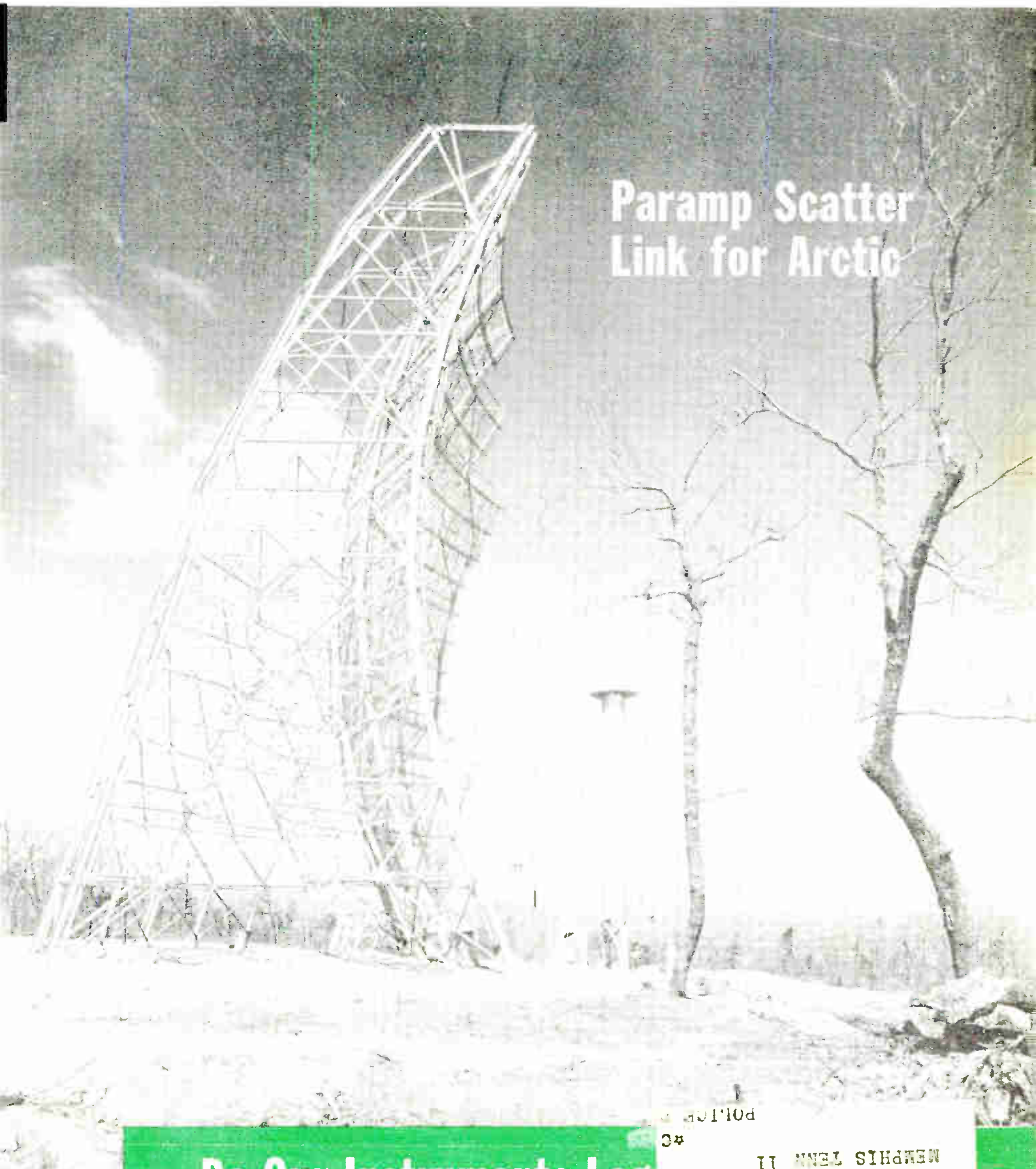
AUGUST 21, 1959

electronics

A McGRAW-HILL PUBLICATION VOL. 32, No. 34 PRICE SEVENTY-FIVE CENTS



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Do Our Instruments Lag

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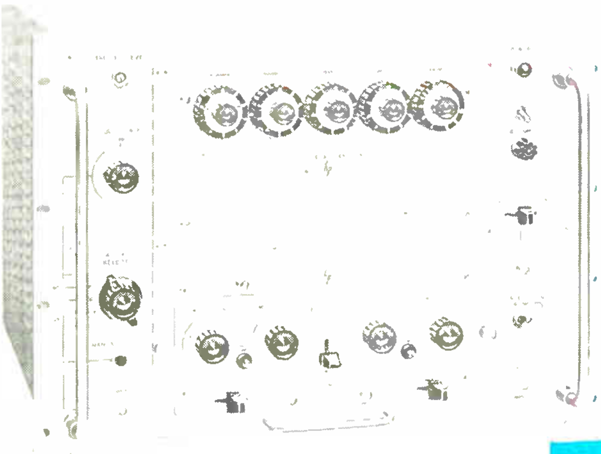
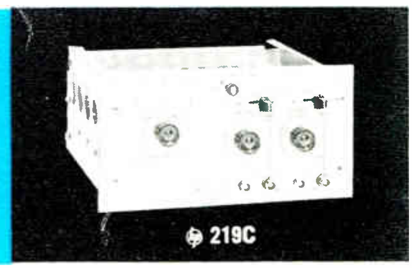


218AR Digital Delay Generator produces crystal controlled pulses accurately spaced in time. It is a perfect slave to any pulse, even though random, and locks in constant phase during each counting period.



Time measurement and pulse simulation in radar, loran, Tacan, DME, oscilloscopes, computers, fast gates, pulse code systems—almost any kind of time measurement single- or double-pulse simulation is now yours quickly and accurately with 218AR Digital Delay Generator.

Built along strict military standards, 218AR uses a pulsed crystal oscillator synchronizable in *constant phase* with an initial trigger pulse (zero time) and two positionable terminating pulses. Time is counted with a 1 Megacycle preset counter, and two independent output pulses are available in any relationship.

PULSE GENERATOR PLUG-INS

For utmost versatility, output pulses are generated in various arrangements by three plug-in pulse generators. These include 219A, supplying two positive pulses, 219B providing two pulses, each positive or negative and variable in amplitude, 219C, providing a high power pulse, positive or negative, digitally controlled as to delay and duration, variable in amplitude.

Condensed Specifications

(Basic 218AR Generator; plug-ins essential)

Time Interval Range:	1 to 10,000 μsec	**Recovery Time:**	50 μsec or 10% of interval, whichever is greater
Accuracy:	± 0.1 μsec ± 0.001%	**Sync Output:**	50 v pos. pulse, 0.1 μsec rise time
Digital Adjustment:	1 μsec steps, full range	**1 MC Output:**	1 v pulses, 500 ohm impedance
Interpolation:	Variable 0 to 1 μsec	**Price:**	-hp- 218A, $2,000.00 -hp- 219A Dual Trigger Unit, $100.00 -hp- 219B Dual Pulse Unit, $450.00 -hp- 219C Digital Pulse Duration Unit, $350.00
Input Trigger:	Internal 10 cps to 10 KC; External 0 to 10 kc pulses, also sine wave		
Jitter:	0.02 μsec or less		

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

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AUGUST 21, 1959

A McGRAW-HILL PUBLICATION
Vol. 32 No. 34

Issue at a Glance

Business

Calibration Lags Defense Needs. Survey shows up problems........16

Victorious Shows 3-D Radar. Report on our exclusive tour..........19

Air Training Market Spirals. Electronics center doubles inventory..20

Ruling Spurs Private Microwave. FCC opens spectrum.............22

Shoptalk 4

Electronics Newsletter 7

Washington Outlook 8

Financial Roundup 11

25 Most Active Stocks......11

Market Research 12

Current Figures 12

Meetings Ahead 23

Engineering

Parametric-amplifier tropo-scatter communications link between Millstone Hill, Mass. and Winston-Salem, N. C. is prototype of link between Thule, Greenland and Cape Dyer on Baffin Island. See p 27...COVER

New Microwave Systems Using Low-Noise Devices. Communications systems incorporate masers, paramps............By T. Maguire 27

Determining Transistor High-Frequency Limits. Technique measures maximum oscillation frequency up to 1,000 mc............ By J. Lindmayer and R. Zuleeg 31

Reducing Errors in Loaded Potentiometers. New method cuts loading errors by factor of 100.......................By M. Kanner 34

Long Wavelength Infrared Detector Cooling Systems. How to achieve best operating temperature..........By A. I. Weinstein 36

Oscillator Design Using Voltage-Variable Capacitors. Reverse biased *p-n* junction controls frequency..........By M. M. Brady 38

How to Design Bandpass Triples. Steps are given in detail, sample problems analyzed and solved.................By R. B. Hirsch 41

Departments

Research and Development. Timer Allows Warmup Interval........46

Components and Materials. Advantages of Using Coiled Waveguide..50

Production Techniques. Dip Solder Metal Radio Chassis............54

On the Market.............58

Literature of the Week.....68

Plants and People..........70

News of Reps..............73

Comment 74

Index to Advertisers........82

Engineers/Designers! Ask for this G-C

MICROWAVE FERRITE APPLICATION CHART

MICROWAVE FERRITE APPLICATION CHART

MATERIAL	BAND	LOWEST OPERATING FREQUENCY**	TYPICAL APPLICATION	TYPICAL POWER LEVEL
R-1	X	8,500 megacycles	Phase Shifter	Low Power
R-4	X	7,000 megacycles	Phase Shifter	Can be used above resonance at peak power $>$ 1 Megawatt (2)
R-4	S	2,500 megacycles	Resonance Isolator (1)	Low Power
R-5*	C	5,000 megacycles	Phase Shifter	Can be used above or below resonance at peak power $>$ 1 Megawatt (2)
R-5*	S	2,500 megacycles	Phase Shifter	Can be used above resonance at peak power $>$ 1 Megawatt (2)
R-5*	L	1,000 megacycles	Resonance Isolator	Low Power
R-6*	S	2,500 megacycles	Phase Shifter	Similar to R-5
R-6*	L	1,000 megacycles	Resonance Isolator	Low Power

*NEW PRODUCT

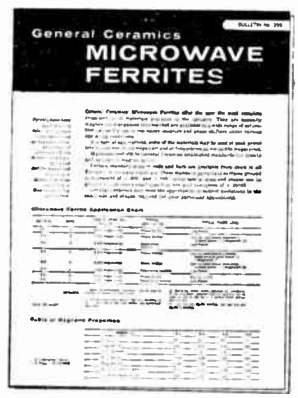
REMARKS:

(1) R-4 saturates more rapidly than R-1 resulting in faster reduction at low field losses. See hysteresis loop data.

(2) Operating power levels reported by customers. It has also been reported that R-5 and R-6 can be used as low as 500 Mc/s in certain phase shifter applications.

R-1 and R-4 are Mg-Mn ferrites. R-5 and R-6 are Mg-Mn-Al ferrites.

**Lowest Recommended Frequency—can be used at frequencies above published value.



—it's included in the new General Ceramics Data Bulletin on Microwave Ferrites

This new comprehensive bulletin contains technical data on the most complete cross-section of materials in the industry, including two grades introduced for the first time. Included are hysteresis loops, magnetic and dielectric properties vs. frequency, and magnetic induction vs. temperature curves on ferrite materials R1, R4 and newly-developed R5 and R6. Application data, magnetic properties tables, and drawings and dimensions of available stock parts are also contained in new Bulletin 259. Request your copy of this informative literature, today; please address inquiries to General Ceramics Corporation, Keasbey, New Jersey—Dept. E.

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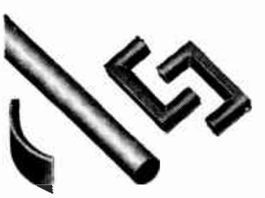
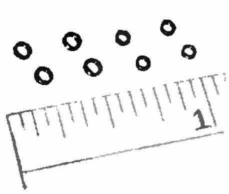
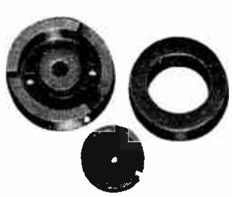
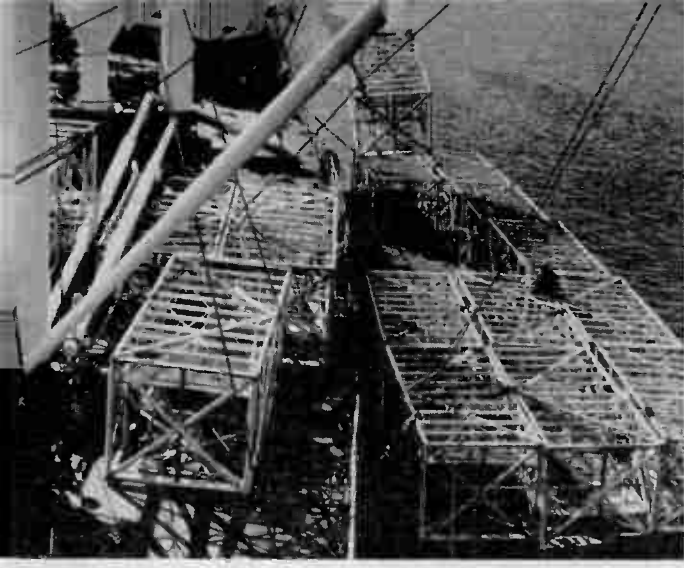

TV and Radio Cores

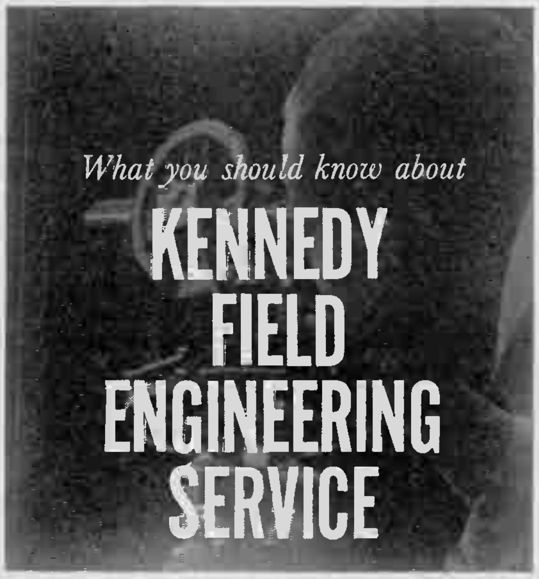

Magnetic Memory Cores

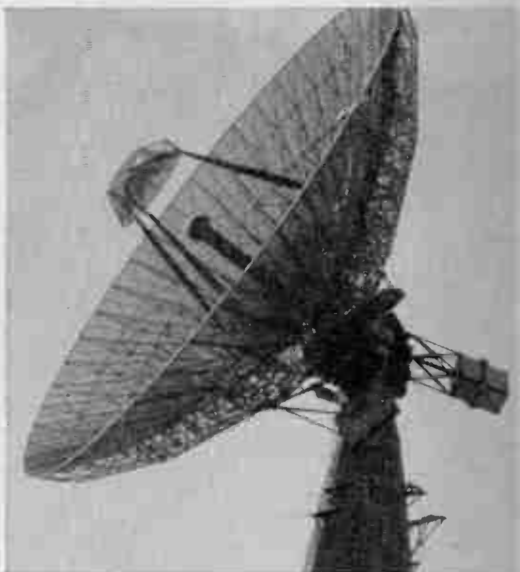

General Purpose Cores


Recording Head Cores


Microwave Ferrites







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electronics

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SHOPTALK . . . editorial

MAN IN SPACE SUIT is John F. Mason, an Associate Editor of ELECTRONICS. He is climbing into the cockpit of an Air Force twin-jet to get first-hand knowledge of how thunderstorms are tracked with radar. This occurred during a four-day tour that took him from Mitchell AFB, N. Y., to Graham AB, Fla., to Keesler AFB, Miss., to Craig AFB, Ala., to Maxwell AFB, Ala. and Bolling AFB, Washington, D. C.

The trip produced the story which appears on p 20 of this issue. In addition, Mason found several potential authors who will soon contribute additional articles to the magazine.

It's all in a day's work for an ELECTRONICS staff man. If you hanker to become part of a top-notch team running a really hot magazine, get in touch with Editor Bill MacDonald. Requirements? Among them are these: a degree in electrical engineering, experience in the electronics industry, ability to judge, edit and write material for publication.

INSTRUMENT ACCURACY. One point brought out in Associate Editor Leary's story "Calibration Lags Defense Needs" (p 16) is that National Bureau of Standards is swamped.

This fine scientific organization is designated by Congress as the national calibration agency. Just doing the legwork of recalibrating existing master standards keeps the Bureau busy; it doesn't often have enough men to develop new standards when—or before—they're needed.

Further, the fact that the Bureau has only two offices, in Washington and in Boulder, Colorado, is awkward. What's needed is half a dozen regional calibration offices close to concentrations of industry. Both these needs trace to a common source. If the Bureau of Standards is to do its daily work in calibrating, do new research and develop new standards, it needs more money.

Coming In Our August 28 Issue . . .

POLARIZED PHOSPHORS. A relatively obscure property exhibited by a wide variety of organic and inorganic phosphors shows great promise in applications to information storage in computer memories and facsimile production processes. According to H. P. Kallmann and J. Rennert of New York University, data is stored in the phosphor by producing a separation of charges in the phosphor body by d-c fields and radiation.

SMALL-WAR COMMUNICATIONS. One of the main problems of today's modern, mobile army is communications. According to W. Harnack of Adler Electronics in New Rochelle, N. Y., the Army's new AN/TSC-16 system, which can be flown anywhere in two C-124 Globemasters, will provide the field commander with direct channels into the Army's global communications network four hours after the planes land.

COSMIC RAYS. To increase our knowledge of cosmic radiation, measurements must be made over a wide geographical area. For this reason there is a need for light-weight, easily adjustable instruments capable of making measurements of these mysterious particles. D. Enemark of Iowa State University describes balloon-borne gear for this purpose which has been used successfully at 130,000 ft.

Now you can specify these popular submins for extra-severe duty — in new Raytheon Reliability-Plus types

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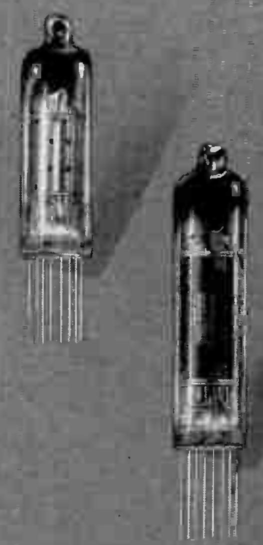

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Life-test end points now 1000 hours instead of 500 hours.

MAXIMUM RATING LIFE

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ELECTRONICS NEWSLETTER

SEMICONDUCTOR INTERESTS of two associations, EIA and NEMA, have just been merged into an integrated program to provide broader coverage in technical standards and marketing data for manufacturers and users of semiconductor devices. NEMA reports that its semiconductor activities will encompass rectifiers and controlled rectifiers, while EIA will cover diodes and transistors generally used in signalling and low-level switching applications. Power transistors fall within the product scopes of both associations. The associations maintain liaison already in matters of statistics, industrial relations and legislative problems. A cooperative standardization program is conducted through the Joint Electron Device Engineering Council, a group financed jointly.

MILITARY PURCHASE of common electron tubes, formerly handled by the services separately, will be carried out by the Air Force for all three military departments by March 31, 1960. During fiscal 1959 the services bought more than $48 million worth of these commonly used tubes, with the Air Force alone accounting for more than half. Procurement change is in line with Defense Department goal of integrating common supply functions so long as military capabilities are not diminished.

Miniature mass spectrometers one half cubic foot in size and weighing no more than 12 lbs will be built for a 35-in. diameter earth satellite to be launched in 1961. Consolidated Systems, a subsidiary of Consolidated Electrodynamics, will build the two devices under a $98,600 contract from NASA's Goddard Space Flight Center. Purpose: to measure and analyze the exosphere, a region 150 to 600 miles from the earth.

SILICON CARBIDE EMITS ELECTRONS. This is reported by Westinghouse research scientists. As a result, they envision a solid-state tube. Clarence Zener, director of Westinghouse research, thinks the discovery of an electron flow from silicon carbide might "reverse the trend" towards transistors and related devices and "bring a new lease on life to the very device which semiconductors seem destine to outmode." The tube envisioned by Zener would have a small semiconductor crystal with a built-in junction instead of a heated cathode. The crystal would consume little power and yield electrons instantly and indefinitely when a small voltage is applied. Zener says the electrons escape from spots 50-millionths of an inch in diameter, producing currents of a millionth of an ampere. Such pinpoint sources, he believes, will simplify focusing of the electron beam and eliminate complicated tube construction.

BROADCAST EQUIPMENT MARKET will be entered this fall by the British-made Marconi IV television camera, marketed by Ampex as sole distributor of Marconi tv camera gear. Ampex will also market tv camera tubes made by English Electric, whose 4½-in. image orthicon is used in the Mark IV. The American firm will sell a studio package that includes the Marconi camera and its own videotape recorder, will aim at both networks and small stations.

RADIOGRAM SERVICE FOR AIR PASSENGERS has been established by El Al Israel Airlines and RCA Communications. Two-way commercial service is similar to that available to sea voyagers. Special gear on airliners maintains contact with station at Chatham, Mass., from any point between New York and Tel Aviv.

Radar telescope with a 142-ft diameter parabolic antenna will be completed in about a year by Stanford University and Stanford Research Institute, with support from AF Cambridge Research Center. Million-dollar-plus 20-60 mc transmitter requires a million-watt power supply. Dish is designed for use between 20 and 2,000 mc. Total cost of the radiotelescope: about $1.5 million.

AROUND-THE-WORLD ECHOES are luring the attention of Air Force and Navy researchers. Signals can be used to detect transmitters, can also interfere seriously with pulse code circuits. USAF's Cambridge Research Center has detected echoes when twilight zone covers substantial part of the earth. Some 50 to 100 milliseconds after direct-path signal is received, echo which travelled around the world in the opposite direction is picked up. Phenomenon occurs mostly in winter. Stanford University is studying these echoes for AF/CRC; Bureau of Standards runs tests for the Navy.

Satellite clock and programmer being developed by Waltham Precision Instrument Co. will help U.S. manned satellite flight go up and come back safely. Chronometric programmer will measure elapsed time from launching, trigger split-second schedule of a dozen or more functions, including reentry procedure. Problem: operation of a clock mechanism in zero gravity of free fall.

SHORTWAVE FADEOUT caused by solar flares is being checked by Naval Research Labs' project Sunflare II. Program uses Nike-Asp solid-fuel rockets. First of series of 12 firings from Point Arguello, Calif., naval missile facility went up over 150 miles during a flare on July 14, measured soft and hard X-rays, Lyman alpha radiation, mapped out development and decay patterns of these ionizing radiations relative to visible light of flare.

WASHINGTON OUTLOOK

WASHINGTON—ELECTRONICS stocks and other defense industry securities dipped quickly on the stock exchanges when the Eisenhower-Khrushchev exchange of visits was announced. Investors reacted as if the outlook for military spending were in question.

But few, if any, in Washington—certainly no one connected with the formulation of the defense budget—expect the summit meeting to produce any hard and fast developments that will directly affect the rate of military expenditures.

Washington's requirement is still an enforceable disarmament agree- ment of the Navy's experimental "high-frequency ionospheric back- **to trimming the Pentagon's spending. The Soviets have yet to indicate that they will go along with such a disarmament scheme, and diplomatic sources anticipate no change with Khrushchev's visit here.**

Defense Secretary McElroy underscores the point: "I think that's one of the things we must guard against . . . the natural inclination of this country to believe that peace is just around the corner because there may be the initiation of what I think is fine to have happening, but, nevertheless is only the first in a series of steps that must be taken before there can really be an acceptance on the governmental policy level of an actual reduction of world tension."

The outlook for military spending in the near future is still fairly clear: A leveling-off in total expenditures at around $41 billion with a continuing rise in outlays for electronics.

- **There was serious opposition** within the Pentagon to the announcement of the Navy's experimental "high-frequency ionospheric back scatter radar" detection device. Some officials objected to what they considered a premature announcement of a detection system which still requires considerable development effort.

  Identified with the project—dubbed "Project Tepee"—is ACF Industries. ACF's Nuckar-Erco division, Riverdale, Md., built the experimental device, is constructing an operational model due by the end of the year. Up to now, the Office of Naval Research has spent $1.1 million on the project, which began in the fall of 1957.

  In brief, the new detection device involves bouncing radio waves off the ionized hot gases created by a giant rocket launching or a nuclear explosion. A radarscope shows the reflected waves and discloses the position of the masses of gases.

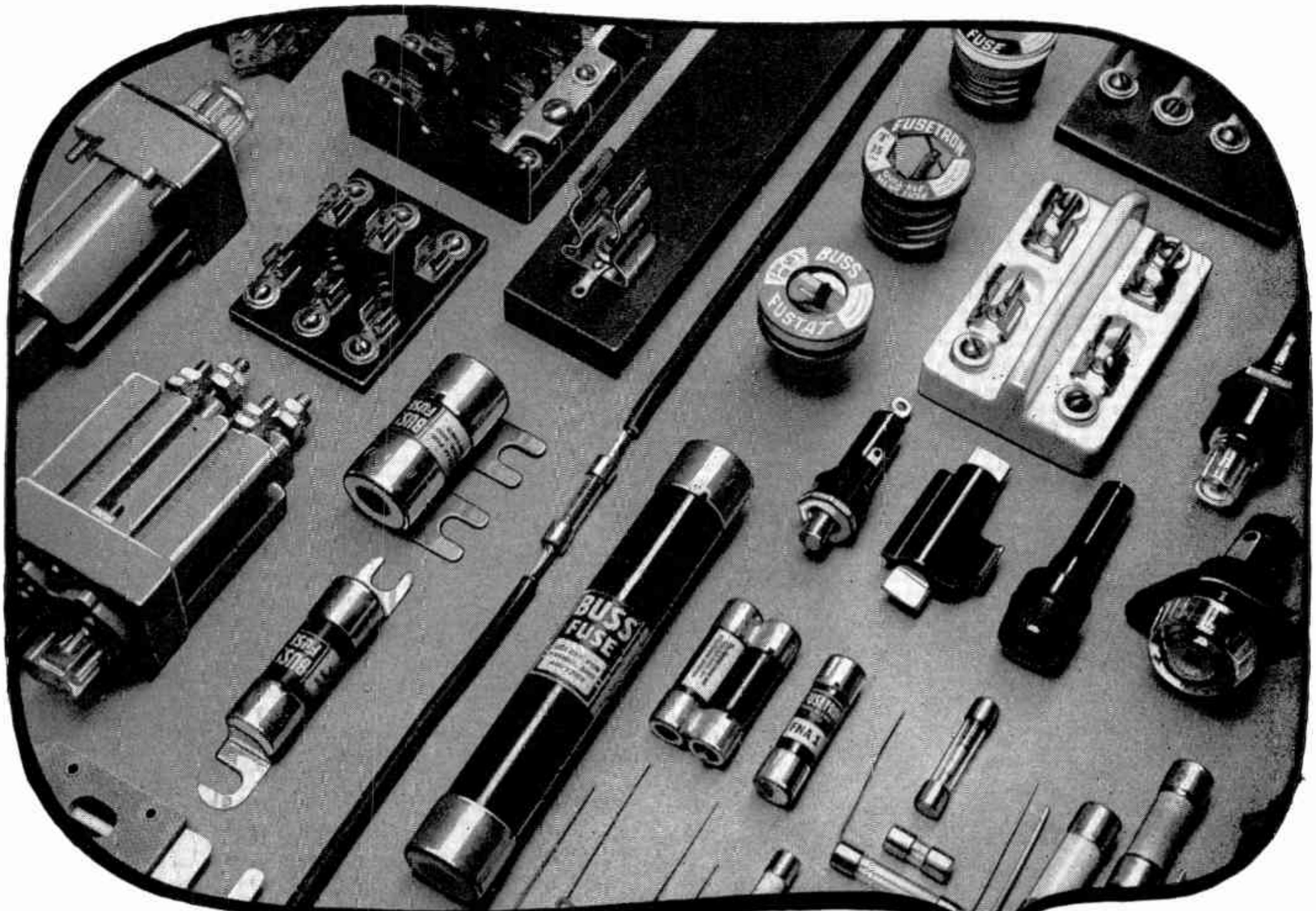
- **The Pentagon's Electronics Production Resources Agency** predicts that defense requirements for transistors will zoom from a present annual level of about 8 million units to a minimum of 100 million units by 1965.

  EPRA's projection, based on known military requirements for the July 1959—December 1961 period, includes a "number of significant weapon systems to develop trend lines and establish minimum requirements by type." About 50 percent of the total quantity covers electronic end-items still in the research and development stage.

  The official military transistor requirement totals 20 million units by 1962. The projection for three years beyond includes anticipated FAA, NASA, and NSA transistor needs.

  Of the 565 transistor types, 32 make up about 80 percent of the total requirement over the next 2½ years. Heaviest requirements are reported for the 2N396, L5129, 2N501, and 2N1135 type transistors.

- **FCC may issue** a proposed rule in September which would add some a-m stations of at least 10 kw to the 24 unduplicated clear channels. The commission vote instructing the staff to prepare a rule was close, and the decision can still go either way.



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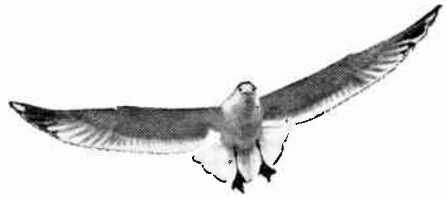

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ONE MORE electronics firm has joined the steadily growing roster of companies in our industry whose stocks are available on the major markets. **Monogram Precision Industries, Inc.,** Culver City, Calif., now has its common stock listed on the American and Pacific Coast stock exchanges.

Under the symbol MGP, Monogram's listing covers more than 1 million shares outstanding of 2 million authorized. The firm, which manufactures microwave gear and ferrite devices, concluded its fiscal year on June 30 with sales of about $8 million and a backlog of more than $7 million.

• **Victoreen Instrument Co.,** Cleveland, O., and **Tenney Engineering,** Union, N. J., have agreed to merger terms to join and create the Victoreen-Tenney Corp. The merger will be based on an exchange of 8/10 of a share of Victoreen stock for each Tenney share outstanding. The exchange represents an approximate market value of $6½ million. Stockholders meetings to vote on the merger plan are slated for early next month.

• **Republic Aviation Corp.** reports consolidated sales of $109,812,737 and net income of more than $1½ million for the first half of 1959. Earnings for the first six months total $1.07 per share. This compares with sales of $86,373,821 and net income of $1,528,967 equal to $1.04 in the same period last year.

• **Allen B. Du Mont Labs., Inc.,** Clifton, N. J. sustained a loss of $117,672 on sales of $9,243,436 for the first 24 weeks of 1959. For the first six months of 1958, the company reported sales of $18,493,000 and a loss of $5,124,000. This deficit included a reserve of $2,900,000 for the estimated loss from the disposal of the Du Mont consumer television business. Presently, all three of the firm's divisions—military, tubes and industrial—are participating in improved operations which are expected to be profitable over the balance of the year.

• **Zero Manufacturing Co.,** Burbank, Calif., reports sales increases of 28 percent during the first quarter of its fiscal year as compared with the same period last year. Profits for the same interval were up 12 percent. The company, which manufactures aluminum and magnesium cases and housings for electronic gear, did not include sales and profits from Electronic Welding and White Aircraft, two recently acquired companies now forming part of the Zero organization. New projects may slow up second quarter earnings and later show increased profit by 1960.

25 MOST ACTIVE STOCKS

WEEK ENDING AUGUST 7

	SHARES (IN 100's)	HIGH	LOW	CLOSE
Gen Tel & Elec	1,577	79	75¼	78⅝
Raytheon	1,386	53⅛	45	47¾
Avco Corp	1,344	15⅜	14¼	14⅜
Intl Tel & Tel	1,176	38	35	35⅝
Zenith	930	120¾	104½	105⅛
Sperry Rand	859	26⅜	24¾	24¾
Gen Electric	610	81¾	79¾	81
RCA	579	66½	62⅜	62⅝
Gen Dynamics	450	54⅞	51	51
Litton Ind	426	130½	108¼	109⅛
Lear	410	16⅞	14⅛	14⅜
Siegler Corp	409	32¾	28⅛	29⅜
Hoffman Elec	396	30½	25¼	26½
Beckman Inst	395	66¼	57	58
Amer Bosch Arma	387	32½	29⅞	30⅛
Univ Control	360	18⅜	17⅝	17⅞
Texas Instr	354	149¾	126⅛	126⅛
Barnes Eng	336	28¾	23⅛	25⅞
Muntz Tv	331	2½	2	2⅜
Emerson	326	17¼	15⅜	15⅜
Standard Coil	325	19⅜	17½	17⅝
Robinson Tech Prod	306	24⅝	20	23¾
Reeves Soundcrft	300	9¾	9	9
Gen Precision	293	43½	39¼	39⅝
Admiral Corp	289	20⅞	19¼	19⅞

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.

NEW PUBLIC ISSUES

	No. of Shares
Central Transformer Company	75,000
Cohu Electronics Incorporated	356,125
Infrared Industries	100,000
Narda Microwave	50,000

STOCK PRICE AVERAGES

(Standard & Poor's)	Aug. 5, 1959	July 8, 1959	Change From One Year Ago
Electronic mfrs.	93.93	97.95	+66.8%
Radio & tv mfrs.	114.60	114.56	+124.5%
Broadcasters	101.31	105.11	+57.9%

Solar Cell Sales to Soar

MARKET FOR SILICON SOLAR CELLS will boom over the next 10 years, indicates Robert F. Edwards, International Rectifier's market research manager and planning specialist.

Annual sales of solar cells, now about $4.5 million should multiply about 25 times by 1970, according to estimates by Edwards and others. Edwards claims future sales of solar cells will rise in proportion to expenditures on space electronics. He looks for space electronics expenditures, which started from scratch in 1958, to rise to $4.8 billion in 1970. Space electronics business in 1959 amounted to $200 million, according to the economic consulting division of Arthur D. Little.

Manufacturers

Increasing number of firms entering the solar cell market lends support to the optimistic sales forecast. In 1958 only two firms—International Rectifier and Hoffman Electronics — reported themselves as manufacturers of solar cells in the ELECTRONICS Buyers' Guide. Six solar cell manufacturers are listed in the new 1959 Guide which contains four new listings under this category: Admiral, Dynapar Corp., Ferranti Electric and Texas Instruments.

History

Devices capable of converting up to 1 percent of solar power to electricity have been known for many years. Archimedes in the year 214 B.C. is supposed to have used the sun's rays to burn the Roman Armada attacking Syracuse.

But the modern silicon solar cell dates back only to 1958 when Drs. Chapin, Fuller and Pearson of Bell Telephone Labs discovered that silicon could be used as a photo electric element with an efficiency as great as 6 percent. A year later BTL announced an improvement in conversion efficiency up to 11 percent. Some cells now have efficiencies up to 13 and 14 percent.

Although present day sales of solar cells are only a fraction of their ultimate market, sales growth to date has been significant. For instance, Hoffman Electronics reports that its solar cell sales increased 10 times between 1955 and 1958.

Applications

The military is presently the greatest user of solar cells and will undoubtedly continue in this position for many years to come. Major military use of the cell is in satellite equipment as a primary source of power.

Solar cells are also used as power sources with transistor radio receivers and transmitters, unattended telephone repeater and weather stations, intermittent signaling and lighting devices, toys and novelties.

Light sensing and control is another broad application area. Sensing and control applications include photoelectric eye applications, light meters, radiation detectors, temperature controls and infrared detectors.

Fast Response

Because of the extremely fast response (20 microseconds), wide spectral range (from 4,000 to 11,500 angstroms), relatively high light-to-electricity conversion efficiency, and self-generating properties, solar cells will solve many control problems now facing design engineers, Hoffman Electronics claims.

High cost of solar cells has limited development of the industrial market in the past. However, electronic engineers are hopeful of reducing costs considerably in future years. Some engineers expect that costs of generating one watt of electricity may be reduced by as much as two-thirds in the not too distant future.

FIGURES OF THE WEEK

LATEST WEEKLY PRODUCTION FIGURES

(Source: EIA)	July 31, 1959	July 3, 1959	Change From One Year Ago
Television sets	91,507	98,426	−8.4%
Radio sets, total	191,895	258,234	+25.0%
Auto sets	47,436	108,459	+21.6%

It takes a TEAM
to solve timing problems

The control of time is an extremely complex science that demands a thorough knowledge of many individual technologies. For this reason, Haydon maintains a team of engineering specialists to provide the reservoir of skill, knowledge, experience, and creative ability necessary to solve industry's timing problems.

When you submit a timing problem to Haydon, it's handled by a team of specialists — *not* an individual engineer. And you can be sure the Haydon Timing Team is equipped with all the electric, electronic, mechanical and manufacturing know-how needed to analyze your requirements and develop the best possible new or modified timing unit for your specific application.

Correctly designed and efficiently manufactured, Haydon timing devices are exhaustively tested before release to a customer. The results are uniformly high quality devices that are known for fine performance, and long life. May we put our Timing Team to work for you?

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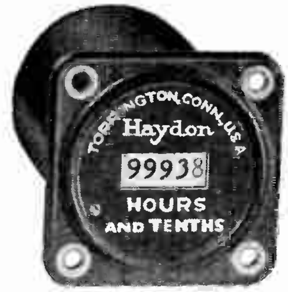
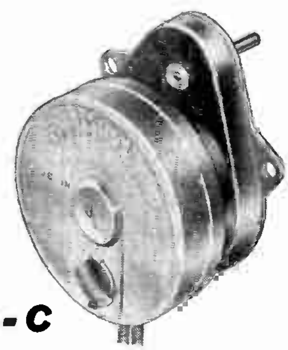


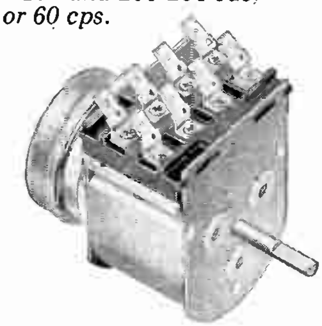
ELAPSED TIME INDICATOR ED-71

Compact, low-cost instrument for machine tools, communications equipment and other commercial applications where an accurate record of operating time is desired. Time Registered: 9,999.9 hours. Weight: 5 oz. Voltages: 120 or 240 v, 60 cps. Power Required: 2.5 watts at 120 v, 60 cps.



A-C TIMING MOTORS

A complete line of synchronous, compact timing motors, speeds from 1/60 to 60 rpm. Guaranteed torques from 6 ounce-inches to 30 ounce-inches at 1 rpm. Voltage ranges 103-132 and 206-264 vac, 50 or 60 cps.

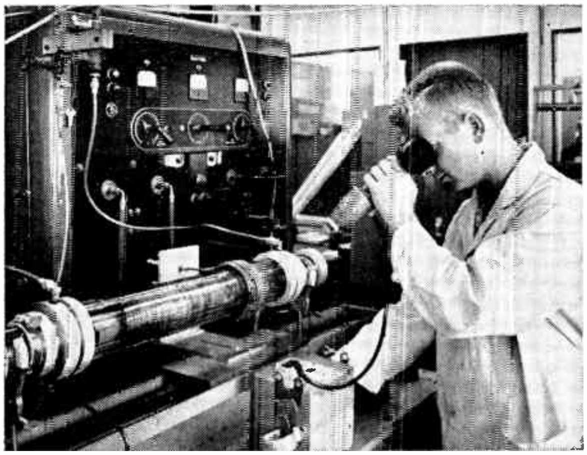


INTERVAL TIMER

Directly controls heavy duty electrical loads. Type AD can be supplied with up to 3 SPST switches. Type AT has 1 SPST switch only. Intervals available with dial and knob: 15, 60 and 180 minutes. Intervals to meet your specific requirements can be supplied. Voltages: 120 or 240 v, 50 and 60 cps. Switch Rating: 28 amps, 250 vac non-inductive; 1 hp, 240 vac.

CIRCLE NO. 13 READER SERVICE CARD

Checking Einstein with



Purity Plus—*Hughes Products Division engineer checks semiconductor materials to insure purity.*

Exit cones *capable of withstanding temperatures of 6000° F. represent one example of advanced engineering being performed by the Hughes Plastics Laboratory.*

an atomic clock in orbit

To test Einstein's general theory of relativity, scientists at the Hughes research laboratories are developing a thirty pound atomic maser clock *(see photo at left)* under contract to the National Aeronautics and Space Administration. Orbiting in a satellite, a maser clock would be compared with another on the ground to check Einstein's proposition that time flows faster as gravitational pull decreases.

Working from the new research center in Malibu, California, Hughes engineers will develop a MASER (Microwave Amplification through Stimulated Emission of Radiation) clock so accurate that it will neither gain nor lose a single second in 1000 years. This clock, one of three types contracted for by NASA, will measure time directly from the vibrations of the atoms in ammonia molecules.

Before launching, an atomic clock will be synchronized with another on the ground. Each clock would generate a highly stable current with a frequency of billions of cycles per second. Electronic circuitry would reduce the rapid oscillations to a slower rate in order to make precise laboratory measurements. The time "ticks" from the orbiting clock would then be transmitted by radio to compare with the time of the clock on earth. By measuring the difference, scientists will be able to check Einstein's theories.

In other engineering activities at Hughes, research and development work is being performed on such projects as advanced airborne systems, advanced data handling and display systems, global and spatial communications systems, nuclear electronics, advanced radar systems, infrared devices, ballistic missile systems...just to name a few.

The variety and advanced nature of the projects at Hughes provides an ideal environment for the engineer or scientist who wishes to increase his professional stature.

Newly instituted programs at Hughes have created immediate openings for engineers experienced in the following areas:

Communications	Environmental Engineering
Thin Films	Logical Design
Electron Tubes	Radar Circuit Design
Field Engineering	Material & Component Eng.
Semiconductors	Systems Analysis
Test Equipment Eng.	Nuclear Electronics

Write in confidence to Mr. Don Eikner, Hughes General Offices, Bldg. 6-D8, Culver City, Calif.

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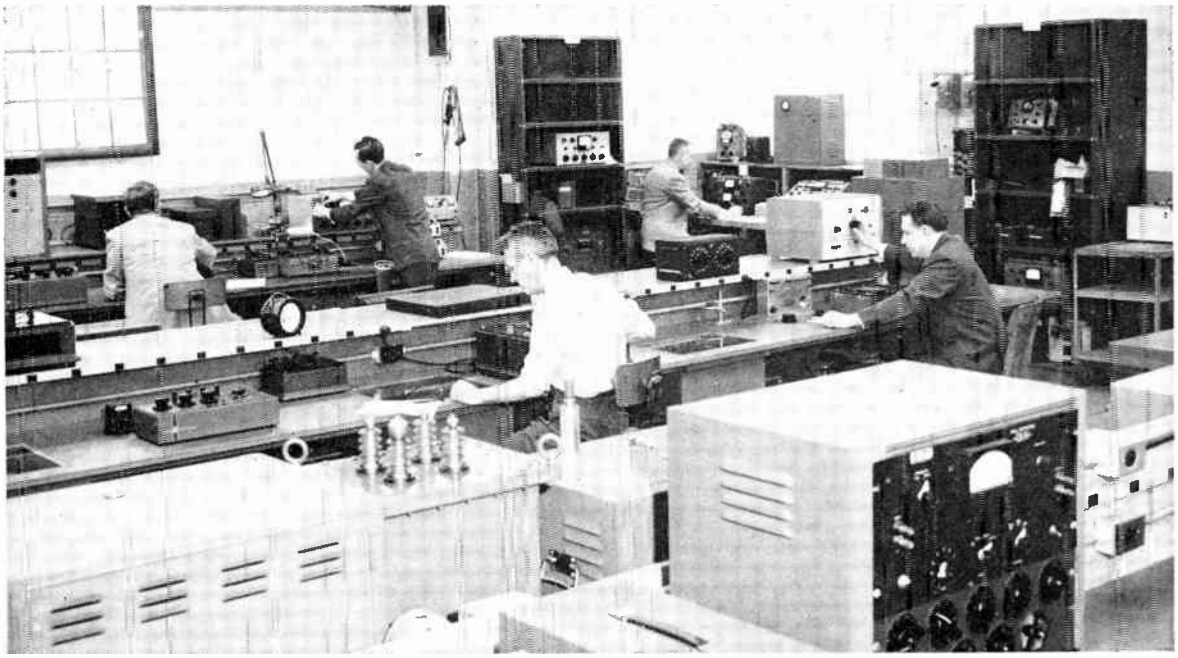


Standards labs in industry—like this one at Goodyear Aircraft—keep industry measurements on the mark, are kept on the mark themselves by National Bureau of Standards. But . . .

Calibration Lags Defense Needs

Air Materiel Command survey of industry measurement standards shows up problem areas, including some in electronics

DAYTON, O.—RECENT SURVEY of industry calibration systems and techniques points up problem areas where available calibration lags both the state of the art and the requirements of defense.

As a byproduct of the survey, which was made under Air Materiel Command auspices, managements in many companies are looking more closely at their calibration program. Better standards should result.

A glaring national deficiency pointed out in the survey is the need for more and finer standards. The National Bureau of Standards, designated by Congress as the national calibration agency from which all measurement must originate, is swamped by industry calibration demands. The Bureau is always faced with a backlog, and can't plow in necessary time to develop new standards and measures.

Survey Results

Some of the results of the survey are pretty shocking. About half of the respondents couldn't determine the ultimate origin of their calibrations. National Bureau of Standards was most frequently cited as prime calibration source in several categories, including r-f, microwave and other electrical standards. Overall results, however, show more general reliance on commercial standards manufacturers and test equipment makers, especially for dimensional and optical measurement and the simpler electrical standards.

Many respondents were unaware of the routine capabilities of NBS: a dozen or so reported struggling with problems for which the Bureau has solutions available on a routine basis.

A number of firms lack adequate plant or lab facilities and controls to house a calibration program.

Many kept few or inadequate calibration records, with resulting loss of control over recalibration intervals. Some didn't even know when their local standards had last been recalibrated.

Most frequently mentioned difficulty arises from the Bureau's location. Plants and labs remote from NBS headquarters in Washington time and again complained of excessive elapsed time in recalibrating their own standards, and of transportation difficulties. Seven-eighths of the surveyed firms would like to see a number of regional calibration centers established—to be operated by NBS or the Defense Department—to serve industrial centers far from the nation's capital.

Another general recommendation made by almost all survey respondents would make one central agency responsible for texts, training and educational material on calibration, and for disseminating latest state-of-the-art information on calibration. General consensus is that NBS would be the logical source for such material.

Problem Areas

Measurement deficiencies unearthed by the survey include internal and external diameters of small holes and a host of electrical areas. "Measurement of blocks represents the highest refinement in the precision measurement field," asserts one measurement expert. "Outside diameters represent a more difficult problem, and inside diameter gaging is the worst area." The same expert adds: "Absolute measurement to the millionth of an inch cannot be achieved with existing available equipment."

R-f and microwave measurements were on the problem list. Measurements are not always possible, according to the survey, to the accuracies required by military systems. Specific areas mentioned by the Air Force included: unmodulated microwave power, average and peak values of pulsed microwave power, attenuation, voltage standing-wave ratio. Power and attenuation measurements across the whole r-f spectrum also were said to lag the state of the art and military tolerance requirements, as were precision measurement of a-c voltage and capacitance.

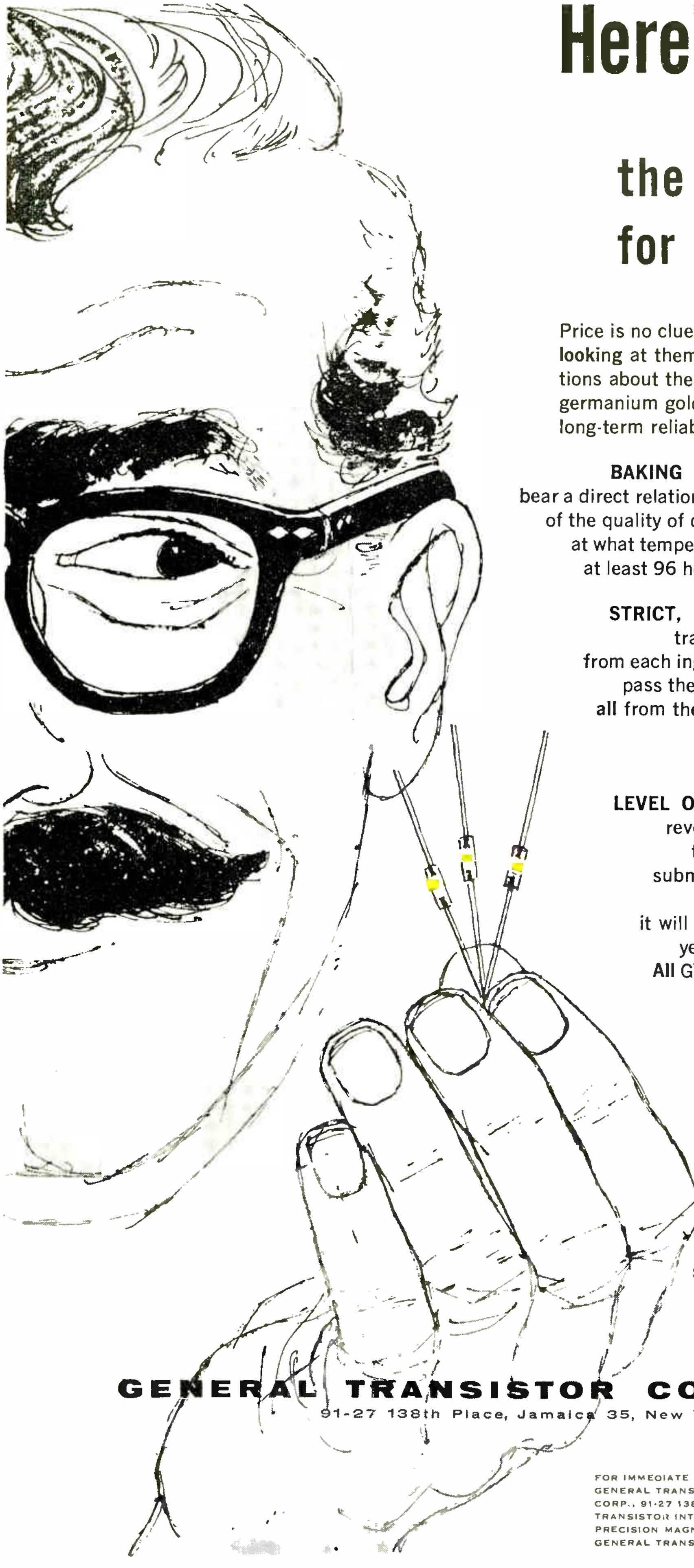
Survey Follow-Up

Information for the evaluation came from three sources thus far, with a follow-up still to come. First, quality control people from AMC headquarters visited over 800 plants and laboratories of Air Force contractors. Then a team of calibration experts from NBS and the Air Force checked a smaller group of missile facilities.

Finally, AMC, NBS and Aerospace Industries Association developed a two-part questionnaire, circulated it to member firms of AIA, Electronic Industries Association and National Security Industrial Association.

Sixty-eight firms answered part I of this questionnaire, most of them middle-sized and large companies, and almost all with at least one foot in electronics. The results were collected and analyzed by Sperry Gyroscope to point out the major problem areas and suggest paths for improvement.

A committee from the AIA is currently following up in these areas with part II of the questionnaire. This added probe will attempt to pin down the problems so that NBS can develop specific new or improved standards, new measurement techniques or higher orders of accuracy, as needed.



Here's how to pick the best DIODES for your money

Price is no clue when diodes sell for about the same, and just **looking** at them tells nothing. But if you ask the right questions about the three key factors in the production of **quality** germanium gold bonded diodes, you have your clues to more long-term reliability for your money. Here they are:

BAKING TIME AND TEMPERATURE
bear a direct relationship to long-term stability. You get a measure of the quality of diodes by asking: "How long do you bake, and at what temperature?" (**All** GT diodes are baked at 140°C for at least 96 hours—the highest and longest in the industry!)

STRICT, STATISTICAL, HISTORY LOGGING
traces the progress of every single wafer made from each ingot of germanium. At GT, if a few wafers fail to pass the stringent GT quality tests along the way, then **all** from the ingot are suspect and can be identified and pulled out. There are no "stowaways" in a shipment of GT quality diodes.

LEVEL OF TESTING STANDARDS
reveals the level of quality. Ask about "everyday" test standards. (In the GT Seal Test, diodes are submerged in a penetrant-dye solution for 24 hours under 75 psi. This test is so sensitive that it will reveal a leak so small it would take over 300 years for 1 cc of gas to diffuse through the case.) **All** GT quality tests—100% electrical, 100% shock and vibration, and 100% temperature cycling —are at the highest industry level... and as a final mark of quality, the color bands on GT Germanium Gold Bonded Diodes are baked on to stay.

GT is equipped to supply diodes tested to individual customer requirements, such as JAN Qualification Inspection Tests and many others.
To get the full measure of quality in Germanium Gold Bonded Diodes, see your GT representative; or write directly to the company with know-how **NOW.**

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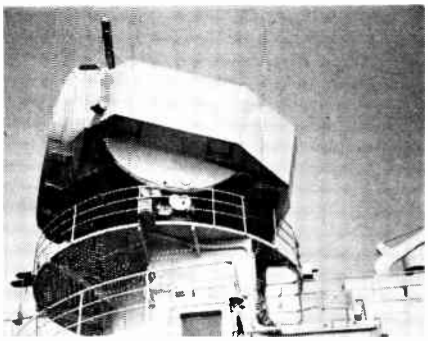
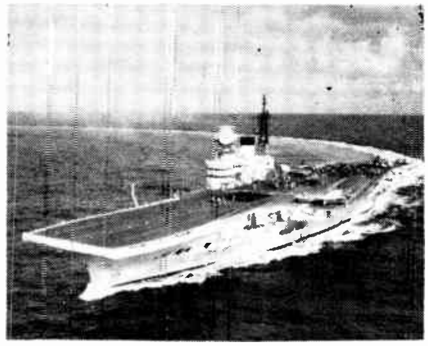
Victorious Shows 3-D Radar

Electronic systems on the British flattop make U.S. Navy men envious. She has new radar, new comprehensive display systems

ELECTRONIC SYSTEMS abord *HMS Victorious*, the gallant veteran of Coral Sea days now rebuilt into an atom-age carrier, have excited a good deal of admiration and envy from U.S. Navy carrier men. Principal reason is her aircraft direction system, which, in Atlantic games with American carriers during July, enabled her to score an overall average of 90 interceptions to 30 for U.S. carriers.

Hottest thing aboard the *Victorious* is her model 984 radar, which gives her direction officer (equivalent to a combat intelligence center officer) not only range and bearing to all targets, but altitude of any selected targets. Planning interception patterns is thus materially simplified.

This system, combined with the latest in combat intelligence centers (called aircraft information organization aboard a British carrier), makes it possible for three carriers and associated air pickets to maintain complete surveillance over a 1,000-mile sea frontier.

Lens director of 984 radar on *HMS Victorious* gives her unique silhouette. Transmitting gear is housed in 27-ton gyrostabilized nacelle (left)

Three-D Radar

The 984 is one of the first successful "three-dimensional" radars. It can acquire altitude data about a target without tracking it and running its polar coordinates through a computer (which is the way a gun-laying radar gets its altitude data). Result: it can maintain an area surveillance and at the same time produce the slant range, pointing angles and altitude data needed to plan fighter intercept patterns.

Details of the 984, its associated computer, and the information center where radar data are translated into combat intelligence, are under tight security wraps. But officers of the ship were able to disclose some operating principles to ELECTRONICS in an exclusive three-hour tour of the completely reconditioned flattop early this month.

The 984 sends out a number of narrow beams stacked vertically to cover about a 50-deg vertical slice of sky and still permit discrimination in elevation angle. Azimuth discrimination is achieved conventionally by rotation of the tower (or nacelle, as the housing is called).

British naval authorities could not disclose the number of beams, but they probably number about two dozen. Of these, one, close to the midpoint of the vertical sector (aimed about 25 deg above the horizon), is at a different frequency from the other, is fixed in elevation, and is used for long-distance surveilance and early warning. The others scan vertically in small fractions of the whole possible elevation angle covered by the radiating array, and provide the fine elevation discrimination needed to compute altitude.

Each beam has a separate receiver channel, with automatic frequency control to correct for frequency variations in the magnetron. The energy is directed by a microwave lens about 14 ft in both diameter and focal length.

Combat Intelligence

Plan-position data are presented on several consoles in the aircraft information organization. Computer and comprehensive display system were engineered by Pye Ltd.

When a direction officer determines that a target is putatively hostile, an operator passes the bearing and range of that target through an associated computer, which determines the elevation from which the strongest return is coming and computes the triangle to derive altitude. Then all known data about that target are stored in the computer, subsequently to be updated as needed.

CIC and direction officers can interrogate the computer store about any target; if the target is being "watched" and the data are in the storage unit, the presentation appears on a ppi-type scope on the interrogation panel, of which there are many in the information center. At each of these locations, too, is a smaller analog computer which translates target data, plus position data of one or more of the carrier's fighter planes, into an intercept course.

Carrier-Controlled Approach

Also new on the *Victorious* is a Ferranti radar system for talking down aircraft in foul weather. The carrier-controlled approach (CCA) radar is one of the first ever designed specifically for shipboard use.

The CCA system has a "variable drive" mechanism which permits close timing of landings. If it is necessary, for example, to land six craft in five minutes, this mechanism figures out a 50-sec separation pattern and provides the CCA officer with the necessary path data to talk the planes down.

Air Training Market

Air Force electronics center at Keesler AFB will almost double its inventory of gear this year

KEESLER AFB, MISS.—JUST BEHIND the Mississippi Gulf Coast's row of waterfront resort hotels lies a spiraling—though little publicized—electronics market.

Here at the Electronics Training Center of the Air Force—one of 25 Air Training Command installations—20,000 electronics specialists are trained each year.

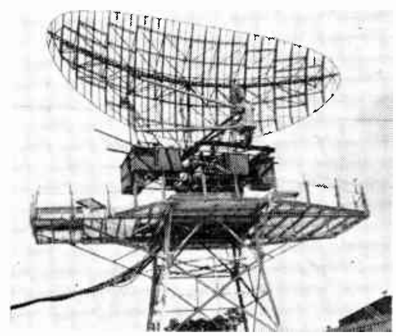
Electronic equipment needed to convert that many untrained high-IQ men into electronics experts means steady, large-volume buying. Locally the electronics center is known as the "largest industry in the South."

Average net inventory of electronic gear has amounted to some $40 million to date. The center has been buying close to $4.5 million worth of new electronic equipment a year and spending $2 million more for replacement of obsolete or worn-out parts.

This year both inventory and buying will take a tremendous leap due to new high-cost items Keesler will buy. Two frequency-diversity radars alone will cost $30 million.

Graduates are qualified for operational and maintenance duties, 20 percent and 80 percent respectively, with all Air Force commands. Their jobs range from operating electronic countermeasures equipment in a B-58, to tracking planes on DEW-line radar scopes, or repairing intercom systems in a C-47. Unfortunately for the Air Force, the majority of these men filter into private industry as soon as their tour of duty is over.

Much of the training equipment used in Keesler's ten specialized departments is designed, developed and built in the training aids section. Giant-sized simulators—so that students in the back row can see what's going on—are built for training SAGE FSQ-7 radar tracking operators. Complete simulator for a power installation for Thule AFB was built to train men before sending them to Greenland.



Long-range radar used for training men for DEW-line and BMEWS at Keesler AFB

Operational equipment of all kinds, such as the ARC-24, is bought and mounted for instructional use. Basic training devices such as radio receivers, amplifiers, and test equipment are designed and built on the spot.

During fiscal 1959 and 1960, $1-million is budgeted for just minor components for training aids. Buying of standard operational items and big industry-made portions of simulators multiplies this amount severalfold.

The fixed communications electronics department maintains an inventory of electronic equipment valued at $7.5 million. New equipment ordered for fiscal 1959 and 1960 will hit $1 million. Gear used includes: radio beacons, TVOR, ILS, TACAN, DF, omnirange, single-side bands, microwave relay, troposcatter and ionospheric scatter equipment.

Airborne counterpart to the fixed communications department keeps in good operating condition about $13-million worth of equipment. Electronic warfare department (ecm) has on hand about $5 million of gear. It turns out 500 electronic warfare officers a year. Ground electronics department uses about $15-million worth of long-range radar detection sets; this is the group that will acquire the two frequency-diversity radars.

ATC&W department (for air

Spirals

traffic control and aircraft warning) trains GCA operators as well as personnel for the overseas SAGE system 212-L (ELECTRONICS, p 29, Apr. 17).

Keesler's SAGE training is carried out at Richards-Gebaur AFB, Mo., in an operating installation. The basic electronics department uses thousands of electronic devices, the majority of which are built or at least modified for demonstrational use by the training aids section.

By last month Keesler had 25 courses going on at factory sites. Companies include GE, Burroughs, Reeves Instrument, Laboratory for Electronics, Gilfillan, IBM, Western Electric, Polytechnic, RCA Service Corp., Westinghouse and Avco.

Right on the base, GE is conducting a course on the Atlas guidance system. RCA recently conducted a course on the installation and maintenance of troposcatter equipment.

Air Training Command consists of 25 bases, 150 mobile and field training units and more than 100 factory training sites. Besides pilot and navigation schools, ATC trains all specialists for the Air Force.

One growing responsibility is programming and managing technical training for missile programs. ATC is now involved in 15 Air Force missile training programs. Graduates to date total 8,000 qualified missile airmen.

Weapon systems training at Sheppard AFB, Tex. includes courses on Atlas, Thor, Titan and Jupiter. Here men learn about airborne guidance equipment, equipment cooling and electrical power generation. Non-missile work includes communications operation and aircraft maintenance.

At Lowry AFB, Colo., a big portion of the work is devoted to armament systems maintenance. Electronic fire-control system for the F-102 utilizes 59 electronics technicians. Each man requires 43 weeks of training.

Amarillo AFB, Tex. provides courses for Quail and Snark, Lackland AFB, Tex. teaches airmen the art of radio communication.

Ruling Spurs Private Microwave

Equipment manufacturers expect burgeoning market as FCC opens spectrum above 890 mc

MICROWAVE EQUIPMENT manufacturers are laying plans to make the most of a boom in sales expected to follow recent Federal Communications Commission action opening up the spectrum at 890 mc and above.

The commission ruled that availability of common-carrier communications will no longer bar a company from getting a private license. This opens portions of the microwave spectrum for private users.

Electronic Industries Association estimates that the new regulations mean a possible 25-percent increase in microwave use within the next six years, and a 50-percent increase by 1976, over and above the normal expansion that would have occurred under the old rules.

A spokesman for one major manufacturer says the industry has awaited such a decision for years, adds it will have "tremendous impact."

Present high cost of microwave installations—about $12,000 to $14,000 for a 35-mile reach plus additional outlay for each added relay point—is expected to limit private systems initially to big users. Manufacturers hope, however, to bring costs down.

Trucking companies, banks and department store chains, as well as manufacturers with scattered plants, are all seen as potential buyers. A communications engineer speaking for the American Trucking Association estimates that once a system is established, a private user will get about three times as much communications per dollar as he would from leasing common-carrier facilities.

Would-be private users may file applications immediately, but ELECTRONICS learns that the commission is already backlogged two to three months.

Past hearings indicate that there are enough available slots in the range above 890 mc to take care of foreseeable demands of both private and common-carriers users. New private systems will receive assignments in the area above 10,000 mc, except for public safety organizations.

Controls for Lacrosse Missile

An angular tracker (foreground) is adjusted to pick up signals from Army's Lacrosse surface-to-surface missile as it streaks toward a target 15 miles away. Other equipment shown above in the radio command guidance system includes a power supply unit (right), a computer and a range and direction indicator. Martin is prime contractor

MEETINGS AHEAD

Aug. 23-26: Electrical Conf. of the Petroleum Industry, AIEE, Wilton Hotel, Long Beach, Calif.

Aug. 23-Sept. 5: British National Radio Industry Council, Earls Court, London.

Aug. 24-26: Gas Dynamics Symposium: Plasma Physics, Magnetogasdynamics; American Rocket Society, Northwestern Univ., Evanston, Ill.

Aug. 24-27: Ballistic Missile and Space Technology, U.S.A.F., Space Technology Labs, Los Angeles.

Aug. 31-Sept. 1: Elemental and Compound Semiconductors, Tech. Conf., AIME, Statler Hotel, Boston.

Aug. 31-Sept. 2: Army-Navy Instrumentation Program, Annual Symposium, Douglas Aircraft and Bell Helicopter, Statler-Hilton, Dallas.

Sept. 1-3: Air Force Association's National Convention, Exhibition Hall, Miami Beach, Fla.

Sept. 7-12: Machine Searching and Translation International Conf., Western Reserve Univ., Rand Devel. Corp.; Western Reserve Univ., Cleveland.

Sept. 14-16: Quantum Electronics Phenomenon, Office of Naval Research, Shawanga Lodge, Bloomingburg, N. Y.

Sept. 17-18: Engineering Writing & Speech, Dual National Symposium, PGEWS of IRE, Sheraton-Plaza Hotel, Boston; Ambassador Hotel, Los Angeles.

Sept. 17-18: Nuclear Radiation Effects in Semiconductors, USASRDL, Western Union Auditorium, New York City.

Sept. 21-25: Instrument-Automation Conf. & Exhibit, ISA, International Amphitheater, Chicago.

Oct. 12-15: National Electronics Conference, IRE, AIEE, EIA, SMPTE, Sherman Hotel, Chicago.

Mar. 21-24, 1960: Institute of Radio Engineers, National Convention, Coliseum & Waldorf-Astoria Hotel, New York City.

There's more news in ON the MARKET, PLANTS and PEOPLE and other departments beginning on p 58.

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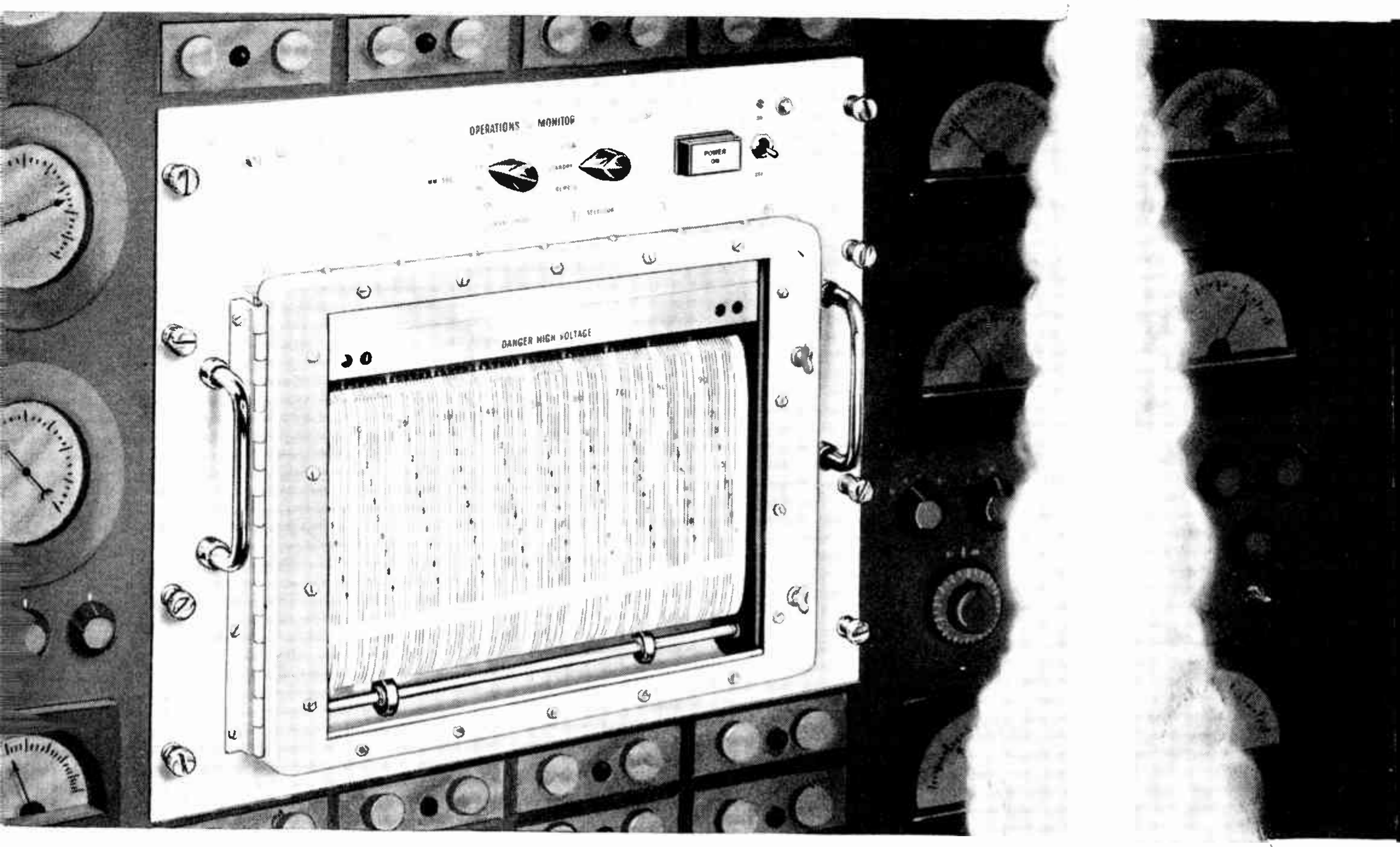

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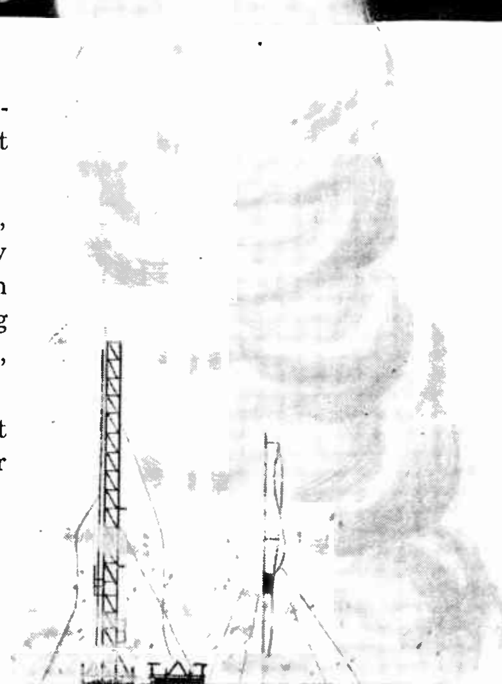

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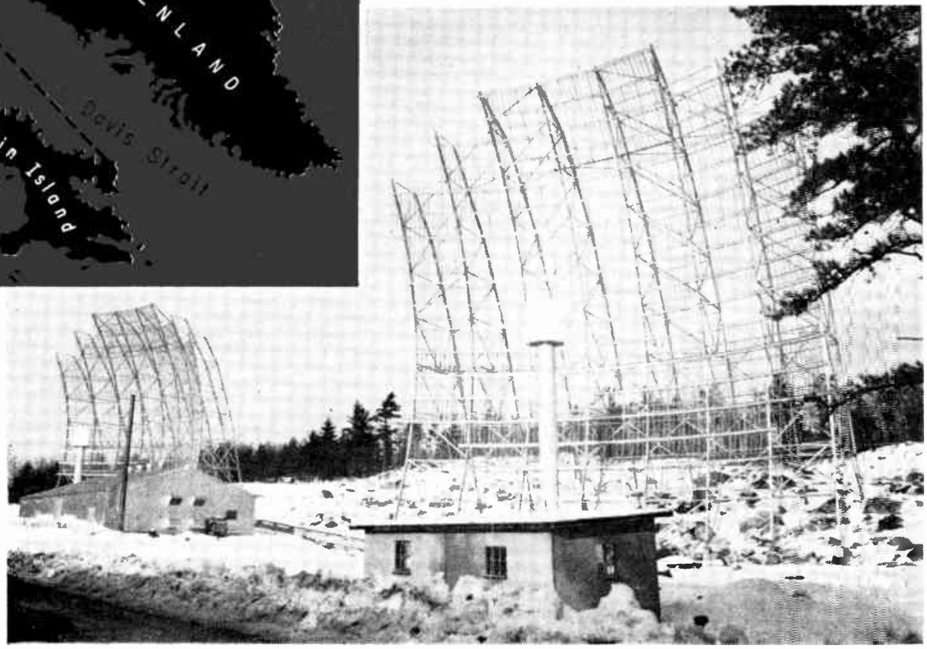


Rugged reflectors for quadruple-diversity single-sideband tropospheric scatter link are part of DEW-line extension in northeast Canada (inset). System is one of first to use parametric amplifiers in receivers

New Microwave Systems Using Low-Noise Devices

Packaged masers and parametric amplifiers are dominating new receiver designs in microwave systems for military applications. Junction diode mavars are boosting revival prospects of uhf television

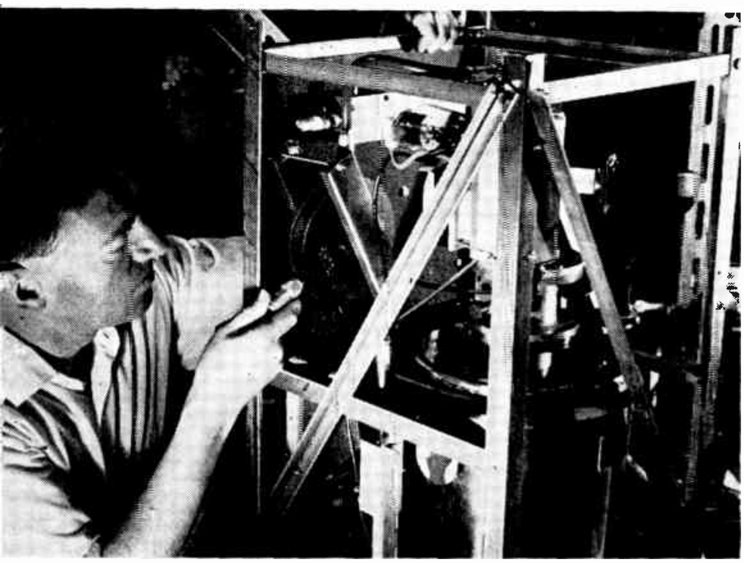
By **THOMAS MAGUIRE,** New England Editor

SURGE IN APPLICATION of parametric amplifiers to radar and communications systems has already begun. Within the next year this is expected to be the dominant feature of the military microwave business.

Virtually all new government contracts for missile acquisition radars, satellite-tracking radars and tropo scatter communications systems incorporate paramps, according to one industry source.

And the multifaceted microwave field hints another surge, in radically different dimensions. Extensive study of semiconductor diode paramps for tv tuners suggests the possibility of a high-volume commercial market, perhaps in less than five years. Trend towards transistorization means solid-state tv's, and set manufacturers as well as tuner makers are looking hard and long at low-noise junction diodes to determine if they or their offshoots will provide the answer to front-end problems, specifically in uhf. Possibilities are all wrapped up in future of uhf, prospects of its eventual revival (ELECTRONICS, May 15, 1959, p 30).

"If we had junction diode paramps 10 years ago,



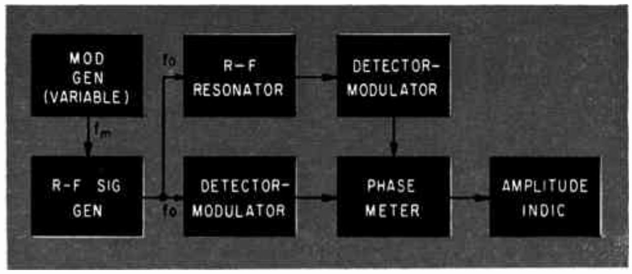


FIG. 1—Test set-up for measurement of resonator Q by observing envelope phase shift

Physicist connects circulator input on maser to be installed on Harvard's radio telescope for hydrogen-line studies

uhf tv would be in extensive use today," claims a paramp enthusiast.

Says a tuner manufacturer: "We're negative about paramps today, hopeful about the future. Working with them at their present stage of development is like working with a bucket of worms."

But microwave amplification for tv was merely a footnote when some 600 researchers met at Harvard last month for the national symposium of the IRE's Professional Group on Microwave Theory and Techniques.

Dominating the formai sessions and campus chats were advances made in parametric amplifiers and masers for large-scale communications systems, radar and radio astronomy; packaging of masers; and the state of the art in quantum-mechanical amplifiers in general.

FUTURE OF MASERS—On masers, researchers' opinions boil down to this: the standard maser will eventually be the traveling-wave variety, offering better gain stability, more bandwidth than the cavity type. Optimum use of masers will be in radio astronomy, where antenna is always pointing at a cold sky; and in communications using passive satellites. One of maser limitations is slow recovery time—0.1 sec is best achieved so far in radar systems—but materials research and other developments may lick this problem.

On the parametric amplifier: the next year will see widespread use in military communications, radar systems; also in the coming year, amplification at X-band will be generally achieved. Already reported is a parametric amplifier operated at 11,000 mc, at Bell Labs. Intensive research shows promise of improving gain stability of paramps, one of the most elusive problems to date.

Among first large communications systems using junction diode paramps is a one-hop single-sideband tropo link for DEW-line extension under construction at Cape Dyer in Northeast Canada and Thule, Greenland, a jump of more than 600 miles. GE expects to install the AN/FRC-47 system for teleprinter and voice communication by December 1959. D. S. Kennedy is building ruggedized reflectors, 135 feet high and 120 feet wide, for the quadruple-diversity scatter system. Prototype is in operation between Lincoln Lab's Millstone Hill, Mass., site and Sauratown Mountain, N. C., 640 miles away. Tests on the prototype showed up-converter type paramp gave average noise improvement of 2 db, with tuning over 100-mc bandwith.

TUNABLE PACKAGED MASERS—X-band maser built by Ewen-Knight Corp. for Lincoln Lab, and now under test in a radar system, operates at signal frequency of 9,300 mc, pumps at 23-24 kmc. Required tunability range is 100 mc, but it reportedly can be tuned over a 400-mc range using single electrically-driven tuning device and changing pump power. The package has a fixed magnet. Stainless steel dewar holds 15 liters of liquid helium, for 2 to 5 days of operation. The power supply and control console can be remoted. System uses Raytheon X-band circulator, also a new low-temperature germanium microwave switch developed at Lincoln Lab to protect the maser from low-power leaks when the t-r tube is fired at the time of pulse. Operation of switch depends on impact ionization of impurities, same principle as in the new low-temperature computer component, the cryosar (ELECTRONICS, May 22, 1959, p 11).

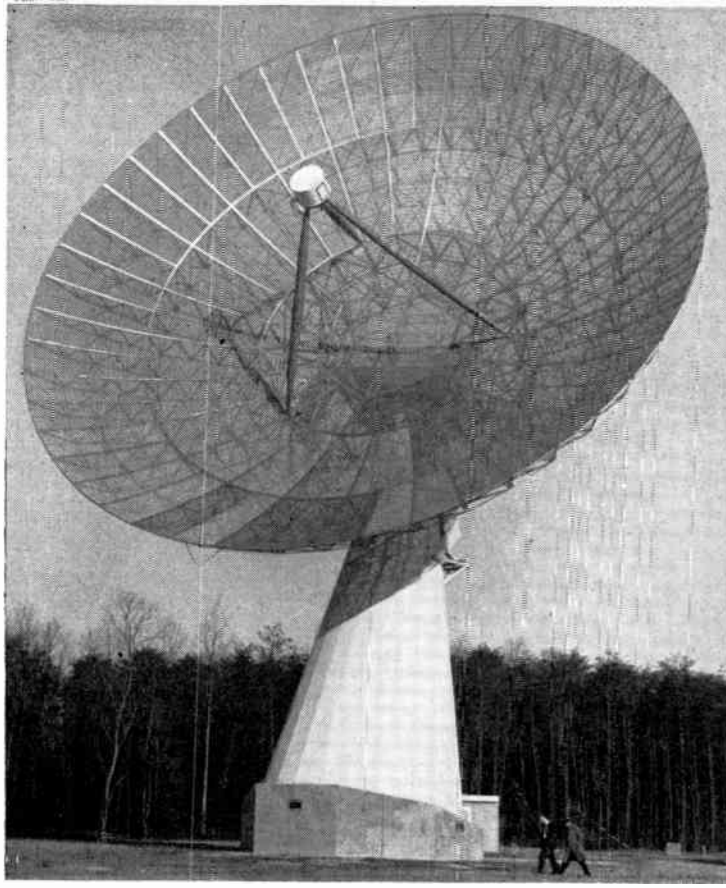
L-band maser developed by Airborne Instruments Laboratory provides a package for very-long-range detection in military field application. AIL designed a 4-port circulator for its maser, says the circulator has only 0.3-db loss, and isolation greater than 20 db. Micrometer heads are used for independent tuning of signal and pump frequency. AIL reports the circulator maser system operates over 200-mc frequency range at L-band. Circulator type determines usable tuning range of system. The maser has been operated over range from 850 to 2,000 mc, and AIL says spanning of two octaves is attainable. Voltage-gain bandwidth product of 37.5 mc was measured at

1,750 mc, with operating temperature of 1.5 K. At 4.2 K, product of 20 mc was measured. The package is 38 inches wide, 6 ft at highest point. Liquid helium supply of 2½ liters can operate 16-18 hours, and a relay-actuated light warns when refill is needed.

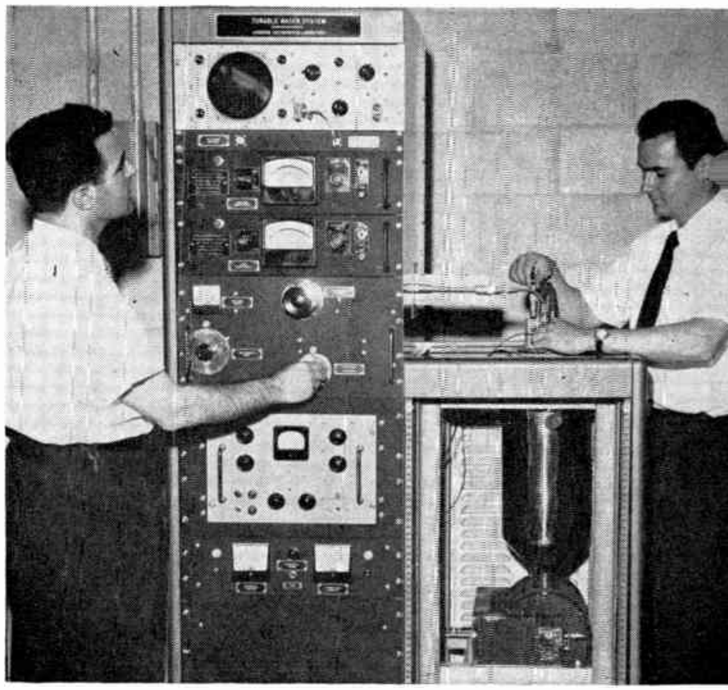
HYDROGEN-LINE MASER—Full system tests begin this month at the Harvard Observatory's Agassiz Station on a 60-foot radio telescope equipped with a maser for the 21-cm wavelength band—the frequency of emission from interstellar hydrogen. It is believed to be the first L-band maser installed on a radio telescope. The maser, developed in 1957 under direction of Prof. Nicolaas Bloembergen, is installed on the focus of the parabolic reflector. Incorporation of a new Raytheon L-band circulator helped simplify the system. Maser pumps at X-band, signal is at 1,420 mc. It uses a stainless steel dewar and 60-pound permanent magnet, has a klystron for pump energy. Dr. John V. Jelley of Harvard Observatory says researchers have had it operating with 20-db gain and 2.5-mc bandwidth. Principal problem will be in getting broader bandwidth. Although 2.5 mc is suitable for much of the hydrogen-line radiation, extragalactic clusters (of great interest to radioastronomy) have wider lines. Weatherized maser package, weighing 200 pounds, is mounted on focus of dish and tilted at fixed 45 deg above horizon. Later, hydraulic actuator will permit shift of maser mount angle.

RESONATOR BANDWIDTH MEASUREMENT—Bandwidth of a high-Q microwave resonator can be measured by observing the transmission phase shift of the envelope of a signal with sine-wave modulation.[1] At the half-power frequencies of a single-tuned resonator, the resistance is equal to the reactance; the phase shift is therefore 45 deg. For a modulated signal with the side-bands at the half-power frequencies, the phase shift of each sideband is 45 deg with respect to the carrier (in opposite directions). This results in a 45-deg delay of the modulation.

For the measurement of small bandwidths, this method relieves the requirements for oscillator stability and precision frequency measurements, does not depend on observing amplitude. Figure 1 shows the test setup. Since the measurement depends only on phase shift, it is not sensitive to amplitude variations of signal generators, detectors or amplifiers. In one example of a resonant cavity, this technique was used to measure a bandwidth of 40 kc at 800 mc, indicating that Q = 20,000. Accuracy in this case is estimated to be within 3 percent, on the basis of setting the phase shift to 45 ±0.7 deg.



Naval Research Lab's 84-ft radio telescope at Riverside, Md., has maser at focal point



Engineers at Airborne Instruments Lab perform final tests on tunable L-band maser before delivery to Department of Defense

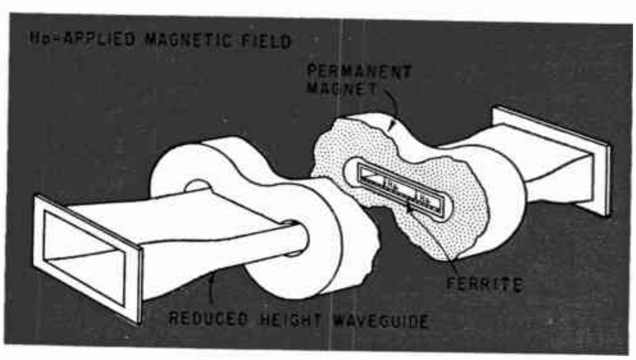


FIG. 2—Method of suppressing unwanted signals in waveguide by use of ferrite slabs magnetized to resonance

REDUCING WAVEGUIDE MICROPHONICS—Weapons noise environments, particularly of jet aircraft and rockets, intensify the problem of microphonics in waveguide. In c-w and pulse doppler radar systems, extraction of doppler information from a microwave signal must be done while eliminating spurious signals in the doppler frequency band, since degrading of system sensitivity results from such spurious signals.

A study made at X-band shows that phase modulation of the microwave energy by acoustic effects in the waveguide can be minimized by heavy walls and damping materials.[2] In severe acoustical environments, both schemes may be necessary. Aquaplas was found to be the most effective coating material tested for waveguide.

Tests determined the acoustical resonant frequencies of the transverse mode of a rectangular waveguide both theoretically and experimentally. Various samples of waveguide were excited by acoustical energy from a tweeter placed about one inch from the broad face of the specimens. Acoustical levels at the waveguide were found with use of a sound level meter.

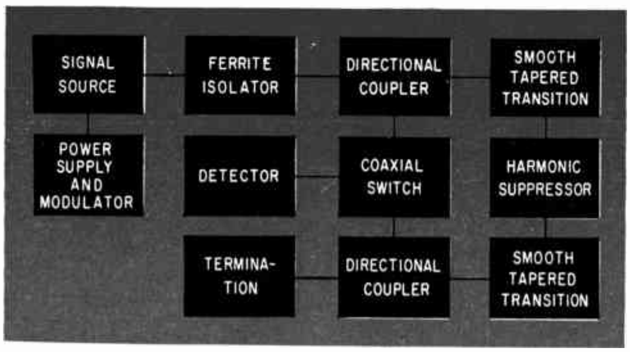


FIG. 3—Low power test setup for measuring effectiveness of spurious frequency suppression

FERRITE PHASE SHIFTERS—Propagation of the microwave energy in a slow-wave mode is proposed as a new approach to the design of ferrite phase shifters for S-band and lower frequencies.[3] The method decreases the physical length of a transmission line for a given phase delay by increasing the phase shift per unit length. A reciprocal phase shifter has been constructed in $\frac{3}{8}$-in. diameter coaxial line which, when six inches long, gives a change of phase shift of 360 degrees at 3,000 mc when the applied field is varied over a range of 60 oersteds. An ordinary $\frac{3}{8}$-in. coaxial line filled with the same ferrite would have to be 40 inches long to give equal phase shift for the same change of applied field.

A slow-wave structure can also be used as a nonreciprocal phase shifter in coaxial line. If only half the coaxial cross-section is loaded with the disk-loaded-rod structure, a circulating r-f magnetic field is generated. With thin slabs of ferrite placed at the interface of the slow-wave structure and air, a differential phase shift of 180 degrees at 3,000 mc has been obtained in a three-inch length of coaxial line.

The slow-wave reciprocal phase shifter is useful in low-frequency, high-speed electronic scanning systems, also as a high-speed switch in coaxial line, when used in conjunction with 3-db hybrid junctions. Main limitation is its inherently narrow band, which can be partially overcome if programmed control currents can be provided. The non-reciprocal phase shifter has more bandwidth and can be used to construct broadband low-frequency circulators in coaxial line.

SUPPRESSING SPURIOUS SIGNALS—Generation of spurious signals by the klystron or magnetron in high power systems can cause high-power breakdown, crystal burnout and interference with other microwave systems. A specialized form of ferrite attenuator is proposed to suppress harmonics and spurious signals propagating in most rectangular waveguide modes.[4] Unwanted signals are absorbed in ferrite magnetized to resonance. The suppressors are essenentially tuned, low-pass filters. But they have the desirable feature of providing absorptive rather than reactive attenuation in the reject band.

Units can suppress unwanted signals from the second through the fifth harmonic by at least 10 db, while attenuating the fundamental frequencies by less than 0.5 db.

Thin slabs of high-Curie-point ferrites are used, mounted against the broad walls of the waveguide. A liquid cooling system holds ferrite temperature as uniform as possible for different levels of absorbed power.

Permanent magnets are used to bias the ferrites. The size of the magnets is closely related to waveguide height because the dimension establishes the air gap across which the magnet must work. Waveguide height is reduced, as shown in Fig. 3, to 0.590 inch for the S-band unit and to 1.34 inches for L-band. For these dimensions, a 124-pound magnet is needed to generate the 6,600 gauss required for the S-band unit. The L-band magnet produces 4,000 gauss, weighs over 400 pounds.

To obtain the required low-pass filter characteristics, the ferrites must be biased far enough above resonance at the highest pass-band frequency to produce negligible loss at that frequency. They must be biased at or near resonance at the reject-band frequencies so that resonance absorption maintains a certain required attenuation level. These requirements set the basic limits on the ferrite types and variety which can be used in a filter of this type once the bandwidth and selectivity are specified. Low-power test apparatus setup is shown in Fig. 3.

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All papers presented at the PGMTT National Symposium, Harvard University, 1959.

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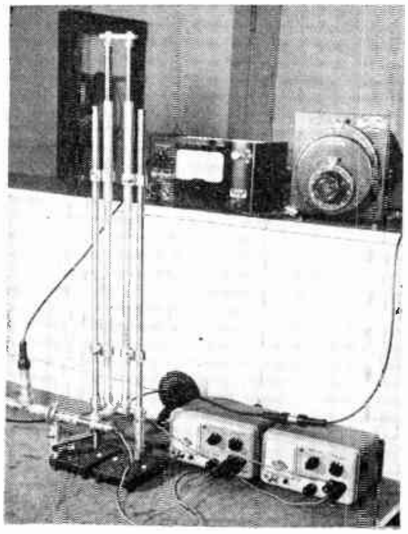
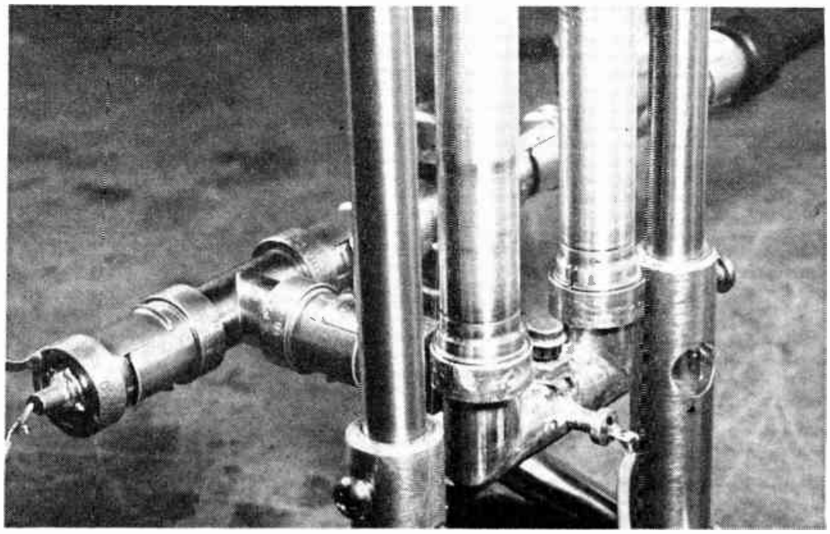
(2) I. Goldstein and S. Soorsoorian, Raytheon Co., Microphony in Waveguide.

(3) R. L. Fogel, Hughes Aircraft Co., A New Approach to the Design of Low-Frequency, Ferrite Phase Shifters.

(4) W. C. Heithaus, S. C. Sloan, B. J. Duncan, L. Swern, Sperry Microwave Electronics Co., Ferrite Multi-Mode High Power Signal Suppressor.



Complete bench setup for determination of maximum frequency of oscillation



Close-up of coaxial setup shows transistor mount, feedthrough capacitors for emitter and collector bias connections, and detector coupling

Determining Transistor High-Frequency Limits

The most direct method of ascertaining the upper frequency limit of transistor performance is by measurement of the maximum frequency of oscillation. A technique which uses a coaxial element structure is described which extends the range of such measurements up to 1,000 mc

By J. LINDMAYER and R. ZULEEG, Sprague Electric Company, North Adams, Mass.

IN RECENT YEARS, high-frequency performance of transistors has been extended by incorporation of an impurity gradient into the base layer. This gradient creates a built-in field which causes drift of the injected minority carriers in the base, rather than the slower diffusion which occurs when no gradient is present. For germanium graded base transistors, a theoretical limit of high frequency performance between 8,000 and 10,000 mc has been predicted.[1,2] Although this ultimate frequency performance has not yet been realized, transistors operating at several hundred megacycles are commercially available.

Frequency Limits

High-frequency performance of a transistor is characterized by the grounded-base and grounded-emitter frequency cut-offs, called $f_{c\alpha}$ and $f_{c\beta}$, respectively, and in addition, by the maximum frequency of oscillation, f_{max}. The latter is the frequency at which the power gain becomes unity. Measurement of f_{max} is the most direct method for ascertaining the upper frequency limit of transistor operation.

The parameters $f_{c\alpha}$, $f_{c\beta}$ and f_{max} usually can be measured in the frequency range below about 100 mc with standard equipment.[3,4,5] A thorough discussion of the maximum frequency of oscillation and the principle of measurement has been given by Drouilhet.[6] However, the circuit described is limited to frequencies below 100-150 mc. This article will describe an equipment which measures f_{max} to 1,000 mc.

Gain-frequency Aspects

A transistor is a bilateral active network. Therefore, the following two theorems which apply to four-pole active networks in general are

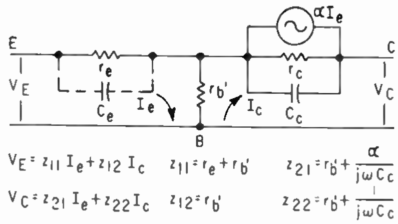


FIG. 1—High-frequency equivalent circuit for a transistor represented as a four-pole tee network

valid for the unilateral power gain.[7] Theorem 1 states that for a four-pole network, the unilateral power gain is independent of the method of dividing the four terminals into pairs corresponding to the subscripts on the impedance parameters; for example, unilateral power gains are equal for a transistor in grounded-emitter and grounded-collector configurations. Theorem 2 states that for oscillation to be possible, unilateral power gain must be greater than or equal to unity. The maximum frequency of oscillation is therefore defined as the frequency at which the unilateral power gain is unity.

On the basis of the equivalent circuit of Fig. 1 for a high-frequency transistor, Angell[8] has shown that unilateral power gain $U = a_o f_{co}/8\pi r_b' C_c f^2$. U is defined as the gain of an active circuit neutralized by a lossless network so that the feedback impedance is zero.

For $U = 1$, this relationship defines the maximum frequency of oscillation in terms of the parameters of the equivalent circuit. Hence, $f_{max} = \sqrt{a_o f_{ca}/8\pi r_b' C_c}$. To verify this in practice, requires careful measurements of f_{ca}. These measurements are complicated by the excessive phase shift inherent in graded base transistors at high frequencies.

In this article, measurements of the maximum frequency of oscillation and of the power gain as a function of frequency are described. When approaching the maximum oscillation frequency, the unilateral gain drops at a rate of 6 db/octave.[9] This characteristic is also exhibited by power gain measurements in the circuit of Fig. 2.

The power gain G_p of a transistor, the ratio of power delivered to the matched load and power applied to the transistor input is given by the relation $G_p = 20 \log_{10} (V_{out}/V_{in}) + 10 \log_{10} (r_{in}/R_L)$. The first term is the voltage drop measured in db across output and input, and the second term is a constant for each transistor. The input impedance of the transistor r_{in} is nearly ohmic over a wide range above 40 mc in the grounded emitter configuration.

The circuit for measuring power gain is shown in Fig. 2. The resistance R_o is used to determine r_{in}, but is shorted during the actual measurement. The transistor input is fed by a voltage generator of 1-ohm internal resistance. In the output circuit, a pi network matches R_L to the transistor output.[10]

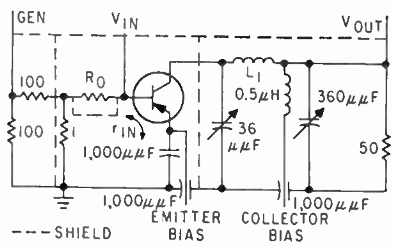


FIG. 2—Sketch shows arrangement of coaxial elements used for measuring f_{max}

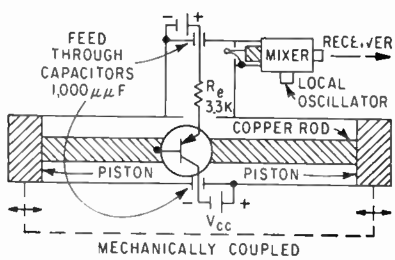


FIG. 3—Basic arrangement for power gain measurement at high frequencies

Circuit

The circuit used to measure the maximum frequency of oscillation is shown in Fig. 3. This arrangement uses a coaxially tuned quarter-wave line. The terminals of the line are shorted by adjustable pistons. The measurement of f_{max} is performed by successively changing the physical length of the line and retuning the loosely coupled detector instrument. Since the amplitude of oscillation near f_{max} falls off 6 db/octave, it is possible with the highly sensitive detector arrangement to measure f_{max} within an error of ± 5 percent.

Figure 4 shows a plot of electrical length, $\lambda/4 = 3 \times 10^{10}/4f$, against the physical length of the coaxial line oscillator. Curve (A) refers to a transistor with 4-cm leads and (B) refers to a transistor with leads shortened to 0.6 cm. It can be seen that the electrical length exceeds the physical length in the lower frequency range by a nearly constant amount. Such an effect would be expected from the presence of a capacitance at the center of the line.[11] The measured curves of Fig. 4 can be explained over the entire frequency range by a series combination of capacitance and inductance, whereby $s = \lambda/4 - (\lambda/2\pi) \tan^{-1}[\pi\lambda l C_o/(\lambda^2 lc - 4\pi^2 L_o C_o)]$ where l and c are the inductance and capacitance per unit length, $2s$ is the physical length measured between pistons, λ is the wavelength, C_o is the effective collector capacitance and L_o is the inductance of transistor and mount.

Test Limitation

The theoretical frequency limitation of the test arrangement is indicated by the above equation since at a certain high frequency the denominator of the $\tan^{-1}$ factor vanishes as $\lambda^2 lc - 4\pi^2 L_o C = 0$.

In practice, the physical length of the coaxial line is limited by geometrical considerations. The corresponding frequency can be obtained to a good approximation by solving the above expression and using frequency-independent values for l and c. Hence, $f_{limit} \approx 1/2\pi \sqrt{L_o C_o}$. Experimental values for L_o and C_o have been found to be

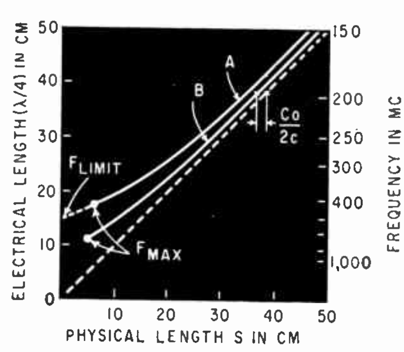


FIG. 4—Relation between electrical and physical length of transmission line. (A) is for 2N501 transistor with 4-cm leads, $V_c = -15$ v, $I_e = 5$ ma. Curve (B) is for 2N502 with 0.6-cm leads, same operating parameters

around 25 milliμh and 1 $\mu\mu$f respectively, which yields $f_{limit} \approx$ 1,000 mc.

Since C_o is the effective collector output capacitance (the space-charge capacitance plus the diffusion or storage capacitance plus stray capacitance) of the transistor, improvement of frequency limit depends mainly on decreasing the inductive part, L_o. This could be accomplished by giving the transistor the form of a coaxial element matched to the concentric line. A coaxial structure should remove L_o and also decrease C_o to a certain extent by eliminating stray capacitance.

Radiation Loss

Since it is not possible to match the transistor in its present form to the line, it has been necessary to deal with not only a non-uniformity, but radiation loss in the center of the line as well. This causes the Q of the line to differ from the theoretical function (1) plotted in Fig. 5. Points measured with the arrangement shown in Fig. 3 are also plotted in Fig. 5. It is seen that the Q decreases at higher frequencies because radiation effects approach the theoretical slope of line (2). With a coaxial mount, this fall-off could be suppressed or even avoided.

The Q of the transmission line will cause a lower measured f_{max}. Near cut-off with a -6 db/octave fall-off, the following expression holds: $f_{max}(meas)/f_{max}(act) \approx 1/(1 + 2\pi\, r_{in}/QR_o)$, where R_o is the characteristic impedance of the line. By inserting values of Q from Fig. 5 into this equation, the error in the measured f_{max} is obtained as a function of frequency. For a line where $R_o = 50$ ohms, this relation is plotted in Fig. 6 (curve 3) assuming $r_{in} = 50$ ohms, which is quite reasonable for graded base transistors at higher frequencies.

Curve 1 in the same figure reveals the excellent performance of the ideal transmission line having no radiation losses.

Results

Power gain of graded base transistors, measured in the circuit of Fig. 2 at various frequencies, is plotted in Fig. 7. In the cut-off region, a 6 db/octave power gain decrease with frequency is closely followed. By extrapolating this curve to the frequency where power gain is equal to zero db (unity power gain), one obtains the maximum frequency of oscillation. The extrapolated values of f_{max} are compared in Fig. 8 with direct measurements of the maximum frequency of oscillation performed with the circuit of Fig. 3. The fact that the points line up along the 45-deg axis confirms the validity of both measurements.

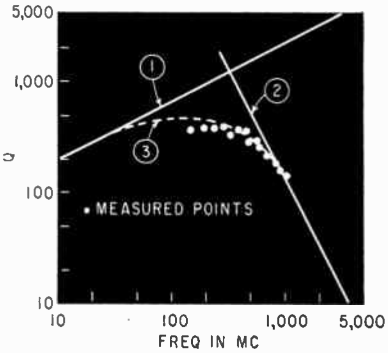


FIG. 5—Q of transmission line as a function of frequency for ideal and actual lines

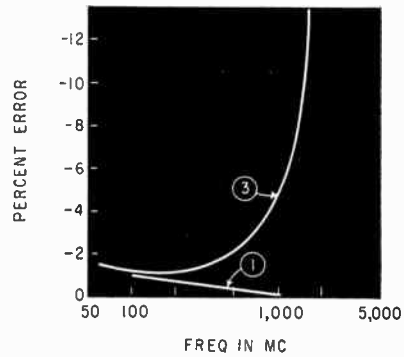


FIG. 6—Error in f_{max} measurements caused by Q factor in ideal and actual line

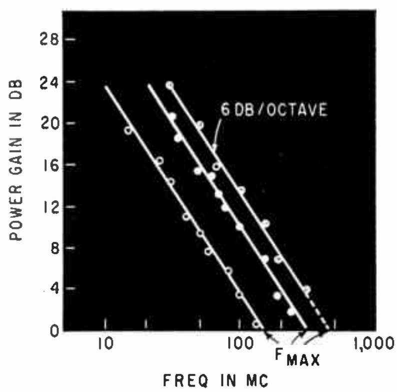


FIG. 7—Power gain characteristics of three graded base transistors in the cut-off region

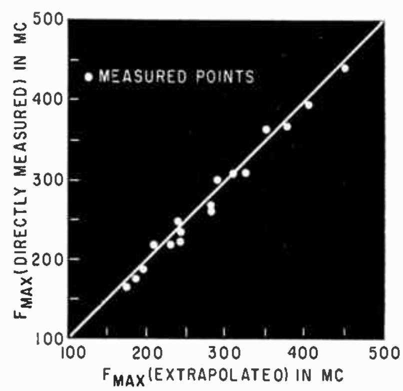


FIG. 8—Correlation of maximum frequency of oscillation values determined by extrapolation and direct measurement

Coaxial line elements have been used to build measuring equipment for determining f_{max} up to 1,000 mc. Present limitations of the test circuit are caused by the effective collector output capacitance of the transistor and the inductance of the mount. Coaxial construction should extend the frequency range.

The authors thank K. Lehovec for helpful comments in writing this paper and F. Stottle for wiring the power-gain test set used in the investigation.

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How to Reduce Errors in

Compensation technique eliminates the need for precise, high-gain isolation amplifiers when linear potentiometers are used as precision voltage dividers in analog computing circuits. Reduction of error by a factor of 100 is possible

By **MARTIN KANNER,**
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WHEN A LINEAR potentiometer is used as a precision voltage divider, the output should be an accurate analog of the amount of rotation. If the load impedance on the wiper is sufficiently high, the output voltage will be an accurate measure of the input voltage multiplied by the amount of rotation. But when the load is appreciable, loading errors result and compensation may be necessary.

A number of methods are used for compensation. One scheme is to wind a nonlinear resistance element that will give a linear output into a specified load. Another method is to present the same loading effect on two sources used in a computer. Both methods are restrictive and are not always applicable. A special nonlinear element, for example, will give a linear output for only one value of load resistance. In the second case, it is not always possible to provide voltage sources whose impedance will vary in an identical manner.

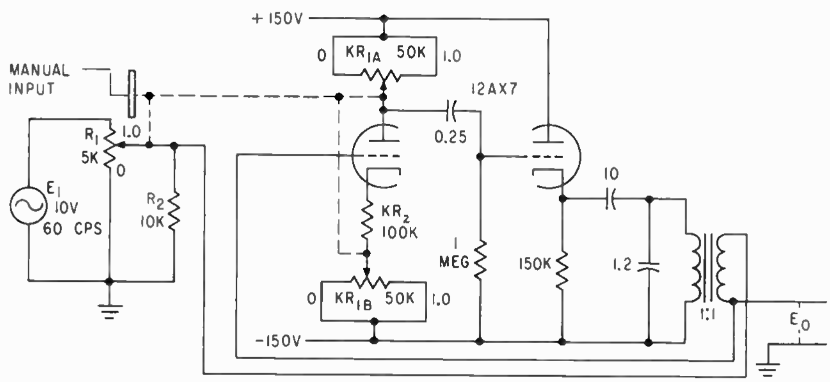


FIG. 2—Practical circuit for error computer reduces loading error 97 percent

The use of an isolation amplifier with a high input impedance is a more general solution. The design of feedback amplifiers for precise applications can be cumbersome because of the high gain required. A different technique is described in this article.

Compensation Method

The compensation method is shown in Fig. 1. Potentiometer R_1 is set to the desired point. Resistor R_2 is a loading resistor. The gain of the error computer is also adjusted by the manual input. The output of the computer is added to the input to produce the corrected output. While the technique appears more complicated than the use of an isolation amplifier, it has several advantages and it is inherently not critical.

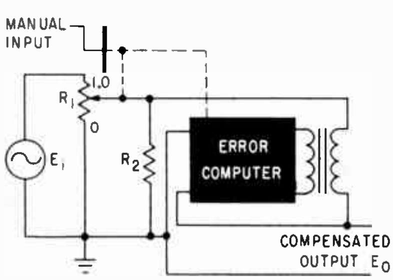


FIG. 1—Loading error is computed and used for compensation

The desired output in Fig. 1 is expressed as $E_o = XE_i$, where E_o is the output, X is the amount of potentiometer rotation and E_i is the input. Potentiometer rotation refers to electrical rotation, not mechanical, and varies from zero to 1.00 corresponding to minimum and maximum potentiometer resistance. The output voltage that will actually appear across load resistor R_2 is: $E_b = XE_ia/(a + X - X^2)$, where $a = R_2/R_1$. The error is the difference between E_o and E_b: $E_x = XE_i(X - X^2)/(a + X - X^2)$. It is the purpose of the error computer to develop the voltage E_x.

The complete circuit for the error computer is shown in Fig. 2. Re-

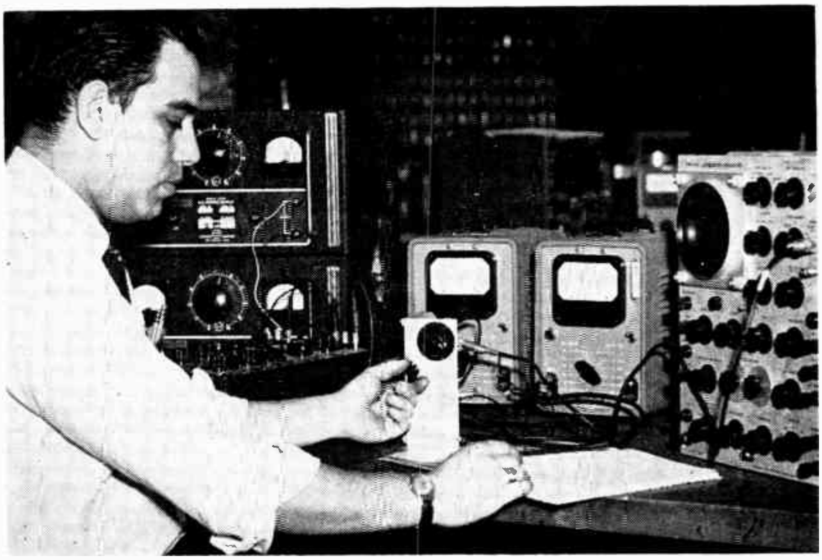
Loaded Potentiometers

sistor R_2 is used to load potentiometer R_1. The gain of a triode amplifier with an unbypassed cathode resistor is given by: $G = R_L/\{(R_L + r_p)/\mu + R_K(\mu + 1)/\mu\}$ where R_L is the plate load resistor, r_p is the plate resistance, and R_K is the cathode resistor. If μ is large, the gain (accurate to one or two percent) can be represented by: $G = R_L/R_K$.

Plate load R_L is the two parts of KR_{1A} in parallel. Cathode resistor R_K is the two parts of KR_{1B} in parallel plus KR_2. For any given value of rotation, X, the gain of the error computer is: $G = (X - X^2)/(a + X - X^2)$. This is the amount of gain required to reduce the compensated output error to zero. The output is: $E_o = E_b + E_x = XE_i$. The constant term K can be any number and is selected to bring the tube into its normal working region. For the circuit shown, K is 10. The output is taken from a cathode follower for low impedance.

The circuit of Fig. 2 was used to reduce a loading error of approximately 6.7 percent to 0.2 percent. This is a reduction in loading error of 97 percent.

The most significant difference between the method described and the use of isolation amplifiers is that in using an isolation amplifier some error must be introduced, while the error computer operates on the loading error and can only improve the overall result. The practical limits to the use of the computer is when the original loading error is to be reduced by a factor of up to 100. A loading error reduction by a factor of 100 requires a 1 percent computing accuracy. Above this limit, the method becomes too complicated.



Technician obtaining test data on compensation of a loaded potentiometer

The versatility of the method is shown in Fig. 3 and 4. In Fig. 3 the computer method is used with a center-tapped potentiometer. By using center-tapped KR_1's we again have exact compensation. An important application of the method is shown in Fig. 4. In this case the load has a capacitive component C. This capacitance will normally come from cables in computers and servosystems and makes the design very difficult. In servo systems this capacity generates quadrature voltages which cannot be continuously balanced out. These voltages will either saturate the amplifiers in computers or else make motors run hot. The computer method continuously balances out the quadrature voltage components thereby eliminating both problems.

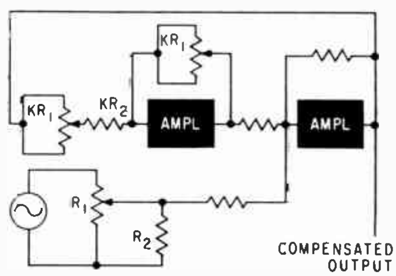


FIG. 5—The general compensation case using operational amplifiers

Relatively simple specific applications of the computer method have so far been discussed. A more general solution is to use an operational amplifier as shown in Fig. 5. With this scheme, the bandwidth is extended from d-c to the upper frequency limit of the amplifiers.

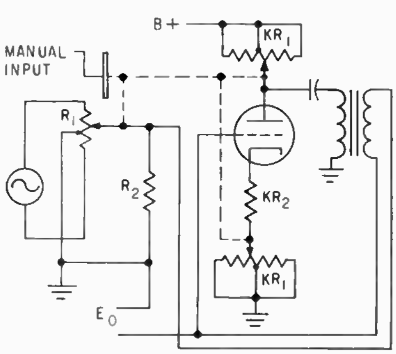


FIG. 3—Error compensation with tapped potentiometers

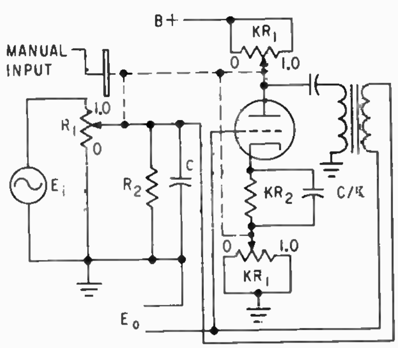


FIG. 4—Compensating for a resistance and capacitance load

Long Wavelength Infrared

Cooling these detectors to very low temperatures reduces the internal molecular and atomic thermal agitation to a minimum and allows the desired spectral response to be obtained

By **A. I. WEINSTEIN,** Senior Engineer, Avionics Division, Aerojet-General Corp., Azusa, Calif.

INVESTIGATION AND USE of the longer wavelength portion of the infrared spectrum is being spurred by increasing military and industrial applications for infrared detection equipment.

Infrared detectors which work well at the longer wavelengths must be cooled to obtain optimum operating characteristics. Some operate best when cooled near −196 C; others in development require even lower temperatures.

COOLANTS—A number of coolants are available. Dry ice and acetone mixtures will produce temperatures around −78 C, liquid nitrogen boils at −196 C. Temperatures below −196 C are obtainable from liquefied neon, −245.9 C; hydrogen, −252.7 C, and helium, −268.9 C.

Using these coolants in the laboratory presents few problems. Detectors may be mounted on the cooled inner walls of a vacuum flask which provides a refrigerant reservoir. Flasks an inch in diameter and two inches long will cool for a half hour, or longer if the supply of refrigerant is maintained.

Aircraft and missile cooling systems, however, must cope with problems arising out of environments, uses and specifications for military systems. The chief problems are outlined in Table I. Various methods in use or in development are summarized below and outlined in Table II.

Table I—Military Infrared Cooling System Design Problems

Accessibility: Detector assembly and infrared system often are buried in maze of assemblies well inside an aircraft or missile, yet must be cooled for extended periods.

Size and Weight: For airborne use, cooling equipment must be small and light to be compatible with rest of infrared system.

Cooling Time: Cooling period may vary from several minutes to several days, without refrigerant recharging.

Operating Conditions: Cooling system must operate reliably at all altitudes, temperatures and positions that aircraft or missile may encounter. Detector assembly and connections must not affect gimbal operation if infrared system has this type of mounting.

Logistics: All coolants must be obtainable and suitable for transport and storage in any required location. Logistics of liquid nitrogen are similar to those for liquid oxygen. Both can be produced by same generator or plant; both have similar handling techniques, but nitrogen is less hazardous.

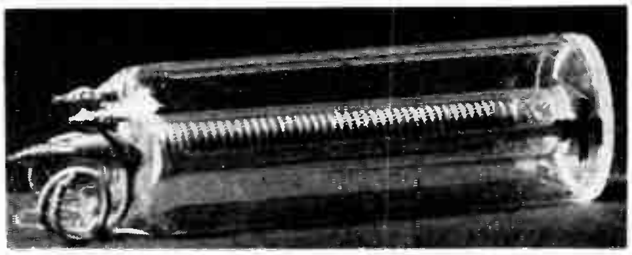
METHODS IN USE—The miniature cryostat illustrated has finned metal tubing wound around a mandrel and inserted in a close-fitting tube which forms the inner wall of a vacuum flask. Nitrogen gas under pressure flows through the finned tubing to an opening near the back of the detector. The gas is cooled by expansion and flows back over the coil, cooling regeneratively, until liquid nitrogen is formed at the opening. Reducing pressure over the liquefied gas produces lower temperatures. Special designs precool neon or hydrogen gas for liquefying in an adjoining cryostat.

Storage tank weight and gas contaminants are chief drawbacks of cryostats.

Gas pressure must be at least 1,200 psi. Pressure falls below 1,200 psi in commercial type tanks when half the gas is used. Tanks holding 220 cubic feet weigh 150 pounds. Such tanks will cool many hours. Some cryostats need only half a cubic foot an hour; others require several times as much. Cooling periods drop rapidly as tank size decreases. Contaminants in the gas will freeze out and plug the cryostat orifice. Large, heavy filters may be required. If the gas has a dew point of −68 C or less, filter paths may be reduced.

Liquid nitrogen converters limit these problems. The liquid is stored in a pressure vessel. High-pressure gas is produced by spontaneous or forced evaporation. As contaminants are frozen out in the liquid, only a small filter, or no filter, is needed. Volume needed is one-fifth that of gas storage for equal operating time.

Detector Cooling Systems



Miniature cryostat, the size of a cigarette, turns nitrogen gas into liquid nitrogen by regenerative cooling

In direct liquid nitrogen transfer systems, the liquid is stored in an insulated flask. Low gas pressure forces the liquid through a tube to the detector area. Various cooling heads may be used. One sprays droplets of liquid nitrogen on the detector's back. In another, the liquid flows into a heat exchanger at the detector and leaves the system as a gas.

Direct contact cooling can be used where space permits. The detector is mounted in a lightweight vacuum flask which holds liquid nitrogen. Remote filling, altitude and attitude problems are being investigated.

Modified cryostats produce dry ice from CO_2 gas. The gas passes through a small coil and cools regeneratively. Flakes of dry ice are deposited at the rear of the detector. Similar techniques with such gases as Freon 13 rely on gas expansion and phase change from gas to liquid for cooling.

Peltier-thermoelectric coolers show promise. Coolers developed give a 30 C to 40 C temperature drop from ambients of 20 C to 25 C. New junction materials may increase effectiveness.

IN DEVELOPMENT — Possible solution to gas storage weight and contamination problems is closed loop units with small liquid nitrogen compressors. Contamination by compressor lubricants, gaskets and flexible materials must be overcome. Piston lubricants can plug cryostats. Bellows and diaphragm compressors may avoid this.

Compression ratio is another closed loop system problem. Increasing pressure at the cryostat's cooling end increases the liquid's boiling point. Input pressure to the compressor, therefore, must be minimized to maintain temperatures close to −196 C.

Expansion engines and gas liquefiers are operational and available in larger sizes. Both can cool to below −196 C. Major development effort is miniaturization. Expansion engines usually liquefy helium. Compressing helium and causing it to lose energy by doing work upon expansion, reduces its temperature. Gas liquefiers employ expansion engines to cool enclosed surfaces. Gas contacting the surface cools until it condenses.

Miniaturized cooling systems composed of such devices are expected to be recirculatory in nature, operating with a single charge of coolant gas.

Table II—Typical Characteristics of Equipment for Cooling Long Wavelength Infrared Detectors

Cooling System	Temp (Approx)	Power Needed	Availability of Cooling	Weight (Approx)	Reliability
COOLING SYSTEMS IN USE					
Cryostat, Stored Gas	−196 C	none[a]	on demand[b]	varies[d]	depends on gas purity
Cryostat, Liquid Converters	−196 C	none[a]	on demand[c]	varies[d]	good
Liquid Nitrogen Transfer	−196 C	none[a]	on demand[c]	varies[d]	excellent
Direct Contact Liquid Nitrogen in Vacuum Flask	−196 C	none[a]	continuous[c]	from ½ lb for 6 hrs	excellent
CO_2 Modified Cryostat	−78 C	none[a]	on demand[b]	varies[d]	depends on gas purity
Freon 13 Modified Cryostat	−80 C	none[a]	on demand[b]	varies[d]	good
Peltier-Thermoelectric	Δt 40 C[e]	2.5 w	on demand	1 to 5 lb	excellent
MINIATURE UNITS IN DEVELOPMENT					
Cryostat with Compressor in Closed Loop	−196 C	500 w	on demand	10 to 20 lb	depends on contamination, tight system, compressor life
Expansion Engine	−269 C	100 w	on demand	10 to 20 lb	depends on operation of equipment and ability to retain charge
Gas Liquefier	−269 C	200 w	on demand	15 to 20 lb	(same as above)

(a) May need small source of power to remotely activate cooler (b) Based on storage-capacity (c) Storage container is filled prior to use of equipment (d) Depends on storage container and running time required (e) From an ambient of 52 C

Oscillator Design Using

Reverse-biased p-n junction diode is used as variable capacitor in design of linear frequency sweep generator. Output waveform is a sinusoid of high purity. Frequency is swept from 400 to 600 kc electronically. Frequency markers are provided

By M. MICHAEL BRADY, Research Engineer, Norwegian Defense Research Establishment, Bergen, Norway

THE CONFIGURATION of an r-f signal generator whose output is a linear frequency sweep may take different forms for different operating frequencies. At microwave frequencies broad sweep widths may be obtained by using a backward-wave oscillator or a voltage-tuned magnetron. In the uhf region, where the sweep width is small compared to the center operating frequency, reactance-tube modulators may be used. At lower radio frequencies it has been necessary to reactance-tube modulate a h-f oscillator and beat it against a constant-frequency oscillator to form a beat-frequency oscillator. If purity of output waveshape is desired, then the beat-frequency oscillator presents a problem in filtering, as the actual oscillator operating frequencies must be eliminated from the usable generator output. For this reason, l-f sweep oscillators often have been designed using a mechanical drive to a variable element of an oscillator resonant circuit. Electro mechanical systems, however, present their own problems and a completely electronic system is usually preferable.

There are two uses of the junction diode that provide methods of controlling the reactance, and thus the resonant frequency, of a resonant circuit. One is a switch diode so biased that it switches a fixed reactance in parallel with the main resonant circuit during a portion of every cycle[1] and the other uses the voltage-dependent reactive properties of a reverse-biased junction diode directly as a frequency-determining element in the resonant circuit.[2]

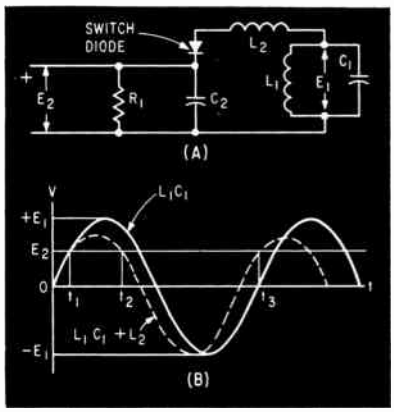


FIG. 1—Fundamental reactance-switch modulator (A) and cycle of operation (B)

Reactance-Switching

A practical circuit for reactance-switching frequency control is shown in Fig. 1A[3]. Resonant circuit L_1 and C_1 has a frequency of ω_0. Inductor L_2 is switched across the resonant circuit during a portion of each cycle determined by the voltage difference between the resonant circuit voltage E_1 and the controlling voltage E_2. Capacitor C_2 is a bypass at the operating frequency while resistor R_1 is the load for the controlling signal.

The instantaneous resonant frequency of the circuit can be determined by considering the effect of the change in the circuit's resonant frequency due to the change in the equivalent parallel reactance presented. The effective mechanism of the circuit is shown in Fig. 1B. From zero to time t_1, the resonant frequency is ω_0. From t_1 to t_2, inductor L_2 has been switched in parallel with L_1 and the resonant frequency of the circuit is thus changed. From t_2 to t_3 the resonant frequency is again ω_0. Thus, over a number of cycles, the resonant frequency changes as a function of the control potential E_2.

Reverse-Biased P-N Junction

The normal capacitance of a *p-n* junction becomes a function of the potential difference across the junction when a reverse bias is applied. This effect is observed in almost any junction diode, but is most prominent in diodes specifically designed to serve as voltage-variable capacitors.[4]

The effective capacitance presented by a reverse-biased *p-n* junction can be expressed as $C = k/\sqrt{V + V_0}$ where C is the capacitance in

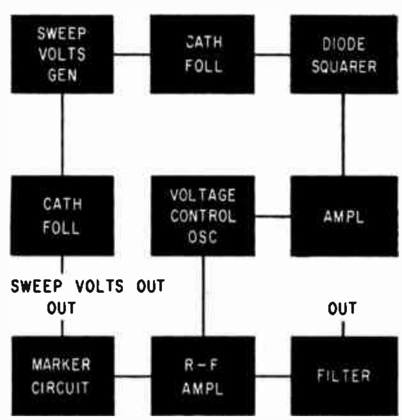


FIG. 2—Output filter of sweep generator sharply attenuates frequencies above and below sweep frequency band

Voltage-Variable Capacitors

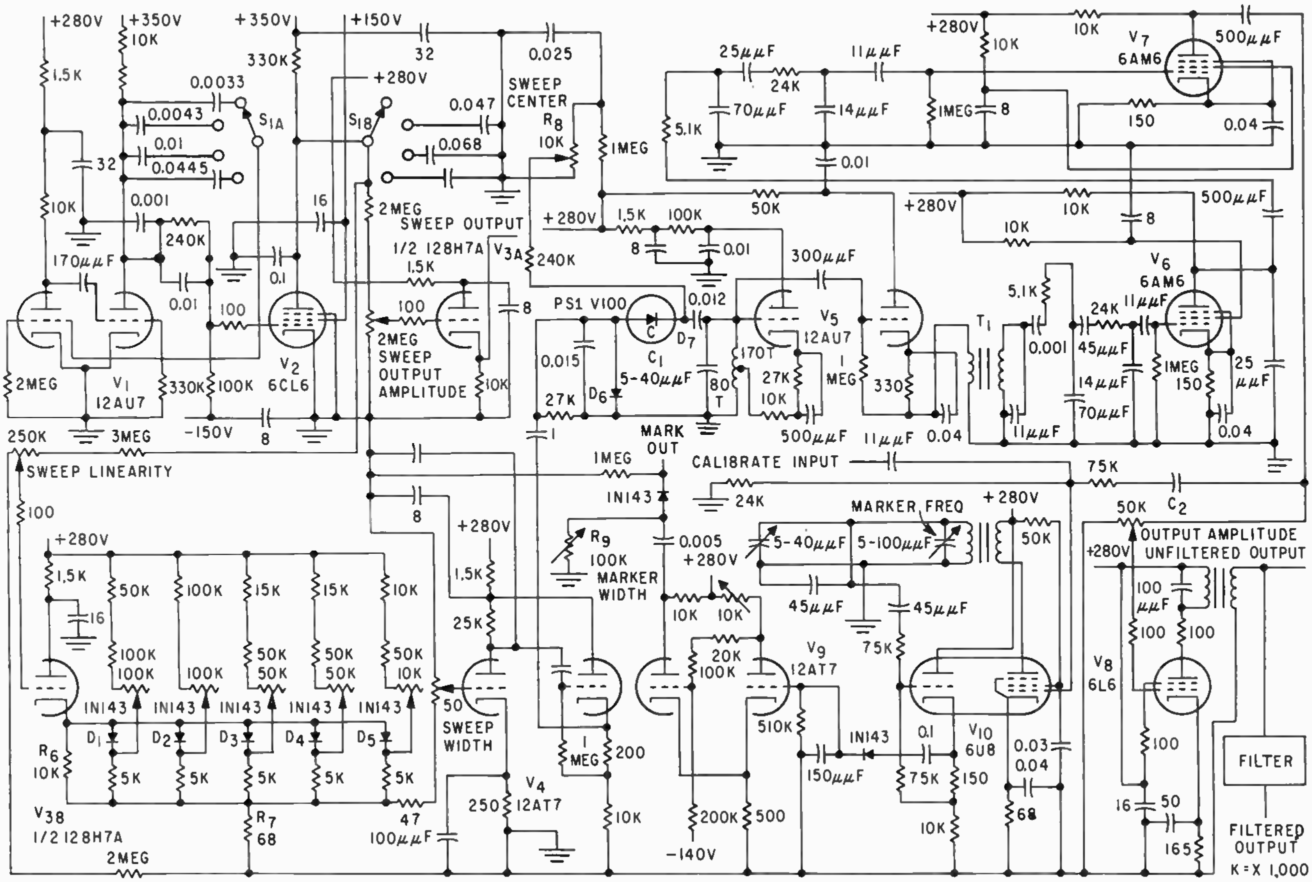


FIG. 3—Oscillator circuit (V_5) shows how reverse-biased p-n junction voltage-variable capacitor is used to generate a variable-frequency output. Plate voltage of squarer V_3 must be regulated

farads, V is the applied bias potential in volts, V_0 is the contact potential across the junction in volts and k is a constant compromising the electrical properties and physical dimensions of the junction. The resonant frequency of a parallel LC circuit consisting of an inductance L_0 and capacitances C_0 and C in parallel may be written as: $\omega = \omega_0[1 + C/C_0]^{-1/2}$ where ω_0 is the resonant frequency of the L_0-C_0 circuit alone. Combining the two equations and expanding in a binomial series gives:

$$\omega/\omega_0 = 1 - k/2C_0 \sqrt{V + V_0} + 3k^2/8C_0^2 (V+V_0) - 5k^3/16C_0^3(V+V_0)^{3/2} + \ldots$$

Within the range where the ratio of C to C_0 is large such that $\omega_0 >> \omega$, the first two terms of the series dominate and the resonant frequency of the circuit may be considered to be a linear function of the square-root of the reverse bias applied to the *p-n* junction. The third- and higher-order terms in the series will cause ω to asymptotically approach ω_0 for large values of the reverse bias V. The design criterion for a sweep oscillator is that V be sufficiently small and the ratio of C to C_0 be sufficiently large as to insure that the third- and higher-order terms in the series are negligible.

Sweep Generator

A block diagram of the sweep generator is shown in Fig. 2. The sweep voltage generator feeds two cathode followers; one provides a sweep-voltage output and the other drives the diode-squaring circuit. The output of the diode-squaring circuit is a squared sawtooth, which is then amplified and applied to the *p-n* junction in the resonant circuit of an r-f oscillator. The 400-600 kc swept-frequency output of the oscillator is amplified and filtered to give a 6-w, 150-ohm output with high purity of waveform. A small portion of the output of one r-f amplifier stage is used to drive a calibrated-marker circuit. The complete schematic diagram is shown in Fig. 3.

The Sweep-Voltage Generator

The sweep-voltage generator is a combination of a highly unsymmetrical astable multivibrator V_1 driving pentode-switched RC sawtooth generator V_2. Switch S_1 selects the proper coupling capacitors in the multivibrator and the proper charging capacitors in the sweep generator to give sweep frequencies of 40, 80 and 120 cps. These particular sweep frequencies were selected to avoid interference from the 50-cycle line frequency used. The output of the sweep-voltage generator is fed through cathode follower V_{3A} to provide a sweep-voltage output of 0 to 25 v.

Squaring Circuit

The squaring circuit uses five diodes. The effective cathode resistance seen by the cathode-follower driver V_{3B} is dependent on the number of diodes that are in a conducting state. The conduction point for the diodes is determined by their respective biases which are set by series resistors and adjusting potentiometers R_1 through R_5. The fundamental operation of the squaring circuit is illustrated in Fig. 4. Ideally, five sections should provide an approximation to a square-law curve that is accurate to within 1 percent[5]. The normal drive to the squaring circuit used in Fig. 3 is a sawtooth of 20 v peak, and the bias potentials on diodes D_1 through D_5 are 4, 8, 12, 16 and 20 v referred to the junction of R_6 and R_7.

Sweep Oscillator

The output of the squaring circuit is amplified by V_4. The negative-going signal is clamped to ground by diode D_6 and applied to voltage-variable capacitor D_7 of oscillator V_5. Because the capacitance of D_7 is large compared to that of C_1, and because L_1 is fixed in value, the resonant frequency of the oscillator is determined mainly by the capacitance of D_7. Voltage divider potentiometer R_8 provides a d-c bias to D_7 such that the center frequency of the oscillator can be controlled.

The output of the oscillator is coupled through a bandpass filter to amplifier V_6. The output of V_6 is coupled through an identical bandpass filter to second amplifier V_7. The output of V_7 drives final power-amplifier V_8. The amplifiers and their associated bandpass filters provide an output from V_8 (into a resistive load) that is constant over the 400- to 600-kc band. The bandpass filters have a greater attenuation at 600 kc than at 400 kc, because the output amplitude of the oscillator increases with increasing frequency.

In the application for which this sweep generator was designed, it is imperative that the output be a pure sinusoid. The interstage bandpass filters have very high attenuations for frequencies higher and lower than the operating frequency band, and the output filter following V_8 is designed with a Tschebyscheff response such that frequencies above and below the sweep-frequency band are sharply attenuated.

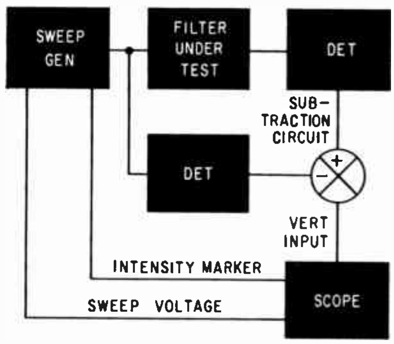


FIG. 5—When the oscilloscope sweep is calibrated in frequency, the characteristics of the filter under test may be observed

Marker

If an oscilloscope is swept with the sweep-voltage output, then its horizontal deflection can be directly calibrated in frequency by using the marker output to intensity modulate the beam.

Capacitor C_2 couples a portion of the V_7 output to the pentode section of V_{10}, which is a calibrated single-tuned transformer-coupled r-f voltage amplifier. The output of the pentode section of V_{10} is coupled through its cathode-follower-connected triode section to provide isolation and to drive the Schmitt trigger V_9. The output of V_9 is a positive-going rectangle which is differentiated and negative limited to provide a positive-going pulse as a marker output. The time constant of the differentiator is controlled by marker width control potentiometer R_9.

Performance

The use of the sweep generator in filter testing is shown in Fig. 5. In this application, filters with ratios of passband-to-stopband transmission of about 70 db have been successfully tested. The 3 db variation in the generator output over the sweep band is canceled in a subtraction circuit, although it is relatively unimportant in view of the large attenuations involved in the test filters.

If the output of the generator must be constant over the swept-frequency band, then the generator output filter can be redesigned to have less attenuation in the stopband and a smoother characteristic in the passband.

The output Tschebyscheff filter was designed to work into 150 ohms, and was constructed using slug-tuned coil forms and fixed and variable capacitors.

Transformer T_1 is wound on a ferrite cup-type core with a 200-turn primary and a 400-turn secondary of No. 36 wire.

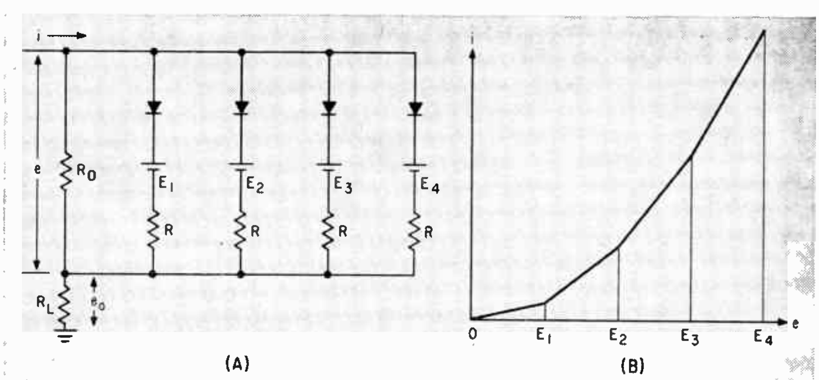


FIG. 4—Fundamental squaring circuit (A) and its operation (B) to produce $e_o = ki = k'e^2$

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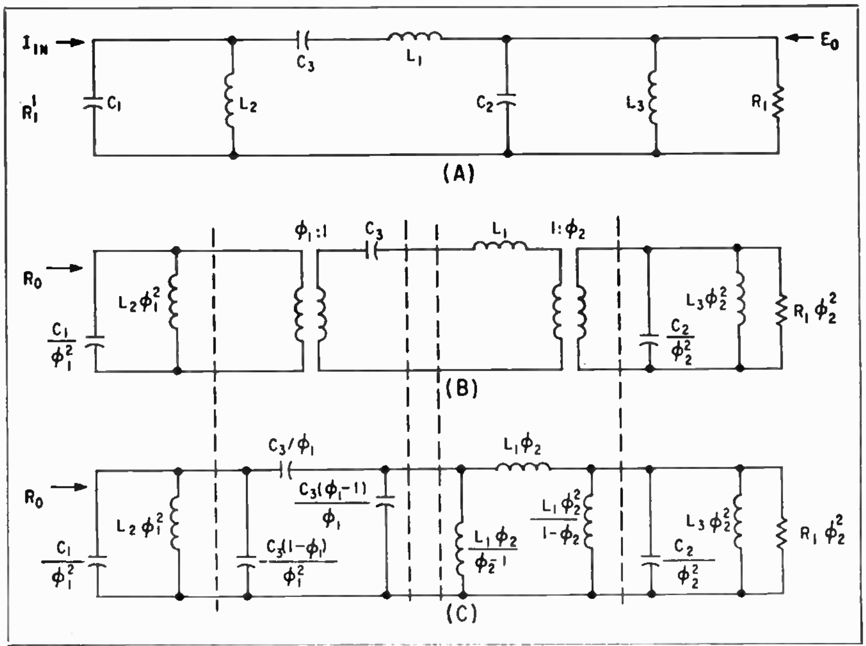

FIG. 1—Triple bandpass filter and equivalent circuits

How to Design Bandpass Triples

Complex problem gets a thorough treatment. Equations are presented in terms of fundamental parameters and an example is worked out. Cascading for very wide bandpass is practical and a design method is included

By **RONALD B. HIRSCH,** Instruments for Industry, Inc., Hicksville, New York

TRIPLE-TUNED bandpass filters are used between stages and at the output and input of i-f strips, mixers and r-f amplifiers. They provide impedance transformation over wide bandwidths as well as giving selectivity in the desired band. Using these filters, skirt selectivity equal to that of a crystal filter can be obtained.

Bandpass Triples

By analyzing the transfer impedance of a simple low-pass filter, and applying a frequency transformation to the expression, a bandpass filter with three poles can be defined (Fig. 1A).

In many applications it is necessary to provide an impedance transformation between input and output. The circuits in Fig. 1B and C indicate the method of placing ideal transformers in the circuit, and then simplifying the circuit by replacing the ideal transformers with their equivalent circuits. In Fig. 1C the transformers have been replaced by their pi equivalents.

The expressions for solving the network of Fig. 1A are: $C_2 = 1/2\Delta\omega S R_1$; $C_1 = C_2 K$; $C_3 = C_1 A$; $L_1 = 1/C_1(\Delta\omega)^2[(S^2+3/4)/2] = 1/\omega_o^2 C_3$; $L_2 = 1/\omega_o^2 C_1$; $L_3 = 1/\omega_o^2 C_2$. Constants K, A and S are defined in the design box.

The filter of Fig. 1 has an input impedance which is essentially the termination R_1. The variation in input impedance is a function of the ripple designed for in the transfer function. The solution for the network of Fig. 1A assumes a constant current source and loading only at the output end. When this filter is fed from a matched voltage source the ripple will be reduced to approximately ½ and the skirt selectivity will be reduced somewhat. Also, less power will be available at the output. The results of loading both ends should be kept in mind.

By regrouping, combining and

assigning new symbols, Fig. 1C can be presented in the form shown in Fig. 2A. The design equations listed in the design box refer to Fig. 1 and 2.

Figure 2B is another representation of the basic bandpass filter. The circuit has transformers in the most common configuration; a primary, a secondary and a mutual element tying primary and secondary together. By using capacitive mutual for one transformer and inductive mutual for the other, geometric symmetry is provided and the use of the circuit is not limited to narrow bandwidths as are most commonly used devices.

Impedances Z_1, Z_2 and Z_3 represent the impedance levels of the various tank circuits. The removal of all mutual coupling in Fig. 2B, and replacement with circuit elements gives Fig. 2A.

The frequency response of the bandpass triple is shown in Fig. 2 C.

Inspection of Fig. 1 and 2 and the design equations will show that where R_o is greater than R, ϕ_1 must be greater than 1; and when R is greater than R_o, ϕ_2 must be greater than 1. In this analysis, neither ϕ_1 nor ϕ_2 can be less than 1. Further, when striving for maximum transformation, either ϕ_1 or ϕ_2 must equal 1, depending on the direction of transformation. For realizable circuit values, it is often necessary to make both ϕ_1 and ϕ_2 greater than 1. Further, ϕ_{1max} and ϕ_{2max} are values which cannot be exceeded without producing negative components.

Table I—Tabulation of S and K values for various ripples

Ripple(db)	S	K
0.0035	2.00	2.68
0.014	1.50	2.50
0.089	1.00	2.14
0.250	0.77	1.89
0.500	0.63	1.69
1.000	0.49	1.49
1.500	0.42	1.38
2.000	0.37	1.30

In the design of broadband amplifiers, as in other devices, the source of many problems is that parameter which exists everywhere —capacitance. If a vacuum tube had zero input and output capacitance, the gain-bandwidth product would approach infinity. For narrow bandwidth circuits, the C is merely tuned out and an appropriate R is used as a load. As the bandwidth broadens, however, the R necessary to maintain a reasonable response over the entire band becomes smaller and smaller. This reduces gain and, in the plate of a vacuum tube, lower available power as well.

Inductance Values

The question of whether a certain coil or capacitor can be used often arises. Determination of this fact can be made quite easily.

A coil is too large if its self-resonant frequency is close to the band of interest. For almost any single layer coil, the distributed

TRIPLE-TUNED FILTER DESIGN

Circuit Constants

1. $f_o = \sqrt{f_1 f_2}$
2. $\alpha = (f_2 - f_1)/f_o$
3. $S = \sinh\left[\dfrac{\cosh^{-1}\left(\dfrac{1}{\epsilon}\right)}{6}\right]$

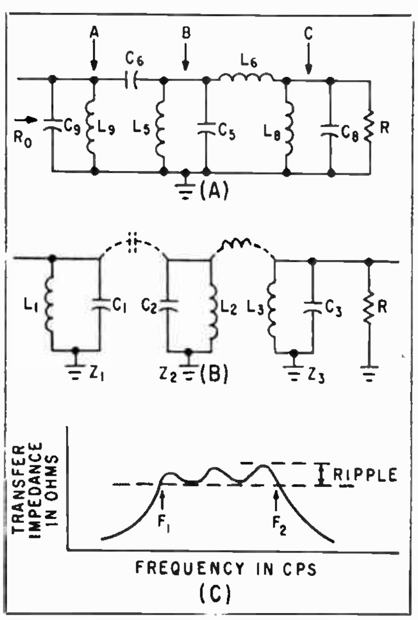

FIG. 2—Circuit used in conjunction with design box (A), triple-tuned bandpass transformer circuit (B) and frequency response of filters (C)

4. $K = (3S^2 + \frac{3}{4})/(S^2 + \frac{3}{4})$
5. $A = \alpha^2(S^2 + \frac{3}{4})/2$
6. $R/R_o = (\phi_2/\phi_1)^2$

Circuit Elements

7. $R = 1/2\Delta\omega SC_8$ or $C_8 = 1/2\Delta\omega SR$
8. $L_6 = 1/(\Delta\omega)^2 C_8 K\phi_2[(S^2 + \frac{3}{4})/2]$
9. $C_5 = C_8 KA(\phi_2/\phi_1)^2\phi_1(\phi_1 - 1)$
10. $C_6 = C_8 KA(\phi_2/\phi_1)^2\phi_1 = C_5/(\phi_1 - 1)$
11. $C_9 = C_8 K(\phi_2/\phi_1)^2[1 + A(1 - \phi_1)]$
12. $L_5 = 1/(\Delta\omega)^2 C_8\phi_2(\phi_2 - 1) K[(S^2 + \frac{3}{4})/2]$ $= L_6/(\phi_2 - 1)$
13. $L_9 = 1/\omega_o^2 C_8 K(\phi_2/\phi_1)^2$
14. $L_8 = 1/\omega_o^2 C_8[1 + AK(1 - \phi_2)]$
15. $\phi_{2max} = 1 + 1/AK$
16. $\phi_{1max} = 1 + 1/A$

17a. $\phi_1 = -C_8K\phi_2^2A/2C_9 + \sqrt{\left(\dfrac{C_8K\phi_2^2A}{2C_9}\right)^2 + \dfrac{C_8K\phi_2^2}{C_9}(1+A)}$

17b. $\phi_1 = -C_1A/2C_9 + \sqrt{\left(\dfrac{C_1A}{2C_9}\right)^2 + \dfrac{C_1}{C_9}(1 + A)}$

where $C_1 = C_8K\phi_2^2$

Resonant Frequencies

18. f_r(of C_9L_9) $= f_o/\sqrt{1 + A(1 - \phi_1)}$
19. f_r (of C_5L_5) $= f_o\sqrt{\left(\dfrac{\phi_1}{\phi_2}\right)\left(\dfrac{\phi_2 - 1}{\phi_1 - 1}\right)}$
20. f_r (of C_8L_8) $= f_o\sqrt{1 + AK(1 - \phi_2)}$
21. f_r (of C_6L_6) $= f_o\sqrt{\phi_1/\phi_2}$

Nodal Resonances

22. f_A (with B and C grounded) $= f_o/\sqrt{1 + A}$
23. f_B (with A and C grounded) $= f_o$
24. f_C (with A and B grounded) $= f_0\sqrt{1 + AK}$

Losses

25. Insertion loss per section (voltage) $= (Q_u - Q_L)/Q_u$
26. Insertion loss per n sections (db) $= 20 \log \left(\dfrac{Q_u - Q_L}{Q_u}\right)^n$

Symbols

f_1 = lower end of bandpass desired
f_2 = upper end of bandpass desired
f_0 = geometric center frequency of bandpass desired
f_r = resonant frequency
α = ratio bandwidth
S = ripple factor
ϵ = ripple in nepers (1 neper = 8.68 db)
R = terminating resistance
R_0 = resistance seen looking into triple, when properly terminated with R
ϕ_1, ϕ_2 = turns ratio used in ideal transformers when evolving the final configuration
Q_u = unloaded Q of a section
Q_L = loaded Q of a section
n = number of sections

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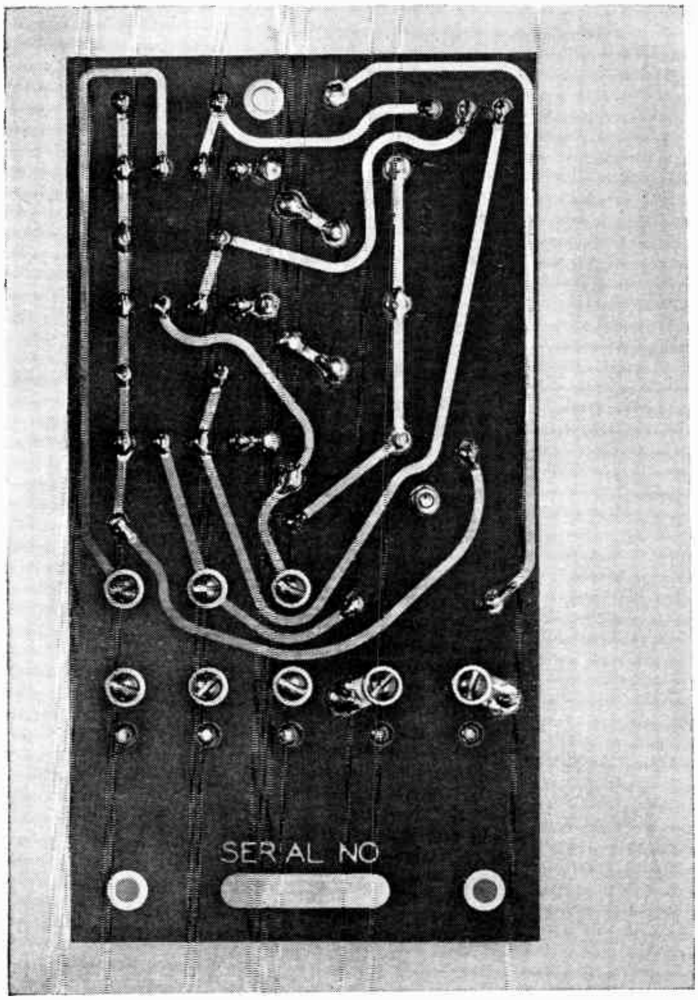

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MAXIMUM CONTINUOUS OPERATING TEMPERATURE (Deg. C.)	120	120	120	150	200
DIELECTRIC STRENGTH (Maximum voltage per mil for 1/16" thickness)	800	900	850	650	700
INSULATION RESISTANCE (Megohms) 96 hrs. at 35°C. & 90% RH (ASTM D257, Fig. 3)	500	150,000	600,000	100,000	75,000
DIELECTRIC CONSTANT 10^6 Cycles	4.5	4.0	3.6	4.9	2.6
DISSIPATION FACTOR 10^6 Cycles	0.040	0.026	0.027	0.019	0.0015
ARC-RESISTANCE (Seconds)	5	10	10	130	180
TENSILE STRENGTH (psi.)	18,000	16,000	12,000	48,000	23,000
FLEXURAL STRENGTH (psi.)	27,000	21,000	18,000	70,000	13,000
IZOD IMPACT STRENGTH edgewise (ft. lbs. per inch of notch)	0.80	0.45	0.42	12.0	6.0
COMPRESSIVE STRENGTH flatwise (psi.)	32,000	28,000	25,000	62,000	20,000
BASE MATERIAL OF LAMINATE	Paper	Paper	Paper	Medium-weave, medium-weight glass cloth	Fine-weave, medium-weight glass cloth
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capacitance can be assumed to be 1 $\mu\mu$f. A rough rule of thumb is: if selfresonance is one octave above the highest frequency of interest, the coil is usable but allowances must be made. At two octaves above, self-resonance should cause no problems.

A coil is too small if it cannot be made or tuned. A 1-in. length of wire has an inductance of approximately 0.02 μh. Thus a coil of 0.003 μh that must span a 1-inch gap is not realizable. A practical lower limit for coils is 0.02 μh. Special cases will allow smaller coils but they must be considered on an individual basis.

Usable Capacitors

If its self-resonant frequency is close to the band of interest, the capacitor is too big to use. Here, self-resonance is of the series variety, due to series-lead length. If there is a coil in series with the capacitor, an adjustment may be made to compensate for the lead length of the capacitor.

Series-lead length produces a lower impedance (because of approaching series resonance) and causes C to appear larger. In special cases, where recognized, allowances may be made for the apparent increase in C, and acceptable performance can be obtained.

A capacitor is too small if its value approaches the point where strays overpower it. For example, a coupling capacitor of 0.01 $\mu\mu$f would be almost impossible to obtain, as free space coupling would be greater than this. Values as low as 0.3 $\mu\mu$f are possible; 1 or 2 $\mu\mu$f is a more acceptable minimum.

Design Procedure

The general design problem is to place a bandpass triple between an input and output load. The input and output may be either resistive or capacitive. The method of solution will be outlined for connecting a line to a line; R and R_o given.

For all cases, first solve for f_o, a, S, K, and A as given in the design box. Table I can be used to find S and K.

From Eq. 6, set the appropriate $\phi = 1$ and solve for the other. Neither ϕ_1 nor ϕ_2 can be smaller than one. Solve Eq. 7 through 14 for

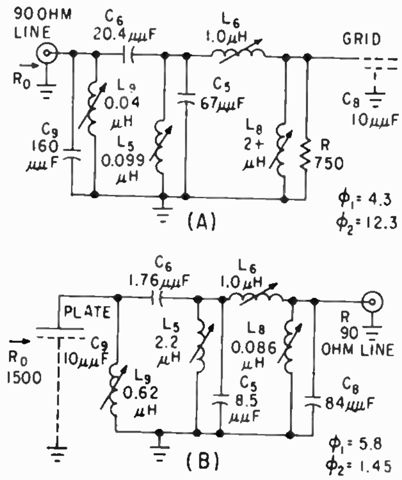

FIG. 3—Transmission from a 90-ohm line to 10-$\mu\mu$f grid (A); from a 10-$\mu\mu$f plate to a 90-ohm line (B)

circuit elements. If unrealizable values are found, ϕ_1 and ϕ_2 can be changed but the ratio ϕ_1/ϕ_2 must be kept the same and neither ϕ_1 nor ϕ_2 can exceed their maximum value.

When too many values in a design are fixed, the S factor or the bandwidth may be changed. The resonance equations listed in the design box are aids to calculation and checking.

Sample Problems

Problem: Design a filter with the following properties: $f_2 = 65.5$ mc; $f_1 = 55$ mc. Design from a 90-ohm line (R_o) to a grid of 10 $\mu\mu$f (C_8) and use S=1.

Solution: First establish all necessary constants. The easiest approach is to set $\phi_1 = 1$. But calculations of L_6 shows it to be self-resonant at 77 mc. Therefore, L_6 is set to 1 μh and the other components calculated accordingly. The

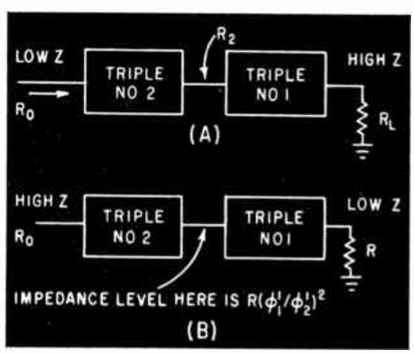

FIG. 4—Cascaded triples with high-impedance output (A); and low-impedance output (B)

final circuit is shown in Fig. 3A. Figure 3B shows the circuit for reverse transmission. Since R_o will be greater than R, ϕ_1 will be larger than ϕ_2. The first choice would be to set $\phi_2 = 1$. However, L_8 would then equal 1.45 μh. This is above the arbitrary limit of 1 μh used in the first problem.

Setting $L_6 = 1.0$ μh, ϕ_2 is 1.45 (Eq. 8). Using this new value of ϕ_2 the problem is solved as indicated.

Cascading Triples

At very large percentage bandwidths, such as $\Delta f/f_o = 2$, the amount of transformation available becomes small, as $\phi_{2max} = 1 + 1/AK$, $\phi_{1max} = 1 + 1/A$ and A is large. To obtain an increase in available transformation ratios, triples may be cascaded in Fig. 4.

In Fig. 4A, with R_L greater than R_o, filter number 1 is designed in a conventional manner, using $\phi_1 = 1$ and $\phi_2 = \phi_{2max}$. Filter number 2 can be designed with a negative L_8, equal to the positive L_9 of filter 1. Setting L'_8 negative allows the use of ϕ'_2 greater than ϕ_{2max}. (Prime components refer to filter 2.) To determine the value of ϕ'_2, set L_9 from filter 1 equal to $-L_8$ from triple 2. Equating Eqs. 13 and 14, and since $R_2C'_8 = R_LC_8$, an expression for ϕ'_2 can be derived: $\phi'_2 = \phi_2 + 1/A$. Also, $\phi''_2 = \phi'_2 + 1/A$ and so on.

When R_o is greater than R_L, as in Fig. 4B, triple 2 is designed first with $\phi_2 = 1$ and $\phi_1 = \phi_{1\,max}$. Now, C_8 is eliminated by making C_9 of triple 1 equal to $-C_8$ of triple 2. In Fig 4B, by referring prime components to triple 1 and equating C_8 to minus C_9', the expression $\phi'_{1\,max}$ equals $\phi_{1\,max} + 1/AK$ is found.

In designing cascaded triples, work must start at the high impedance end first. The maximum values of ϕ_2 and ϕ_1 normally are: $\phi_2 = 1 + 1/AK$ and $\phi_1 = 1 + 1/A$. At very large bandwidths, these values do not allow a substantial transformation. By cascading two triples, these maximums may be exceeded by allowing a C or an L to go negative at the node where the units are joined, and cancel a positive C or L of the adjoining triple.

Since we are striving for maximum transformations, the appropriate ϕ should be kept at 1.

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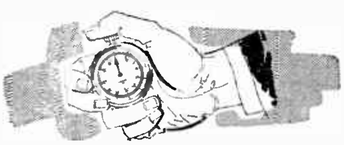

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Timer Allows Warmup Interval

By RONALD L. IVES, Palo Alto, Calif.

CONVENTIONAL TIMERS, consisting of electric clock motor, gear reduction, setting clutch and switch, turn on electronic equipment after a predetermined time delay quite satisfactorily. However, they do not hold the equipment inactive during warmup time and have no provision for suppressing warmup instability common to many types of electronic equipment.

Special delayed action cycling timers to perform such functions are commercially available, but are usually costly, complicated and difficult to maintain. Similar fault can be found with the combination of a delayed action timer, thermal time delay and relay.

Construction

By adding a cam, switch and two coils to a conventional delayed-action timer, the modified single unit can turn on the equipment at a fixed time before operation is scheduled, hold the equipment inactive until the initial warmup instability has died out and then start it in full stable operation.

Warmup interval is determined by dephasing the two cams, as indicated in Fig. 1. Warmup interval is the same regardless of timer delay. For smooth operation, the two cams were mounted on a shaft extension, flexibly coupled to the clock drive, and the extension was supported on panel bearings.

Coil modification, to increase clock drive torque and provide an integral generator of hold-off voltage, is shown in the photograph. The added clock drive coil and core

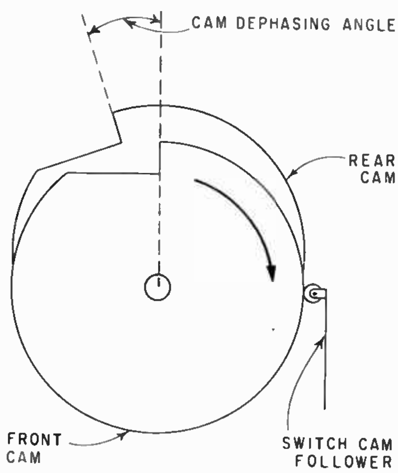


FIG. 1—Cams provide warmup time equal to dephasing angle divided by 360 multiplied by time of one shaft revolution

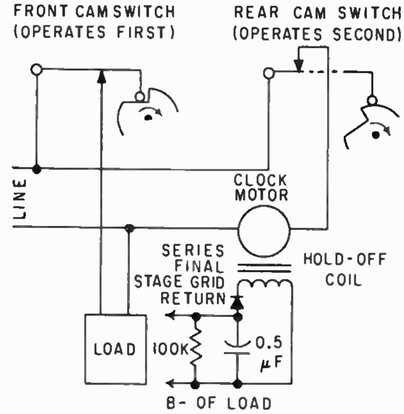


FIG. 2—Hold-off voltage permits warmup to continue until second cam switch closes

pieces were salvaged from inoperative clocks of the same manufacturer. Spare coils are generally plentiful, since the clock motors fail after about five years of continuous duty, whereas the coils seem to last considerably longer.

The center coil, which provides hold-off voltage, is a small a-c/d-c receiver choke and provides about 50 volts at no load when the clock is running. Clock drive coils are connected in parallel electrically, and in series aiding, magnetically. Hum is removed from the coil and core assembly by insulating varnish.

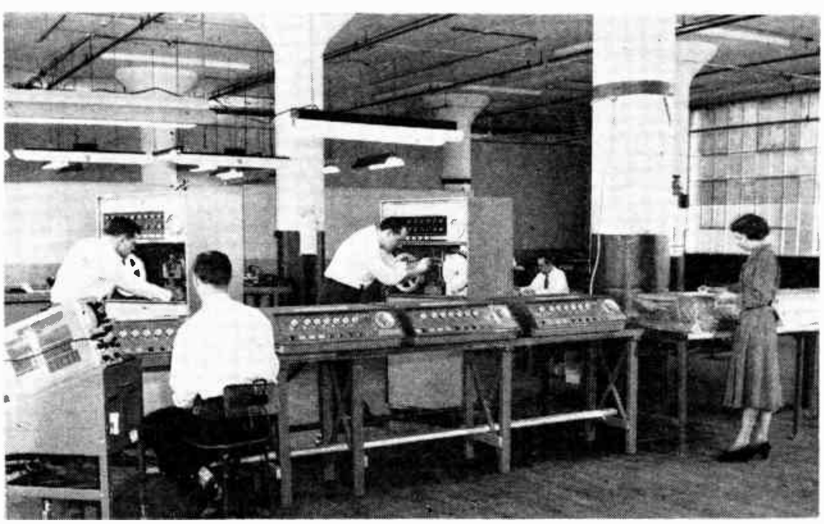
Operating connections for the clock circuit are shown in Fig. 2. Several alternative circuits can be used to perform additional functions, if desired.

Operation

In operation, the clock is set for the desired delay. Setting the clock automatically closes the front cam switch, energizing the clock, and opens the rear cam switch, so that the equipment does not operate. The hold-off voltage generator works continuously while the clock is running.

After the interval for which the timer was set has elapsed, less warmup time, the rear cam switch closes, energizing the equipment. Because the hold-off voltage generator is functioning, the equipment will not operate but warms up and

Computer Pre-Input System



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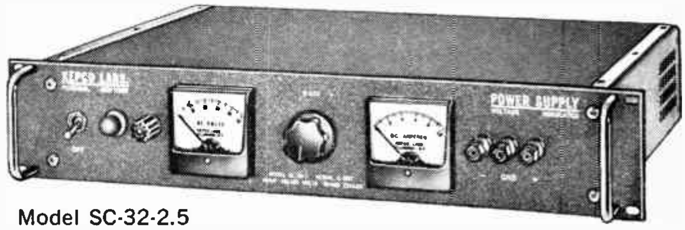

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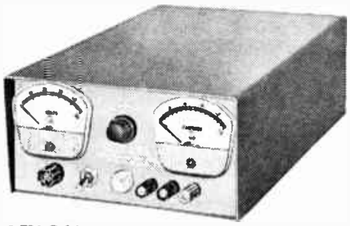

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SC-18-2	0-18	0-2
SC-18-4	0-18	0-4
SC-36-0.5	0-36	0-0.5
SC-36-1	0-36	0-1
SC-36-2	0-36	0-2
SC-3672-0.5	36-72	0-0.5
SC-3672-1	36-72	0-1

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MODEL	DC OUTPUT VOLTS	DC OUTPUT AMPS.
SC-32-0.5	0-32	0-0.5
SC-32-1	0-32	0-1
SC-32-1.5	0-32	0-1.5
2SC-32-1.5	0-32	0-1.5
DUAL OUTPUT	0-32	0-1.5
SC-32-2.5	0-32	0-2.5
SC-32-5	0-32	0-5
SC-32-10	0-32	0-10
SC-32-15	0-32	0-15
SC-60-2	0-60	0-2
SC-60-5	0-60	0-5
2SC-100-0.2	0-100	0-0.2
DUAL OUTPUT	0-100	0-0.2
SC-150-1	0-150	0-1
SC-300-1	0-300	0-1

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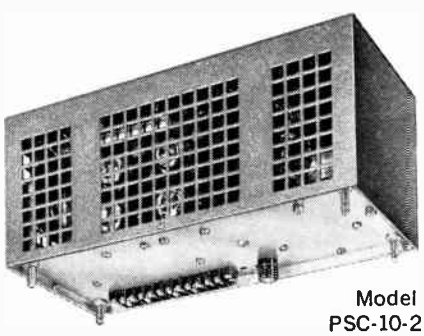

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MODEL	DC OUTPUT VOLTS	DC OUTPUT AMPS.
PSC- 5-2	0- 7.5	2
PSC-10-2	7.5-12.5	2
PSC-15-2	12.5-17.5	2
PSC-20-2	17.5-22.5	2
PSC-28-1	22.5-32.5	1
PSC-38-1	32.5-42.5	1

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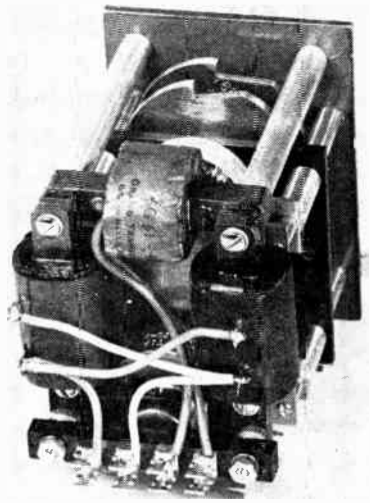


Rear view of modified time delay show clock coils and choke

stabilizes.

After the lapse of an additional short time interval, the warmup time, the front cam switch opens, stopping the clock and removing the hold-off voltage. The equipment operates until turned off externally.

A timer of this type is desirable for use with recording equipment, which requires a finite warmup interval after equipment turnon before it functions properly. It is economically desirable whenever a single observation must be taken at an odd hour, as its use can eliminate one observer shift in many instances.

Experience with timers of this general type indicates a service life in excess of 40,000 hours.

New Technique for Electronic Scanning

PURE electronic scanning for a fixed array usually involves a traveling-wave tube or a ferrite phase shifter. With these methods, phase of the signal is controlled at each radiating element.

The Electromagnetic Radiation Laboratory of the Air Force Cambridge Research Center has developed and tested a new method for steering a radiated beam electronically by a linear array that only requires a single control of phase. The method uses principles of periodically loaded lines and is made possible by a new component called a Varactor.

The Varactor, recently placed on the market, is a silicon junction diode. It is presently of interest as the variable reactance part of low-noise amplifiers. However, the low losses and variable-capacitance properties of the high-frequency device open up new areas of antenna applications.

Scanning Technique

In the new electronically scanned antenna, Varactors are spaced in a row along a strip of transmission line. Distance between Varactors may range from an inch to several feet, depending on antenna operating frequency.

A bias voltage is applied to the transmission line to control loading. As bias voltage is changed, velocity of propagation is varied along the transmission line and a progress phase shift is applied to radiating dipoles coupled to the stripline. The phase shift changes the direction of the radiated beam. To date, scan angles of ± 20 deg have been measured with an experimental antenna.

The technique, developed by A. Schell, is said to be much simpler than previous electronic scanning methods and may result in cheaper methods of pure electronic beam shifting.

Double-Plot Display

Strain in vibrating beam is plotted against time in upper waveform at same time as beam strain is plotted against acceleration of beam by DuMont dual-beam oscilloscope

Advantages of Using Coiled Waveguide

By H. S. JONES and H. K. MORLOCK, Diamond Ordnance Fuze Labs., Washington, D. C.

RIGID WAVEGUIDE and various types of coaxial transmission lines have been used extensively in microwave work to simulate free space distances and time delay. Until recently most of these delay lines have been a labyrinth of waveguide constructed from extremely long waveguide sections. The so-called packaged units that are used in test consoles or depot testers are not only bulky structures, but are also inadequate in terms of electrical performance. One method used to simulate a delay line is to suspend long lengths of waveguide joined by waveguide elbows or bends from the ceiling or wall. Another common technique is to wind the waveguide in a helix around a form of fairly large diameter.

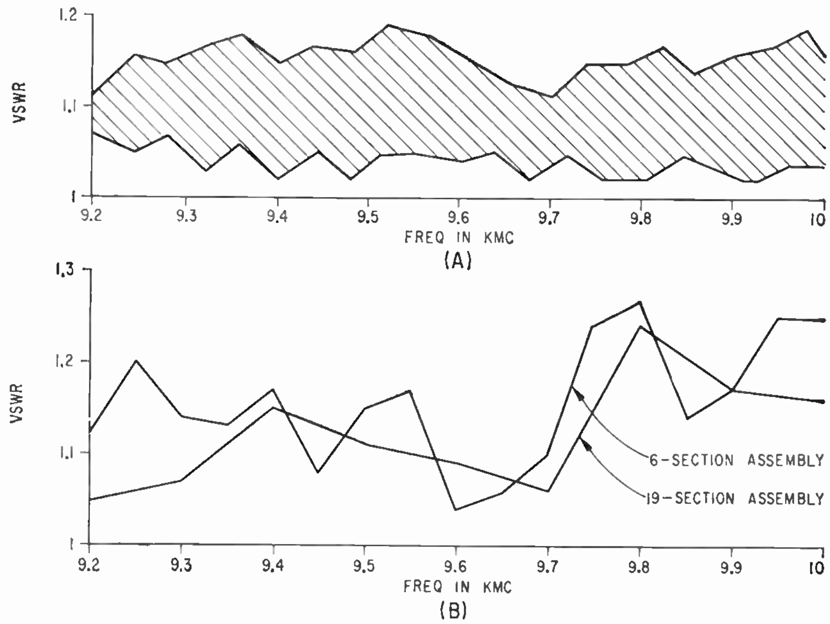


FIG. 2—Frequency in kmc plotted against vswr. Maximum and minimum deviation is given for 40 individual coiled waveguide sections, (A), and for coiled waveguide assemblies, (B)

Coiled Waveguide

A unique method of packaging waveguide in a compact form was developed at the Diamond Ordnance Fuze Labs.[1] Aluminum X-band waveguide, 0.3 x 1.0-in., OD, was selected primarily to reduce size and weight.

The individual coiled waveguide is essentially a 40-ft section of straight waveguide wound around an eight-inch diameter disc in the E-plane. It was found that this method of fabrication improved the voltage standing-wave ratio, offered greater reliability and consistency in electrical performance, and a reduction of weight and size.

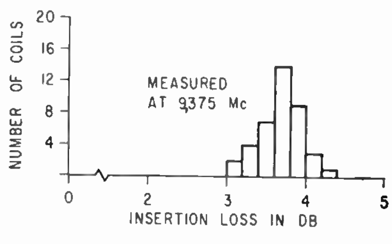
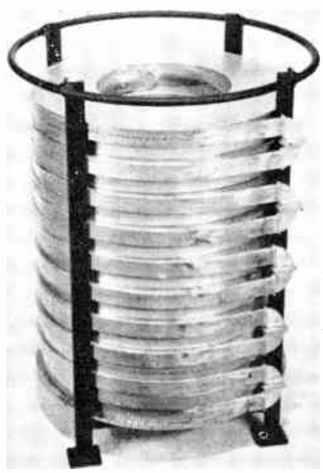


FIG. 1—Distribution of insertion loss values for 40 coiled waveguide sections



Nineteen-coil waveguide assembly

Fabrication

. . . details for these waveguide coils, including plans of the bending equipment, were reported in an earlier DOFL report (ELECTRONICS, p 88, Oct. 24, 1959). This article is a further report, giving additional information on the electrical characteristics of the coils over a frequency range of 9,000 to 10,000 mc. Additional DOFL reports are also referenced.

By properly locating the flexible steel mandrel (the internal support to walls while bending) in the guide, controlling winding speed, avoiding entry of metal filings, and improving on the flushing techniques, very good electrical results were observed. The use of a water-soluble lubricant to facilitate bending and removing the mandrel substantially improved insertion loss characteristics because it could be easily flushed from the guide.

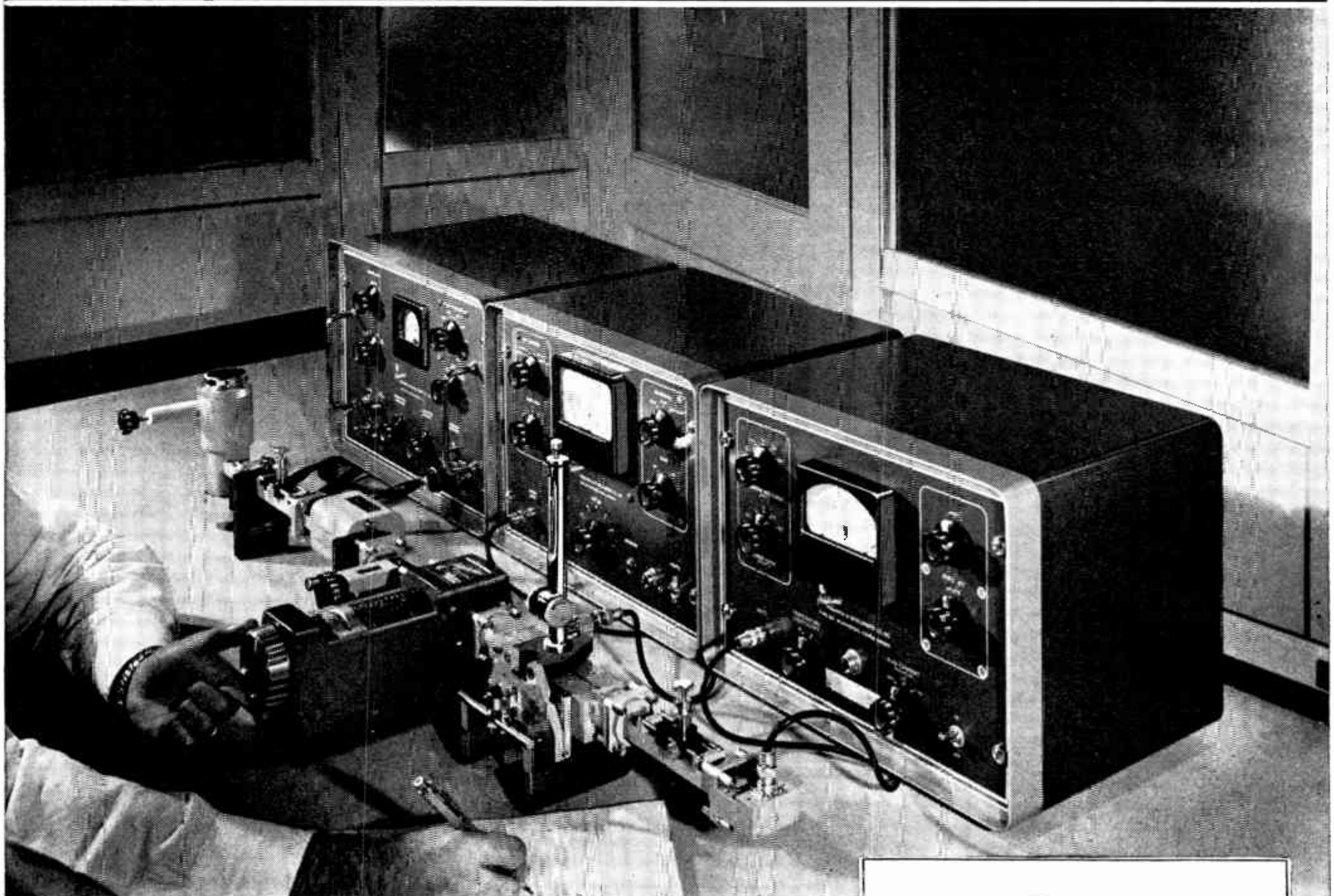
Test Measurements

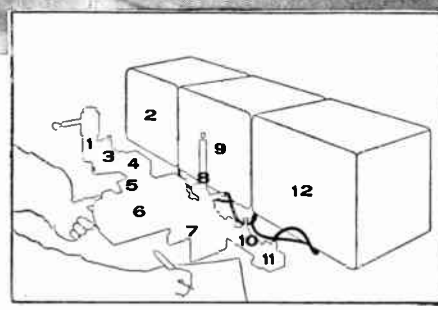
The reflectometer test system was used to determine the reflection coefficients and insertion losses over a frequency range from 9,000 to 10,000 mc. The reflection coefficient values were converted to vswr's and plotted as a function of frequency. The other measuring scheme made use of a technique developed at DOFL.[2]

Distribution of insertion loss values of coiled waveguides, measured at 9,375 mc are given in Fig. 1. Figure 2A gives maximum and minimum deviation in vswr as a function of frequency for 40 individual waveguide sections. Figure 2B plots vswr vs frequency for a 6- and 19-section assembly.

A variety of waveguide bends

HOW TO MEASURE POWER





This microwave bench set-up is for the measurement of power by the Self-Balancing Bolometer Bridge method. Other systems, including PRD's more accurate Calorimetric Instrumentation could have been shown, but the Bridge represents the most universally used technique.

The operating procedure is quite simple. First adjust the PRD 650-B Universal Power Bridge for the thermistor or bolometer available. Next tune and match the transmission line for a minimum VSWR indicated on the PRD 277-A Standing Wave Amplifier. Then record the reading of the PRD 650-B Self-Balancing Bridge (directly in milliwatts) and you're ready for your next microwave measurement.

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4—1203 Isolator, catalog page A-21
5—159-A Level Set Attenuator, catalog page A-17
6—535 Frequency Meter, catalog page D-12
7—203-D Slotted Section, catalog page B-11
8—250-A Broadband Probe, catalog page B-12
9—277-A Standing Wave Amplifier, catalog page E-7
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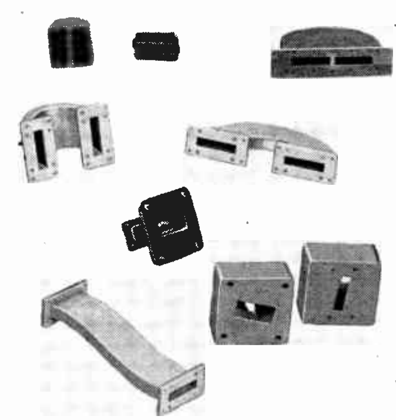


Bends and adapters used in conjunction with coiled waveguide assemblies

and adapters have been developed for the assembly of coiled sections. The most common configurations are the 180-deg. E and H-plane ½-in. radius bends and the S-type bend shown in the photographs. Although difficult to form, these adapters have good electrical characteristics when fabricated properly.[3] Vswr measurements taken on these components did not exceed 1.09 and in most cases stayed below 1.06 from 9,000 to 10,000 mc.

Another technique for connecting coils utilized 180-deg. zero radius bends which can be used in either E- or H-plane.[4]

REFERENCES

(1) R. R. Palmisano and A. Sherman, Coiled Waveguide Delay Line, DOFL Technical Report No. TR-511, Sept. 20, 1957.
(2) H. A. Conklin, Jr. and H. B. Bruns, A Simple Short Pulse Radar Reflectometer, DOFL Technical Report No. TR-398, Nov. 15, 1956.
(3) H. W. Jones and R. T. Smithea, A Study of Waveguide-Band Designs and their Fabrication Techniques, DOFL Technical Report No. TR-406, Nov. 14, 1956.
(4) H. S. Jones and K. L. Hakes, Microwave Component Development, DOFL Technical Report No. TR-520, Oct. 18, 1957.

Copper-Clad Laminates For Printed Circuits

A GLASS-EPOXY copper-clad laminate, GEC-500, recommended and supplied by Taylor Fibre Co., Norristown, Penn., replaced a paper-base phenolic resin copper-clad laminate first used in the Athena, computer for the Titan missile.

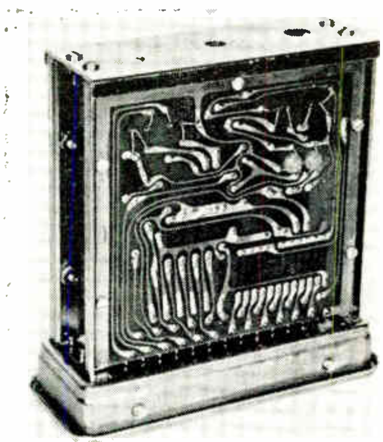
It was found that the latter laminate did not have the dimensional stability or moisture resistance to meet the military specifications, MIL-P-18177A GEE, of the computer application and that there were too many imperfections in the copper surface.

Made with rolled copper instead of electrolytic copper, the laminate does not come in contact with lead, thus eliminating the possibility of lead inclusions. Electrolytic copper is made by depositing on a lead drum.

The rolled copper is bonded to the base laminate by a special process that assures high bond strength, even under high temperatures, humidity and mechanical stress. These laminates can be converted to printed circuits by any of the conventional methods.

Basic Module

A sealed chassis, the basic module of the Titan computer, is a hermetically sealed package which protects the circuitry from environmental hazards. In assembling the chassis, two circuit boards are mounted on a connector which is then placed in a metal container. The container, after being pressurized with dry nitrogen and helium, is sealed, protecting the circuitry and simplifying maintenance.

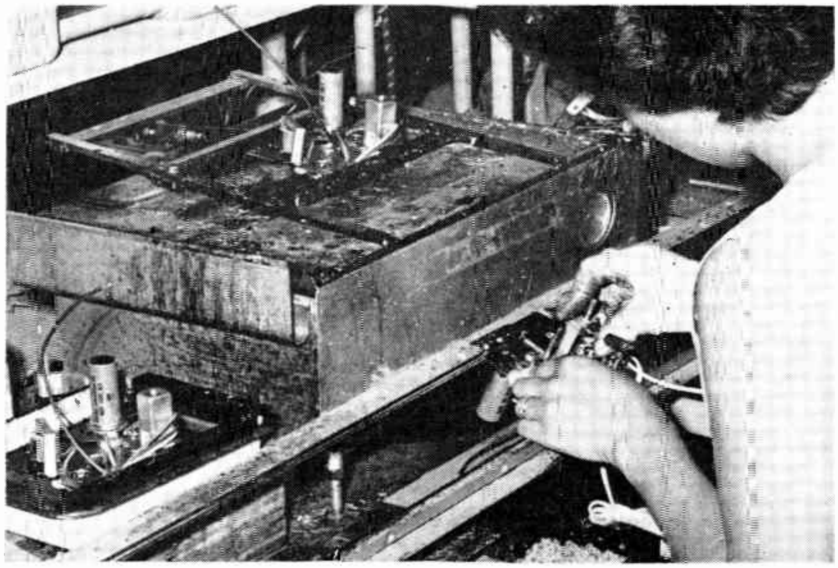


One of the most significant single component developments in building of the computer for the Titan was the use of a sealed chassis. A glass-epoxy copper-clad laminate was chosen for the circuit board material

The computer contains 1,185 of these sealed units with 25,000 resistors, 35,000 diodes and 10,000 transistors. Overall reliability of the computer, which contains 100,000 parts, is 99.8 percent.

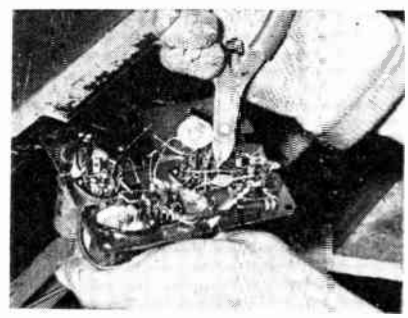
The Remington Rand computer records the life history of each component that goes into its own construction on punched cards, permitting operational defects to be traced rapidly.

Dip Solder Metal Radio Chassis



Chassis at lower left is in flux bath. The other chassis is on the cam-operated jig which lowers terminal tips and wire connections into solder bath

Assembler uses hollow tube tool to weave wire through slots in tube socket terminals



After soldering, unwanted sections of wire are clipped away

DIP-SOLDERING, adapted to hand-wired radio chassis by means of special tube socket terminals, saves production time and permits smaller chassis to be used. The method is currently used by Packard Bell Electronics, home products division, Los Angeles, Calif., in production of 4-tube and 5-tube table radios.

The firm reports the process saves approximately 20 percent in wiring time, 60 percent in soldering time and improves solder joint quality. The chassis used are half the size of previous chassis, because it is not necessary to allow room between terminals for soldering iron tips, pliers and fingers.

The terminals (Fig. 1) are made for the firm by a jobber, at about the same cost as conventional ones. Instead of holes for the ends of connecting wires, they have slots into which uninsulated wire is laid.

The slots have a narrow opening to prevent the wire from slipping out of place. To further prevent slipping, the wire is warped around the prongs. A 270-degree turn is used wherever possible.

Component leads are used for connections whenever possible. For remaining connections, a continuous length of wire is wound from terminal to terminal. The operator uses a hollow wire holder, about the size and shape of a nut pick, through which the wire is threaded. She rapidly weaves this back and forth from terminal to terminal.

After wiring is in place, the chassis is dipped into a flux bath to wet terminal tips. A cam-operated jig then dips the terminal tips and wire connections into a solder pot (500 F) for 2.5 seconds.

Sections of wires not required by the circuit are then clipped off by hand with cutters.

The method requires that the uninsulated wires not touch each other, but this has not caused any major design problems. Quality is improved by uniform fluxing and soldering. The smaller chassis used costs some 60 percent less than previous hand-wired chassis.

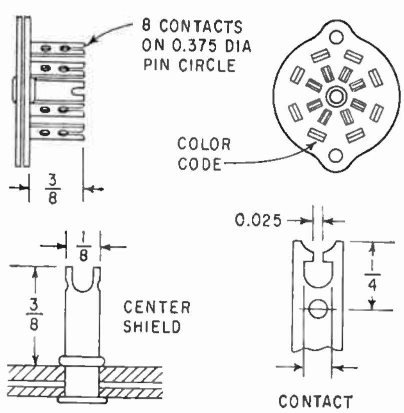


FIG. 1—Tube socket terminal design

Classifies Semiconductor Dice

VACUUM FEED STOP and electronic classification are used in a semiconductor dice gaging system developed by Airborne Instrument Laboratory division of Cutler-Hammer, Inc., Mineola, N. Y. The system will automatically gage dice or wafers at speeds up to 3,600 an hour.

Operation is illustrated in Fig. 1. Dice are delivered by a vibratory hopper to a linear feeder. They move in single file to a set of vacuum holes. If 2 dice ride piggyback, the outer die drops into a track

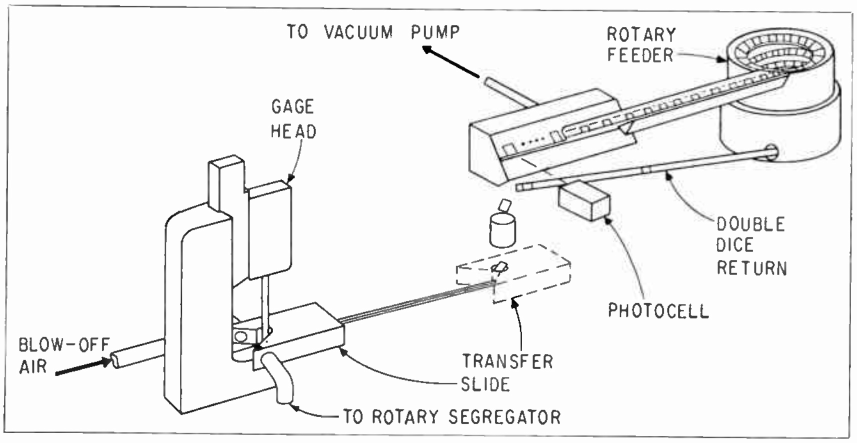
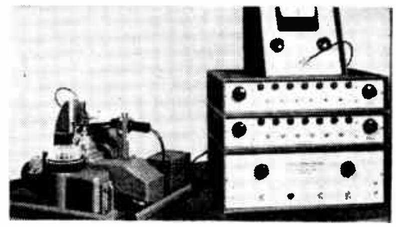


FIG. 1—Basic parts of gaging and sorting mechanism. Vibratory feeder, gravity, cam-operated slide and air blow are used to move dice

which carries it back to the hopper.

As the first wafer passes the photocell, the vacuum is applied to the following dice to prevent them from moving. The first die falls into a chute and is transferred to the gaging anvil. It is gaged to 0.00005 inch and classified into thickness increments.

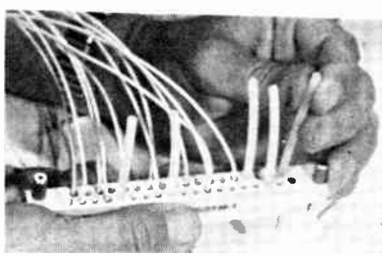
The gage information is transmitted from a control unit to a 13-grade rotary segregator. The proper segregation vial is lined up under the gage exit and the gaged die is transferred into the vial. The system then resets for the next die.



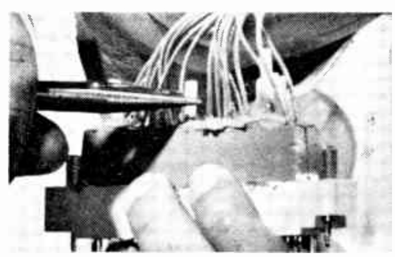
Bench setup of gager and electronic equipment

The gaging equipment consists of Microtrol Type 160 gage head, comparator and 2 classifiers.

Rods Help Add New Connections



Plastic rods are inserted in plug connector (Burndy PD35M-1)

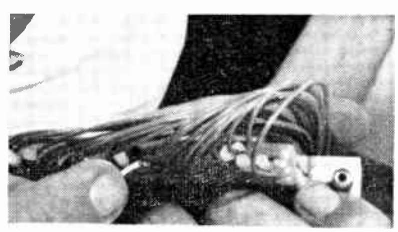


Pliers are used to free rod from potted connector

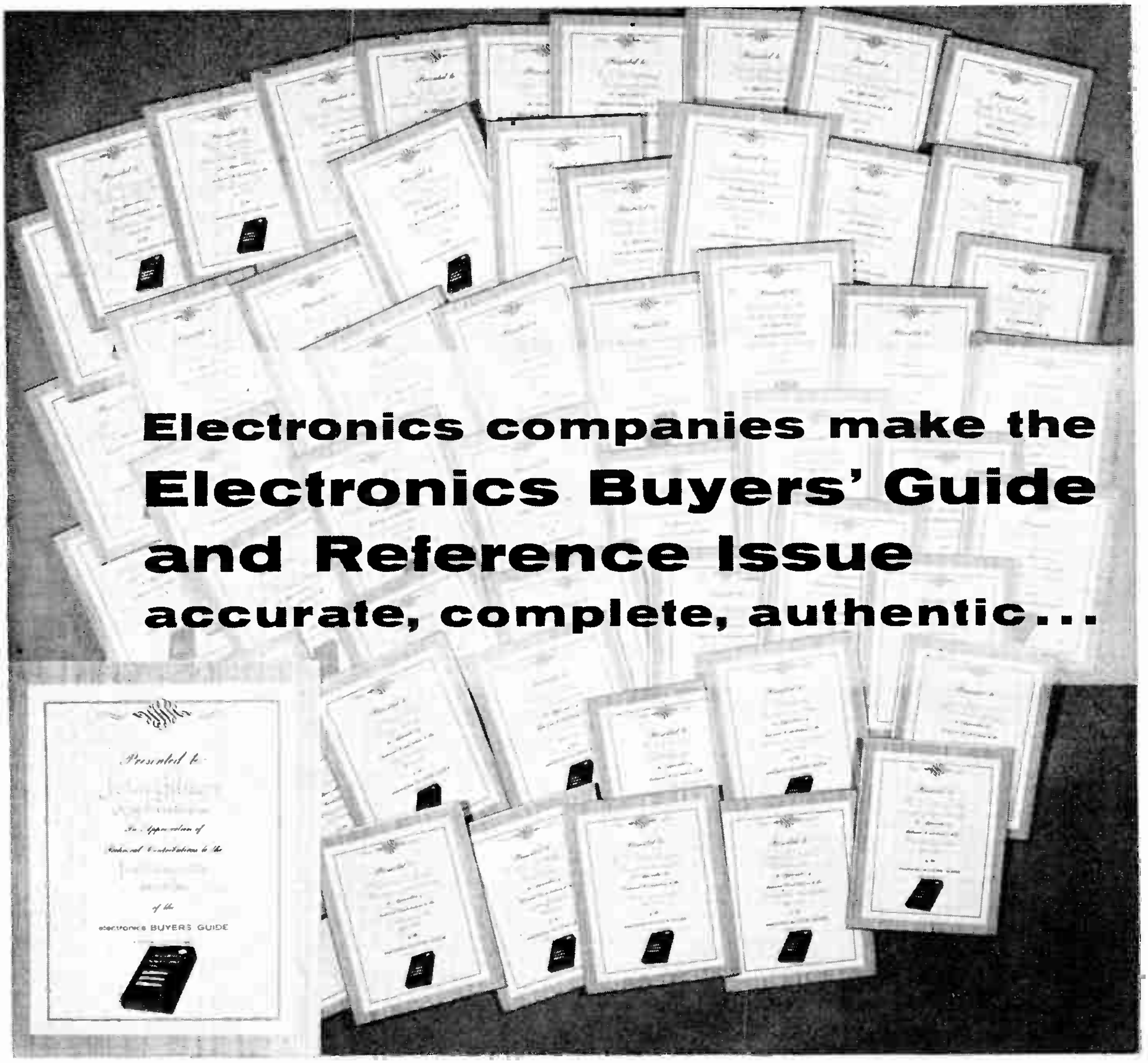
NEW circuits can be added to plug connectors after potting by plugging the unused holes with plastic rods before potting. When engineering design revisions require new connections, the rods are pulled out, leaving clean plug holes.

The technique is used by Lockheed Missiles & Space Division, Sunnyvale, Calif., in Polaris test vehicles.

Adding new circuits to a connector was previously prevented by hardened potting compound. Developed by Howard Estes, supervisor in modification and fabrication, the method is saving an estimated $2,500 per vehicle.



New circuit is added after plastic rod is removed from connector



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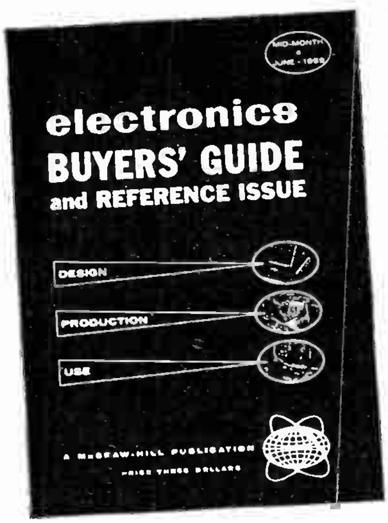

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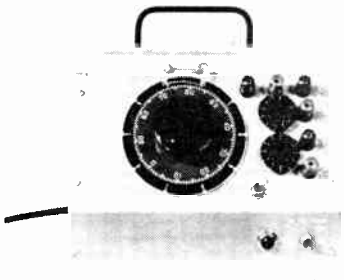

Servo Ratiometer accurate unit

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BDH Indicator for TACAN, VOR

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Coax Attenuators can handle 10 w

WEINSCHEL ENGINEERING, 10503 Metropolitan Ave., Kensington, Md. New features of model 10 fixed coaxial attenuators are bilateral matching, black anodized aluminum body for greater heat dissipation and stainless steel connectors for longer service. The attenuators can handle up to 10 w of power and are designed to dissipate this power without any appreciable change in characteristics. Frequency range is d-c to 1,000 mc; attenuation range, 1 to 10 db; impedance, 50 ohms; maximum input vswr, 1.15, bilateral; connectors, type N.

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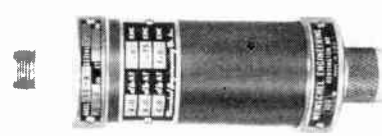

Z-Angle Meter compact, portable

ACTON LABORATORIES, INC., 533 Main St., Attleboro, Mass. Type 310-B features direct readings of impedance (ohms), phase angle (degrees), dissipation factor (D), and storage coefficient (Q). Frequency range is 30 cps to 40 kc. There are internal 60 and 400 cps test signals. Measurements can be made of impedances from 0.5 to 100,000 ohms over the frequency range. Uses include measurements of amplifiers, electro-acoustic transducers, transmission lines, filters, indicating meters and transformers.

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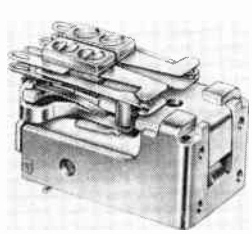
Miniature Relay highly sensitive

COMAR ELECTRIC CO., 3349 W. Addison St., Chicago 18, Ill. Type TQA is a sturdy relay intended for d-c operation at sensitivities from 20 to 100 mw. Where shock and vibra-



tion are negligible, sensitivity of 15 mw per pole is available. Contact assemblies forms A, B or C, up to a total of 18 springs. Contact rating with resistive load at 28 v d-c, or 115 v a-c: silver contacts, 3 amperes; palladium or gold alloy, 0.5 ampere. Contact life: 100,000

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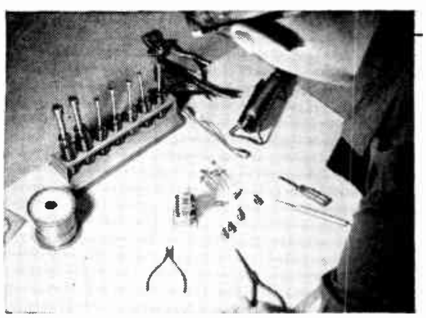

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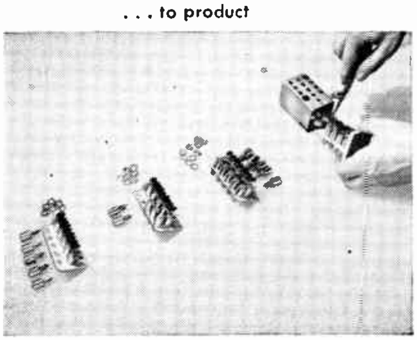

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operations, minimum. Operating temperature: −55 C. to +100 C.

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Panel Meters ultrasensitive

GREIBACH INSTRUMENTS CORP., 315 North Ave, New Rochelle, N. Y. A new series of ultraprecision current and voltage panel meters combining high sensitivities with extreme overloads is available. The 700 series direct measurement instruments are available in up to 23 ranges in one model with full-scale sensitivities to 0.20 μa. They feature extremely low resistance (2 mv drop on the 1 μa range) with ability to withstand overload surges of 100,000 percent. Overload protection of better than 1,000,000 percent on all ranges is available on special order.

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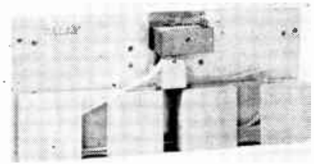

Paper Tape Reader bidirectional

TALLY REGISTER CORP., 5300 14th Ave., N.W., Seattle 7, Wash. Model 424 is a self-contained bidirectional asynchronous paper-tape reader designed for any standard perforated tape of 5, 6, 7 or 8 levels. It is available either panel mounted or as a console unit. Speed range is for any reading speed up to 60 characters per sec. Tape holes are sensed by star wheel actuated contacts which are spdt configuration.

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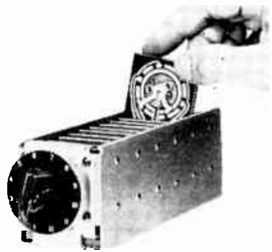
Circuit Breaker compact unit

Wood Electric Co., 244 Broad St., Lynn, Mass. The 2300 series commercial model circuit breaker weighs only 2½ oz. It is said to have performance characteristics which would be considered outstanding in breakers three times the size. It has push-pull button action, protects circuits up to 5,000 amperes, 120 v, 60 cps. Unit is highly shock-resistant and is precison calibrated.

CIRCLE NO. 207 READER SERVICE CARD

Rotary Switch replaceable wafers

Chicago Dynamic Industries, Inc., 1725 Diversey Blvd., Chicago 14, Ill., offers a new rotary switch, any wafer of which lifts out instantly without unsoldering or disassembling for fast, easy cleaning or instant replacement. Switches are available in sizes approximately 2 in. by 2 in., 3 in. by 3 in. and 4 in. by 4 in. with lengths to accommodate up to 36 wafers. All connections are to a single bank of receptacles and are conveniently accessible from one side of the aluminum housing. Wafers can be made to include printed circuitry and components in addition to their normal switching function.



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Connectors heavy duty

DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y. Series 2000 miniature rectangular connectors are available in three contact arrangements for various power applications requiring combinations of coaxial and conventional contacts, contacts for No. 16 and No. 18 Awg wire, and 41 contacts for No. 18 Awg wire. The self-aligning polarizing shells have corner keying design to prevent mismatch and provide easy engage-

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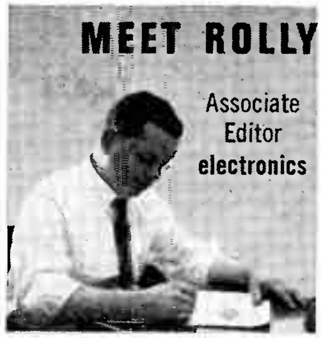
MEET ROLLY CHAREST



RESUME:

Charest, Roland J., Boston University, BS in Journalism. Formerly New England editor for **electronics**. Navy sonarman. Writer, reporter, editor for Lynn Item, Boston Globe, Boston Traveler. Won a New England Associated Press (AP) award in 1955 for writing feature articles in the major city newspaper class.

PRESENT OCCUPATION:

Rolly Charest supports Managing Editor Jack Carroll for editorial content accuracy and expediting putting each weekly issue to bed. Rolly reworks headlines for greater readability, is involved in makeup, and helps polish editorial content. Rolly's across-the-board background assures you accuracy in the face of journalistic pressures; articles in this week's issue that could be held over to the next deadline, but are not. The readers' interests come first!

REFERENCES:

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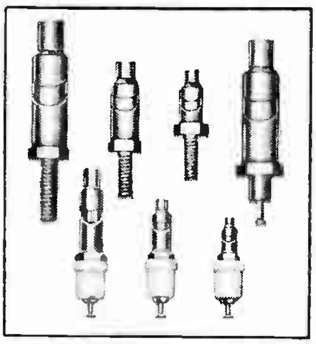

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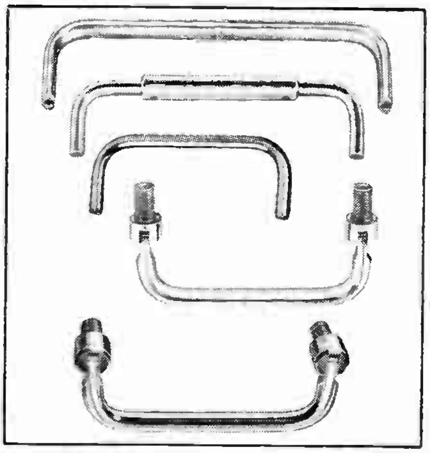
Positive-gripping clips with a wide range of application for component mounting in conventional and printed circuits. Spring-loaded and spade types. Screw-stud or rivet mounted types. Teflon type for press-mounting. Stand-off or feed through design. Spring-loaded types take wire from .069" to .085" diameter. Spade types take pins from .005" to .080" diameter.



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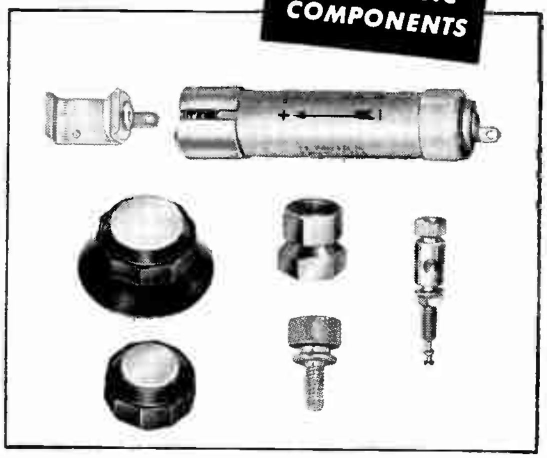
Full line of 28 type-and-finish combinations. Fixed, full-folding, and 90° folding types. Adjustable (telescoping) and oval types. Stainless steel and aluminum. Brass, plated as specified. Long-lasting, high luster. Custom made handles on request.



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Kollet Knobs, molded from Tenite II with black satin finish. Snap-in caps available in 9 code colors. With or without skirts. Arrow in skirt optional. Positive grip on shaft assured by locking device. Mercury battery holders for 1 to 5 cells. Also a complete line of binding posts, thumb screws, brackets and stand-offs.

SPECIFICATIONS	**Plating:**
Brass . . . QQ-B-626a	Cadmium . . . QQ-P-416
Stainless Steel . . . QQ-B-7	Nickel . . . QQ-N-290
Aluminum . . . QQ-A-325	Silver . . . QQ-S-365
	Gold . . . ASTM-A219 (24K)

For details write Cambridge Thermionic Corporation, 437 Concord Avenue, Cambridge 38, Mass.

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ment of plug and receptacle. Closed entry contacts with leaf spring provide increased reliability and maintain a low millivolt drop under constant and uniform insertion pressure.

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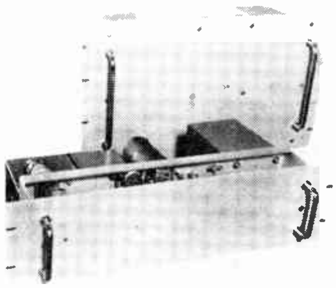

Power Supplies meet MIL-T-945A

LAWN ELECTRONICS CO., INC., Woodward Road, Englishtown, N. J., announces a line of regulated power supplies for military application to cover most normal power requirements of amplifiers, radar computers and communications equipment. Models are available with outputs of ±150 v d-c and 300 v d-c; and current ranges of 200, 400 and 1,000 ma. Standard input is 115 v ±10 percent, at 60 cycles but 400 cycle models are available. Regulation is better than ¼ of 1 percent for line or load changes, ripple is below 5 mv, and output impedance is less than 0.5 ohm. Output voltage is adjustable ±10 percent.

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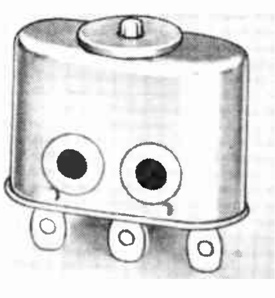

Tiny Switch withstands 700 F

HAYDON SWITCH, INC., Waterbury 20, Conn. A new precision snap-acting switch measures only ¾ in. by 45/64 in. by 23/64 in. Use of

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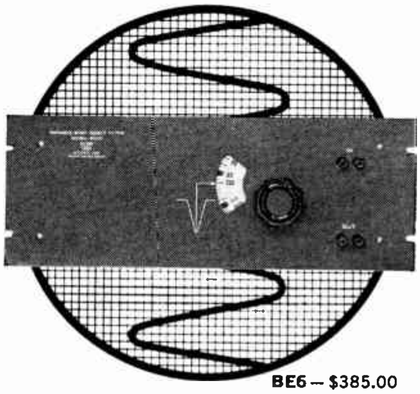
CIRCLE NO. 63 READER SERVICE CARD

Announcing the

BE6

BAND ELIMINATION FILTER



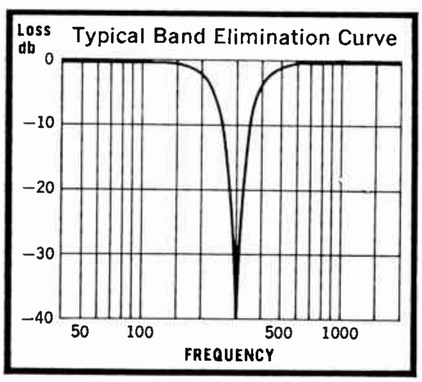
BE6—$385.00
Rack Mount Model Illus.

A New Allison Filter With Single Knob Control

The Allison Model BE6 Band Elimination Filter is a passive network filter with a direct reading dial, continuously tunable over full audio frequency range from 20 cps to 20,000 cps. It will transmit all frequencies from DC to more than 100 kcps, except for the reject band to which the filter is tuned.

SPECIFICATIONS

More than 40 db attenuation at one frequency.
Passive network—no power supply.
No vacuum tubes.
Impedance (in and out), 600 ohms.
Reject band less than 1 octave wide.
Loss in pass bands, ⅓ db.
Single dial control.
Direct reading frequency dial.
Maximum input for minimum distortion, 5 V.
Size of portable units, excluding knobs and handle, 17" long, 5¾" deep, 8" high.
Rack models are mounted on 7" rack panel.



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14195 EAST SKYLINE DRIVE
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special refractory materials in its construction insures stability of operating characteristics over the temperature range of −65 F to 700 F, throughout the life of the switch. Life at rated load is 25,000 cycles at 700 F and 100,000 cycles at 450 F. Switch is qualified to MIL-S-6743 and to the vibration requirements of MIL-E-5272A, Procedure II.

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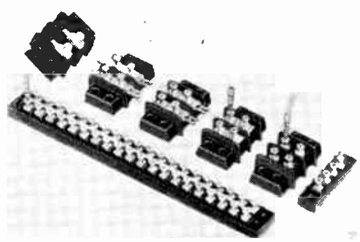

Terminal Blocks meet MIL-M-14E

EXCELLENT ELECTRONICS INC., 335 Van Siclen Ave., Brooklyn 7, N. Y., introduces a new line of miniature connector terminal blocks using solderless taper pin connections. All the various combinations of marker strips are available as illustrated as well as the new miniature "Fast Fit" tabs. The terminal blocks are designed and manufactured to meet MIL-M-14E.

CIRCLE NO. 212 READER SERVICE CARD

Delay Line built to MIL specs

CONTROL ELECTRONICS CO., INC., 10 Stepar Place, Huntington Station, L. I., N. Y., has developed a compact, lumped constant delay line with applications in the field of data converter equipment. The F341 has an impedance of 300 ohms and rise time of 0.15 μsec. Total delay time is 2.4 μsec, tapped at 0.8 μsec and 1.75 μsec. Dimensions are 3/8 in. high, 1 7/16 in. wide and 5 in. long.

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ENGINEERS RESEARCH OPPORTUNITIES

Aeronutronic, a new division of Ford Motor Company, has immediate need for computer engineers to staff its new $22 million Research Center in Newport Beach, Southern California. Here, you have all the advantages of a stimulating environment, working with advanced equipment, located where you can enjoy California living at its finest.

Look into these ground floor opportunities in research and development work that is challenging and exceptionally rewarding to qualified men.

POSITIONS NOW OPEN:

- Systems Engineer
- Magnetic Memory Engineers
- Communications Engineers
- Digital Computer Programmers
- Transistorized Circuit Engineers
- Logical Designers
- Circuit Engineers
- Mechanical Engineers
- Optical Engineers

Qualified applicants are invited to send resumes or inquiries to Mr. R. E. Durant, Aeronutronic, Box NK-486, Newport Beach, California.

Visit Aeronutronic's exhibit booth 3822-24 at the WESCON show.

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Advertisers in the *electronics* BUYERS' GUIDE use the 52 regular issues of *electronics* magazine to promote new products and keep the industry informed about their latest technical developments. *electronics* advertisers are offered the opportunity to up-date their product advertising by keying it to the catalog-type advertising in the BUYERS' GUIDE.

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NEW INDICATING 3AG FUSE POSTS

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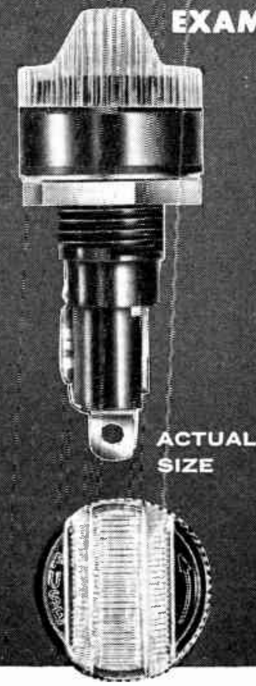


1. New patented knob design to assure high degree of illumination for instant blown fuse indication.
2. Positive finger grip for knob extraction.
3. Quick service bayonet lock.
4. Constant tension beryllium copper coil & leaf spring for positive contact & lower millivolt drop.
5. Optional—at extra cost—neoprene "O" ring to assure splash-proof feature.
6. New high degree vacuum neon lamp for greater brilliance & visibility.
7. Impact black phenolic material in accordance with MIL-M-14E type CFG.
8. One piece brass hot tin dipped non-turning bottom terminal.
9. Double flats on body to permit mounting versatility.

SPECIFICATIONS:

PART #	VOLTAGE RANGE
344006	2½- 7 volts
344012	7 - 16 volts
344024	16 - 32 volts
344125	90 -125 volts
344250	200 -250 volts

Maximum current rating 20 amps.

PHYSICAL CHARACTERISTICS—Overall length 2⅜" with fuse inserted • Front of panel length ¹³⁄₁₆" • Back of panel length 1⁹⁄₁₆" • Panel area front ¹⁵⁄₁₆" dia. • Panel area back ¹⁵⁄₁₆" dia. • Mounting hole size (D hole) ⅝" dia. flat at one side.

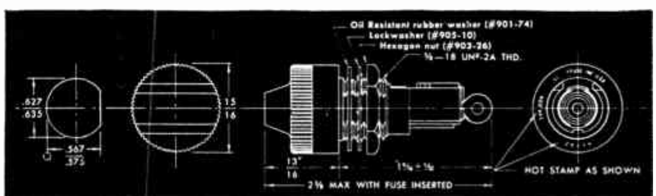
TERMINAL—Side—one piece, .025 brass—electro-tin plated • Bottom—one piece, lead free brass, hot tin dipped.

KNOB—High temperature styrene (amber with incandescent bulbs —2½ thru 32 volts—and clear with high degree vacuum neon bulbs—90 thru 250 volts) • Extractor Method—Bayonet, spring grip in cap.

HARDWARE—Hexagon nut—steel, zinc cronak or zinc iridite finish • Interlock lock washer—steel, cadmium plated • Oil resistant rubber washer.

MILITARY SPECIFICATIONS—MIL-M-14E type CFG. Fungus treatment available upon request per Jan-T-152 & Jan-C-173.

TORQUE—Unit will withstand 15 inch lbs. mounting torque.



LITTELFUSE

DES PLAINES, ILLINOIS

Literature of the Week

MATERIALS

Fiberglass Tubing. L. Frank Markel & Sons, Norristown, Pa. A 4-page illustrated brochure describes Hygrade Polytube, a class B polyester varnished fiberglass tubing which is compatible with the new high temperature wire enamels, glass served magnet wire and polyester resins. Samples and literature are available upon letterhead request.

COMPONENTS

Transistor Chart. Bendix Aviation Corp., Red Bank Division, Long Branch, N. J. A recently revised transistor chart lists typical operation and maximum ratings of all the company's production transistors.

CIRCLE NO. 214 READER SERVICE CARD

Synchro Transmitters. Daystrom Transcoil Division, Daystrom, Inc., Worcester, Montgomery Co., Pa. A size 8 synchro transmitter line is described in data sheet 801-T4.

CIRCLE NO. 215 READER SERVICE CARD

Rotary Selector Switches. Chicago Dynamic Industries, Inc., 1725 Diversey Blvd., Chicago 14, Ill. Four catalog pages are devoted to rotary selector switches with wafers which lift out instantly for cleaning or replacement.

CIRCLE NO. 216 READER SERVICE CARD

Vernier Variable Resistor. Chicago Telephone Supply Corp., Elkhart, Ind. Data sheet 174 describes the compact type VA-45 12½ to 1 ratio $\frac{13}{16}$ in. diameter vernier carbon variable resistor designed for fine tuning applications.

CIRCLE NO. 217 READER SERVICE CARD

EQUIPMENT

Punched-Card Computer. Remington Rand Division of Sperry Rand Corp., 315 Fourth Ave., New York 10, N. Y., has published a detailed case history describing the use of the Univac 60 punched-card electronic computer and allied equipment by the Lynchburg Foundry Co.

CIRCLE NO. 218 READER SERVICE CARD

Power Supplies. Electronic Measurements Co., Inc., Eatontown, N. J. Bulletin 765C describes a complete line of power supplies for laboratory and control use.

CIRCLE NO. 219 READER SERVICE CARD

Core-Grading Instrumentation. Boesch Mfg. Co., Inc., Danbury, Conn. A core-grading instrument called "Permeameter" is described in a bulletin now available.

CIRCLE NO. 220 READER SERVICE CARD

Counters. Veeder-Root Inc., Hartford 2, Conn. Included in a recent condensed catalog is an illustrated description of the company's new high-speed electronic counters.

CIRCLE NO. 221 READER SERVICE CARD

FACILITIES

Aircraft/Missile Products. Bohanan Mfg. Co., 15800 S. Avalon Blvd., Compton, Calif. A 12-page booklet describes facilities and capabilities for the development and manufacture of aircraft/missile hardware.

CIRCLE NO. 222 READER SERVICE CARD

Data Processing. Franklin Electronics Inc., Communications and Control Division, Van Nuys, Calif. Bulletin CC-220 describes an advanced research, design, and development facility for data-processing systems and components.

CIRCLE NO. 223 READER SERVICE CARD

Computer Consulting. Marc Shiowitz and Associates, Inc., 13520 Crenshaw Blvd., Gardena, Calif., has published a booklet describing consulting services available in computers and controls, data processing, guidance systems, and logical design.

CIRCLE NO. 224 READER SERVICE CARD

Meet John Mason

Associate Editor, **electronics**

MILITARY ELECTRONICS EXPERT

Resumé:

Mexico City College, Mexico, BA. Air Force officer, navigator with 32 combat missions; Director of Flight Training, Pathfinder Radar School; head of Loran School. News editor, associate editor of aeronautical trade magazine, wrote free lance aviation articles. Recalled to Air Force, 1951, and studied at Georgetown Graduate School. Assigned to Libya, then Munich. Wrote news stories plus daily digest of iron curtain radio news.

Present Occupation:

As an associate editor of **electronics** John is deeply involved with the technical and business aspects of military electronics (the current $4.5-billion government market) and draws heavily on his electronics and Air Force background.

References:

John is typical of the 26-man staff of specialists who edit **electronics** . . . men who produced 2,856 pages of editorial material during 1958. A mature, experienced staff, averaging 36 years of age, these people are dedicated to serving the needs of the reader of **electronics.** If your subscription to **electronics** is expiring, or if you are not a subscriber . . . if you will miss reading some of the exciting articles John Mason is planning for the near future . . . fill in the box on the Reader Service Card. It's easy to use. Postage is free.

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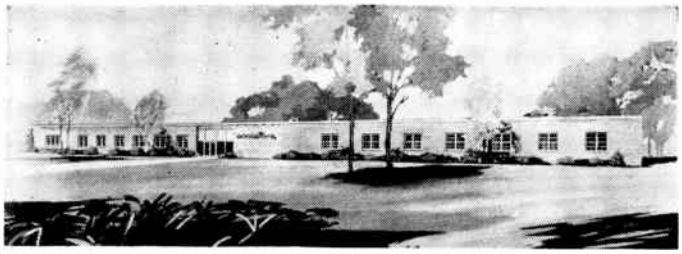


Acoustica: A New Milestone

A large plant devoted exclusively to ultrasonics was recently opened in Plainview, L. I., N. Y., by Acoustica Associates, Inc., manufacturer of ultrasonic systems for industry, national defense, hospitals, and the home. The 50,000 sq ft plant consolidates the company's executive headquarters and eastern division production and research operations which were previously conducted in four different plants (with substantially less floor space) located in Mineola, and Glenwood Landing, L. I., N. Y.

The new building marks a milestone in the history of Acoustica's rapid expansion from its start only four years ago with three employees to its present position with more than 425 employees in five plants. The four others are located in Los Angeles, Culver City, and Santa Barbara, Calif.; and Hartford, Conn. Acoustica now has over 87,000 sq ft total space in five plants.

To highlight the opening event, Acoustica demonstrated a new long-range underwater antisubmarine warning device recently developed for the U. S. Navy. This device, called SEFAR, employs silent ultrasonic energy. It was used to cut the ribbon to officially open the new plant.

Robert L. Rod, president of Acoustica Associates, Inc., told the approximately 350 guests attending the ceremonies that the new plant and other expansions of the ultrasonics industry will bring about major scientific breakthroughs during the coming year.

Promote Cameron At Varian

EMMET CAMERON recently moved up from vice president and general manager to executive vice president and general manager of Varian Associates. He will be assigned complete operating authority for the company's Palo Alto operations.

Cameron joined Varian Associates in 1953 as chief product engineer; was elected vice president, tube production in 1954; named to head up the newly formed tube division in 1956 and appointed vice president and general manager in 1957. He has been a member of the Varian board of directors since 1954.

Daystrom Pacific Ups Zillman

JACK H. ZILLMAN has been named vice president of Daystrom Pacific Division, it was announced recently by Thomas Roy Jones, president of Daystrom, Inc. In assigning the position to Zillman, Jones pointed out that Daystrom Pacific is one of the parent company's fastest growing operations and that its increasing scope and importance call for administration on the vice presidential level.

Zillman has been general manager of the operation since November of last year. Prior to that he was director of sales and engineering and assistant general manager.

The expanded airborne instrument and system work, and potentiometer production, is being performed in Upland, Calif., and a new plant in El Segundo, in addition to the administrative, engineering and production headquarters in Los Angeles.

Daystrom Pacific, with its three operations in California, is one of ten divisions and subsidiaries of Daystrom, Inc., operating throughout the U. S. and foreign countries.

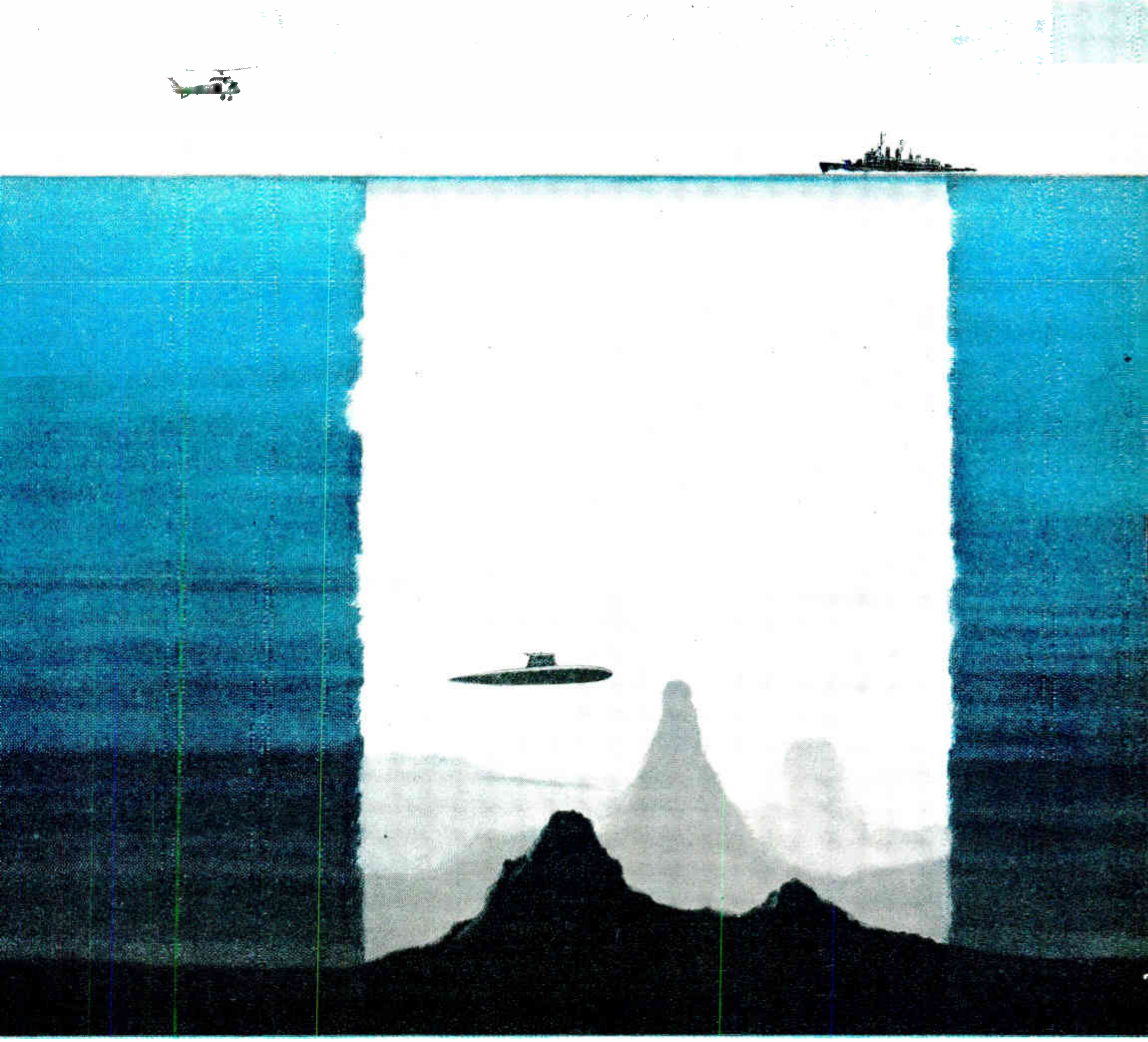
REL Elects Executive V-P

FRANK A. GUNTHER was recently elected executive vice president and general manager of Radio Engineering Laboratories, Inc., Long Island City, N. Y., a wholly-owned subsidiary of Dynamics Corp. of America.

As operations head of the DCA subsidiary, Gunther, a 34-year veteran with REL, will direct the company's multi-faceted activities in the communications field. Company is a leading producer of tropospheric scatter telephone equipment and also a product of ssb radio and tv-radio equipment.

Appoint Dannals Engineering V-P

DYNATRONICS, INC., Orlando, Fla., has named George C. Dannals vice president of engineering. He fills the position formerly held by G. F. Anderson, recently appointed vice



president and general manager of the firm.

Dynatronics is currently engaged in work for the Department of Defense, specializing in automatic tracking antenna systems and pcm telemetry ground stations.

GTIC Advances W. S. Bower

APPOINTMENT of Walter S. Bower as president of General Transistor International Corp., Jamaica, N. Y., was recently announced.

Bower, who has been a vice-president of GTIC since the corporation's founding in 1957, will be in charge of all international affairs and foreign licenses for General Transistor Corp. and its subsidiaries.

Mid-Eastern Hires Reynolds

WILLIAM REYNOLDS has joined the engineering staff of Mid-Eastern

Electronics, Inc., Springfield, N. J., as project engineer in the magnetic components department. He was formerly production manager for Stuart Electric Co., Orange, N. J., and head of quality control for the Harrison Transformer Co., Springfield.

News of Reps

Sheridan Associates, Inc., of Cincinnati, Ohio, has been appointed Ohio, Kentucky and western Pennsylvania sales rep for Shockley Transistor Corp., Palo Alto, Calif.

Jackson Edwards Co., North Hollywood, Calif., rep firm, appoints **Edward J. Foley** as field engineer, covering the state of Arizona.

A. Friedman & Associates of Jamaica, N. Y., is named by Wyco Metal Products, North Hollywood, Calif., to handle the company's line of racks, panels, cabinets and chassis for the electronics industry in New York City and northern New Jersey.

Lawrence Research & Electronics of Detroit, Mich., is now national and international representative for The Digitrols Co., Baltimore, Md., in the sale of all transistor products.

Amplifier Corp. of America, New York, N. Y., has appointed **Lawrence Research & Electronics** of Detroit, Mich., to handle its line of transistor transformers in Michigan, Illinois, Indiana and Wisconsin.

Mid-Eastern Electronics, Inc., Springfield, N. J., has appointed **Ed Granzow Associates** of Phoenix, Ariz., sales rep for Arizona.

Penn Resistor Corp., Lansdale, Pa., has appointed the following reps: **Norman Hardy Associates** of Melbourne, Fla., for the state of Florida; **Richard Legg Co.** of Portland, Ore., for the northwest territory; **Lee Grant Snyder** of Hollywood, Calif., for southern California and Arizona; and **Spicer-Lindsay Associates** of Denver, Colo., for the Rocky Mountain area.

COMMENT

More Abbreviations

In your June 26 issue (Comment, p 84), the item "Abbreviations," you say you "find no record of international agreement" as to using *Mc* for megacycle rather than your usage of *mc*.

My copy of *Physics Today*, dated November 1956, p 23, refers to the Commission on Symbols, Units and Nomenclature of the International Union of Pure and Applied Physics (SUN Commission); Professor H. H. Nielsen, chairman of the Commission, Dept. of Physics and Astronomy of Ohio State University. The article starting on p 23 stipulates upper-case *M* for mega-.

I believe there is weight for the argument in favor of the upper-case *M* in *Mc* for megacycle.

WM. M. HURST
FT. WORTH, TEXAS

How can you be so stuffy in defending your error in your reply to the June 26 comment of H. T. Greatorex of the BBC. No thinking man has used *M* for 1,000 in the electronics industry of Canada or the U. S. for over 10 years. And I am not forgetting the obstinacy of one component manufacturer who cannot bring himself to go modern.

R. SPENCER SOANES
CANADIAN RESEARCH INSTITUTE
TORONTO, CANADA

We seem to have started a tempest in a teapot. We will go only this much further: that we reserve the right to defend, not errors, which we regard as indefensible, but opinions.

The ASH Sensor

During World War II, the Navy was disinterested in my proposal for a specialized form of mass spectrometer, to be developed for detecting the "spoor" (diesel fumes) of enemy subs and homing upwind on the source. I am at least mollified to observe that some admiral has presumably come up with the same idea 10 or 15 years later—just as diesel power is becoming obsolete; (See "How We're Fighting Sub Threat," p 20, July 3.)

My copy of the proposal is in

our files, but one feature I recall was a provision for an IFF function, involving prearranged introduction of trace amounts of unusual elements in the diesel fuel of friendly subs, which would be separately detected in the spectrometer by special interchangeable masks used as anodes. Enemy subs using the wrong trace elements, or more or less than the trace amounts specified by the daily code, would give an alarm.

CHARLES C. LITTELL JR.
ENGINEERING ASSOCIATES
DAYTON, O.

Night Vision

We were very interested to see in your issue of June 26 ("How Military Sees in Dark," p 20), in an article on detecting low-level energy, a suggestion that a Vidicon-type tube employing thermal detection should be used for infrared observation, and that such tubes did not in fact exist.

In this company we produced a number of tubes of this type during 1956 as part of a government contract, and were able without the use of any cooling to detect objects with such a tube, which were only 12 C above ambient temperature. Work on these tubes is still continuing . . .

G. B. F. GOFF
CATHODEON LTD.
CAMBRIDGE, ENGLAND

Ceramic Magnets

Reference Newsletter, p 11, July 10, wherein it is stated that the Soviets are now making ceramic magnets out of compressed iron and barium oxide.

This sounds suspiciously akin to the ceramic permanent magnets that Stearns Magnetic, a division of Indiana Steel Products, has been manufacturing and applying to industrial uses for at least two years.

C. M. SCHLOSS
SCHLOSS & SHUBART
DENVER, COLO.

We're always interested in reporting Soviet progress, especially when it bears suspicious resemblance to earlier American work.

Explore new areas at IBM in

MECHANICS

At IBM, engineers are applying the principles of mechanics in radically new ways in order to keep pace with recent scientific advances. One project, for example, involves the design of mechanical and electromechanical devices and servos in the 5-10 millisecond range that will insure minimum noise, vibration, and wear. In another project, new concepts of magnetic recording systems are being sought that will enable great quantities of data to be stored in highly miniaturized "memory" devices. Also under development are extremely fast, extremely small output mechanisms that will open a new era in office equipment design. For assignments like these, IBM is seeking engineers who can solve the unusual mechanics problems posed by recent technological break-throughs.

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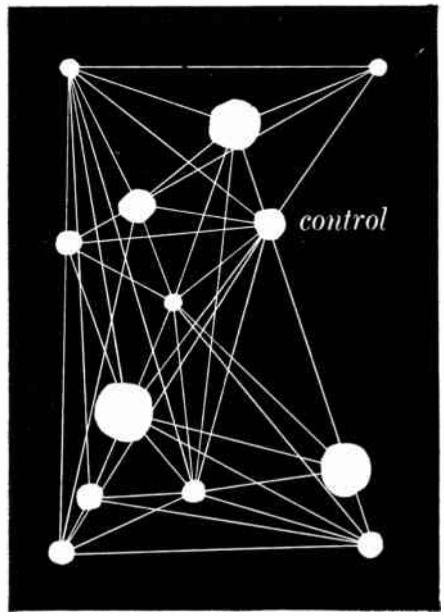

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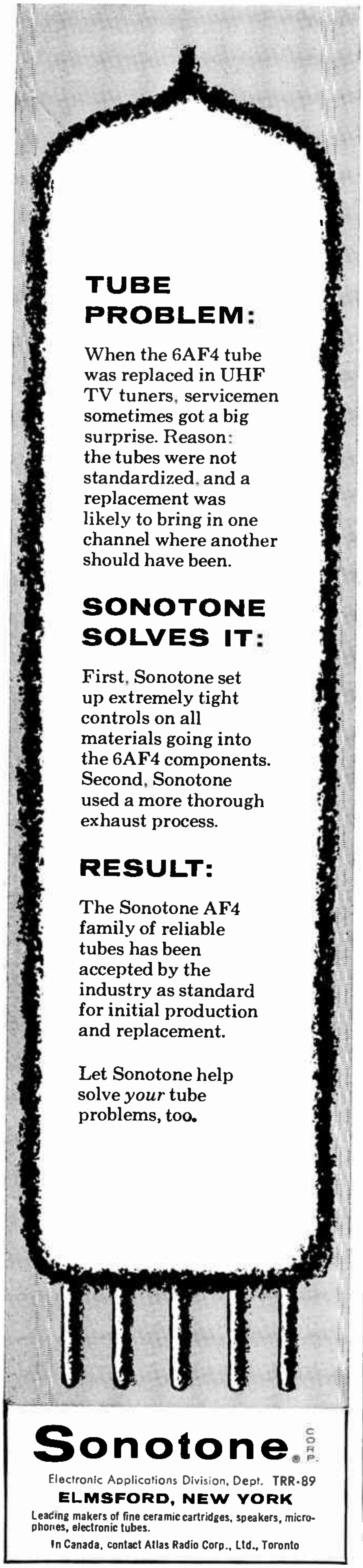

INDEX TO ADVERTISERS

Aeronutronic 64
Allison Laboratories, Inc. 64
Arnoux Corporation 53

Barnstead Still and Sterilizer Co. 8
Beattie-Coleman Inc. 11
Black & Webster, Inc. 68
Boeing Airplane Company 75
Bradley Semiconductor Corporation 23
Brush Instruments Division of Clevite 26
Bussmann Mfg. Division McGraw-Edison Co. 9

California Technical Industries 56
Cambridge Thermionic Corporation 59, 60, 61, 62
Continental-Diamond Fibre, Subsidiary of the Budd Company 43

Dano Electric Company, The 60
Durant Manufacturing Co. 73
Dynacor Inc., A Subsidiary of Sprague Electric Co. 72

Gamewell Company, The 74
Gardner-Denver Company 45
General Ceramics Corporation 2
General Electric Apparatus Dept. 69
General Transistor Corporation 18

Haydon Division of General Time Corporation 13
Hewlett-Packard Company .... 2nd Cover
Hughes Aircraft Company 6, 14, 15

Jones, Howard B., Division Cinch Mfg. Co. 63

Kennedy & Co., D. S. 3
Kepco Inc. 47
Kintel Division of Cohu Electronics, Inc. .... 3rd Cover

Lampkin Laboratories Inc. 81
Littelfuse 67
Lockheed Aircraft Co. 72

MacDonald Inc., Samuel K. 81
Magnavox Company 55
Minneapolis-Honeywell Regulator Co. 49

National Carbon Company 63
North Electric Company 10

Phillips Control Corporation 73
Polytechnic Research and Development Co., Inc. 51

Radio Corporation of America .... 4th Cover
Raytheon Mfg. Co. 5, 48, 52, 71
Relay Sales 59, 62, 67, 69

Sonotone Corp. 82
Sprague Electric Company 20, 21
Stromberg-Carlson 22

Telrex Laboratories 74
Transitron Electronic Corporation 24, 25

White Company, S. S. 17

Yuba Consolidated Industries, Inc. 12

■

Professional Services 81

■

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

EMPLOYMENT OPPORTUNITIES 76-81
EQUIPMENT (Used or Surplus New) For Sale 81

ADVERTISERS INDEX

Avco Research & Advanced Development 80
Bell Aircraft Corporation 78
Bristol Company 81
Electro-Timer Inc. 81
General Electric Company 77-79-80
International Business Machines Corp. 76-77
Legri S. Company 81
Minneapolis-Honeywell, Aeronautical Div. 78
Monarch Personnel 81
Monsanto Chemical Company 80
Pennsylvania State University 79
Philco Corp., Gov't & Industrial Div. 79
Radio Corporation of America, Electron Tube Div. 78
Sterling Precision Corporation 81

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