumption. Small towns and rural areas will be checked as the truck travels; a three-day stopover is planned for Chicago. The five-week journey will loop through the midwest to Pennsylvania and Washington D.C., return through Tennessee, Arkansas and Oklahoma.

Diesel generator and engine are used on the truck to eliminate sparkplugs; special suppressors will filter out static from the tires.

Instrument Production Triples In India

INSTRUMENT MANUFACTURE in India has more than trebled in value in the last three years. In 1956, production of industrial process instruments—pyrometers, temperature recorders, controllers, thermocouples, multipoint recorders—was $1.3 million, and by 1958 had risen to $3.15 million. Last year, estimates of production reached close to $4.5 million. Local manufacture of X-ray equipment will soon be begun. India needs such instruments for her burgeoning industrial plant, prefers to manufacture her own rather than spend precious rupees for imports.

The New Delhi government has also decided to mass-produce cheap radio receivers (under $25) in hopes of attracting buyers in the nation's 500,000 villages. Manufacturers, being propelled by the government, have agreed to devote 25 to 30 percent of production capacity to the low-cost sets, which will be capable of receiving both medium- and short-wave broadcasts. Initial production goal is set at 60,000 sets.

2 Strong Piezoelectric Materials Discovered

HIGH DEGREE of piezoelectricty in zinc oxide and cadmium sulfide has been discovered by A. R. Hutson of Bell Telephone Laboratories.

In studying unusual conductivity properties of the two materials—expecially the large phonon-drag effect observed in thermoelectric power measurements, and the temperature dependence of this effect—Hutson decided that a large piezoelectric constant could explain the anomalies. By doping zinc oxide with lithium, he succeeded in quenching its conductivity.

A series of resonance-antiresonance and direct squeeze measurements were made on vapor-phase grown single crystals of both materials and flux-grown platelets of zinc oxide. The measurements disclosed that the piezoelectricity of doped zinc oxide is about four times that of quartz, and that of cadmium sulfide about twice as great.

Sun-Powered Car

Detachable "fuel" panel on top of car consists of more than 10,000 silicon solar cells made by International Rectifier Corp.

GM 6012

meters

Broadband Millivoltmeter, type GM 6012

Frequency range: 2 c/s - 1 Mc/s

Measuring range: 1 mV (f.s.d.) - 300 V in 12 steps

dB scale: -80 dB up to +52 dB (0 dB = 1 mW into 600 Ω).

Input impedance: 4 MΩ in parallel with 20 μμF (up to 3 V) 10 MΩ in parallel with 10 μμF (in the other ranges).

Overall accuracy with respect to full scale:
within ± 2,5%, 5 c/s - 100 kc/s
within ± 5%; 2 c/s - 1 Mc/s

Pre-deflection: < 100 μV

High Frequency Millivoltmeter, type GM 6014

	Without pre-attenuator	**With pre-attenuator**
Frequency range:	1 kc/s - 30 Mc/s	10 kc/s - 30 Mc/s
Measuring range:	1 mV (f.s.d.) - 300 mV in 6 steps	100 mV (f.s.d.) - 30 V in 6 steps
dB scale:	-80 dB up to -8 dB	-40 dB up to +32 dB
Damping at 1 kc/s	1 MΩ	50 MΩ
1 Mc/s:	700 kΩ	10 MΩ
30 Mc/s:	50 kΩ	2 MΩ
Input capacitance:	7 μμF	2 μμF

Pre-deflection: Compensated by electrical zero setting

Variations of the frequency characteristics:
< 5% over the whole range, with respect to the response at the frequency of the calibration voltages.

Overall accuracy: < 3% with respect to full scale and with reference to the frequency characteristic.

DC Microvoltmeter, type GM 6020

	Input I	**Input II**
Measuring range:	100 μV (f.s.d.) 10 V in 11 steps	10 mV (f.s.d.) 1000 V in 11 steps
Input impedance:	1 MΩ (± 1.5%) in parallel with 20μμF	100 MΩ (± 1.5%) in parallel with 10 μμF

Overall accuracy with respect to full scale: 3%

Pre-deflection: < 5 μV

Drift: < 1 μV per hour after 1 hour of warming-up

Automatic polarity indication doubles the effective scale length with respect to centre-zero instruments.
DC currents may be measured directly with this instrument due to the high accuracy of the input resistance.

Measuring-range: 100 μμA (f.s.d.) - 10 μA

Accuracy: < 3.5%

GM 6014

instruments: quality ***tools*** for industry and research

PHILIPS

MEETINGS AHEAD

June 22-24: Standards & Electronic Measurements, NBS, AIEE, IRE, NBS Laboratories, Boulder, Colo.

June 23-24: Solid-State Electronics Workshop, IRE, ASEE, Purdue University, Lafayette, Ind.

June 26-29: New England Electronic Conf., ERA, the Balsams, Dixville Notch, N. H.

June 26-July 1: Materials Sciences, ASTM, Chalfonte-Haddon Hall, Atlantic City, N. J.

June 27-29: Military Electronics, National Convention, PGME of IRE, Sheraton-Park Hotel, Washington, D. C.

June 27-July 7: Automatic Control, International Conf. of IFAC, AACC, ISA, ASME, AIEE, IRE, AIChE, Moscow, Russia, contact: R. Oldenburger, Purdue Univ., Lafayette, Ind.

July 4-7: British Computer Society Conf., Leeds University, Sun Pavilion, Harrogate, Yorkshire, England.

July 21-27: Medical Electronics, International Conf., Inst. of Electrical Engineers, Olympia, London.

Aug. 1-3: Global Communications Symposium, PGCS of IRE, U. S. Sig. Corps, Statler Hilton Hotel, Wash., D. C.

Aug. 8-11: American Astronautical Society, Western National, Olympic Hotel, Seattle, Wash.

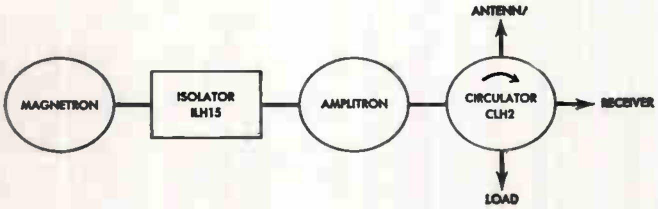
Aug. 9-12: American Institute of Electrical Engineers, Pacific General, San Diego, Calif.

Aug. 15-19: High-Speed Photography, Stroboscopic Light Laboratory, MIT, Cambridge, Mass.

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

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

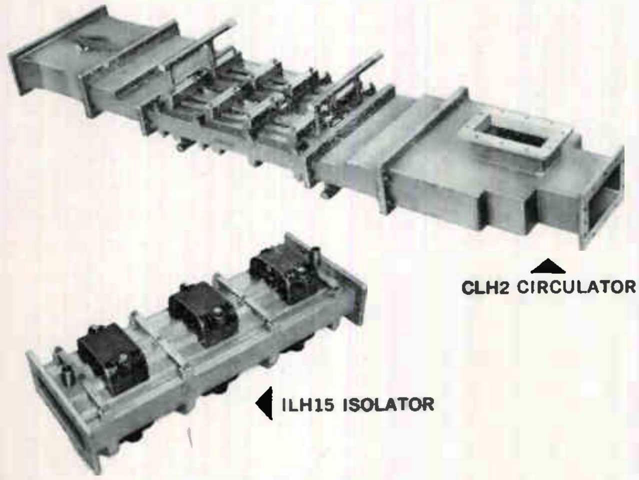
FERRITE DEVICES FOR HIGH-POWER RADAR



RAYTHEON ISOLATORS AND CIRCULATORS IN IMPROVED L-BAND "FLIGHT TRACKER" SYSTEM THAT BOOSTS OUTPUT TO MORE THAN 5 MEGAWATTS

With an output of more than 5 megawatts at 1,280 to 1,350 mc., the improved FAA "Flight Tracker" radar system has *ten times* the power of its predecessor. In the microwave generator and amplifier circuits, Raytheon isolators and circulators help achieve this power level by providing the required broadband match between magnetron and Amplitron®...and between Amplitron and antenna. The isolator also aids in maintaining frequency stability during the 5 megawatt pulse peaks by acting as a buffer between magnetron and Amplitron.

The L-band ILH15 isolator and CLH2 circulator in the "Flight Tracker" are part of Raytheon's line of L-band devices with ratings from 1.5 to 10 kilowatts average and peak power capabilities as high as 6.5 megawatts.



TYPICAL SPECIFICATIONS

	ILH15 ISOLATOR	CLH2 CIRCULATOR
Frequency range (mc)	1250-1350	1280-1350
Power, average	2.5 KW	5 KW
Power, peak	2 MW	6.5 MW
Isolation, min.	22db	26db
Isolation, max.	24db	32db
Insertion loss, min.	.7db	.65db
Insertion loss, max.	.9db	.8db
VSWR, min.	1.28	1.04
VSWR, max.	1.30	1.12
Weight, lbs.	60	140
Length, in.	22	69 1/16
Flanges	½ ht. L-band	mates with UG418/U
Waveguide (liq. cooled)	½ ht. L-band	WR 650

On Massachusetts' Route 128 in the Waltham Industrial Park, Raytheon has recently opened the most modern facility devoted exclusively to microwave ferrite device and materials development, testing and production. To learn more about the work now underway at these new facilities, or for information on your particular microwave ferrite problem, **please write to the address below.**

RAYTHEON COMPANY
SPECIAL MICROWAVE DEVICE OPERATIONS
WALTHAM INDUSTRIAL PARK
WALTHAM 54, MASSACHUSETTS

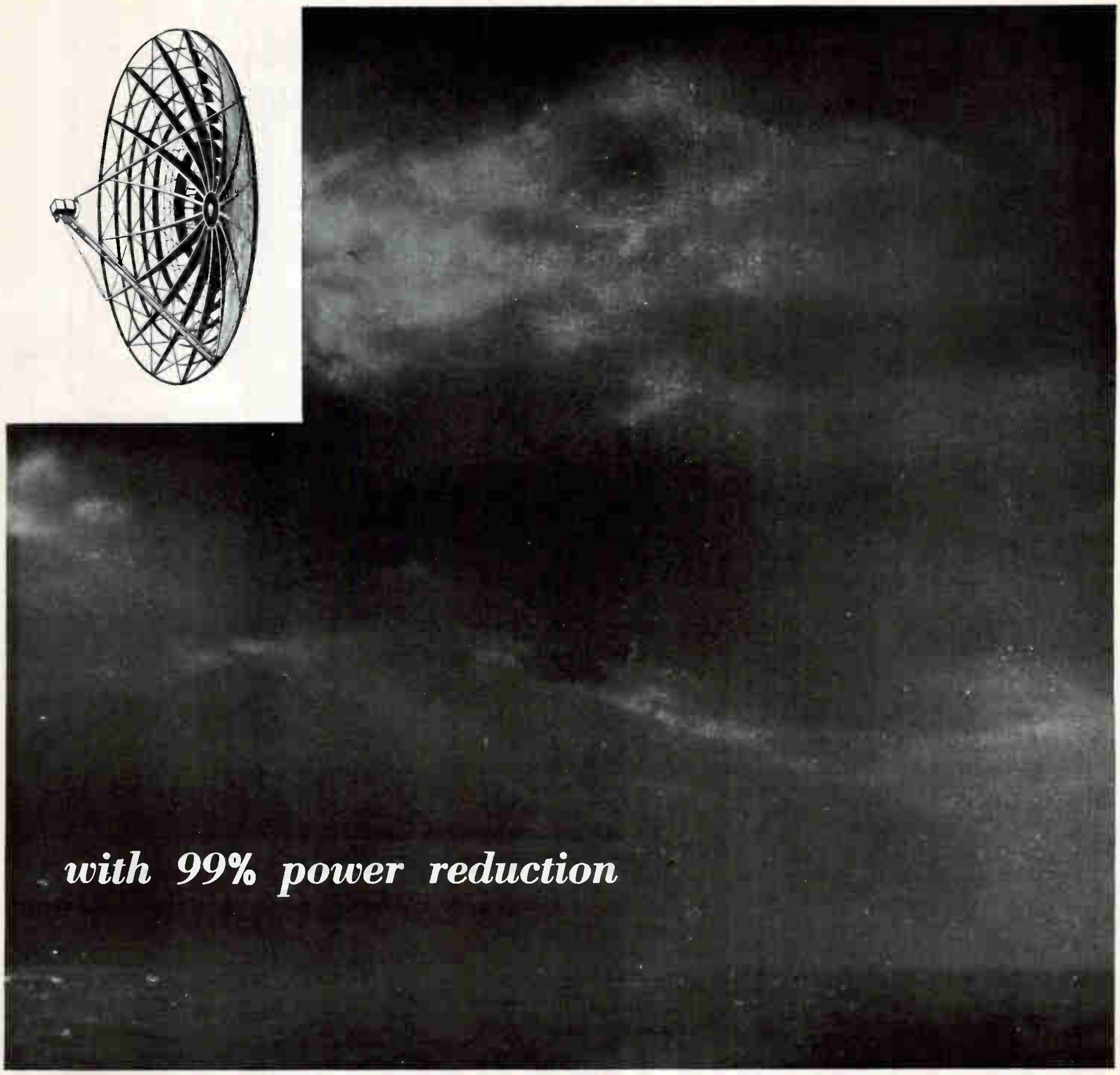
RAYTHEON *Excellence in Electronics*

Here is an important new advance in microwave communications—NEC's High Sensitivity Reception system. By combining high sensitivity reception, parametric amplifier, low feeder loss design, and the high antenna gain possible at 2000 mc, this system improves S/N ratio by more than 20 db.

This permits hops at 1/100 of the power required for conventional links. For example, a 400 W OH-2000 using a 33-ft. dish is capable of a 300-mile hop at 99.0% reliability with quadruple diversity and reliability of 99.9% at 260 miles. Other systems would require a 40 KW transmitter for the same hop.

The OH-2000 is drastically reducing installation and maintenance costs of over-the-horizon links in capacities up to 60 voice channels. A descriptive brochure is available on request.

Components / Systems NEC

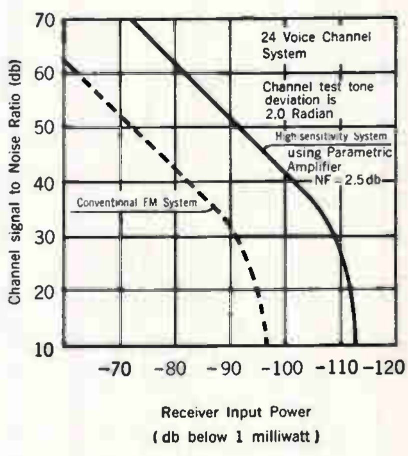


OH-2000 in military communications

First major OH-2000 installation will be a 17-station system for the United States Air Force linking radar sites on the three main islands of Japan. The system contains no active repeaters. Longest hop is 145 miles at 100 W output. Guaranteed reliability is a character error of no more than 1:10,000 for 99.9% of a year's hours.

OH-2000

The compact 100 W transmitter uses economical planar tubes in the final stage. A quadruple diversity station requires a radio room of only 100 Sq. ft. NEC can also supply completely transistorized carrier equipment.



Nippon Electric Company Limited. Tokyo, Japan

BORG-WARNER and EMCOR unite to better serve you!

Back in 1954 a totally revolutionary concept in metal cabinetry was introduced bearing the trademark EMCOR. Comprising a group of over 600 basic frames and a versatile line of components, this modular system of enclosures utilizing "erector set" simplicity provided the design engineer with never before dreamed of flexibility. Almost immediate acceptance with engineers throughout the fields of electronics, instrumentation and electro-mechanics was the result. Over the years the EMCOR trademark has gained a reputation for engineering ingenuity, quality craftsmanship and dependability.

Today, the EMCOR trademark holds even greater promise for the plants and people we serve as a result of the recent merger of EMCOR with the Ingersoll Products Division of the Borg-Warner Corporation.

The Ingersoll Products Division brings to EMCOR three quarters of a century of manufacturing "know-how," serving the fields of national defense, oil, steel, chemicals, agriculture, industrial machinery, aviation, the automotive industry and home equipment and now electronics.

Thus, giving and receiving, the two have reinforced each other. From the world-wide prestige of *Borg-Warner*, EMCOR draws increased strength. From the proven acceptance of the EMCOR Modular Enclosure System, *Ingersoll Products Division* inherits a quality line of metal cabinetry.

We of EMCOR are proud indeed to join ranks with the 42 divisions and subsidiaries of *Borg-Warner* in a continuing quest for better products to better serve industry and people everywhere.

EMCOR INGERSOLL PRODUCTS DIVISION serving the needs of electronics, instrumentation and electro-mechanical engineers coast to coast with nationwide representation

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Philadelphia Office:
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52 B Crestmont Road
Binghamton, New York
Telephone: RAymond 3-9661

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Telephone: HOward 3-8301

ROCKY MOUNTAIN AREA:
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Denver 23, Colorado
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TWX: DN 863

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Box 8394
Albuquerque, New Mexico
Telephone: ALpine 5-0669
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Salt Lake City Office:
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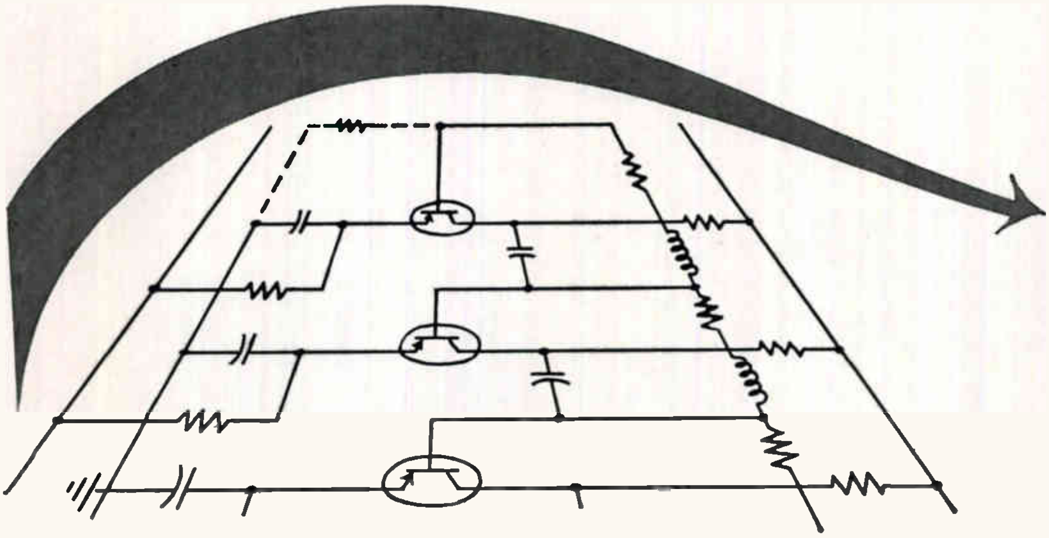
WRITE YOUR LOCAL REPRESENTATIVE FOR CONDENSED CATALOG 106

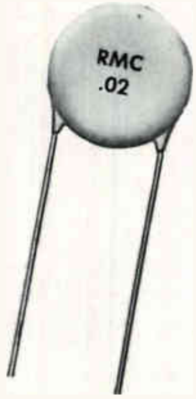
Originators of the Modular Enclosure System

Ingersoll PRODUCTS DIVISION
BORG-WARNER CORPORATION
630 Congdon • Dept. 1242 • Elgin, Illinois

RMC

"HEAVY DUTY" BY-PASS DISCAPS®





SPECIFICATIONS

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

POWER FACTOR: 2.5% Max. @ 1 KC (after humidity)

WORKING VOLTAGE: 1000 V.D.C.

TEST VOLTAGE (FLASH): 2000 V.D.C.

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

INSULATION: Durez phenolic—vacuum waxed

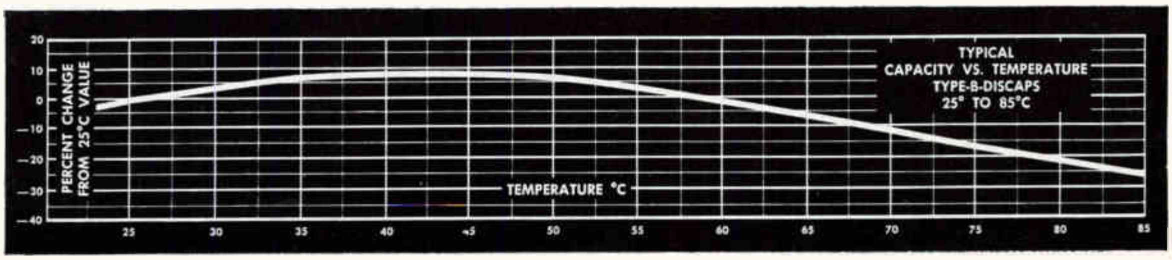
INITIAL LEAKAGE RESISTANCE: Guaranteed higher than 7500 megohms

AFTER HUMIDITY LEAKAGE RESISTANCE: Guaranteed higher than 1000 megohms

Type B DISCAPS meet or exceed all EIA RS-198 specifications for Z5U ceramic capacitors. Designed for by-passing, coupling, or filtering applications, Type B DISCAPS are manufactured in capacities between .00015 and .04 MFD.

A heavy ceramic dielectric element provides a safety factor where steady or intermittent high voltages occur. Type B DISCAPS show a minimum capacity charge between +10°C and +85°C (see curve).

Type B DISCAPS are rated at 1000 working volts and cost no more than ordinary lighter constructed units.



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.

CIRCLE 61 ON READER SERVICE CARD

SOLID STATE announces

THE VIBRACHOPPER

DC DRIVEN **ADJUSTABLE FREQUENCY**

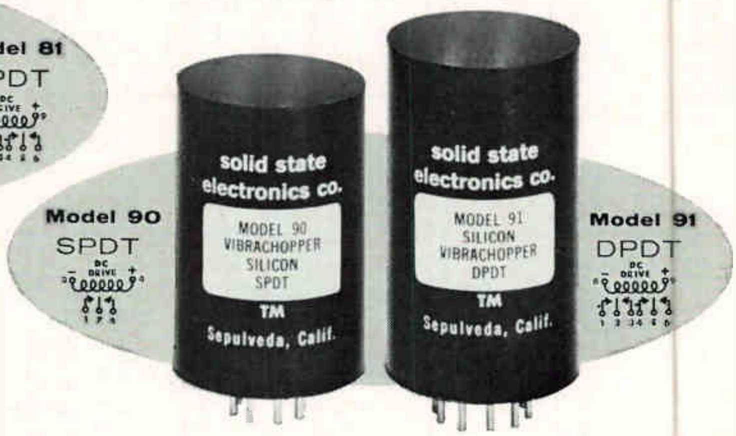
First all-transistor modulators with a self-contained drive ...completely encapsulated...operates entirely on DC!

The **VIBRACHOPPER** is an all-electronic solution to an electronic design problem. Its exclusive self-excitation circuitry embodies an entirely new and unique approach to low level chopper design. High linearity and temperature stability are basic characteristics that have been achieved. Four models are available in both germanium and silicon for SPDT and DPDT operation.

The physical nature of the **VIBRACHOPPER** makes it immune to many of the most important weaknesses of electro-mechanical choppers. Having no moving parts it is not subject to wear, contact bounce, pitting or arcing. Being an inertialess device, **VIBRACHOPPERS** are virtually unaffected by shock, vibration and acceleration.

−55°C to +90°C

−55°C to +150°C



ACTUAL SIZE

DESCRIPTION

The solid state **VIBRACHOPPER** embodies a new and unique approach to low level chopper design which eliminates the necessity of supplying an AC driving source at a fixed frequency. A self-contained adjustable-frequency solid state vibrator acts to drive a transistorized chopper under the most optimum of conditions. Activation is induced merely by supplying a DC voltage with low power drain. The Models 80 and 90 are equivalent to single-pole double-throw, break-before-make switches. The Models 81 and 91 are double-pole double-throw versions of the 80 and 90 respectively and may be used for synchronous modulator-demodulator applications.

High linearity and temperature stability are evident over a wide dynamic signal range extending from a fraction of a millivolt up to a nominal ±15 volts for the 80 and 81 and up to a nominal ±7 volts for the Models 90 and 91. The chopping frequency is externally adjustable by varying the DC drive voltage. This provides an additional design freedom heretofore unattainable with electromechanical type choppers. The Models 80 and 81 have a frequency range from 1.5 to 6.5 kcps, while Models 90 and 91 range from 1.8 to 4.4 kcps.

The Models 90 and 91 employ silicon transistors and are especially suited to high temperature applications up to a rated 150° C.

SPECIFICATIONS Signal input voltage: from fraction of a millivolt to ±15 volts DC for Models 80 & 81; to ±7 volts DC for Models 90 & 91. **Chopping frequency:** 1.5 to 6.5 kcps for Models 80 & 81; 1.8 to 4.4 kcps nominal for Models 90 & 91. **Signal current:** to 50 milliamperes for Models 80 & 81; to 20 milliamperes for Models 90 & 91. **Rise and fall time:** 2 microseconds nominal. **Linearity:** less than ±0.5% deviation from best straight line. **Dissymmetry:** ±5% or less. **Operating temperature:** −55° C to + 90°C for Models 80 & 81; −55°C to +150° C for Models 90 & 91. **DC power requirement:** .02 to 0.5 watts nominal. 6 to 32 volts DC for Models 80 & 81; 12 to 32 volts DC for Models 90 & 91.

MECHANICAL DATA Shock resistance: 500 G, 11 milliseconds, any direction. **Vibration:** 50 G, zero to 2000 cps. **Acceleration:** 1000 G, any direction. **Humidity:** to 100% up to 90°C. **Dimensions:** Models 80 & 81, 1¼ inches long; Model 90, 1½ inches, Model 91, 1¾ inches. All models 1 inch diameter. **Weight:** Models 80, 81, 32 grams; Models 90, 91, 40 grams. **Connections:** Plug-in, standard miniature tube socket. Models 80 & 90, 7-pin; Models 81, 91, 9-pin.

Write or Phone for Bulletins Describing Above Units

SOLID STATE
ELECTRONICS CO.
15321 Rayen St. / Sepulveda, Calif.
EMpire 4-2271

NOW NINE-NINETY-NINE AT YOUR NEAREST RCA SEMICONDUCTOR DISTRIBUTOR

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The Most Trusted Name in Electronics
RADIO CORPORATION OF AMERICA

SELECT FROM INDUSTRY'S BROADEST LINE OF SILICON DIODES AND RECTIFIERS

HIGH CONDUCTANCE GENERAL PURPOSE SILICON DIODES

Type	Case Type	PIV	V_z	Min DC Fwd I @ 25°C ma @ 1v	Maximum LI_b @ 25°C μa	Maximum LI_b @ 100°C μa	P @ 25°C mw
1N645	N	225	275	400	0.2	15	600
1N645A	N	225	275	400	0.2 0.05@60v	15 10@125°C @ 60v	600
AF1N645	N	225	275	400	0.2	15	600
1N646	N	300	360	400	0.2	15	600
AF1N646	N	300	360	400	0.2	15	600
1N647	N	400	480	400	0.2	20	600
AF1N647	N	400	480	400	0.2	20	600
1N648	N	500	600	400	0.2	20	600
AF1N648	N	500	600	400	0.2	20	600
1N649	N	600	720	400	0.2	25	600
AF1N649	N	600	720	400	0.2	25	600

GENERAL PURPOSE SILICON DIODES

Type	Case Type	PIV	V_z	Min. DC Fwd I @ 25°C ma @ 1v	Maximum LI_b @ 25°C μa	Maximum LI_b @ 150°C μa	P @ 25°C mw
1N456	N	25	30	40	0.025	5	500
1N456A	N	25	30	100	0.025	5	500
1N457	N	60	70	20	0.025	5	500
1N457A	N	60	70	100	0.025	5	500
JAN 1N457	N	60	70	20	0.025	5	500
1N458	N	125	150	7	0.025	5	500
1N458A	N	125	150	100	0.025	5	500
JAN 1N458	N	125	150	7	0.025	5	500
1N459	N	175	200	3	0.025	5	500
1N459A	N	175	200	100	0.025	5	500
JAN 1N459	N	175	200	3	0.025	5	500
1N461	N	25	30	15	0.5	30	200
1N462	N	60	70	5	0.5	30	200
1N463	N	175	200	1	0.5	30	200
1N464	N	125	150	3	0.5	30	200
1N482	N	30	40	100*	0.25	30	500
1N482A	N	30	40	100	0.025	15	500
1N482B	N	30	40	100	0.025	5	500
1N483	N	60	80	100*	0.25	30	500
1N483A	N	60	80	100	0.025	15	500
1N483B	N	60	80	100	0.025	5	500
1N484	N	125	150	100*	0.25	30	500
1N484A	N	125	150	100	0.025	15	500
1N484B	N	125	150	100	0.025	5	500
1N485	N	175	200	100*	0.25	30	500
1N485A	N	175	200	100	0.025	15	500
1N485B	N	175	200	100	0.025	5	500
1N486	N	225	250	100*	0.25	50	500
1N486A	N	225	250	100	0.025	25	500
1N486B	N	225	250	100	0.05	10	500
1N487	N	300	330	100*	0.25	50	500
1N487A	N	300	330	100	0.025	25	500
1N488	N	380	420	100*	0.25	50	500
1N488A	N	380	420	100	0.025	25	500
600C	M	27	30	3	1 @ −10v	20 @ −10v**	150
601C	M	45	50	10	0.025@ −10v	40@ −10v	150
604C	M	4.7	5.5	60	0.1	40	150
606C	M	6.8	7.5	35	0.1	40	150
608C	M	10	11	25	0.1	40	150
610C	M	15	17	20	0.1	40	150
612C	M	22	25	20	0.1	40	150
614C	M	33	37	20	0.1	40	150
616C	M	47	52	10	0.2	40	150
618C	M	68	75	10	0.2	40	150
620C	M	100	110	10	0.2	40	150
622C	M	150	170	7	0.2	20**	150
624C	M	220	250	3	0.2	20**	150

* Measured at 1.1V
** At 100°C

GALLIUM ARSENIDE TUNNEL DIODES

Type	Case Type	I_P @ 25°C ma	I_P/I_V @ 25°C	Capacitance @ V_V @ 25°C μμf	V_F @ 25°C volts
1N650	U	10 (±10%)	> 15:1	30 (typ)	1.10 (±10%)
1N651	U	10 (± 2%)	> 10:1	30 (typ)	1.10 (± 5%)
1N652	U	5 (±10%)	> 5:1	40 (typ)	0.98 (±10%)
1N653	U	5 (±10%)	> 5:1	60 (typ)	0.98 (typ)

SILICON COMPUTER DIODES

Type	Case Type	PIV	V_z	Max. T_r @ 25°C μsec	Maximum LI_b @ PIV @ 25°C μa	Maximum LI_b @ PIV @ 100°C μa	Min Fwd Current @ 1 volt ma dc
1N625	N	20	30	1 †	1	30	4*
1N626	N	35	50	1 †	1	30	4*
1N627	N	75	100	1 †	1	30	4*
1N628	N	125	150	1 †	1	30	4*
1N629	N	175	200	1 †	1	30	4*
1N643	N	175	200	0.3**	0.025 @ 10v 1 @ 100v	10 @ 10v 15 @ 100v	10
1N658	N	50	120	0.3 ‡	0.05	25 @ 150°C	100
1N659	N	50	55	0.3 †	5	25	6
1N660	N	100	110	0.3 †	5	50	6
1N661	N	200	220	0.3 †	10	100	6
1N662	N	80	100	0.5 §	1 @ 10v 20 @ 50v	20 @ 10v 100 @ 50v	10
1N663	N	80	100	0.5**	5 @ 75v	50 @ 75v	100
1N914	N	75	100	0.0004♯	5 @ 75 v 0.025 @ 20 v	50 @ 150°C @ 20v	10
1N916	N	75	100	0.0004♯	5 @ 75v 0.025 @ 20v	50 @ 150°C @ 20v	10

* E_b equals 1.5v
† JAN 256 (30 ma forward, switched to −35 v reverse, recovery to 400 K ohms)
** JAN 256 (5 ma forward, switched to −40 v reverse, recovery to 200 K ohms)
‡ JAN 256 (5 ma forward, switched to −40 v reverse, recovery to 80 K ohms)
§ JAN 256 (5 ma forward, switched to −40 v reverse, recovery to 100 K ohms)
♯ EGG Type 2236A (10 ma forward, switched to −6 volts reverse, recovery to 1 ma reverse)

HIGH VOLTAGE DIODE STACKS
(48 Standard Units)

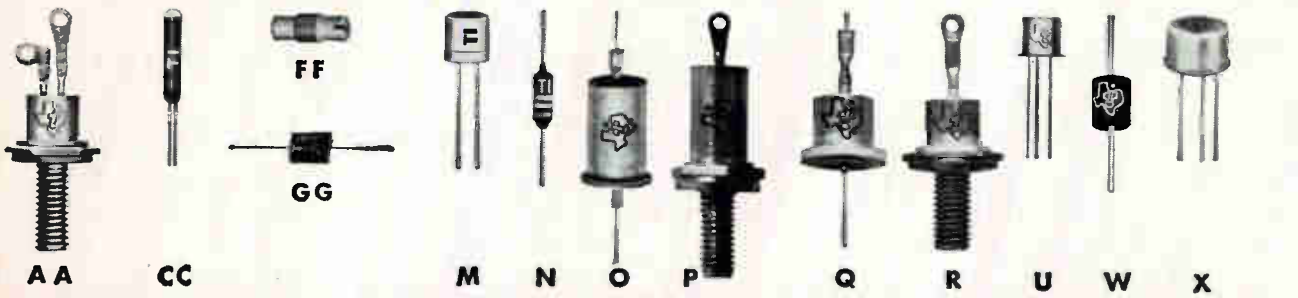
Type	Case Type	PIV	V_F Max @ 250 ma @ + 25°C	Max Operating Freq. @ PIV (Sinusoidal)	Zener Min	Zener Max	No. of Diodes
1N2878 through 1N2925	GG	700	2	10 KC	800	1400	2
		6500	13	4.0 KC	7150	9100	13

VOLTAGE REGULATOR DIODES

Type	Case Type	Zener Voltage @ 25°C @ 5 ma I_z	Zener Voltage @ 25°C @ 20 ma I_z	Power Diss @ 25°C mw	Power Diss @ 150°C mw	Max. Z_z @ 25°C @ I_z Ohms	Typ Temp Coef %/°C
1N746†	N		3.3	400	100	28	−0.062
1N747†	N		3.6	400	100	24	−0.055
1N748†	N		3.9	400	100	23	−0.049
1N749†	N		4.3	400	100	22	−0.036
1N750†	N		4.7	400	100	19	−0.018
1N751†	N		5.1	400	100	17	−0.008
1N752†	N		5.6	400	100	11	+0.006
1N753†	N		6.2	400	100	7	+0.022
1N754†	N		6.8	400	100	5	+0.035
1N755†	N		7.5	400	100	6	+0.045
1N756†	N		8.2	400	100	8	+0.052
1N757†	N		9.1	400	100	10	+0.056
1N758†	N		10.0	400	100	17	+0.060
1N759†	N		12.0	400	100	30	+0.060
650C*	M	3.7 −4.5		150	40		
651C*	M	4.3 −5.4		150	40		
652C*	M	5.2 −6.4		150	40		
653C*	M	6.2 −8.0		150	40		
654C9*	M	8.5 −9.5		150	40		
655C9*	M	9.5 −10.5		150	40		

† Suffix A (±5% tolerance)
* (±5% or ±10% tolerance available)
Units 1N746 through 1N749 (A) meet Mil specification MIL-E-1/1258 (Navy) and are available with USN prefix.

silicon diodes and rectifiers



GALLIUM ARSENIDE VARACTOR

Type	Case Type	Min Breakdown Voltage—v	Junction Capacitance @ 0 volts bias $\mu\mu f$	Min Q @ 3 Kmc	Min Cut-off Frequency Kmc
XD-500	FF	−6	0.1 min 1.0 max	20 @ −2 volts 30 @ −6 volts	60 @ −2v

STABISTORS

Type	Case Type	I_F ma	PIV Volts	V_F Volts at 1 ma	V_F Volts at 100 ma	LI_b μa at −2v at 25°C
G 129	N	250	10	0.56±10%	1	0.1
G 130	N	150	6	0.64±10%	1	0.1

POWER REGULATORS AND DOUBLE ANODE CLIPPERS

Available with either anode or cathode to stud

Type	Case Type	Zener Voltage @ 25°C	I_z ma	Power Diss @ 50°C w	Reverse Current LI_b 25°C μa @ −5v	Reverse Current LI_b 25°C μa @ −10v	Max Z_z @ 25°C @ I_z Ohms	Typ Temp Coef %/°C
1N2498†	R	10	500	10	40	—	2	0.06
1N2499†	R	11	500	10	30	—	2	0.06
1N2500†	R	12	500	10	25	—	2	0.06
1N1816†	R	13	500	10	25	—	2	0.07
1N1817†	R	15	500	10	15	—	2	0.07
1N1818†	R	16	500	10	10	—	3	0.07
1N1819†	R	18	500	10	10	—	3	0.07
1N1820†	R	20	250	10	—	10	3	0.08
1N1821†	R	22	250	10	—	10	3	0.08
1N1822†	R	24	250	10	—	10	3	0.08
1N1823†	R	27	250	10	—	10	3	0.08
1N1824†	R	30	250	10	—	10	4	0.08
1N1825†	R	33	150	10	—	10	4	0.08
1N1826†	R	36	150	10	—	10	5	0.09
1N1827†	R	39	150	10	—	10	5	0.09
1N1828†	R	43	150	10	—	10	6	0.09
1N1829†	R	47	150	10	—	10	7	0.09
1N1830†	R	51	150	10	—	10	8	0.10
1N1831†	R	56	150	10	—	10	9	0.10
1N1832†	R	62	50	10	—	10	12	0.10
1N1833†	R	68	50	10	—	10	14	0.10
1N1834†	R	75	50	10	—	10	20	0.11
1N1835†	R	82	50	10	—	10	22	0.11
1N1836†	R	91	50	10	—	10	35	0.12
1N2008†	R	100	50	10	—	10	40	0.12
1N2009†	R	110	50	10	—	10	47	0.12
1N2010†	R	120	50	10	—	10	56	0.12
1N2011†	R	130	50	10	—	10	65	0.12
1N2012†	R	150	50	10	—	10	82	0.12

†Suffix A (± 5% Tolerance)

Units 1N1816 through 1N1836 (A & RA) meet Mil specification MIL-E-1/1259 (Navy) and are available with USN prefix.

PHOTO DEVICE

Type	Case Type	Bias Voltage v max	Dark Current @ 25°C ±50v max μa	Dark Current @ 100°C ±50v max μa	*Typ Light Current @ 25°C @ ±10v μa	*Typ Sensitivity @ 10v $\mu a/mw/cm^2$
1N2175	CC	50	0.5	100	200	22.3

* Light current measured in terms of radiation. Radiation = 9 mw/cm² in a frequency bandwidth of 0.7 to 1 micron.

SILICON RECTIFIERS—ECONOMY PACKAGE

Type	Case Type	PIV	I_o ma 25°C	I_o ma 100°C	Recurrent Peak Current @ 25°C a	DC Forward Voltage Drop @ 25°C v @ ma	Max Reverse Current @ 25°C μa @ v
1N2069	w	200	750	500	6	1.2 @ 500	10 @ 200
1N2070	w	400	750	500	6	1.2 @ 500	10 @ 400
1N2071	w	600	750	500	6	1.2 @ 500	10 @ 600

SILICON RECTIFIERS

Type	Case Type	Mounting	PIV v 25°C	PIV v 150°C	Io ma 25°C	Io ma 150°C	Recurrent Peak Current −65°C to +150°C ma	E_b @ 25°C v@a	LI_b @ PIV @ 25°C μa
1N588	O	Axial	1500	1000	25	10	150	10@10ma	50
1N589	O	Axial	1500	1000	50	25	250	8@50ma	50
1N1130	P	Cathode Stud	1500	1000	300	150	1 a	15@0.3	50
1N1131	P	Anode Stud	1500	1000	300	150	1 a	15@0.3	50
1N570	BB	plug in	1500	1000	37.5*	25*	1.2a@25°C*	10@50ma*	50
1N538	Q	Axial	200	200	750	250	2.5a@25°C	1@0.5	10
JAN 1N538	Q	Axial	200	200	750	250	2.5a@25°C	1@0.5	10
1N539	Q	Axial	300	300	750	250	2.5a@25°C	1@0.5	10
1N540	Q	Axial	400	400	750	250	2.5a@25°C	1@0.5	10
JAN 1N540	Q	Axial	400	400	750	250	2.5a@25°C	1@0.5	10
1N547	Q	Axial	600	600	750	250	2.5a@25°C	1@0.5	10
JAN 1N547	Q	Axial	600	600	750	250	2.5a@25°C	1@0.5	10
1N1095	Q	Axial	500	500	750	250	6a@25°C	1@0.5	10
1N1096	Q	Axial	600	600	750	250	6a@25°C	1@0.5	10
1N253†	R	Cathode Stud	100	100	3 a	1a@135°C	10a@50°C	1.1@1	10
JAN 1N253†	R	Cathode Stud	100	100	3 a	1a@135°C	10a@50°C	1.1@1	10
1N254†	R	Cathode Stud	200	200	3 a	0.4a@135°C	10a@50°C	1.1@1	10
JAN 1N254†	R	Cathode Stud	200	200	3 a	0.4a@135°C	10a@50°C	1.1@1	10
1N255†	R	Cathode Stud	400	200	3 a	0.4a@135°C	10a@50°C	1.1@1	10
JAN 1N255†	R	Cathode Stud	400	200	3 a	0.4a@135°C	10a@50°C	1.1@1	10
1N256†	R	Cathode Stud	600	200	3 a	0.2a@135°C	10a@50°C	1.1@1	10
JAN 1N256†	R	Cathode Stud	600	200	3 a	0.2a@135°C	10a@50°C	1.1@1	10
1N1124†	R	Cathode Stud	200	200	3 a	1 a	10a@50°C	1.1@1	10
1N1125†	R	Cathode Stud	300	300	3 a	1 a	10a@50°C	1.1@1	10
1N1126†	R	Cathode Stud	400	400	3 a	1 a	10a@50°C	1.1@1	10
1N1127†	R	Cathode Stud	500	500	3 a	1 a	10a@50°C	1.1@1	10
1N1128†	R	Cathode Stud	600	600	3 a	1 a	10a@50°C	1.1@1	10
1N1614†	R	Cathode Stud	200	200	15 a	5 a	50a@50°C	1.5@10	10
1N1615†	R	Cathode Stud	400	400	15 a	5 a	50a@50°C	1.5@10	10
1N1616†	R	Cathode Stud	600	600	15 a	5 a	50a@50°C	1.5@10	10

* For each half-wave section
† R Suffix denotes anode to stud configuration, i. e. 1N1124R

SILICON CONTROLLED RECTIFIERS

Type	Case Type	At 80°C Case Temp: Av Rect Fwd Current Amps	At 80°C Case Temp: Recurrent Peak Current Amps	Non-Recurrent Surge Current 1 Cycle at 60 cps Amps	Min Fwd Off Voltage* v	PIV	Min Breakdown Voltage v	Max Case Temp °C	Max Fwd Gate Current ma	Gate to Cathode PIV v	max Fwd Voltage Drop @ Avg Rect. Fwd. Current @ 25°C Stud Temp v @ a	Gate Current Req to Fire ma Typ	Gate Current Req to Fire ma Max
2N1600	AA	3	10	25	50	50	60	150	100	5	2 @ 3 amps	1	10
2N1601	AA	3	10	25	100	100	120	150	100	5	2 @ 3 amps	1	10
2N1602	AA	3	10	25	200	200	240	150	100	5	2 @ 3 amps	1	10
2N1603	AA	3	10	25	300	300	360	150	100	5	2 @ 3 amps	1	10
2N1604	AA	3	10	25	400	400	480	150	100	5	2 @ 3 amps	1	10
2N1595	X	1	3	15	50	50	60	150	100	5	2 @ 1 amp	1	10
2N1596	X	1	3	15	100	100	120	150	100	5	2 @ 1 amp	1	10
2N1597	X	1	3	15	200	200	240	150	100	5	2 @ 1 amp	1	10
2N1598	X	1	3	15	300	300	360	150	100	5	2 @ 1 amp	1	10
2N1599	X	1	3	15	400	400	480	150	100	5	2 @ 1 amp	1	10
TI-010	X	1	3	15	50	50	60	150	100	5	See data sheet for switching information		
TI-025	X	1	3	15	50	50	60	150	100	5			
TI-050	X	1	3	15	50	50	60	150	100	5			

* Measured with 1K resistor gate to cathode

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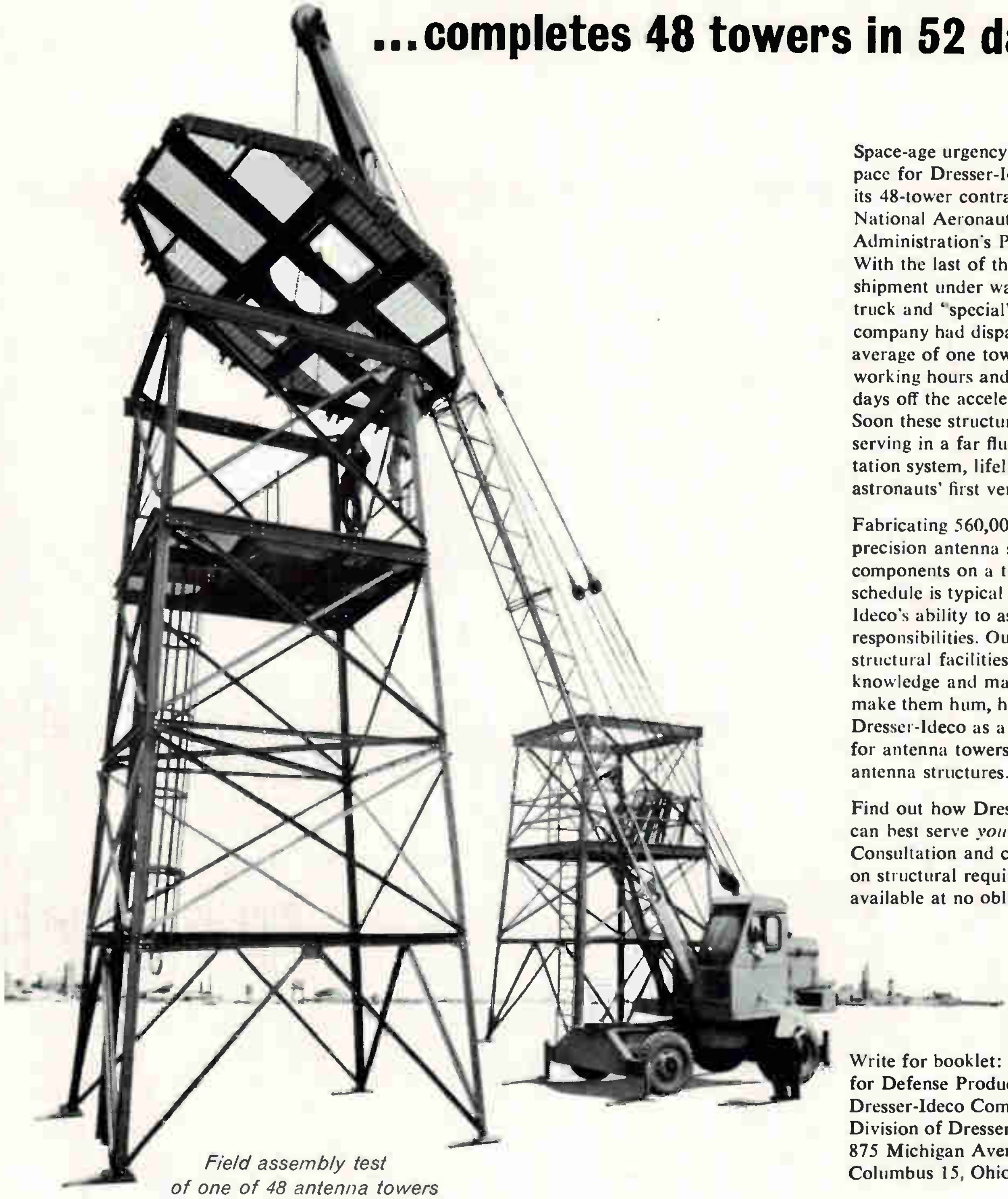

Field assembly test of one of 48 antenna towers for the Man-In-Orbit program. This Dresser-Ideco contract included transmitting, receiving and boresight designs.

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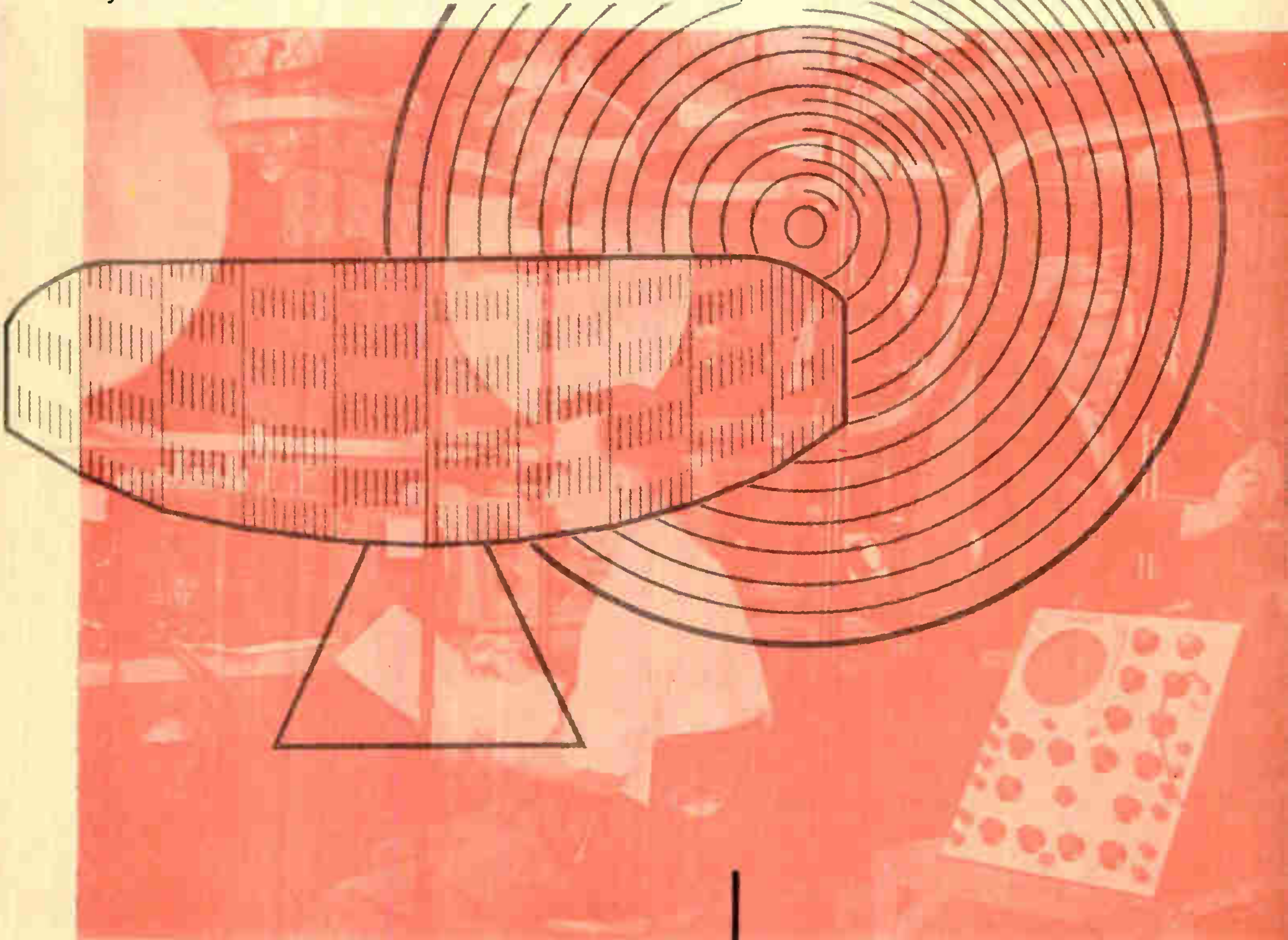
modern microwaves

By SYLVESTER P. CARTER and LESLIE SOLOMON, Associate Editors



1 Applications
2 Antennas
3 Generators and Amplifiers
4 Components
5 Test Equipment

MICROWAVE EQUIPMENT produced in the past year is estimated at $1.2 to 1.3 billion.[1] Radomes, towers and other equipment associated with microwave systems but not included in the estimate may be double this figure. Spectacular growth has been achieved in two decades, and expansion of the microwave industry is continuing. Growth in the next decade is expected to be twice that of the fast-growing electronics industry as a whole.

Radar has so far been the principal application. The basic concept of detecting aircraft by means of reflected electromagnetic waves was reported in ELECTRONICS in September of 1935. However, during World War II the need to detect enemy aircraft and to control antiaircraft artillery spurred large investments in money and scientific manpower to develop microwave devices.

The Korean conflict and continued threats to peace have maintained military interest in mirowaves. Last year, more than 80 percent of all expenditures for generating, amplifying, radiating and receiving microwaves, including test equipment, was by the military. In addition to radar, this expenditure was for microwave communications, countermeasures, telemetering equipment, air traffic control and navigation systems.

Many techniques and devices developed for the military are now being used in commercial applications. Communications is the largest nonmilitary application. Microwaves are also being used in nonmilitary radar, air traffic control, microwave computers, spectroscopy, microwave ovens and medical diagnosis. The percentage of the total microwave market represented by commercial equipment is expected to slowly but surely increase.

The future of microwaves, and of the higher frequency "millimeter waves," is bright but difficult to predict in detail. There is growing awareness of the value of basic research in this area. Such effort could result in materials and devices that might revolutionize the industry. Efficiency, reliability, simplicity and other characteristics of present equipment may be greatly improved. And applications not even visualized may become commonplace in the next ten years. Although results are not yet fully known, some trends are evident in equipment and components described in the report.

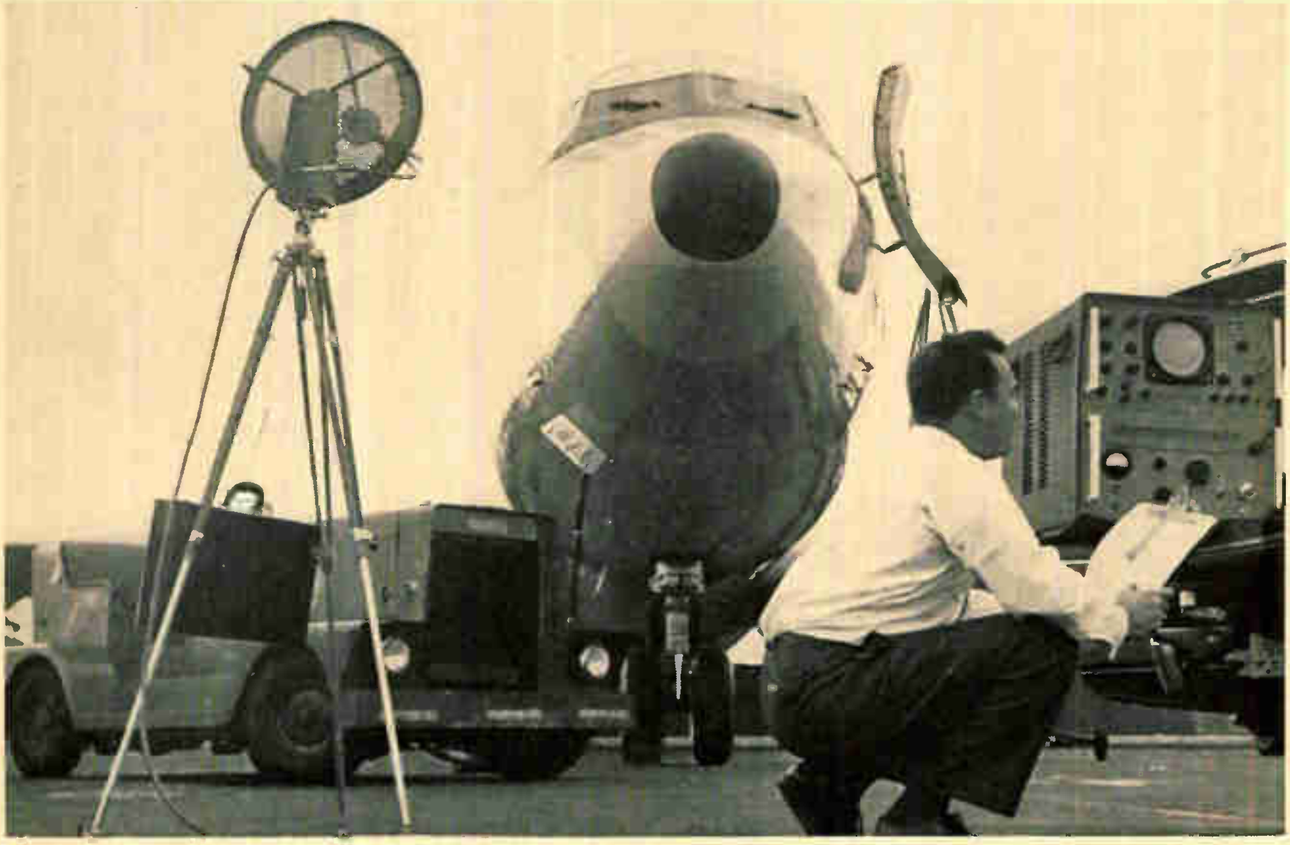


FIG. 1—Navigation systems in long-distance commercial airliners use doppler radar to measure ground speed

APPLICATIONS

Besides conventional radar and communications applications, microwaves are also being used in computers, remote control and cooking. New uses include medical research and microwave spectroscopy to determine the properties of matter

PRACTICAL APPLICATIONS of microwaves are growing in number and the versatility of microwave systems is increasing. This expansion is partly the result of the basic properties of microwaves but is also dependent on the increasing variety of characteristics obtainable with newer microwave devices and components.

Most applications of microwaves rely on the transmission and reception of intelligence in some form. Communications at these frequencies does more than expand the usable space in the spectrum. Microwaves tend to propagate in straight lines, and high-gain antennas that can radiate beams in predetermined patterns are possible. Microwaves permit transmission of more information or provide higher resolution or both, and the short pulses that can be generated and transmitted can increase the speed of communicating data.

RADAR—Although most radar equipment is designed for military use, nonmilitary applications are increasing.

Because of the heavy emphasis of the military on radar developments, it is difficult to get detailed information about newer radar developments. However, a number of trends can be seen from the characteristics of new microwave devices now available. In addition, authorities in microwaves indicate efforts to develop components with characteristics that could have obvious value for radar.

For example, a need exists for surveillance radar with up to 50 or even 100 megawatts peak pulse power. Systems manufacturers cite efforts to develop antennas and other devices capable of handling such large amounts of power. Low-noise circuits such as masers or paramatric amplifiers can also provide significant increases in effective range of some types of radar.

Efforts are also being made to develop microwave devices capable of operating over broad bands of frequencies. Military radars that could change operating frequency readily would be more immune to jamming and other electronic countermeasures. Another possible reason for this capability is that some types of electronic scanning rely on changing frequency.

Electronic scanning is another trend in military radar. Although efforts at electronic scanning have been made for a long time, it is only recently that practical methods have evolved. Electronic scanning eliminates some mechanical problems associated with driving large parabolic reflectors. High-speed electronic scanning also illuminates targets more frequently than mechanical scanning, increasing the probability of detection.

Another capability being refined in military radars is moving target indication. Use of the doppler shift principle or cancellation of detected response noted on successive antenna sweeps can be used to indicate moving targets. Some mti radars provide a conventional display with moving targets superimposed. Relative brightness can be controlled to permit orientation of the moving target in its surroundings.

High-resolution search radars like the AN/APQ-55 by

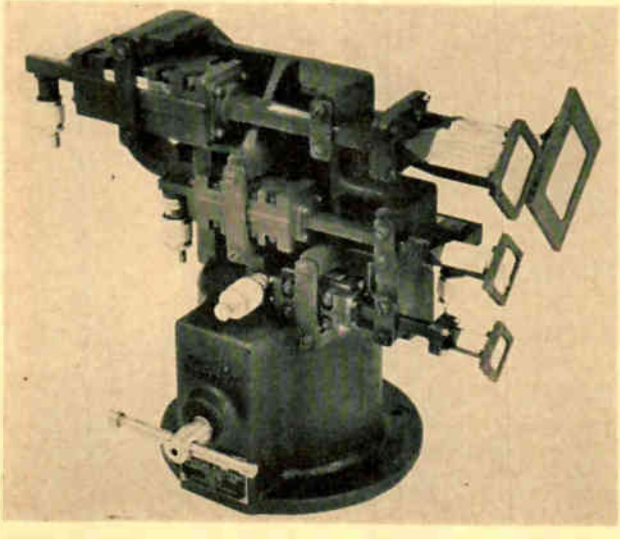


FIG. 2—This microwave equipment detects signals having frequencies from 8,200 to 40,000 Mc

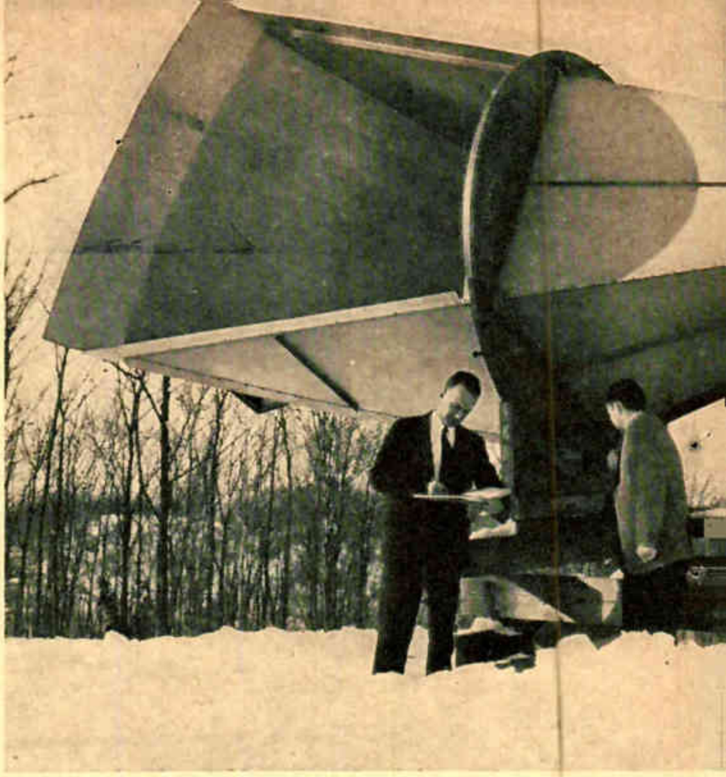


FIG. 3—Low-noise antenna (left) designed by Bell Labs for passive satellite communications system operates in

Texas Instruments Incorporated are being used for radar mapping. Some of these systems incorporate sweeps that compensate slant range, providing a display in which distances are linear.

Because of size limits of airborne radar antennas, resolution is limited. In Project Michigan, a small antenna reportedly provides resolution equal to a much larger antenna. Forward motion of the aircraft and a data storage system for echoes are used.

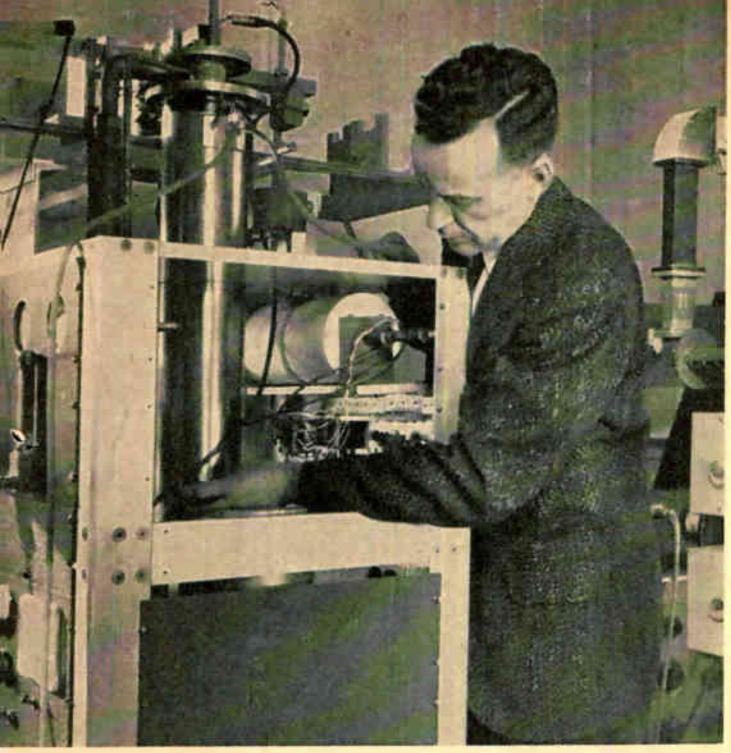
Automatic range-tracking circuits in receivers provide continuous range data. Angular tracking can be accomplished by several methods, with monopulse becoming popular (see ELECTRONICS, p 51, April 22). Range and angular rates and accelerations enable prediction of future target position for fire-control systems and missile testing.

Track-while-scan capabilities are being incorporated in more military radars. Also, with coordinate information about a target available, it is possible to illuminate it with c-w radar, enabling a homing device to intercept a target even with abrupt changes in target direction.

The doppler effect can provide relative velocity information. Military aircraft and a growing number of long-range commercial planes are using this principle to determine ground speed. A ground test of this gear using Polarad equipment is shown in Fig. 1.

Commercial radar is being used for aircraft traffic control, marine and aircraft navigation, and to some extent on smaller pleasure boats. Doppler radars have received considerable attention in contemplated automobile collision-avoidance systems, although equipment costs and other problems must be overcome. A widespread nonmilitary application of doppler radar is for checking automobile speed.

Doppler shift is also being used in bomb-navigation systems to detect changes in altitude. Information obtained from doppler radar can also be used to provide altitude information in helicopters. A radar tracking system being developed at Philco uses c-w signals for missile testing.[a]



conjunction with the low-noise traveling-wave ruby-loaded maser (right) with 30-Mc bandwidth

COUNTERMEASURES—The U-2 incident has forcibly brought countermeasures and counter-countermeasures to the attention of the public. It has been reported that the craft was equipped with countermeasures devices.

Electronic countermeasures are attempts to nullify the effectiveness of enemy electronic equipment; counter-countermeasures are attempts at offsetting the effectiveness of enemy countermeasures. An example of an earlier countermeasure was the dropping of chaff or bits of metal foil from penetrating aircraft during World War II to mislead enemy radar. Since then many of the devices and methods of radar have been borrowed for countermeasures. Countermeasures have in turn influenced radar design.

Tight security measures prevent gathering much information in this area, although many microwave developments can be related to countermeasures. For example, one method of disrupting enemy electronic equipment is the transmission of noise at high power over a broad band of frequencies. This may partially account for efforts to develop broadband high-power microwave devices, including some antennas described in this report.

Another countermeasures technique is to wait for reception of enemy transmissions to determine their characteristics. Equipment to do this has been developed. For example, American Electronics Laboratories, Inc., developed the AN/GLA-15 Troop-User antenna set. This lightweight crystal video detection system covers frequencies from 8,200 to 40,000 Mc. Circularly polarized horn antennas are used in the system shown in Fig. 2. Beamwidth varies from about 50 degrees at the low-frequency end to about 40 degrees at the high end.

When characteristics of enemy transmissions are known, equipment that operates with reasonable efficiency over a broad band of frequencies may be tuned to disrupt enemy equipment. Transponders somewhat similar to those used in beacons may also be triggered by radar pulses and retransmit an echo after a deceptive delay or some other misleading process.

A radar echo augmentation device may also be used in countermeasures. A Temco unit is a compact, self-contained traveling-wave tube amplifier designed for radar cross-section enhancement. Operating between 8,500 and 10,250 Mc, it provides a reply with less than 0.1 μsec delay and is effective against pulsed and c-w radars. The device provides a dispersed return signal to respond against systems that use a radar in one location and a receiver in another. It can be used in target drones and decoys and for missile tracking and aircraft anticollision devices. A small target drone equipped with the unit can simulate the cross section of a B-52.

Defenses against countermeasurers include equipment that can operate over broad bands of frequencies and systems in which operating frequency can be readily changed. Increasing radiated power, gain and other characteristics of transmitting and receiving antennas, and improving receiver signal-to-noise ratio all enhance the probability of successful operation in the presence of jamming. Encoding transmissions so that a receiver rejects signals not similarly encoded is also effective.

MICROWAVE COMMUNICATIONS—Both military and commercial uses of microwave communications are expanding rapidly. Total military and nonmilitary expenditures on point-to-point links amounted to about $85 million in 1959, with about $50 million for the military. An estimated $100 million more was invested in tropospheric scatter systems, largely for military use.

Economic and technical factors are involved in the growing use of point-to-point microwave links. Installation costs are low compared to wire lines when many channels are required or when a single broadband channel like a tv link is needed. In some terrain, stringing wire is impracticable. The high frequencies of microwaves permit broadband multiplexing to carry a large number of channels over a single link.

High antenna gains and easily directed energy keep power consumption of microwave links down. Also microwave antennas can be small compared with those required for radio communication at lower frequencies.

Microwave point-to-point systems are furnishing links in telephone and telegraph systems, relaying tv programs and performing a wide variety of industrial functions.

An example of control by microwaves is the offshore natural gas condensate production installation. One typical platform has three gas condensate wells, allied production gear, safety and navigation equipment. Microwaves permit 21 continuous and 12 selective telemetered functions, with 23 platform controls. The rig and a master control are linked with a Motorola system.

A 10-mile microwave system will enable the U. S. Weather Bureau to transmit data between computer stations of the National Bureau of Standards in Washington and the National Meteorological Center in Suitland, Md. The system will accept data from magnetic tape and record it on similar tape at the opposite station. The tape is used as direct computer input.

Tropospheric scatter systems permit microwave communication over mountains, water or long distances. Because serious fading can occur on tropo links, several methods are used to maintain communications. Two dual diversity receivers use the same antenna to provide quadruple diversity reception in a 180-mile path between

Nassau and Florida. Up to 72 telephone trunk circuits are provided by two 10-Kw Standard Telephone and Cables transmitters operated near 2,000 Mc. They feed two 30-ft parabolas.

Ferrite phase modulators are mounted in the waveguides from the diversity antennas. A rotary phase shifter after each channel-branching filter continuously corrects each r-f channel separately. The center section of the phase shifter contains circular waveguide that is rotated by a servo motor to correct phase of the incoming signal. If one signal is phase modulated, an error signal derived from the combined i-f signal drives the servo.

When signals are equal and in phase, a net advantage of 3db is obtained over a single antenna. With no signal from one antenna and full signal from the other, net loss is 3 db, and fading range is limited to 6 db.

Ultimate sensitivity of earth-based microwave communications is limited by thermal noise. Bell Labs has developed a low-noise antenna and receiver combination that increases the possibility of transoceanic communications by reflecting microwave energy from passive earth satellites. The narrow-beam highly directional horn reflector antenna has low noise when pointed skyward. Overall input temperature as low as 17.6 K at 5,650 Mc has been observed, including noise contribution from sky, antenna and maser preamplifier.

Improvements now underway indicate feasibility of systems having an overall noise temperature of 7.5 K at 6,000 Mc for reception near the sky's zenith.

The 50-sq ft nonpolarized radiating aperture of the Bell antenna in Fig. 3 has half-power beamwidth of 1.75 degrees and gain of 41 db at 5,650 Mc. The traveling-wave maser in Fig. 3 is a two-port device that amplifies in the forward direction only. Nonreciprocal action is obtained with a ferrimagnetic material having 30-Mc bandwidth. The signal is tunable over 230 Mc and pump frequency is 18,500 to 18,900 Mc at 100 mw.

COMPUTERS—Computer-like devices are being constructed using microwave techniques.[3] Their successful operation indicates that microwave components are useful in computer logic circuits. Components include impedance transformers, resonant circuits, phase-inversion networks, frequency-sensitive filters and modulators. They offer attractive possibilities not available in the baseband computer approach. With a microwave carrier frequency (about 1,000 Mc), components such as ferrite isolators, directional couplers and special multiport linear devices including hybrid rings become usable. Operation at microwave frequencies permits pulse rise times of less than 1 nanosecond, using narrow-band components.

One example of design and construction of a high-speed carrier computer subassembly is underway at RCA. The computer has a density of logic modules at least comparable to that of commercial baseband computers. Conventional rectangular waveguide and traveling-wave tube amplifiers, prominent in earlier microwave computers, are too large for this objective. Components for 50,000 Mc or above were ruled out because emphasis was on the computer and not microwave component developments.

A modular bistable circuit was developed using variable-capacitance diodes with a pump frequency of 4,000 Mc and a subharmonic output of 2,000 Mc. At these frequencies, commercial microwave test components are available and the diodes operate efficiently.

An earlier logic module used a pair of diodes in a balanced circuit operating with a 2,000-Mc pump. Volume was 0.71 in.^{3}, compared to 0.16 in.^{3} for the present logic modules.

An experimental computer having ten logic modules was made to get statistical data on required pump and signal output power. Seven units operated with 40 mw or less pump power and minimum output was 1.5 mw.

Varactors can be used for a fast digital computer because a pumped varactor can oscillate at a subharmonic of the driving frequency.[4] A tuned circuit resonant at one-half driving frequency is required.

Phase of the half-harmonic oscillation may be at one of two states relative to pump frequency. If the pump is operated in the absence of other disturbances, oscillation phase occurs randomly in one or the other state. However, if some subharmonic oscillation is present when the pump is turned on, it can influence phase of the subharmonic oscillation.

Since little power is required to establish phase one way or the other with a high degree of certainty, high amplification occurs; much more power can be withdrawn from the subharmonic oscillation (once established) than is needed to establish it in one or the other phase.

Thus binary data can be transferred from one subharmonic oscillator to the next. Information through the computer can be made to follow prescribed paths if pump power to the oscillators is turned on at the proper times. Varactor computers may be possible with at least 100-Mc repetition rates. Higher speeds could be obtained if varactor cutoff frequency were improved.

Tunnel diodes in high-frequency oscillator circuits using waveguides and cavities as tuned elements have encountered parasitic oscillations. The oscillations arise from driving the circuit with a low-impedance d-c source. One approach, developed at IBM[5], is based on lumped-parameter principles and is free from biasing problems. Oscillators were made that operate up to 3,000 Mc.

In the structure used, a highly doped *n*-type germanium wafer about 2 mils thick is soldered to a 3-mil nickel mounting tab that serves as one electrode. Two closely spaced tin impurity dots, one doped with gallium and the other with arsenic, are alloyed to the *n*-type wafer. The SnGa dot forms a recrystallized *p* region that makes an abrupt junction with the heavily-doped *n* material. This creates a tunnel diode and a negative resistance is produced when the diode is forward biased at 50 to 350 mv. The SnAs dot forms an ohmic contact to the *n*-type wafer. If resistance between the SnAs dot and the mounting tab is less than absolute diode negative resistance, the system oscillates at a very high frequency when a shorting bar (the second electrode) is connected across the dots. A biasing current flows through the resistive part of the circuit sufficient to produce a d-c voltage across the tunnel diode, making it a negative resistance.

Oscillator frequency is increased as dot dimensions and spacing decrease. Oscillator frequency can be increased by etching away some areas of the Ge wafer. This procedure reduces diode junction area, hence its capacitance. Etching also isolates the bias resistance portion of the circuit from the diode part and suggests a simplified lumped-parameter circuit. Experimentally, frequency increased as tunnel diode junction area decreased.

Tunnel diode development is permitting higher oscillator frequencies. It has been reported that at IBM, R. F.

Rutz and his colleagues have attained frequencies to 5,300 Mc, and observed second and third harmonics at 10,600 Mc and 15,900 Mc, respectively.

MICROWAVE HEATING—Using microwaves for cooking is no longer a novelty. However microwave generators capable of higher average power could presage wider use of microwave cooking and also other industrial applications of microwave heating.

A conveyor belt system has been developed by Philips, Eindhoven, Netherlands. Five Amperex magnetrons generate 10 Kw average power at 2,450 Mc. The system cooks complete meals at 150 per hour, raising temperature of previously prepared frozen food from −13 to 176 F.

EXPERIMENTAL APPLICATIONS—Microwaves are finding increasing uses in scientific research. Investigations range from analyses of atomic and molecular structures to gathering data about the ionosphere and outer space. Microwaves are helping solve a variety of problems from semiconductors to medical techniques. In controlled fusion research, microwaves can determine the properties of plasmas at extremely high temperatures.

Microwave spectroscopy is used to determine properties of matter. An electron paramagnetic resonance (EPR) spectrometer developed by Varian Associates is shown in Fig. 4. It permits accurate nondestructive analyses of biological systems, chemicals, semiconductors and metallic ions. Applications include enzyme substrate reactions, polymerization, radiation damage and photosynthesis.

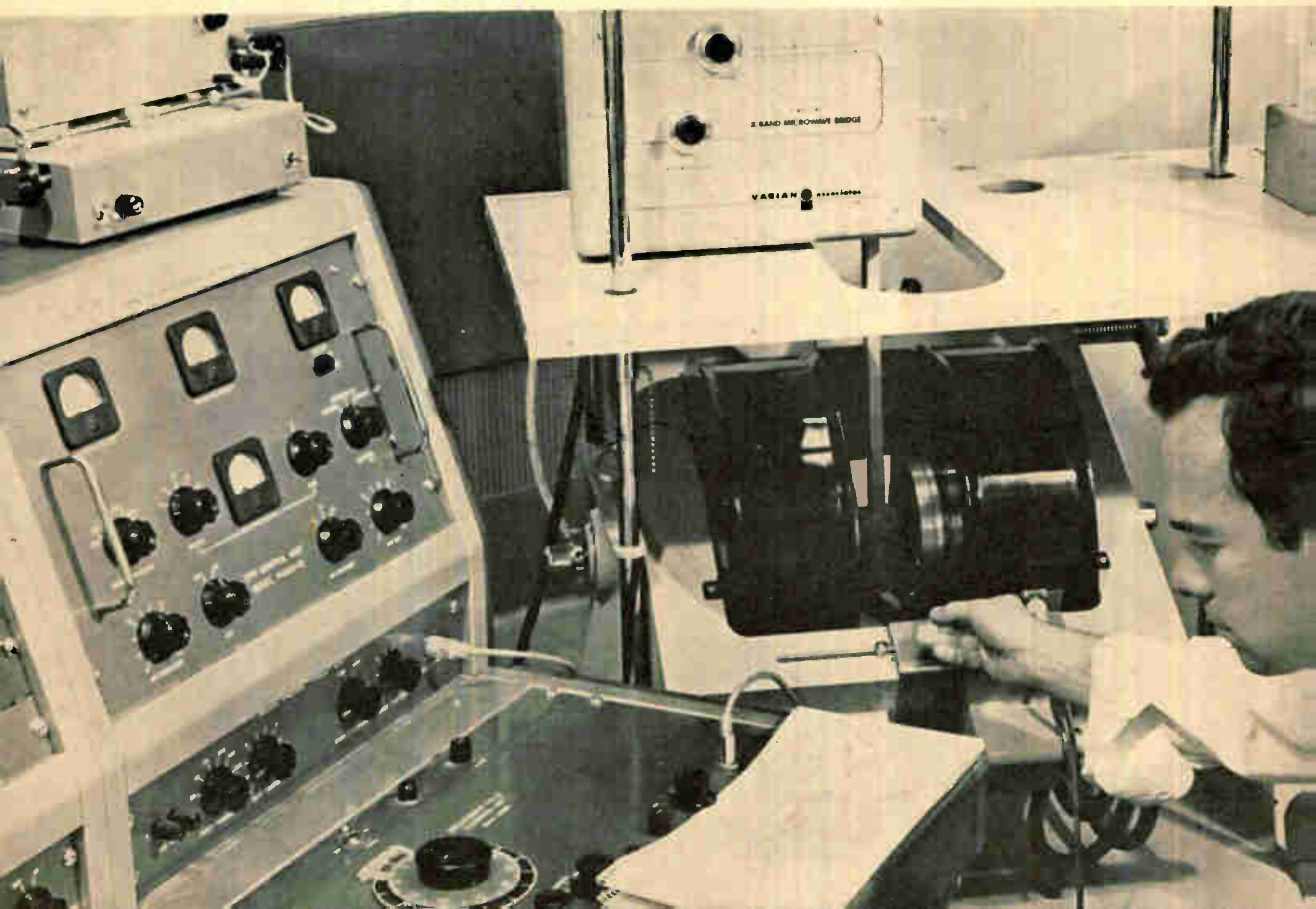
The spectrometer is sensitive to free electrons in molecular structures, each of which has a characteristic spin. When the spinning charged particle is placed in a magnetic field, it precesses at a frequency dependent on the ratio of magnetic field strength to frequency. Because the physical constants are such that precession frequency is about 9,500 Mc with the sample in a magnetic field of about 3,000 gauss, the X-band reflex oscillator and microwave bridge are suitable for inducing and providing for observation of EPR.

The possibility of using microwave absorption for measuring semiconductor properties is reported by RCA.[6] No direct electrical connection to the sample is required. It is possible to inject pulses of minority carriers either optically or through contacts and use microwave techniques to measure minority carrier lifetime decay.

A reflex klystron delivers power into a 12,000- to 18,000-Mc waveguide, and an isolator absorbs all reflected power to maintain constant klystron output. The semiconductor sample is mounted in a waveguide holder so it can be supplied with light, controlled atmosphere, coolant and electrical signals. Any changes in these cause variations in transmitted or reflected power or both, which are observed on an oscilloscope.

This technique may be useful for minority-carrier lifetime measurements in comparatively high resistivity materials like germanium and silicon.

FIG 4—Electron paramagnetic resonance spectrometer is one of the latest research tools to use microwaves



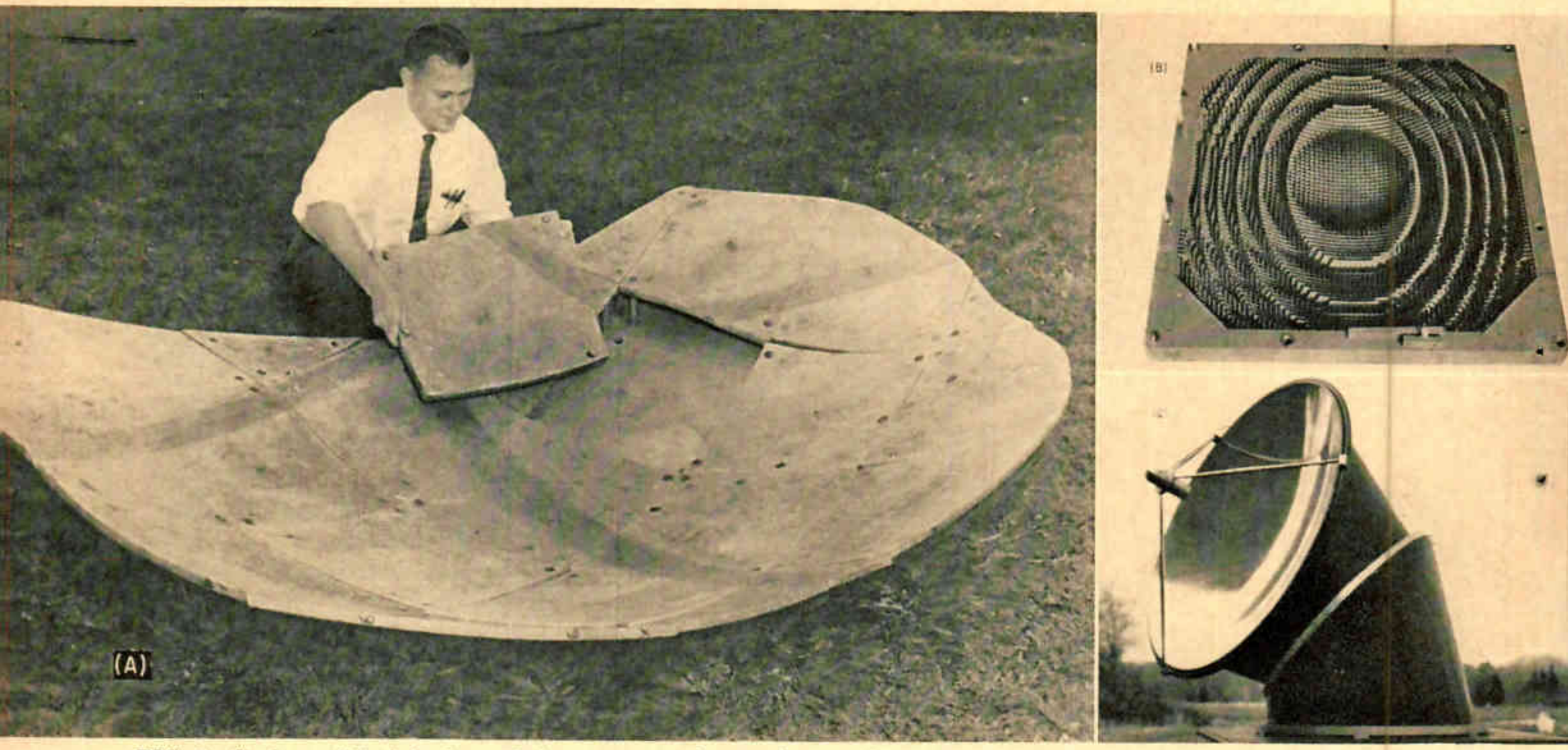


FIG. 5—Scale model of dual parabola antenna reflector that combines both search and height-finding functions (A), multiple focal length lens can be used by two or more radars (B) and steerable mount for large parabolas gives continuous rotation through any point (C)

modern microwaves ANTENNAS

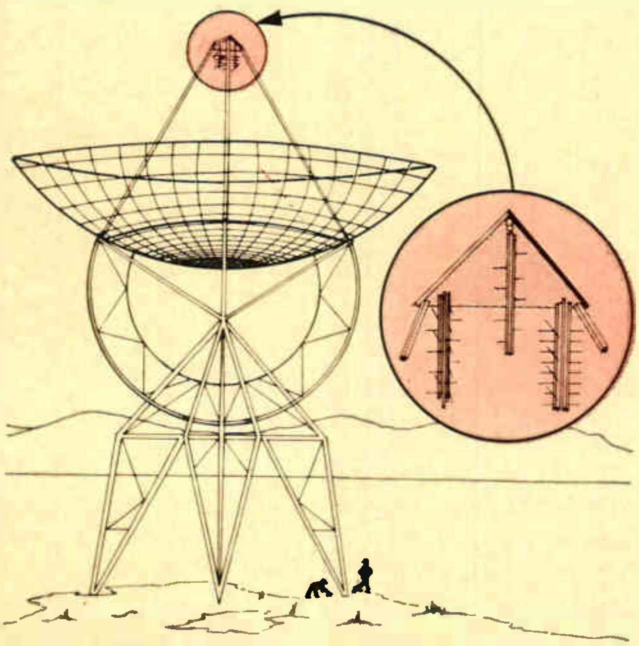


FIG. 6—Wide-band electronic scanning system uses triplet of wide-band feed elements at focal point of parabola

EFFECTIVENESS of much microwave equipment is directly dependent on antenna design in that almost all microwave systems rely on the propagation and reception of electromagnetic energy. With the increased versatility and improved performance of microwave systems, there has been a comparable evolution in antenna design.

Microwave transmitting antennas convert energy from a transmission line into a free-space wave with a beam pattern suitable for the system in which it will be used. Receiving antennas reverse the process. Radiation and transmission-line theory is the basis for many antenna designs, but optical principles are also used for designing such devices as lenses and reflectors.

BEAM PATTERNS—Individual antenna beam patterns are designed for a specific purpose. The toroidal or azimuth omnidirectional beam is often used in beacon transmitters or communication systems, or for identifying and receiving intelligence. The radiation pattern is substantially uniform in all directions in the azimuth plane, although elevation beamwidth can be controlled for specific applications.

The pencil beam illuminates a small area and is com-

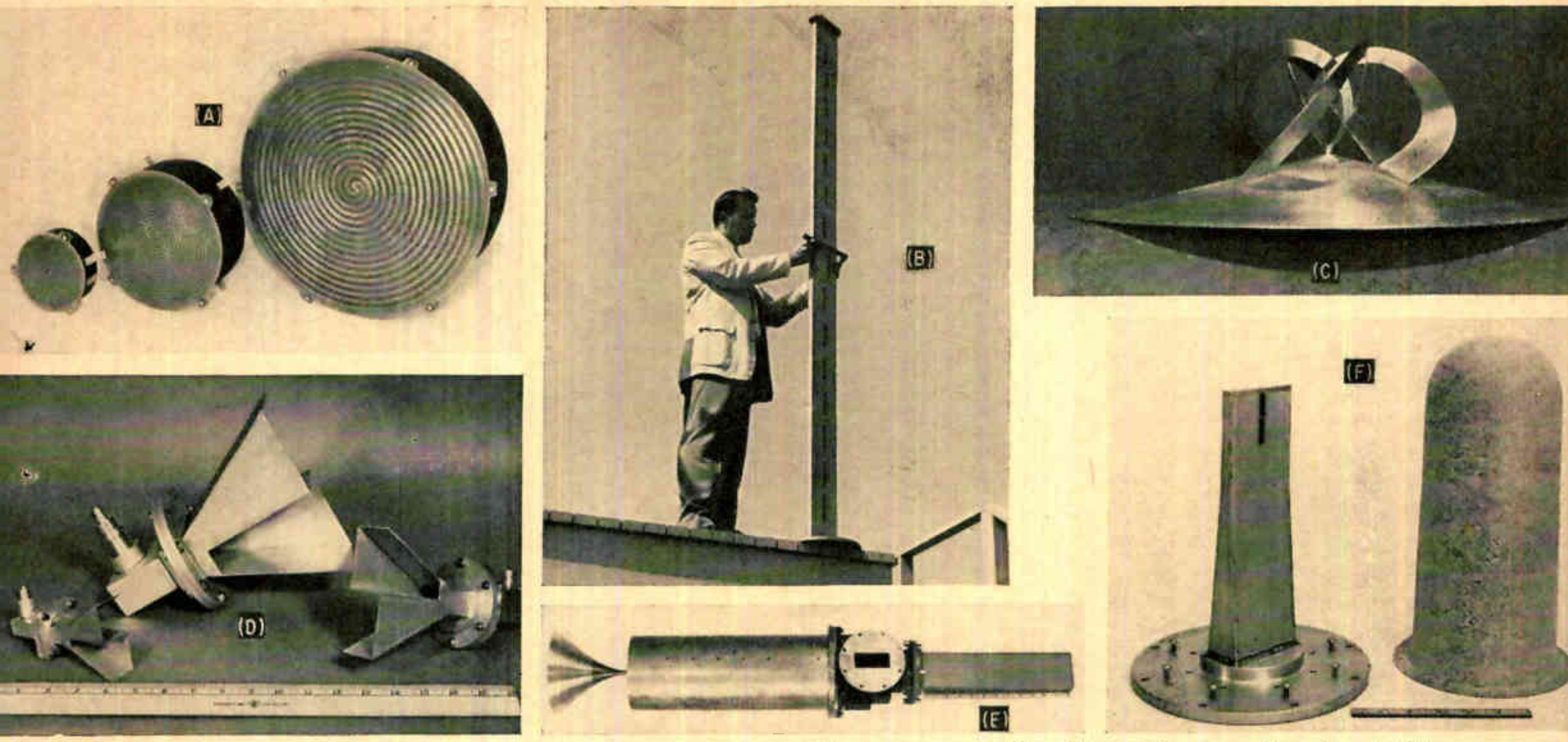


FIG. 7—New look in antennas includes Archimedian spirals (A), cosecant omnidirectional (B), auger broadband (C), S-shaped horns (D), omnidirectional with splash plate (E) and horizontally-polarized beacon antenna (F)

With the demand for broadband and multipurpose antennas increasing, some antennas have an out-of-this-world look. Many companies are developing frequency-scanning systems, while others are concentrating on high-gain arrays for particular frequencies

monly used in radar and point-to-point communications systems. For radar, the pencil beam can scan a variety of patterns including conical, raster, spiral or more complex forms. Azimuth search systems often use the fan-shaped beam to locate ships, aircraft, storms or landmarks.

Other beams are tailored to specific requirements. A beam may be shaped to cover a large area to maintain a level of reflected energy independent of range.

A stacked beam may incorporate one or more of the beam types described. Orientation, phase and amplitude of individual beams determine the configuration of the composite stacked beam. If each beam is connected to a receiver, relative levels of a return in each beam can determine height, range and azimuth.

The V-beam consists of two fan beams and can be used for height finding. Multiple receivers are not required because height is independent of receiver signal level and is a function of range, angle between the two fan beams and time between target returns from the two fan beams.

PARABOLIC REFLECTORS—Directing energy from a feedhorn against a parabolic reflector is the basic method of propagating a microwave pencil beam. If the parabolic curve is in one plane only, a fan-shaped pattern results. Resolution is partly dependent on both reflector size and shape. Size is limited in some applications, but even when it is not, it is difficult to maintain the true parabolic shape in large reflectors. Techniques have been developed that permit making even large parabolas to close tolerance.

The modification in Fig. 5A is a scale model of a dual parabola designed by Sperry Gyroscope for the Marine Corps TEW line (Tactical Early Warning). The final version will be 90-ft high. Special molding techniques are used to combine both search and height-finding functions in a single antenna. The antenna generates a V-beam pattern. Because the dual parabolas are polarized dielectric lenses, beams of the appropriate polarization from two separate feeds will either reflect or pass energy.

The Cassegranian antenna uses a feedhorn that protrudes slightly outward through the parabolic reflector so that its r-f energy is reflected from a hyperbolic reflector back to the parabola. Electronic components are mounted behind the parabolic reflector, eliminating long waveguide runs that can introduce differential phase shifts and losses that are critical in monopulse systems.

For a chosen illumination of the secondary aperture (hyperbolic reflector), greater latitude in feedhorn choice is afforded. Magnification between image and actual feedhorn size eliminates problems in focal-point-feed monopulse systems having focal length to diameter ratios less than 0.5. The actual feeds are larger, well above cutoff size. Dielectric loading of feed apertures is not necessary, mutual coupling between adjacent ports of the feed is reduced and power handling capacity is increased.

Because operating frequency of the parabolic antenna is limited by feed type, it is difficult to change frequency rapidly because the feed structure must be changed. For operation over a narrow band of frequencies, other antenna types can be superior: high-gain end-fire antennas can be rapidly directed to a desired point, can be electronically scanned and sometimes can provide higher gain.

MULTIPLE-PURPOSE ANTENNAS—A variety of antennas with combinations of polarization isolation, frequency isolation and time isolation can save weight, cost and space. Even array types, with their electronic and frequency scanning capabilities can be combined with other types to provide even more possibilities.

For example, greater ranges are obtainable at lower frequencies, while higher frequencies provide better resolution and accuracy. Instead of adding weight and bulk by duplicating costly radar equipment, functions can be combined into a single multiple-frequency unit.

The multiple focal length radar lens in Fig. 5B was developed by Sperry for high-power missile-control radar. In addition to having track-while-scan capability, the antenna radiates other beams enabling two or more radars to be combined into a single system.

The wide-band electronic scanning system shown in Fig. 6 was designed by Ramo-Wooldridge and can be installed in large parabolic reflectors. It consists of a triplet of wide-band antenna elements approximately disposed about the focal point of the parabola. Scanning is accomplished by three-phase amplitude modulation of the element outputs, which can then be connected to a common point. Output phase is compared with modulating voltage to obtain direction. Scan rate and angle of the resulting conical scan are easily controllable.

With frequency scanning, a system can provide range, azimuth and height information simultaneously. A line source feed can be scanned in elevation by changing transmitter frequency. Beamwidth in the elevation plane is formed by the primary feed, and azimuth beamwidth is a function of the secondary parabolic cylinder reflector dimensions. Azimuth beam position is controlled by mechanical rotation of the antenna.

Beam scanning occurs because the relative phase of each radiation element is varied by changing frequency. At each frequency, differential phase between elements is constant. Scanning can be accomplished at a fixed frequency by independently controlling phase of each radiating element in the array either electrically or mechanically, but ferrite phase shifters are getting considerable attention. By combining slot radiator characteristics with the field displacement caused by a magnetically biased ferrite iris, continuous and independent control of amplitude and phase is achieved. Integration of the ferrite control with the radiating elements results in a compact, low-noise antenna. Variable beam shaping and inertialess scanning are made practical.

Logical pattern synthesis for microwave antennas is reported by Hughes. Logical and switching operations used are like those in digital computers. The operations combine separate antenna patterns into a single system with improved characteristics. This technique provides a simple method of designing antennas with precise patterns. A logical 5-element antenna can produce a cosecant beam superior to a 13-element conventional array. One lobe of a multiple-lobe pattern can be logically selected to permit search-while-track operation.

Time modulated antennas are also being explored at Hughes. Using time as an additional parameter is effective in multiple-pattern operation, simultaneous scanning or side-lobe suppression.

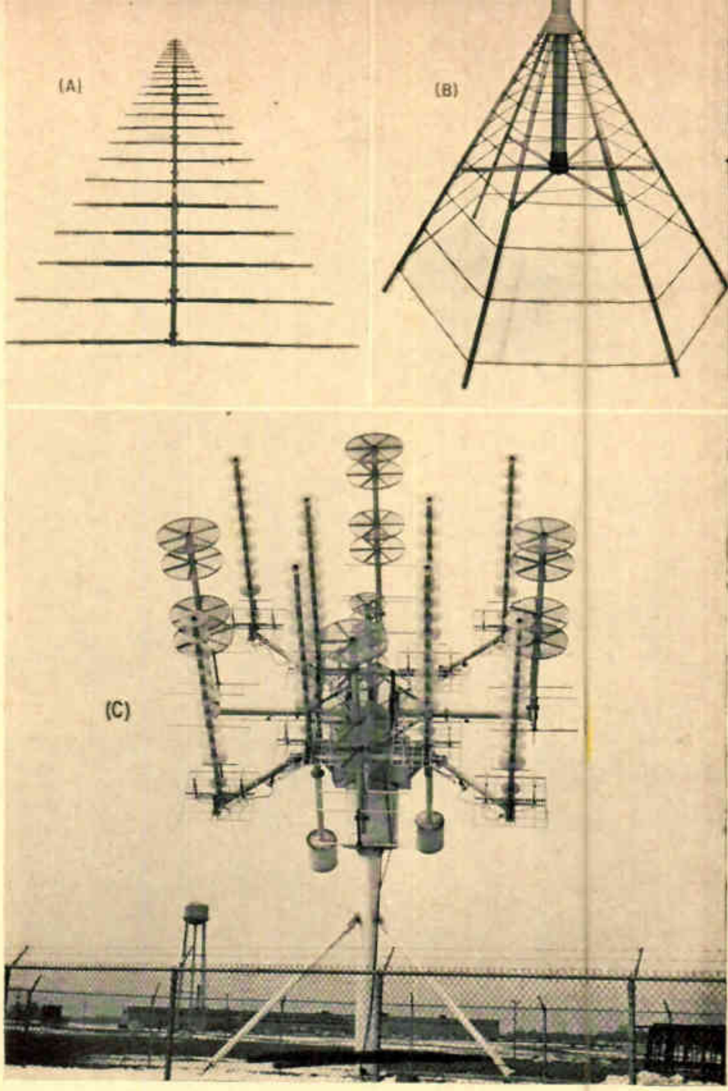


FIG. 8—Planar log periodic antenna (A), frequency-independent conical helix (B) and end-fire antenna used to track Tiros satellite (C)

OTHER ANTENNA TYPES—Although some of the newer antenna types look unconventional, they have characteristics that would not otherwise be attainable.

Amongst the Ramo-Wooldridge antennas shown in Fig. 7 the Archimedian spiral antennas in Fig. 7A use a multicavity design and wide-band balun to eliminate beam tilt. Frequency range of one of these antennas is 200 to 1,200 Mc with vswr less than 3 to 1. The antennas provide circular polarization with a unidirectional 50- to 90-degree beamwidth. There is no lobe splitting or beam tilt and impedance is 50 ohms.

The cosecant omnidirectional antenna in Fig. 7B con-

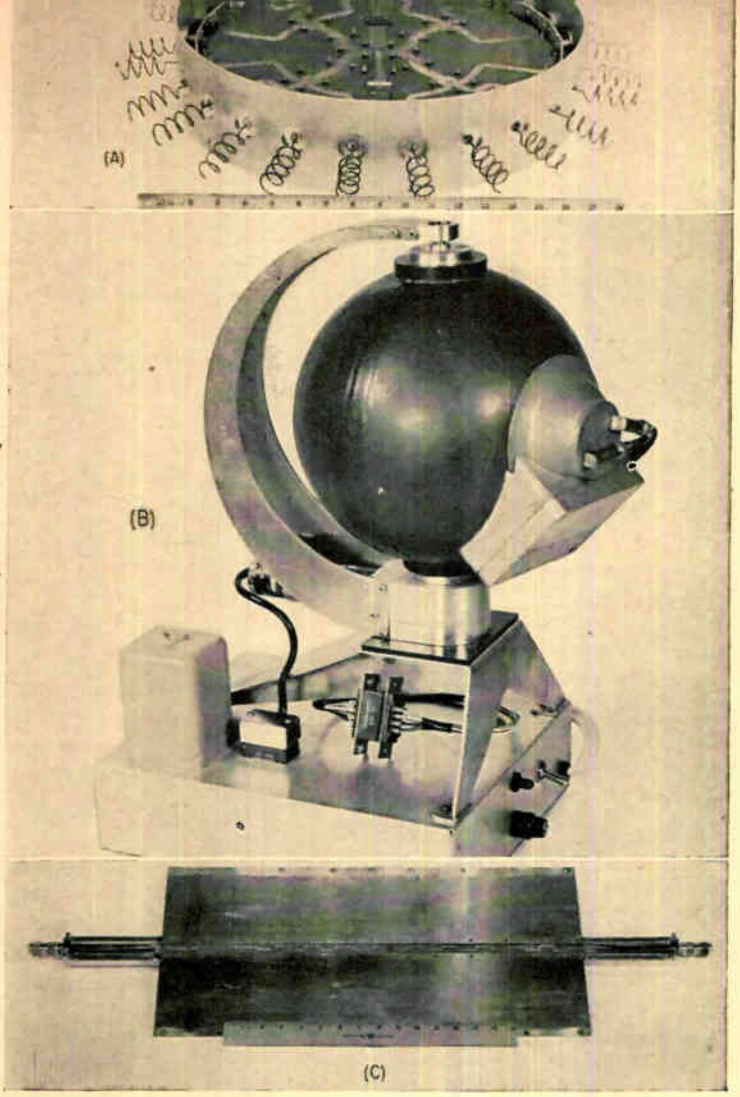


FIG. 9—Circular array (A) uses printed circuit power divider, radar augmentation device for drones (B) and flush-mounted sandwich (C)

sists of a line source array of in-phase longitudinal shunt slot pairs in the broad wall of a narrowed waveguide. The antenna operates between 1,250 and 1,350 Mc, and polarization is linear. The pattern is omnidirectional in the E-plane within ± 1 db and a shaped cosecant from $+4$ degrees in the H-plane. The beacon antenna in Fig. 7F provides a horizontally polarized omnidirectional beam in the E-plane within ± 1 db. The beam is tilted in the elevation plane up to 20 degrees by a small annular collar placed below the slots.

The auger antenna in Fig. 7C is a foamed-in-place assembly with equiangular radiating elements that produce omnidirectional patterns for two polarizations. Frequency range is 2,000 to 4,000 Mc. The S-shaped horn in Fig. 7D has an aperture designed for broad H-plane beamwidth. Polarization is linear and the pattern is a fan-beam in the H-plane. The omnidirectional antenna in Fig. 7E incorporates a splash plate to alter beam pattern. Width and position of the elevation plane pattern of the azimuthally omnidirectional beam can be readily altered to suit requirements.

Pyramidal and planar log periodic antennas are developed by American Electronics Labs. Figure 8A shows a typical planar log periodic antenna. They operate over a 20 to 1 frequency range between 50 and 1,000 Mc. Power gain over an isotropic source is about 6.5 for the planar and 9 db for the pyramidal antenna. These antennas can be used as the feed for a parabolic reflector.

The conical helix in Fig. 8B is independent of frequency. Lowest operating frequency is fixed by the physical size of the helix and highest determined by the coaxial feed technique. The firm is building conical helix antennas to operate from 50 to 11,000 Mc, achieving on some units bandwidths of 20 to 1.

The end-fire antenna being used to monitor the Tiros I satellite was developed by General Bronze. Shown in Fig. 8C, this antenna is an extension of the cigar or ladder antenna and is designed to limit radiation along most of the length. Directivity is proportional to a first order to phase velocity of the confined surface wave. This 24-ft diameter antenna has minimum gain of 18 db at about 108 Mc, 23 db between 215 and 260 Mc and better than 12 db at about 140 Mc. End-fire arrays of this type are showing increasing promise in microwave applications.

The circular array in Fig. 9A is fed by a printed-circuit power divider. This Dalmo-Victor antenna was fabricated to substantiate pattern calculations for circular arrays yielding specified pattern variations. Intended use is in high-speed vehicles requiring omnidirectional coverage about the roll axis. In the final design, flush mounting will be used.

The Dalmo-Victor device in Fig. 9B is for radar augmentation in connection with target drones. Because of the relatively small radar cross section of most drones, a synthesized radar return is required comparable to a simulated target. Passive devices often used present little or no bistatic cross section. This augmenter combines the Luneberg lens-type reflector and the Eaton-Lipman lens reflector combining the largest monostatic-bistatic cross section for a given lens diameter.

The flush-mounted sandwich wire antenna in Fig. 9C is based on the work of Rotman and Karas of Air Force Cambridge Research Center. In the Dalmo-Victor experimental unit, design parameters are being determined. Preliminary tests indicate sufficient control over antenna characteristics to synthesize shaped patterns for ground-mapping applications.

There is a trend toward larger antennas for space communications and tracking, but large antennas on steerable mounts introduce many problems. The cyclotronic mount in Fig. 5C was developed by D. S. Kennedy to give continuous rotation through any point. It is suitable for antennas of 200-ft diameter and larger.

If normally incident, linearly polarized electromagnetic radiation falls on an infinite grating of circular wires, the electromagnetic vector is perpendicular to the wires and most of the energy is transmitted. When the electric vector is parallel to the wires, a large part of the incident energy is reflected. This principle results in two advantages in microwave antenna design.

The solid reflector surface of a microwave antenna can be replaced by a parallel-rodded structure set on a given profile. This method reduces weight and windage effects. It is easy to make and is polarization sensitive.

The wire grating structure can eliminate cross-polarized sidelobes that occur on a shunt-inclined slotted linear array. A grid of vertical wires is placed in front of the array, which transmits horizontal polarization to reduce the vertically polarized component. Investigations are being made of this device for waveguide filters.

GENERATORS and AMPLIFIERS

Trend is towards more power, less noise and greater bandwidth. Parametric amplifiers are gaining ground, as are tunnel diodes. Hybrid microwave tubes may provide new approach

CONVENTIONAL OSCILLATORS and amplifiers for microwave frequencies still dominate the commercial picture, despite great interest in newer devices. During 1959, about $55 million worth of magnetrons were sold, $40 million of klystrons, $3 million of traveling-wave tubes and $11 million of backward-wave oscillators.

Emphasis in improving older devices, as well as developing new ones, has been on high power, broadband operation and low-noise performance.

LOW-NOISE DEVICES—A number of practical considerations are behind a sustained effort to develop new low-noise microwave oscillators and amplifiers. From an economic point of view, they offer increased efficiency. In commercial communications systems, repeaters could be spaced farther apart and communications links could operate over greater distances. In the military area, they can increase operating range of some types of radar and greater reliance could be placed on vital communications systems. In addition, low-noise amplifiers could significantly improve the communications capabilities of some planned satellites.

Parametric amplifiers do not offer as good noise performance as the maser, but they are superior to vacuum-tube amplifiers. They also do not require a magnetic field or refrigeration, although refrigeration does improve noise performance.

Parametric amplifiers require a variable reactance, and variable inductance in the form of thin magnetic films has been used. However, variable capacitance is more common, with two modes of operation possible—the negative-resistance mode and the up-converter amplifier. Both use a variable-capacitance diode as the active element and a high-frequency pump signal as the principal source of energy.[7]

The up-converter amplifier offers high stability, but for reasonable gain requires a pump frequency many times signal frequency, which has limited use to uhf frequencies. Also signal frequency is usually shifted in the up-converter. Pump-to-signal frequency ratio for the negative-resistance type is nominally 2 to 1. Output can be at either the original frequency or the lower sideband.

The Manley-Rowe theorem suggests a hybrid of the two parametric amplifiers. Like the negative-resistance type, it would use the lower sideband. In common with the up-converter, pump frequency is many times signal frequency. The lower sideband, which is much higher in frequency than the input signal, is the useful output. The amplifier offers higher gain and better stability than the negative-resistance amplifier. Bell Labs and ITT have made uhf amplifiers of this type.

Electron beam parametric amplification is also possible, since a traveling electric field can parametrically amplify transverse or longitudinal waves or electrons in a beam.[8]

This type of amplification is available for fast-wave beams as well as slow-wave beams, and is important for low-noise amplification. Traveling-wave tubes and klystrons amplify by interaction with a slow-wave beam. Special steps are required to lower equivalent temperature of the beam to limit noise, but these steps are

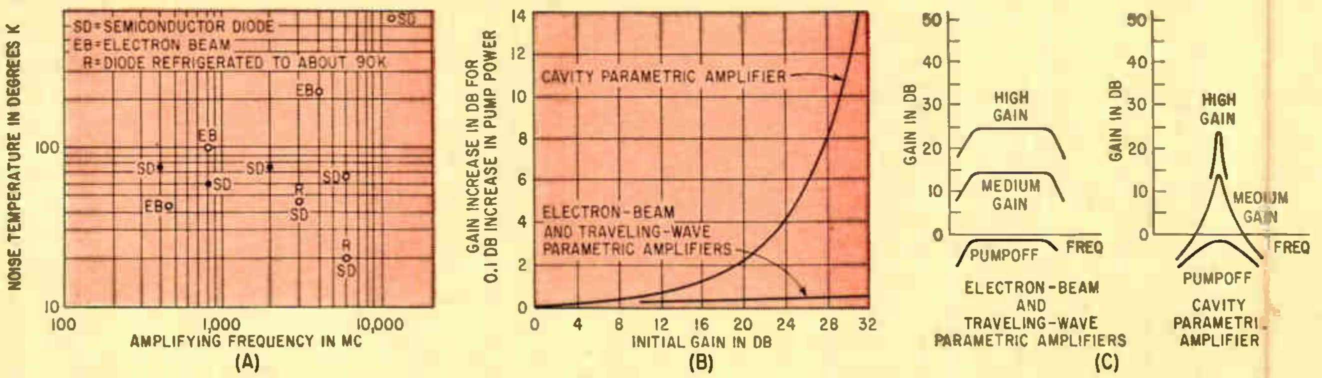


FIG. 10—Excess noise temperature and frequency are shown at (A) for low-noise parametric amplifiers; gain is plotted in (B) for 0.1 db increase in pump power; and gain is compared in (C) for varying pump power in different types of parametric amplifiers

more difficult for slow than for fast-wave beams. Theoretically noise can be completely removed or cancelled for fast waves. An experimental fast-wave cyclotron achieved a beam temperature below 25 K.

In operation, fast-wave components of beam noise are removed and a fast-wave component corresponding to the input signal modulates the beam. The tube is like a traveling-wave diode amplifier, with relatively wide-band operation and gain that depends on pump power.

Noise measured as excess noise temperature for both diode and electron-beam parametric amplifiers is shown in Fig. 10A. Each dot represents a reported measurement for a single-channel amplifier and each circle for a double-channel amplifier. Lowest noise performance attained was by a refrigerated diode amplifier built at Bell Labs. Lowest noise temperature for an unrefrigerated amplifier was 43 K for an electron-beam amplifier built at Zenith.

CAVITY-DIODE AMPLIFIER—The cavity-type diode amplifier is rugged and inexpensive, and it requires little pump power. However, slight changes in pump power cause drastic changes in gain, as shown in Fig. 10B. With an initial gain of 25 db, if pump power is increased 0.1 db, gain increases almost 6 db. The corresponding increase in gain with either an electron-beam or traveling-wave parametric amplifier is less than 0.5 db.

The cavity-type amplifier is completely reciprocal and for best performance requires a circulator. The traveling-wave parametric amplifier can be designed to be nonreciprocal. Theoretically it is capable of short-circuit stability, but in practice reflections in the transmission line make this and other theoretical capabilities difficult to attain.

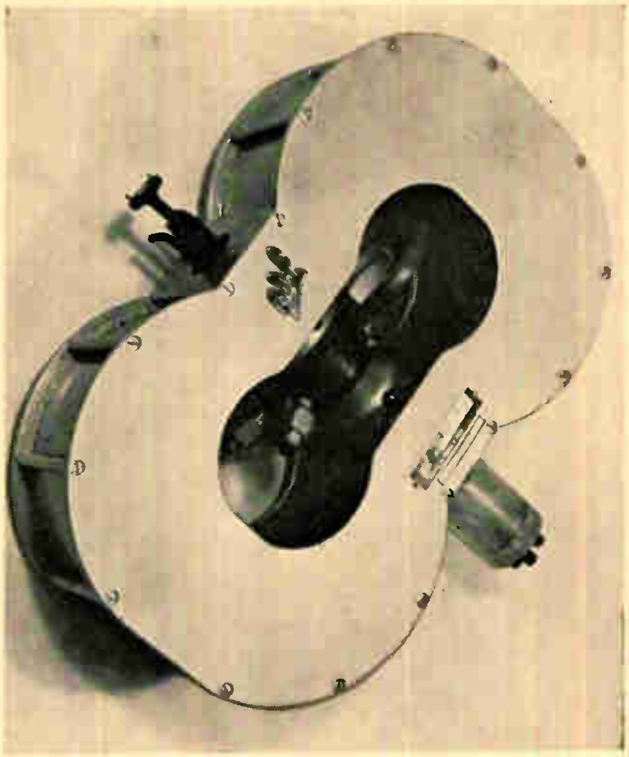
The electron-beam amplifier is nonreciprocal. An output signal will not be carried by the beam and appear at the input terminal. The amplifier has, effectively, a built-in circulator and is always short-circuit stable.

Cavity-type parametric amplifiers are narrow-band devices, although increased bandwidth is possible. Preliminary experiments at Bell Labs indicate that a 40 percent bandwidth at 500 Mc is not unreasonable. Normally bandwidth is a function of gain, as shown in Fig. 10C.

Although an electron-beam parametric amplifier operating at 4,000 Mc has been built, it is doubtful that upper frequency can be greatly extended. As indicated in Fig. 10A, X-band diode amplifiers have been built and give good low-noise performance.

HARMONIC GENERATORS—High frequencies can be obtained from a low-frequency oscillator using harmonic generators. One commercial unit has two waveguides coupled to each other by a probe structure terminated in the crystal mount. The input waveguide receives the exciting frequency, which is coupled to the crystal to cause harmonic generation. The harmonic frequency then propagates through the output waveguide. Lower order harmonics, usually second and third, are used since harmonic power decreases rapidly as order of harmonic increases.

Diffused *p-n* junction silicon diodes are efficient harmonic generators.[9] In a test setup, attenuators were



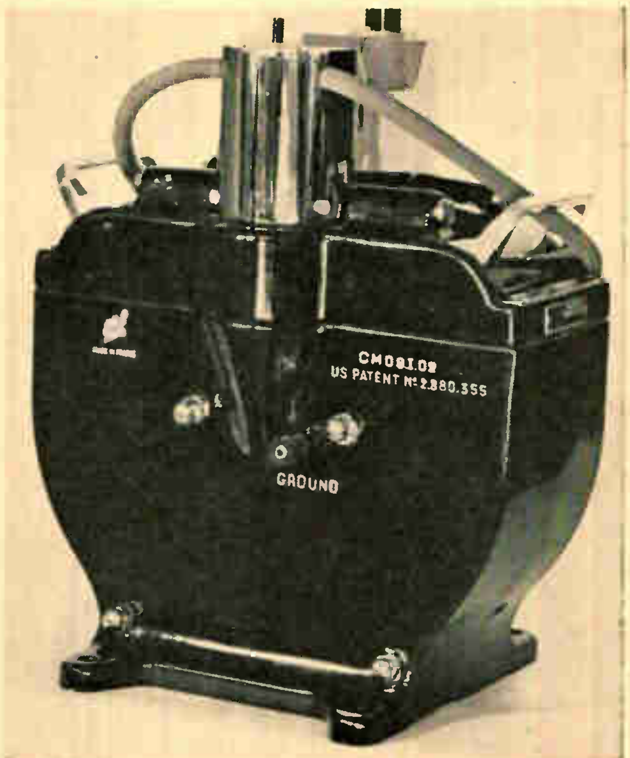


FIG. 11—Carcinotron at top delivers 2 w at 4 mm, while that directly above provides 20 w at 8 mm

incorporated in a broadband circuit to provide resistive terminations. Efficiencies were measured, and conversion loss of the second harmonic of 400 Mc was 11 db and the third harmonic of 300 Mc was 19.7 db.

With tuning elements replacing the pads or resonant cavities and tuned to the desired harmonic frequency, conversion loss for the third harmonic of 320 Mc was only 4 db. Unusually high harmonic yields were obtained in some experiments. Outputs exceeded those to be expected from an ideal nonlinear capacitor in broadband operation or from a tuned nonlinear resistor.

TUNNEL DIODE AMPLIFIER—A broad-band, traveling-wave, tunnel-diode microwave amplifier has been developed at Bell Telephone Laboratories. It uses the negative resistance of the tunnel diode combined with nonreciprocal ferrite attenuation to achieve high amplification without oscillation.

The traveling-wave concept is used with a row of tunnel diodes along the center of a strip waveguide. Diode negative resistance increases signal power progressively as it travels along the waveguide. Ferrites absorb reverse waves.

Many applications of tunnel diodes become possible by eliminating one major difficulty in using them in amplifiers. Although the present amplifier operates at about 1,000 Mc, future models may operate above 3,000 Mc and still use germanium diodes. Much higher frequencies, possibly millimeter waves, should be possible with indium antimonide diodes, which have been made by R. L. Batdorf at Bell Laboratories.

HYBRID TUBES—Hybrids of microwave beam tubes are now under development. They combine the best features of multicavity klystrons and helix traveling-wave tubes, according to W. A. Edson, manager, klystron subsection, General Electric microwave laboratory.

Results may be a microwave tube of high stability and efficiency, coupled with substantial frequency range and power. Among possible interaction principles, one method uses an electron beam in a smooth-walled waveguide, such as a circular metal tube. Propagation is characterized by a wave of higher phase velocity than the speed of light. This wave interacts with an electron beam having much lower velocity if the beam is periodically perturbed in velocity by a magnetic field or other means. Many useful devices are expected from this interaction principle, especially for extremely high peak and average power.

Other promising structures use electron streams in parallel, such as the traveling-wave klystron, the multistream, multihelix twt, and the hollow-stream twt's and klystrons. Edson also forecasts a ten-fold increase in average power output of octave-wide twt amplifiers and peak power of octave-wide pulsed twts. Parallel circuit devices, hollow-stream devices and fast-wave interaction may greatly increase power output from c-w single-beam klystrons and narrow-beam twt's.

Until about three years ago, minimum noise figure of a traveling-wave tube was about 6 db but is now 1 to 2 db. The current trend in traveling-wave tubes is toward lower broadband noise figure, periodic permanent-magnet tubes and relatively high-power (about 0.5 w) low-noise tubes. Such tubes could be used to feed transmission lines and for preamplification at antennas.

Increasing dynamic range of a traveling-wave tube is also under consideration. Lowering noise figures extends dynamic range slightly. A better approach may be to increase saturation level of a low-noise twt using external circuits (video delay lines and helix adding circuits).

Power output of twt's has risen in recent years from a few watts to about 30 Kw. The heavy, power-consuming electromagnet has been removed, size and weight reduced, and ruggedness improved.

KLYSTRONS—Rather than magnetron oscillators, klystron amplifiers are providing higher microwave transmitter power. Litton Industries recently delivered an L-band klystron rated at 30 Mw peak and 100 Kw average power to Lincoln Laboratories for further evaluation. Varian Associates is making a c-w klystron to deliver 20 Kw at 8,000 to 10,000 Mc and a pulsed klystron to deliver 25 Mw peak and 25 Kw average power at 2,700 to 2,900 Mc.

A klystron developed by General Electric provides 15 Mw peak and 22.5 Kw average power in the L-band for pulsed radar systems. Developmental work to increase operating bandwidth and power is continuing.

Some millimeter generators and amplifiers are appearing. The French C.G.F. device in Fig. 11 is an 0-type carcinotron that delivers up to 2 w at 4 mm. The N-type carcinotron in Fig 11 delivers up to 20 w at 8 mm.

Magnetrons developed by Sylvania operate up to 35,000 Mc providing 100 w peak power output, and backward-wave oscillators operate up to 75,000 Mc with 3 mw output. The permanent-magnet focused oscillators can be used for both c-w and pulsed operation.

The Soviet Union is reported to have developed several microwave generating devices.[10] Spiratrons have been made that operate from 100 to 10,000 Mc, with a typical one operating between 1,450 and 3,500 Mc with a gain variation of 4 db. Tails of the gain curves extend up to 5,000 Mc and down to 1,000 Mc. Average power is 300 mw. Another tube, operating from 1,400 to 2,900 Mc, provides 2 to 3 watts peak, and with an improved collector design, achieves 10 w peak. These tubes use coupled helix attenuators in which the lossy element is a tungsten smear on a glass rod outside the coupling helix. The 10-watt tube is said to achieve 25-percent efficiency.

In forming cathodes for these tubes, an aluminum cylinder is machined to the proper shape, and then nickel is deposited on it electrolytically. The aluminum is etched out to form the cathode surface.

Backward-wave oscillators have been reported that operate from 1,000 to 4,500 Mc. An electronic tuning range of 30 to 50 percent is available by voltage adjustments.

Other Soviet microwave research includes backward-wave oscillators using bifilar helices. One uses a 6,000-Mc backward-wave oscillator helix and a backward-wave amplifier helix at 2,900 Mc coupled along a single electron beam. About 13 db gain is obtained from the backward-wave amplifier and 5 db more with the backward-wave oscillator.

In parametric beam amplifier experiments by the Russians, a 2,500-Mc backward-wave oscillator is followed by a 4,500-Mc pumping helix and then a 2,500-Mc amplifier helix. No results have been reported as of the time of writing.

modern microwaves

COMPONENTS

Refinements in ferrites and semiconductors have helped development of isolators, circulators and high-speed switches. Strip transmission-line techniques reduce physical size and line losses

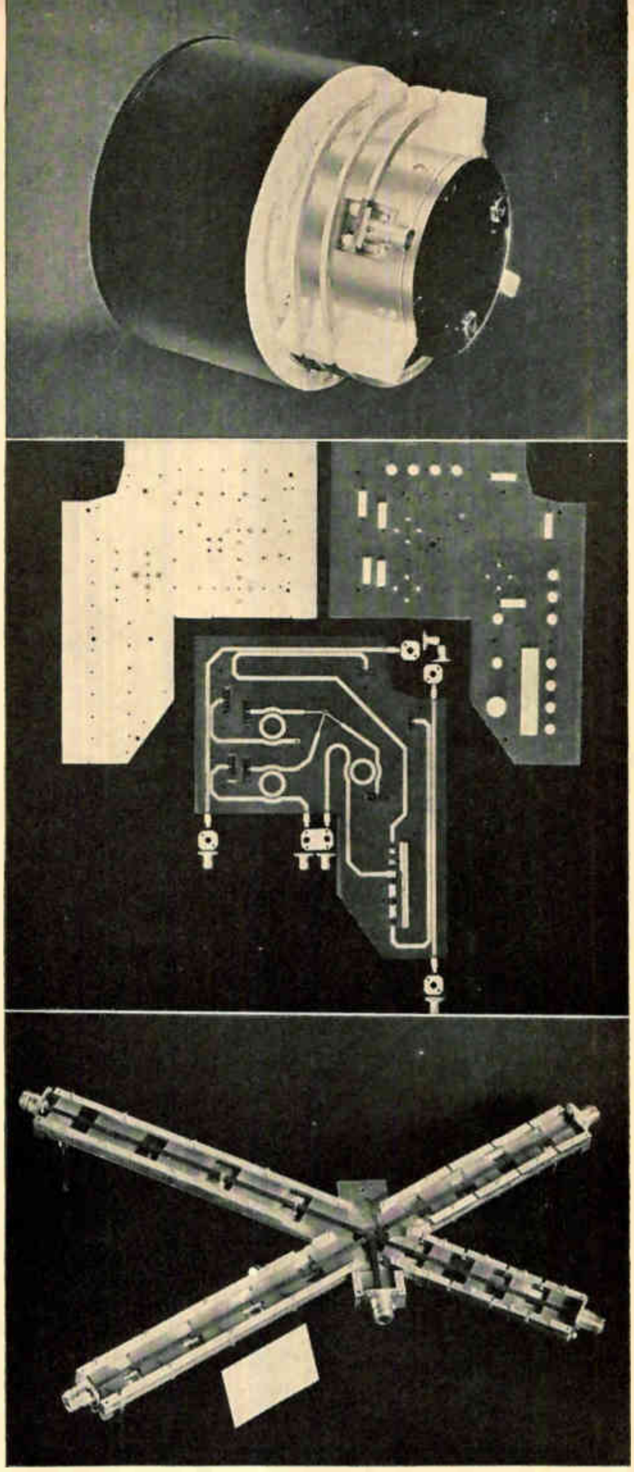


FIG. 12—Delay (top) uses low-loss ceramic as dielectric; strip device (center) combines four directional couplers, three injection filters, one power splitter and two frequency-dividing networks; strip band-pass filter (bottom) is analogous to resonant waveguide cavities

ELECTROMAGNETIC ENERGY at microwave frequencies must be controlled in a variety of ways in addition to its generation and amplification. Improvements are being made in the transmission lines that confine this energy and in the devices and materials that act on it in particular applications. Ferrites and semiconductors are two of the more important control materials available.

Ferrites are crystalline materials formed of iron oxide and one or more other oxides. By varying ingredients and processes, a wide variety of characteristics can be obtained. Electromagnetic fields can exist throughout them and can be propagated through them except under certain controllable conditions. Permeability can be controlled with an external field. Therefore, without moving parts, it is possible to control phase shift, polarization, attenuation and many other affects.

ISOLATORS—Several devices exist that permit microwave energy to be propagated in one direction but not in the opposite direction.[11] The Faraday rotation isolator relies on the characteristics of ferrites.

Radio-frequency permeability varies with intensity of magnetic field for two senses of circular polarization. At zero applied field, permeabilities for the two senses are equal. As field intensity increases, permeability for the negative wave increases, but permeability of the positive wave decreases. Exploiting the difference in velocities of the two circularly polarized waves in this unsaturated region permits design of an isolator based on Faraday rotation in a circular waveguide. Using ferrites to achieve Faraday rotation in circular waveguide is the basis of many other microwave components, such as circulators, switches, amplitude modulators and phase shifters.

As the ferrite becomes saturated, permeability for the negative sense changes little, but permeability for the positive sense reaches ferromagnetic resonance when field intensity reaches a critical value. At resonance, the loss characteristic can be used to design resonant isolators, usually in rectangular waveguides.

The region between the unsaturated state and resonance

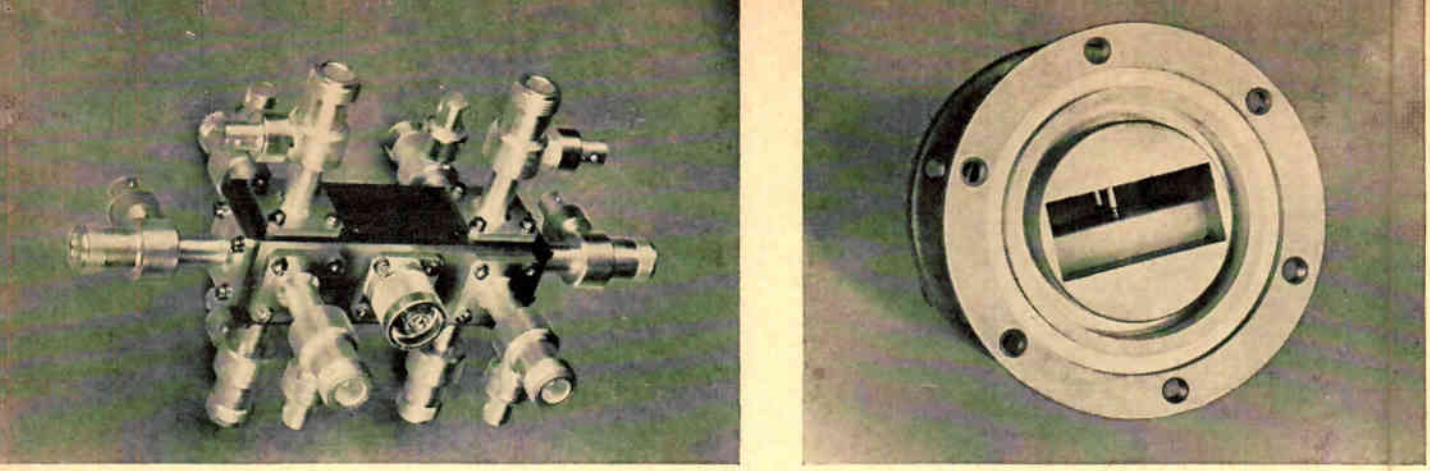


FIG. 13—Solid-state switch commutator (above), waveguide switch (above) has 0.5-db insertion loss,

can be used for field displacement and differential phase-shifting devices like circulators and duplexer-detectors.

The ferrite isolator is designed so that 90 percent of the energy passes in one direction but almost none in the opposite direction. To achieve isolation, the TE_{10} mode of rectangular waveguide is converted to the TE_{11} mode of circular waveguide. A resistance card is inserted perpendicular to the E field but does not affect it. The ferrite rotates the plane of polarization 45 degrees. Another transition converts the circular waveguide back to rectangular guide. Another resistance card is oriented perpendicular to the E field so that it does not attenuate it. However, in the reverse direction, the ferrite rotates the field 45 degrees, so that it is absorbed by the resistance card at the input end.

The Faraday rotation isolator can be made much smaller and lighter than other isolators. However, because power is absorbed by the resistance cards, average power is limited to about 5 watts. Also output polarization is elliptical rather than linear becauses of losses in the ferrite. Thus maximum isolation is limited to about 30 db.

LOADED WAVEGUIDE—Ferrite-loaded rectangular waveguide with transverse magnetic field can also provide the nonreciprocal propagation required for an isolator. The H loops in rectangular waveguide lie in planes parallel to the broad face. The longitudinal and transverse H components are in phase quadrature, with amplitude variations across the guide. There are two planes equidistant from the center line and parallel to the narrow faces in which amplitudes of the two H components are equal. Since these components are in phase quadrature, total H field is circularly polarized in a plane parallel to the broad faces at every point in the two planes.

Because the longitudinal H component has odd symmetry about the center line, the circularly polarized fields rotate in opposite directions in each of the two planes parallel to the narrow faces. A ferrite in this plane with an applied transverse magnetic field is nonreciprocal. With sufficiently large magnetic fields, there is a large difference in attenuation of waves propagated in opposite directions.

A dielectric slab in the waveguide concentrates most r-f energy to keep the point of circular polarization at or near the ferrite for a broad band of frequencies. Without the dielectric, the circularly polarized point moves with frequency and limits bandwidth. Power is limited to about 250 watts average because absorbed power appears as heat in the ferrite. Only three units are required to cover the frequency band from 3,950 to 12,400 Mc.

A C-band isolator has been designed by the microwave applications laboratory of Motorola's communications division. Isolation between magnetron and r-f energy reflected from line mismatches is at least 40 db. Maximum insertion loss is 1 db from 6,575 to 6,875 Mc. The isolator operates in ambient temperatures of 130 to 160 F.

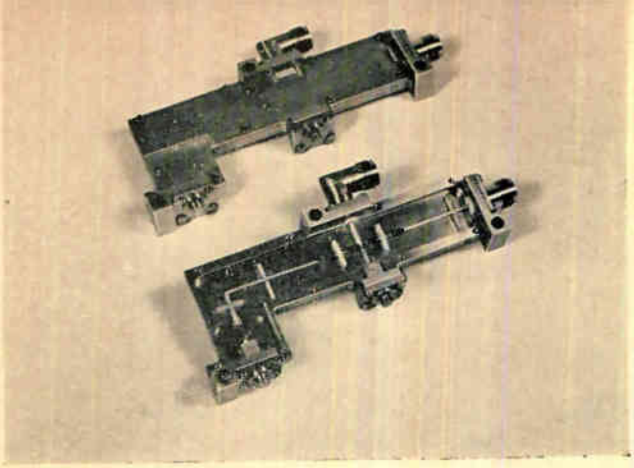
Coaxial isolators require that the TEM mode be distorted because it has no region where a circularly polarized magnetic field exists. Circular polarization is formed by inserting a dielectric asymmetrically in the guide. Coaxial isolators covering about an octave of bandwidth are used in broadband radars and countermeasures equipment. They operate up to about 11,000 Mc. Isolation is 10 to 20 db and insertion loss less than 1 db.

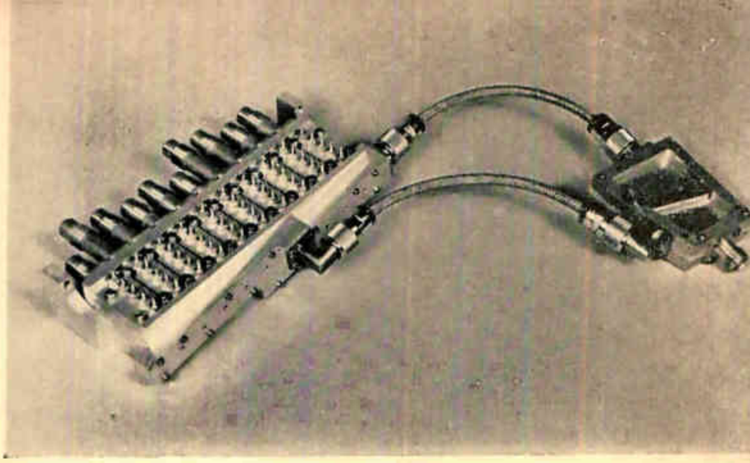
CIRCULATORS—Ferrite circulators are multiport devices that permit microwave energy to enter one port, pass through another port, but not to pass through the remaining ports. This switching function was formerly performed by gas switching tubes in earlier radars. Ferrite circulators have long life, fast switching speeds and fast recovery times. They also operate over a relatively broad band of frequencies.

In a four-port Faraday-rotation circulator, input into the first port may be rotated 45 degrees by a ferrite section so that it is directed out of the second port. Energy into the second port is directed out of the third, the third out of the fourth, and the fourth out of the first. A transmitter could be connected through an isolator to the first port, an antenna to the second, a parametric first stage amplifier for a receiver to the third, and a receiver to the fourth. Thus the same antenna can be used for transmitting and receiving.

Differential phase-shift circulators operate by virtue of the nonreciprocal phase-shift properties of ferrites. Transmitter power entering a folded magic-T is divided into two paths in identical phase. As the signals pass through the magnetized ferrite, phase of one signal is advanced 90 degrees while that of the other is unchanged. The signals can be combined additively in the antenna arm of a 3-db hybrid coupler, while they are cancelled in the load arm. Signals received by an antenna in such a system are divided in the hybrid coupler. Again one signal is advanced 90 degrees in phase while the phase of the other is unchanged. In passing through the ferrite, the first signal is advanced another 90 degrees in phase and the second is again not affected. The signals are added in the receiver arm but cancelled in the transmitter arm.

The bandpass of differential phase-shift circulators is





spdt slab line switch (above) covers 2:1 bandwidth, and bandpass filter (above) is used as frequency-filter

much greater than that of the Faraday-rotation type being limited only by the hybrid coupler. As much as 30-db isolation can be realized over a 12-percent frequency range. Because the ferrites are bonded to the waveguide walls, which are excellent heat sinks, they can handle as much as 1,800 watts average power.

The basic circulator can not be used in some applications without protecting the receiver from leakage from the transmitter arm and from power reflected from the antenna during transmission. With antenna vswr of 1.2, isolation between transmitter and receiver is 20 db. Because antenna reflections in high-power systems could cause receiver crystal burn-out, a t-r tube, ferrite switch or ferrite limiter may be required.

Ferrite circulators can be used for duplexing two transmitters with the same antenna. The signal from the first transmitter leaves the antenna port in the usual manner. Signals from the second transmitter pass into the port of the first transmitter. They are reflected by the first transmitter, which operates at a different frequency, and are then passed to the antenna.

A transmitter and receiver can be connected to either of two antennas by reversing current in the ferrite magnetizing coil. Circulators can also separate input and output signals of one-port parametric amplifiers.

OTHER FERRITE DEVICES—The Faraday rotation effect of ferrite can be used to make fast-acting microwave broadband switches. Motorola is developing such a ferrite switch for X band. It operates over a 20-percent bandwidth with rise time of about 0.5 μsec.

Amplitude modulation of microwaves can be accomplished with a device based on Faraday rotation. Alternating current applied to the magnetizing coil varies the magnetic field, modulating the microwaves in amplitude.

At modulating frequencies above a few cycles per second, metal waveguides in modulators or switches act as a shorted turn inside the coil, attenuating the magnetic field. This problem can be overcome by slotting the circular waveguide for operating at low modulating frequencies. For high modulating frequencies, thin-walled waveguide can be used.

The ferrite duplexer-detector permits simultaneous transmission and reception and also detects the received signal. A Motorola device has 250-Mc bandwidth with receiver isolation of 30 db. Insertion loss in transmit direction is 1 db and in receive direction is less than 2 db.

SEMICONDUCTOR R-F SWITCHES—With the advent of microwave computers and the increase in prf of some radar equipment, much research is underway on fast microwave switches.

One researcher[12] reports on an *n*-type point contact germanium diode that has been used to switch X-band frequencies. By placing the diode across the center of a waveguide and impressing a reverse or forward biasing voltage across it, the diode will either reflect or pass microwave energy. In the reverse-biased mode the ratio of reflected to incident power defines isolation. The same ratio with the diode forward-biased defines insertion loss. Isolation of 25 to 35 db with constant insertion losses of 1 db has been reported over a 1,000-Mc bandwidth at 1 mw incident power.

Experiments with a commercially available microwave diode indicated rapid deterioration of isolation occurred for incident microwave peak powers greater than 5 mw. However, ambient heating from 20 to 150 C affected insertion loss little, with only slight deterioration of isolation. It has been shown that decreasing the donor density of germanium allows switching up to 1 watt peak.

The pulse time constants of the diode switch were found to be a function of germanium donor density and to be from 3 to 19 nanoseconds.

Fabrication efforts in high-power switches have provided a more rugged switch, but they cannot yet be mass produced with 1-db insertion loss. Despite intensive efforts to analyze the diodes, they seem to defy accepted laws of transistor physics. If point-contact junctions of germanium and silicon are made in identical cartridges in which the equivalent circuit is known for X-band and junction impedances are measured at X-band while varying diode bias, the intrinsic impedances of the two junctions are different. Neither seems to behave above 10 Mc according to high-frequency semiconductor theory.

In the design of semiconductor microwave devices in the past, the empirical approach, in the absence of theory, has proved fruitful. Thus, the empirical approach has been used to provide a test that may allow diode switches to be mass produced with 1-db insertion loss. A relationship between microwave attenuation and 10-Mc small-signal junction resistance has been determined and has been supported by temperature and pulsing measurements. This relationship, at the same time, provides an understanding of the heating and reverse pulsing effects. It predicts switching times of 0.2 to 0.3 nanosec.

American Electronics Laboratories has developed a line of semiconductor coaxial switches that can switch frequencies between 40 and 12,000 Mc at speeds exceeding 1 nanosecond. The individual switches can be used as spst switches or as r-f modulators. The unit can also be used as an r-f chopper for c-w detection.

A number of these solid-state switches can be combined to form an assembly like that shown in Fig. 13. Design work is currently being done on combining a number of multiple throw switches to produce a solid-state fast switching commutator for a Wullenweber antenna array.

High-power versions are being made with switches that operate between d-c and 400 Mc and switch 500 watts peak power. Units operating between 400 and 4,000 Mc are capable of switching 10 watts peak power. Because these switches use solid-state diodes, switching speeds are limited only by diode recovery time. Present units will switch in less than 10 nanoseconds.

AEL is also engaged in developing waveguide switches for use from 8,000 to 18,000 Mc and with design goals of 20-db isolation or better. Present units switch in less than 10 nanoseconds.

Development work is also being carried out on units similar to the spst switch to produce phase shifters. The basic principle involved is again the change of diode impedance with bias current or voltage. The phase shifters are inherently broadband devices.

By using the elements of a spdt switch with one circuit connected to a 50-ohm dummy load, an attenuator with relatively good vswr can be achieved. This unit attenuates r-f power to the load continuously instead of in discrete steps and keeps the vswr low by feeding properly controlled power to the dummy load. The spst switch can be used as a voltage-variable solid-state attenuator. However vswr becomes high at high attenuation since attenuation is achieved through reflection not absorption. The present unit requires 20 mw of driving power into each arm. Bands of greater than 2 to 1 are practical.

The spst waveguide switch in Fig. 13 was developed by Sylvania. Typically, the switch has 0.3 to 0.5 db insertion loss with 30 to 40 db isolation when operating in reversal periods of 5 to 20 nanoseconds over 10 to 20 percent frequency bands. For 2 to 1 frequency bands, insertion loss is 1 to 2 db with 25 to 35 db isolation. A 2 to 1 bandwidth slab line switch is shown in Fig. 13.

A microwave gas switch recently developed by Sylvania has no spike leakage and less flat leakage than a conventional t-r tube. Leakage is eliminated by prefiring the device. A developmental unit performs well at 100 C.

MULTICHANNEL FILTER—The frequency-analyzing filter in Fig. 13 is a ten-channel unit made by Sylvania. Each channel is a five-pole bandpass filter aligned for a ± 1.5 db Tchebyscheff response. Adjacent channels are reactively coupled to separate input manifolds (feedlines) and minimize adjacent channel interaction. Two manifolds are combined in the 3-db directional coupler. The cavities used are the open-circuited quarter-wave coaxial type. The manifolds are of slab line construction.

DELAY DEVICE—A typical wideband, low-loss miniaturized delay device, manufactured by Ramo-Wooldridge is shown in Fig. 12. The high dielectric constant, low-loss ceramic material employed as the dielectric medium is formed into a helical configuration to obtain maximum dielectric path length for a given overall package size. The propagation mode in the dielectric medium is TEM for the two-conductor transmission lines (parallel plates) in the S-band. This line provides a time delay of 0.1 μsec for signals from 2,200 to 4,200 Mc. A replacement for over 100 ft of conventional coaxial cable is provided in a package of about 25 ounces.

For higher frequency operation, specifically the C and X bands, the same high-dielectric constant material is used with a rectangular cross section. It is silver plated on all four sides for operation as a waveguide propagating in the TE_{10} mode.

STRIP TECHNIQUES—Several companies are making studies of stripline techniques for microwave components. Strip transmission-line assemblies provide the desired circuit functions with considerable reduction in space, weight and complexity, as compared with conventional waveguide assemblies. The Ramo-Wooldridge stripline unit in Fig. 12 is ready for final assembly. It combines four directional couplers, three injection filters, one power splitter and two frequency-dividing networks. Basically, each assembly uses two metal ground planes with the conductor midway between the planes.

Functionally similar to coaxial line, stripline operates in the TEM mode and its characteristic impedance can be calculated using a parallel-plate capacitance formula modified to account for fringing capacitance.

Another Ramo-Wooldridge development resulting from the study of strip transmission-line techniques is the design of equivalent filter circuits, one of which is shown in Fig. 12. In this example, resonant sections of bar line are used to make bandpass filter. Such sections are analogous to resonant waveguide cavities at microwave frequencies or tank circuits at lower frequencies. The frequency response characteristic is a function of the length of the bars and their spacing.

TRANSMISSION LINES—With increased interest in wide-band microwave devices, transmission line components have been required to keep up with the potential needs of wide-band equipment.

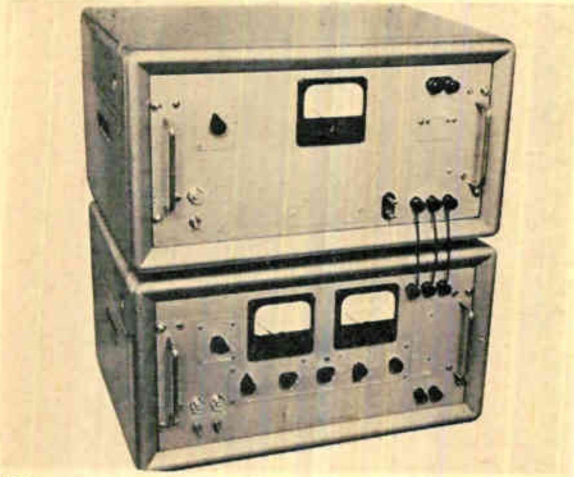
Double and single ridge waveguides are in common usage. Circular waveguides have recently been standardized for both TE_{11} and TE_{01} operating modes.

Strip transmission lines have been undergoing further development. Strip transmission line applications have been limited to those applications where space considerations are paramount and slight performance degradation can be allowed. For the bulk of high-performance microwave systems, the use of striplines is limited.

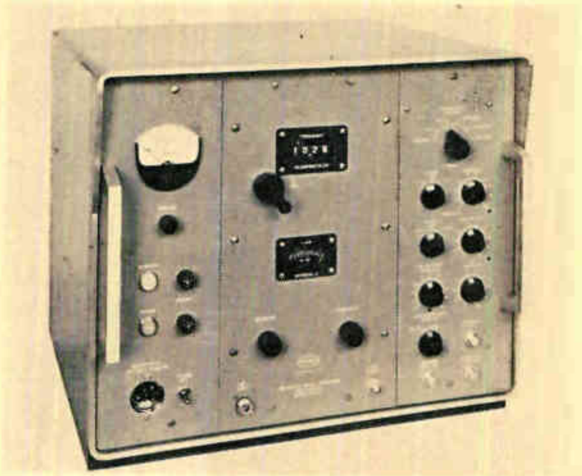
Surface wave transmission lines, hybrid EH modes in dielectric rods for the millimeter region, image lines, etc., all foretell of possible low-loss transmission line structures for the high-frequency frontiers.

Flexible waveguides can be considered essentially equivalent to rigid waveguides. New manufacturing techniques provide for seamless construction, good repeated flex life and high-temperature construction techniques. All-aluminum flexible waveguides are under development using silicon rubber jacketing to meet continuous operating conditions at 500 F.

Circular guides are being used more often, especially where very long runs are involved. A typical circular guide using corrugated construction and designed for use in a fundamental circular electric TE_{11} wave has demonstrated attenuation as low as 0.006 db per foot at X-band, thus making runs of 1,000 ft practical.

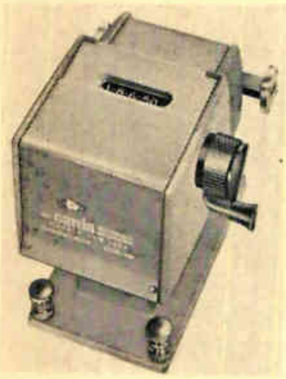


Microwave wattmeter (Weston) measures power in microwatt range



Signal generator (Polarad) is continuously tunable from 4,200 to 11,000 Mc

TEST EQUIPMENT



Direct digital readout frequency meter (Narda)

Accurate measuring instruments are required to design high-efficiency microwave systems and maintain maximum performance. A great variety of test equipment is available to provide the necessary quantitative data—such a variety, in fact, that only a few typical items can be covered here

Frequency doubler (Hewlett-Packard) covers 26,500 to 40,000 Mc with 1 mw output

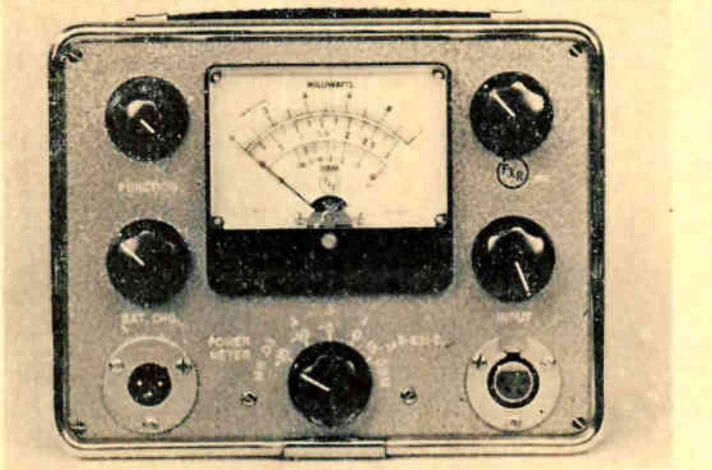
Meter operates from 90 to 500 pps to determine noise figure of radar receiver

PROGRESS in the microwave industry depends to a large extent on the ability of microwave engineers to accurately measure the parameters of the equipment undergoing design and development.

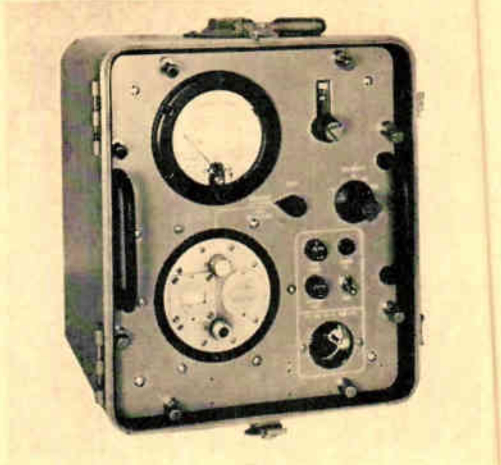
As the trend in modern microwaves is towards higher power and broader bandwidth, test equipment must follow suit. Accuracy and repeatability are of prime importance.

Due to the great variety of test equipment available for use by the microwave engineer, only a few typical examples are illustrated.

On the next page is a partial listing of microwave test equipment manufacturers compiled from ELECTRONICS Buyers' Guide. For further information about these companies, consult the Buyers' Guide.



Transistorized power meter (FXR) for 30 μw to 3 mw has thermistor temperature compensation



Dry calorimetric power meter (PRD) for 0 to 40,000 Mc at 0.5 to 50 mw

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(13) DeMornay-Bonardi, Pasadena, Calif.

TYPICAL MICROWAVE TEST EQUIPMENT MANUFACTURERS

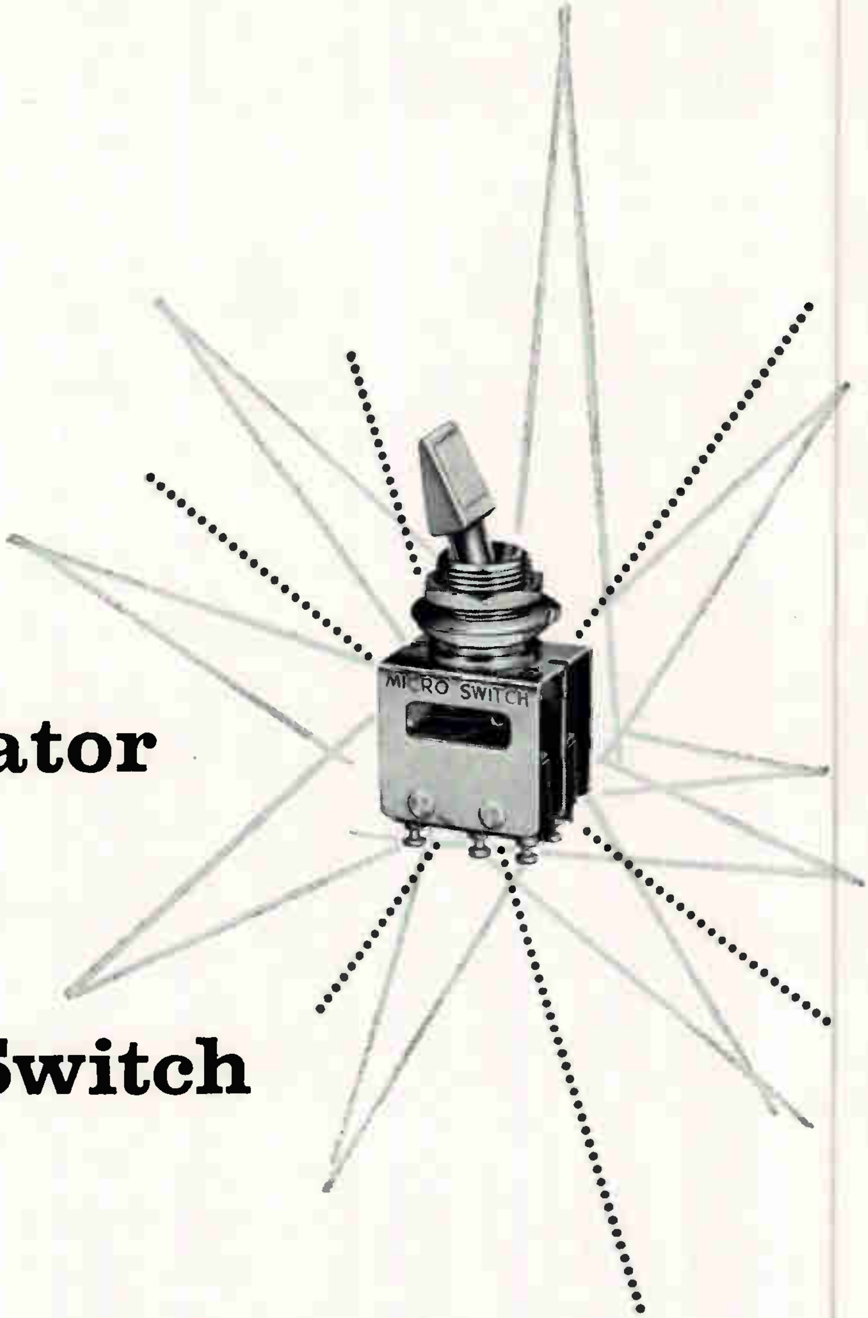
Adler Electronics, Inc.
Aerotronic Assoc.
Airborne Inst. Lab.
Aircom Inc.
Airtron, Inc.
Amerac, Inc.
American Res. & Mfg. Corp.
American Electronics Labs Inc.
AMF Co.
Anton Electronic Lab, Inc.
Applied Research Labs, Inc.
Arra Corp.
Avion Division
Bausch & Lomb Optical Co.
Bell Aircraft Corp.
Bellaire Electronics, Inc.
B & K Instruments, Inc.
Bogart Mfg. Corp.
Bomac Labs
Boonton Electronics, Corp.
Briggs Associates, Inc.
Budd Stanley Co. Inc.
Caswell Electronics Corp.
CGS Laboratories
Chemalloy Electronics Corp.
Colortone Electronics
Consolidated Electrodynamics Corp.
Control Electronics Co., Inc.
Convair Instruments
Creative Electronics Corp.
Cubic Corp.
Cutler-Hammer, Inc.
CWS Waveguide Corp.
Davies Laboratories Div.
Decade Instruments
Deeco Instruments
DeMornay-Bonardi
Diamond Antenna and Microwave Co., Inc.
Donner Scientific Co.
Dymec, Inc.
E-H Research Labs Inc.
Electro Impulses Labs
Electronic Assistance Corp.
Electronic Communications Inc.
Electronic Development Co., Inc.
Electron-Radar Products
Elk Electronic Labs Inc.
Elsin Electronics
Emerson Electric Mfg. Co.
Empire Devices Prod. Corp.
Engineering Associates
Fairchild Camera & Inst. Corp.
Federal Mfg. & Eng. Corp.
Federal Scientific Corp.
Frequency Standards Inc.
FXR Inc.
General Applied Science Labs
General Radio Co.
General Communications Co.
Gerber Scientific Inst. Co.
Gombos Co.
Hamner Electronics Co., Inc.
Haller, Raymond & Brown Inc.
Hallicrafters Co.
Hazeltine
Hermes Electronics Co.
Hewlett-Packard Co.
Interstate Electronics Corp.
Itek Corp.
Jarrell-Ash Co.
Jones Electronics Co., Inc.
JVM Microwave Co.
Kay Electric Co.
Kearfott Co., Inc.
Kellogg Switchboard & Supply
Kings Electronics
Kuss Industries Inc.
Lavoie Labs Inc.
LEL Inc.
Levinthal Electronics Prod. Inc.
Lieco, Inc.
Manson Labs Inc.
Marconi Instruments
McGraw-Edison
McMillan Industrial Corp.
Melabs
Meridian Metalcraft
Mico Inst. Co.
Microwave Associates
Microwave Dev. Labs
Millen Mfg. Co.
Missouri Research Labs Inc.
Model Eng. & Mfg. Inc.
Narda Microwave
National Spectrographic Labs Inc.
Northeast Electronics Corp.
Northeastern Eng.
Nucleonic Corp. of America
Omega Labs Inc.
Panoramic Radio Prod.
Perkin-Elmer Corp.
Philco Corp.
Photo Crystals, Inc.
Pitometer Log, Corp.
Polarad Electronics Corp.
Port Chester Inst., Corp.
PRD Co. Inc.
Premier Inst., Corp.
Probescope Co.
Radar Design Corp.
Radar Measurements Corp.
Radiation, Inc.
Radio City Prod., Co., Inc.
Raytheon Mfg. Co.
RCA
Remanco
Renupp Co.
Rohde & Schwarz
Sage Labs Inc.
Scientific Atlanta Inc.
Shielding, Inc.
Sierra Electronic Corp.
Spectrum Inst. Inc.
Sperry Microwave Electronics Co.
Standard Tel. & Cables Ltd.
Suffolk Prod., Corp.
Sunshine Scientific Inst.
Technical Measurement Corp.
Telechrome Mfg. Corp.
Telerad Mfg. Corp.
Topatron, Inc.
Trepac Corp. of America
United Shoe Machinery Corp.
Uniwave, Inc.
Van Horman Industries
Varian Associates
Victoreen Inst. Co.
Victor R-F & Microwave Co.
Vitro Corp. of America
Wac Line, Inc.
Waltham Electronics Corp.
Waveline, Inc.
Wayne-Kerr Corp.
Weinschel Eng. Co., Inc.
Westinghouse Electric Corp.
Weston Inst. Div.
Wintronics

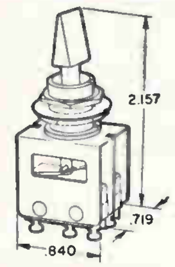
New

Tab-Indicator

Toggle

Switch





"400" SERIES TOGGLE SWITCHES
Five models available, including 2-position and 3-position types. All are rated at 5 amperes, 250 vac.

The new "400" Series Toggle Switch from MICRO SWITCH has a paddle-shaped tab which can be numbered or color-coded as an indicator. The standard model has a natural metallic finish which will maintain a fresh appearance through long and constant use. The anodized aluminum tab is also available in black or in colors.

The basic switches used are precision snap-action, long-life units, requiring a minimum of space. They conform to specifications for MIL-S-6743, with two isolated single-pole double-throw circuits. Turret terminals make wiring easy, and contact enclosures are dust-tight.

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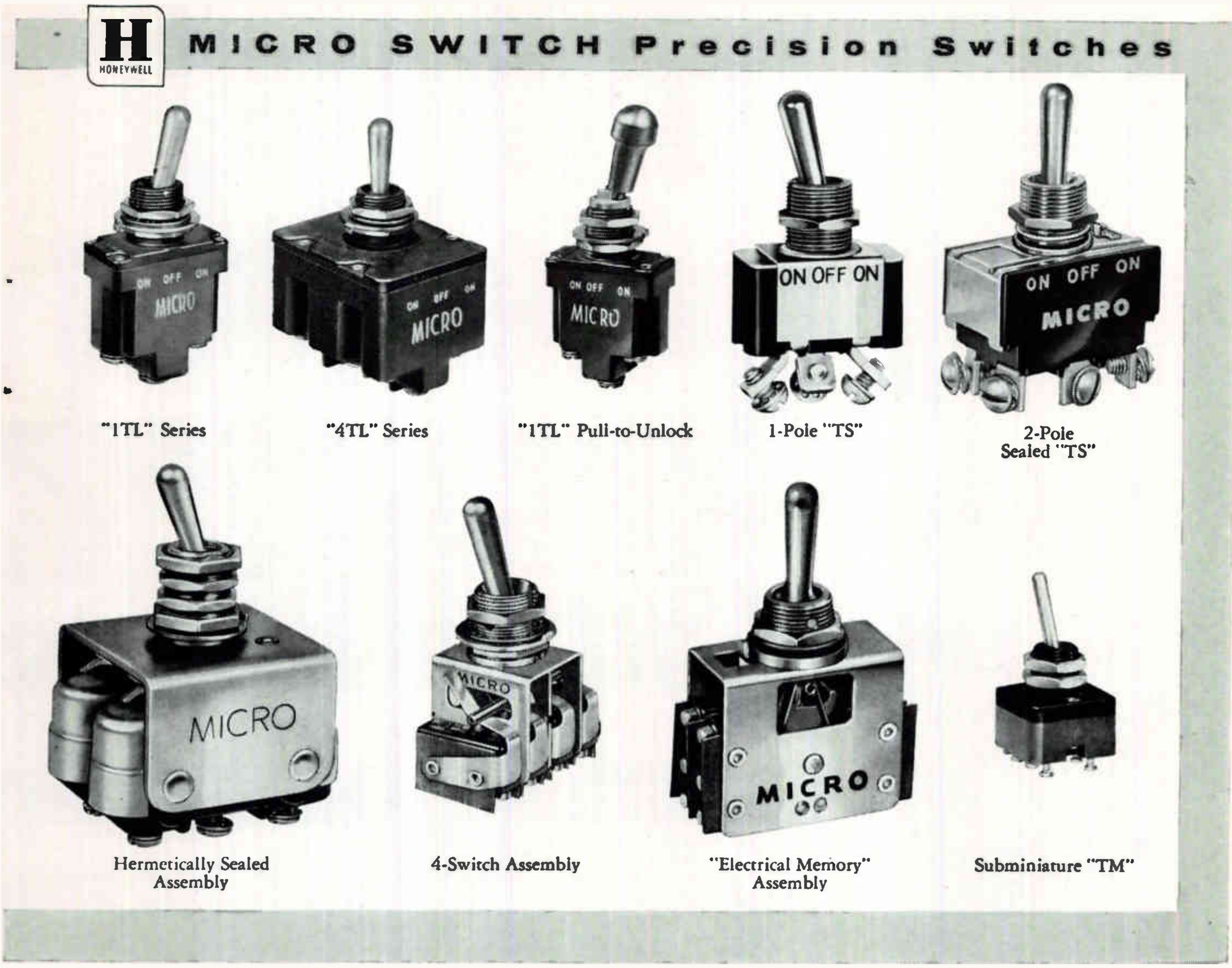

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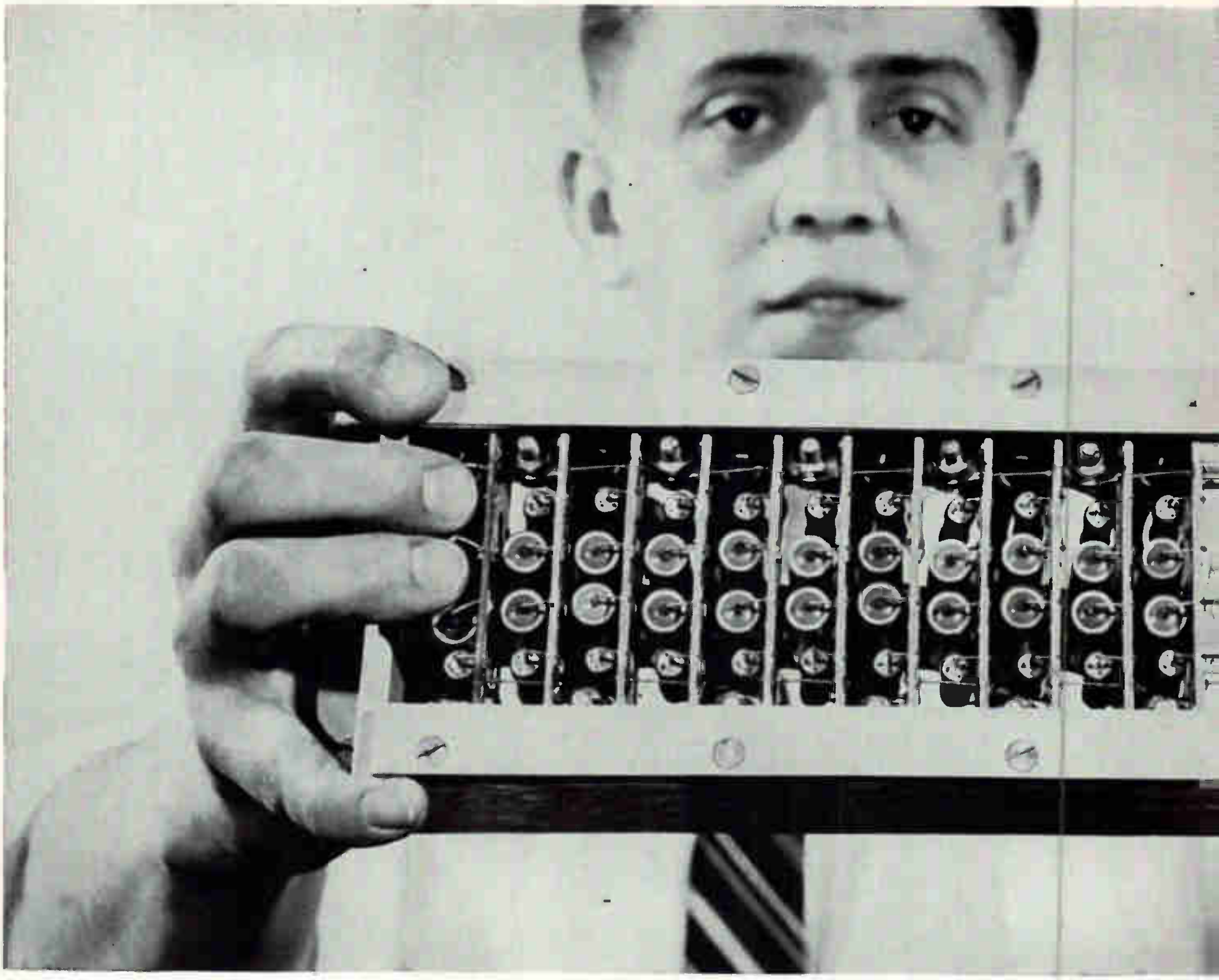

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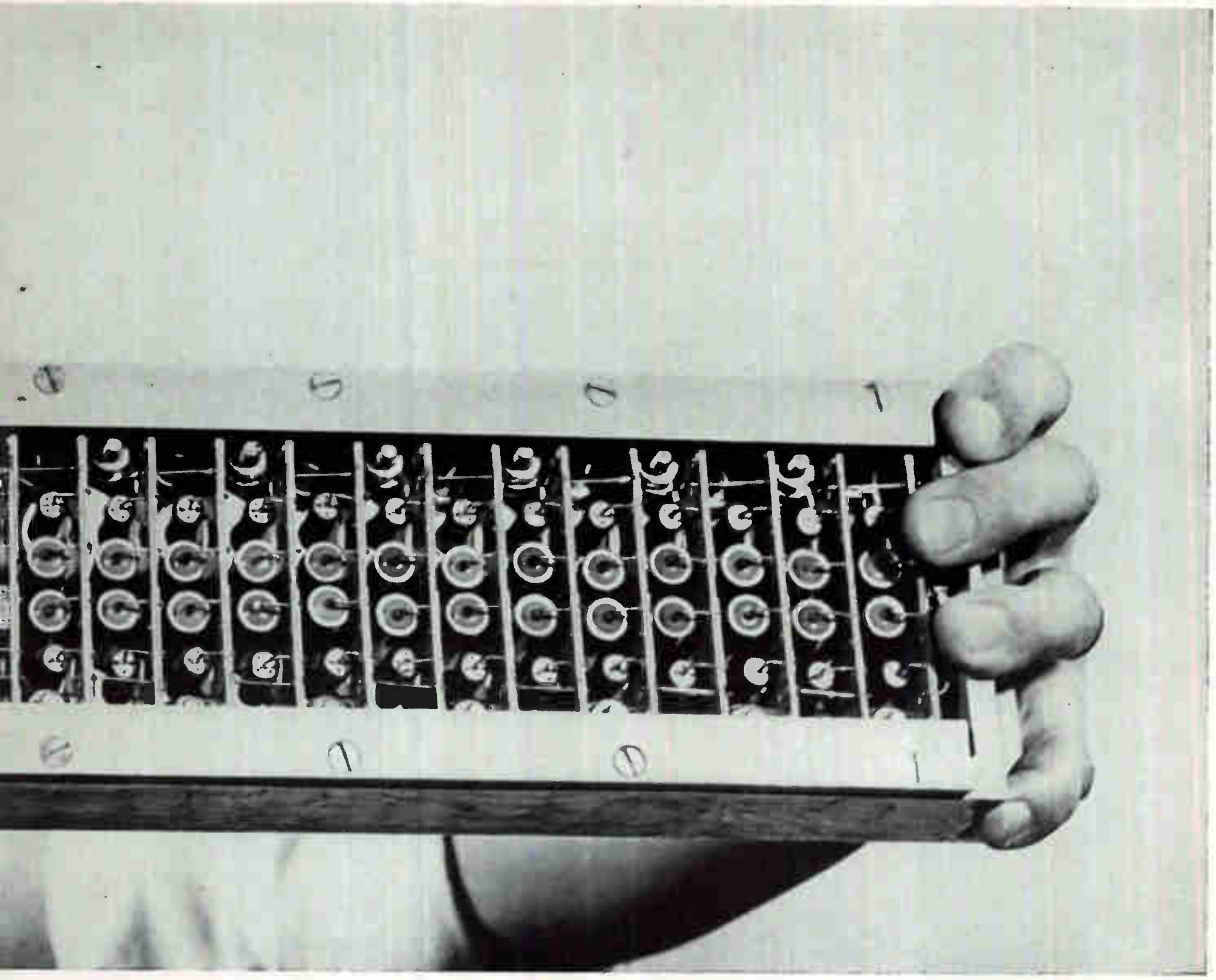

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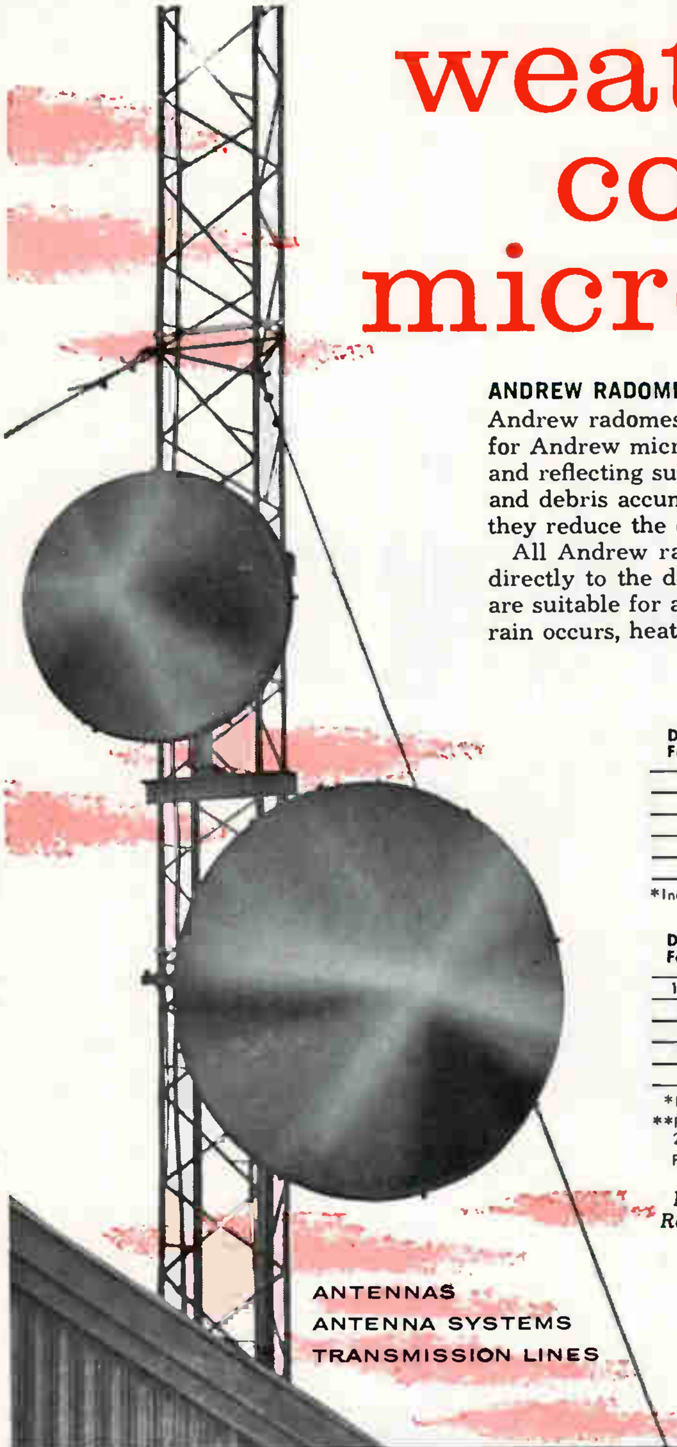

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10	R10	0.4	0.02	1,990
8	R8	0.4	0.02	1,270
6	R6	0.4	0.02	714
4	R4	0.4	0.02	320
2	R2	0.4	0.02	75

*Including antenna

HEATED RADOMES

Dia. Feet	Type No.	Attenuation @ 6 kmc. db	VSWR Contribution @ 6 kmc.	Thrust at* 30 psf. (Flats), lbs.	Power** Reqmts.
10	HR10	0.7	0.02	1,990	3,400 watts
8	HR8	0.7	0.02	1,270	2,400 watts
6	HR6	0.7	0.02	714	1,200 watts
4	HR4	0.7	0.02	320	550 watts
2	HR2	0.7	0.02	75	150 watts

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**Power requirements for HR10 and HR8 are 3 wire single phase 60 cycle 220 volts.

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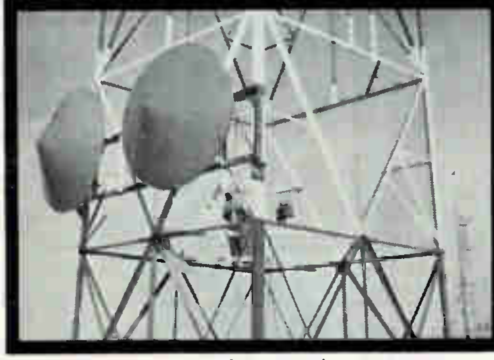
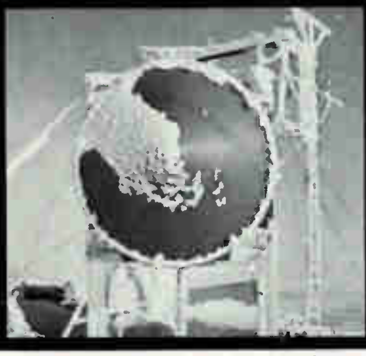
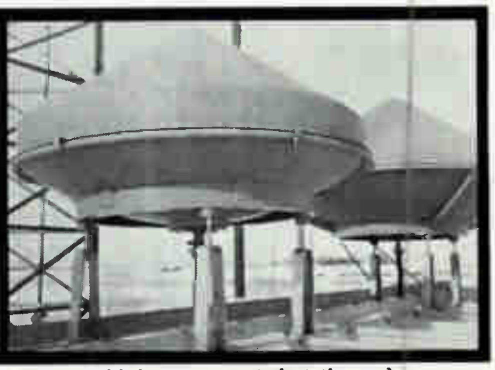


"We have paid particular attention to antennas during high wind conditions of gusts up to 40-60 m.p.h. It is very obvious that these radomes quite materially reduce the wind loading on the parabolas—due to their shape factor." *Washington State Patrol, Kennewick, Washington*



"We have had up to four inches of ice on the radome with practically no reduction of antenna effectiveness." *KLIX-AM-TV, The KLIX Corporation, Twin Falls, Idaho*



"Our field forces report that the radomes produce a signal loss of less than 1 db per antenna. Several radomes were removed and antennas inspected following a heavy snow storm and no snow or ice was found in the antennas." *Natural Gas Pipeline Company of America*

Uses of Sonar in Oceanography

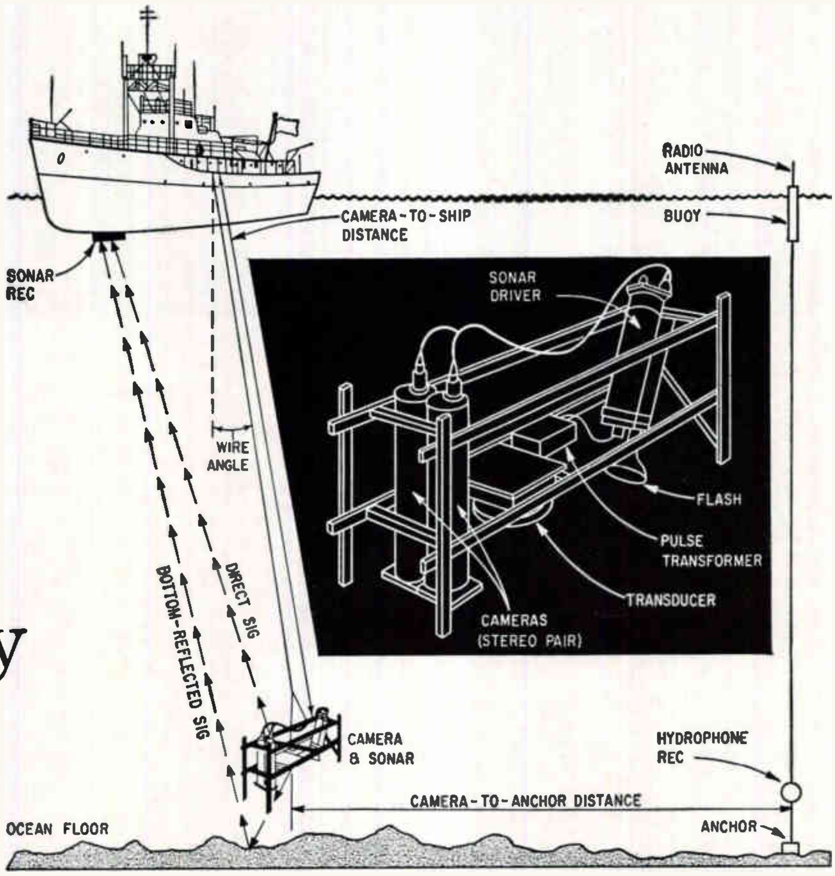


FIG. 1—Underwater-camera photography system. Two buoys and two hydrophone receivers (only one set is shown) help find position of ship

Scientists position underwater cameras and take samples of sea water and bottom sediments with the help of sonar in placing gear

By HAROLD E. EDGERTON,
Professor of Electrical Measurements, M. I. T., Cambridge, Mass.

IN SUBOCEAN photography, lowering the camera to a position just above the sea floor is a critical operation. Once the camera has been lowered, a high degree of technical proficiency and teamwork is needed to hold the camera at a constant distance from the bottom for several hours despite ship drift and roll, changing bottom topography and a host of complicating conditions.

Deep-sea photography seems to have been started in 1893 by Boutan off the Mediterranean coast of France.[1] By 1946, scientists were exhibiting considerable interest in the ocean floor.[2]

In early attempts at underwater photography made at shallow depths, cameras were lowered until a slackening of the camera cable indicated that the camera had bottomed. The camera was then raised just above the ocean floor to make an exposure. One of the disadvantages of this rather elementary technique was that the effects of ship drift and underwater currents on the cable tension made it difficult for the operator to judge the camera-to-bottom distance correctly. At greater depths, it was almost impossible to detect a change in tension because of the great weight of the suspended cable.

A much more sophisticated slack-wire technique requires positive contact with the bottom. Here, sensitive tensional changes in the wire lowering rope are detected by a specially constructed mechanical-electrical force gage which converts the tensional changes into electrical signals.[3]

One sonar-pinger system employs

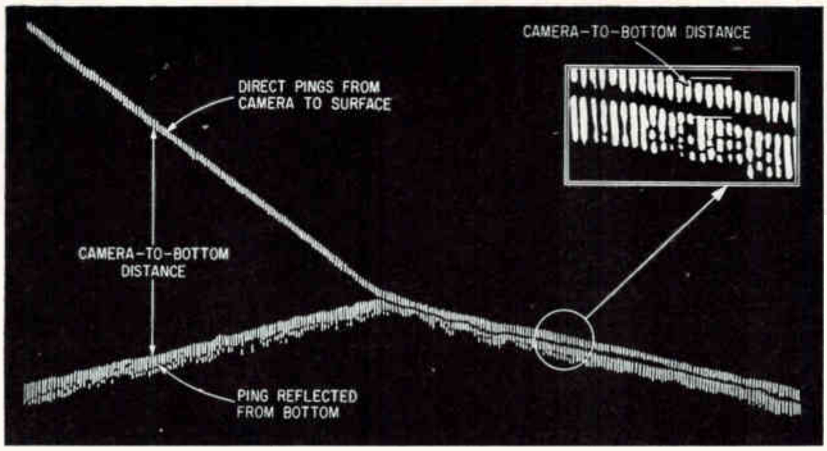


FIG. 2—Convergence of recorder-pen tracks indicates camera's approach to sea bottom

a bottoming switch suspended below the camera which works in conjunction with the sonar pinger to send sound signals to the surface.[4] The sonar which is attached to the camera can be operated continuously at a slow pulse rate until shorted out by the bottoming switch. Absence of a ping indicates to the winch operator that the camera has bottomed. Using this method the operator has an opportunity to hear his subject until the ocean floor is reached.[5] In other pinger systems,[6] the bottom switch is arranged to speed up the ping rate when the bottom is touched.

The sonar pinger equipment to be described is part of a complete battery-operated underwater photo system capable of withstanding the crushing pressure (17,000 psi) encountered at 37,500 ft, the greatest known sea depth. The complete system includes a special pair of cameras, a pulse transformer, a sonar transducer and driver, and an electronic flash source as shown in Fig. 1 (see inset). Using the sonar pinger, the camera can be positioned at any distance from the bottom with a precision of approximately one meter. Physical contact with the bottom is eliminated. This is a decided advantage since camera bottoming may foul the lens, raise an impenetrable cloud of mud and silt, or frighten away sea creatures on the sea floor. Several hundred photographs may be taken automatically over a 100-minute period at 12 to 15-sec intervals.[7]

The pulse-sound transducer generates short bursts of high-frequency energy (12 Kc) at one-second intervals. The transmitted pulse or ping travels directly to the surface and is also reflected from the bottom. The reflected signal arrives at the surface sometime after the direct signal and the time difference, which is a measure of the camera-to-bottom distance (D), can be derived from $D = vT/2$ where D is the camera-to-bottom distance (ft), v is 5,000 ft/sec (approximate velocity of sound in sea water), and T is the time in seconds between pulses received at the surface.

Any standard sonar receiver or cathode-ray-tube display system can be used to pick up and display the pings. For continuous indication and position monitoring it is advantageous to use a recorder to write a mark each time a direct or reflected signal is received. These marks, separated by a distance proportional to the difference between time of arrival of the direct and reflected signals, are a measure of the camera-to-bottom distance (Fig. 2).

The sonar pinger system consists of a driver, a pulse transformer, and a transducer. The driver is housed in a pressure-resistant casing (as are the underwater camera and light source). It is powered by a rechargeable silver-zinc battery capable of providing 16 hours of operation. A transistor power supply generates a high d-c voltage which charges a 4-μf capacitor as shown in Fig. 3. The contacts of d-c timer *MOT* close once each second to fire strobotron V_1 which discharges this capacitor through the primary of pulse transformer T_1.

Transformer T_1 has a 35-to-1 turns ratio so that an 800-v input pulse, caused by capacitor discharge current through the primary, generates an 8-Kv pulse in the secondary. The secondary circuit includes a set of ADP crystals mounted in the transducer. The pulse transformer is located external to and some distance from both driver and transducer to minimize magnetic coupling with the casings of these units. The transformer is oil-immersed in a thick-walled lucite tube, closed at each end by a rubber stopper.

Crystals of the transducer are housed in an oil-filled aluminum casing with a rubber cover. The secondary of the pulse transformer and the transducer crystals form a tuned circuit which oscillates at a frequency of about 6 Kc for a period of about ½ msec. The 12-Kc vibration of the crystals produces the sonar ping that is transmitted downward to the water through the oil and the rubber diaphragm. The ½-msec period provides adequate resolution for positioning the camera within three feet of the bottom. Since only a small fraction of the energy is reflected from the bottom, a direct signal transmitted through the top of the unit would normally be about ten times stronger than the reflected signal. Hence the direct signal is attenuated by a sheet of phenolic and a ½-inch aluminum plate, both built into the transducer housing; thus both signals are received at about the same intensity.

Two types of systems are being produced; one for depths to 6,500 ft, and the other for depths to 37,500 ft. Except for the casing of the driver unit, these two systems are identical.

When the sea floor is being photographed during mapping operations, it is necessary to pinpoint the geographical location for each frame exposed by the camera despite ship drift and deep water currents. The Woods Hole Oceanographic Institution is developing and testing a technique for determining this information, using the system shown in Fig. 1.

Anchored by taut cable to the ocean bottom are two accurately-located buoys, each containing a sonar receiver and radio transmitter. Sonar pings arriving at the two submerged receivers are retransmitted via radio to the ship with essentially no delay. Thus, a given ping produces four signals at the ship. The first signal is that received directly through the water. The second is the signal reflected from the bottom. The third and fourth are those radioed from the nearest and farthest buoy, respectively. The distance between ship and camera is read from a winch meter which indicates the amount of camera cable that has been payed out. This distance and the distance derived from the time difference between the first and third signals provide the camera-to-buoy distance of the nearest buoy; that is, from $T = (B - A)/v$, $B = vT + A$, where A is camera-to-ship distance, B is camera-to-buoy distance, v is velocity of sound in water, and T is time difference between first and third signals.

By simple geometry, the position of the camera can then be accurately determined with respect to each of the buoys whose geographical position is already known.

As one might expect, strong underwater currents and surface winds can often combine causing the wire to loop away from the ship. Thus, even at a stabilized height from the bottom, the camera may not rest directly beneath the ship. For this reason, locating the camera itself is preferred to locating the ship. For accurate mapping it is always best to keep the wire angle, angle between the vertical and the suspended cable, as small as possible. This may be done by maneuvering the ship into the surface direction taken by the wire. The wire angle can also be reduced by weighting the camera heavily to minimize the effects of currents.

It may often be desirable to relate each picture to the camera's position at the time of exposure. (Exposing 500 frames takes 1⅝ hours, during which time considerable drift may take place.) The pinger can be interconnected with the camera so that one ping is omitted after each exposure. Thus, the absence of a ping from its normal position on the recorder track indicates a camera exposure. The position of the camera at the time of exposure can be derived from the ping record. Each exposure includes a view of an accurate clock mounted on a data board within the camera casing.[8] The clock reading on each frame can be easily correlated with the time reference of the recorder marks, from which the position of the camera is also derived.

A Nansen bottle is an ingeniously stoppered device used to obtain a sample of sea water at a specific height from the bottom. Samples at different heights are obtained by use of a number of bottles secured to a single line. Positioning the bottle nearest the ocean floor is similar to camera positioning. Here, the problem is to suspend the lowermost bottle of the string just above the bottom without imbedding it in mud. If the cable does bottom there is some likelihood that it will coil and become fouled. However, when Nansen bottles are employed in a system which includes the sonar pinger, accurate determination of the height of the deepest bottle off the bottom can be made. This ensures that the length of cable payed out and the known spacings between bottles accurately fix the sampling depth of each bottle.

The deepest bottle and the sonar pinger are both suspended at the end of a cable, making it a simple problem to lower just enough line to position this bottle at any distance from the bottom. When the underwater camera is used in this arrangement, not only is the information yield increased, but the camera acts as a stabilizing weight on the line. Graham reports that in the Red Sea in 1958 the sonar pinger was used to position Nansen bottles in hydrographic stations some exact distance from the bottom. A camera and sonar were used in this way from the USNS CHAIN as a bottom weight for experiments conducted during the summer of 1959 in the Atlantic and Mediterranean. Some 16 camera lowerings were made by sonar during the cruise.

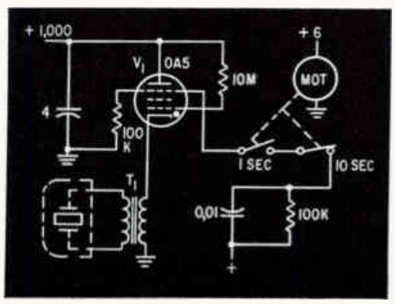


FIG. 3—Closing of 1-sec switch triggers V_1, whose breakdown pulses the crystal transducer

The sonar pinger has also been used by Woods Hole Oceanographic Institution for making detailed topographical surveys of the ocean floor. An echo sounder mounted on the hull of the ship has inadequate resolution capabilities because the transmitter is thousands of feet above the bottom. Even a narrow transmission beam spans a wide area of the bottom. By use of a sonar pinger suspended about 30 feet from the bottom, the detailed contour of the bottom with respect to the pinger can be determined by recording the direct and bottom-reflected pings.

Another application of the pinger is in assisting the operation of a bottom corer, a device which takes samples of strata from the ocean floor.

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CONVERTING OSCILLOSCOPES For Fast Rise Time Sampling

This attachment for conventional oscilloscopes can resolve pulse rise times of 1/3 nanosecond with repetition rates of up to 50 Kc

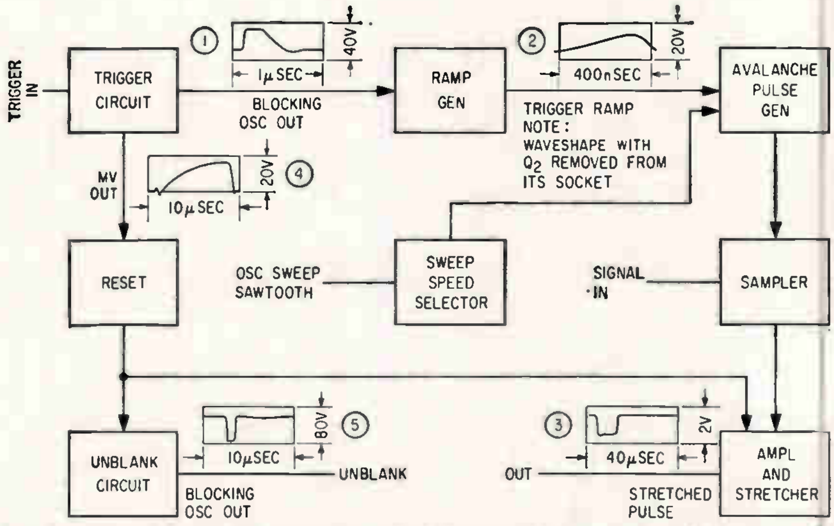

FIG. 1—Sampling oscilloscope attachment uses transistors operating in the avalanche mode and efficient pulse-shaping networks

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Electronic Data Processing Div.,
Industrial Electronic Products,
Radio Corporation of America,
Camden, N. J.

INCREASED EMPHASIS on high-speed digital equipment and the need for observing broad spectrum phenomena have resulted in an acute need for improving the art of oscilloscopic display. In response to this need, several new systems have been developed—each with its peculiar advantages and disadvantages.

One such system is the traveling-wave tube oscilloscope which features a deflection plate structure of the traveling-wave type. This device reduces the effective transient time of deflection by an order of magnitude. It also increases the deflection sensitivity by a similar amount, although signals of several volts amplitude are still required for useful observation. A different approach to the problem has resulted in the sampling oscilloscope attachment described in this article.

The sampling oscilloscope attachment offers sampling techniques which effectively stretch the time scale of the signal and allow conventional oscilloscope display of repetitive waveforms. This is achieved by taking samples of the instantaneous amplitude of the signals at different instants of time and reconstructing the original shape by peak detecting the amplified and stretched samples. This method offers the advantages of high sensitivity and relative simplicity, since available oscilloscopes can be used as part of the system.

The sampling attachment for conventional oscilloscopes permits resolving pulse rise times of 1/3 nanosecond with repetition rates of up to 50 Kc. The sampling circuitry is completely transistorized and contains its own power supply. The delay necessary between signal and trigger is 30 nanoseconds, and trigger sensitivity is one volt at a pulse width of two nanoseconds. The attachment has a calibrated time scale and usable sensitivity greater than 0.03 v/cm. Figure 1 is a block diagram of the system.

Sampling techniques for displaying broad spectrum repetitive waveforms have been described in several publications. One type of sampling oscilloscope was described and built by R. Sugarman[1]. The transistorized approach to the problem was first suggested by G. B. B. Chaplin, who used a transistor operated in the avalanche mode to obtain rise times of the order of one nanosecond with a conventional oscilloscope.[2]

*Now at David Sarnoff Research Center, RCA Laboratories Div., Princeton, N. J.

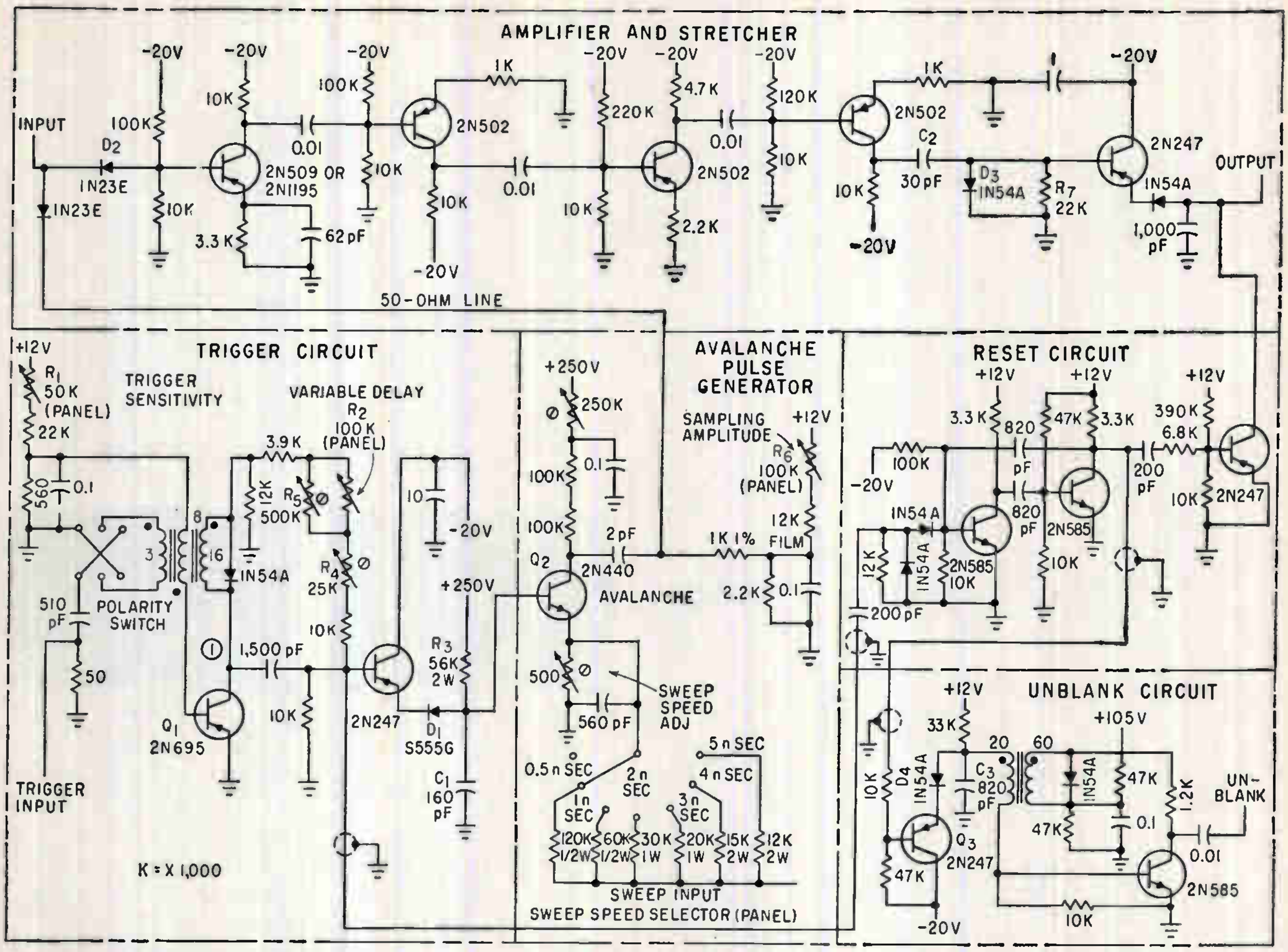

FIG. 2—Attachment samples instantaneous amplitude of signals at different instants of time and reconstructs original shape by peak detecting the amplified and stretched samples

Following lines suggested by these early techniques, work was started to develop a faster unit as part of, and for use in, the instrumentation work for an experimental, high-speed, data processing system. However, it was to be useful for all applications requiring the viewing of fast rise times.

Performance of the sampling attachment relies on the ability to generate accurately timed pulses of short duration, which are used to obtain almost instantaneous samples of the signal amplitude. The width of the sampling pulse and the accuracy of its timing are the determining factors in the resolution obtainable. Transistors operating in the avalanche mode are used together with efficient pulse-shaping networks to obtain pulses with widths of the order of ⅓ nanosecond. The operation of the sampling attachment requires that the waveform to be viewed be repetitive and that the signal to be used as a trigger be synchronous with the input waveform.

The trigger pulse will occur prior to the pulse being viewed by an interval of time fixed by the external delay lines. The trigger blocking oscillator produces a pulse which turns off diode D_1 (see Fig. 2). This starts the ramp that triggers the avalanche transistor, producing a voltage step which is differentiated and clipped to form the sampling pulse. The sum of the instantaneous input signal (Fig. 3A) and the coincident sampling pulse (Fig. 3B) is applied to the sampler diode whose clipping level is set slightly above that of the maximum input signal amplitude as shown in the combined waveshape of Fig. 3C. The output is a series of pulses, shown in Fig. 3D, which are amplitude modulated by the input signal in a stretched time scale.

The time shift of the sampling pulse relative to the input signal is accomplished by applying a slow ramp (derived from the oscilloscope sweep sawtooth) to the emitter of the avalanche transistor. Thus, the firing is delayed by a small interval each successive time by the increment in voltage; that is, the magnitude of this interval is controlled by the slope of the slow ramp, which in turn determines the effective sampling sweep speed; when the sawtooth wave returns to the zero level the sampling pulse returns to its starting position and the process is repeated. The output of the sampler is amplified, stretched and displayed on the cathode-ray tube of the oscilloscope.

The sampling process entails a time transformation which is vital to the operation of the system. This time stretching which, in a visual sense, is equivalent to slow-motion photography should be kept in

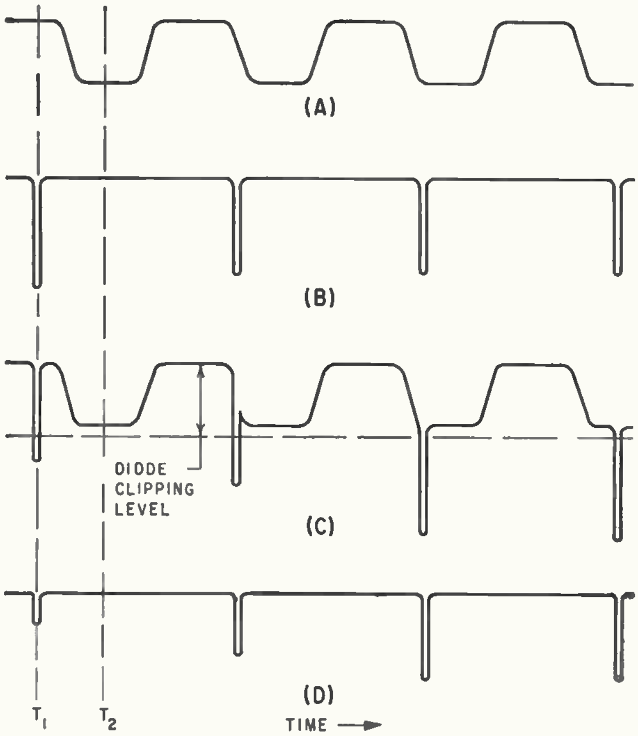

FIG. 3—Input signal (A) and sampling pulse (B) are summed (C) and applied to sampler diode. Sampler output is shown in (D)

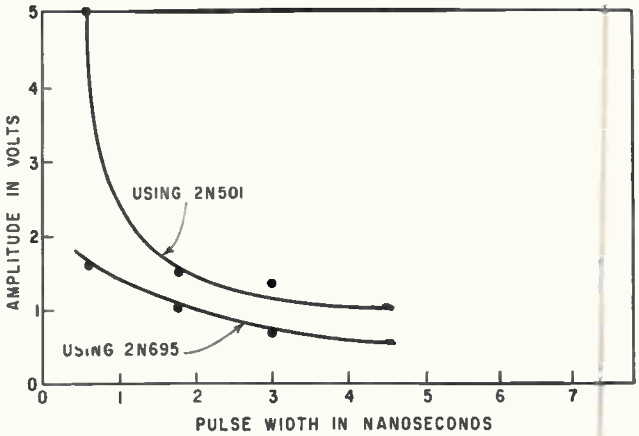

FIG. 4—Trigger sensitivity curves for 2N695 and 2N501 transistor

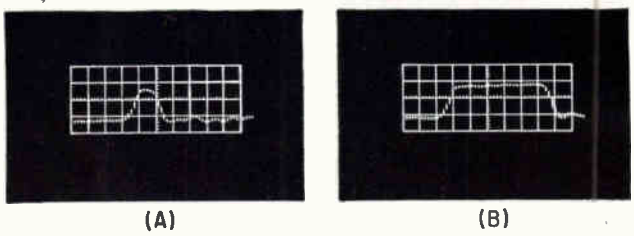

FIG. 5—One-nanosecond pulse is shown in (A) and 3.3-nanosecond pulse in (B). Horizontal scale is 0.5 nsec/div and vertical is 100 mv/div

mind so as not to confuse real time and sampled time (that is, a long interval of real time may be used to display a very short portion of sampled waveform).

Since the slow sawtooth wave that produces the progressive delay of the sampling pulse is derived from the oscilloscope sweep, the horizontal displacement of the spot on the crt and the displacement of the sampling pulse in reference to the input signal are linearly related.

In other words, if a certain horizontal distance d on the oscilloscope screen corresponding to a time interval t is scanned by the sampling pulse, the following will hold true: $t = Kd$ seconds, where K is a constant determined by the slope of the fast-triggering ramp and the attenuation ratio of the sweep-speed selector; that is, if d is measured in cm and t in nanoseconds, K becomes the sampling sweep speed in nanoseconds/cm. It is noted that the oscilloscope sweep speed does not appear in the formula; this setting only determines the number of samples taken along a unit distance on the screen.

The circuits comprising the sampling attachment are the trigger circuit, the delay mechanisms, the pulse generator, the sampling circuit, the low-frequency amplifier, the reset and unblanking circuits, and the power supply.

The trigger circuit consists of a conventional blocking oscillator with an emitter follower isolation stage. The blocking oscillator produces a pulse of 15-volt amplitude and 0.4-microsecond duration (waveform 1 on Fig. 1). Potentiometer R_1 of Fig. 2 controls the trigger sensitivity by varying the back bias on transistor Q_1. Curves of the trigger sensitivity are shown in Fig. 4 for either a 2N501 or a 2N695 transistor in the Q_1 stage. The choice of transistor depends clearly on the narrowest pulse requirement.

The pulse from the blocking oscillator turns off the diode, D_1, which clamped the base of avalanche transistor Q_2 at a negative voltage selected by the variable-delay potentiometer R_2. This initiates a trigger ramp (waveform 2 on Fig. 1) as capacitor C_1 is charged through resistor R_3. A very linear ramp (except for the first 10 nanoseconds) will result, since only a small portion of the total R-C charge curve is used.

The initial nonlinearity is due to the finite diode turn-off time and feedthrough of the leading edge from the blocking oscillator output. When the ramp voltage reaches the emitter voltage, the transistor fires. (This is not necessarily true in all transistors since the firing can occur when the base is still back-biased with respect to the emitter. However, this is not important as long as the firing point is consistent). The time that it takes the ramp to reach this level is determined by the R-C time constant and the setting of the manual-delay selector, R_2. This potentiometer simply varies the d-c voltage at which the ramp gets started between the limits set by R_4 and R_5. At the minimum setting of the manual selector, the total delay necessary between the sampled signal and trigger is set at approximately 30 nanoseconds to avoid using the nonlinear portion of the ramp. The emitter follower arrangement of the 2N247 transistor is used as a d-c clamp. The emitter diode of the transistor has little effect on the fast leading edge of the blocking oscillator pulse, which turns off the fast-switching S555G diode.

The pulse generator is composed of the triggered avalanche transistor and the pulse shaping network. The point at which the avalanche step occurs is controlled by the triggering ramp and the delaying ramp (derived from the scope sweep), which is fed in at the transistor emitter. The slope of the emitter ramp determines the progressive delay between samples and, therefore, the sampling sweep speed. This slope is easily controlled by means of a voltage divider composed of the emitter resistance and the adjustable sweep selector resistance.

Sweep speed calibration is obtained by means of the 500-ohm potentiometer in the emitter. In a typical transistor, the avalanche step would have an amplitude of 35 volts and a duration of 1.5 nanoseconds. It was found that 10 percent of the commercially available 2N440 units are suitable for this job and the yield was found to be greater in newer commercially available types like the GT1188 If optimum rise time is not required, a larger percentage can be used.

The pulse shaping of this step is done by one stage of differentiation and one stage of clipping with the 1N23E diode. The clipping level can be varied by means of potentiometer R_6. Use of a small capacitor in the differentiator circuit keeps the loading on the avalanche transistor to a minimum, thus optimizing the switching time for the given unit. This makes it possible to obtain an extremely narrow pulse with just one stage of differentiation.

The sampling circuit is composed of back-biased diode D_2 working into the base of the first stage of the low-frequency amplifier. The sampling and clipping diodes are both housed in a specially made right-angle coaxial holder. Type 1N23E diodes were chosen because of their performance, although less expensive microwave or fast switching diodes may be used where optimum rise time and signal-to-noise ratio are not required.

The first two stages of the low-frequency amplifier use high-frequency transistors in order to gain sensitivity and signal-to-noise ratio. The extremely narrow sampling pulse would be considerably attenuated by a lower-frequency transistor. The last three stages of the amplifier serve to stretch the pulse and amplify it somewhat further (waveform 3 in Fig. 1). The clamping diode D_3 sets the base line of the pulses at close to zero d-c voltage. The amplifier is capable of more gain than is necessary with the present number of stages. Sufficient stabilized gain can be obtained with four stages, but transformer coupling will then be necessary to maintain the proper polarity. Capacitor C_2 and resistor R_7 act as a high-pass filter to avoid the additional burden of low-frequency amplifier noise.

In the reset and unblanking circuits a monostable multivibrator, when triggered by the pulse from the trigger circuit blocking oscillator, produces a pulse eight microseconds wide (waveform 4 in Fig. 1). The pulse is differentiated and its trailing edge turns on the reset transistor so that the pulse-stretching capacitor is discharged, readying the system for another sample.

The unblanking blocking oscillator is triggered on after a five-microsecond delay and produces a pulse 1.5 microseconds wide (waveform 5 on Fig. 1) to be applied to the cathode of the crt in the oscilloscope. This unblanks the signal after the initial transients have disappeared, thus reducing the spot smear. Also, because of the short duration of the unblank pulse, the tilt in the displayed part of the stretched pulse is negligible.

The five-microsecond delay is obtained as follows. The positive pulse from the monostable multivibrator turns off Q_3 and D_4, which in turn allows C_3 to charge towards the 12-volt supply voltage. When the capacitor voltage gets high enough to forward-bias the blocking oscillator base, the unblank pulse is generated. The diode in the collector prevents ringing and lengthens the recovery time so as not to obtain multiple firings.

When the monostable multivibrator returns to its quiescent state, the base of Q_3 becomes negative once again and quickly clamps C_3 to this negative voltage. This system results in a delay which is independent of repetition rates in the range of interest. Transistor Q_3 also acts as a buffer stage to prevent the large blocking oscillator signal from feeding back into the monostable multivibrator and resetting it prematurely.

The power supply is of standard design and provides +250 volts at 6 ma, +12 volts at 5 ma and −20 volts at 12 ma. The ripple is less than 2 mv for the low voltages and less than 10 mv for the 250 volts.

The sampling attachment is capable of resolving rise times of ⅓ nanosecond. Figure 6 shows narrow pulses, generated by a mercury relay generator, as displayed on a conventional 10-Mc oscilloscope with the aid of a sampling attachment. Some of the faster units have 3-db bandwidths as high as 2 Gc and rise time capabilities which could not yet be tested because of lack of appropriate pulse-generating equipment.

The sensitivity of the units is limited only by the noise generated in the avalanche process. Usable sensitivities ranging between 10 mv/cm and 30 mv/cm have been obtained in the units constructed. Much improvement in signal-to-noise ratio can be obtained by using to advantage the frequency transformation properties of the system by means of filter detection. The sweep linearity is better than five percent and the amplitude distortion is less than five percent in most units, provided the signal amplitude is kept within the proper limits.

The writer thanks M. D. Nelson of RCA Camden and G. B. Herzog of the RCA David Sarnoff Laboratories for many fruitful discussions held during the development of the unit.

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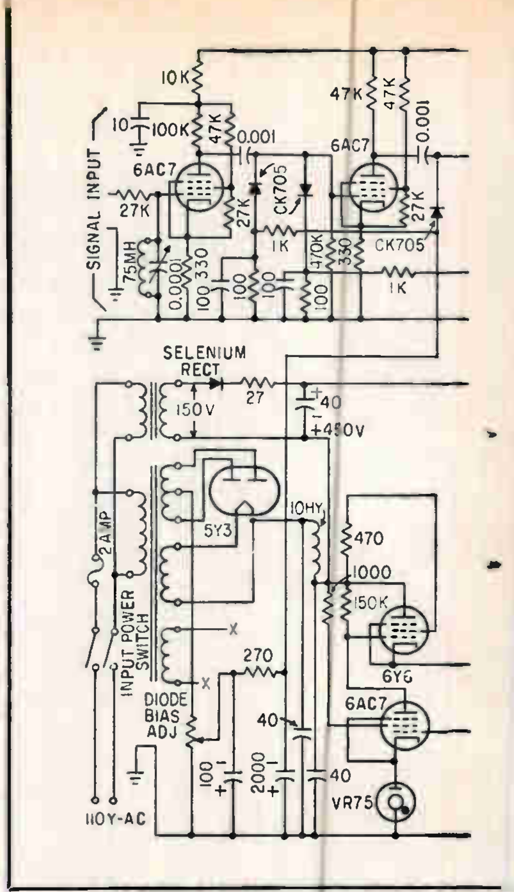
Precise Measurement Of Wow and Flutter



Equipment is used to test tape recorder performance. A 40-Kc carrier signal is first recorded on the tape recorder under test, and during playback on the same machine a discriminator circuit measures carrier frequency deviation caused by wow and flutter. Calibrated crt display gives wow and flutter percentage as a deflection of the trace from its equilibrium position

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IN ANY ELECTRICAL recording system, disk, film or tape, certain distortions in reproduction are inevitable. This paper discusses the properties and measurement of those distortions known as flutter and wow.

It is impossible to go through the process of recording and reproducing sound without having the medium experience some instantaneous variations in speed. In a typical instance, if a pure 1,000-cycle signal is recorded, it may not be reproduced exactly; it may rise momentarily to 1,003 cycles, then fall to 997 cycles, again rise to 1,003 cycles and so on. In this case the system causes the frequency to change by ±3 cycles or ±0.3 percent.

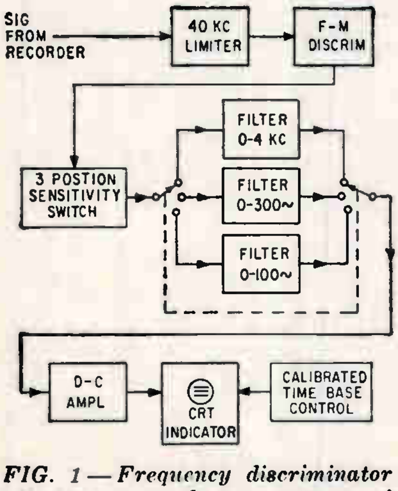

FIG. 1—Frequency discriminator separates wow-flutter content of recorder output

The number of times a second that this cyclical variation occurs is the period of the flutter or wow. If higher than six cycles per second, the effect is known as flutter.

In sound recorders it is essential that these products be held below a certain limit so that the ear will not detect the objectionable forms of distortion caused by them. In instrumentation recorders degrees of flutter and wow which are acceptable to the ear often cannot be tolerated, and it has become necessary to design elaborate tape drive mechanisms.

Flutter and wow components in a given system can be complex, with a mixture of many different sources contributing to the overall pattern.

For example, a capstan may cause wow at its rate of rotation, which in a particular recorder may be six cycles. A rotating filter wheel may contribute a component of two cycles. A motor may add 20, 60 or 120 cycles, or even all three. In such instances these are discrete frequencies, but in addition there may be others which vary in frequency and amplitude with the amount of tape on a reel, torque motor or belt adjustments and other causes. Sources of this type are caused by the mechanical deficiencies of the machine itself.

Another source of flutter arises, however, from the effect of sliding the tape over the recording and playback heads and over any stationary guides or pressure pads which contact the tape in the vicinity of the heads. This is best described as scrape flutter. It is usually random in nature with a concentration of energy in the vicinity of some discrete frequency such as 1,000 or 3,000 cycles.

Scrape flutter has most often been completely ignored in flutter analyses because commercial measuring devices do not usually respond to flutter rates higher than 300

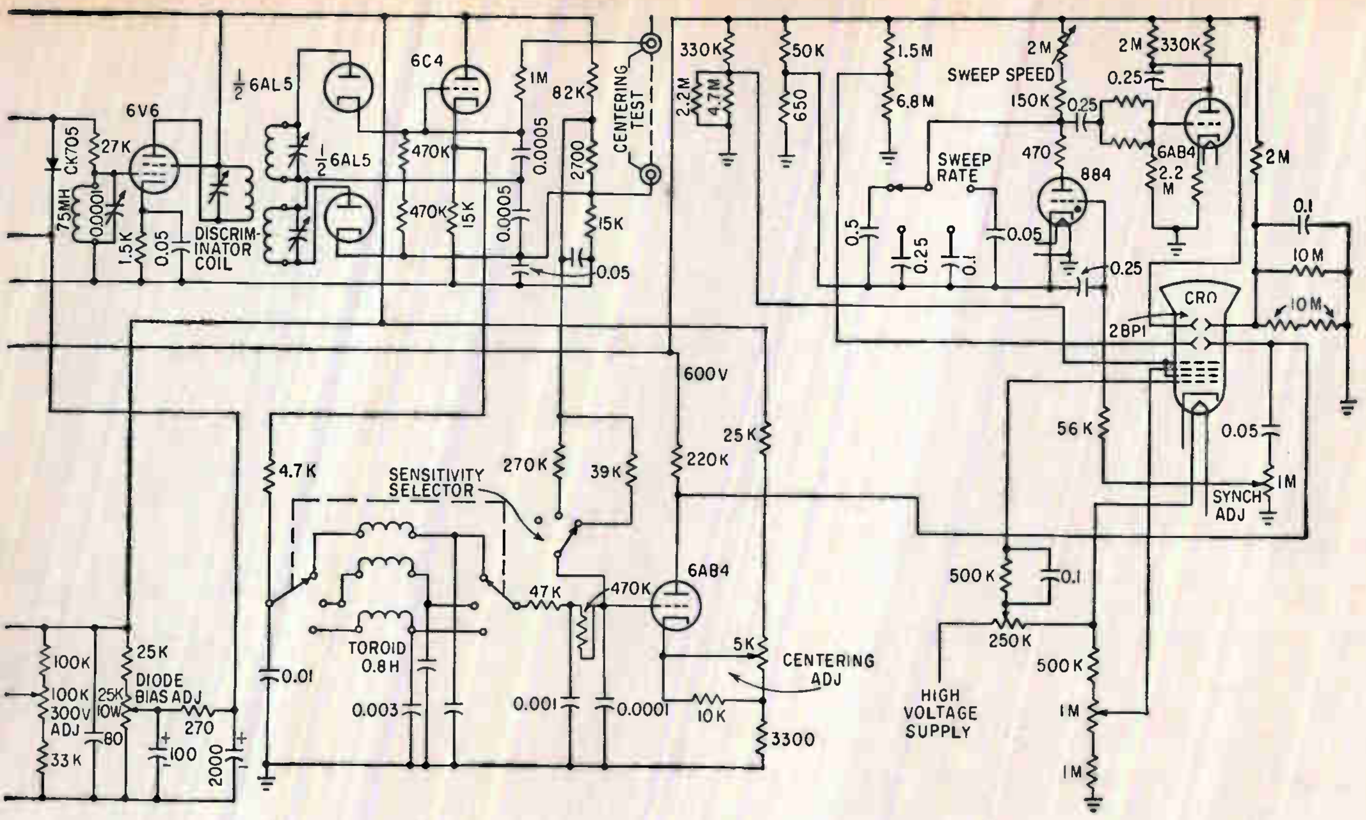

FIG. 2—Reproduced signal is rendered constant in amplitude before it is passed on to the discriminator circuit. Bandwidth selector permits wow and flutter display in one of three frequency ranges

cycles. Such devices are satisfactory in sound recording measurements for disk and optical film recording where scrape flutter does not exist. However, introduction of tape recording and the subsequent conversion of motion picture recording from optical to magnetic film is an important factor in which scrape flutter should be considered.

Discussion will be confined to the method employed with a tape recorder, although the process is similar with any other medium. First, a steady tone is recorded on the magnetic tape. During this process, of course, the tape will experience the effects of flutter which will thereby be recorded into the tape itself, causing it to be an imperfect recording. On playback the machine again contributes wow and flutter components which add algebraically to those already on the tape.

The reproduced tone, with these variations in frequency and amplitude that are brought about by imperfections in the tape transfer process, is fed into an amplifier and then into an amplitude limiter. The limiter removes the amplitude variations and residual information in the signal is conveyed only by frequency variations. Wow and flutter information is then derived by passing the signal through an f-m detector.

An indicator of some sort measures the discriminator output. In commercially available flutter meters the indicator is most generally a D'Arsonval meter, calibrated in percent flutter and wow.

A convenient indicator for instrumentation measurements is therefore the cathode-ray oscilloscope. While a flutter indicator of this sort is more complex than one using a D'Arsonval meter, it has many compensating advantages. Absolute peak-to-peak values can be seen on a calibrated scale and can be photographed with continuously moving film to provide visible analysis of system deficiencies. The major contributing factors causing flutter and wow can be visually determined since the oscilloscope trace can be synchronized to hold a given component stationary on the screen. From this the speed of the trace is observed, giving the periodicity of the offending mechanical component.

A flutter and wow indicator has been constructed which is useful for checking any type of recorder capable of reproducing a 40-Kc signal. This confines its use to the field of instrumentation, but it is here that the greatest need for such a device exists. The equipment employs a 40-Kc carrier frequency, and a calibrated oscilloscope plus various spectrum cut-off filters.

In addition, the equipment has response down to d-c. This is essential for accurate calibration since known absolute frequencies can be read from a commercial decade counter and the degree of crt spot displacement observed.

In practice, the carrier frequency is raised and lowered 0.05 percent from mean value and the total excursion of the spot is adjusted by a gain control until it fits within two calibrating lines representing peak-to-peak flutter of 0.1 percent.

The device in its full range position shows all drift, wow and flutter components from d-c to 4,000 cycles. Figure 1 shows a block diagram of the complete flutter indicator; Fig. 2 is a schematic diagram.

Tape recorder output is fed through a two-stage amplifier whose gain is broadly peaked at 40 Kc. The amplifier includes two

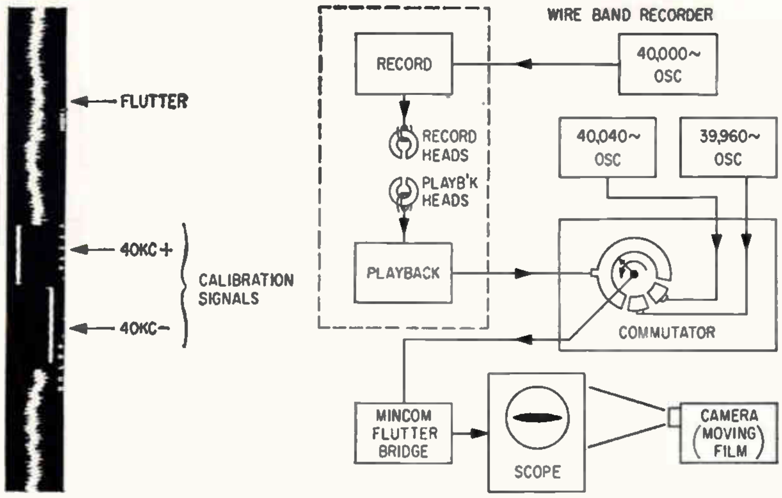

FIG. 3—Calibrating signal of alternately plus then minus one percent of the 40-Kc carrier is fed to the wow-flutter monitor. Crt display due to this 40-cycle artificial flutter is filmed as shown

sets of amplitude limiters and the constant amplitude signal coming out of these limiter stages is shaped again into a sine wave and applied to the f-m discriminator. Here, two coils, one tuned above and the other below the carrier frequency, feed a pair of diodes. The output of the diodes is essentially a d-c voltage with ripple at the carrier frequency. The diodes are connected with the d-c voltage in opposition, resulting in zero output at center frequency of the 40-Kc carrier. While the deviation in frequency of the 40-Kc carrier is seldom in excess of ±1 percent in the worst cases of flutter, the additional bandwidth of this discriminator is necessary to pass the sidebands representing the flutter components up to 4 Kc.

A three-position sensitivity control follows, which permits the oscilloscope graticule marks to represent 0.1, 0.3, or 1.0 percent peak-to-peak flutter. Three filters follow, which may be selected to pass zero to 4,000 cycles. Following these is a d-c amplifier to supply vertical deflection voltages to the oscilloscope. The horizontal time base is of variable speed and can be synchronized to components of the flutter signal. It is calibrated so as to enable the frequency of such components to be readily determined.

A two-inch cathode ray tube is employed. The graticule marking vertical deflections is calibrated to read 0.1, 0.3, or 1.0 percent per division, a division being 5/16 inch. The 0-4,000 cycle filter position indicates all measurable flutter of any significance. It includes mechanism and scrape flutter. The 0-100 cycle filter provides the conventional method of observing those components which are essentially machine deficiencies. The 0 to 300-cycle filter provides a comparison between the results obtained by flutter meters having such cutoff characteristics and the full range response of this instrument.

Compared to a 300-cycle cutoff, the flutter indicated on the full range 4,000 cycle position may be anywhere from 20 to 200 percent greater, depending on the design characteristics of the machine being tested.

Figure 2 is a schematic of the equipment. A two-stage pentode amplifier (6AC7's) is broadly tuned by two L-C networks to pass frequencies near 40 Kc. Diode limiters in each stage slice the signal symmetrically about the axis.

Discriminator (6AL5) output is d-c coupled to the 6C4 and the 6AB4. A three-position sensitivity selector changes the signal level into the 6AB4. Output of the 6AB4 is a d-c signal directly connected to one vertical plate of the oscilloscope unit. A centering control in the cathode of the 6AB4 determines its standing plate potential and thus the vertical position of the crt spot.

The filter circuits between the cathode of the 6C4 and the grid of the 6AB4 provide flat response to 4 Kc and a sharp cutoff above this frequency. Thus the instrument will show on the oscilloscope all components of flutter from zero to 4 Kc.

Resistor values in this unit must be determined experimentally. Values shown for the 4-Kc filter will probably need adjustment in each individual case, but calibration is easy with the use of a frequency meter of the Berkeley type.

Circuits of the oscilloscope are conventional, the 884 tube supplying the usual horizontal sweeps. Voltage dividers are used on the supplies to the crt terminals to equalize their potentials to the 6AB4 plate, thereby eliminating focusing problems.

The three-position attenuator at the grid of the 6AB4 changes the sensitivity so that a quarter inch of crt deflection can represent flutter ranges 0.1, 0.3 and 1.0 percent. Frequency discrimination is extremely sensitive to small increments of frequency, so it is important that the absolute frequency of the discriminator be determined before recording. This frequency is not likely to be exactly 40,000 cycles—it may even be several hundred cycles to one side or the other. The absolute frequency will drift a little when the device is first turned on so it is well to let it warm up thoroughly before establishing the center frequency.

Determination of center frequency is undertaken in the following manner. Set the sensitivity switch to position 3 (1.0 percent per ¼ inch) and feed a signal (close to center frequency) from the oscillator into the flutter meter. Adjust the centering knob to center the trace on the crt. Flip the sensitivity knob to position 2 (0.3 percent per ¼ inch). If the trace shifts, the center frequency has not been found. Readjust frequency and try again, using the centering knob to keep the trace well within the screen. When no relative shift is found between positions 2 and 3, switch to position 1 for a last sensitive adjustment.

When the trace stands still in positions 1, 2, and 3, the center frequency has been determined within one or two cycles.

Provision is made for filming the crt display as shown Fig. 3. In this case a commutator automatically introduces a 0.1 percent calibrating signal at predetermined intervals, which is then superimposed on the film trace.

TUNNEL DIODE LOGIC CIRCUITS

Three important facets of tunnel diode logic circuits are examined: diode current-voltage characteristics, modes of operation and effect of circuit component tolerances. Derived tolerance equations serve as valuable design tools

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THE tunnel diode is a single *p-n* junction diode that meets two physical requirements: the junction is narrow; and both *p*-type and *n*-type regions are highly doped (they have a high impurity content). Under these conditions. there is appreciable probability that an electron incident upon a very narrow junction barrier will tunnel through the barrier, even though the energy barrier be high, to a state of equal energy on the other side. This effect is known as quantum mechanical tunneling. A typical tunnel diode current-voltage characteristic is shown in Fig. 1A. An explanation of this characteristic based on the quantum mechanical tunneling phenomenon has been given in the literature.[1, 2]

The current-voltage characteristic of a tunnel diode (Fig. 1A) can be divided into three regions. Region 1 begins from the reverse biased condition and ends at a small positive bias voltage V_p which corresponds to the peak diode current I_p. In this region the characteristic has a positive slope that is practically constant except in the vicinity of the peak current point. Region 2 corresponds to the negative slope portion of the curve which begins at the peak point (I_p, V_p) and ends at the valley point (I_v, V_v). The magnitude of the incremental negative conductance increases from zero to a maximum value somewhere near the middle of this region and it decreases to zero at the valley points. There is only a small portion of the curve where the negative conductance is approximately constant. Region 3 begins at the valley point and extends towards the highly forward biased area where normal forward biased diode characteristics prevail.

The a-c properties of a tunnel diode are different from its d-c characteristics. They are not given simply by the slope of the d-c characteristic shown in Fig. 1A, for other unavoidable circuit elements, such as lead inductance, body resistance and junction capacitance must be taken into account. However the lead inductance and body resistance can be reduced by proper fabrication and mounting techniques.

Figure 1B shows idealized tunnel diode characteristics which are useful in circuit analysis.

A device having a negative conductance is useful in many applications, such as amplifiers and oscillators, but one of the most important areas is probably in digital circuits. Described here are various operating modes of tunnel diode logic circuits and the requirements imposed upon the tunnel diode characteristic with respect to the tolerance of other circuit components.

The two obvious modes of operation are the monostable and the bistable conditions. For monostable operation (Fig. 1C), a bias resistance and an inductance are connected in series with the diode. This resistance and the bias supply are small enough such that *a* is the only stable point. This point is in Region 1 of the diode characteristic. When there is no input signal pulse, the diode remains at *a* where the diode current is I_a and the diode voltage is V_a. When an input pulse is equal to or greater than I_p-I_a, the voltage across the diode increases momentarily due to the excursion of the bias point into Region 3 of the I-V characteristic curve. An output can be taken as the voltage swing across the diode,

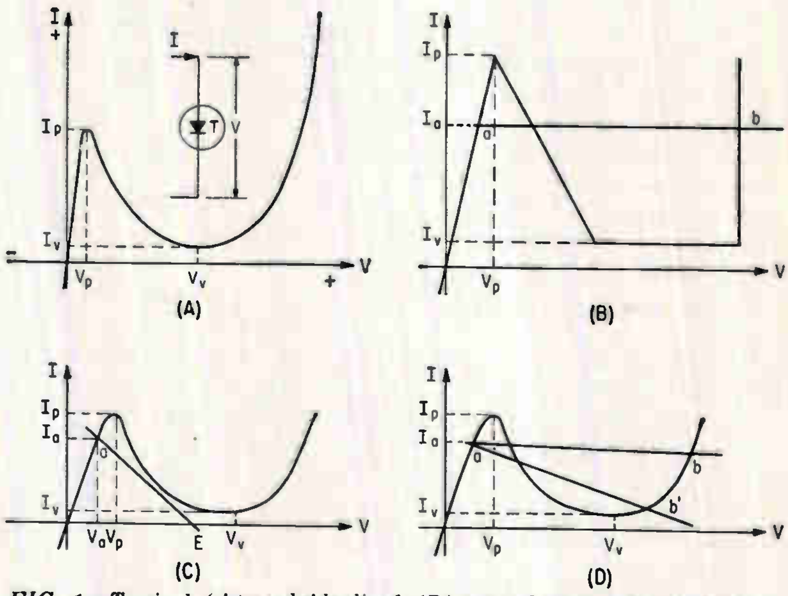

FIG. 1—Typical (A) and idealized (B) tunnel diode characteristics. Two modes of operation for digital applications are: monostable bias condition (C) and bistable bias condition (D)

or the voltage swing across the inductance by using a secondary winding inductively coupled to L as shown in Fig. 2A and B.

When a tunnel diode is operated in the bistable mode, the bias resistance is high enough to intersect the I-V curve of the diode at two stable points. If the bias resistance is very large in comparison with the negative resistance, the two stable points are a and b as shown in Fig. 1D. Diode current at b is of about the same magnitude as I_a. However, if the bias resistance is only slightly larger than the negative resistance, the two stable points are a and b'. Diode current at b' is approximately equal to the valley current I_v of the diode.

Assuming that, initially, the diode is at a, an input current pulse equal to or greater than I_p-I_a will switch the diode over to b or b'. In the case of point b, the output is a current which equals the diode voltage divided by the output resistance R_o as shown in Fig. 2C. For the point b' case, the output is the change of current in R_b'' of Fig. 2D. After switching the diode to b or b', a negative resetting pulse is required to reset the diode back to a. Reset can also be accomplished by temporarily removing the supply voltage.

In either monostable or bistable operation, there is an output if the input current is equal to or greater than I_p-I_a. If this amount of input current is equally contributed by n input circuits, the logic circuit is operated as an AND gate of n inputs. If any one of the n inputs has an amplitude I_p-I_a, the logic circuit is operated as an OR gate of n inputs. Thus the logic decision is based on the analog summation of input signals and the threshold level of the gate. Hence this type of logic may be termed analog-threshold logic.

Negation or inversion can be obtained by using a transformer which reverses the polarity of the output pulse. This output pulse is combined with a clock pulse at the input of an OR gate. Thus the output of the combined stages will be ONE when the first stage does not switch, and the output will be ZERO when the first stage does switch. The circuit shown in Fig. 2D can be used as the negation. When the

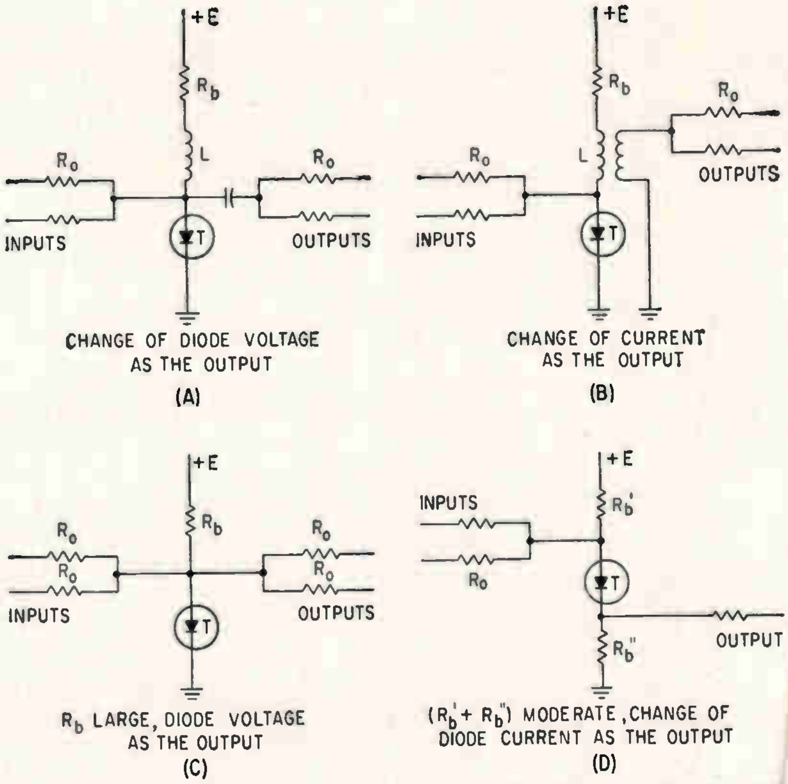

FIG. 2—Monostable logic circuits (A) and (B). Bistable circuits (C) and (D) use analog-threshold logic

diode is at point a (Fig. 1D), the output voltage is I_vR_b''. Since I_v is much smaller than I_a, I_vR_b'' can be considered as ZERO and I_aR_b'' as ONE.

Logic circuits employing the principle of majority decision can be built by connecting two tunnel diodes in series as shown in Fig. 3. The binary informations ONE and ZERO are represented by a positive and a negative signal current of equal amplitude respectively. The number of inputs is limited to an odd number so that there is no ambiguity. The analog sum of the input signals should be in the correct polarity and its amplitude should be larger than the difference between the two diode currents during the logic operation. Supply voltage can be either of square or of sinusoidal waveform. Peak amplitude of the supply is such that the only one of the diodes can be switched to the high voltage state while the other diode will remain in Region 1 during the whole positive half cycle. Since the supply voltage is symmetrical with respect to ground, the diodes form the arms of a balanced bridge before each logic operation and therefore there is no output at point C to ground. When the supply voltage goes into the positive half cycle, both diodes begin to conduct in the forward direction. When the input is positive, D_2 will reach its peak current first; consequently D_2 is switched. The bridge is unbalanced. The output voltage is positive with respect to ground. On the other hand when the input is negative, D_1 will be switched, and the output is negative. Negation is obtained by using a transformer which reverses the signals.

The difficulty arising from the non-unilateral behavior of the above circuits can be overcome by using either a backward diode[2] or rectifying diode to block the backward transmission, or by using a three phase supply similar in principle to that described for digital circuits using parametric oscillators.[3] The logic stages are arranged in such a way that the backward flow of information does not affect the operation, or the NAND circuit is used to perform the logic operation. Thus the interconnection of logic stages becomes straightforward. However, the allowable number of input circuits and the allowable number of output circuits are limited to a

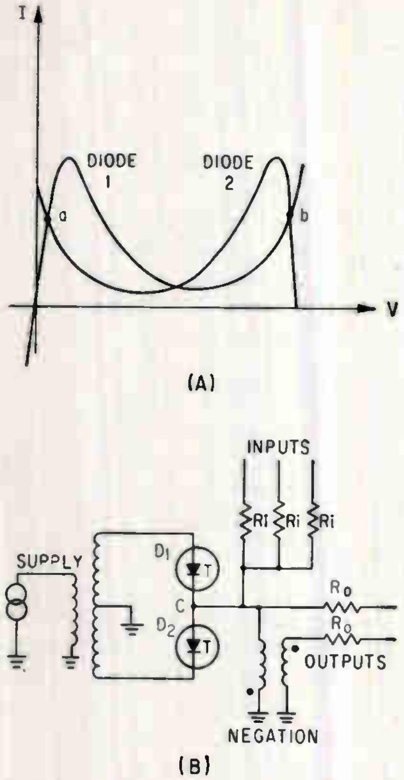

FIG. 3—Characteristic (A) and circuit (B) for majority logic

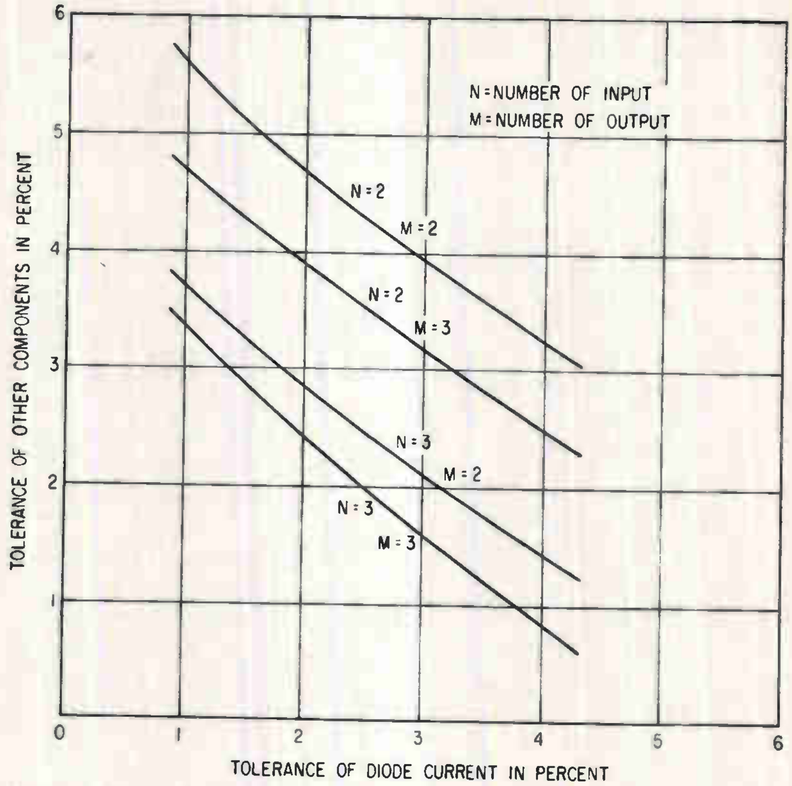

FIG. 4—Relationship of tolerances of tunnel diode and components to fan-in and fan-out numbers

small value. They are related to the allowable tolerances of the circuit components.

To simplify mathematical expressions, many assumptions will be made in obtaining the relationship between tunnel diode and component tolerances. These assumptions are:

(a) The I-V characteristic of a tunnel diode is represented by idealized four line segments, as shown in Fig. 1B. The peak current region which centers around the point (I_p, V_p) is now represented by a point. From the point of view of the requirement of triggering pulse amplitude and switching speed, this assumption is somewhat of an over simplification. (b) With the peak current region represented by a single point, the minimum triggering current required is assumed to be I_p-I_a. Under this assumption the calculated results are on the optimistic side. (c) The input signals to each stage are the outputs of similar stages. In other words the input and the output circuits are standardized to a nominal current value. (d) The effects of junction capacitance on the tolerance requirements are neglected.

Analog-Threshold Logic — The monostable and bistable circuits shown in Fig. 2 can be studied together by assuming that L is reasonably large so that during a large part of the output period L behaves as a current source.

Let the number of input circuits be n, the number of outputs m, the nominal peak current of the diode I_p, the valley current I_v and the variation of these currents $\pm k$ percent. Let the variation of output voltage across the diode, the variation of resistances and supply voltage be $\pm\delta$ percent. The nominal value of a ONE input is represented by voltage V_b minus V_a divided by the resistor R_o, and a ZERO by $(V_a' - V_a)/R_o$ where V_a' is the bias voltage of an OR gate. The condition for an AND gate of n ONE inputs is

$$n\frac{(V_b - V_a)(1 - \delta)}{R_o(1 + \delta)} \geq I_p(1 + k) - I_a(1 - \delta) \quad (1)$$

The condition for an AND gate of $(n - 1)$ ONE inputs and one ZERO input is

$$(n - 1)\frac{(V_b - V_a)(1 + \delta)}{R_o(1 - \delta)} \leq I_p(1 - k) - I_a(1 + \delta) \quad (2)$$

The condition for an OR gate of $(n - 1)$ ZERO inputs and one ONE input is:

$$\frac{(V_b - V_a')(1 - \delta)}{R_o(1 + \delta)} - (n - 1)\frac{(V_a' - V_a)(1 - \delta)}{R_o(1 - \delta)} \geq I_p(1 + k) - I_a'(1 - \delta) \quad (3)$$

where V_a' and I_a' are the voltage and current of the bias point of an OR gate. The condition for an OR gate of n ZERO inputs is

$$n\frac{2\delta V_a'}{R_o} \leq I_p(1 - k) - I_a'(1 + \delta) \quad (4)$$

Let $(V_b - V_a)/R_o = I_{in}$ and simplify Eq. 1 and 2. By neglecting δ^2 and $k\delta$ terms we have

$$nI_{in}(1 - \delta) \geq I_p(1 + k + \delta) - I_a \quad (5)$$

and

$$(n - 1)I_{in}(1 + \delta) \leq I_p(1 - k - \delta) - I_a \quad (6)$$

Under the worst condition the signs of inequality are changed to signs of equality. These equations are combined to give

$$I_{in}/I_p = 2(k + \delta)/[1 - (2n - 1)\delta] \quad (7)$$

Expressions (3) and (4) can also be simplified to give:

$$I_{in}(1 - \delta) - (n - 1)(1 + \delta)(V_a' - V_a)/R_o \geq I_p(1 + k + \delta) - I_a' \quad (8)$$

$$n2\delta V_a'(1 - \delta)/R_o \leq I_p(1 - k - \delta) - I_a' \quad (9)$$

where $(V_b - V_a')/R_o$ is taken as approximately equal to I_{in}. The sign of inequality is replaced by a sign of equality under the worst condition and the combination of these two equations gives:

$$I_{in}(1-\delta) - [(n-1-\delta)(V_a' - V_a) + n\delta(3V_a' - V_a)]/R_o = 2I_p(k+\delta) \quad (10)$$

Equation 10 gives the relation between the bias point of an OR gate and that of an AND gate.

At the output of the preceding stage, the nominal maximum available output current is

$$I_b - I_v = I_a - I_v \quad (11)$$

If no non-linear devices, such as backward diodes or rectifying diodes are used in the input circuits to block the backward flow of information, each output current will be

$$I_o = \frac{I_a(1-\delta) - I_v(1+k)}{(m+n)} = I_{in} \quad (12)$$

If non-linear devices are used to block the backward flow of current, each output circuit will have

$$I_o' = [I_a(1-\delta) - I_v(1+k)]/m = I_{in}' \quad (13)$$

Since at the input, from Eq. 1 and 2,

$$I_a = I_p - [(2n-1)/2]I_{in} \quad (14)$$

by combining equations 7, 12 and 14, we obtain the expression

$$m+n = \left\{[1-(2n-1)(k+2\delta)](1-\delta) - \frac{I_v}{I_p}(1+k)[1-\delta(2n-1)]\right\}/2(k+\delta) \quad (15)$$

Using Eq. 13 instead of Eq. 12 leads to

$$m = \left\{[1-(2n-1)(k+2\delta)](1-\delta) - \frac{I_v}{I_p}(1+k)[1-\delta(2n-1)]\right\}/2(k+\delta) \quad (16)$$

Equation 16 shows the advantage of using a non-linear device to block the backward flow of information. As an example, if $I_p/I_v = 10$, the relationships between the tolerances on the diode currents and the tolerances on the other components are shown in Fig. 4.

Majority Logic — The tolerance for the circuit components shown in Fig. 3 is calculated as follows: Let the tolerance of diode currents be $\pm k$ percent. Figure 5A shows an equivalent circuit during the positive half-cycle of the supply before the switching of either diode. The input circuit is represented by a small voltage V_{in} in series with R_{in}. Voltage V_{in} is the equivalent voltage which produces the desired input current. The value of R_{in} depends upon the number of input circuits. Resistor R represents the internal resistance of supplies E_1 and E_2. These two supply voltages may be slightly unbalanced in amplitude and in phase if an a-c voltage is used. Let the total combined value be represented by a tolerance of voltage $\pm\ \delta$ percent, and the variation of R_o be $\pm\ \delta$ percent. Each input current is equal to the ratio of the output voltage to the resistance. Hence each input signal current will have a tolerance of $\pm\ 2\delta$ percent.

Let the number of input be $(2n-1)$ and the number of output be m, where n is a positive integer. Let the nominal value of each input current be I. Under the worst condition the resultant of the inputs will be

$$I_{in} = I[1-2(2n-1)\delta] \quad (17)$$

Figure 5B shows the time interval within which one of the diodes must be switched into the third region of its I-V characteristic. The peak amplitude of the sinusoidal supply across two diodes should be such that after one of the diodes is switched into the third region, the peak amplitude is not enough to switch the other diode, as shown in Fig. 5C. The solid line represents the characteristic of diode 2. Point b represents the condition after diode 2 is switched. Figure 5D shows the condition before either one of the diodes is switched. Diode 2 has an additional amount of current which corresponds to the difference between point 2 and point 1. This current is the input current.

Let the angle of the sine wave supply at which the diode switches be θ, where θ is measured from the beginning of the positive half-cycle of the supply to the time the current in one of the diodes is equal to its peak value (Fig. 5B). Thus, if $R << R_{in}$, the currents in the diodes are

$$I_1 = \frac{E_2}{R} + \frac{E_1 - E_2}{R_o/m} = [E(1-\delta)\sin\theta]/R + 2mE\delta\sin\theta/R_o \quad (18)$$

$$I_2 = I_{in} + E_2/R = I_{in} + [E(1-\delta)\sin\theta]/R \quad (19)$$

For proper operation, we have $I_1 < I_p\ (1-k)$ and $I_2 \geqq I_p\ (1+k)$, or $I_2 - I_1 > 2k\ I_p$

For the worst case where the two diodes reach their peak cur-

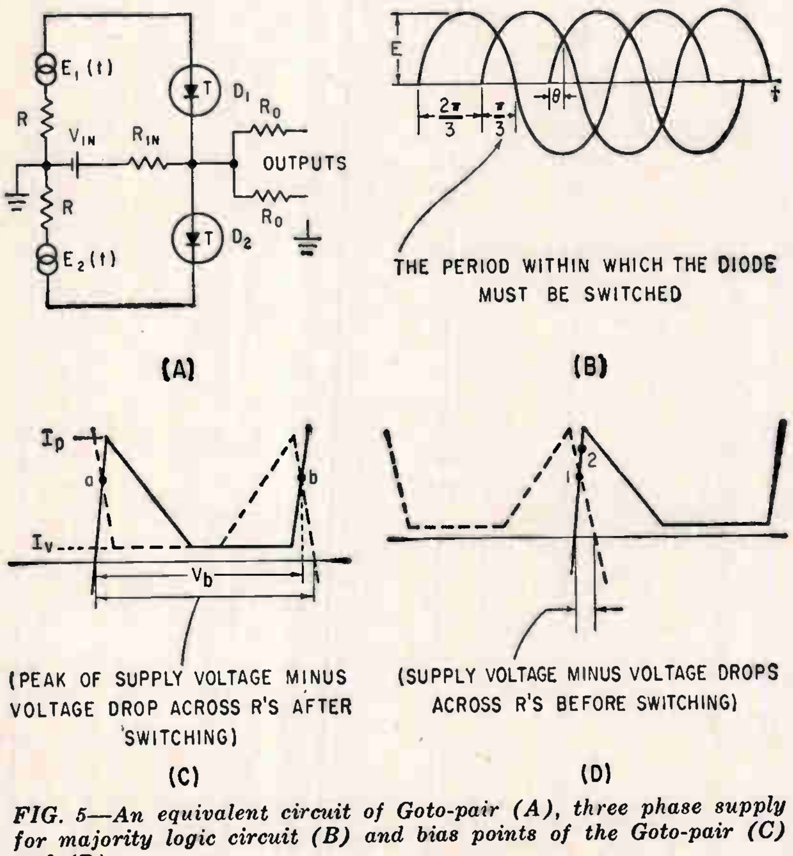

FIG. 5—An equivalent circuit of Goto-pair (A), three phase supply for majority logic circuit (B) and bias points of the Goto-pair (C) and (D)

rents simultaneously, we have

$$I_2 - I_1 = 2kI_p = I_{in} - 2mE\delta \sin\theta / R_o$$

or

$$I[1-2(2n-1)\delta] = 2kI_p + 2mE\delta \sin\theta/R_o \quad (20)$$

Equation 20 gives the relationship between the fan-in and fan-out numbers and other circuit parameters.

After diode 2 has been switched, the peak of the supply voltage should not drive diode 1 over its peak current. Thus, the total current in diode 1 at the peak of the supply is

$$I_1' = I_2' + \frac{E(1+\delta) - I_2'R}{R + R_o/[m + (2n-1)]} < I_p(1-k) \quad (21)$$

Where I'_1 and I'_2 are the currents in diode 1 and diode 2 respectively. Rearranging Eq. 21, we have

$$E(1+\delta) < [I_p(1-k) - I_2'] \left[R + \frac{R_o}{m+(2n-1)}\right] + I_2'R \quad (22)$$

Equation 22 specifies the peak amplitude of the sinusoidal supply voltage in terms of device properties and fan-in and fan-out numbers.

After passing its peak voltage the supply voltage decreases. Let ϕ be the angle at which the supply voltage becomes too small to retain the information; in other words, the diode which has been switched will return to its first region. Thus

$$2E\sin\phi = V_v + 2RI_v + R\frac{E(1+\delta)\sin\phi - RI_v}{R+R_o/[m+(2n-1)]} \quad (23)$$

where V_v is the voltage at the valley point and I_v is the valley current. Equation 23 gives the relationship between the angle of reset and the fan-in and fan-out numbers. Since the clock has three-phases, ϕ must be between 120 and 180 degrees and θ has to be between 0 and 60 degrees.

As an approximation, the voltage drop across R in the above equation is neglected. Angles θ and ϕ are assumed to be approximately 30 and 150 degrees respectively. Combining expressions 22 and 23 and taking the limiting case leads to

$$V_v(1+\delta) = [I_p(1-k) - I_2'] R_o/[m+(2n-1)] \quad (24)$$

The total output current is given by

$$I_{total} \cong [V_v(1+\delta)\sin\phi][m+(2n-1)]/R_o = \sin\phi[I_p(1-k) - I_2'] \quad (25)$$

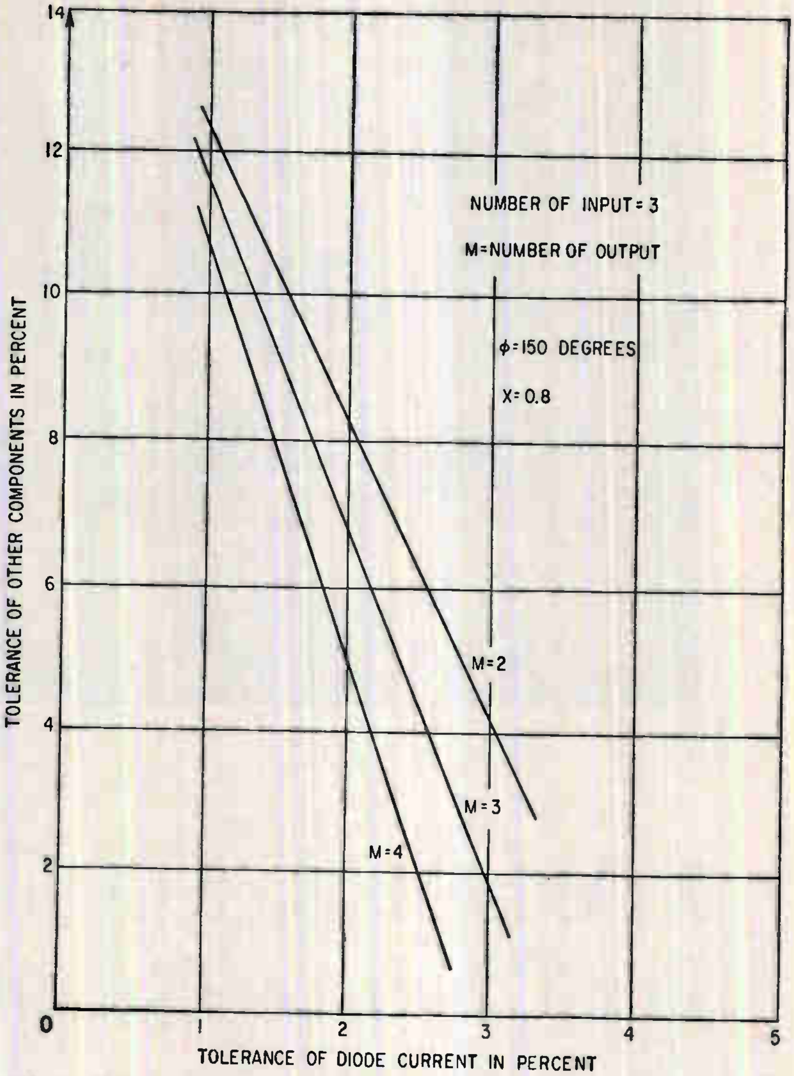

FIG. 6—Tolerance relationship for majority logic

Letting $I_p(1-k) - I_2' = xI_p$ and since

$$I = I_{total}/[m+(2n-1)]$$

combining Eq. 20 and 25 gives

$$\delta = \frac{1 - 2k[m+(2n-1)]/x\sin\phi}{2(2n-1)} \quad (26)$$

It is desirable to keep x as close to unity as possible. However, the limit of x is determined by $(1 - I_v/I_p)$. Figure 6 shows the relationship between the tolerance of the diode and the tolerance of other circuit components for $\phi = 150$ degrees, $x = 0.8$, and $(2n\text{-}1) = 3$.

Among the basic tunnel diode logic circuits described above, the two-diode circuit which is known as the Goto-pair appears promising if the two diodes are carefully selected for matched currents. However, unless both diodes have essentially identical I-V characteristics with respect to all environmental conditions, a slight change in the environment, such as the temperature, may upset the circuit operation.

The difficulties inherent in the discussed tunnel diode logic circuits should not be considered as indicative of the future. It is the author's belief, based on present laboratory work, that with improvement of tunnel diode fabrication techniques and accumulation of knowledge concerning circuit behavior, practical tunnel diode logic circuits will be produced.

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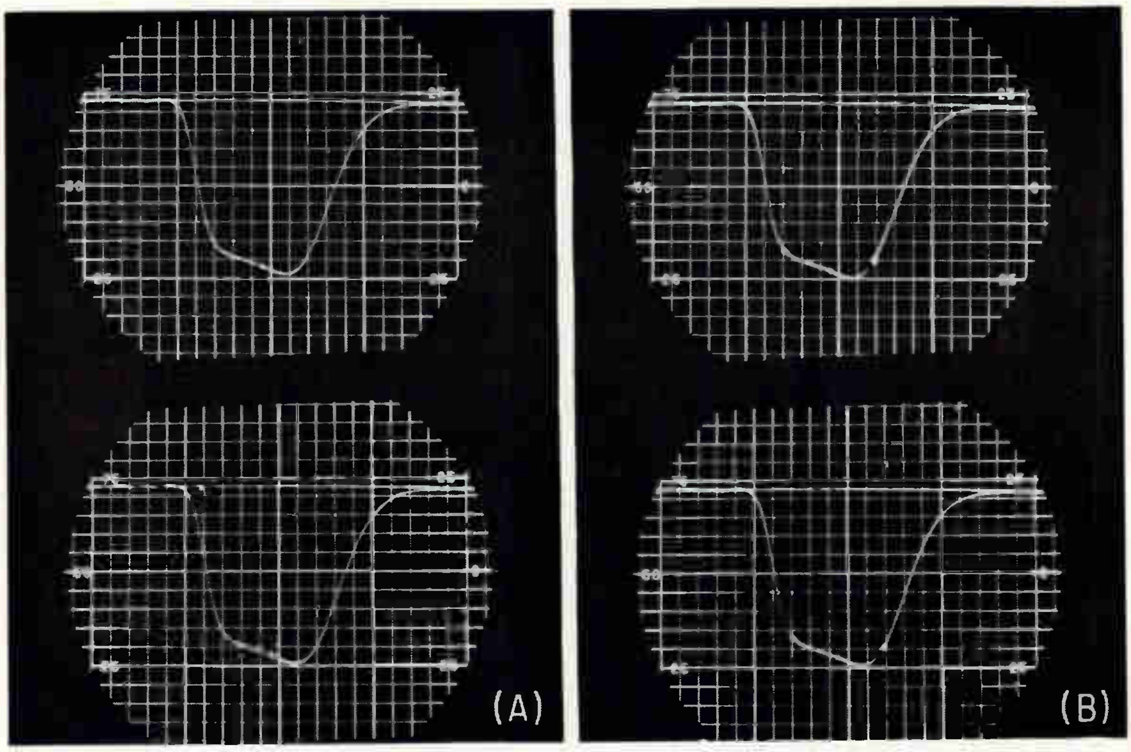

Variable intensity marker is at 15 Mc in both (A) and (B) but auxiliary markers have been added in (B) at 11.7 and 18.3 Mc

Z-Axis Marker Generator For Bandpass Circuit Alignment

Two-tube circuit provides variable frequency oscilloscope intensity marker for wideband bandpass measurements. Easily calibrated circuit maintains long term accuracy of better than 1 percent

By DOMINICK J. ODORIZZI, Senior Project Engineer, Hughes Aircraft Company, Tucson, Arizona

USUAL METHOD for aligning and measuring i-f amplifier strips and similar circuits is to use a swept frequency oscillator and an oscilloscope. The oscillator feeds the amplifier under test and the amplifier's detected bandpass curve is observed on the oscilloscope. It is then necessary to determine the frequency of various points on the bandpass curve in order to properly align the amplifier and make necessary measurements.

Some of the more commonly used frequency marker systems employ birdie markers, oscilloscope vertical axis markers, or oscilloscope intensity markers. The intensity marker possesses the advantage of being independent of amplifier and oscilloscope gain settings and, in addition, does not distort the bandpass curve. The circuit described here provides an accurate, stable intensity marker over the frequency range of 8 to 22 Mc. With minor changes, operation at other frequencies is also possible.

Figure 1 shows the overall system block diagram using the marker generator. A small portion of the r-f signal feeding the amplifier under test is fed into the marker generator. The marker generator consists basically of a tuned tank circuit and a detector. When the r-f signal frequency sweeps past the tank circuit frequency, a high amplitude signal is obtained from the tank circuit. The signal envelope is detected and the resulting pulse is fed to the oscilloscope Z-axis.

A bright mark appears on the bandpass curve at a frequency de-

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termined by the setting of the tank circuit. This mark, appearing as a dot on the trace, is apparent on the bandpass curve photographs. Marker frequency is read from a calibrated dial attached to the tank circuit capacitor. The 60 cps sawtooth from the sweep oscillator provides the proper horizontal sweep for the oscilloscope.

The circuit for producing the marker is shown in Fig. 2A. The r-f signal is fed into J_1 through C_1 and R_1 to the grid of V_{1A}. Resistors R_1 and R_2 comprise an isolating pad to prevent loading of the sweep oscillator by the marker circuit. The input signal is amplified by V_{1A} and fed through C_2 to a tank circuit. The tank circuit consists of C_3 and C_4 in parallel with either L_1 or L_2 as determined by the range switch S_1. Coil L_1 or L_2 is fed from a tap to minimize tank circuit loading by V_{1A}. This results in a higher tank circuit Q which is necessary to produce a sharp marker pulse. Capacitor C_4 is the tuning element which varies the frequency of the tank circuit from 8-14 Mc or 12-22 Mc, depending upon the setting of S_1. Trimmer capacitor C_3 sets the tuning range of C_4.

The envelope of the r-f voltage developed across the tank circuit at resonance is detected by V_{1B}, an infinite impedance detector. This type detector is used primarily to prevent tank circuit loading which would result in reduced Q. The detected pulse appears on the cathode of V_{1B}, which is r-f by-passed by C_6. Both r-f and pulses are bypassed to ground by L_3 and C_5 in the plate circuit of V_{1B}.

Pulses from V_{1B} are fed to the grid of V_{2A}, Fig. 2B. When using a 1 milliwatt signal generator, pulses to the amplifier will vary in peak amplitude from approximately 5 to 10 volts through the tuning range of the marker generator circuit. This amplitude variation is dependent upon the tank circuit Q which is determined by the setting of C_4 (Fig. 2A). Because of the grid leak bias developed by C_9 and R_5, which provides increasing bias for increasing pulse amplitude, all pulses appearing in the plate circuit of V_{2A} will be equal in amplitude. In addition, the pulses will be narrowed in width from approximately 100 to 50 μsec since only the upper portion of the positive peaks are amplified by V_{2A}.

Pulses from the plate circuit of V_{2A} are fed through C_{10} and R_9 to the grid of the summing amplifier V_{2B}. Auxiliary markers, obtained from another variable marker or fixed crystal marker generator, can be injected through C_{11} and R_{11} into V_{2B}. These auxiliary markers are amplified by V_{2B} along with those obtained from V_{2A}. The composite marker signal is fed through C_{12} to the oscilloscope Z-axis input. Diode D_1 removes any negative component of the output.

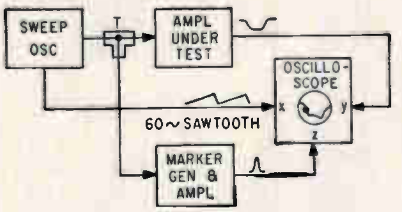

FIG. 1—Marker generator is essentially a parallel-tuned resonant circuit and a detector. A pulse is generated when the swept oscillator passes through the frequency to which the tank is tuned

Auxiliary markers are useful for measuring and aligning bandpass curves. For example, if it is necessary to maintain a minimum and a maximum frequency within the bandpass, these frequencies can be marked with auxiliary markers. These markers are often available from crystals in the swept frequency oscillator being used. The variable marker can then be used to determine other desired frequencies and to measure bandwidth.

Calibration of this unit is accomplished by connecting a standard signal generator to J_1 in place of the swept oscillator and attaching a d-c vtvm to TP_1. The vtvm reading is peaked for maximum voltage by adjusting C_4. This tunes the tank circuit to the standard generator frequency. The dial of C_4 may then be marked to indicate the standard signal generator frequency.

The marker circuit can be used at higher or lower frequencies and has been used to 65 Mc. The only changes necessary are in the tank circuit elements and possibly the plate circuit coils of V_{1A} and V_{1B}. The range switch and one tank coil may be eliminated if narrower tuning ranges or higher frequencies are used.

The last stage, V_{2B}, is not necessary if the oscilloscope using the marker requires a negative pulse and auxiliary markers are not desired. In that case the output is taken directly from the plate of V_{2A}. For this case it is desirable to eliminate R_7 and make R_6 a 50,000 ohm potentiometer.

Circuits of V_1 were contained in a shielded box, but the circuits of V_2 do not need shielding.

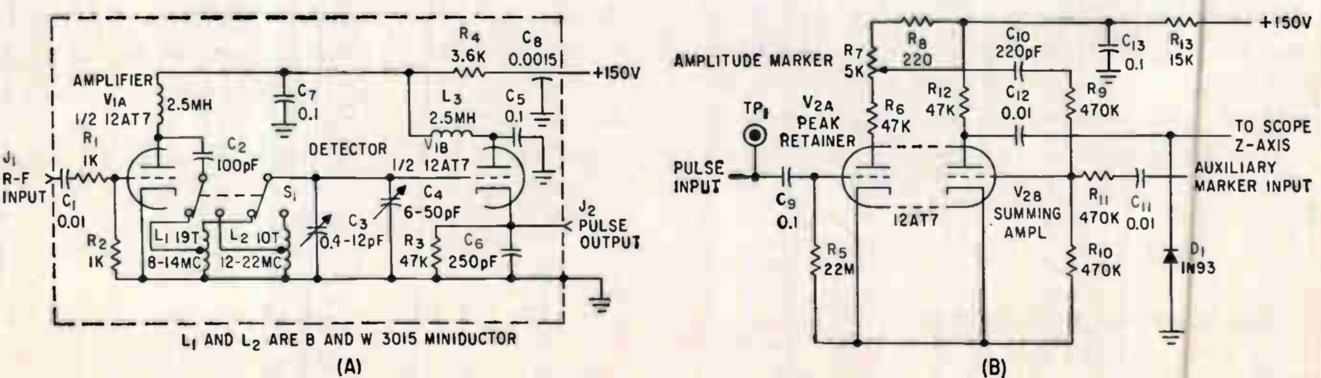

FIG. 2—Circuit details of marker generator for 8 to 22 Mc—in two overlapping ranges—is shown in (A). Summing network, with pulse amplifier, (B) allows auxiliary markers to be added

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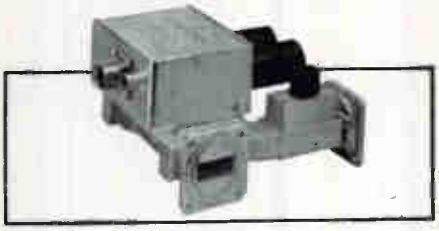

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Finding Ultrasonic Velocity

By D. E. KAUFMAN, Univ. of Calif., Los Alamos Scientific Lab., Los Alamos, N. M.

EQUIPMENT and techniques have been developed for displaying ultrasonic velocity of immersed media on an oscilloscope. These velocities can be used to analyze and classify materials and determine elastic moduli of solids. Minor velocity variations of metal samples can be correlated with grain structure, amount of cold working and direction of flow lines from forging and rolling. Velocities at different points in a sample can also indicate density inhomogeneities.

The immersion technique for finding ultrasonic velocity is convenient, practical and accurate. In the direct-coupling method formerly used, position of the ultrasonic source plane at the start of the pulses causes an error. Empirical corrections partly offset this error, but immersion techniques eliminate it entirely. Although the solid-replacement technique also eliminates the error, it requires that the sample be clamped between solid members and velocity compared with that in a standard sample.

Shear wave velocities can be found using Y-cut crystals that vibrate in the shear mode, but little energy is coupled to the sample. Longitudinal waves can also be fed into a coupling wedge using mode conversion at the interface of wedge and sample, but again coupling is rather poor. It is also difficult to distinguish ultrasonic pulses transmitted by longitudinal waves from shear waves passing through the solid. This is especially true in the many solids in which longitudinal velocity is near twice shear wave velocity.

In the immersion method, a transmitting and a receiving piezoelectric transducer are mounted in the walls of an immersion box. Pulses with fast rise time are generated to produce acoustical pulses with steep leading edges. Prf is nominally 60 cps but other rates are possible. Pulse amplitude is adjustable in 300-volt steps from 900 to 3,600 volts; output impedance is variable from 50 to 6,000 ohms for different crystals.

With dispersive materials or thin samples, oscillation of the acoustic pulse is reduced by a pulse delayed from 0 to 1.5 μsec to coincide with the first reverse swing of the acoustic output, and amplitude is adjusted for best cancellation.

A variable sweep delay for the oscilloscope of 20 to 250 μsec allows for ultrasonic transit time through a water path up to 14 inches between crystals. Jitter between the sweep trigger and the received ultrasonic pulse is held to $\pm$20 nanosec. An RC circuit and diode control a blocking oscillator that triggers the sweep.

Sweep time is indicated by synchronized clock pulses. One clock generates 0.2-μsec pulses; another generates 2-μsec pulses that index the 0.2-μsec pulses into groups of ten. Switches allow oscillator calibration during operation by comparison with a 5-mc crystal oscillator. After a 15-minute warmup, oscillators need a calibration recheck only every 2 or 3 hours.

Minimum vertical sensitivity of each channel of the dual-trace oscilloscope used is 0.5 v/cm; minimum sweep time resolution is 1 μsec/cm, with variable sweep magnification up to 5 times.

Goniometer dial in immersion box indicates angle of sample for ultrasonic measurements

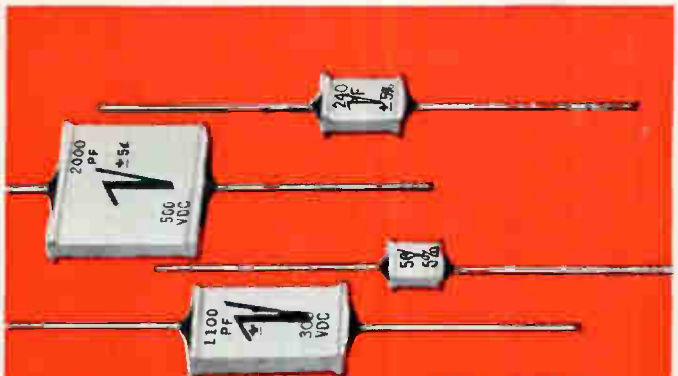
Amplifier gain, continuously variable from unity to about 10,000, can display pulses through samples up to 1 inch thick. Maximum output is 2 volts peak-to-peak. The upper limit of the 500-Kc to 18-Mc bandpass amplifies pulses from crystals with natural resonant frequencies to 10 Mc. The high level of the lower limit reduces response to slowly decaying trailing edges and improves recovery time after overload. High input impedance permits use of all types of receiving crystals. Low-impedance units need only a shunt impedance across the input.

Velocity Measurements

Except for thick or dispersive samples, longitudinal wave velocity is measured by the multiple-reflection technique. With the sample face normal to the ultrasonic beam, time t between successive reflections is read. Since the pulse travels twice sample thickness d, longitudinal velocity is $c_l = 2d/t$. Since most samples have at least two reflections, several time readings increase accuracy.

For thick or dispersive samples, the liquid-replacement method is used. With the sample normal to the beam, time difference Δt with and without the sample is noted. Velocity is $c_l = d/(t - \Delta t)$, where transit time through a liquid path equal to sample thickness is $t = d/c_f$ and c_f is velocity of liquid. Since liquid velocity depends on

Liquid-replacement method at left shows sample pulse (a) and first reflection (b) on trace 1 with direct water pulse on trace 2. Goniometer technique at right produces longitudinal wave pulse (a) and shear wave pulse (b) on trace 1 with direct water pulse on trace 2



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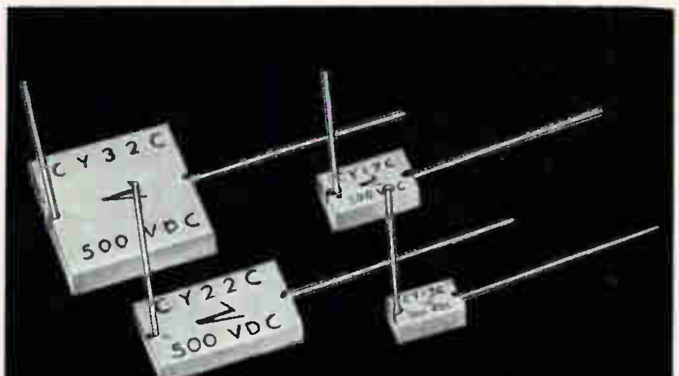

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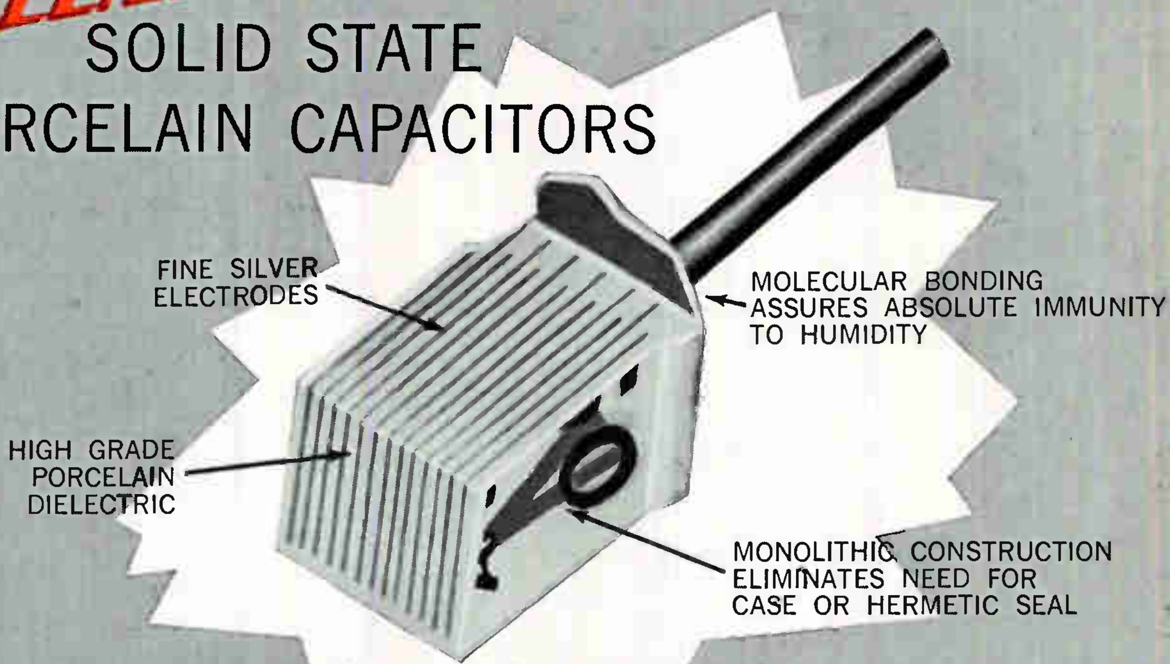

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temperature, temperature must also be measured, reducing accuracy.

The goniometer technique can measure ultrasonic shear velocity. The sample is rotated to angle θ from the beam so that mode conversion at the sample face produces a shear wave in it. A mechanism in the equipment can rotate the sample 45 degrees in either direction with a dial indicating θ within 10 minutes. Transit time with and without sample produces scope patterns like that in the figure. Considerable time expansion between shear wave and pulse is necessary. Noting liquid temperature and θ, shear velocity c_s is $1/c_s^2 = (\Delta t/d)^2 + 1/c_f^2 - 2\,(\Delta t \cos\theta/d\,c_f)$.

Goniometer rotation at and beyond angle θ_c, given by $\sin\theta_c = c_f/c_l$, shifts shear wave phase, invalidating results. Uncertainty can be reduced by averaging measurements for several values of θ on each side of the beam.

Accuracy with multiple-reflection is 1 percent and with water replacement and immersion 3 percent. Velocities were used mainly to find elastic constants but also to classify solids.

This work was sponsored by the Atomic Energy Commission and described at the Second Southwest Convention of the Society for Nondestructive Testing.

WWV Adds Experimental Standard Time Code

EXPERIMENTAL timing code has been added to the regular broadcasts of WWV. The code provides a standardized timing basis for simultaneous scientific observations at widely separated locations. For example, to analyze information from a satellite or to track it requires that signals received by a tracking station be identified by time and date.

The experimental code and broadcast were developed by several organizations including the Inter-Range Instrumentation Group, NASA, Convair Astronautics and the National Bureau of Standards. The time-code generator that pulse modulates WWV was designed by Electronic Engineering Company of California.

The experimental code is presently broadcast for one-minute intervals, ten times per hour.

The code is a 36-bit, 100-pps binary code. A complete time frame is one second. Nine binary groups per second include 2 groups for seconds, 2 groups for minutes, 2 groups for hours and 3 groups for day of year.

The binary groups follow the time frame reference marker. The least significant binary group and the least significant binary digit in each group appear first, making it necessary to read only as much code as desired. The exact point of time is indicated by the leading edge of all pulses.

The experimental code also contains blank spaces that may be used to transmit additional information.

Possible Use of Sun to Relay Radio Signals

POSSIBLE use of the sun as a huge reflector to relay radio signals between distant points on the earth during periods when the moon is not available was described by an RCA scientist.

D. J. Blattner said that such a method is technically feasible with presently known transmission techniques, and may be justified by the growing demand for more communication channels. The solar atmosphere of ionized gases can reflect coded radio signals with sufficient reliability for relaying limited amounts of data.

Signals of 40 Mc would be reflected from the corona. Such a system would require output of about one million watts, and a 120-foot parabolic antenna capable of following the sun. Because of the rotational speed of the sun there would be some smearing of the relayed signals, necessitating a wide-band receiver, with which would be associated data-handling equipment.

To overcome the spurious noise created by the solar atmosphere, Mr. Blattner suggested the use of 20-second pulses. A single digit would require several minutes for transmission, while a complete word would take nearly half an hour. In addition, the signal would take approximately 16 minutes to cover the round-trip distance between the earth and the sun.

Report on High-Temperature Ceramics

TO FILL THE NEED for more reliable data about high-temperature ceramic bodies, now very important for electronics applications, a specimen bank of such materials has been established for the measurement of physical properties and constants. This bank contains samples from the leading manufacturers. The samples are metal-ceramic combinations designed for use at elevated temperatures and will provide useful information that may be helpful.

The long range goal of the investigation is to supply reliable engineering data for these new classes of materials. The properties to be investigated include mechanical strength, elastic and anelastic characteristics, the temperature dependance of these properties, and thermal properties generally.

A mongraph[1], issued by the National Bureau of Standards, describes the materials and some of their fabrication data; bulk densities; theoretical densities; and the dynamic room temperature elastic constants. Data are given for 46 sets of specimens representing 20 different materials; these include oxides, carbides, borides, cermets, and an intermetallic compound.

Results of the room-temperature measurements show that significant variations are common both in the specimens of one group and from group to group of specimens prepared from the same material. The largest variations occur for specimens formed by hot pressing, although averages are higher for hot-pressed specimens. Measurements of the dynamic elastic constants by the sonic method are more sensitive as indicators of homogeneity and group uniformity than bulk-density measurements.

The 45-page monograph, originaly prepared by S. M. Lang who is now with the U. S. Atomic Energy Commission, has been revised by M. D. Burdick and S. Spinner. Most of the materials listed are commercially available; some are experimental. Some 25 tables are presented that give materials, source, and general fabrication data as well as the properties mentioned. The paper contains detailed descriptions of the methods used in calculating both the elastic constants and the statistical parameters.

These detailed descriptions have been included to leave no doubt as to the exact procedure, and to act as a guide to other workers who might wish to make similar determinations.

It is anticipated that significant advances will be achieved in the uniformity of commercially available materials only recently developed, such as hot-pressed stabilized zirconia. And the report points out that as more general experience in the hot-pressing techniques is accurately accumulated, one can reasonably expect to realize the advantages of both higher density and optimum uniformity of the products. Although production costs

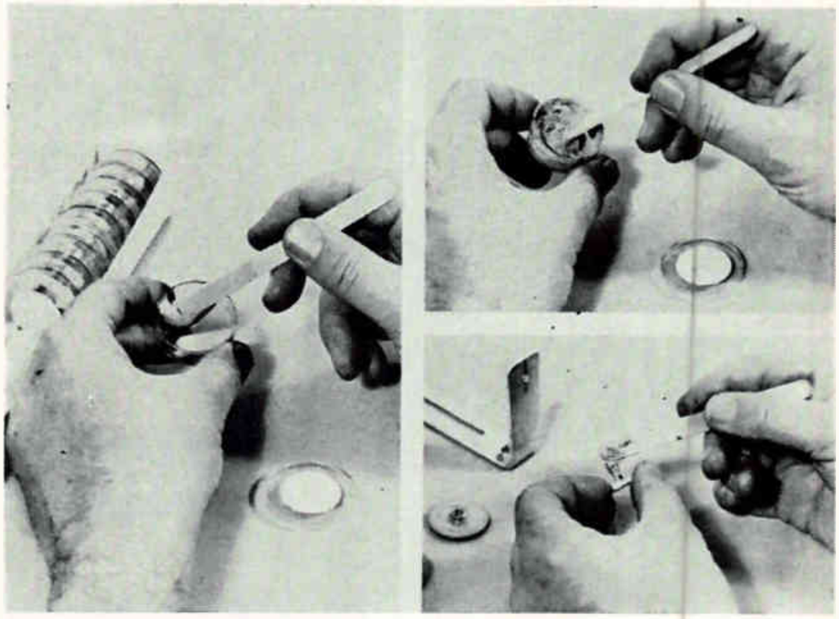
(*Continued on p 118*)

Bonding Components to Circuit Boards

TWO-COMPONENT epoxy adhesives that cure at room temperature generally harden within an hour after mixing. As a result, new batches must be mixed at frequent intervals. If the quantities used at each work station are small, this creates a measuring and mixing problem, as well as a clean-up problem.

Small plastic containers, introduced by Plastic Associates, Laguna Beach, California, each hold a premetered quantity of both adhesive and catalyst. The contents are mixed immediately prior to use, the adhesive applied to the parts to be bonded, and the empty containers thrown away.

A typical assembly-line application for these PACKETTE adhesives is the bonding of electronic components to circuit boards, applying adhesive to screw threads, and similar uses.



Pack (left) contains adhesive and activating catalyst and serves as mixing container (upper right) for adhesive application (lower right)

would dictate a minimum time at minimum heat-treating temperatures, a more uniform and reproducible product would result from increasing both firing time and temperature. This improvement in the product appears to be readily achievable at a slightly increased production cost. The value of a statistical analysis for selecting the optimum temperature and time should be apparent.

One of the main deterrents to the use of ceramic and cermet materials in many applications where they seem to be potentially useful is the lack of knowledge of the physical properties and constants of these materials and, when such information is available, the lack of confidence in the uniformity or reliability of the reported values. A great deal of information on product uniformity could be provided by the fabricators and suppliers, usually without additional expense.

The following materials were among those investigated in the NBS report: aluminum oxide, ruby alumina, magnesium oxide, mullite, thorium dioxide, uranium dioxide, stabilized zirconia, alumina + chromium, Ni-bonded titanium carbide, boron carbide, silicon carbide, zirconium carbide, zirconium diboride, molybdenum disilicide and nickel aluminide.

REFERENCE

(1) S. M. Lang, Properties of High-Temperature Ceramics and Cermets, Elasticity and Density at Room Temperature, National Bureau of Standards Monograph 6, March 1, 1960.

Solventless Resin

SILICONES Division, Union Carbide Corporation, announces that its solventless silicone resin for high temperature insulation is now commercially available. Formerly marketed under the experimental designation Y-2090, it is now sold as XR-65 Silicone.

The silicone is used commercially in the manufacture of glass reinforced spacer bars for transformers. It can be used for form-wound coil impregnation, for lamination using wet lay-up techniques, and for potting and encapsulation.

This material can be effectively used for lamination of glass cloth using wet lay-up techniques, such as are common in the polyester and epoxy fields. This technique gives a new degree of freedom for the fabrication of both simple and complex shapes for high temperature service where high pressure laminating equipment is not available. It is a 100 percent reactive silicone resin. In addition, it can be combined with organic monomers to provide tailor-made insulating resins.

The need for solvent removal during curing is eliminated by its use. This advantage has already led to important forward steps in the manufacture of spacer bars for high temperature service by a continuous process developed by Polyglas Division of Pittsburgh Electrical Insulation Company.

"This process was not possible until the development of a new solventless resin which eliminates the need for removal of volatiles during cure," R. D. Kidney, of Polyglas Division of P. E. I. and F. W. Bailey, of Union Carbide, said in a paper delivered at the Second National Conference on the Application of Electrical Insulation, held in Washington last December.

Polyglas bars were adopted by the I-T-E Circuit Breaker Company of Philadelphia for their new line of transformers.

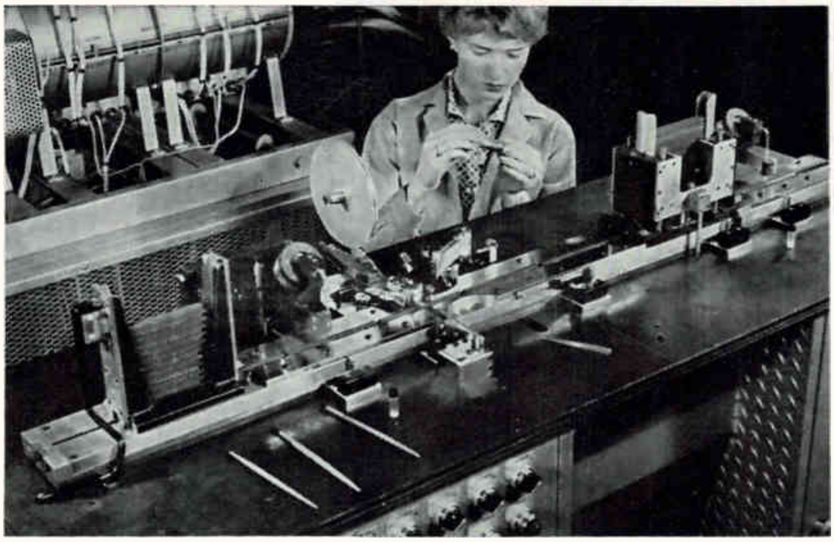
Flue Dust Used To Make Germanium

VIENNA, AUSTRIA—The staff of the Raw Materials Institute at Kutna Hora (Czechoslovakia) established only a year ago, has developed a new method for the production of germanium from the flue dusts of certain types of Czechoslovak coal. The method will be introduced in industrial production soon. Czechoslovakia has so far had to import germanium, which is mainly used for the production of transistors, according to CTK, the Czech State News Agency stated.

The construction of a plant for the production of transistors, is being completed in Benesov, near Prague. Part of the plant, which will employ mainly women, will be put into operation during the second half of this year.

Boat Loader Boosts Transistor Production

By W. T. SHINN, Mechanization Section Head, Semiconductor Division, Raytheon Co., Newton, Mass.

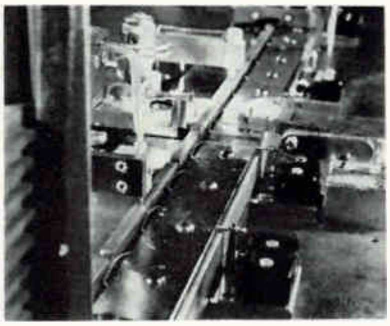


Loading machine stations (left to right) are: boat magazine, emitter, base tab, crystal, cover and collector feeders. Attendant holds container of emitter spheres

THIS DIVISION is converting to automated production of its medium frequency *pnp* germanium transistors. Besides direct savings in labor, reliability is greatly improved by the changeover from manual methods. In addition, the equipment is readily adaptable to production of other transistors.

First stage in the production line are automatic alloy boat loaders. Manual loading methods formerly used to produce alloy junction transistors required a great deal of patience and skill from operators. The new loaders need only an observer to monitor operation. Filled and covered boats are prepared at a rate of 2,500 transistors an hour.

Three loaders are in operation, with others under construction. Some of the succeeding production steps are also automated and equipment for other steps is in design and development. Provision is made for automatic testing, sorting and reprocessing of individual units throughout the line. Carrier and boat design allows automatic removal and replacement of individual units, or batch processing of entire carrier loads. Close spacing of cavities in boats and carriers permits rapid machine transfer from, cavity to cavity.



Boats being fed through feeding stations along track

A line of multicavity boats are indexed through stations where parts of the transistor subassembly are fed and positioned. The cavities are uniformly spaced in a single row. Transistor base tabs extend beyond the side of the boat, providing a handle for further automatic processing. The boat cover helps position the parts and protects the base tab extension.

Empty boats are fed from a magazine. The transfer bar has a series of pins, each of which pushes a boat along a guided path. The bar is indexed in single-cavity increments, positioning the boat cavities in feeding stations. The stations are spaced at multiples of boat lengths and feed corresponding cavities simultaneously.

Each boat is completely filled at a feeder station. While the last cavity in a boat is being filled, the transfer rotates 90 degrees to swing down the transfer pins. The bar then returns and rotates back, bringing the pins in position to pick up the next boat. The arrangement assures maximum accuracy in parts positioning since each feeder always has the boat it is filling positioned by the same pin.

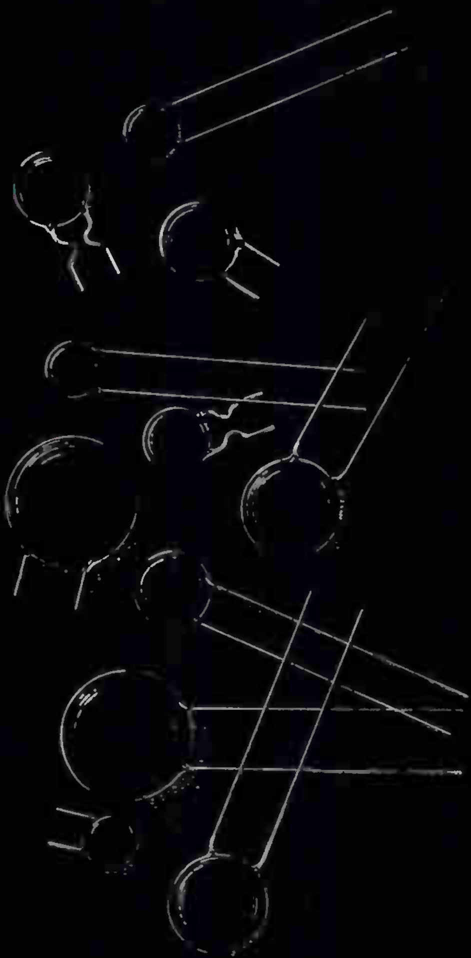
The transfer bar is advanced for ¼ of the machine cycle in a modified harmonic motion. The bar is indexed by an arm engaged in a rack on the bottom of the bar. The arm is engaged for ½ of every other revolution of its driving eccentric.

The emitter, a 0.009 inch indium sphere, is fed first. Such small, soft spheres tend to adhere to most materials, making a conventional escapement difficult to use. The feeder developed for Raytheon's machine has a cavity into which a single sphere is isolated by a vacuum system. The sphere is pneumatically directed into the boat cavity through a tube.

Base tabs are fed from a continuous coil of prestamped, tin-clad nickel ribbon. The ribbon is fed, tinned side up, over the boat cavity by a hitch-feed mechanism. The mechanism engages a prestamped reference surface of the tab to

Closeup of carbon boats and covers

CDE *Consistently Dependable Capacitors*



TINY MIKE®

Cornell-Dubilier's low-inductance ceramic-disc capacitor for transistorized applications

Tiny Mike miniature ceramic disc capacitors are designed to meet the limited-space, low-voltage requirements of portable transistorized radios and a wide variety of other miniature battery-powered and line-powered equipment. Especially applicable for bypass and coupling use, their tough phenolic coating and high-temperature wax impregnation provide excellent insulation, protect against high humidity and severe vibration. Immediately available in production quantities.

For detailed information and engineering assistance, write for Bulletin SEB-2 to Cornell-Dubilier Electric Corporation, South Plainfield, New Jersey. *Manufacturers of consistently dependable capacitors, filters and networks for electronics, thermonucleonics, broadcasting and utility use for 50 years.*

SPECIFICATIONS AND FEATURES

Capacitance values available: .005, .01, .02, .05, and .1 mfd.

Diameters: .350" to .625"

Working Voltage: 50 VDC

Crimped and Straight-Cut Leads for Automation. These units are available in 600 and 1000 VDCW ratings on types C, JA, JB, JC, BYA and other general purpose capacitors. Leads are accurately spaced for easy insertion into printed wiring boards. Crimped leads prevent bottoming on printed wiring boards, assuring positive contact for soldering. Straight-cut leads save height off the board and may be inserted to circumference of disc. Controlled phenolic dip avoids "rundown" of the phenolic on straight-cut leads. Assures always-uniform soldered connections.

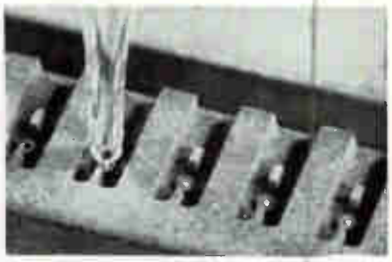
CDE **CORNELL-DUBILIER ELECTRIC CORPORATION**

AFFILIATED WITH FEDERAL PACIFIC ELECTRIC COMPANY

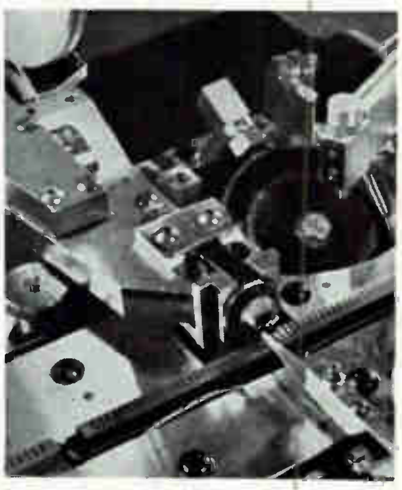
CIRCLE 123 ON READER SERVICE CARD

assure accurate positioning without cumulative error. A finger guides and presses the ribbon into the cavity. The ribbon is sheared, forming a tab. The emitter sphere is within a hole in the base tab.

A germanium crystal, 0.045 inch square by 0.0025 inch thick is next placed over the hole in the tab. A rotating dish inclined at about 30 degrees from horizontal contains square recesses located in a circular array. Each recess is wide enough to contain and orient crystals lying flat and is deep enough for several crystals. The dish, partly filled



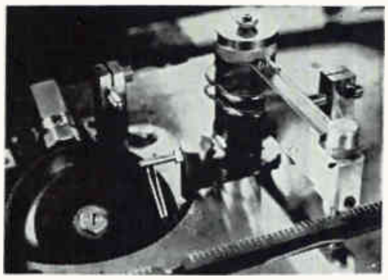
Pneumatic tube feeds emitter spheres into boat cavity



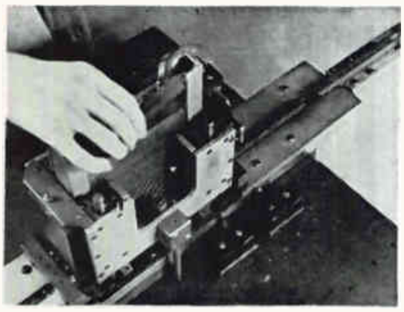
Base tabs being punched from ribbon and placed in boat. Scrap take-up reel is at upper left

with crystals, is indexed about its center. As each recess passes beneath the crystals, it receives several crystals and carries them to the top of its path. A vacuum capillary pickup, mounted on an arm, removes the top crystal and deposits it in the boat.

The boat then passes under the cover storage magazine. Vertical slides at each end of the magazine carry pairs of metal fingers. When the slides are up, the fingers grasp the bottom cover and the gate is opened. The fingers are lowered by



Crystals are deposited in cavity by vacuum pickup arm at right



Filling cover magazine. Track at right carries loaded boats to alloying furnace

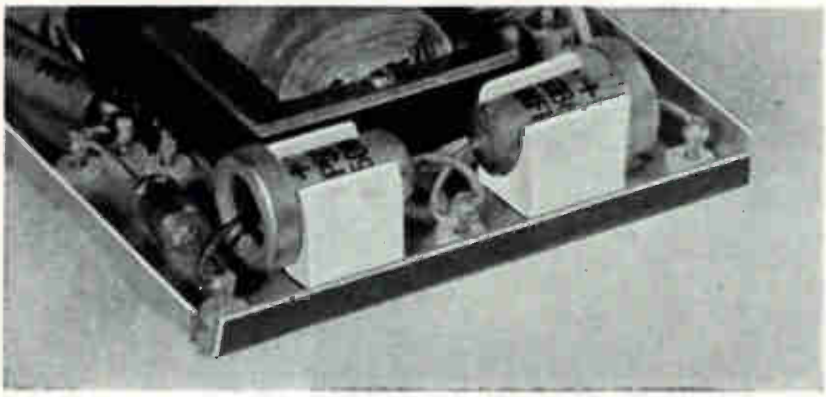
the slides, carrying the cover down, and the gate closes. The fingers put the cover on the boat. The cover is slotted to provide a spring-loaded fit with the boat. Another set of spring-loaded fingers seats the cover.

Indium collector spheres are fed with a mechanism similar to that used for emitter spheres. Tapered holes in the boat cover locate the spheres on the crystals. Since additional weights or plungers are not required in production of this transistor, the boat is ready for the alloying furnace.

Filter Tape Monitors High-Purity Water

SOLIDS CONCENTRATION in high-purity rinse water can be monitored with an instrument developed by Graver Water Conditioning Co., New York, N. Y. A measured amount of water is passed through a Millipore filter. The degree of discoloration of a portion of the tape indicates the amount of trace contaminates. Further identification of the contaminates can be made by analysis. The filter tape is backed by nylon, so samples can be taken in sequence. The time each sample is taken is printed on the tape.

New On The Market



Component Holders
PRESS INTO BOARD

PROTECTION FOR tantalum capacitors is afforded by snap-fit nylon component holders, manufactured by Industrial Devices, Inc., 982 River Rd., Edgewater, N. J.

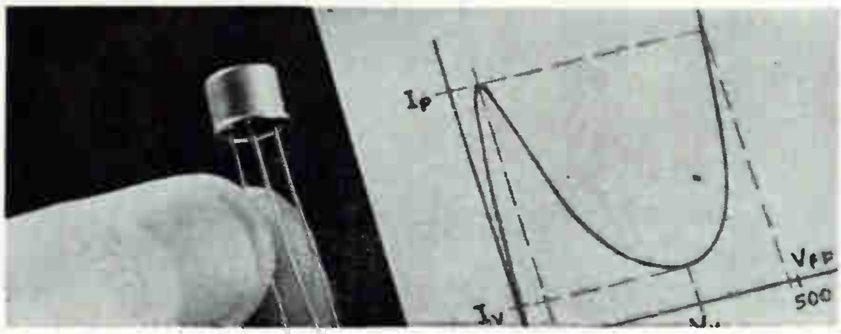
Known as Cap-Sure holders, the units are light in weight and low in cost. They are installed by pressing into the mounting board. The tantalum capacitor snaps into the holder. Moisture trapping mounting holes are eliminated and minimum board space is needed.

The units will withstand over 30 lb pull-out from the mounting board over a −55 to 125 C temperature range and will hold the capacitor securely under temperature, humidity and vibration extremes.

Model 1470, for 9/32-in. diameter components, is 5/16-in. long, 0.398-in. wide and weighs less than 1 gram; model 1471, for 3/8-in. diameter components is 3/8 in. long, 0.483 in. wide and weighs under 1.3 grams. Both are available for either 0.136 or 0.172 dia. mounting holes.

Model 1470 is priced at $.85 and model 1471 at $.105 in production quantities. Delivery from stock for small quantities.

CIRCLE 301 ON READER SERVICE CARD



Tunnel Diodes
GERMANIUM DENDRITES

PROTOTYPE sample quantities of dendritic tunnel diodes are now available from Westinghouse Electric Corp., Box 2278, Pittsburgh, Pa. These devices are suited for applications in logic, switching and computer circuits where faster switching times than those possible with transistors are required.

The new diodes have a typical peak-to-valley ratio of 8 to 1 and operate at high frequencies. Other ratings include: forward current 25 ma; reverse current 25 ma; dissipation 50 mw; junction temperature 100 deg. C.

These tunnel diodes (type WX-822) are made of germanium grown by the dendritic crystal process that produces uniform strips of material in the exact form in which it is used. This process permits greater utilization of high cost semiconductor crystal, and as a result, it has been possible to introduce this new device at a low price.

Prices of the type WX822 germanium tunnel diodes will depend on type and quantity ordered, and will range from $4.00 to $5.50 per unit in quantities up to 24; from $3.20 to $4.00 for 25 or more.

CIRCLE 302 ON READER SERVICE CARD

Image Intensifier
INCREASED AMPLIFICATION

IMAGE intensifier tube for x-ray work with 300 percent increase in amplification over presently available tubes is announced by Machlett Laboratories, 1063 Hope Street, Springdale, Conn., a subsidiary of Raytheon Co.

The tube can increase the brightness of a fluoroscopic screen 3,000 times and, when used with the Dynamax 50 grid-controlled x-ray tube, makes possible x-ray movies of the heart and other body processes with less than one fourth of previously required exposure.

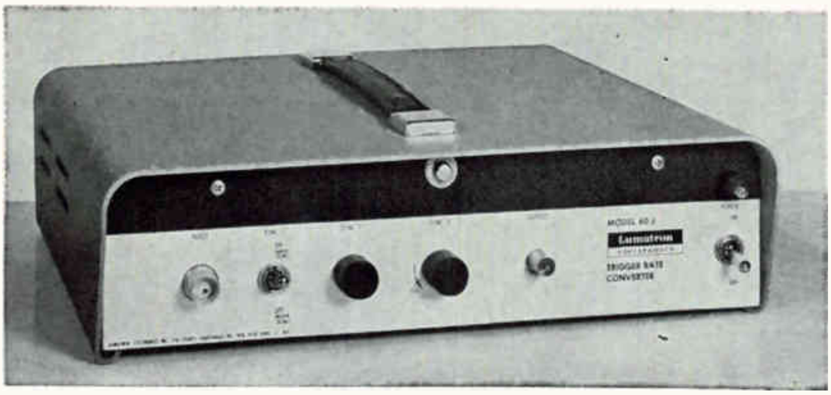
Both the input screen and the photocathode structure of the ML-9421 image intensifier tube are multilayered. The primary coating is a zinc-sulphide silver-activated phosphor that produces the initial light image. The photoemissive layer accepts this light energy and converts it into electrons which are accelerated toward and focused upon a fluorescent output screen.

The brightened smaller image

may be viewed directly, recorded on film, or monitored by a television system.

Using a 9-inch input screen, the ML-9421 has a minification factor of 8.7 and delivers the picture on a screen one inch in diameter with a brightness amplification of 3,000 times. Minimum contrast is 4 percent and minimum definition is 40 line pairs per inch.

CIRCLE 303 ON READER SERVICE CARD



Unique Rate Converter

TRIGGERS OSCILLOSCOPES

CONVENTIONAL and sampling oscilloscopes can be triggered at rates up to 300 Mc using a trigger rate converter manufactured by Lumatron Electronics, Inc., 116 County Courthouse Road, New Hyde Park, L. I., New York. The model 602 makes it possible to view sine waves up to 60 Mc on 30 Mc oscilloscopes, and to view waveforms recurring at 300 Mc on ultrahigh speed oscilloscopes which, by themselves, can handle only much lower trigger rates.

The model 602 generates pulses of nanosec rise times at a 50 Kc repetition rate. These pulses are synchronous with the input signal. By connecting the model 602 between the trigger source and the external trigger input of a conventional oscilloscope, the oscilloscope will trigger with excellent stability at rates exceeding the oscilloscope manufacturers' specifications.

The instrument is fully transistorized and fits on top of typical oscilloscopes. It is 3½ in. high, 13 in. wide and 10 in. deep.

Only one control is used for input frequencies below 30 Mc. A second control tunes the unit to the higher frequencies. When using the model 602, the trigger controls of the oscilloscope become so stable that virtually no readjustment is needed after the initial setting.

Price is $440, including a built-in transistorized and regulated power supply. The Model 603 (with an additional low frequency output at approximately 700 cps) is priced at $480. The units are available for prompt delivery.

CIRCLE 304 ON READER SERVICE CARD

Needle Thermistor Probe

SPRING LOADED GUIDE

LINE of retractable, through-surface probe tips for making temperature readings at desired depths of nonrigid masses such as chemicals, plastics and rubber is announced by Atkins Technical, Inc., 1276 W. Third St., Cleveland, Ohio.

The sensitive needle tip of the probe is protected within a sheath when not in use. When temperature readings are desired, the user turns a dial selector on the probe. This permits insertion of the tip into nonrigid masses to the proper depth to obtain an accurate temperature reading. On withdrawing the needle the combination adjustable stop and needle sheath protects the user and the needle against damage.

The nonrigid mass measuring probes are water tight and abrasion proof and are designed for use with Atkins A+ Thermophil instruments covering −150 to 410 F temperature on multiple scales. The model 4412 instrument measures from 32 to 410 F on three scales. Readings are to ¼ deg and accuracy is within 0.2 percent for the first third of the total 390 deg range.

Accuracy at the extreme point is within 0.7 percent. Portable models using standard dry cell batteries, and a-c powered models, are available.

CIRCLE 305 ON READER SERVICE CARD

Power Density Meter

LIGHT AND PORTABLE

A DIRECT READING meter, used with one of three constant gain calibrated probes, permits speedy and precise determination of r-f power density. Designated model NF-157, and made by Empire Devices Products Corp., Amsterdam, New York, the broadband indicating device is capable of reading power density from 0.1 mw per sq. cm.

Using small batteries as a power source, the basic unit weighs ten pounds; physical separation of probes from the main unit increases the applications. Applications include: indication of personnel safety in high density r-f fields; near-field intensity measurements; measurement of absolute power from 0.1 mw to 2 w; the detection of hot spots and leakage near antennas, feeds and other high-power components.

In operation, power densities are converted by the probes to corresponding power levels in watts, then fed to an attenuator as selected by the power level setting. Attenu-

Microwave Component News from SYLVANIA

Millimeter devices now available in six product lines

SMALLER, LIGHTER BACKWARD-WAVE OSCILLATOR

Type BW-1757 delivers up to 15 mw from 26.5-41 kmc in a streamlined new package. Also available are types from 18 to 26.5 and 40 to 75 kmc. BWO's above 75-100 kmc are in development.

FERRITE CIRCULATORS AND ISOLATORS

In production at Sylvania are Tee circulators and waveguide isolators in the 18 to 26 kilomegacycle range. Development programs are under way for devices above 26 kmc.

MAGNETRONS DELIVERING UP TO 100 KILOWATTS

Sylvania's line of rugged Ka-band magnetrons have output powers from 20 to 100 kw. K-band type M-4154 delivers 55 kw. Samples are available of new, rugged Ka-band type M-4218, weighing only 4½ pounds. Techniques are available for development of types to 100 kilomegacycles.

NEW WAVEGUIDE WINDOWS AVAILABLE

Sylvania is now producing two new waveguide windows in K and Ka bands, with flanged mica windows:

Type WG-4224	18 to 26 KMC
Type WG-4223	26 to 40 KMC

SYLVANIA TR AND ATR TUBES

Sylvania-developed TR and ATR tubes for Ka-band operation are available with power handling capability up to 100 kw.

IN THE DEVELOPMENTAL STAGE:

Sylvania has proved research and development capability for O and M type devices. One of the important projects now programmed at Sylvania's Bayside Physics Laboratory is a harmonic generator in the 200 to 400 kmc range which takes advantage of the non-linear conductivity characteristics of Germanium. And the Bayside labs are at work on the Tornadotron, with which 0.1 MM will be reached; millimeter amplifiers are also in development.

For further information write Sylvania Special Tube Operations, 500 Evelyn Ave., Mountain View, California, indicating the product lines in which you are interested.

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

GENERAL SYSTEM

ated power is measured by a thermistor element in a temperature compensated d-c bridge. Power density is shown directly. A self-calibration feature permits checking zero balance and bridge sensitivity at all times.

CIRCLE 306 ON READER SERVICE CARD

Sensitive Accelerometer

MEASURES TO 0.0025 G

SENSITIVITY of 100 millivolts peak per g peak is obtainable for low-level g measurement and vibration studies with the model 408 accelerometer announced by Columbia Research Laboratories, MacDade Blvd. and Bullens Lane, Woodlyne, Pa.

The accelerometer has a case design that permits operation with minimum spurious response in high intensity noise fields of 160 db and other nonvibrational environments. Maximum acceleration is 10,000 g, frequency response is from 1 cps to 3 Kc with resonant frequency at 55 Kc and amplitude linearity is plus or minus 1 percent. Temperature range is −65 to 300 F for standard units; −65 to 500 F for high temperature units, with less than ±10 percent variation in sensitivity throughout both temperature ranges.

Case is a stainless-steel $\frac{3}{4}$ in. hexagon 0.45 in. high with a threaded mounting stud on the underside of the case; unit weight is 23.5 grams. The model 408 can be furnished with its seismic element electrically insulated from the metal case.

The unit is available on two-week delivery at single unit price of $160, decreasing to $136 each for 50 units.

CIRCLE 307 ON READER SERVICE CARD

Angular Motion Transducer

LOW REACTION FORCE

CONVERSION to voltage of angular motion up to plus or minus 40 deg with better than 0.25 percent linearity is available with the Metrisite transducer. This device operates at 60 cps. Designated type 34A, the unit is available from Brush Instruments, division of Clevite Corp., 37th and Perkins, Cleveland, Ohio.

The transducer is designed for measurements of high accuracy under rugged environmental conditions in both industrial and military applications.

A small force will move the armature since only bearing friction need be overcome. Reactive force is negligible—about 9 milligram cm per degree. Scale factor is 0.57 volt rms per deg. Null is less than 0.1 volt. Size is 3 by 2⅝ by 1⅞ inches; weight is 20 oz.

The device has a three-legged magnetic core with an electrical coil around each leg. Identical secondary coils are connected in series opposition.

The center leg has an air gap in which a small lightweight, nonmagnetic armature moves. When an alternating-current input energizes the center primary coil, a magnetic field is set up in both loops of the core which induces a voltage in the outer secondary coils.

With the armature at dead center the magnetic fields are symmetrical and the induced voltages in the secondary coils are equally opposed. Output is zero.

Movement of the armature produces an imbalance of the two magnetic fields which results in an output signal directly proportional to armature movement.

CIRCLE 308 ON READER SERVICE CARD

Low Current SCR's

GLASS-TOP DESIGN

GENERAL ELECTRIC CO., Charles Building, Liverpool, N. Y. General applications of the new line of silicon controlled rectifiers are expected in circuits for pulse and phase controlling d-c output as well as power inversion. Featuring a glass-top design, the scr's are specially engineered for a long creepage path, an important consideration when the device is operating at high voltages and high altitudes. Eight models are available. They differ by repetitive piv ratings, which range from 25-v for the C10U to 400 v for the C10D.

CIRCLE 317 ON READER SERVICE CARD

Frequency Meters

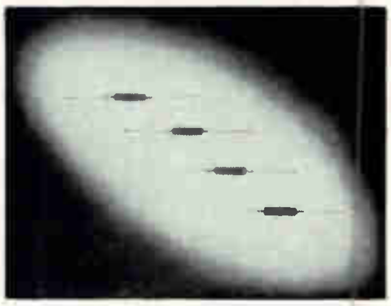
EXPANDED-SCALE

AIRPAX ELECTRONICS INC., Seminole Division, Fort Lauderdale, Fla. For highly accurate measurement of 400 and 60 cps power frequencies, these expanded-scale frequency meters are said to provide an exceptional degree of reliability and readability. Accuracy of frequency indication is 0.1 percent. These display type panel meters feature a combination pointer and a 4½ in. anti-parallax mirrored scale for precision measurement and elimination of reading errors. Meters are also available for nonstandard ranges having a center frequency as high as 100 Kc and an

CIRCLE 131 ON READER SERVICE CARD

expansion as narrow as ±5 percent around the center frequency.

CIRCLE 318 ON READER SERVICE CARD



L-V Capacitors

HIGH RELIABILITY

DEARBORN ELECTRONIC LABORATORIES, INC., 1421 North Wells St., Chicago 10, Ill. Subminiature 50 and 100 v capacitors for transistor circuitry are designed to meet reliability requirements of specifications MIL-C-14157B and MIL-C-26244 (USAF). They are lightweight, small and real space savers with quality assurance guaranteed. Capacitance ranges from 0.001 μf to 1.0 μf with an operating temperature range of $-$ 55 C to $+$ 125 C. Capacitance tolerance is $\pm$ 10 percent, however $\pm$ 5 percent is available on request.

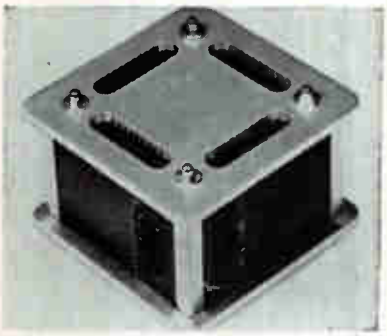
CIRCLE 319 ON READER SERVICE CARD

Film Potentiometers

LOW-NOISE

COMPUTER INSTRUMENTS CORP., 92 Madison Ave., Hempstead, L. I., N. Y. New potentiometers, available in diameters from ½ in. to 5 in. and linearities to 0.015 percent, are engineered around a smooth, stepless, infinite resolution hard carbon film element. Quality of this element is such that less than 0.1 percent of the excitation voltage appears in the output as noise. Also featured are multi-million cycle life, operation at video frequencies, MIL-spec design and rotational speeds to 1,000 rpm. Pots are available with linear or nonlinear outputs to a conformity ten times better than that available in comparable wire-wound units.

CIRCLE 320 ON READER SERVICE CARD

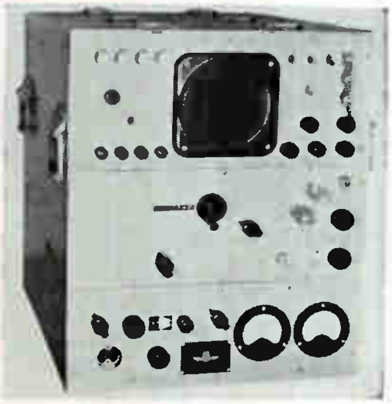


Memory Core Stacks

BOXED 50 MIL O-D

FERROXCUBE CORP. OF AMERICA, Saugerties, N. Y., announces a complete line of boxed 50 mil o-d memory core stacks for use in coincident current, transistorized computers. These stacks are available in any wiring configuration with switching times as low as 3/10 μsec and drive currents as low as 360 ma. Word range is from 256 to 16,384 words. All cores are thoroughly checked prior to insertion in the memory and again following assembly.

CIRCLE 321 ON READER SERVICE CARD

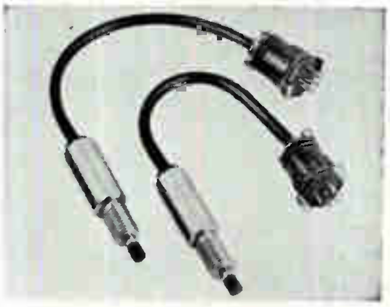


Pulse Power Calibrator

X-BAND UNIT

GENERAL COMMUNICATION CO., 667 Beacon St., Boston 15, Mass. Model PCX-9 X-band pulse power calibrator covers the range of 8,500 Mc to 9,600 Mc, and is designed to measure the power of pulsed r-f signals above the level of 0.5 mw within an accuracy of $\pm$0.5 db. A reference level is established each time the equipment is used. Ease of operation is assured by direct reading of power. Parallax and other instrumental errors are eliminated by the notch and reference line display and built-in facilities eliminate the necessity for factory adjustment.

CIRCLE 322 ON READER SERVICE CARD



Transducers

LINEAR DISPLACEMENT

DAYTRONIC CORP., 225 S. Jefferson St., Dayton 2, Ohio. Accurate electrical measurement of linear displacement, motion, size, strain and similar mechanical phenomena with minimum transducer size and weight is achieved with the new series 103A transducers. Based on the differential transformer principle, the units offer resolution to 0.5 μin., linear ranges to $\pm$ 0.100 in., and freedom from the wear and "noise" problems of potentiometer type transducers. Output is 3.0 mv per 0.001 in. per v of excitation. Diameter is $\frac{1}{2}$ in., length is $1\frac{3}{4}$ in. Linearity is 0.25 percent.

CIRCLE 323 ON READER SERVICE CARD

Voltage Regulator

STATIC-MAGNETIC

SOLA ELECTRIC CO., 4633 W. 16th St., Chicago 50, Ill. New Solamatic line of static-magnetic voltage regulators is designed for three-phase circuits from 50 Kva to 2,000 Kva. Line is capable of serving very large machines, or entire bays or departments of commercial or industrial plants. Typical applications are in a-m, f-m, and tv broadcast stations. Units automatically and continuously deliver output voltage controlled within ± 1 percent under line voltage variations as great as ± 10 percent. Response time is 1.5 cycles or less. Regulation is maintained even during extremely fast load changes ranging between zero load and rated load as well as simultaneous changes in load power factor ranging between unity and 85 percent lagging. Output is sinusoidal, with less than 5 percent total rms harmonic content at any load, making the regulator well-suited to critical applications where harmonic-free supply is required.

CIRCLE 224 ON READER SERVICE CARD

Beam Pentode

VARIED USES

PENTA LABORATORIES, INC., 312 N. Nopal St., Santa Barbara, Calif. The PL-4E27A beam pentode tube, suitable for use as an amplifier, modulator, or oscillator is now available. In Class-C service it will deliver over 400 w usable power output with approximately 2 w driving power. As a Class-AB, linear amplifier, the tube will provide over 260 w of usable power output. The tube has a plate dissipation rating of 125 w. Maximum plate voltage is 4,000 v, and maximum plate current is 200 ma. Grid-screen mu factor is 5.0, and transconductance is 2,500 μmhos. PL-4E27A maximum ratings apply to 75 Mc;

forced-air cooling is not required, except at frequencies higher than 75 Mc, or where the ambient temperature is exceptionally high.

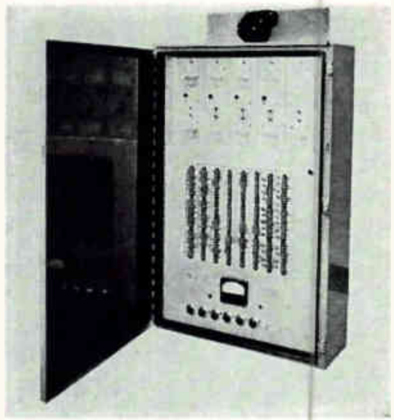
CIRCLE 325 ON READER SERVICE CARD

Thin Sheet Ceramic

HIGH DIELECTRIC

MULLENBACH DIVISION, Electric Machinery Mfg. Co., 2100 E. 27th St., Los Angeles 58, Calif., has available thin sheet ceramic in dielectric constant ranges of 1,200, 1,600, 1,800, 1,900 and 2,200 for capacitor manufacture or substrate applications. Capacitance varies only ±10 percent for 1,200 K and ±15 percent for higher values from −55 to +150 C. Leakage resistance 20,000 megohm-μf. Stock thicknesses are from 3 to 10 mils with the extended range of 1.5 to 20 mils available. Breakdown voltage is 400 v/mil. Production quantity ceramic is available plain or silvered, in various sizes.

CIRCLE 326 ON READER SERVICE CARD



Analog Computer

ALL SOLID STATE

SOUTHWESTERN INDUSTRIAL ELECTRONICS CO., 10201 Westheimer, Houston 27, Texas. The CM-3 analog computer provides continuous "real time" solutions for mathematical computations and "real time" control of variables in the chemical, petrochemical, refining and process industries. It will increase efficiency, product purity and overall profitability by eliminating human error in computation and/or adjustment of set points, and by optimizing control conditions. A single CM-3 cabinet contains a

maximum of 12 amplifiers, however there is no electronic limit to the number of amplifiers which can be used. Any number of amplifiers, square root and logarithmic networks may be specified according to functional requirements.

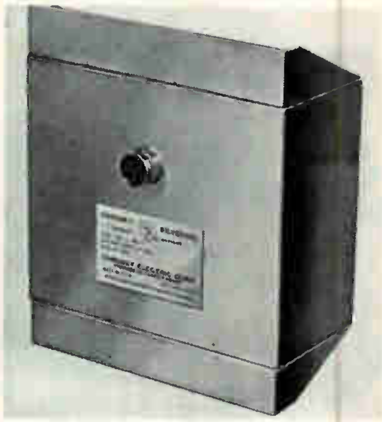
CIRCLE 327 ON READER SERVICE CARD

Subcarrier Oscillator

PRECISION UNIT

HOOVER ELECTRONICS CO., 110 West Timonium Road, Timonium, Md. Through the use of novel circuits, the model 10087 oscillator offers a linearity within 0.1 percent of bandwidth, and a frequency and sensitivity stability within 0.3 percent over the temperature range of 0 to 85 C, and 0.6 percent over the temperature range of −18 C to +100 C. This model is manufactured to IRIG standards and is available for channels 8 through 18 and A through E.

CIRCLE 328 ON READER SERVICE CARD



Missile Battery

SILVER-ZINC

YARDNEY ELECTRIC CORP., 40-50 Leonard St., New York, N. Y. A miniaturized automatically activated silver-zinc battery that weighs only 4.25 lb, including case, heaters and activation mechanism, has been developed for missile applications. This 19-cell powerpack is 2.75 in. high, 5.07 in. wide and 6 in. long. Rated at 1 ampere hour, the P-1542 is capable of being discharged at 15 amperes for 3 minutes. It has an open-circuit voltage of 33-35 v and an operating voltage range of 26-33 v. It has a minimum dry shelf life of 5 years, an

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For your electronic/electromechanical packaging problems, consult Oster specialists. Compact, transistorized, MIL spec, hermetically sealed, plug-in modules are available for numerous applications.

Typical building block basic units are illustrated. Temperature range is —55°C to +105°C. Basic units can be modified easily or completely redesigned to your specific requirement.

Oster engineers are specialists in creating densely packaged black boxes. These boxes can help you design more compactness and less weight into your systems. Phone or write your nearest John Oster office today.

GENERAL ENVIRONMENTAL CONDITIONS

A. Temperature—	—55°C to +75°C
B. Altitude—	—1000 Feet to +80,000 feet
C. Humidity—	Section 4.4.3 of MIL-E-5272
D. Vibration—	0.30 inch double excursion from 3 to 18 cycles per second and ± 2 g. acceleration from 18 to 500 cycles. (Without vibration isolators)
E. Crash Safety—	Repeated shocks of 30 g. with durations of 11 milliseconds
F. Salt Atmosphere—	Section 4.6.1 of MIL-E-5272
G. Fungus Growth—	Section 4.8.1 of MIL-E-5272
H. Sand and Dust—	Section 4.11.1 of MIL-E-5272

GENERAL PERFORMANCE SPECIFICATIONS

A. Gain Variation—	Less than 10% due to any given parameter extreme variation.
B. Linearity—	Better than 10% through the range of 3% to 80% of full output.
C. Noise—	Less than 5% of maximum output.
D. Phase Shift—	Less than 8 degrees.

Oster ®

TYPE 9805-20— SYNCHRONIZER
Same as 9805-19 except Control Transformer Speed is 10 degrees/second—Min.

TYPE 9805-19—SYNCHRONIZER


Synchronizer

Motor Control Phase— 40/20 volts, 1.7 watts, 400 cycles
Motor Reference Phase— 57.5 volts, 2.2 watts, 400 cycles
Generator Excitation— 57.5 volts, 3.0 watts, 400 cycles
Generator Output— 0.3 volts/1000 R.N.M. Min.
Control Transformer Speed- 100 degrees/second-Min.
Control Transformer— John Oster Mfg. Co. 4053-19
Motor Generator— John Oster Mfg. Co. 6232-17

TYPE 9616-08—DEMODULATOR AMPLIFIER


Demodulator Amplifier

Input Impedance— Greater than 25,000 ohms
Output Impedance— 2830 ohms (Dual)
Voltage Gain— Greater than 115
Supply Voltage— 28.0 D.C.

TYPE 9616-07—SYNCHRONIZER AMPLIFIER


Synchronizer Amplifier

Input Impedance— Greater than 50,000 ohms
Voltage Gain— Greater than 250
Load— Control Phase of Motor Generator of 9805-19 or 9805-20

TYPE 9616-16—4-CHANNEL ISOLATION AMPLIFIER


4-Channel Isolation Amplifier

Input Impedance— 1200 ohms per channel
Voltage Gain— .98 ± .01 per channel
Load Impedance— 1200 ohms per channel
Supply Voltage— 48VDC

TYPE 9616-09—SERVO ACTUATOR AMPLIFIER


Servo Actuator Amplifier

Input Impedance— Greater than 50,000 ohms
Output Impedance— 400 ohms
Voltage Gain— Greater than 900
Supply Voltages— 100.0 volts D.C. 28.0 volts D.C.

TYPE 9616-15—RELAY AMPLIFIER


Relay Amplifier

Input Impedance— Greater than 15,000 ohms
Relay Closing Voltage— 150-175 Millivolts, 400 cycles
Relay Opening Voltage— 125-150 Millivolts, 400 cycles
Relay Contacts— 4 Pole, Double Throw—Dry Circuit
Supply Voltage— 28.0 V. D.C.

TYPE 9616-06—SUMMING AMPLIFIER (DUAL)


Summing Amplifier

Summing Inputs— 10 (per channel)
Gain— Nominal 1.0; variable from 0.1 to 10.0
Input Impedance— Dependent on Summing Channel. (50,000 ohms—500,000 ohms)
Load Impedance— Greater than 10,000 ohms
Supply Voltage— 28 V. D.C.

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

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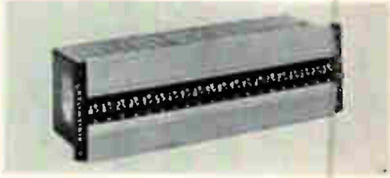
operating temperature range of –35 F to 165 F and a storage temperature range of –65 F to 165 F.

CIRCLE 329 ON READER SERVICE CARD

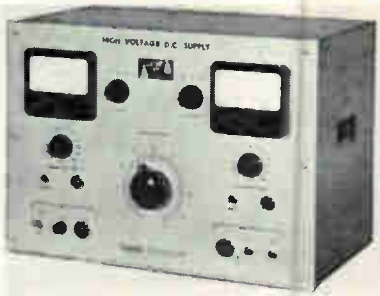


Digital Switch

16-POSITION

THE DIGITRAN CO., 660 So. Arroyo Parkway, Pasadena, Calif. Series 7320 Digiswitch has 16 single-pole switching positions plus an off position. It features in-line visual read-out, positive finger-detent operation, and modular construction which permits 4-to-1 savings in panel space. Optional features include color-coding of decades, internal lighting, and special dial characters. Life is 1,000,000 counts.

CIRCLE 330 ON READER SERVICE CARD



D-C Power Supply

HIGH VOLTAGE

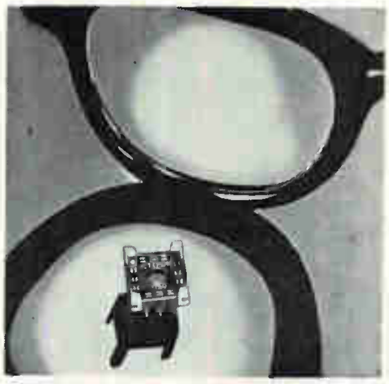
DEL ELECTRONICS CORP., 521 Homestead Ave., Mt. Vernon, N. Y. Model PSC30-5-1 has a d-c output of 35 Kv at 1 ma and 30 Kv at 5 ma. The power supply features: no exposed h-v components; continuously adjustable from 5 percent to 115 percent overvoltage and overcurrent relays; a zero-start interlock; and adjustment of the output voltage is accomplished by means of a variable transformer which is front panel mounted. Measuring 12 in. by 14 in. by 12 in. deep and weighing 60 lb, unit operates on 115 v, 60 cycles. Either negative or positive polarity above ground may easily be obtained by changing simple plug-in internal connections. Ripple factor is less than 0.5 percent per ma rms. Instrumentation consists of two 4½ in. meters, a 3-range Kv meter and a 3-range ma meter.

CIRCLE 331 ON READER SERVICE CARD

Data Amplifier
MINIATURIZED

THE MIRA CORP., 2656 North Pasadena Ave., Los Angeles 31, Calif., offers a miniaturized data amplifier with high input impedance for use in airborne instrumentation applications requiring the amplification of millivolt a-c signals. Model 3300 is a high-gain, low-power device, employing silicon transistors to provide a gain stability of the order of ±1 percent over the temperature range of −55 C to 100 C. Other models employing germanium transistors for use in temperature environment of −50 to 55 C available on request. Some typical applications of model 3300: in strain gage data systems, for synchro position transmitter systems, and in servo-amplifier systems.

CIRCLE 332 ON READER SERVICE CARD



Micromodule Socket
FOR P-C APPLICATION

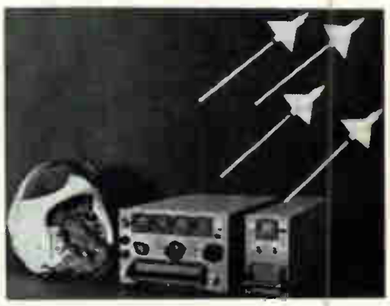
JETTRON PRODUCTS, INC., 56 Route 10, Hanover, N. J. This socket is designed to mount on a p-c board and is only 0.094 in. high. Micromodules may be mounted on 0.400 centers because the square dimension of the socket is 0.400 in. maximum. The insulating material is DIALL FS-5 and the contacts are heat treated beryllium copper, heavily silver plated. The corner guide brackets are made of 18-8 stainless steel. Contact terminations are 0.018 diameter wires, hot tin dipped for ease in soldering. Contact construction will give extremely low contact resistance and will mate the 0.013 diameter lead wires of the RCA micromodule. Insulation resistance between contacts is greater than 50,000 megohms.

CIRCLE 333 ON READER SERVICE CARD

Transducers
PIEZOELECTRIC TYPE

AUTOMATION INDUSTRIES, INC., 3613 Aviation Blvd., Manhattan Beach, Calif., announces a new series of transducers, employing a ferroelectric element, for ultrasonic nondestructive testing. Series have been designated as the "White Line" and are available in all standard sizes in the range from 200 Kc to 10 Mc. The new transducers are designed to be compatible with all types of equipment without modification and are available in any of the standard connectors used by various manufacturers. The "White Line" is available in all standard focal lengths.

CIRCLE 334 ON READER SERVICE CARD



Amplifier & Power Supply
FOR AIRBORNE USE

ELECTRONIC COMMUNICATIONS, INC., 1501 72nd St. North, St. Petersburg, Fla. Model 42A is an ultrahigh gain (18 db), single stage amplifier for airborne use. It can be employed directly with most of today's low power transmitters operating in the 225 to 400 Mc band. It features an exceptionally light

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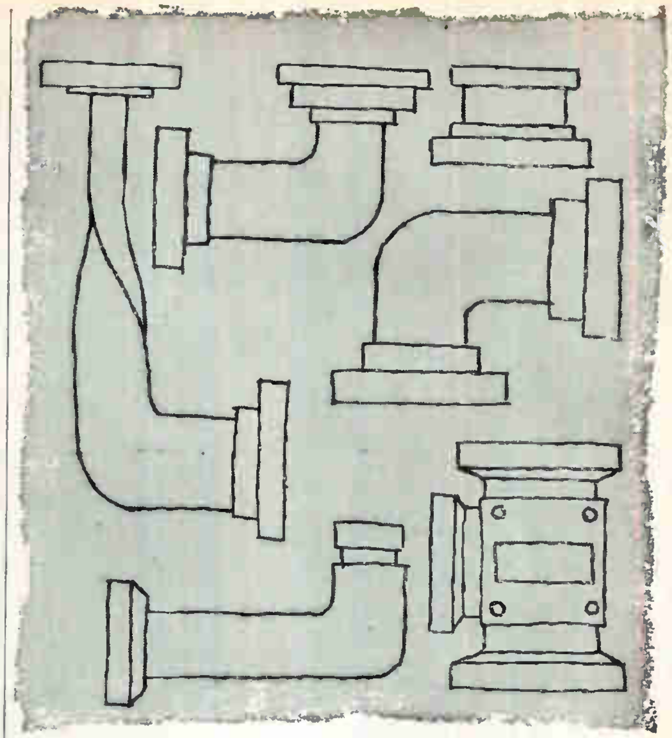

MEMCOR

PRECISION MICROWAVE COMPONENTS

MEMCOR designs and produces waveguide components in standard and special configurations with all types of adapters, flanges, probes, accessories and other hardware which may be specified.

These components and fittings are available in alloys of brass, aluminum or magnesium (which MEMCOR pioneered), to MIL or customer specifications, with approved plating or other applied finishes.

Components for all bands from K/a to and including S bands, are produced; but MEMCOR also designs and manufactures special prototypes for new or experimental frequencies or applications, according to your project requirements.

MEMCOR is backed by 15 years of intensive experience developing and manufacturing microwave components, and offers unduplicated service and facilities in this field.

YOUR INQUIRY CONCERNING MEMCOR'S STANDARD COMPONENTS OR SPECIALIZED DESIGN CAPABILITIES IN THE MICROWAVE FIELD IS INVITED, AND WILL RECEIVE PROMPT RESPONSE.

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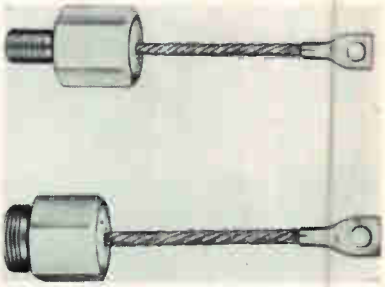
MEMCOR

Model Engineering and Manufacturing, Inc.
50 Frederick Street • Huntington, Indiana

CIRCLE 143 ON READER SERVICE CARD

and compact power supply, with all high voltage components in a hermetically sealed enclosure filled with silicone oil. This not only assures effective heat transfer but prevents the formation of corona at high altitudes. Only 16 w drive power is required for f-m, fsk, and ssb operation at 1 Kw minimum. Only 8 w drive power is required for a-m operation with a 350 w carrier level.

CIRCLE 335 ON READER SERVICE CARD



Silicon Rectifiers

POWER TYPE

SYNTRON CO., 241 Lexington Ave., Homer City, Pa. Styles ES-40 and ET-40 silicon power rectifiers have peak forward voltages of 1.2 v maximum at 100 amperes. The peak inverse current is 25 ma at 100 C case temperature. The thermal drop is 1.00C/w maximum from junction to case. Temperature range is − 35 C to + 120 C (case) and − 35 C to + 150 C (junction). Mounting torque for style ES-40 is 600 in.-lb maximum and for ET-40 it is 900 in.-lb maximum. Overall length for ES-40 is 5 9/16 in. maximum and ET-40 is 4⅞ in. maximum. Piv ranges from 100 to 400 v in 100 v steps.

CIRCLE 336 ON READER SERVICE CARD

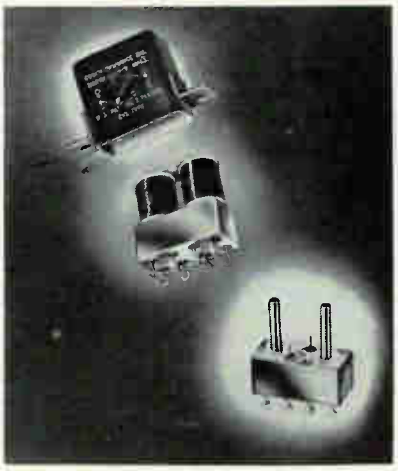
Signal Correlator

ONE-PERCENT ACCURATE

FLOW CORP., 85 Mystic St., Arlington, Mass. Model 13A1 random signal correlator may be used to

measure the normalized cross correlation between any two signals, either random or periodic. Its frequency range is between 2 cps and 250 Kc. It provides two identical amplifier channels with independent adjustable gains. The output selector circuit permits selection of either of the two channels or of the correlated signal. After the two channels have been equalized, positive or negative correlation can be read out directly on a true rms voltmeter. Its input voltage range is 20 mv to 2 v rms and it has a continuously variable gain of 1 to 100 in each channel. Unit can be used in many applications where simple and direct correlation techniques permit the evaluation of the performance characteristics of electronic components and apparatus.

CIRCLE 337 ON READER SERVICE CARD



Microminiature Relay

WEIGHS 18± 1 GRAMS

COUCH ORDNANCE, INC., 3 Arlington St., North Quincy 71, Mass. Type 2M relay features a hermetically sealed contact chamber to isolate contacts from contamination. A patented CVE rotary armature, pivoted on jewels, enables the relay to meet shock tests of 50 g's minimum and vibration tests of 30 g's to 2,000 cps. Contacts are 2 form C rated at 2 amperes at 30 v d-c with resistance of 0.05 ohm maximum. Contact life is 100,000 operations minimum. Contact terminals are located on 0.2 in. grid centers. Dielectric strength is 1,000 v, 60 cps, minimum. Relay measures 0.875 in. by 0.8 in. by 0.4 in.

CIRCLE 338 ON READER SERVICE CARD

CIRCLE 147 ON READER SERVICE CARD

Literature of the Week

DIGITAL INFORMATION SYSTEM Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio. Operation of Metrotype digital information system using all solid-state components is described and illustrated in new 8-page bulletin E-72-2.

CIRCLE 350 ON READER SERVICE CARD

BREADBOARD EQUIPMENT Engineered Electronics Co., 1441 E. Chestnut Ave., Santa Ana, Calif. A well-illustrated 4-page folder describes the company's completely transistorized T-series digital system breadboard equipment.

CIRCLE 351 ON READER SERVICE CARD

PROCESS CONTROL SYSTEMS Daystrom, Inc., Control Systems Division, Miramar Road, LaJolla, Calif. A new 12-page, 3-color booklet graphically outlines the Daystrom approach to industrial process control systems.

CIRCLE 352 ON READER SERVICE CARD

HIGH ALUMINA CERAMICS Diamonite Products Mfg. Co., Shreve, Ohio, has available a new brochure covering data and the application of high alumina technical ceramics to the electronics industry.

CIRCLE 353 ON READER SERVICE CARD

PRECISION POTS Maurey Instrument Corp., 7924 S. Exchange Ave., Chicago 17, Ill., has available a complete catalog of single turn, wire-wound precision potentiometers from ½ in. diameter to 3 in. diameter.

CIRCLE 354 ON READER SERVICE CARD

SECONDARY FREQUENCY STANDARD The Haddam Mfg. Co., 30 Rockefeller Plaza, New York 20, N. Y., announces a brochure on the ZERoBEAT portable secondary frequency standard for use in the mobile communications field.

CIRCLE 355 ON READER SERVICE CARD

INSTRUMENTATION TAPE RECORDERS Precision Instrument Co., 1011 Commercial St., San Carlos, Calif. New 2-color catalog sheet, bulletin 58, describes the company's recently introduced 16-channel digital magnetic tape recorder, model PS-216-D. Company also offers a new revision of bulletin 55, covering the entire PS-200 line of advance-design, transistorized, magazine - loading instrumentation tape recorders.

CIRCLE 356 ON READER SERVICE CARD

TEMPERATURE INDICATORS Princeton Division, Curtiss-Wright Corp., Princeton, N. J. Brochure CS-177-000 describes Thermochrom crayons and DetectoTemp paints for checking the temperature of any hot surface.

CIRCLE 357 ON READER SERVICE CARD

AIRBORNE TRANSFORMER - RECTIFIER General Electric Co., Schenectady 5, N. Y. Bulletin GEC-1540, 2 pages, gives specifications of GE's unregulated airborne transformer-rectifier, model 6RW162-YF1, 28 v, 200 amperes.

CIRCLE 358 ON READER SERVICE CARD

SILICON RECTIFIERS Fansteel Metallurgical Corp., North Chicago, Ill., announces the publication of four separate data sheets helpful to any engineer or designer who specifies, uses or is concerned with silicon rectifiers.

CIRCLE 359 ON READER SERVICE CARD

SYSTEM BUILDING BLOCKS Digital Equipment Corp., Maynard, Mass. New color-coded six-page folder gives logic diagram and complete description, including input, output and price data, on 17 500-Kc plug-in system building blocks.

CIRCLE 360 ON READER SERVICE CARD

FACILITIES BROCHURE Melpar Inc., 3000 Arlington Blvd., Falls Church, Va., has available a brochure describing its specialization in research, development and production of electronic equipment for the U. S. Government and major prime contractors.

CIRCLE 361 ON READER SERVICE CARD

P-C BOARD PRINTER Wyrco Projects, Inc., 66 Main St., Binghamton, N. Y. Precision automatic screen printer for high speed production of printed circuit board is described in a 6-page fully-detailed illustrated bulletin.

CIRCLE 362 ON READER SERVICE CARD

NEW BOOKS

Fluctuation Phenomena in Semi-Conductors

By A. VAN DER ZIEL.
Academic Press, Inc., New York, 168 *p*, $6.50.

A CONSIDERABLE part of recent literature in the field of semiconductors has been concerned with the limitations set by fluctuation phenomena in the use of semiconductors for device purposes. Papers dealing with this subject have, however, been scattered throughout a heavy volume of literature. The present book attempts to bring together in one place the diverse aspects of the subject, both theoretical and experimental.

The book discusses various sources of noise in semiconductor material, in photo-conductors, in semiconductor resistors, in semiconductor diodes, and in junction transistors. Distinction is made between flicker and shot noise, and the properties of generation-recombination noise, diffusion noise, and modulation noise are presented.

There is also a considerable discussion of the McWhorter theory of 1/f noise, also known as flicker noise. McWhorter has related the problems of flicker noise and field effect in semiconductor material. It appears that the surface traps which contribute to the frequency dependence of the field effect also contribute to the flicker noise. The author concludes that McWhorter's theory gives the most promising approach to the problem of 1/f noise in semiconductors and echoes McWhorter's view that the same mechanism might be responsible for contact noise observed in single contacts and granular materials.

Noise measurements and noise-measuring equipment are discussed in the brief space of four pages. In view of the difficulties and subleties connected with efforts in this area, it is to be regretted that the author did not treat the subjects at greater length.

With the exception of noise measurements and noise-measuring equipment, the author appears to have treated his subject rather completely, but fault may be found with his organization of the book. For example, Chapter 2 is concerned with the characterization of noisiness in two- and four-terminal networks. It is not clear why the material of this chapter appears where it does. Moreover, the third chapter is concerned with mathematical methods for analyzing fluctuation phenomena. These include topics from probability, statistics, Fourier analysis and the Langevin equations. With the exception of the last-named item, it would seem that the material of this chapter could well have been deleted since the topics are adequately covered in standard references and are not and could not be adequately covered in the limited space allotted to them in this book. Discussion of the Langevin equation could then be relegated to the appropriate points in the text where it is needed. In addition, it is possible that the readability of the book would be improved by more attention to transition between the topics of the various chapters and also by the introduction of motivating statements at the beginning of each chapter.

In spite of these deficiencies the book constitutes a useful addition to the body of literature dealing with fluctuation phenomena in communication devices. Assembly of such material in one place should be of value to the design engineer.—LEONARD S. SCHWARTZ, *New York University, College of Engineering, New York.*

Principles of Optics

By M. BORN and E. WOLF

Pergamon Press, Inc., New York, 803 p, $17.50.

THIS book is substantially different from the volume "*Optik*" published by Professor Born more than twenty-five years ago. Nevertheless, the method of approach is similar, especially in those sections dealing with the more general aspects of the theory.

The principles of optics are presented deductively as a system based on Maxwell's equations. The historical discussions which accompany the deductions do not detract from the rigor of the derivation of the principles. This historical perspective is especially illuminating in the treatment of Huygens' construction and diffraction phenomena.

The basic theory, which is derived in the earliest chapters, is applied in considerable detail to the various types of optical devices—image forming instruments as well as interferometers. An unusually complete discussion is given of the phenomena connected with interference and diffraction with partially coherent light.

This book is unique in the generality and completeness with which it covers the entire subject of optics. It should be particularly useful to those engaged in teaching and research in this field.—ERIC BRODHEIM, *Principal Research Engineer, Electronics Research Laboratory, Columbia University, New York.*

La Science et la Theorie De L'Information

By LEON BRILLOUIN.

Masson & Cie, St. Germaine, Paris, 302 *p,* $9.60.

PROFESSOR L. BRILLOUIN presents in this book not only the scientific theory of information, but also the application of this theory to pure science. This new field covers mostly the problems of statistical thermodynamics, telecommunications, automation, calculating machines and coding.

Statistical definition of information shows a very close relationship between entropy and information, which can be considered as a negative term of the entropy in the system of physics. The close relationship between entropy and information was studied first in 1929 by Szilard and continued by Shannon in a great variety of problems.

Generalization of the second principle of thermodynamics is presented as a principle of neugentropy of information and the position of thermodynamics is consolidated by elimination of a certain number of paradoxes such as the demon of Maxwell. Problems of semantic information are given by statistical data and based exclusively on the works of Carnap and Bar-Hillel with their methods of symbolic logic.

This scientific theory of information really constitutes a point of departure for an important and new chapter of scientific research.

This important book is addressed to the engineers and technicians concerned with telecommunications, calculating machines and automation control, to the theoreticians of physics, and to scientists, who can find in the book many interesting developments to solve their familiar problems.—DR. A. KIRILOFF, *Electronics Research Laboratories, Columbia University, New York.*

THUMBNAIL REVIEWS

Microwave Transmission. By J. C. Slater, Dover Publications, Inc., New York, 309 p, $1.50. This reprint of the original 1942 edition (with only minor typographical corrections) is justified on the basis that students should have the opportunity of reading the classic literature in their field. Although microwave technology has grown phenomenally, the basic physics presented in this book is still valid. A tremendous amount of material considering the price.

Ingenious Mathematic Problems and Methods. By L. A. Graham, Dover Publications, Inc., New York, 237 p, $1.45. One hundred provocative and fresh problems specifically selected because of their widely differing modes of solution are presented. Although logical reasoning or high school mathematics sometimes gives the answer, such advanced fields as number theory, statistics, compass geometry, networks and inversion are often required. Electronics men will find this volume a challenging wit sharpener.

Experiments in Hearing. By Georg von Bekesy (translated and edited by E. G. Wever), McGraw-Hill Book Co., Inc., New York, 1960, 745 p, $25.00. Most of the papers published by the author during the last 34 years are contained in this volume. Initial chapters deal with the historical development of the subject, the anatomy of the ear, and experimental apparatus and methods for auditory investigations. Subsequent parts of the book deal with conductive processes, psychology of hearing and cochlear mechanics. Electronic circuits for measuring, monitoring, and recording during experiments are discussed in some detail. Engineers or physicists working in the prosthetic, acoustic, or audio field will find information in this book which has, for the most part, not been conveniently available for a number of years.

DataMation Moves to New Quarters

DATAMATION, INC., recently moved into its own custom-designed building in Gardena, Calif., reports founder and president Philip L. Kramer.

The modern $125,000 facility will house the company's completely equipped data processing plant, as well as a cafeteria and executive offices. Working area now totals 16,500 sq ft, more than twice the size of the former quarters, which were also located in Gardena.

The firm was established two years ago on a working capital of $20,000 and consisted of just three people—Kramer as president, Graham A. Truman as vice president and J. D. MacLeith as secretary-treasurer.

Within a few months the volume of business warranted the leasing of eight computing machines. In less than two years the firm had grown to an annual gross of $1 million, employed a staff of over 100 and used intricate computing equipment valued in the hundreds of thousands of dollars.

As its title implies, DataMation, Inc., provides, through a system of automatic computing machines, a means by which highly technical engineering data—such as technical publications, provisioning documentation, parts lists, microfilm cards and the like—can be translated and catalogued efficiently, accurately and economically.

Included in the firm's increasing client list are government, commercial, industrial and military accounts. Among them are Convair Astronautics, Litton Industries, RCA, Aerojet, Hughes and Standard Oil.

Skidelsky Joins Dorne & Margolin

LEO SKIDELSKY has joined Dorne & Margolin, Inc., Westbury, N. Y., manufacturer of airborne antennas and related electronic systems, as an engineer in the engineering department. He was formerly with Polarad Electronics Corp.

Aircraft Armaments Elects Three V-P's

THE DIRECTORS of Aircraft Armaments, Inc., Cockeysville, Md., recently elected three new vice presidents.

Marvin J. Kahn was elected vice president-marketing. He has been associated with the company since 1951. He was appointed director of the firm's Plans and Programs Division in 1959 after having served as chief structures and aerodynamics engineer and assistant director of engineering.

Newly elected vice president-engineering is Raymond W. Wells. Associated with Aircraft Armaments since 1953, he became the company's director of engineering in 1959. Prior to this assignment he served as chief electronics engineer.

Irwin R. Barr was elected vice president-development. One of the original members of the firm, he first served in the capacity of chief design engineer. In 1952 he was appointed chief ordnance engineer directing the company's ordnance design activities until his promotion to director of special research earlier this year.

Telex Appoints Assistant V-P

ROBERT L. SELL, engineering executive for Telex, Inc., has been named assistant vice president of the Twin Cities electronics company.

Sell will continue as director of engineering. In addition to his engineering duties he is being given new responsibilities as director of sales and marketing for the company's Components Group which includes Special Products, Communications Accessories Division, and Magnetics.

Prior to joining Telex a year ago, Sell was chief engineer at Audio Development Co., Minneapolis, with 10 years service there.

Telectro Occupies Added Facilities

IN A MAJOR expansion move, Telectro Industries Corp. has shifted all consumer magnetic tape recorder production to new quarters in Long Island City, N. Y., which will house about 500 employees and will permit boosting output 100 percent, Harry Sussman, president, announced.

Modern production tools, conveyor systems and other innova-

tions have been installed in 54,000 sq ft of work space in the leased building. "Our fast-growing Telectro consumer line, marketed by our wholly-owned sales subsidiary, Telectrosonic Corp., has overtaxed the main plant," Sussman said.

"Military and industrial electronic equipment and components, including recorders, communications and test equipment and the new Telectrovision, which permits low-cost tv transmission over ordinary telephone lines, will continue to be produced in the main plant."

Magnetico Appoints Chief Sales Engineer

JOHN HACKETT has been named chief sales engineer of Magnetico, Inc., East Northport, N. Y. He will primarily handle the northern New Jersey, Long Island, and greater New York City areas.

Hackett had recently been with Control Electronics, Huntington Station, New York.

He will concentrate on the sales of Magnetico's new developments in the magnetic and control field, which include new designs in magnetic and transistor servo amplifiers, magnetic control logic switches and ultrasensitive relay amplifiers.

He will also be responsible for sales engineering for Magnetico's recently expanded toroidal winding facility.

Deltron Hires New Chief Engineer

DELTRON INC., Philadelphia, Pa., announces the appointment of Ori Even-Tov to the position of chief electronics engineer.

Even-Tov is a specialist in solid

state circuit applications embracing the digital and analog fields. His past experience includes significant contributions in these fields at Boonshaft and Fuchs Co. and prior to that with the Remington Rand Computer Division.

Senft Assumes New Position

IN ANOTHER MOVE to strengthen its position in the capacitor industry, William L. Pfeiffer, president of The New Haven Clock and Watch Co., New Haven, Conn., announces the appointment of Frederick J. Senft to the post of chief engineer of the Condenser Products Co., a division of New Haven Clock and Watch.

Senft served in various line and management responsibilities with major capacitor manufacturers for over 13 years. He recently resigned as chief engineer of Mica Mold Products to take his new post.

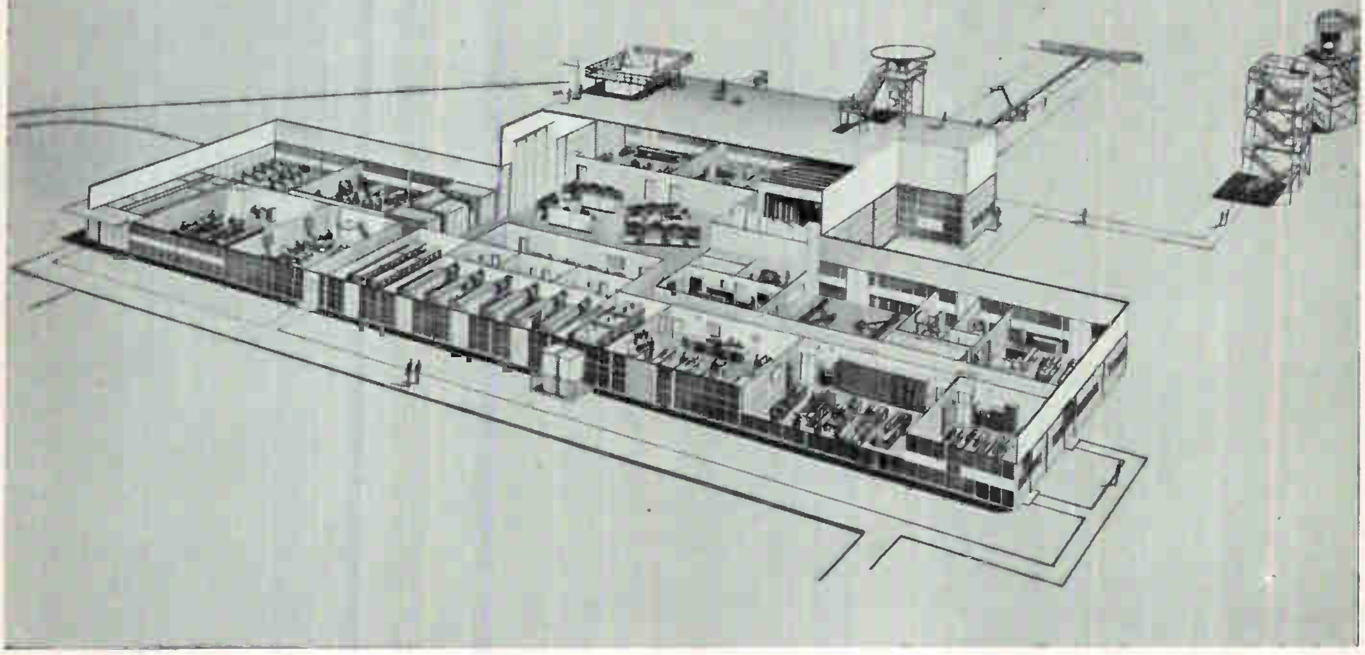
Michigan Magnetics Names Chief Engineer

APPOINTMENT of Leo Page as chief engineer of Michigan Magnetics, Inc., Vermontville, Mich., is announced. He has been associated with the magnetic tape recording head manufacturer for the past three years, having started in design engineering, and successively held the positions of chief production engineer and assistant to chief engineer.

In his new capacity, Page will direct design and production engineering, areas of activity in which his previous efforts have been centered, and from which came the development of two new tape recording heads which were recently introduced.

THE LID IS OFF...

Electronics opportunities at Grumman Aircraft



Indicative of Grumman's increasing stature in the electronics field is the new $5,000,000 Avionics Systems Center, housing an impressive array of advanced equipment for the testing, evaluation and integration of electronics.

So designed as to minimize the effects of electrical interference, the Center has the following outdoor facilities: 2 2000-foot AEW antenna test ranges, a 300-foot antenna and model test range, and a precision radome bore-sight range.

Indoor features are:

- The largest anechoic chamber in the U.S. devoted exclusively to aircraft antenna testing.
- A Flight Control Simulation Laboratory which evaluates automatic flight control systems under "actual mission" conditions.
- Facilities for the precise evaluation of inertial and stellar guidance equipment.
- A Systems Evaluation Area to accommodate complete aircraft avionics systems for operational testing and evaluation.
- An Electrical Systems Laboratory equipped to evaluate aircraft power systems of the most modern aircraft.
- Extensive general purpose test facilities for evaluation of all types of electronic equipment.

If you are interested in growing with Grumman, and have experience in Equipment Development, Systems Analysis, Systems Synthesis, Project Engineering, or Circuit Development, you may well qualify for a career position in one of the following long range programs:

- Airborne Inertial Navigation Systems
- Synthesis of Radomes and Antennas using Digital Computers
- Friction-Free Suspension for Evaluation of Space Attitude Controls
- Airborne General Purpose Digital Computers
- Long Range Search Radar
- Advanced Techniques for ASW Detection
- 3-D Terrain Presentation for Low-Flying Aircraft

Send your resume in strict confidence to Mr. A. Wilder, Manager, Engineering Employment, Dept. GR-76, or call Wells 1-4833 for a mutually convenient interview.

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Direct your ingenuity to the design of circuits forming integral parts of CW range measuring equipment and the integration of complex timing and coding circuitry for earth satellites. You will also establish and supervise test programs, direct the testing of setups, component parts, circuits and complete ranging systems, supervise and monitor electrical and environmental testing for qualification. Familiarity with transistor switching circuitry is required.

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If your experience includes low-frequency phase measurements, tracking or radar, openings exist at PHILCO WDL for engineers to design, develop and insure fabrication of specialized test equipment.

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QUALITY ASSURANCE

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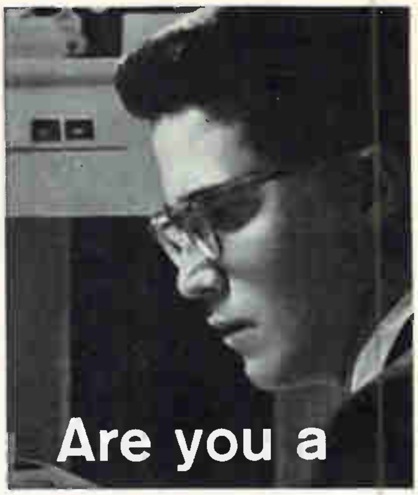

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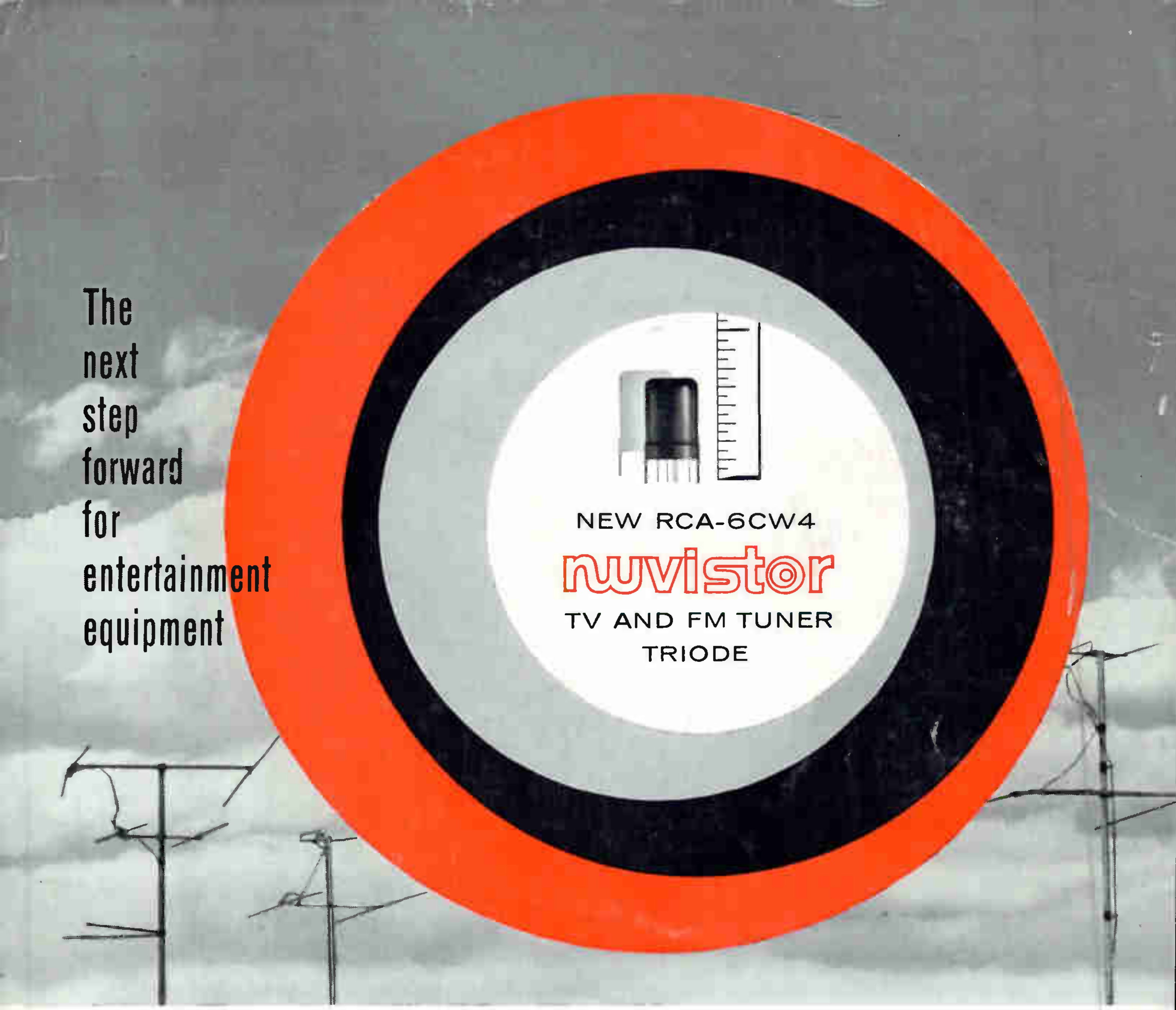

Now commercially available for TV and FM tuner designs

2 to 4 db better NOISE FACTOR than tubes currently in use in TV receivers.

Superlative Performance—and not just tiny size—is the reason this latest RCA nuvistor triode should soon be the preferred rf-amplifier tube in entertainment equipment. Nuvistorized TV tuner circuits can make possible excellent reception in fringe areas where reception is now unsatisfactory.

Noise Factor is 2 to 4 db better than that of other tuner tubes in commercial use. In addition, this mighty midget provides this unmatched combination of advantages:

Excellent Signal Power Gain

High Transconductance PLUS high gm to I_b ratio (12500 μmhos at 8 milliamperes and 70 volts)

Very Small Power Requirements: Plate and heater input—each less than 1 watt. PLUS ALL THE INHERENT ADVANTAGES OF NUVISTOR DESIGN: exceptional reliability, excellent stability, extreme ruggedness, small size, light weight, high unit-to-unit uniformity, extreme sensitivity, very high input impedance, and high perveance. The last word in entertainment rf-amplifier triodes is nuvistor 6CW4!

For further information, see your RCA Field Representative—or write to RCA Electron Tube Division, Commercial Engineering, Section F-19-DE-4, Harrison, N. J.

Heater, for Unipotential Cathode:	
Voltage (AC or DC)	6.3 ± 10% volts
Current at 6.3 volts	0.13 amp.
TYPICAL OPERATION	
Plate Voltage	70 volts
Grid Supply Voltage	0 volts
Grid Resistor	47000 ohms
Amplification Factor	68
Plate Resistance (Approx.)	5440 ohms
Transconductance	12500 μmhos
Plate Current	8 ma

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