April 29, 1960

electronics

SPECIAL REPORT *developments such as this megawatt klystron used for missile-detecting radar are described in a survey of what's new in electron tubes*

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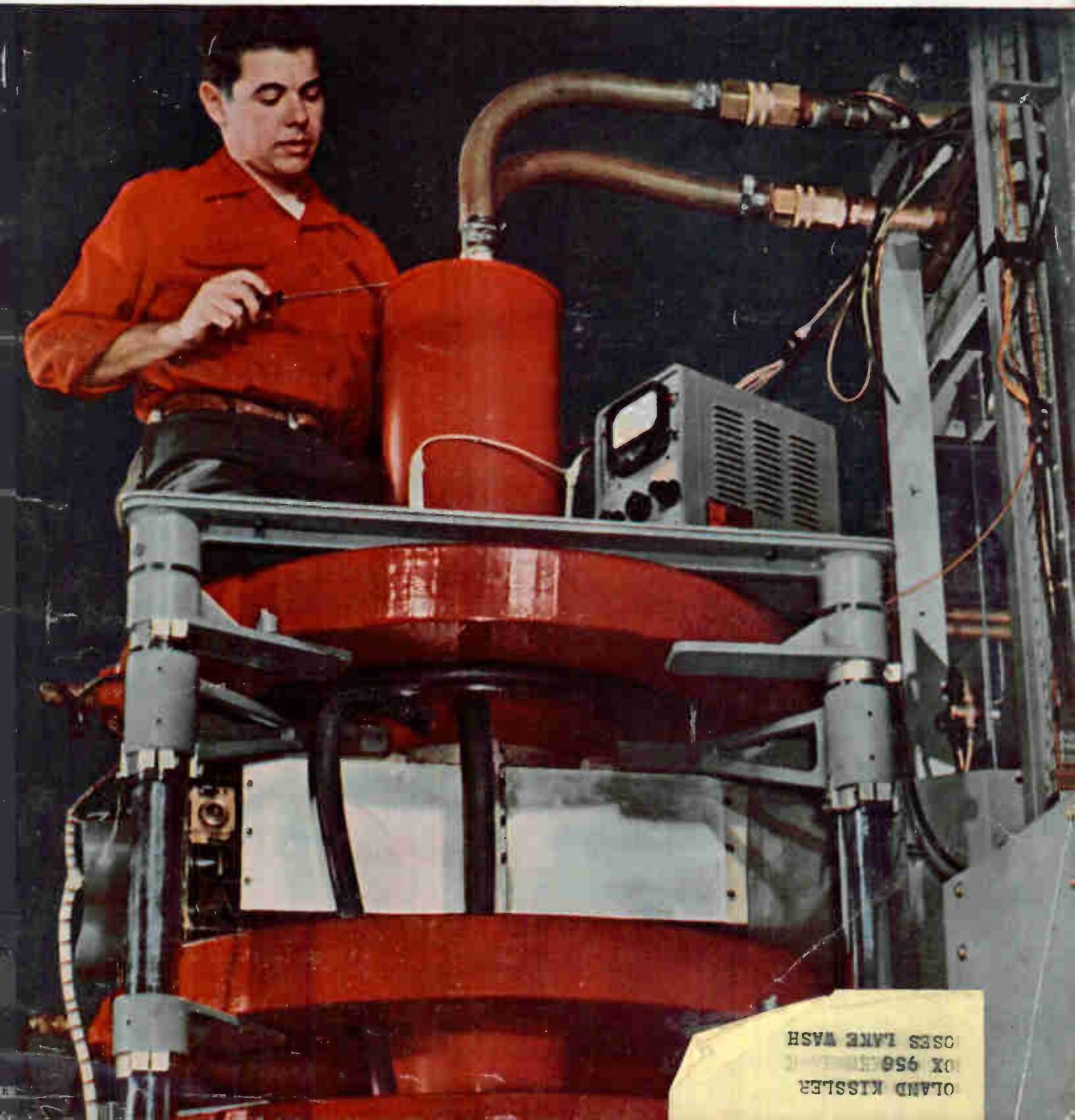
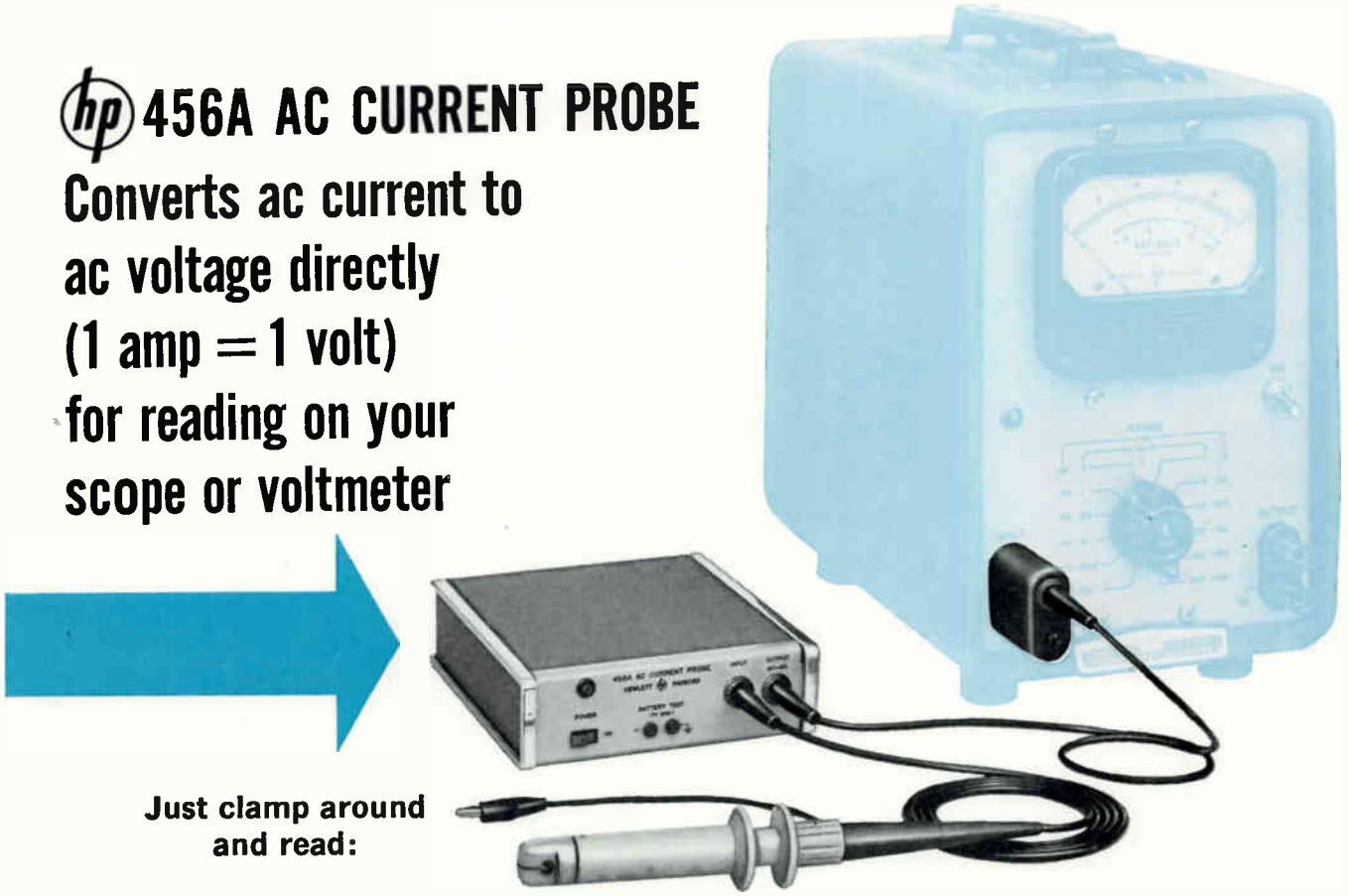


456A AC CURRENT PROBE

Converts ac current to ac voltage directly (1 amp = 1 volt) for reading on your scope or voltmeter



Just clamp around and read:

Tube circuits . . . . . view current on your scope or measure it with a VTVM

Transistor circuits . . . . . measure small signals dynamically, without clipping leads or circuit loading; study diodes at breakdown

Logic circuits . . . . . measure ac current in presence of dc current

Impedance measuring . . with a dual-channel scope, measure current, voltage magnitude; phase angle

Power measuring . . . . . with dual-channel scope read current, voltage directly, calculate power

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Sensitivity: 1 mv/ma ±2% at 1 KC
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±5%, 60 cps to 4 MC
±3 db, 20 cps to beyond 5 MC
Maximum Input: 1 amp rms; 2 amp peak
Maximum dc current: Dc up to 0.5 amp has no appreciable effect
Input Impedance: Probe adds to test circuit only approx. 0.03 ohms with 0.1 uh shunt
Output Noise: Less than 50 μv rms (100 μv ac powered)
Power: 10 radio mercury cells; approx. 400 hours service normally supplied. Ac supply available. Specify -hp- 456A-95A, $32.00 extra. Factory installed, without batteries, $20.00 extra.
Size: 5¾" wide, 2½" high, 4" deep, weight 3 lbs.
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Data subject to change without notice

Just clamp the hp 456A probe around a wire under test and view or read ac current directly on an indicating device. Model 456A's 1 mv to 1 ma unity conversion permits direct readings up to 1 ampere rms. The instrument's wide bandwidth permits use with oscilloscopes to view complex current waveforms with rise times to 0.08 μsec. No direct circuit connection is required; there is no loading, no appreciable impedance change in the circuit under test, and the impedance of the test circuit is immaterial.

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electronics

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CROSSTALK

WEATHER & SPACE. There now exists a network of weather rocket stations which permits routine observation of the atmosphere at twice the 100,000-ft altitude probed by radiosonde balloons. Moreover, it turns out, this network has important implications for the future development of large spacecraft.

Instrumented low-cost Arcas and Loki rockets have already been fired for one month on a daily basis from Wallops Island, Va., and Point Mugu, Calif. Additional month-long daily firings are slated for this spring, summer and fall. These weather rockets can reach higher than 40 miles. Primarily, they gather data on winds. Radars track the paths of parachutes or clumps of falling "chaff."

As to how data being collected will help development of spacecraft, the National Academy of Sciences says: "The rocket measurements are of immediate importance to understanding of the winds which large rockets and space vehicles will have to encounter during their flight."

This gathering of information with a double value—telling us what weather is doing today and what ships may face in space tomorrow—makes interesting reading (see p 43).

MADE IN JAPAN. Television receivers, long the exclusive province of U. S. domestic manufacturers, are now being imported from Japan. As this issue of ELECTRONICS goes to press the first shipments are being unloaded. To gage the effect of these shipments on American manufacturers, Associate Editor Emma conducted personal interviews with major tv manufacturers in the eastern and midwestern regions of the country. Some feel the competition will be a healthy spur, some see serious complications. The Japanese imports will include transistorized 8-in. portables and 23-in. color sets. The reactions of U. S. manufacturers are as varied as the imports. To read comments of some American companies, turn to p 32.

Coming In Our May 6 Issue

FRENCH COLOR TV. As brought out in a recent ELECTRONICS report (p 75, Feb. 12) communications and tv systems are receiving considerable attention from French researchers. One result of this effort has been the Henri de France method of compatible color tv proposed for use in France.

In our next issue, R. Chaste of Compagnie Generale de TSF, and P. Cassagne and M. Colas of Compagnie Francaise de Television in Paris, reveal the circuits of this experimental tv system. Sequential transmission of chrominance is used in conjunction with a one-line memory in the receiver.

SATELLITE TELEMETRY. With earth satellites performing more numerous and complex experiments, demands for new or more sophisticated electronic devices and circuits are continually being made. Next week, ELECTRONICS adds to the lengthy list of feature articles that have kept you up to date on the advances in space electronics.

A. J. Fisher of the Army Ballistic Missile Agency in Huntsville, Ala., has teamed up with W. R. Talbert and W. R. Chittenden of Motorola in Scottsdale, Ariz., to describe the telemetry transmitter for a satellite designed to investigate the Van Allen radiation belt from a high-apogee orbit. The disk-shaped transmitter uses a novel phase modulator circuit based on a modification of a conventional bridged T network.

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RAYTHEON "KILOLINE" RECORDING STORAGE TUBES

A Raytheon-designed tetrode gun insures higher resolution — 1,000 TV lines at 50% modulation — and improved control over beam cut-off in Raytheon's new CK7571/QK685 and CK7575/QK787 recording storage tubes. A new multiple collimating lens improves background uniformity and results in a signal-to-shading ratio of ten.

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- Scan conversion for bright display and target trails.
- Slow-down video for transmission of still pictures over telephone lines.
- Stop motion to permit analysis of production machinery or to stop action in a sporting event.
- Signal-to-noise improvement of radar or other still pictures by integration.
- Conversion of television pictures from one transmission standard to another.
- Indication of moving targets by electrical comparison of pictures taken at different times.

For scan conversion applications, both r.f. read-out and video cancellation techniques have proved equally effective with Raytheon single- and dual-gun storage tubes.

Raytheon's single-gun CK7571/QK685 and dual-gun CK7575/QK787 recording storage tubes are available from stock in sample quantities. Detailed technical data bulletins are yours for the asking — write direct to Dept. 2527.

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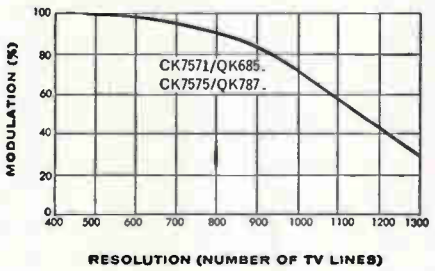
Anode Voltage	4,000 Vdc
Magnetic Focus Resolution	1,000 Lines (nominal)
Electrostatic Resolution	700 Lines (nominal)
Output capacitances:	
CK7571/QK685	12 $\mu\mu$f (nominal)
CK7575/QK787	27 $\mu\mu$f (nominal)
Maximum Deflection Angle	30 Degrees

TYPICAL RESOLUTION CURVE



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COMMENT

A Vote For Short Articles

Congratulations! The April 1st issue of ELECTRONICS was a honey of an issue! Especially enjoyed the Japanese coverage.

The April 8 issue has a fine example of a good article for a technical weekly: Paul Harris' "Insuring Stability in Time Delay Multivibrators," on page 73, tells a whole story on one page. I will stop and read that kind.

I cast my vote for more one-page technical articles a la the one by Harris.

FRANK C. ALEXANDER, JR.
SWARTHMORE, PA.

Unity-Gain Amplifier

As a response to our article, "Unity-Gain Amplifier Offers High Stability," that appeared in ELECTRONICS (p 66, Feb. 26), we have received a letter from J. Ross Macdonald, director, solid state physics research, of Texas Instruments, Inc.

Mr. Macdonald cites two articles written by him as disclosing circuits similar to those discussed in our article.

The articles cited were:

(a) "An A. C. Cathode Follower Circuit of Very High Input Impedance." *The Review of Scientific Instruments, Feb.* 1954.

(b) "Some Augmented Cathode Follower Circuits," *IRE Transactions on Audio*, May-June 1957.

The first article does in fact describe a circuit similar to our Fig. 2 except that an additional tube section is used as a constant current cathode load, as suggested by Valley and Wallman in their book *"Vacuum Tube Amplifiers"*. Also, four separate d-c supply voltages are indicated in the circuit diagram. The circuit operation is similar to our Fig. 2 and it is shown that the transmission accuracy is greatly improved over that of the normal cathode follower. However, it is not pointed out that the *gain stability* is an inverse function of the product of the tube amplification factors. The authors also feel that their circuit offers a certain basic simplicity in requiring only two

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FREQUENCY: 380 to 420 cycles
OUTPUT: 115V ± 1V from 2 to 8 amperes
RESPONSE: <100 ms / 9V_{IN} increments
DISTORTION: 5% mox over input voltoge and frequency ronge (exclusive of source)
OPERATING TEMPERATURE RANGE: —55°C to +71°C
DUTY CYCLE: Continuous

ENVIRONMENT CONDITIONS:

Altitude: to 50,000 ft.
Humidity: 95% 50°C 360 hours
Shock: 15 g's
Vibration: 10 g's 5 to 500 cycles

MECHANICAL CHARACTERISTICS:

Size: 5" x 5" x 12"
Weight: Less thon 10 lbs.

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tube sections and one supply voltage.

The second article describes a rather complex circuit of five tube sections, two of which are connected in a configuration similar to that of our Fig. 3.

However, the input cathode follower is not of the stepped up variety; thus the input impedance would be lower and the signal input range capability would be smaller. Also, two power supply voltages are required for Mr. Macdonald's circuit.

The authors wish to extend their thanks to Mr. Macdonald for bringing the above articles to their attention.

GARETH M. DAVIDSON AND
ROBERT F. BRADY
GARDEN CITY, N. Y.

Monostable Multivibrators

I find that the article "Choosing Transistors For Monostable Multivibrators" p 58, Jan. 22, appears to have inaccuracies.

(1) Equation (5) should read $E_0(t) = (V_T + I_c R_L - V_E)\,[1 - \exp(-t/R_T C_T)] + V_E - I_c R_L$.

(2) The recovery path time constant is given as $(R_E + R_L)C_T$. This is true as long as $R_E << R_L$ (and $R_E << R_T$). However, since the curves in Fig. 4 include values of R_E/R_L as large as 2, a more careful estimate should be used. If, as assumed, Q_2 is in saturation with $V_{c1} = 0$ and $R_{L1} = R_{L2} = R_L$, for R_E, $R_L << R_T$ here and in Eq. 8, 9, R_E should be replaced by $R_E R_L/(R_E + R_L)$. Equations 9, 9A, and 10 should have $1 + R_L/R_L$ replaced by $(1 + 2R_E/R_L)/(1 + R_E/R_L)$. The values of R_E/R_L, Fig. 4, would then be replaced by 0, ½, 1, ∞, and the curve labeled 2 would not be present.

(3) In the two examples the β_{min} used is the small signal β_{min} and not the d-c β_{min} at saturation.

BARRY C. DUTCHER
PROVIDENCE, R. I.

Upon reading Mr. Dutcher's letter and checking my initial work prior to writing "Choosing Transistors for Monostable Multivibrators," I find that he has three well-taken points.

J. R. KOTLARSKI
CULVER CITY, CALIF.

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*3⅛" high
400 - 1000 cy.

PRECISION FORK UNIT
TYPE 50

Size 1" dia. x 3¾" H. Wght., 4 oz.*

Frequencies: 240 to 1000 cycles
Accuracies:—
Type 50 (±.02% at —65° to 85°C)
Type R50 (±.002% at 15° to 35°C)
Double triode and 5 pigtail parts required
Input, Tube heater voltage and B voltage
Output, approx. 5V into 200,000 ohms

FREQUENCY STANDARD
TYPE 50L

Size 3¾" x 4½" x 5½" High
Weight, 2 lbs.

Frequencies: 50, 60, 75 or 100 cycles
Accuracies:—
Type 50L (±.02% at —65° to 85°C)
Type R50L (±.002% at 15° to 35°C)
Output, 3V. into 200,000 ohms
Input, 150 to 300V, B (6V at .6 amps.)

*3½" high
400 to 500 cy.
optional

PRECISION FORK UNIT
TYPE 2003

Size 1½" dia. x 4½" H. Wght. 8 oz.*

Frequencies: 200 to 4000 cycles
Accuracies:—
Type 2003 (±.02% at —65° to 85°C)
Type R2003 (±.002% at 15° to 35°C)
Type W2003 (±.005% at —65° to 85°C)
Double triode and 5 pigtail parts required
Input and output same as Type 50, above

FREQUENCY STANDARD
TYPE 2005

Size, 8" x 8" x 7¼" High
Weight, 14 lbs.

Frequencies: 50 to 400 cycles (Specify)
Accuracy: ±.001% from 20° to 30°C
Output, 10 Watts at 115 Volts
Input, 115V. (50 to 400 cycles)

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Accuracies:
2007-6 (± .02% at —50° to +85°C)
R2007-6 (±.002% at +15° to +35°C)
W2007-6 (±.005% at —65° to +125°C)
Input: 10 to 30 Volts, D. C., at 6 ma.
Output: Multitap, 75 to 100,000 ohms

FREQUENCY STANDARD
TYPE 2121A

Size
8¾" x 19" panel
Weight, 25 lbs.
Output: 115V
60 cycles, 10 Watt
Accuracy:
±.001% from 20° to 30°C
Input, 115V (50 to 400 cycles)

FREQUENCY STANDARD
TYPE 2001-2

Size 3¾" x 4½" x 6" H., Wght. 26 oz.

Frequencies: 200 to 3000 cycles
Accuracy: ±.001% at 20° to 30°C
Output: 5V. at 250,000 ohms
Input: Heater voltage, 6.3 - 12 - 28
B voltage, 100 to 300 V., at 5 to 10 ma.

FREQUENCY STANDARD
TYPE 2111C

Size, with cover
10" x 17" x 9" H.
Panel model
10" x 19" x 8¾" H.
Weight, 25 lbs.
Frequencies: 50 to 1000 cycles
Accuracy: (±.002% at 15° to 35°C)
Output: 115V, 75W. Input: 115V, 50 to 75 cycles.

ACCESSORY UNITS
for TYPE 2001-2

L—For low frequencies multi-vibrator type, 40-200 cy.
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CIRCLE 10 ON READER SERVICE CARD

ELECTRONICS NEWSLETTER

Portable Fuel Cell Power Supply For Field Radar To Be Delivered

Portable fuel cell power supply that can be mass-produced and offered to the military as an off-the-shelf item is the aim of a program disclosed this week by GE's Aircraft Accessory Turbine department. Next month GE is scheduled to deliver the first of 10 units developed for the Electronics division of Navy's BuShips and the Radar division of Army Signal Corps.

The 22 by 15 by 14-in units, which will supply power for a Marine and Army portable field radar, produce 200 watts of 24-v d-c for 14 hours.

GE says the 30-lb power pack, which is designed to operate at full load for a minimum of 2,000 hours without maintenance, will take the place of a 55-lb engine operator or 80 lb of secondary batteries.

The company says silent operation for a week requires only 72 lb of fuel compared to a half ton of freshly charged batteries. Fuel cells have been operating continuously for more than a year, says GE.

Power pack uses 30 ion-membrane fuel cells, each an 11-in sq. assembly about ¼-in thick, which consume only oxygen from the air and hydrogen produced by the decomposition of a metal hydride "fuel." The cells have no moving parts, use a solid electrolyte and operate at negligible internal pressure and temperature.

Aviation Agency Gets Five More Megacycles for Traffic Control

The Federal Aviation Agency reports that five additional megacycles of radio frequencies have been allocated for its use, adding 100 channels to the air traffic control system.

New frequencies will mean a rejuggling of station frequencies, with more than 300 reassignments to become effective July 7 and another 300 later in July and in August and September. Frequencies to be added: 132.025 through 135.0 Mc, primarily for communications with transports of the larger airlines flying at the middle and upper altitudes, using new 50-Kc-separation gear; 126.825 Mc, mainly for the airlines and the limited number of private and executive type aircraft equipped with receivers ranging above 127 Mc.

FAA said that not all aircraft will be able to use the additional megacycles due to limitations of radio equipment aboard many planes, both in tuning above 127 Mc and in selectivity.

Solid-State Character Generator For Data System Use Is Reported

Solid-state 2-cu ft device which electronically generates numbers, characters and symbols, with circuitry taking the place of metal type fonts and graphic originals, has been developed by CBS Laboratories, Stamford, Conn. Output appears as brightly displayed words, numbers and pictures on a cathode ray tube.

The character generator, called VIDIAC (for Visual Information Display And Control), will first be used in a new Thompson Ramo Wooldridge military data processing system.

Unit is a word-oriented, wired-program type of memory with non-critical ferrite switch cores for character storage. High-speed parallel-to-serial converter achieves very high video signal frequencies from relatively slow speed cores, says the company.

Display speed of the unit is flexible, depending on the picture quality and speed requirements of the system in which it is used, says CBS Labs. However, in a general purpose display system, the company says, 300 different characters of typewriter quality could be used at writing speeds up to 25,000 characters per second. In this case, the firm says, character resolutions would exceed 280 television picture elements.

Electronics Export Trade Push: How One Company Approaches It

With the U. S. stepping up its export trade program, many electronics companies are looking hard at foreign trade and exploring new approaches. One move, announced last week by Motorola, Inc., involves two steps designed to beef up the company's foreign business this year by 20 percent over its 1959 mark of $15 million. New approach is being taken to export through newly-organized Motorola Overseas Corp., which will handle direct sales to distributors in 60 foreign countries. Formerly, the company dealt with independent export firms which handled non-competing but allied products of other companies. Meanwhile, Swiss-based Motorola International, S.A., is expanding its overseas manufacturing operations by negotiating deals for joint manufacturing ventures.

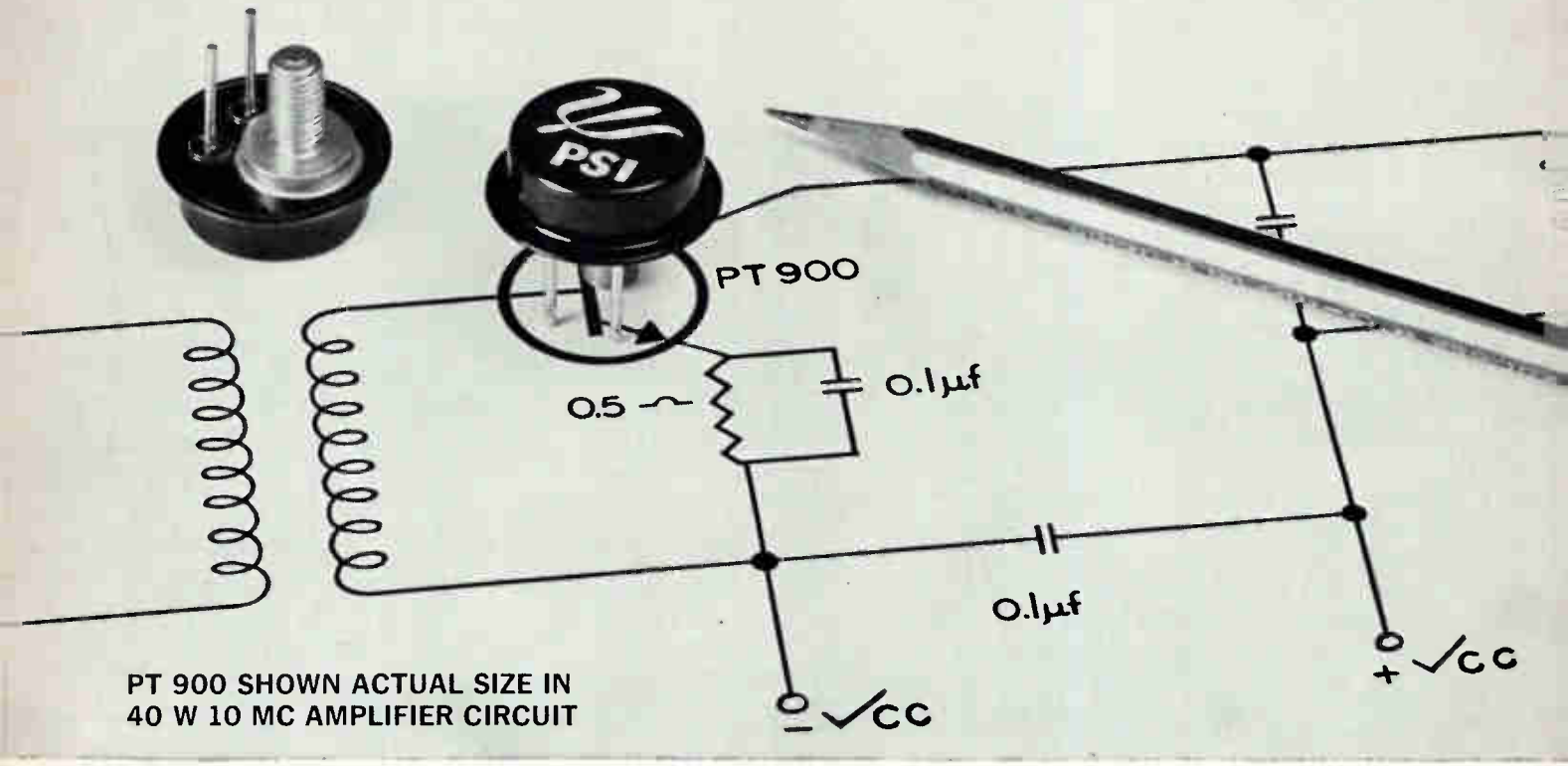
Japanese Trade Fair Features Consumer Items for U. S. Market

Four-track stereo tape recorder, which can be used for monaural or two-track recording, will be marketed in Japan for about $140 and sold in the U. S. under the name of Superscope. This and other entertainment electronic products, many designed to sell in the American market, are at the annual Japan Industrial Fair in Osaka.

Standard Radio Co., Tokyo, is showing a new miniature 7-transistor, 45-rpm radio-phonograph which it claims is the smallest in the world. Yokohama price is $36. At least six firms are showing miniature transistorized tape recorders. One $40 set uses seven transistors, operates on a-c and will record up to 40 hours on four flashlight batteries.

Available for evaluation...

the only silicon power transistors offering 100 w at 5 mc...less than 100 nanosecond* high current switching!



PT 900 SHOWN ACTUAL SIZE IN
40 W 10 MC AMPLIFIER CIRCUIT

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TYPES PT 900, PT 901

- 50 mc alpha cut off frequency
- 125 w at 25°C. case temp.
- 10 amp continuous at 25°C.
- 0.2 ohm saturation resistance

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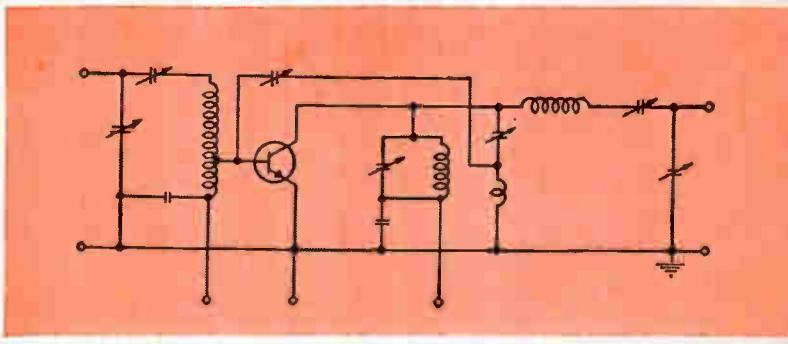
NPN VHF Power Amplifiers and Oscillators

Types 2N1505, 2N1506

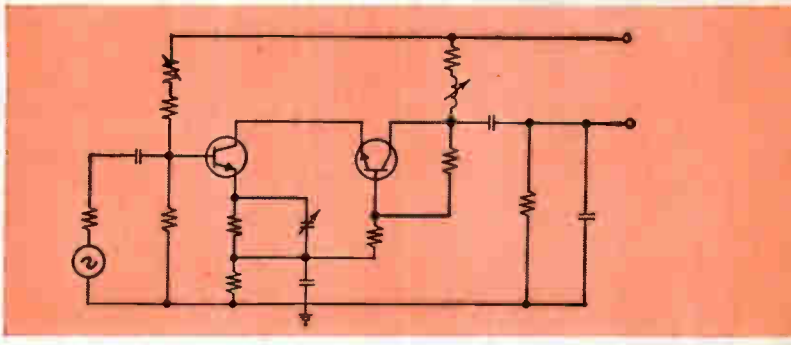
Specially designed for high frequency, high power operation at low supply voltages, these transistors give typical power outputs of 1 w at 70 mc and 500 mw at 200 mc. Highly efficient high frequency operation is assured by combining either type with a Hi Q Varicap frequency multiplier. *At right: Typical amplifier circuit for 200 mc power gain measurement.*



NPN VHF, High Voltage, High Power Amplifiers... Switches... Oscillators

Types 2N1335 thru 2N1341

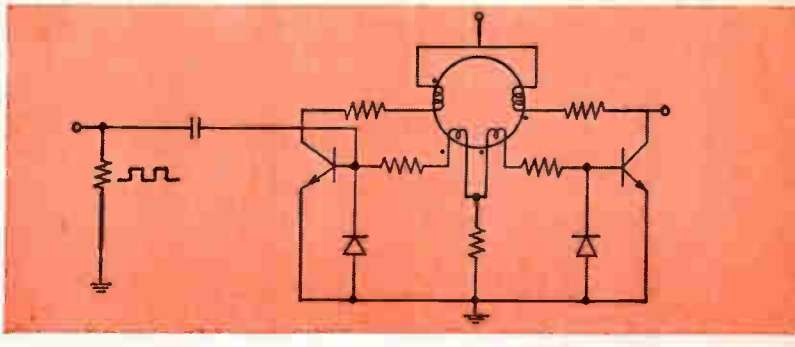
A unique combination of high voltage, high frequency and high power makes it possible for the first time to design video amplifiers with output voltages of 140 v and bandwidth of 10 mc. Other applications are power amplifiers, power oscillators and high voltage switches. *At right: Typical high voltage video amplifier.*



NPN High Speed, High Current Core Drivers and General Purpose Switches

Types 2N1409, 2N1410

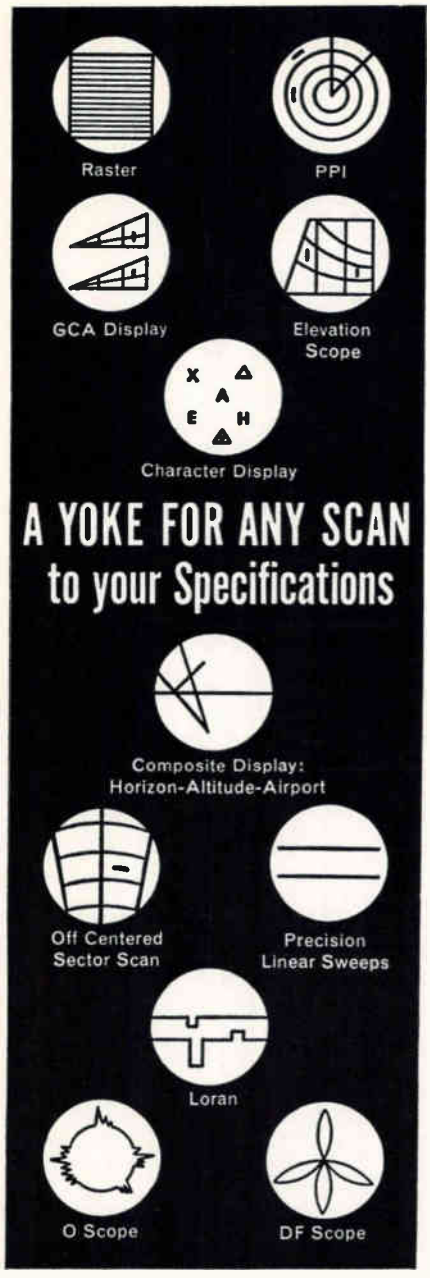
Fastest switching time at high current ratings combined with extremely low saturation resistance make these units ideally suited for transistor-ferrite circuitry and many other computer applications. *At right: Transistor-core flip flop.*



TYPES 2N696 and 2N697 *are also immediately available from PSI.*

PSI

Write today for complete information and specifications on PSI silicon transistors.
PSI regional or district sales offices are located in all major electronic centers. Consult your yellow pages.



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WASHINGTON OUTLOOK

A DRIVE IS BUILDING UP here to consolidate the military buying of many types of electronic end-items, components, spares and replacement parts. This would mean setting up one central defense agency to buy for all military branches that use electronic gear. Moreover it could portend unifying other activities of supply management, such as determining requirements, warehousing and distributing.

Buying of electron tubes has already been consolidated. Gentile Air Force Depot, Dayton, O., is the sole military purchaser.

The new pressure to consolidate buying comes first from a General Accounting Office survey of radio and radar procurement. GAO found many cases in which some defense agencies were buying or overhauling equipment which other agencies were selling as surplus. GAO has just sent a report to the Pentagon, asking for comment on its recommendation that single supply managers to be set up for several categories of electronic equipment as a way to eliminate such supply blunders.

A second pressure for unified electronic buying stems from an extensive inquiry into the electronic supply program now under way. The inquiry is being run by the Armed Forces Supply Support Center, an interservice agency set up by the Pentagon two years ago to push consolidation of supply management.

The agency surveys specific items to determine whether unified supply management is feasible in each case. The agency takes into account volume of buying, whether commercial items make up a significant part of the volume and the peculiarities of service requirements.

There is much opposition within the Pentagon, notably in the Navy, to setting up single managers or single buyers. One argument is that requirements differ so much from service to service for certain kinds of material that it would be impractical to have a central agency do all the buying.

For instance, a Navy fighter plane and an Air Force fighter plane have such different environmental requirements that design specifications for similar fighter-plane equipment differ substantially.

This, say the Navy opponents to consolidated buying, would lead to operational headaches if an agency unresponsive to the Navy's peculiar requirements were to be entrusted with buying Navy equipment.

THE RCA-NBC CONTRACTS for acquiring radio-television stations in Boston and San Francisco are under study by Justice Dept. anti-trusters. Under a consent decree signed last September with RCA-NBC, the government may ask a Federal Court to decide before any such deals take place whether any coercion has been exerted through use of NBC's network affiliation power and whether any conduct has been engaged in that unreasonably restrains trade.

Under the deals now being examined, NBC would exchange its radio and television stations in Philadelphia for Boston stations, now owned by RKO General, Inc.; RCA would also sell its Washington, D.C., stations to RKO for $11.5 million. The other contract calls for RCA-NBC to acquire independent station KTVU in San Francisco.

Antitrusters are in the new arrangements because of the consent signed last year. The decree ended a Justice Dept. suit charging RCA and NBC with a conspiracy to obtain television stations in five of the nation's top markets—and specifically attacked the exchange by which RCA-NBC acquired Westinghouse Broadcasting Co.'s Philadelphia stations. To settle the suit—after the Supreme Court had upheld the Justice Dept.'s right to intervene, despite Federal Communications Commission approval of the deal—RCA-NBC agreed to dispose of the Philadelphia stations.

Minuteman

...Another major USAF weapon system in development

Minuteman, a three-stage solid propellant intercontinental missile, is moving through its early development and test programs on or ahead of the time schedule originally set for it. This advanced ICBM, the fourth in a family of four Air Force ballistic missiles, is designed to be fired automatically from underground silos or mobile launchers. Minuteman will be constantly at "ready" giving America an almost instantaneous retaliatory capability for defense • The Minuteman concept developed early in 1957 when Space Technology Laboratories conducted a study of the characteristics of second-generation missiles to satisfy the requirements of the Air Force Ballistic Missile Division. STL provides over-all systems engineering and technical direction for Minuteman as it has for the Atlas, Titan, and Thor programs. The application of compatible components, systems, and experience developed through the years is bringing Minuteman closer to the threshold of operational capability • Among the industrial organizations developing Minuteman are such major contractors as: Boeing Airplane Company for assembly and test; Thiokol Chemical Corp., Aerojet General Corp., and Hercules Powder Company for engines; Autonetics, a Divisionof North American Aviation for guidance; and Avco Corp. for re-entry vehicle.

To assure continued growth in these and related space programs, STL is already projecting state-of-the-art advances five and ten years ahead. Outstanding scientists and engineers with unusual capabilities in propulsion, electronics, thermodynamics, aerodynamics, structures, astrophysics, computer technology, and other related fields and disciplines are invited to investigate positions at STL. Please send resumes to:

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Service to scientific exploration has been performed by the Guided Missiles Range Division of Pan American World Airways since 1953.

Pan American has prime responsibility for the engineering, operation and maintenance of the Air Force Missile Test Center's 5,000 mile Atlantic Missile Range beginning at Cape Canaveral.

Now, having been awarded a prime contract by the Army Signal Corps, Pan Am has the new responsibility for engineering and operating an Electronic Environmental Test Facility near Fort Huachuca, Arizona. Fort Huachuca will be the brain center of the Test Facility, where information gathered in the field will be analyzed in the Army's automatic data processing facilities, among the most modern and complete in the world.

Additionally, Pan Am will engineer, install, operate and maintain facilities for a test range for Army drone aircraft, with drone flights to be monitored by radars, telemetry, and optical equipments.

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- Optics

To investigate career opportunities with Pan Am at the Atlantic Missile Range, contact J. B. Appledorn, Dept. H-1, Guided Missiles Range Division, Patrick AFB, Florida; or at Fort Huachuca, contact C. A. Hodgins, Dept. H-1, 1535 East Broadway, Tucson, Arizona.

PAN AM

GUIDED MISSILES RANGE DIVISION

PATRICK AIR FORCE BASE, FLORIDA

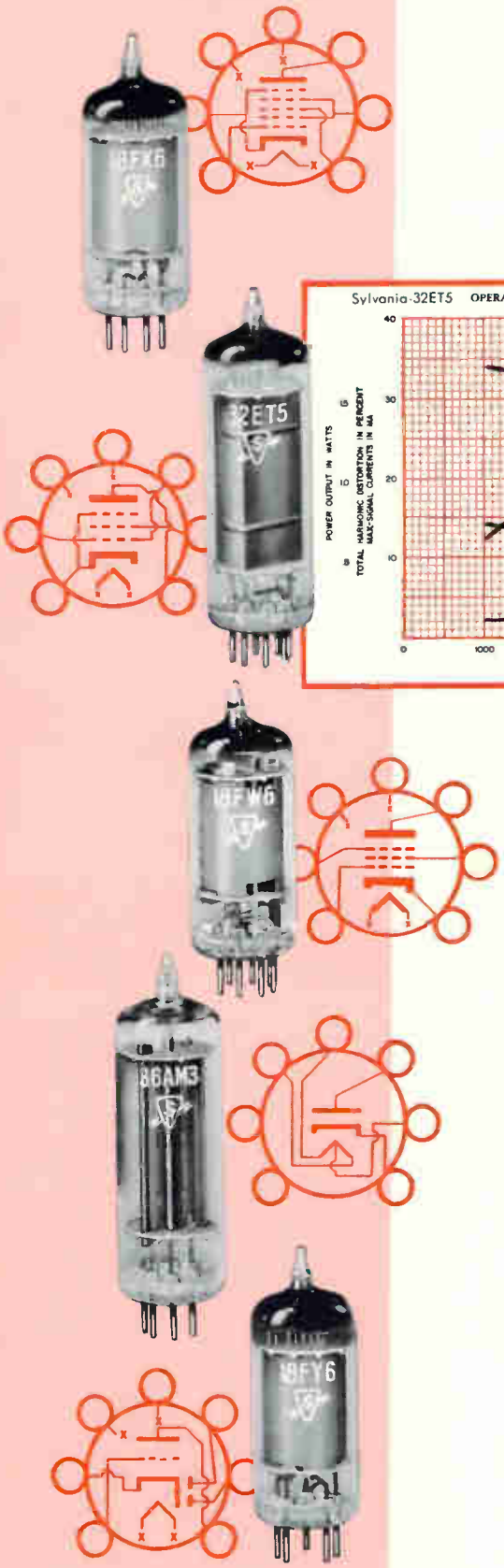
CIRCLE 17 ON READER SERVICE CARD→

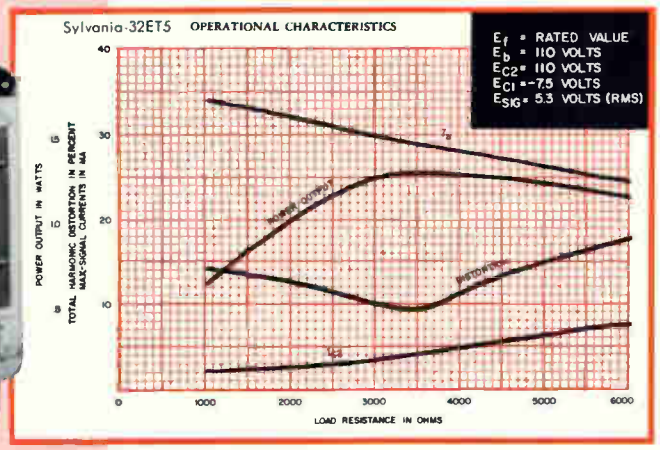
Electron Tube News ...from SYLVANIA

Cool operation sparks home-radio sales when you design around

SYLVANIA 100-mA ALL-AMERICAN FIVE

Originated by Sylvania—the 100-mA All-American Five requires ⅓ less heater power, opens new design possibilities and offers significant merchandising opportunities. Now, tube layout is comparatively unrestricted, cabinet styling is more flexible. Cost reductions in cabinetry, circuitry and components are within easy grasp. Tube reliability is enhanced. Printed circuit techniques can be used advantageously. Here, then, are important advances in home radio design—made possible by the Sylvania 100-mA All-American Five.





Named to the All-American Five are: 18FW6, semi-remote cut-off pentode; 18FX6, pentagrid converter; 18FY6 high mu triode-double diode; 32ET5, beam power pentode; and the 36AM3, half-wave rectifier—a tube complement with proven field experience.

Lower ambient temperatures increase design flexibility and offer substantial economies. Radio cabinets utilizing this carefully mated complement show temperature reductions of 20-25%. The area of the power output tube shows an even greater temperature decrease—as much as 30%. As a result, less expensive plastics can be used. Vertical chassis can be designed without special heat shielding. Placement of the power output tube is no longer critical because of heat—wide, outside "berths" are unnecessary—designs can be compact. Printed circuit boards may be used without deterioration in set life and performance caused by high ambient temperatures.

Tube reliability is increased. Sylvania heater design of the 100-mA line provides for more balanced distribution of the heater voltages in the heater string. Surge voltages across individual tubes are minimized.

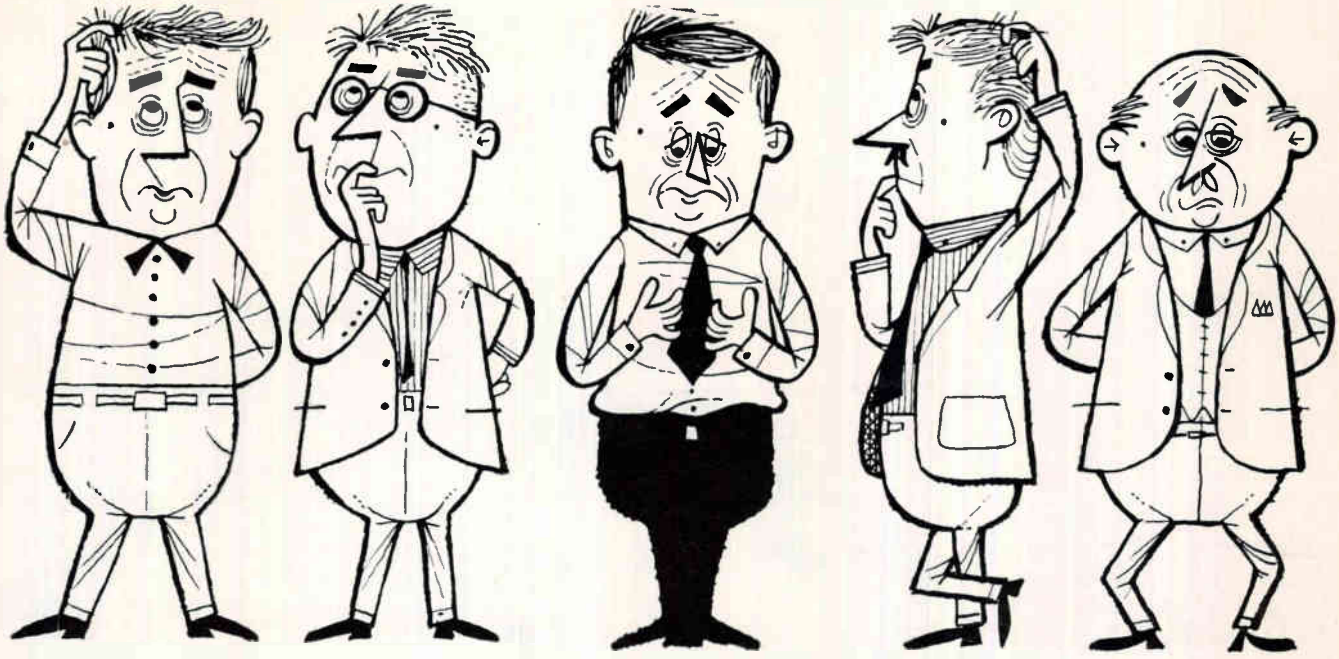
Sylvania 100-mA All-American Five can be used in existing 150-mA designs with a minimum of redesign time. The 100-mA tube complement presents many advantages that can be directly translated into consumer benefits and increased home radio sales.

New developments in the 100-mA line. Sylvania is developing further tube complements that will incorporate the inherent advantages of a cooler-operating 100-mA line. These include a four tube line for home radio sets, a complement for FM radio receivers, and two new types that hold exciting possibilities for quantity-produced Hi-Fi.

Your local Sylvania Sales Engineer will gladly give you the whole story on the Sylvania 100-mA line. Call him or write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. 195, 1740 Broadway, New York 19, New York.

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**



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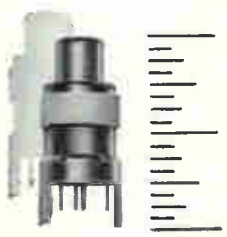
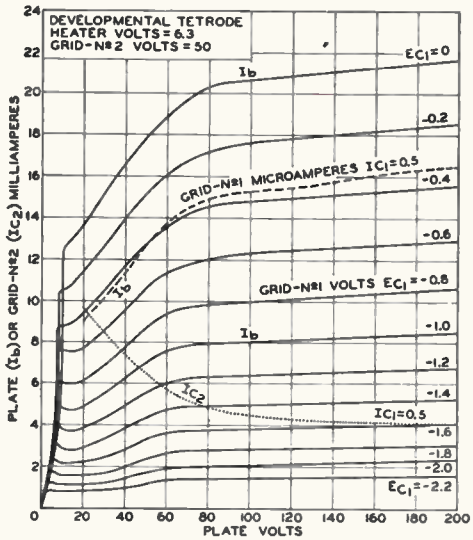
RCA

TAKES ANOTHER BOLD STEP INTO THE FUTURE OF ELECTRON TUBES



THE DEVELOPMENTAL nuvistor TETRODE!

Following RCA's announcement of the nuvistor concept and subsequent announcement of the first commercial nuvistor type—the 7586 general-purpose industrial triode—comes news that a nuvistor tetrode is now available to equipment manufacturers on a limited sampling basis. This developmental small-signal tetrode—RCA Dev. No. A-2654—promises to extend the horizons of the nuvistor concept far into the entertainment, industrial, and military electronic fields.



Incorporating all the advantages of nuvistor design, this small-signal general-purpose tetrode is Step 2 of a daring electron-tube-improvement program by RCA. Our developmental work indicates that the nuvistor tetrode will establish new high standards of tube performance for the electronics industry.

Dynamic in Concept

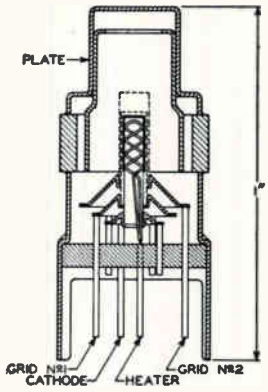
RCA had as its objective in the design of the nuvistor tetrode superior performance in many amplifier applications, particularly at the higher radio frequencies. The new tube is ⅓ the size of conventional rf-amplifier tetrodes, and consumes approximately ½ the heater power.

The nuvistor method of construction eliminates or minimizes many of the known causes of tube failure. Use of only ceramics and strong metals provides a structure of extreme ruggedness. Brazing of all connections in a hydrogen atmosphere at extremely high temperatures eliminates structural strain and element distortion. Exhaust and seal-off at very high temperatures minimizes gases and impurities from metal parts.

Opening a New Era: "Nuvistorization"

The nuvistor tetrode shows great promise for mixer, oscillator-mixer, if-amplifier and low-level video-amplifier service.

Application tests in laboratory circuits show that the nuvistor tetrode will give top performance in industrial and military equipment. Outstanding performance has been obtained in the mixer and if-amplifier stages of such equipment.



Nuvistor Developmental Small Signal Tetrode A-2654

TYPICAL DATA

ELECTRICAL:		
Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3±10%	volts
Current	0.165	amp
DIRECT INTERELECTRODE CAPACITANCES (approx.):		
Grid No. 1 to plate	0.01	μμf
Grid No. 1 to cathode heater, grid No. 2, metal shell and internal shield	6.0	μμf
Plate to cathode, heater, grid No. 2, metal shell and internal shield	1.4	μμf
Heater to cathode	1.4	μμf
CHARACTERISTICS, CLASS A_1 AMPLIFIER:		
Plate Supply Voltage	125	volts
Grid No. 2 (Screen-Grid) Voltage	50	volts
Cathode Resistor	68	ohms
Plate Resistance (approx.)	0.2	megohm
Transconductance	10,400	μmhos
Plate Current	9.6	ma
Grid—No. 2 Current	2.9	ma
Grid—No. 1 Voltage (approx.) for plate current of 10 μa	—5	volts
MAXIMUM RATINGS, ABSOLUTE-MAXIMUM VALUES:		
PLATE VOLTAGE	250 max.	volts
GRID—NO. 2 VOLTAGE	110 max.	volts
GRID—NO. 1 VOLTAGE:		
Negative bias value	55 max.	volts
Positive bias value	2 max.	volts
GRID—NO. 2 INPUT	0.2 max.	watt
PLATE DISSIPATION	2.2 max.	watts
GRID—NO. 1 CURRENT	2 max.	ma
CATHODE CURRENT	20 max.	ma
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	100 max.	volts
Heater positive with respect to cathode	100 max.	volts
MAXIMUM CIRCUIT VALUES:		
Grid—No. 1 Circuit Resistance:		
For cathode-bias operation	1.0 max.	megohm

DESIGN ENGINEERS: You will want to evaluate this tetrode for possible use in your equipment designs. For more details on nuvistors and information on how you may obtain samples of the tetrode call your RCA Field Representative at the Field Office nearest you.

Among other nuvistor types in development at RCA is a beam power tube for military, industrial, and entertainment applications. Half the size of its present-day counterpart, the nuvistor beam power tube will have a maximum plate-dissipation rating of 30 watts, and an output of several watts with less than 75 volts on the plate.

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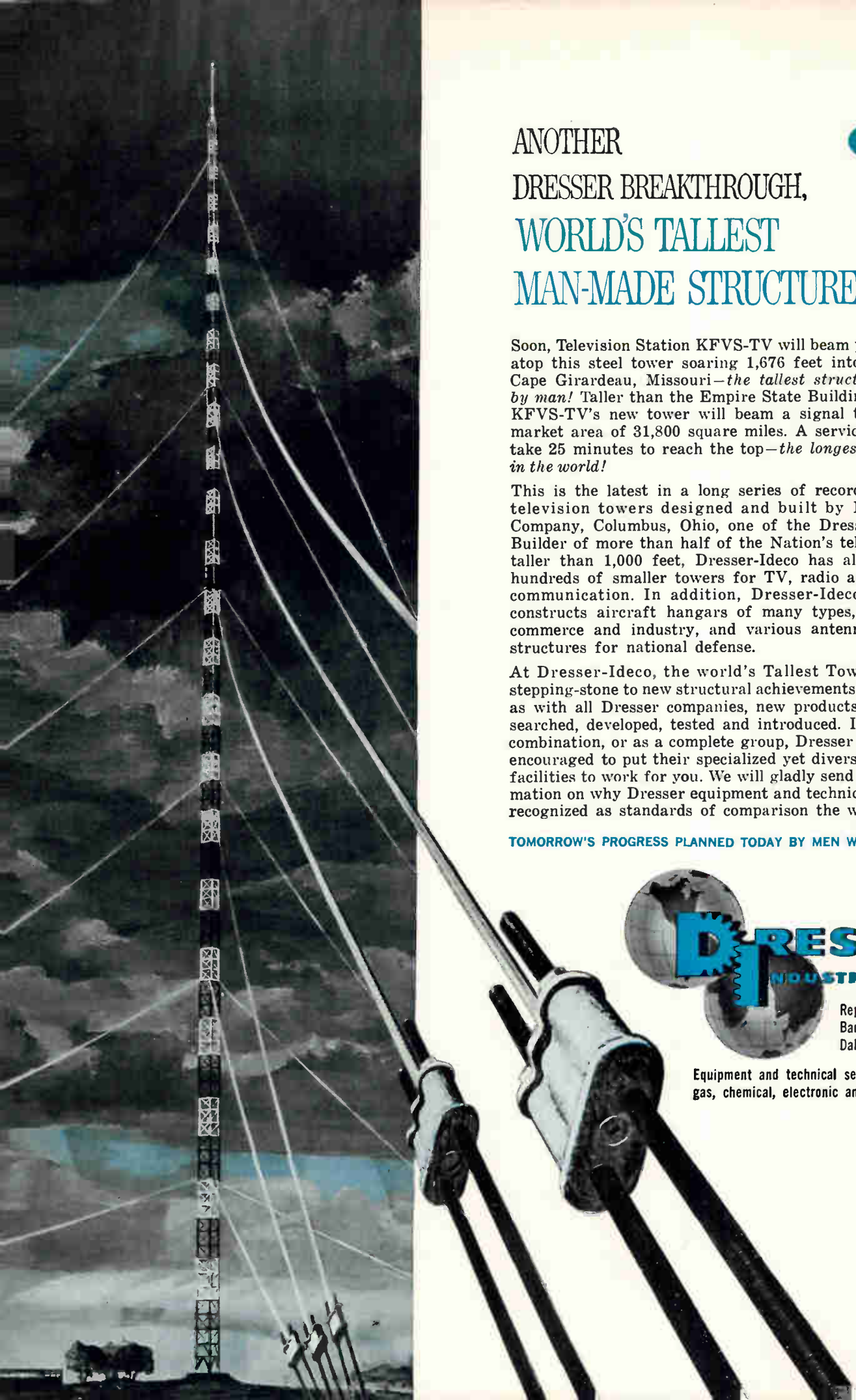

DRESSER IDECO

ANOTHER DRESSER BREAKTHROUGH, WORLD'S TALLEST MAN-MADE STRUCTURE

Soon, Television Station KFVS-TV will beam programs from atop this steel tower soaring 1,676 feet into the sky near Cape Girardeau, Missouri—*the tallest structure ever built by man!* Taller than the Empire State Building by 204 feet, KFVS-TV's new tower will beam a signal to an enlarged market area of 31,800 square miles. A service elevator will take 25 minutes to reach the top—*the longest elevator ride in the world!*

This is the latest in a long series of record-breaking tall television towers designed and built by Dresser-Ideco Company, Columbus, Ohio, one of the Dresser Industries. Builder of more than half of the Nation's television towers taller than 1,000 feet, Dresser-Ideco has also constructed hundreds of smaller towers for TV, radio and micro-wave communication. In addition, Dresser-Ideco designs and constructs aircraft hangars of many types, buildings for commerce and industry, and various antenna towers and structures for national defense.

At Dresser-Ideco, the world's Tallest Tower is another stepping-stone to new structural achievements to come. Here, as with all Dresser companies, new products are being researched, developed, tested and introduced. Individually, in combination, or as a complete group, Dresser companies are encouraged to put their specialized yet diversified skills and facilities to work for you. We will gladly send you full information on why Dresser equipment and technical services are recognized as standards of comparison the world over.

TOMORROW'S PROGRESS PLANNED TODAY BY MEN WITH IMAGINATION

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Dallas 21, Texas

Equipment and technical services for the oil, gas, chemical, electronic and other industries

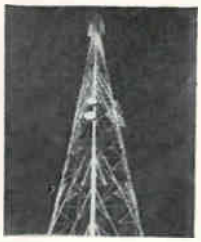
From 100 to 2000 feet... Dresser-Ideco builds any type of antenna tower

No matter what the antenna support problem, Dresser-Ideco can design and build a tower to do the job. Below are some of the many hundreds of Dresser-Ideco towers serving the nation's communications industries and military electronics facilities.

Surveillance radar towers on the DEW line. Designed for hurricane force winds and heavy ice and snow loads. These are some of more than 1000 radar towers built by Dresser-Ideco for the nation's aircraft warning system.

Multiple antenna tower. This big 729' tower in Baltimore supports three television antennas on a 105' wide platform at the top.

Antenna test range tower for height finding radar.



Microwave antenna tower typical of those used in systems built for the Ohio Turnpike and the Illinois Toll Road.

Dresser-Ideco offers a *complete* tower service. To benefit from Dresser-Ideco's design experience and proved ability to deliver quality structures at minimum cost, write or phone Dresser-Ideco Company, 875 Michigan Avenue, Columbus 15, Ohio. Branch: 8909 So. Vermont Avenue, Los Angeles 44, California.

DRESSER-IDECO COMPANY

DRESSER IDECO®

IBM Quarter Sales $339 Million

INTERNATIONAL BUSINESS MACHINES reports net income for the three months ended Mar. 31, 1960, was $35,178,509 after U. S. estimated federal income taxes. This income is equivalent to $1.92 a share on the 18,280,759 shares outstanding at the close of the period. In the corresponding period of 1959, the net figure was $28,964,684 or $1.59 a share on 18,231,464 shares. The net income figure this year before taxes was $72,028,509, compared with $59,297,684 in 1959. The gross income for the 1960 period from Jan. 1 to Mar. 31 from sales, service and rentals in the U. S. amounted to $339,852,677, compared with $295,631,278 in the corresponding 1959 period.

Automation Industries, Manhattan Beach, Calif., announces sales of $3,777,668 for the twelve months ended Dec. 31, 1959. This income includes that of **Jobbins Electronics, Inc., Ultrasonic Testing and Research** and **Industrial Leasing**—all wholly-owned subsidiaries. This sales figure represents a 45-percent rise over the 12-month period ended Apr. 30, 1959, according to C. D. Denny, president. Earnings remained substantially constant at 9 cents a share for both periods.

Compudyne Corp., Hatboro, Pa., manufacturer of computer-operated electrohydraulic control systems, announces signing of an acquisition agreement with **American Measuring and Control Inc.,** Waltham, Mass. This is the second acquisition by Compudyne. Terms of the merger are an exchange of 80,000 shares of Compudyne stock for all the shares of AM&C.

Directors of Avnet Electronics, Westbury, L. I., report completion of voting on a recommendation for a two-to-one stock split. A stockholders' meeting slated for May 10 will be asked to authorize an increase in shares from the one million now authorized to three million and a reduction in par value from the present figure of ten cents to five cents to allow for the planned split. Avnet assembles and distributes semiconductors, connectors and other components to the electronics industry. The company maintains plants in Westbury, Los Angeles and Sunnyvale, Calif., and Chicago.

Energy Fund, Inc., announces present total assets of $10,103,597 at the close of business on the 4th of this month. D. C. Samuel, president, says in less than 4½ years the fund has grown from about $950,000 to the current amount. Per-share net asset value during this period has risen 95 percent from $12 to $23.39, including capital gain distribution of $2.45. Currently, the fund's largest holdings are in Ampex, Texas Instruments, Litton Industries and Philips' Lamp.

Minnesota Mining & Manufacturing reports purchase of **Mutual Broadcasting System** for an undisclosed sum. This is the third ownership MBS has had since 1957. R. F. Hurleigh will remain president.

25 MOST ACTIVE STOCKS

WEEK ENDING APRIL 15

	SHARES (IN 100's)	HIGH	LOW	CLOSE
RCA	1,335	75¼	70⅞	75¼
DuMont Labs	1,134	10	8¾	9⅝
Int'l Tel & Tel	1,079	40½	38¾	40
Ampex	783	36	34⅛	34⅝
Philco Corp	635	35⅛	32¼	33⅞
Sperry Rand	531	22	21¼	21½
Westinghouse	469	54½	52⅛	54½
Gen Elec	457	93⅞	91⅞	93⅞
Gen Tel & Elec	430	84½	81⅛	84¼
Siegler Corp	429	38¼	35⅜	38
Sterling Precis	423	2¾	2½	2⅝
Texas Inst	374	219¼	209	215½
Litton Ind	343	79½	75⅛	77¼
Heli Coil	323	44½	31⅝	44¼
Fairchild Camera	317	171	146¾	166
Avco	317	13½	13	13
Varian Assoc	317	50	48⅛	48⅝
Victoreen Inst	302	12⅛	10⅝	12
Univ Controls	291	15⅜	13¾	13¾
Magnavox	240	45	40⅞	45
Amphenol Borg	240	45¼	42½	45¼
Reeves Sndcrft	236	8¼	7⅜	7⅞
Electron Corp	213	14⅜	12¾	14⅜
Dynamics Corp Amer	212	11⅜	10½	10¾
Raytheon	209	44¼	41¾	43⅛

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

When it comes to SEMICONDUCTORS

For the most **complete** line of solid state devices...

● Westinghouse has perfected the widest selection of rectifiers, transistors, and special semiconductor devices available in the industry. In Silicon power rectifiers, Westinghouse is the acknowledged leader in the field.

For the most **dependable** semiconductor devices...

● Every Westinghouse semiconductor device has been carefully designed, manufactured, and thoroughly tested to assure long life, high reliability, and excellent stability.

For **true voltage ratings** in silicon power transistors...

● Only Westinghouse 2N1015 and 2N1016 silicon power transistors offer *true* voltage ratings, guaranteed by 100% power testing—means they may be operated continuously at the V_{CE} listed provided the power dissipation of the transistor is not exceeded. Other conventional power transistors derate the V_{CE} voltage under comparable conditions.

For **new and unusual ideas** in semiconductors...

● Westinghouse is constantly pioneering in exciting new semiconductor devices. Among the latest: a new 50 ampere "TRINISTOR"* controlled rectifier; new thermoelectric cooling devices; an extremely rapid and sensitive infrared detector.

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Westinghouse Semiconductor Department, Youngwood, Pa.

COME TO WESTINGHOUSE!

SILICON RECTIFIERS

		P. R. V.	Max. DC Current at T°C Resistive Load	Max. One Cycle 60 C.P.S. Surge Full Load	Max. Rev. Peak Current @ Max. Temp. & P.I.V.
LOW POWER RECT.	1N1217 SERIES	50-1000 V.	500 MA @ 110°C. AMB.	15 AMPS.	1.5 MA @ 150°C. JUNCTION
	1N1227 SERIES	50-1000 V.	1.6 A @ 140°C. CASE	15 AMPS.	
MEDIUM POWER RECT.	1N1341 SERIES	50-600 V.	6 A @ 150°C. CASE	160 AMPS.	10 MA @ 190°C. JUNCTION
	1N1199 SERIES	50-600 V.	12 A @ 150°C. CASE	200 AMPS.	
	1N1191 SERIES	50-600 V.	18 A @ 140°C. CASE	220 AMPS.	
	1N1183 SERIES	50-600 V.	35 A @ 140°C. CASE	220 AMPS.	
HIGH POWER RECT.	1N1396 SERIES	50-500 V.	70 A @ 150°C. CASE	1200 AMPS.	30 MA @ 190°C. JUNCTION
	1N1660 SERIES	50-500 V.	160 A @ 125°C. CASE	2000 AMPS.	40 MA @ 190°C. JUNCTION
	1N1670 SERIES	50-500 V.	240 A @ 125°C. CASE	3000 AMPS.	50 MA @ 190°C. JUNCTION
	439 SERIES	50-600 V.	240 A @ 125°C. CASE	3000 AMPS.	

GERMANIUM TRANSISTORS

	Class	Typical Operation			Maximum Ratings			
		I_{CBO} μa	h_{FE}	f mc/s	V_{CE} V	I_C ma	P_C mw	T_J °C
2N59	AUDIO-PNP	10	100	1.2	20	200	180	85
2N60	AUDIO-PNP	10	70	1.1	20	200	180	85
2N403	AUDIO-PNP	10	33	0.85	20	200	180	85
2N614	IF -PNP	3	5	3	20	150	125	85
2N616	IF -PNP	3	20	9	20	150	125	85
2N617	IF -PNP	3	14	7	20	150	125	85

SILICON POWER TRANSISTORS

	Type	h_{fe} or h_{FE}	$f_{\alpha mc}$	V_{CEX} Volts	I_C Amps	T_J °C
2N1015 SERIES—2 AMP.	NPN	10 (V_{CE}=4 V I_C=2 A)	ALPHA CUTOFF .300	30-200	7.5a	150
2N1016 SERIES—5 AMP.	NPN	10 (V_{CE}=4 V I_C=5 A)	ALPHA CUTOFF .300	30-200	7.5a	150

50 AMPERE SILICON "TRINISTOR"* CONTROLLED RECTIFIER

Breakover Voltage @ 125°C T_J	Reverse Blocking Voltage @ 125°C T_J	Turn-on Time	Turn-off Time
TYPICAL			
50-200 VOLTS	50-200 VOLTS	1.0 μ SEC.	15-20 μ SEC.

RECTIFIER ASSEMBLIES

Standard rectifier assemblies are available in all types of circuit configurations, and are designed for either forced air or natural convection cooling with a wide range of ratings. Nickel-plated copper plates and other materials used in these assemblies have been chosen to insure satisfactory performance in corrosive atmospheres and high ambient temperatures.

THERMOELECTRIC COOLING DEVICES

Two types are available in commercial quantities: WX814 (2.5 oz.) and WX816 (3.0 oz.). Both types measure about an inch and a half square and will find immediate application in cooling germanium transistors, infrared detectors, optical systems, mechanical and electric instruments, laboratory and portable medical equipment, and related fields where spot cooling below ambient is necessary.

INFRARED DETECTORS

Type	Noise Equivalent Power (NEP) Watts		Wave-length Response. Microns	Time Constant, μ SEC.	
	TYPICAL	LIMIT		TYPICAL	LIMIT
812	5×10^{-11}	10^{-10} MAX.	1-12	0.1	0.2 MAX.

The types listed are just a small sampling of the complete line which can be supplied in volume quantities for prompt deliveries.

Specify
SPERRY
for
2N327A
2N328A
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SILICON
PNP TRANSISTORS

New low levels of I_{co} baked at 200°C for 200 hours for utmost stability.

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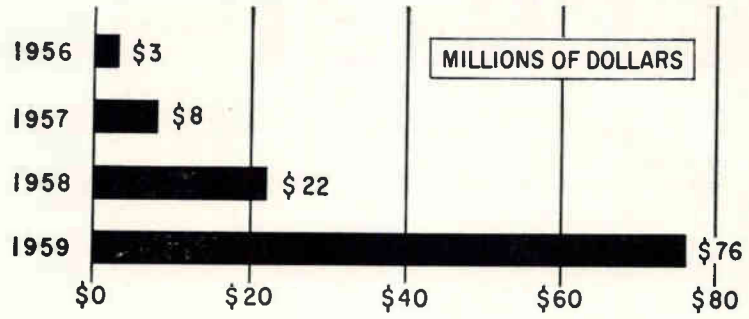
AVNET•2728 N. Mannheim Rd., Melrose Park, Ill.• GL 5-8160

Japan Goods to U. S. Triple in Year



JAPANESE ELECTRONICS EXPORTS TO U. S.

MULTIPLYING nearly three and one-half times in one year, Japanese exports to the United States rose from $22 million in 1958 to $76 million in 1959, reports the Business and Defense Services Administration's Electronics division.

Of the total value of Japan's exports of electronic products in 1959 to all countries—$135.3 million—those to the United States accounted for 56 percent.

Radio sets continue to dominate exports from Japan. Last year six million radios valued at $62 million were sent here, in comparison with two and one-half million sets worth $18 million in 1958.

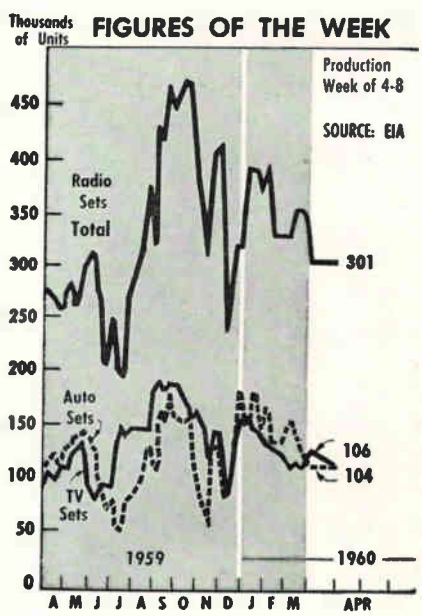
Table lists products exported in 1959 from Japan to U. S.:

	Units	Dollars (Thousands)
Radio receivers, total...	6,052	62,373
Tube type	457	2,552
3 or more transistors..	3,990	57,272
Other	1,605	2,549
Radio-phonos	21	547
Sound recorders	41	1,617
Amplifiers	34	460
Microphones	161	321
Speakers	455	1,155
Condensers	8,925	533
Earphones	2,741	619
Electron tubes, total....	7,911	2,088
Receiving	7,704	2,034
Other	207	54
Transistors	2,393	1,581
Other semiconductors.	597	92
Phono parts	—	824
Other products	—	3,432

Both transistor radios and receiving tubes showed heavy gains. Interim export records reveal rising trend through 1959: radio receivers with three or more transistors —1.2 million units in the first half, 1.3 million in third quarter and 1.5 million in fourth quarter; receiving tubes—2.1 million units in first half, 2.6 million in third quarter and 3.0 million in fourth quarter.

Railroads in 1959 spent $100 million for electrical and electronic supplies—an increase of 16 percent over 1958 levels, according to reports from the Association of American Railroads.

Railroad purchases of electric and electronic products amounted to seven percent of the $1.4 billion total the carriers spent in 1959 for day-to-day supplies of all kinds, the A. A. R. reported. The railroads also spent $818 million for capital equipment and other improvements, including such items as traffic control and communications, it added.



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SILICON PNP TRANSISTORS IN PRODUCTION QUANTITIES

Newly-added to the world's widest line of general-purpose PNP silicon transistors, these popular types are available immediately for your audio, switching and control applications.

More than an additional production source for these devices, you will find Sperry Semiconductor to be the source, with new standards of quality and reliability.

Like all other Sperry transistors, these units feature new low levels of I_{CO} and are baked at 200°C for 200 hours for utmost stability. For immediate delivery on the 2N327A series, contact the nearest Sperry sales office as listed below.

SPERRY STOCKING DISTRIBUTORS:

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Tel. EDgewood 3-5800 TWX: Westbury NY 2617

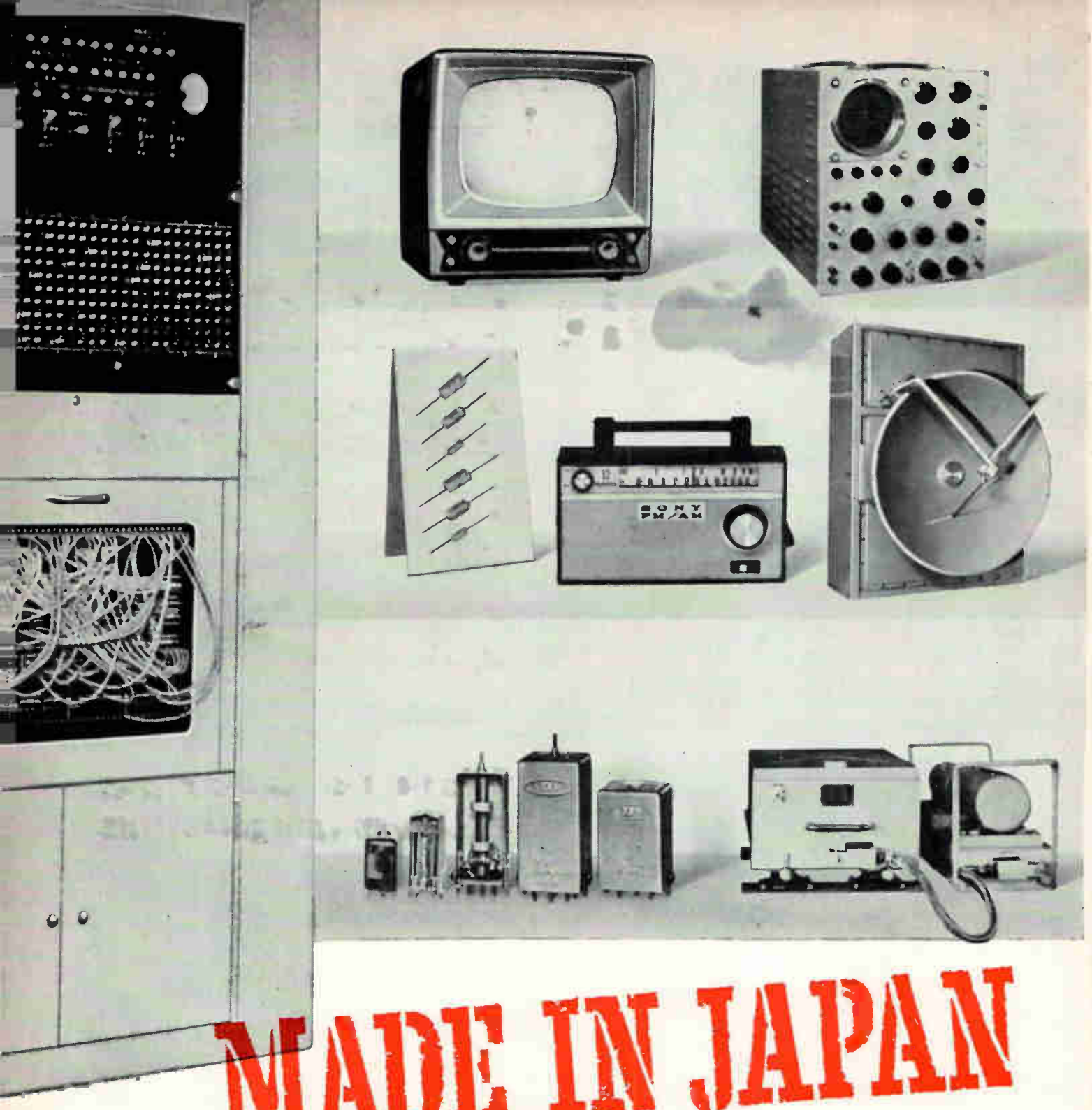
AVNET ELECTRONICS CORPORATION OF MASSACHUSETTS
751 Main Street, Waltham, Massachusetts
Tel. TWinbrook 9-8330

AVNET ELECTRONICS CORPORATION OF OHIO
4180 Kettering Boulevard, Dayton 39, Ohio
Tel. AXminister 8-1458 TWX: DY 410

AVNET ELECTRONICS CORPORATION OF ILLINOIS
2728 No. Mannheim Road, Melrose Park, Illinois
Tel. GLadstone 5-8160 TWX: Franklin Pk. 2187

RADIO PRODUCTS SALES, INC.
1501 South Hill Street, Los Angeles 15, Calif.
Tel. RIchmond 9-7471

SPERRY SEMICONDUCTOR DIVISION, *SPERRY RAND CORPORATION, SOUTH NORWALK, CONNECTICUT*
Call or write: *Sperry Semiconductor, Wilson Avenue, SOUTH NORWALK, Conn., VOlunteer 6-1641; in NEW YORK PLaza 2-0885; 3555 W. Peterson Ave., CHICAGO 45, Ill., KEystone 9-1776; 2200 East Imperial Highway, EL SEGUNDO, Calif., ORegon 8-6226.*



MADE IN JAPAN

THREAT OR OPPORTUNITY?

Top quality Japanese components, radios, electronic computers and many other products have already captured nearly ONE BILLION DOLLARS in U. S. sales... *annually.*

Excellent quality plus low overhead enable Japan to give U. S. design and production men the toughest competition for domestic markets in electronics history! Competition that grows each year.

GET THE FACTS!

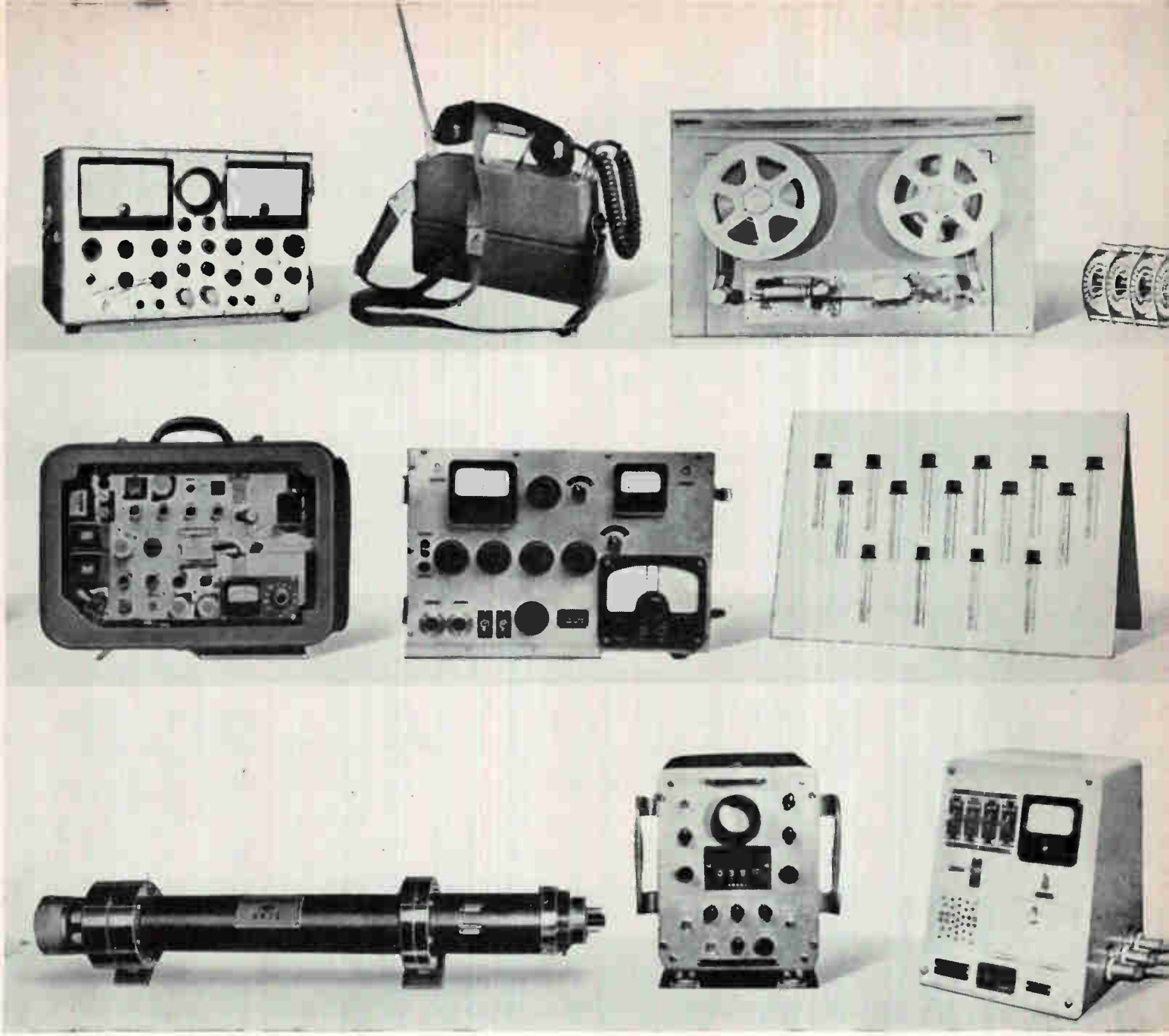
Frank Leary, talented Staff Editor of **electronics**, was sent to Japan for two months to work with the world-wide McGraw-Hill News Bureau in reporting the unvarnished truth about Japan's thriving electronics industry *from the inside* in our May 27 issue.

They tell: Why Japan is concentrating on the U. S. market. Which products. News about Japan's brilliant and original design achievements. The position of Japan's trade officials.

Mature, thoughtful reporting that will help U. S. electronics men to plan *intelligently.*

ELECTRONICS MEN WANT TO KNOW!

Rugged, intelligent competition from Japan can only be successfully met through an objective appraisal of the facts. Only such understanding can lead to constructive



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NOW  for L-Band Small-size, light-weight Tunable Magnetrons power output, high

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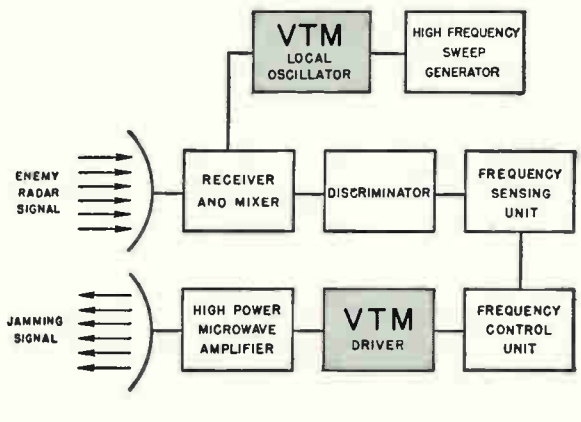
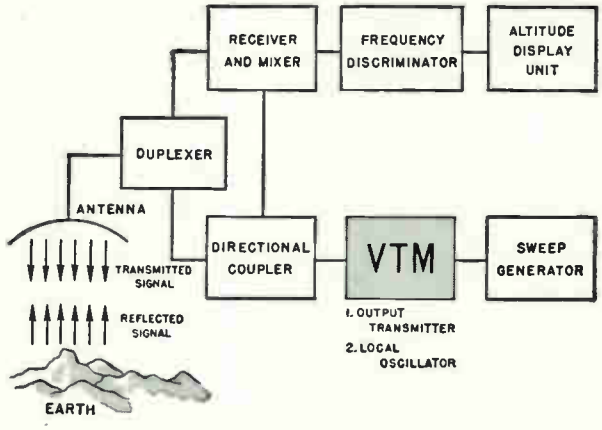


COUNTER-MEASURE SYSTEM



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as well as S-Band.

General Electric Voltage-oscillate with uniform efficiency, linear tuning.

New L-Band VTM . . . 1000-2300 MCS

3 lbs. . . . Shown 1/4 Size

Features which make the new Z-5405 particularly valuable in equipments like sophisticated radar:

Linear Tuning. Permits designing simpler circuitry to use information generated.

High Efficiency. Eliminates need for forced air-cooling. Also reduces battery load, therefore lengthens battery life.

Uniform Power Spectrum. Assures driving traveling wave tubes at optimum conditions.

Smallest in Size, Lightest in Weight, Higher Power Output. Aids in design of compact, light-weight equipments.

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Phone your nearest General Electric Power Tube Department office for samples and application assistance.

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Dayton, Ohio
BAldwin 3-7151

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Los Angeles, Calif.
BRadshaw 2-8566

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Newtonville, Mass.
WOodward 9-9422

•

Washington, D. C.
EXecutive 3-3600

Japanese Tv Sets Arriving This Week

Line includes 8-in all-transistor portable and two large color models.

Importer says prices will be "substantially lower," distribution national

JAPANESE TELEVISION SETS—both color and monochrome—are being unloaded in quantity in U. S. ports for the first time this week. Their cost: "substantially lower." Their sizes: from 8- to 23-in screens. Their distribution: nationwide.

The impact of this long-expected development has not yet made itself felt on American manufacturers and consumers, but makers, users and sellers are watching the situation closely.

Much Assembling Here

Many of the Japanese models are arriving as bare chassis which will be inserted in American cabinets made to Japanese specifications. Others are arriving complete except for picture tubes which will be inserted from stocks purchased from U. S. manufacturers.

These assemblies will be made by the importer, Delmonico International, a division of Thompson-Starrett Co. The work will be done in the company's 90,000-sq-ft assembly plant in Corona, L. I.

It's expected that one of the most closely watched items in the line, from a sales performance viewpoint, will be an 8-in all-transistor portable that operates from batteries or standard line current. This set contains two features that American companies to date have shied away from—small screen and battery power.

Small-screen sets have not sold well to American consumers. More than one company looks back with regret to production runs of small-size sets which fell far below the most pessimistic sales expectations.

One major mid-west manufacturer told ELECTRONICS: "We tried an 8-in set a few years back. The customers turned out to be relatives looking for a different present for the graduate who had everything. We sold that market and there it stopped." The spokesman added that his company has "no immediate plans to try that particular experiment again."

Battery-powered sets have been studied as commercial items for some time. Inevitably, the weak link has been in the battery.

U. S. sets that have been demonstrated usually used rechargeable batteries that operated for about four hours after each charge. The actual life of the batteries often proved to be far less than expected, averaging out at about 100 hours.

Importers of the Japanese sets are not yet giving any information on anticipated lifetimes of the batteries they will use. "We have figures but we want to see how the sets actually perform in the field before we comment," a spokesman tells ELECTRONICS.

Talks with American manufacturers indicate doubt of the sales success of the small sets, both in consumer acceptance and the operating life of the batteries.

Color: Boost or Bust?

Regarding the expected impact of Japanese color sets, U. S. marketing experts seem to be divided into two categories:

One group feels that any set that gets more people watching color will be good for business no matter where it comes from.

The other school of thought is that color sets need a lot of maintenance expenditure, and that if the imported sets don't perform well they will only detract from color's few hard-won gains.

U. S. television production facilities like this Westinghouse assembly line in Metuchen, N. J., are now facing competition from Japanese plants

Price of the set has been cited often as the major stumbling block to mass acceptance of color.

Although Delmonico is holding off on price announcements until the May 16-18 Parts Show in Chicago, the importer says prices of all items in the Japanese line will be "substantially lower".

Presently, a Japanese color-tv set sells for the equivalent of $600 in Japan. It is estimated that only 10 percent of the manufacturing cost of a tv set is represented by labor. The remaining 90 percent is accounted for by materials in the set.

In view of this, U. S. manufacturers say, it's not likely that the Japanese color sets will be priced significantly below U. S. models.

One area where U. S. companies feel the Japanese sets will frighten off customers is in service.

Delmonico points out the sets are being made under an RCA license by Nippon Victor in Tokyo, and should resemble U. S. receivers closely enough to present no difficulty to repair men now servicing American sets.

The imported color models will be mostly 21-in units, although some 23-in sets will also be available.

Many Points of Sale

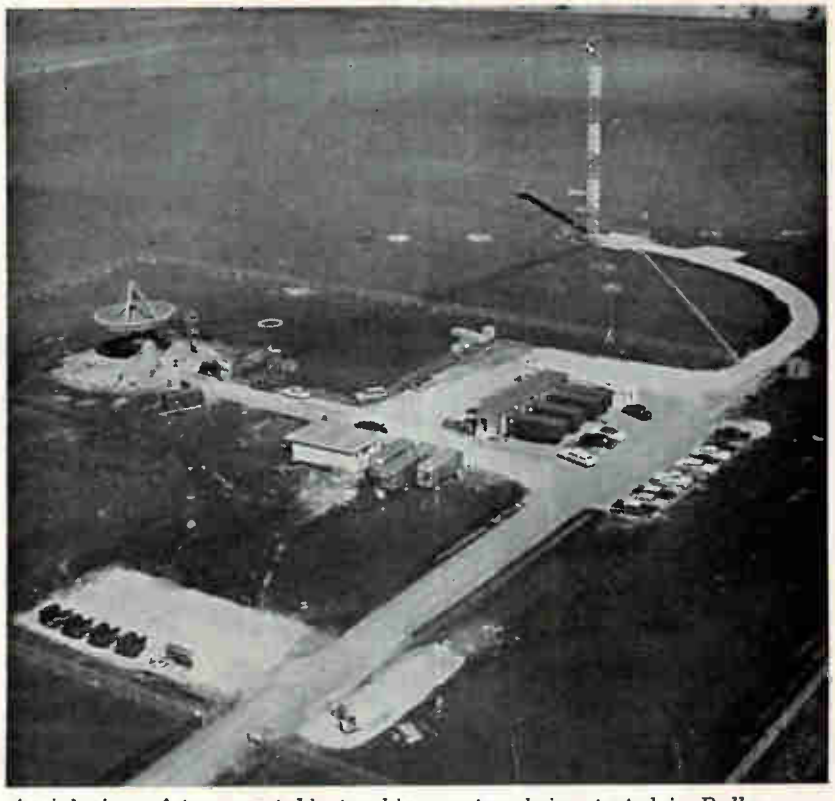
News of the Japanese imports has started sales managers and distributors speculating on what methods of distribution will be used. A commonly asked question: "Will the tv sets be sold in variety stores, supermarkets and other unusual outlets?"

The importer isn't saying just yet, but points out he is importing the sets to sell them and will use whatever channels that do this.

Delmonico has a nationwide distribution net which includes such names as Lynn Stewart in Chicago and Radio Products in Los Angeles.

In addition, almost all the nation's major department stores and discount houses have served as retail outlets for Japanese radios now so familiar on the American scene.

In the matter of servicing, the importer plans to distribute service information to local repairmen through the dealer network. Data will cover the full line of sets. This includes the 8-in transistor battery portable mentioned, a 17-19-21- and 23-in black and white line, and the two color models.



Aerial view of transportable tracking system being tested in Dallas

Space Trackers Need Bigger Antennas

Pioneer V tracking points up importance of large antennas like one at Jodrell Bank

SATELLITE tracking performance is tied to the size of antennas, the National Aeronautics and Space Administration reports.

On April 6, when the 60-ft tracking antenna at South Point, Hawaii, was said to have trouble "reaching" the 94.8-lb Pioneer V interplanetary satellite, the 250-ft Jodrell Bank dish at Manchester, England, had no difficulty turning the probe on and off.

Transmitting Commands

The British antenna, largest in the free world, was transmitting commands to the probe at 500 watts, as Pioneer V whizzed by the 3.5 million-mile mark. At the same time, however, reports NASA, the smaller Hawaii dish had to transmit at up to 16 times the output of the Jodrell Bank dish—8,000 watts—and had to repeat commands several times before getting a response from the probe.

Another development in space probe tracking is reported from Dallas, Tex., where the Alpha Corp., a subsidiary of Collins Radio, is testing a transportable tracking facility under a joint Army Signal Corp—Advance Research Projects Agency (ARPA) program.

Test station (shown in photo above) is part of a $6.25-million contract awarded by the Signal Corps for three stations. The Dallas station will be moved to an as yet unnamed location after testing. It consists of a 40-ft antenna weighing 66,000 lb and a trailer-type data collection facility.

Alpha says the antenna can track from horizon to horizon, explains that telemetered data along with azimuth and elevation information on positioning of the dish is processed in a van. Data is then transmitted to a computing facility, which also receives data from several other tracking stations.

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When designs call for products in the field of electronics, the Guide solves problems *in advance.*

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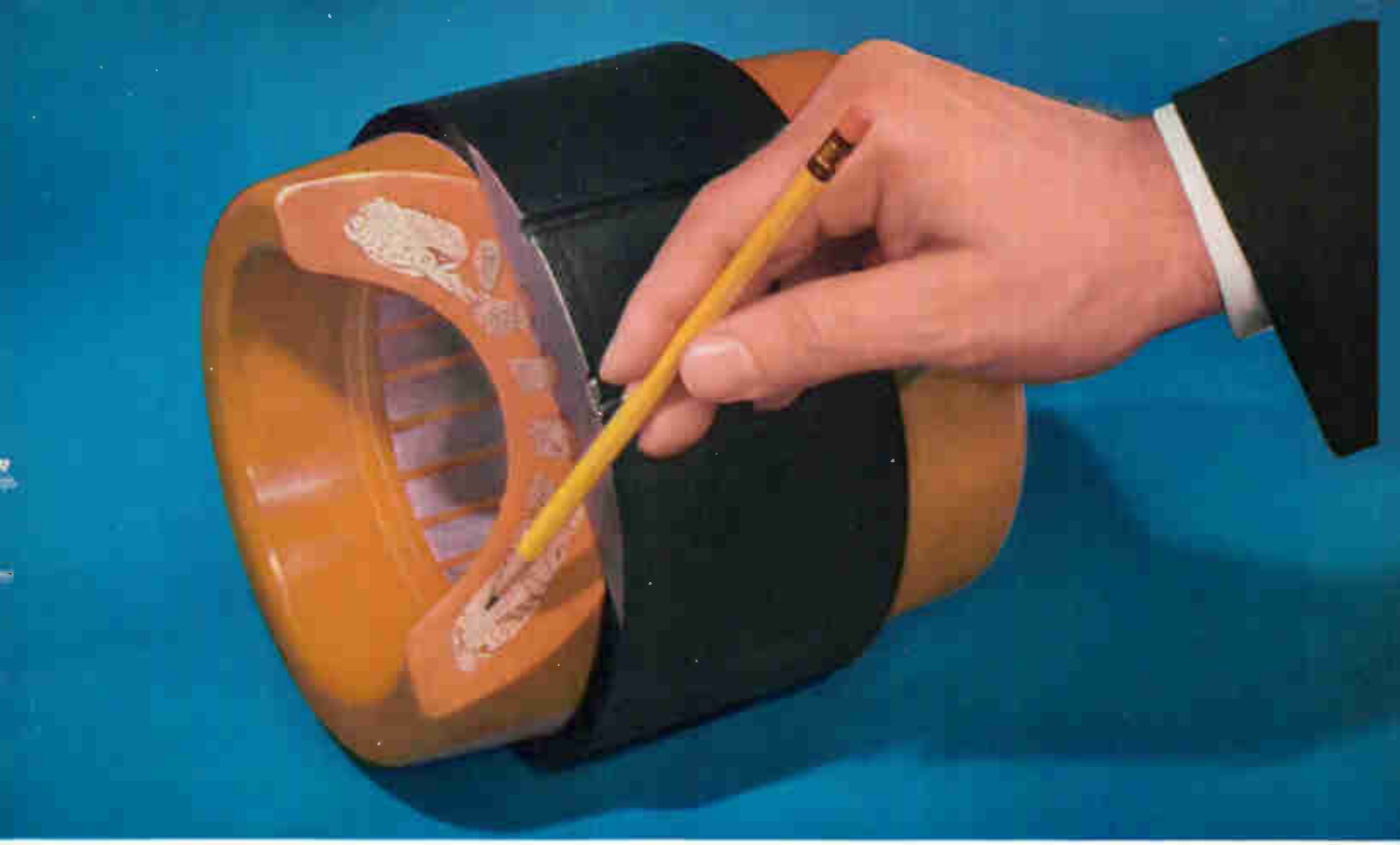

This is a cutaway of an Epoxy encapsulated stator wound with Epoxy magnet wire. All-Epoxy—an ideal combination for severe applications.

EPOXY MAGNET WIRE . . . IDEAL FOR ENCAPSULATED SYSTEMS UP TO 130° C

A magnet wire must offer you *all* these important advantages when used in encapsulated systems.

The wire must have outstanding compatibility—a requirement for good bond strength at elevated temperatures—high dielectric strength under adverse moisture conditions.

The ideal magnet wire must also have excellent thermal and high-impact shock resistance. And—it must be able to resist corrosive and abrasive atmospheres.

Anaconda Epoxy meets all these requirements and more. For this 130°C (AIEE Class B) magnet wire is compatible with virtually every encapsulating compound tested to date. Equally important, Anaconda Epoxy contains no polyester modifiers —therefore offering greater resistance to hydrolysis.

In addition, Anaconda Epoxy costs no more than most Class A magnet wires—which means you can often thermally upgrade your components to Class B without additional cost. It's readily available, too—in a full range of round, square and rectangular sizes.

Epoxy can also be furnished in combination with Vitrotex (glass-served) for added thermal overload protection.

So you can see how it offers you many interesting possibilities for cutting costs and simplifying production through standardization.

Our technical staff and Research and Development Laboratory facilities are available to give you assistance in your encapsulating and other magnet wire problems. See the Man from Anaconda. Or write: Anaconda Wire & Cable Company, 25 Broadway, New York 4, N. Y.

60252

ASK THE MAN FROM **ANACONDA®** *FOR* **EPOXY MAGNET WIRE**

ANATHERM 155°C (AIEE Class F) high temperature resistance

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OZALID NEWSLETTER

NEW IDEAS TO HELP YOU WITH ENGINEERING REPRODUCTION AND DRAFTING

Standard materials, plus new thinking, result in big time and cost savings.

How to break the halftone costs barrier

Some of the sharper repro men looking to cut the high cost of using halftones in quantity have come up with this little timesaver that goes for pennies per halftone. Here was the problem: 200 rush copies of 16 technical photographs were needed for a service manual . . . a total of 3200 prints. This job would usually run about $2,000 and take ten days . . . that was too long and cost too much.

A bright lad thought about their Ozalid whiteprinting equipment and worked out this procedure: First an 8" x 10" screened film positive was made by projection from a 4" x 5" negative, emulsion away from emulsion. This insured proper orientation of the print in the final stage.

Next, the film positive and Ozalid black-line plastic-coated paper (105SZ) were processed in an Ozalid Printmaster 810 at a rate of 12 feet per minute. The 42-inch width of this machine permitted two operators to work simultaneously, cutting total production time virtually in half! The choice of Ozalid paper Type 105SZ was an excellent one. It gave crisp, black-line images of great density due to the paper's plastic coating. The entire project took just under a fast six hours instead of the usual ten days, and cost about $100.

Total savings: $1900 and 9½ days of production time. Pretty smart, we think. By the way, we've got sample packages available for the asking that might very well give you the same dramatic results. Why not write us at Ozalid, Box DF, Johnson City, New York. We'll be glad to help.

Looking for a fast case of the blues?

The happy kind, we mean. The clean, rich, decisive blue image that Ozalid's new Super-Speed Blue-Line (200SS) gives. And when we say fast, that's exactly what we mean. *Poor originals are copied up to ten feet per minute faster than with regular copy papers.*

This is the first Ozalid copy paper specifically designed for copying semi-opaque originals at higher speeds . . . at no sacrifice of line density in any sense!

But what does all this mean in practical benefits, other than increased production at no loss in quality?

Well, for one thing, it means that you can now do a fine job on semi-opaque material, such as one-sided letters, documents and bulletins, at the lowest cost of any copying process . . . even if they're printed on bond papers!

Another benefit is the clean, readable copies you can now produce from soiled, yellowed documents and low-translucency materials much faster than ever before.

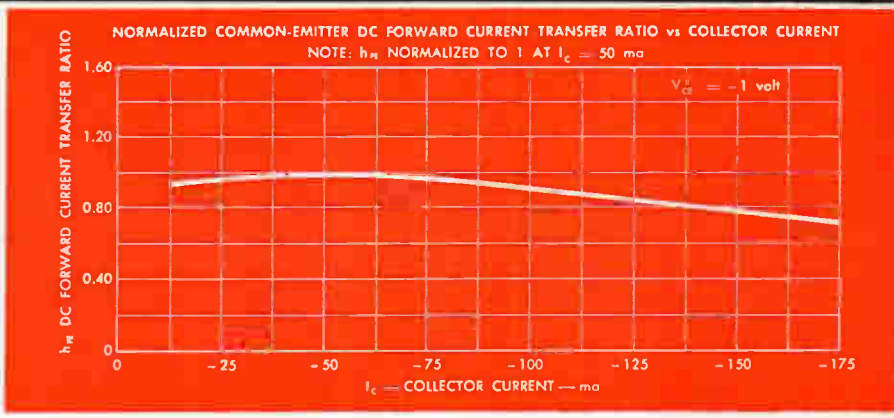
Is that all? Not by a long shot. 200SS actually turns low-powered ultraviolet machines into pretty fast units. And the faster printing speeds mean faster return of the original after each cycle.

Why not try this superb, high-density blue-line paper today? It really makes sense. Just call your local Ozalid representative for a demonstration.

***Ozalid**—Division of General Aniline & Film Corp. • In Canada: Hughes-Owens Co., Ltd., Montreal*

TI low cost germanium general purpose transistors give you 250 mw dissipation

...with beta spreads as low as 2:1



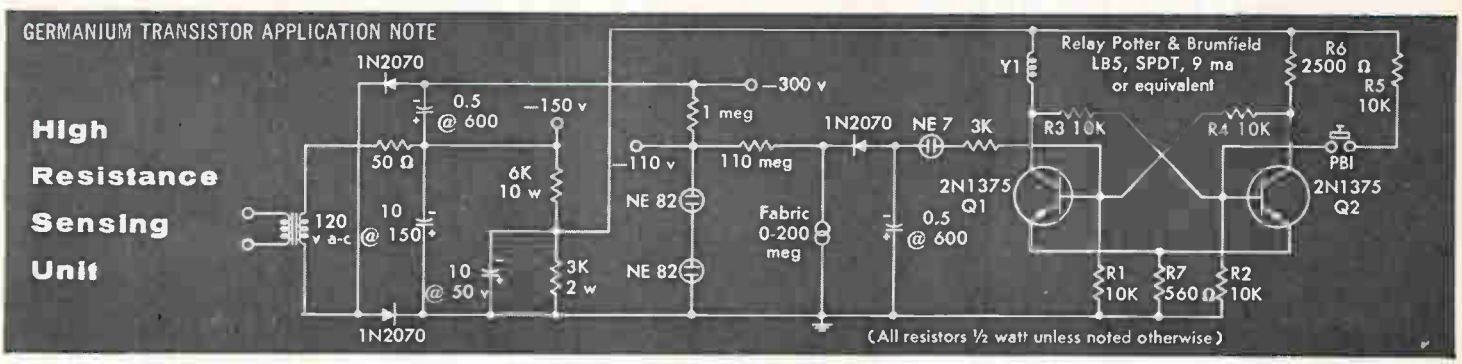
Available in commercial production quantities, TI 2N1372 series germanium P-N-P alloy transistors make possible low-cost applications that provide linear beta, high power gain and low distortion characteristics. These general purpose economy transistors are especially suited for your medium frequency switching circuits, audio amplifiers and motor control applications.

Fully automatic testing and classification by CAT (Continuous Automatic Testing) completely eliminates human error and assures uniformity and reliability ... ideal for your production assembly and testing requirements.

Evaluate the specifications below and contact your nearby TI distributor or TI sales office for the devices most suited to your particular requirements.

maximum ratings at 25° C ambient	2N1372	2N1373	2N1374	2N1375	2N1376	2N1377	2N1378	2N1379	2N1380	2N1381	Unit
Collector—Base Voltage	−25	−45	−25	−45	−25	−45	−12	−25	−12	−25	v
Collector Current	−200	−200	−200	−200	−200	−200	−200	−200	−200	−200	ma
Total Device Dissipation	250	250	250	250	250	250	250	250	250	250	mw
Storage Temperature Range	−55 to +100										°C
electrical characteristics at 25° C ambient											
I_{CBO} Collector Reverse Current											
(V_{CB} = −12v I_E = 0) (max)							−7		−14		μa
(V_{CB} = −20v I_E = 0) (max)	−7	−7	−7	−7	−7	−7		−7		−14	μa
(V_{CB} = −1.5v I_E = 0) (typ)	−3	−3	−3	−3	−3	−3	−3	−3	−3	−3	μa
h_{FE} dc Forward Current Transfer Ratio* (min)	30	30	50	50	75	75	95	95	30	30	
(V_{CE} = −1v I_C = −50 ma) (typ)	45	45	80	80	95	95	200	200	100	100	
(max)	95	95	150	150	150	150	300	300	300	300	
$f_{\alpha b}$ Common-Base Alpha-Cutoff Frequency (typ)	1.5	1.5	2	2	2	2	3	3	2	2	mc
(V_{CB} = −5v I_C = −1 ma)											
Noise Figure 1000 cps† (typ)	7.0	7.0	6.5	6.5	5.5	5.5	4	4	5.5	5.5	db

*Tolerance on all values ±10% for test set correlation. †Conventional noise compared to 1000 cps and 1 cycle bandwidth.



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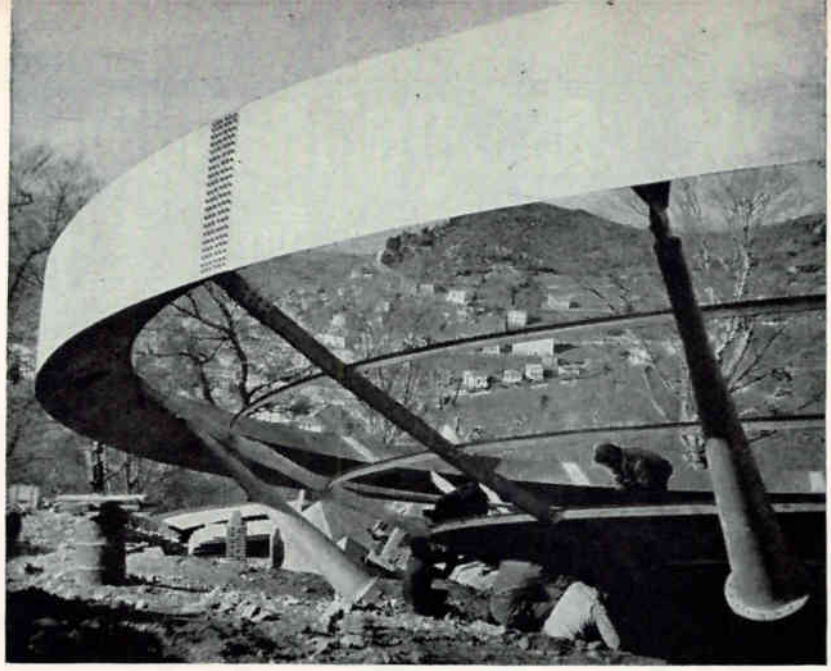
CIRCLE 37 ON READER SERVICE CARD 37

Tropo Scatter Spans a Continent



60-ft tropo scatter antenna goes up near Rome as part of NATO system

Tropospheric scatter is the backbone of Project Ace High, a 4,000-mile communications network for NATO. The story is told by Ace High's former project officer for planning and implementation

By LT. COL. H. R. JOHNSON

Chief, Communications Systems Standards Section, Director of Communications, Headquarters USAF, Washington, D. C.

A 4,000-MILE tropospheric scatter system, designed to stretch an electronic fence around the European edge of the Iron Curtain, is nearing completion. The NATO system, called Project Ace High, will link all major radar outposts and operational headquarters in Europe into an integrated military controlled communications system.

Constructed under the direction of the Supreme Headquarters Allied Power Europe (SHAPE), the system will make an arc from Norway to Turkey.

When completed, Ace High will incorporate an already-operating troposcatter system in Norway called Hot Line and will operate in conjunction with an ionospheric scatter system extending from Paris to Naples to Izmir, called Double Jump.

The backbone route of the final system will consist of one and ten-kw tropospheric forward scatter links extending from northern Norway through central Europe and the United Kingdom to the Mediterranean NATO countries and into eastern Turkey. Circuit capacity of the main route will be 36 voice equivalent channels (several of the voice channels are equipped to provide telegraph service on the basis of 12 to 18 telegraph channels per voice channel).

Spur circuits consisting principally of line-of-sight microwave, but in some cases relying upon low-power tropospheric scatter, will provide access to the main system.

The total route length of the system is somewhat over 4,000 miles; however, the longest operational circuit that has been required to date is on the order of 2,500 miles. In all, over 400 of the most critical voice and telegraph circuits of Allied Command Europe will be carried in the Ace High system. Many more circuits of a less critical nature will be carried through the European civil telephone and telegraph systems, which have also been improved and expanded under the NATO intrastructure program.

Construction of Project Ace High is well along toward completion. Operation of the system will be carried out by technicians from 15 nations under the direct control of SHAPE and through a military chain of command.

The quality standards applied in engineering the Ace High system are among the most stringent ever applied to a military system. The basic guide lines governing system design were those of the CCIR and CCITT (International Consultive Committee for Radio and International Consultive Committee for Telephone and Telegraph). However, in some cases even these quality engineering standards were modified and made more stringent.

To achieve reliability in excess of 99.9 percent, care is being taken to engineer the radio equipment under the "operating spare" concept wherein two independent amplifiers and four receivers are constantly in operation at each circuit terminal. Thus, equipment failure may cause slight degradation in circuit quality but will not result in a communications failure. Quadruple diversity, in frequency and space, will be employed in conjunction with the operating spare concept to overcome the deep Raleigh-type fading that is characteristic of tropospheric forward scatter propagation.

Special emphasis has been placed upon the development of alarm and monitor control facilities to give constant GO/NO-GO indication of equipment. These facilities are being designed to provide a degree of fault localization in addition to presenting a fault indication. Provi-

sions are being made for monitor control equipment to present a local display at attended stations or to permit automatic remote monitoring of unattended microwave repeaters.

Organization

SHAPE has overall responsibility for the project and exercises control through its Forward Scatter Branch project office in Paris. This international project office passes on all plans, issues and approves all criteria, conducts international competitive bidding procedures and buys all required equipment, maintains all program schedules and accounts for all financial aspects of the project to higher NATO authorities.

International Standard Engineering, Inc., a subsidiary of International Standard Electric Corp. (ISEC), and Hermes Engineering carry out the detailed systems and equipment engineering and installation necessary to produce an operating system. International Standard Electric is part of the International Telephone and Telegraph corporate family.

The equipment suppliers for Ace High were chosen after competitive bidding and represent industry from practically all NATO nations. For example, forward scatter amplifiers and receivers are being supplied from the U. S., antennas from Germany, microwave and multiplex equipment from European sources.

36 *Voice Circuits*

Hot Line, which went into operation in 1958, consists of over-the-horizon and line-of-sight links. Built by International Standard Electric Corp. with U. S. funds, the system has a capacity of 36 voice circuits, any of which can be utilized for 12 telegraphic circuits. It links Oslo in the south with Bodo in the north, with intermediate stations at Trondheim and Mosjoen.

Double Jump, not a part of Ace High, connects SHAPE in Paris with Allied Forces Southern Europe at Naples and the Allied Land Forces Southeastern Europe at Izmir, Turkey. Overall distance is 1,600 miles. Contractor was Page Communications Engineers, a subsidiary of Northrop Corp. The system, now operational, has one voice and 16 teleprinter circuits.

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BINARY TO DECIMAL CONVERTER

for converting any 4 bit code to decimal illuminated display

Performs better

...Costs less

Binary to Decimal Converter, Model 260, shown approx. ½ size

$95

(Nixie Bulb not included)

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NO FALSE READOUTS
Relays and tubes eliminated

MAXIMUM RELIABILITY
100% solid state circuitry

LONG USEFUL LIFE
No preventive maintenance required

OPERATIONAL FLEXIBILITY
Variety of four bit codes can be converted

LATCHING CIRCUITS
Provide *memory* for binary information

Write for Technical Bulletin 260

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PRICES CUT UP TO 50% ON GENERAL ELECTRIC SILICON LOW-CURRENT RECTIFIERS

Let's say you need 1500 PIV service. This is the way you've probably been doing it:

5 units [1N1694] with 300 PIV at 75¢ = $3.75

There was an easier way, but it cost more:

3 units [1N1696] with 500 PIV at $1.35 = $4.05

But not any more!
Now you can do it the easier way, at less cost than the old way:
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EVEN GREATER SAVINGS ON 1N500 SERIES!

BETTER WAY TO BUY SILICON RECTIFIERS!

General Electric's new low prices on low current rectifiers let you use fewer units with higher PIV's for less cost; also give you greater safety margin to handle voltage transients

Until now it was more economical to buy silicon rectifiers with low PIV ratings and string them together in series. But since General Electric has lowered prices as much as 50 percent, there's a new and better way to specify rectifiers.

You can buy fewer, but higher-rated rectifiers to get the PIV rating you want in series circuits at less cost. You also save size, weight and installation costs.

You can buy greater safety against voltage transients (more PIV) at the same or less cost than before. For example:

1N1095 (500 PIV), old 100-lot price....$3.50
1N547 (600 PIV), new 100-lot price....$2.45
You save 30%, and get a higher-rated rectifier.

Check the sample price reductions listed at right and see how much you stand to save. In general, the higher the PIV, the greater the saving—with the most sizable reductions at the high end of the 1N540 line. All 500 PIV units are now priced at 400 PIV levels. Reductions apply to MIL-spec rectifiers, too.

This is just one of the many ways General Electric helps you build greater reliability into your circuits. G.E. sets its PIV ratings after derating at least 20%, which means an additional safety margin at no extra cost. All General Electric medium and high-current silicon rectifiers now carry *transient* PIV's so you buy only the continuous rating you need and still get full protection against occasional voltage transients.

G-E medium and high-current rectifiers can be worked right up to maximum current and temperature ratings, even on highly cyclical loads. They are completely free of soft-solder joints which so often fail as a result of thermal fatigue. And new I^2t ratings now give you a precise basis for picking the right fuse.

Put all these extra advantages to work for you. Call your G-E Sales Representative or Authorized Semiconductor Distributor for more information. *In Canada:* Canadian General Electric Co., 189 Dufferin St., Toronto, Ont. *Export:* International General Electric Co., 150 E. 42nd St., N. Y., N. Y.

Here are some sample price reductions (for quantities of 100 or more):

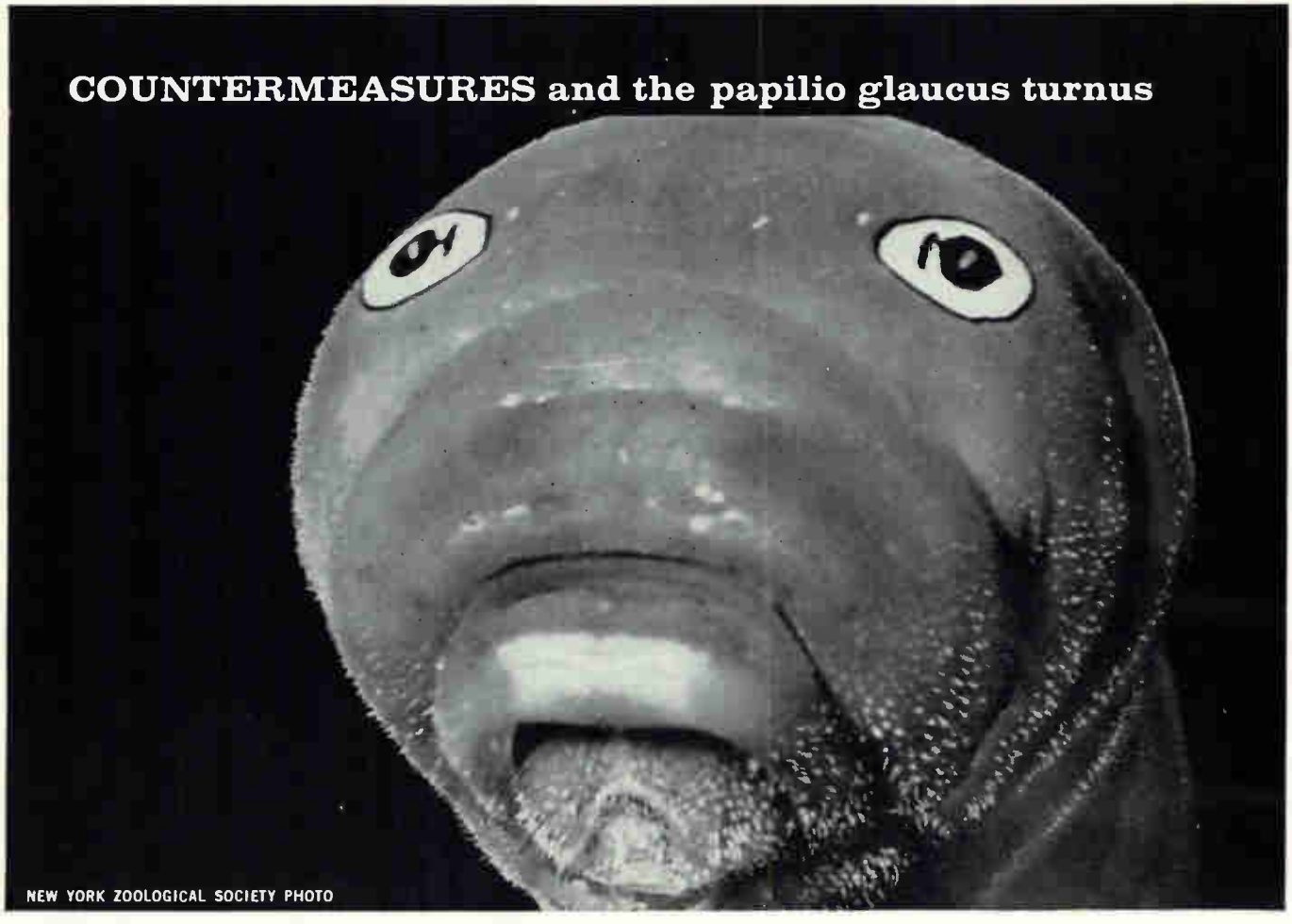
MODEL	PIV	OLD PRICE	NEW PRICE (NET)
1N538	200	1.05	.90
1N539	300	1.35	1.20
1N540	400	2.00	1.80
1N1095*	500	3.50	1.80
1N547	600	4.30	2.45
JAN/USAF 1N538	200	1.55	1.40
JAN 1N540	400	2.50	2.30
JAN 1N547	600	4.80	2.95

*Note that 500-PIV units are now priced the same as 400 PIV.

GENERAL ELECTRIC

Semiconductor Products Dept., Electronics Park, Syracuse, N. Y.

COUNTERMEASURES and the papilio glaucus turnus



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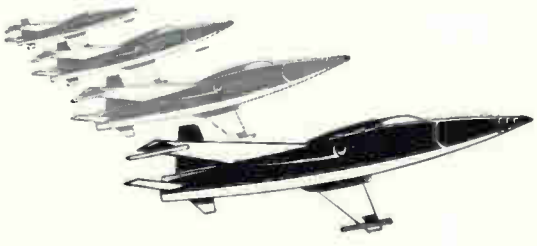
CONFUSE THE ENEMY...
and gain modern warfare's greatest defense...time!

A first look leads to a second thought, at least on the part of an enemy of a Swallow-tailed caterpillar. His adversary delays, uncertain as to what he is seeing, and our friend quickly departs. Another natural counter-measure.

Using the same basic psychology as nature, the electronic industry has developed a system which enables a single aircraft to appear as a whole squadron to the electronic eyes of an aggressor.

While the enemy attempts evasions we gain time —time to destroy him.

Many countermeasure systems are presently under development at Instruments for Industry. Many more have been successfully designed for all branches of the military and produced in quantity. The total facilities of I.F.I. permit every phase from initial design through final production to be completed at one facility. We invite your investigation of our company or if you prefer write for our comprehensive facility brochure.



A squadron of phantoms or a deadly reality?

MILITARY INSTRUMENTS ifi INC. FOR INDUSTRY ELECTRONICS

INSTRUMENTS FOR INDUSTRY, Inc.
101 New South Road, Hicksville, L. I., N.Y.

Graduate engineers with two or more years of circuit application in the fields of electronics or physics are invited to meet with Mr. John Hicks in an informal interview or send complete resume to: Dir. Personnel, IFI, 101 New South Road, Hicksville, New York.

Weather Rocket Network Opens

Month-long daily firings slated for this spring, summer and fall. Launchings hold important implications for future large spacecraft

A NETWORK of weather rocket stations permitting routine observation of the atmosphere at twice the 100,000-ft altitude now probed by radiosonde balloons was reported this month by the National Academy of Sciences-National Research Council.

Instrumented low-cost Arcas and Loki rockets were fired from Jan. 18 to Feb. 19 on a daily basis from Wallops Island, Va., and Point Mugu, Calif. Now it is disclosed that month-long daily firing periods are slated for this spring, summer and fall.

The seasonal firing periods will be part of the U. S. contribution to a series of International Rocket Weeks sponsored by the international Committee on Space Research (COSPAR).

The present network, consisting of meteorological rocket firing stations at Tonepah, Nev., Eglin AFB, Fla., and Cape Canaveral, Fla., plus Wallops Island and Point Mugu, is a joint undertaking of the Air Force, Army Signal Corps, Atomic Energy Commission, National Aeronautics and Space Administration, Navy and the Weather Bureau. The Army Signal Missile Support Agency, White Sands, N. M., provided rocket vehicles and launched the initial test rockets.

Weather rockets can reach higher than 40 miles, primarily to gather data on winds; radars track the paths of parachutes or clumps of falling "chaff." However, the National Academy of Sciences-National Research Council also indicated that the regular firing of such meteorological rockets had important implications for the future development of large spacecraft.

NAS-NRC expects rocket system improvements will lead to routine observations of temperatures and pressures as well as winds in the high atmosphere. This data will be coupled with the information from balloons and satellites, such as Tiros I, to help scientists understand the atmosphere.

"The rocket measurements are of immediate importance to understanding of the winds which large rockets and space vehicles will have to encounter during their flight," says the Academy. "It has been learned that winds in the region of the atmosphere which is being explored by the rocket system may exceed 250 mph, and that remarkable changes in this wind sometimes occur."

The 77-lb, 8-ft solid-propellant Arcas rocket carries 12 lb of instruments in its nose cone which separates and is tracked as it parachutes earthward. Telemetry package sends temperature information. Rawin (radio wind) ground gear at the stations uses direction-finders, provides recording of data and tracking.

National Academy of Sciences is the U. S. member of COSPAR, which was established in Oct. 1958 by the International Council of Scientific Unions. Coordinating U. S. study and planning efforts in the meteorological field is the Academy's Space Science Board.

Although the meeting indicated that most radar weather efforts aim at prediction, there was some discussion of quantitative studies using radar. SRI's Ronald T. H. Collins suggested that radar be applied in measuring ordinary rainfall over large areas. He said radar wave attenuation caused by precipitation could be related directly to the amount of precipitation, suggested the precise amount of rain falling into a lake or reservoir could be determined.

Radar Conference

In another weather research development, some 200 meteorologists and radar specialists attended the Eighth Weather Radar Conference last week in San Francisco sponsored by the Northern California branch of the American Meteorological Society and Stanford Research Institute.

George R. Tenery of Chance Vought reported that the Vought Astronautics division is simulating satellite passes and analyzing proposed meteorological experiments using satellites, and will be able to rank satellite experiments in order of merit for the National Aeronautics and Space Administration.

Transistors Aweigh

Transistorized radio receiver built into ship model hull allows naval reserve officer trainees at Cornell to study ship-handling problems. Models are controlled by equipment (right). Scaled-down vessels cost $2,000 each

Measure transistor characteristics—

Alpha (h_{fb})
Beta (h_{fe})
Input Resistance (h_{ib})

—with the new BRC Type 275-A Transistor Test Set

Price: $935.00 F.O.B. Boonton, N. J.

The BRC Type 275-A is an exceedingly flexible and efficient instrument for the precise measurement of basic transistor parameters over an extended range of operating conditions. It can also be used to measure the characteristics of diodes and other semi-conductor devices. Direct readout of the following parameters—

- **Alpha (h_{fb})** • **Beta (h_{fe})**
- **Input Resistance (h_{ib})**

is presented on a large, easy-to-read dial without correction or interpolation. Two built-in, fully regulated, low ripple power supplies furnish completely variable emitter current and collector voltage.

Exclusive BRC features—

- Unique null-type measuring circuit completely unaffected by signal level fluctuations
- Reads Alpha to three significant figures
- Accurately measures at extremely low emitter currents

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- Permanent Calibration
- Direct Readout of Alpha, Beta, and Input Resistance on large easy-to-read dial
- Built-in adjustable, metered collector and emitter power supplies
- Handles up to 5 amperes emitter current
- Measures both NPN and PNP transistors
- Special test circuit guards against transistor burnout

SPECIFICATIONS

Alpha Measurement (h_{fb}):
RANGE: (a) 0.100 to 0.999 (b) 0.9001 to 0.9999
ACCURACY: (a) $\pm (0.1 + \frac{0.09}{h_{fb}})$ %* (b) ± 0.2%*
*when $f\alpha \geq 500$ Kc.

Beta Measurement (h_{fe}):
RANGE: 7 to 200
ACCURACY: $\pm (0.6 + \frac{30}{h_{fe}})$ %*
*when $f\alpha \geq 500$ Kc.

Input Resistance Measurement (h_{ib}):
RANGE: (a) 0.30 to 30 ohms (b) 3.0 to 300 ohms (c) 30.0 to 3000 ohms
ACCURACY: (a) ± 3%* (b) ± 3%* above 30 ohms (c) ± 3%*
* for linear impedances

Collector Voltage Supply:
RANGES: Internal: 0 to 100 V.D.C.
External: 0 to 100 V.D.C.
METERING: Range: 0 to 2, 5, 10, 20, 50, 100 volts
Accuracy: ± 1.5% full scale

Emitter Current Supply:
RANGE: Internal: 0 to 100 ma D.C.
External: 0 to 5 amp. D.C.*
*h_{fb} only; $I_b \geq 100$ ma D.C.
I_E and I_C metered externally
METERING: Ranges: 0 to 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100 ma.
Accuracy: ± 1.5% full scale

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in accordance with Spec. MIL-C-14157A
300, 400, 600 volts DC Working

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Insulated Body Type CPM09

CAPACITANCE RANGE: .001 mfd. to 1.0 mfd.
TEMPERATURE RANGE: −55°C to +125°C without derating

MILITARY & INDUSTRIAL "TWK" SERIES
in accordance with MIL-C-26244 (USAF)
200, 300, 400, 600 volts DC Working

Uninsulated Body Type TWKN (equivalent to MIL-CPV08)

Insulated Body Type TWKP (equivalent to MIL-CPV09)

CAPACITANCE RANGE: .001 mfd. to 1.0 mfd.
TEMPERATURE RANGE: −55°C to +125°C without derating

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So when you design electronic equipment in which *failure can't be tolerated,* specify Cornell-Dubilier *High-Reliability* Capacitors. For complete details and engineering assistance, write for Bulletins 188A-1 and 188A-2 to Cornell-Dubilier Electric Corporation, South Plainfield, New Jersey. *Manufacturers of consistently dependable capacitors, filters and networks for electronics, thermonucleonics, broadcasting and utility use for 50 years.*

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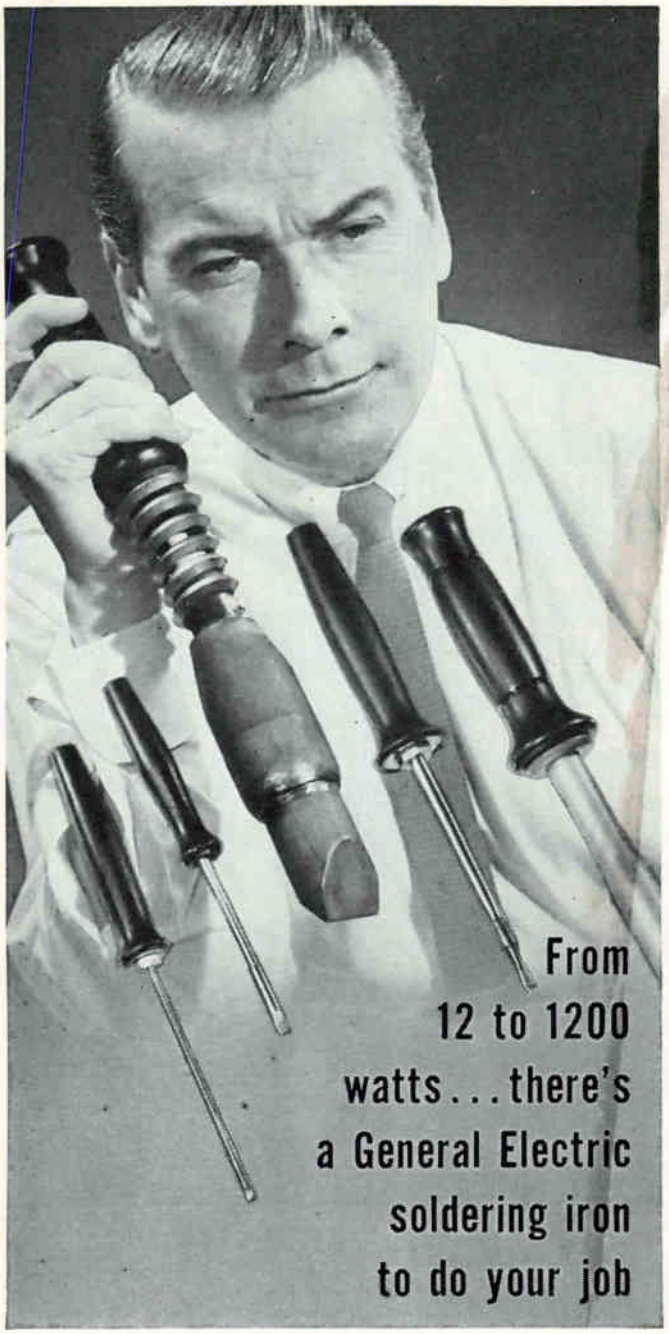

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Whatever your soldering requirements may be—from complex miniature electronic sub-assemblies to heavy-duty industrial uses—one of the high-speed soldering irons in General Electric's complete line will do the job. The G-E irons shown above include (left to right):

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LIGHTWEIGHT for soldering of most electronic components.

INDUSTRIAL for general industrial soft-solder applications.

For expert assistance in choosing the *exact* iron you need, contact your General Electric distributor or local G-E Apparatus Sales Office; or write Section 758-03, General Electric Co., Schenectady 5, N. Y.

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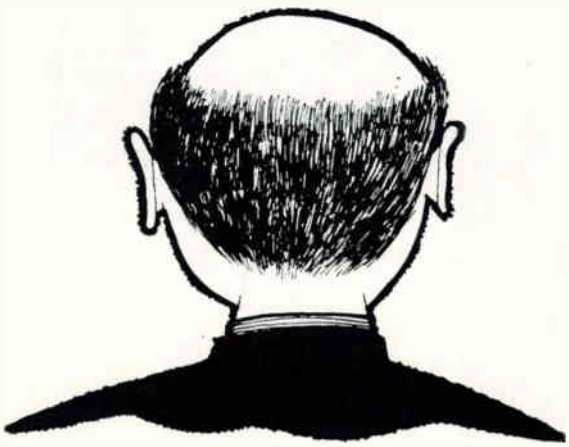

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It pays to know more than the next man! The questions above are just 6 reasons why you should subscribe to *electronics*.

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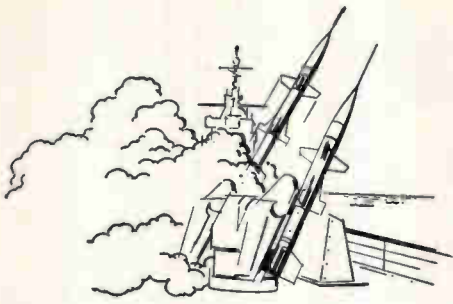

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An exciting new application in the missile control field is the development by the Surface Armament Division at Sperry Gyroscope Company of a silver-coated plastic lens for use with the Navy's Talos missile. As compared to earlier metal versions, the new lens weighs substantially less and provides twice the signal gain at the same production cost! The Talos delivers, with extreme accuracy, a high explosive or nuclear warhead to any altitude at which airplanes now fly, as well as far beyond the range of human visibility.

The silver coat imparts RF reflectivity and electrical conductivity to the lens and is applied in paint form. As the silver base for this paint, Sperry uses Handy & Harman's Silver Flake. An important quality of this flake is that its waferlike particles are asymmetrical and overlap on the surface of the lens, affording up to 35% of the conductivity of an equivalent weight and shape of fine silver.

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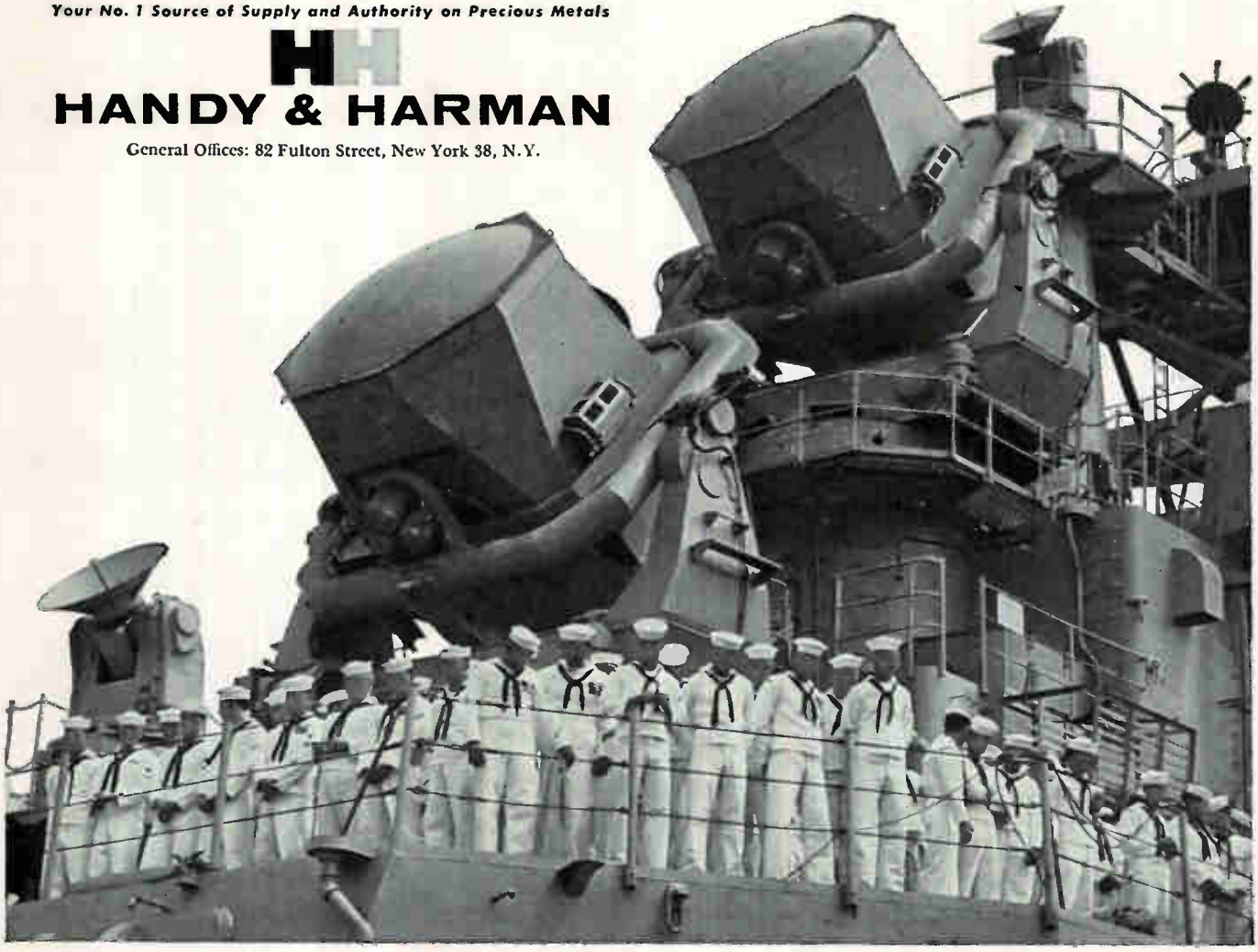

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Space Emphasis: Components

High-thrust propulsion systems on the way are quickly making electronics problems critical

DALLAS — High-thrust propulsion systems projected during the next five years will shift the critical emphasis in satellite development to components and instruments, including reliability in radiation environment.

That's the feeling expressed by a number of speakers at a conference in Dallas recently on electrical engineering in space technology. Conference was sponsored by the American Institute of Electrical Engineers, Institute of Radio Engineers, and the American Rocket Society.

Richard E. Horner of NASA said that adequate thrust will become available in two to five years for deeper space probes than are now possible (ELECTRONICS, p 11, Apr 8). This, he declared, will mean critical emphasis in the future will shift from "the lifting problem" to components.

Herbert Friedman, superintendent of the Naval Research Laboratory's Atmosphere & Astrophysics division, said the instrumentation of payload space in rockets and satellites of the future presents a "tremendous problem." Friedman said there is some doubt about space measurements of radiation taken so far, due to the "primitive nature" of the measuring equipment.

He added there is need for much more accurate homing controls in future satellite launchings, and said the problem of stabilizing systems is a difficult one. Orientation is likely to be accomplished, he said, by rotating objects inside the satellite package.

Long-Life Problem

John R. Pierce, director of research for Bell Telephone Laboratories, said components for future satellite communication systems must have "assured lives of many years" to economically justify extensive commercial systems. Pierce said the present problem of space communications is that of evaluating the life and reliability of different types of satellites, plus the communication and orientation equipment that go with them.

In May, he said, plans call for a balloon communications satellite to be put up in a 1,000 mile orbit as part of NASA's Project Echo. This effort will provide data on just how durable such a satellite is. If the lifetime should be satisfactory, he said, this could mean that worldwide communications via satellites is near. Echo will also furnish more data on sky noise, Pierce said.

Both Pierce and George Mueller, director of Space Technology Laboratories' telecommunications laboratory, said work so far indicates silicon solar cells are best suited for the space vehicle's transmitter power source.

Antenna Instrumentation

Mueller said at the present time transmitter efficiencies of 50 to 80 percent are possible at frequencies below 1,000 Mc; efficiencies of 10 to 50 percent are possible at higher frequencies.

Both men said great receiving gains are made by increased an-

Finding Sensitivity

A steel marble, rolling down inside this sloping spiral channel at ITT Laboratories, helps engineers analyze the sensitivity of fuzes used in guidance and detonation missiles. The rolling ball acts as a moving short circuit

tenna diameter, but Pierce pointed out that antenna costs rise sharply with increased diameter. He thinks better instrumentation of antennas is needed instead of just "bigger ones." Pierce said the horn reflector type of parabolic antenna shows considerable promise for future satellite communications systems.

Stresses Simplicity

Navy Captain K. M. Tebo, said two nuclear submarines — the *George Washington* and *Patrick Henry*—will be ready this year to fire the Polaris missiles. The missiles will have a range of 1,200 miles; each sub will carry 16 missiles.

Tebo added that all tests of guidance, accuracy, shipboard fire control system, and other systems on the Polaris have shown excellent results so far.

Col. E. S. Chandler said Minuteman will be available in "large numbers" by 1963, but he said electrical engineers must "give greater emphasis to simplicity of equipment." Such emphasis, he said, will "automatically increase reliability."

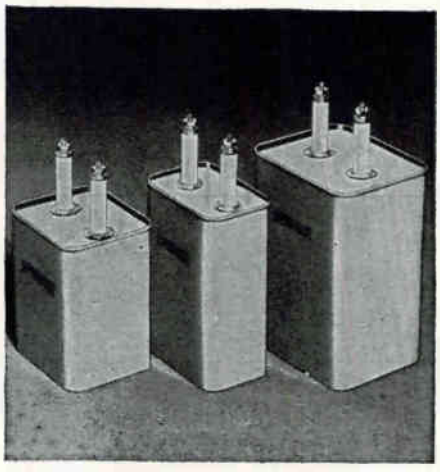
Dual-Purpose System For Navy's Missiles

NAVY'S SURFACE WARSHIPS will get a new dual-purpose guided missile system called Typhon. Equipped with two different missiles, the system will provide defense for the fleet against enemy aircraft and missiles, as well as an offensive capability for off-shore missile attacks.

Applied Physics Laboratory will have prime responsibility for engineering the new complex. The two missiles to be used are the Super Talos, now to be called the "long-range Typhon" and the Super Tartar, renamed "medium-range Typhon."

A new fire control system will use advanced long-range search, tracking and guidance radars. Concept of the new radar, which incorporates high data rate and high power features, was originated at APL. Westinghouse will develop a prototype model under a $38.5-million contract.

New Dual-Dielectric Capacitors Surpass MIL-C-25A CP-70 Requirements



A new series of large drawn-rectangular case capacitors recently placed in production by the Sprague Electric Company surpasses MIL-C-25A Type CP-70 requirements for performance, reliability, size and maximum operating temperature without voltage derating. Sprague Type 272P Difilm Vitamin Q® Capacitors withstand the most severe operating conditions encountered in military and industrial electronic equipment. Unlike MIL-CP-70 units which require derating above 40 C and are limited to 85 C maximum, these new Sprague Capacitors can be operated at full voltage up to 125 C.

A duplex dielectric is used in these capacitors. It consists of both synthetic polyester film and the highest grade capacitor tissue. The impregnant is Vitamin Q, a synthetic polymer which has been used by Sprague with outstanding success in paper capacitors for many years. Seamless construction of the capacitor cases provides a virtually leakproof container with increased reliability over MIL-type units using fabricated cases.

The smaller size of Type 272P Difilm Vitamin Q Capacitor in comparison with that of oil-paper units for similar applications is important in many jam-packed equipment applications.

For complete engineering data, write for Engineering Bulletin 2340 to Technical Literature Section, Sprague Electric Company, 35 Marshall St., North Adams, Mass.

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Capacitor sections are of the extended-foil design and are housed in pre-molded phenolic shells with plastic-resin end seals for protection against moisture and mechanical damage.

For complete technical data on ISOFARAD Capacitors, write for Engineering Bulletin 2037A to Technical Literature Section, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts.

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MEETINGS AHEAD

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

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

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

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

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

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

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

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

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

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

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

May 16-18: Electronic Parts Distributors Show, Electronic Industry Show Corp., Conrad-Hilton Hotel, Chicago.

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

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

There's more news in ON the MARKET, PLANTS and PEOPLE and other departments beginning on p 128.

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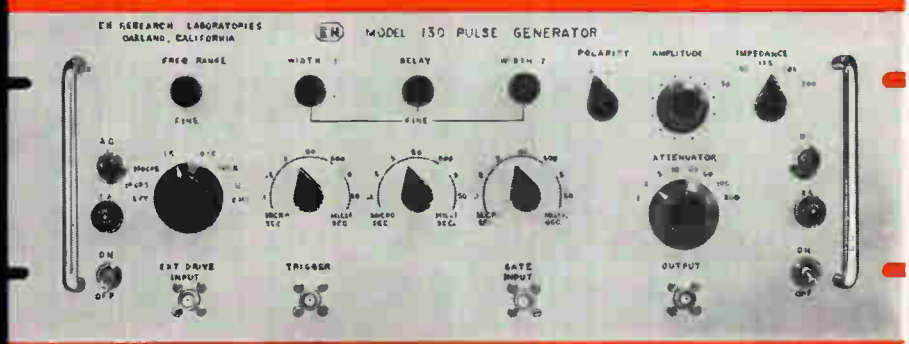

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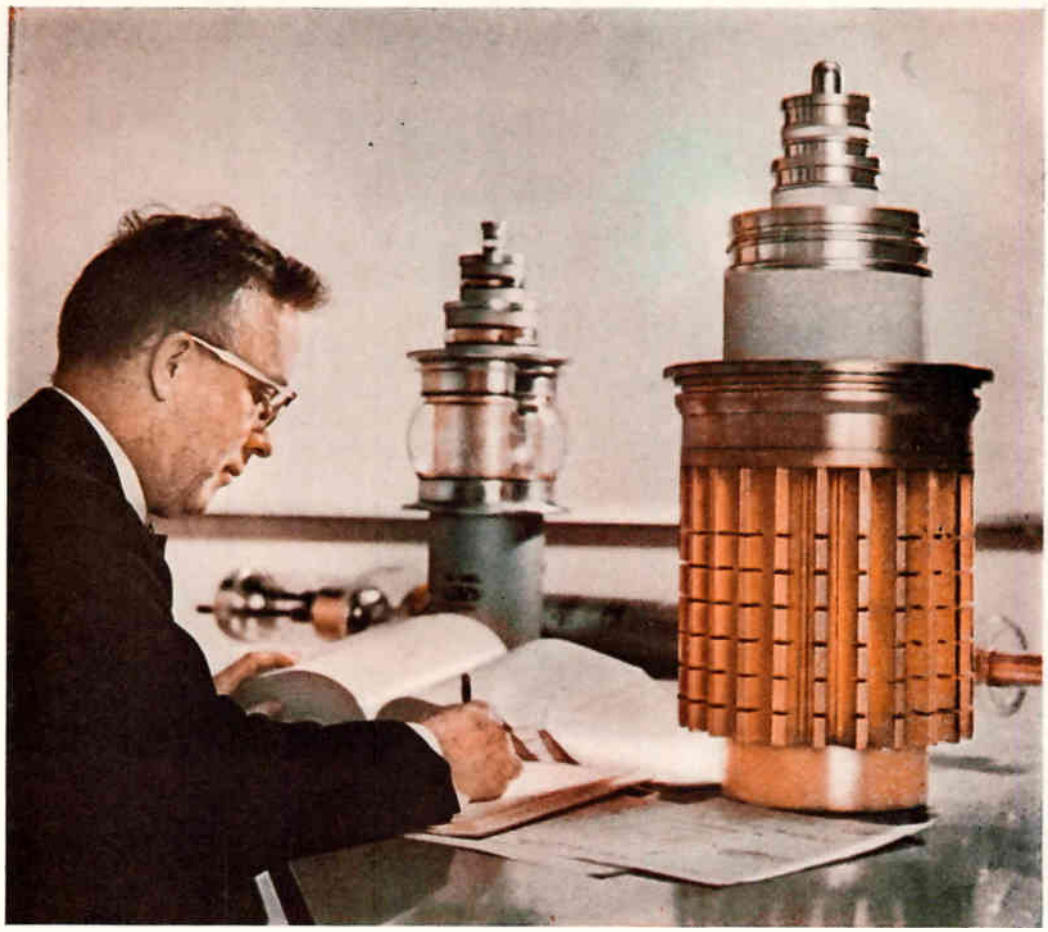

EVOLUTION OF R-F POWER TUBES is graphically illustrated by array being studied by Machlett Laboratories' Associate Director of Engineering, Dr. H. D. Doolittle. In background is the ML-298A, an 80-Kw tube from the mid 1930's; at center, the ML-5682, a 200-Kw tube of early 1950; and in foreground, the new ML-7482, a 400- Kw triode for continuous class C output or oscillator service up to 30 Mc

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What's New in
ELECTRON TUBES

ADVANCES during the past decade have changed the size, shape and capabilities of almost every type of electron tube. These advances have been achieved not by spectacular technological breakthroughs but by a long series of evolutionary gains that have themselves benefited from advances in semiconductor physics, materials research and mechanical design for extreme environments.

Any engineer, who during the past few years took his hand off any portion of the electron tube field, might today have some difficulty recognizing the latest developments in that field. That is how far-reaching electron-tube developments have been. In nearly all fields tubes are smaller for the same or even higher power-handling capabilities.

Power-handling capability has been extended by use of new high-temperature ceramic materials for seals and for portions of the envelope walls as well as better heat sink design and more efficiently designed electrode structures. Vapor-cooling techniques promise even further advances in this direction. A major result of more effective heat dissipation schemes has been to permit making better use of the volume inside an electron-tube envelope; today, not so much space is used to hold nothing, that is to say, the vacuum.

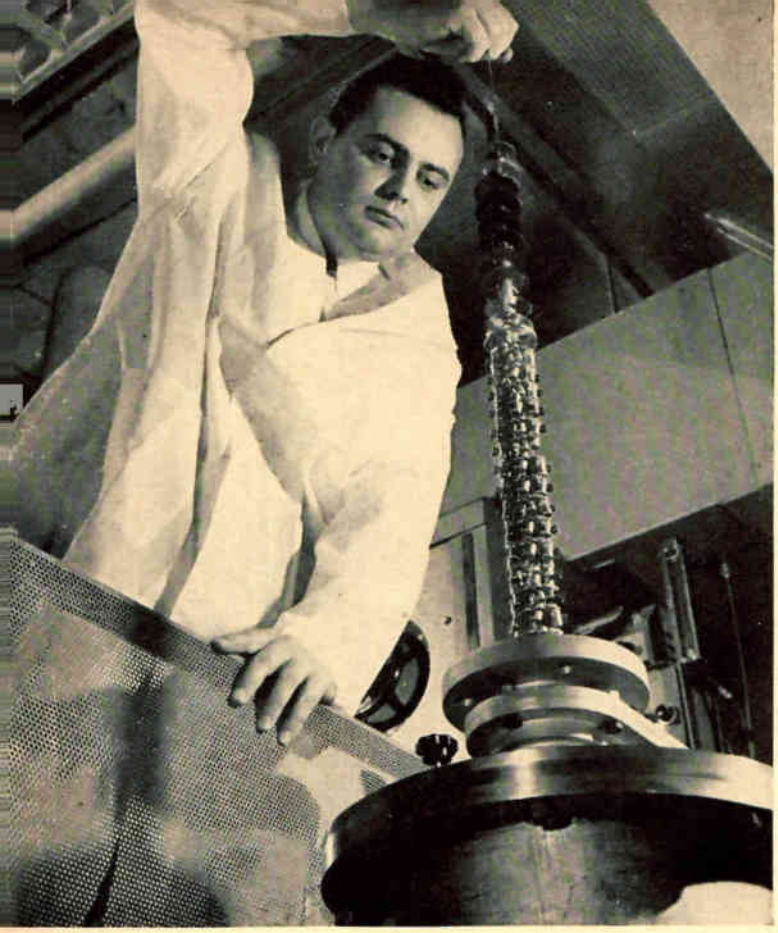
Improved mechanical design of electrode structures, for example the cantilever construction used in certain new receiving-type tubes, has provided greater resistance to shock and vibration and has reduced chances of tube failure due to metal fatigue. Materials research has afforded more efficient substances for both thermionic and photoelectric cathodes.

Microwave tube technology has advanced at perhaps a faster clip than have most other tube fields. The traveling wave tube is still relatively new. There have been major advances both in linear-beam microwave tubes and in crossed-field microwave devices. Gas-filled tube design has, of course, benefited from the large amount of research effort currently going into plasma physics. In the research stage is a traveling-wave tube that uses a plasma as the slow-wave structure.

All these developments show clearly that there will always be a place in electronics for the electron tube. At the present time there is no other way to generate high power for industrial and communications use nor to generate high frequencies approaching the millimeter range. Neither are there other ways to display electronic phenomenon nor to convert extremely low-level light signals to electrical signals. Moreover, it can frequently be shown that at lower frequencies, lower power levels and in more conventional applications, an electron tube can give the most gain for a given expenditure of power and a given rise in ambient temperature.

This special report will help you get up to date in a classic field of electronics that is showing remarkable vitality and progress.

JOHN M. CARROLL *Managing Editor*



Engineer lowers shish-kebab of approximately 100 Nuvistors into an exhausting and heat-sealing machine. Tubes are subjected to 1,800 F during this operation

RECEIVING-

IT IS EASY TO ASSUME that a long-practiced art like tube manufacturing reaches a saturation point in development. However, "break-throughs" need not await fundamental advances in the science; they are more often triggered by advances in materials and fabrication techniques. Fundamental electron-tube theory has long predicted potential performance well beyond that so far achieved in practical tubes. A review of some of the basic design requirements for receiving tubes shows how new developments in technology promise more striking progress in the near future than the tube industry has achieved in recent years.

R-F AMPLIFIER PERFORMANCE—Tubes for small-signal amplifiers have design objectives of high gain and low noise, preferably with low power consumption. High transconductance, g_m, is a major indicator of good noise and gain performance, although small interelectrode capacitances must also be achieved. These objectives lead to the use of fine grid wire, fine wire pitch, small spacings, and small-area electrodes and to the attendant problem of small tolerances.

Present tubes seem to be nearing the practical limits of the conventional grid structure, and recent efforts have been directed toward improved structural approaches. The conventional grid uses two siderods with self-supporting lateral wires joined mechanically to the siderods by notching and peening. (See Fig. 1.) Because the span between siderods is long for fine wires, mechanical strength considerations have required that the minimum diameter of the grid be at least 0.8 mil in commercially produced tubes. Two methods are presently being used to circumvent this problem—to wind the wire under tension over a support frame and to increase the number of siderods and thus shorten the lateral wire span. Both approaches usually use brazing to join the wires to the frame or siderods.

The frame-grid technique has been used with otherwise conventional structures for special high-performance tubes, and recent efforts have reduced the cost of frame grids sufficiently to permit their use in a family of moderately priced receiving tubes having improved performance. Grid wire as fine as 0.4 mil is being used on these frame grids.

Another form of frame grid resembles a washer with the grid wires stretched across it. This type of grid is used with a planar cathode. Grid wires as small as 0.3 mil with one-mil center-to-center spacing are used in these grids.

Cylindrical multiple-siderod grids usually use a helix of fine wire for electrical control, and small-diameter siderods which have a small electrical effect compared to the regular control wires. In some cases, the roles may be reversed, with the siderods being used for electrical control and the helix, or lateral, wire used mainly for mechanical support. Multiple-siderod grids are usually supported from one end, cantilever style, so that mica spacers are not used. In this type of structure, some of the differential thermal expansion problems are avoided, and assembly jigs may be inserted and withdrawn from the free end. Wire as fine as 0.5 mil has been used in this type of grid.

UHF TUBES—For maximum frequency capability of tubes, the best available electrode designs must be combined with structures having minimum lead reactances and losses. The result is a variety of disk-seal tubes. One uses cylindrical electrodes while the remainder are of the planar type. (See Fig. 2.)

Because of the past trend to use wire-lead tubes having familiar sockets as high in frequency as possible, disk-seal tubes have been kept in a specialty class and have not had the benefit of high-volume production for the purpose of reducing cost. The newer designs are challenging the cost barrier, however, and substantial economies can be anticipated as the market grows and

Improving mechanical and electrical characteristics of grid structures, development of more efficient cathode materials and forms, better internal tube design for electrical efficiency and improved heat transfer all characterize the state of the receiving-tube art

TYPE TUBES

By M. B. KNIGHT,

Electron Tube Division, Radio Corp. of America, Harrison, N. J.

techniques for making small, precise electrode structures show further improvement.

POWER CONSUMPTION—The tube design factors necessary for high gain at low plate current and small cathode area coincide with those for good high-frequency gain and noise performance. Good r-f amplifier tubes also have high gain at low currents, although plate-voltage and heater-power reductions do not always follow. For example, planar construction is quite wasteful of heater power compared to cylindrical structures having the same cathode areas.

The theoretical limitation of g_m-to-plate-current ratio, which depends on the distribution of electron velocities at normal cathode temperatures, is 11 millimhos a milliampere (11:1). In a miniature triode such as the 6BN4, however, the g_m is only about 8 millimhos at 10 milliamperes (0.8:1). For the same plate current, a g_m of about 10 millimhos (1:1) is achieved in commercial frame-grid tubes, and values of 13 to 15 millimhos (1.3:1 to 1.5:1) are obtained in Nuvistors and some planar tubes. Ratios of transconductance to plate current which more nearly approach the theoretical limit can be achieved at lower plate currents. Nuvistors, for example, have ratios of 2:1 at 5 milliamperes and 4:1 at one milliampere, and many tubes have ratios exceeding 6:1 at lower current levels.

POWER AMPLIFIERS—Although the desired tube performance characteristics for higher-power-level circuits may appear to be different, the demands upon tube design and technology are fundamentally the same as those for small-signal amplifiers. Fine grid wires closely spaced in sufficiently strong structures are needed. One step in the direction of additional mechanical support has been made in frame grid construction. Another is the multiple-siderod approach used in the experimental Nuvistor power tube.

If power tubes are thought of as scaled-up small-signal tubes, however, the thermal problems become quite different. For example, planar cathodes are relatively inefficient in the use of heat. Conduction heat paths do not scale like the electrical design factors, and radiation usually becomes a more significant means of heat dissipation. Receiving-type power tubes dissipate the bulk of their heat by radiation to and through the envelope, although the grids are cooled principally through conduction. The Nuvistor power tube in development uses ceramics for improved thermal conduction and may indicate a future trend toward smaller power tubes cooled by conduction. In this respect, the receiving-type power tubes will more nearly resemble large power tubes.

DEVICE SIZE—The evolutionary change to straight-sided miniature and subminiature envelopes in which the wire leads serve as base pins made possible a great reduction in size. Some further efficiency in space utilization has been gained by the inclusion of more than one tube unit within one envelope, although these designs still constitute a subassembly cage placed in a container. There is currently a gentle revolution toward use of the tube enclosure as an integral part of the mechanical support of the electrodes, as in the Nuvistor and microminiature types. Even these tubes are much larger than their active parts, however, and both tubes and transistors have certain limitations as regards the making of terminal connections. Further size reductions have been demonstrated by integration of the device and the circuit, but the flexibility of plug-in or solder-in devices is desired in many cases.

THERMAL DESIGN—Heat transfer is perhaps the most fundamental consideration in miniaturization. There is a complex interrelation between the transfer of heat from devices and components within an equipment package and the dissipation of heat from the package to its surroundings. The tube designer must go one step further and provide for heat flow from all electrodes except the heater and the cathode, which present the converse problems of thermal isolation.

If the surface area of a device or a package is reduced, then heat transfer must be more efficient, power input must be reduced or the permissible temperature rise above ambient must be increased. In this area, the relative merits of transistors (which require lower power input) and tubes (which can operate at higher temperature) are difficult to determine. In a transmitter, for instance, the plate efficiency of a tube is as high or higher than that of a transistor, and heater power is a small part of the total power dissipation; the high temperature capability of tubes is thus a distinct

advantage. In receivers handling only small signals, however, the absence of heater power and the small B+ power may offset the temperature advantage of tubes particularly when power-supply size is considered. The choice is not clear-cut in many applications, even when cost is disregarded. Tube designers are presently trying to strengthen their competitive position by improving tube efficiency as well as by extending the range of high-temperature operation. Semiconductor-device engineers, on the other hand, are seeking to narrow the gap in temperature capabilities.

The leading heat-transfer role in miniaturized devices or equipment is played by conduction. Radiation and convection become less effective as surface area is reduced, and a goal of small temperature rise makes radiation virtually useless. On the other hand, the reduced length of conducting paths tends to compensate for the smaller cross-section area. These considerations are currently demanding some major revisions in the design approaches to tubes and sockets, as well as chassis design. The new small ceramic tubes exploit the unusual combination of good thermal conductivity and good electrical insulating properties of Forsterite ceramics. There are still greater opportunities in the use of aluminum oxide and beryllium oxide ceramics, the latter material has the conductivity of brass at room temperature, but is still expensive.

Ceramic envelopes also increase the permissible operating temperatures of the tube envelope to the extent that factors other than envelope deterioration or gas evolution usually limit the practical temperature range. The cathode coating is a semiconductor material having typical characteristics of a narrow range of suitable operating temperatures; the wide range of permissible ambient temperature is actually a result of operating the cathode so hot that relatively cool surroundings have little influence on the net radiation from the cathode of the tube.

A major practical temperature limitation is thermionic emission from the grid. The new small tubes generally have less temperature difference between the grid and the grid terminal than conventional designs, but trouble can still develop in sensitive circuits having high values of grid resistance if the grid temperature exceeds 300 C. In another approach being tried, the grid is deliberately kept so hot that it is not contaminated by material from the cathode and thus remains a poor emitter. This promise for higher temperatures, however, does not necessarily improve the range of permissible ambient temperatures.

POWER DISSIPATION—The basic limitation on tube power input is signal power to be handled, although tube-making technology is the present limitation in very-small-signal amplifiers. Proper scaling down of tube dimensions reduces plate power and heater power so that improved performance and efficiency can go hand-in-hand. The Nuvistor, for example, has heater power slightly lower than that of its miniature counterparts, while its plate power can be reduced to one-fourth to one-tenth. Further reductions in future models appear quite feasible.

Complete elimination of the heater is the subject of several research projects. A cold magnesium-oxide emitter requiring only a small keep-alive electrode power has been demonstrated jointly by the Signal Corps and Tung-Sol Electric. Other projects involve high-field emission, which may become useful at least for rectifiers, and low-temperature semiconductor emitters. It is too early to claim accurate evaluation of these projects, but the outlook seems promising that useful products may be made, if only for specialized applications.

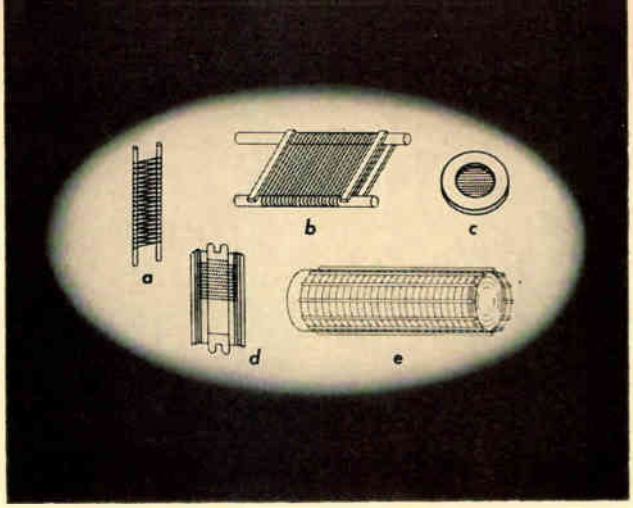


FIG. 1—Several methods for constructing electron-tube grids showing: (A) conventional wound grid with two notch-peen siderods, (B) frame grid, (C) planar frame grid, (D) Frame-Lok grid and (E) multiple-siderod cylindrical grid of outside-siderod type that solves some thermal expansion problems

RELIABILITY—The balance between initial cost and price of maintenance is difficult to determine, and is vastly different in, for example, a moon rocket and a hi-fi set. Nevertheless, the trend to more complex equipments demands greater tube reliability on all fronts, and a growing consciousness of reliability in the consumer markets tends to narrow the gap between industrial and entertainment needs.

Catastrophic tube failure is the universal evil. With a given design, such failures are quality problems, and the difficulty of improvement is an exponential function of the quality level. Recent approaches in tube structures promise substantial improvements by eliminating the most troublesome construction features through the use of new techniques expected to have fewer troubles of their own. For example, removal of the need for a vaporized-type getter eliminates a potential source of particles and leakage. The absence of mica spacers removes a source of particles and gas. The use of brazing in place of resistance welding eliminates a procedure that requires considerable operator skill to avoid shorts, opens and loose particles.

LONG LIFE—The degenerative type of tube failure which causes inadequate circuit performance is harder to evaluate because of the great variation in sensitivity of circuits to tube change. One category of altered characteristics is spurious electrode currents, including gas, grid emission and leakage. Steady progress is being made on gas and leakage problems by developing materials that are freer from gases and volatile metals. In the new ceramic tubes, such materials are exploited because high-temperature processing is practical and the troublemakers are removed while the tube is being pumped. Grid-emission problems are being attacked by

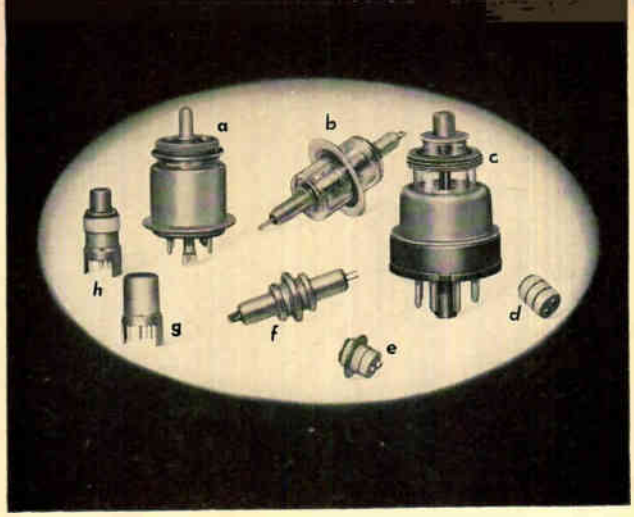


FIG. 2—New receiving-tube types: (A) WE-416B planar triode, (B) Sylvania 6BA4 Rocket planar triode, (C) Philips EC56 Lighthouse planar triode, (D) GE 6BY4 microminiature planar triode, (E) GE 7077 microminiature planar triode, (F) RCA 7552 ceramic Pencil triode, (G) RCA Nuvistor triode and (H) Nuvistor tetrode

metallurgical techniques and by constructions which provide improved heat flow.

As the causes of early failure are lessened, the ultimate life of the cathode assumes even greater significance. The long-life capabilities of oxide-coated cathodes are well known; current effort is directed toward consistent achievement of this capability with minimum cost. The Bell Telephone System has long experience with the need for long life, and it is significant that they have sunk thousands of specially designed and processed receiving-tube amplifiers to the bottom of the Atlantic and expect twenty years of continuous service.

Although cathode life is profoundly influenced by operating conditions of temperature and current density, the basic determining factors are the oxide coating material, the base metal and the gas or vapor environment during processing and operation. The chemical composition of the coating has not been changed radically, although recent improvements have been made in freedom from possible contaminating agents. The future holds many possibilities, however, such as pre-preparation of the coating in oxide form rather than as carbonates to be broken down during tube exhaust.

Recent years have shown a trend toward increasing purity of the nickel base metal and better control of the impurities used. The recognition of sleeping sickness, or interface resistance, led to use of less active nickels for certain applications. This experience demonstrated the general life improvement obtainable from the more pure metals, and removed some earlier stigmas relating to initial activation.

Within the last several years, normally active materials have almost disappeared from use. Materials once considered relatively passive are now thought of as normal, and tubes departing from this new standard usually use more passive materials.

The environment of the cathode is known to be of vital importance; certainly some materials are notorious as lethal cathode poisons. Although much remains to be learned about the theory of emission, and especially its application to practice, advances in metal technology and structures conducive to cleanliness, high-temperature processing and gas-absorbing metals are providing more healthful climates.

MECHANICAL ENVIRONMENT—The mechanical reliability of conventional tube designs has been considerably improved by design modifications and inspection procedures, but the new small tubes have even greater promise for the future. Miniaturization is itself an advantage. As a structure is scaled down, its resonant frequency increases in proportion to the scale factor and the displacement under stress decreases in proportion to the square of the scale factor. High resonant frequency is especially important because high vibration frequencies are usually less common, lower in amplitude and more easily absorbed in the transmission medium than low frequencies.

From the standpoint of microphonics or possible shorts, the reduced displacement under vibration or steady acceleration is partially offset by the use of smaller interelectrode spacings in the scaled-down tube designs. Nevertheless, there is a net advantage from the higher resonant frequency and the substantial reduction of displacement. Furthermore, the new designs are free from the sliding fits needed to allow for differential thermal expansion in conventional tubes, so that the troublesome low-frequency rattles associated with loose fits are avoided.

The physical survival of tubes under mechanical stress requires that internal stresses be kept within the elastic range of the materials and that damaging abrasion be avoided. The high resonant frequency and small displacement in small tubes combine to reduce chances of deformation. Furthermore, advanced technology is making available improved metals and insulators.

MECHANIZED ASSEMBLY—Cost often consumes more engineering effort than any other factor. In electron-tube manufacturing, parts fabrication has reached a high degree of mechanization, but considerable trained labor has been required in assembly. In the past several years, automatic cage-assembly machines have been developed. These machines have progressed from mere assembly of the cathode, plate and two mica spacers of simple rectifiers to the present state of assembly of double triodes and triode-pentodes. Heater insertion and welding to stem leads are still hand operations, but progress is being made on machine welding with relatively simple tube types. Cage-assembly machine speeds are in the order of 2,000 an hour, and both quality and cost of product can be superior to manual assembly.

The trend to mechanized assembly is especially apparent in the new ceramic tube designs; these structures were designed to fit a machine and so do not require the design of a machine to fit the tubes. There have been developments at Eitel-McCullough and Sylvania toward a stacked ceramic tube using ceramic washers as insulating spacers as well as parts of the tube envelope. The commercially available General Electric microminiature is similar in principle, and uses precision-ground ceramic insulators to maintain proper electrode spacings between planar electrodes. The RCA Nuvistor uses cylindrical parts which can be mechanically loaded into a jig that establishes electrode spacings before the assembly is brazed. Although none of these designs has been fully mechanized in production as yet, nearly continuous-flow automatic production is easily visualized.

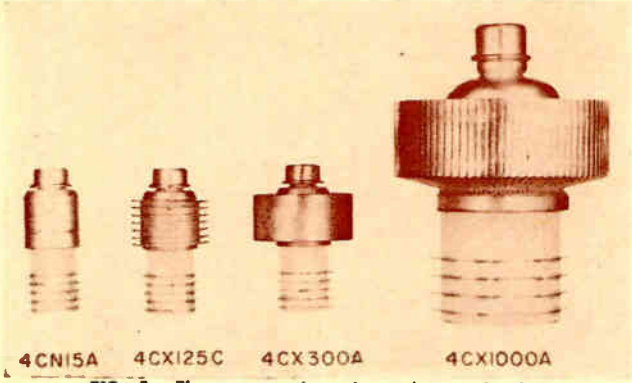


FIG. 1—Eimac ceramic-and-metol tetrode line

HIGH-VACUUM

By DAVID D. MEACHAM, Research & Development Marketing Product Specialist, Power Tubes, Eitel-McCullough, Inc., San Carlos, Calif.

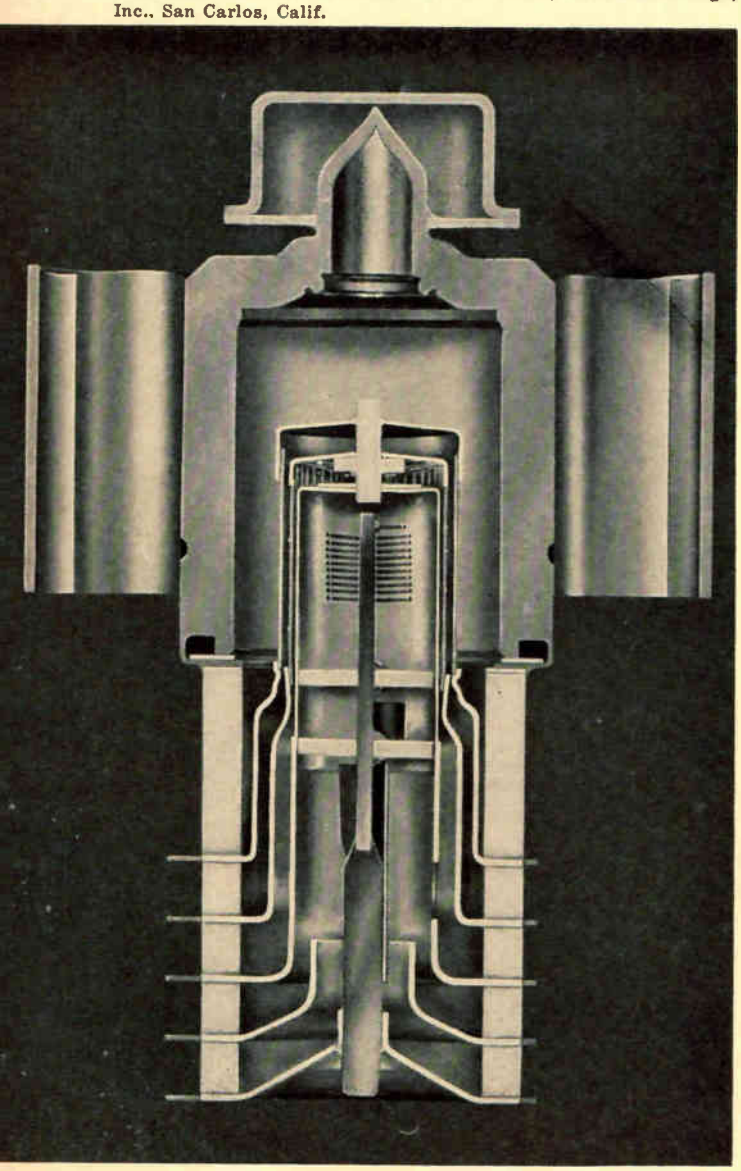


FIG. 2—Cross-sectional view of Eimac 4CX300A

THE POWER TUBE INDUSTRY has come a long way since the initial discoveries of Edison, Fleming, and DeForest. Present day tubes still retain, however, the basic original control-type electrode in one form or another. Electron optics may be much more sophisticated in modern tubes, but the operating principle is the same as that in the DeForest triode.

In recent years more exotic vacuum tubes have taken advantage of some of the inherent limitations of grid controlled tubes and have tended to overshadow the continuing advancements and importance of conventional power tubes. In addition, power tube manufacturers seem to be going in different directions, each company exploiting and emphasizing different special features, each with its own particular advantages. The content of this article is intentionally restricted to the most significant and proven advances which have occurred in the past two or three years and which are now reflected in production tube types.

RADIO FREQUENCY POWER TUBES—Increasing military demands for tubes which are highly resistant to shock, vibration, and constant acceleration have fostered the development of tubes with improved mechanical characteristics. An insulating material which has almost universally replaced glass in such tubes is aluminum oxide ceramic. This material is metalized and brazed to other metal tube parts resulting in a rigid envelope. Another advantage gained by the use of ceramic-and-metal construction is higher operating temperature limits. Maximum operating temperatures can usually be increased by 50 to 75 degrees centigrade over an equivalent glass insulated tube. This is due in part to the use of higher outgassing temperatures for ceramic-and-metal tubes. Another reason is the superiority of ceramic-to-metal seals over glass-to-metal seals at high temperatures.

Mechanical considerations in rugged tube design dictate that structures be made relatively small to minimize cantilever effects which cause excessive element movement under vibration. The use of ceramic insulators leads to

Conventional power tubes are constantly attaining higher frequency and power levels while their size is decreasing. Improvements include better electrode structures, high-temperature envelope and sealing materials, more efficient cathode materials and better heat sink design. Specific advances include mesh thoriated-tungsten filaments and vapor cooling

POWER TUBES

external anode construction. This type of anode is usually forced-air cooled rather than radiation cooled due to size considerations. An example is the Eimac tetrode line pictured in Fig. 1. These transmitting tetrodes feature stacked ceramic ring construction with external air cooled anodes.

Figure 2 is a cross-sectional drawing of the Eimac 4CX300A tetrode illustrating constructional details. The unitized electrode design is evident since the support for each element is a drawn truncated cone with a flange formed at the base for socketing tabs. This type of geometry results in an extremely rugged tube capable of withstanding high impact, acceleration, and vibrational forces. A ceramic insulating pin inserted between grid and cathode at the inactive top surfaces serves to join the internal assembly as a single mechanical unit. The cone-type electrode supports also result in very low series inductance which is attractive for very high frequency and ultra high frequency operation.

Electrical characteristics of the 4CX300A illustrate the high performance that may be obtained from modern ceramic-and-metal power tetrodes. The anode is capable of dissipating 300 watts with 11.7 cubic feet per minute of airflow at a static pressure of 1.20 inches of water at sea level with inlet air temperature of 50 C. Maximum ceramic-to-metal seal temperature is 225 C. Typical Class C amplifier operation at frequencies where tube and circuit losses are negligible results in 500 watts of r-f output power with 625 watts of d-c plate input power. The driving power under these conditions is only 2.8 watts. Typical operation at 500 megacycles, the upper frequency limit, is characterized by 500 watts input with 225 watts output. The tube is capable of withstanding impact forces of 50 g for 11 milliseconds duration or vibratory accelerations of 20 g at frequencies of 20 to 500 cycles per second

ONE-PIECE ELECTRODES—A different approach to ceramic-and-metal tube design is reflected in the RCA line of tetrodes featuring one-piece electrode fabrication. The 6816, pictured in Fig. 3, and the 7213, Fig. 4, both incor-

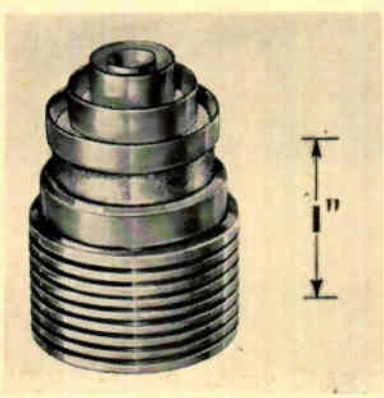


FIG. 3—Ceramic-metal tetrode with one-piece electrode construction, RCA 6816

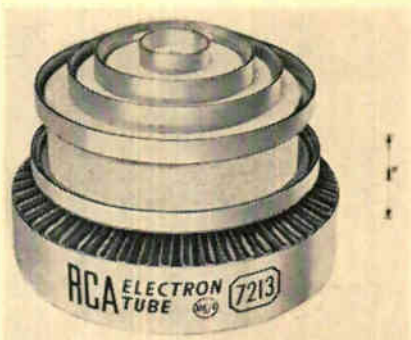


FIG. 4—Ceramic-metal tetrode with one-piece electrode construction, RCA 7213

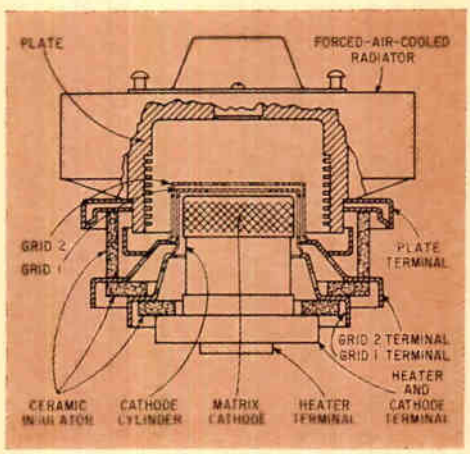


FIG. 5—Structural arrangement of RCA 7213 tetrode

FIG. 6—Shielded triode, RCA 6949

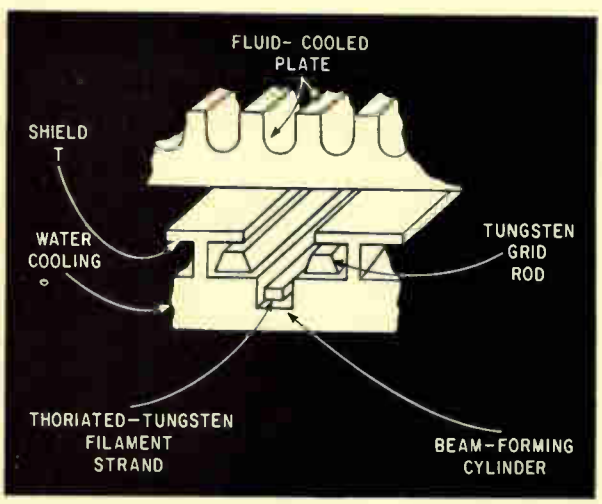


FIG. 7—Cross section of electron optical system used in RCA 6949

porate this new type of electrode construction. One-piece construction makes for manufacturing simplicity equal to that of a triode. With this kind of fabrication the tetrode has the advantage over the triode since either better performance can be obtained with the same structure or identical performance can be secured with a coarse and more reliable structure. Figure 5 is a cross-sectional view of the 7213.

The control grids and screen grids in these two tubes are formed by a unique new method.[1] Special copper-alloy grid and screen cups are first drawn by conventional techniques and then brazed to copper-clad Kovar support cones. Pressure rolling is the next step to obtain the correct wall-thickness and to straighten the cups with respect to the supports. Finally the parts are jigged and brazed together with a ceramic ring, completing the preparation for the new process. The grid and screen bars are now simultaneously formed by removing material, one slot at a time, with an electronic eroding process. An electron discharge machine is used to remove the material. This process assures accurate grid-screen alignment because both grid and screen are formed at the same time and are held in alignment by previously brazed joints. The copper-clad Kovar support cones extend out through the seals and these together with the one-piece electrode construction provide short heat paths and low r-f losses. Low thermal loss leads to cooler grids and therefore to grids having desirable low emission characteristics and high dissipation capability. This type of structure is also rugged and is suitable for use under adverse environmental conditions.

Another feature of the RCA 6816 and 7213 is their one-piece cathode sleeves. A single nickel cup is formed into a cylinder, a portion of which is rolled very thin, creating an integral and unbroken heat dam. In addition, the 7213 features a matrix-oxide cathode material. This cathode material consists of porous nickel impregnated with barium-strontium carbonate by a cataphoretic process resulting in a cathode which is resistant to ion bombardment and arcing, and which has long life due to the reserve of emissive material.

For an example of performance characteristics, consider the 6816 which carries a rating of 180 watts maximum c-w input power up to 1,200 megacycles. The maximum plate dissipation is set at 115 watts. Forced-air

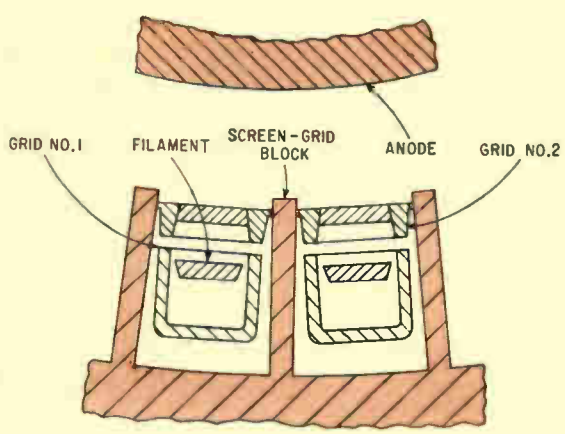


FIG. 8—Unit electron control system used in RCA 6952

FIG. 9—RCA type 6952 tetrode

cooling at a rate of 10 cubic feet per minute is sufficient to keep the seal temperature below the maximum temperature of 250 C at sea level with inlet air temperature of 50 C and maximum plate dissipation, provided that a suitable air cowling is used. Typical Class C operation at 400 megacycles results in 80 watts of r-f power output with 153 watts of d-c plate power input. At 1,200 megacycles with the same input power the r-f output is halved to 40 watts. Driving power at 400 megacycles is 3 watts, at 1,200 megacycles it is 5 watts.

SUPER-POWER TUBES—A spectacular achievement in recent years has been the development of a number of super-power electron tubes. In the power tube (grid-controlled) field a typical example of super-power c-w tubes is the RCA 6949 shielded-grid beam triode pictured in Fig. 6. Tubes of this type use a new electron-optical system which has many advantages.[2] A view of one unit of such an electron-optical system is shown in Fig. 7. Typically, a complete tube consists of a large number of these units (24 in the 6949) in a circular array. The active elements form an annular ring with the beam-forming cylinder on the inside; the cylindrical anode forms the outside of the annulus. Both inside and outside cylinders are water cooled. The cathode consists of a number of thoriated-tungsten filament strands set in slots in the beam-forming cylinder. Two pure tungsten grid rods of trapezoidal cross-section are positioned on either side of the filament slot. These grids are in turn shielded by part of the beam-forming cylinder formed into the shape of a letter T in cross-section. The electronic effect is that of grid control and very good separation of input and output circuits, permitting grid-driven operation well into the vhf region. In addition, little beam current is intercepted by the grids. The multiplicity of units essentially in parallel results in high perveance and also high power capability since there is ample surface area in contact with the cooling water. Because of the unique electron-optical system the shielded-grid beam triode exhibits little curvature of constant current plate characteristic lines. This feature enables the tube to operate with low distortion in linear amplifier service. The use of radial-compression ceramic vacuum seals in the 6949 is also worthy of note.

As an example of super-power performance, the RCA 6949 can deliver 500 Kw of c-w power output up to 75 megacycles. At 425 Kc this same output power can be obtained with only 2 Kw of driving power. Plate dissipation is set at 400 Kw maximum and plate voltage at 20 Kv. The maximum d-c plate input is 1,000 Kw.

Super-powered tetrodes have also appeared in recent years, developed by RCA, using somewhat the same geometry as the shielded triodes.[2] Again a circular array consisting of many individual unit electron-control systems comprises the complete tube, except that in the tetrodes the anode is the inner cylinder and the outer cylinder is the screen-grid block, within which are nested the filament and control-grid assemblies as shown in Fig. 8. In this system conventional wires are used for grid and screen; however, they are specially wound and aligned for each unit on a channel-shaped support in the case of the grid, and on a window panel to make up the screen.

For short-pulse service, instead of using thoriated-tungsten filaments, a matrix-oxide coating is applied to directly-heated filament strands in RCA super-power tubes to obtain high peak-emission currents at low duty factors.[2] At the same time the heating power is reduced to about 10 percent of that required for thoriated-tungsten filaments.

Typical performance of super-power tetrodes intended for pulse applications is illustrated by the ratings of the RCA 6952, Fig. 9. This tube is designed for use as a grid-driven plate-pulsed amplifier in the frequency range of 174 to 600 megacycles and will deliver 2,000 Kw peak power output at 425 megacycles in short-pulse service. It incorporates 40 individual electron-control units.

POWER TUBES FOR PULSE MODULATORS—More radar applications are appearing for hard-tube pulse modulators. Hard tubes are attractive for pulse modulator use because of their lack of finite delay and recovery times (ionization and deionization times). They are capable of performing at high switching rates and without bothersome jitter. An approach for high perveance in pulse modulator tubes is the shielded-grid triode design by Machlett Laboratories, Inc. This design consists of a multiple radial beam structure as shown in Fig. 10. The cathode cylinder is splined with a large number of grooved cathode slots, which in cross-section are semi-circular. An oxide coating is applied to the surface in each slot. Opposite the land between each

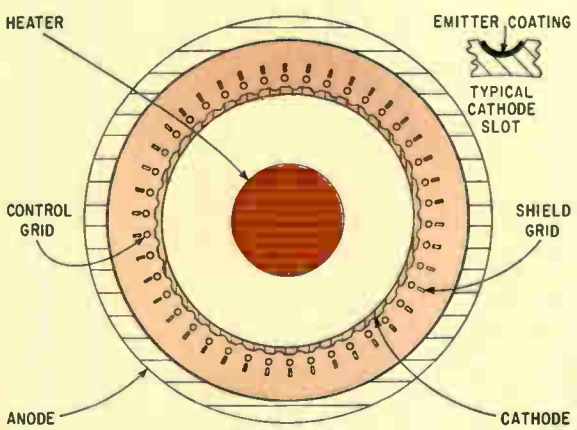


FIG. 10—Electrode structure used in Machlett ML-7002

FIG. 11—Machlett ML-7002 shielded-grid triode

FIG. 12—Machlett ML-7482 vapor-cooled triode

FIG. 13—Triode with aluminum cooler, Machlett ML-6697

cathode slot is a round grid bar. In line with and beyond each grid bar is a shield grid, rectangular in cross-section, which is connected to the cathode. Finally, the outer cylinder makes up the anode. Such an arrangement minimizes grid current, provides high mu, and is used in the ML-7002 shown in Fig. 11. This tube is capable of switching 3,500 Kw of 6 microsecond pulse power in pulse modulator applications.[3] The ML-7002 operates at 65 Kv with a plate dissipation of 2,000 watts and is cooled by immersion in circulating oil.

MISCELLANEOUS FEATURES—An innovation which is quite popular in Europe but has yet to find wide acceptance in the United States is the mesh thoriated-tungsten filament. Rather than conventional filamentary strands arranged in a cylindrical shape, it consists of a mesh of crisscrossed wires welded together at the cross points and formed into a cylinder. This type of filament has the advantage of a more or less unipotential surface and is more rugged than conventional filaments. It is suited for high frequency operation since more emission can be obtained with much less overall length.

A new technique which makes tube socketing simplified and positive is the Eimac breechblock base. This base is used on all the tubes pictured in Fig. 1, the only difference being in the number of tabs on the particular tube.

With this breechblock base a tube is inserted into its mating socket and turned clockwise a fraction of a turn, locking firmly into place. This type of socketing eliminates broken finger stock and uncertain seating sometimes associated with coaxial based tubes. It also provides a path for cooling air to flow past the base seals on the way to the radiator.

Vapor cooling of external anode tubes is popular in Europe and is now finding acceptance here in the United States. Vapor cooling takes advantage of the high heat of vaporization of water to cool the anode. The external anode incorporates a number of massive fins which increase the effective area exposed to the cooling water and also serve to stabilize the heat transfer characteristics. Figure 12 shows the Machlett 7482 general purpose vapor cooled triode, and is a good example of vapor cooled anode geometry. This anode is only 10 inches in diameter, yet it is designed to dissipate 200 Kw with reserve dissipation for momentary overloads. The ML-7482 operates at a maximum plate voltage of 20 Kv and plate input of 600 Kw at frequencies up to 30 Mc. It is also capable of switching 14 megawatts in pulse modulator service.

Aluminum cooling fins on low power external anode tubes have been commonplace for years. A relatively recent development is a high power triode using a large aluminum cooler, the Machlett 6697, pictured in Fig. 13.[4] The advantage is a large saving in total weight. The ML-6697 weighs only 29 pounds, yet it is capable of dissipating 35 Kw. The cooling fins are approximately 5 inches in diameter and 10 inches long. Use in a special air distributor takes the utmost advantage of the large number of fins and requires an inlet flow rate of 1,700 cubic feet per minute at a static pressure of 7.8 inches of water with an ambient air temperature of 50 C. The tube has maximum ratings of 16 Kv d-c plate voltage and 120 Kw d-c plate input power up to 30 megacycles. In typical Class C operation the ML-6697 delivers 80 Kw of r-f output power with a d-c input of 105 Kw and r-f driving power of 600 watts.

The author acknowledges the assistance of A. P. Sweet and W. Bennett of the Radio Corp. of America, and of Dr. H. D. Doolittle of Machlett Labs.

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Progress in gas tubes has come largely from the availability of new materials and the improvement of sealing techniques. Today, the gas tube business stands on the forefront of science with interests in many vital fields.

FIG. 1—High vacuum thermianic converters having an output of one watt at ½ to ¾ volt direct potential

GAS-FILLED TUBES

By H. C. STEINER

Power Tube Department, General Electric Company, Schenectady, N. Y.

THE LAST DECADE in gas tubes has been marked more by the design of special tubes for new and special applications than by the introduction of radically new devices or principles. New materials, such as zirconium, titanium, niobium and various nitrides, borides and hydrides, have become commercially available and are finding application in electron tube designs. Ceramic materials and ceramic sealing techniques, first developed and used in high-frequency tubes, are finding use in gas tubes when precise spacing and high temperature operation are required. Titanium and its matching ceramic permit the assembly of certain types of gas filled tubes by clean techniques.

RESEARCH—The largest current research project in gas discharge phenomena is undoubtedly Project Sherwood. Project Sherwood is the U. S. Atomic Energy Commission's designation of the quest for atomic power generation through the thermonuclear fusion of deuterium and tritium. Similar projects exist in England, Europe and Russia. To create the conditions for self sustained reaction, the heavy hydrogen atoms must be raised in energy to temperatures ranging from 45 million degrees (Kelvin) to over 400 million degrees. Ignitron tubes perform important control functions in these studies.

Studies directed more specifically toward developing low-arc-drop controllable rectifier tubes were conducted by Malter, Johnson, and Webster, and Wehner and Medicus. From this work was developed a tube called the Plasmatron. The tube consisted of a main anode and cathode, and an auxiliary source of electrons which could be used to create ions in the space between the main anode and cathode. The tube was filled with helium gas at about a millimeter pressure and the anode supply voltage (a d-c battery for inverter operation) was maintained below the ionization potential of helium (24.46 volts). The auxiliary cathode was garroted by an enclosing grid with small openings so that ionization did not occur inside the grid. Variation of the auxiliary cathode potential with respect to the main cathode from 0 to approximately 100 volts provided control of the anode current. In a design modified by introduction of a grid between the main anode and cathode, control of the main anode current was obtained, with constant auxiliary ion generation by varying the ion sheath thicknes around the grid wires and thus making the conduction cross-section larger or smaller.

A further outgrowth of these gas discharge studies was

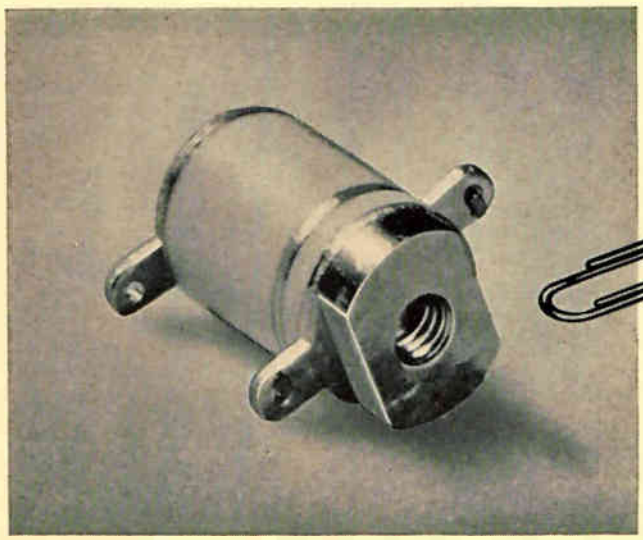


FIG. 2—Ceramic hot-cathode xenon diode for 400 C operation is relatively insensitive to atomic radiation

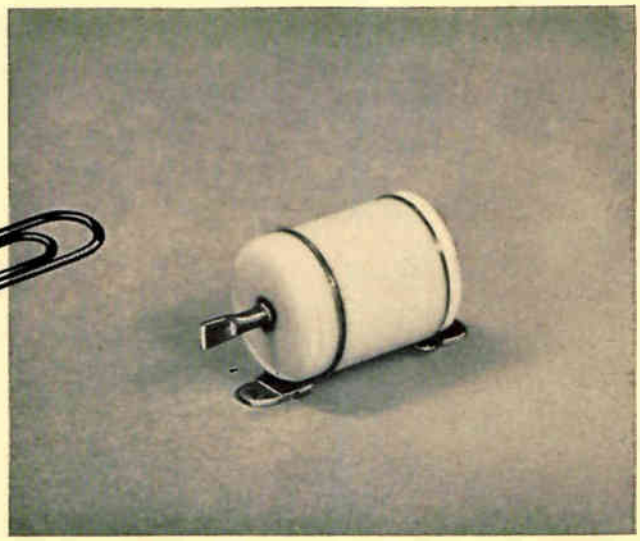


FIG. 3—Ceramic, shock-resistant triggered spark gap designed for remote switching of stored energy and for protection

the development of a low-noise thyratron capable of current interruption by grid action. The tube, called the Tacitron, operated by limiting plasma formation to the region between the grid and anode. Fine grids were required to prevent ion diffusion into the cathode region. The usual noise in arc discharges was virtually eliminated and current cutoff was achieved at least within the limits of the laboratory models.

Considerable attention is being devoted currently to the possibility of the direct conversion of heat to electricity by thermionic converters. The reason for this interest is the need for light-weight power supplies for satellites and space vehicles. Other forms of converters, such as thermal-electric, solar cells, other semiconductor devices and fuel cells are under consideration. Thermionic converters, however, are unique in that the heated area can be operated at a temperature sufficiently low to be contained by presently available materials. Low temperature area can be operated at a sufficiently high temperature to permit dissipation of losses by direct radiation from reasonable size and weight radiators.

Thermionic converters consist essentially of a heated cathode for electron emission and an anode for collection. Both vacuum or gaseous conduction designs are under investigation. The cathode is selected and operated to have a high work function and the anode a low work function. The difference in potential between these two work functions represents the emf available for overcoming the internal losses in the device and providing useful output. Figure 1 shows developmental samples of the vacuum converters presently being produced.

In the vacuum converter the internal losses are minimized by placing the anode close to the emitter, separations of the order of 0.0002 to 0.0005 inch being required. In the gas or vapor converter spacing is less critical since positive ions are generated and these serve to provide a medium through which the electron charge may travel with minimum work. Such ions are generated when atoms of a vapor having a low ionization potential (cesium—3.87 volts) strike a heated surface of higher work function (for example, tungsten—4.52). Efficiencies of 5 to 6 percent, and roughly double these values for the vapor devices, are indicated. Outputs of the order of 0.5 to 1 watt/sq cm at 0.5 to 0.7 volt have been attained in the vacuum device. Output in the range of 1.5 to 2 volts seem attainable for the vapor devices.

COLD CATHODE GAS-FILLED TUBES—Missiles, high-speed jet planes and space ships require regulator tubes capable of operating at elevated temperatures (300-400 C) and of withstanding high accelerations (Mach 3 or more) and shock. Using some of the new ceramics and matching metals together with clean techniques, some remarkably stable regulator tubes have been produced. The voltage variation with life of such a tube operating at 105 volts and at the elevated temperature of 400 C was not more than 0.1 volt over 1,100 hours of test. Figure 2 shows a hot-cathode, gas-filled ceramic diode of about the same size and appearance as the regulator tube and for operation under the same environmental conditions. In addition to withstanding temperature and shock both the diode and regulator are relatively insensitive to atomic radiation.

Triggered spark-gaps, Fig. 3, using the same general techniques provide essential protection and the control of stored energy in certain systems. The gaps are designed to withstand potentials in the range of 2 to 10 Kv and to rapidly transfer from the glow to the arc stage on triggering.

Capacitor-protective gaps have been developed for voltage limitation in systems using series capacitors for power-factor corrections. Lagging power factor loads can be corrected at the load point through the installation of series capacitors. Normal operation is improved but in event of a fault which short circuits the normal load resistance, the LCR stability of the system may change from nonoscillating to oscillating, with appreciable over voltage developing across the capacitor. To protect the capacitors these gaps conduct with approximately 100 percent over voltage and maintain it until the capacitor fuse opens, or cease conduction if the fault is removed.

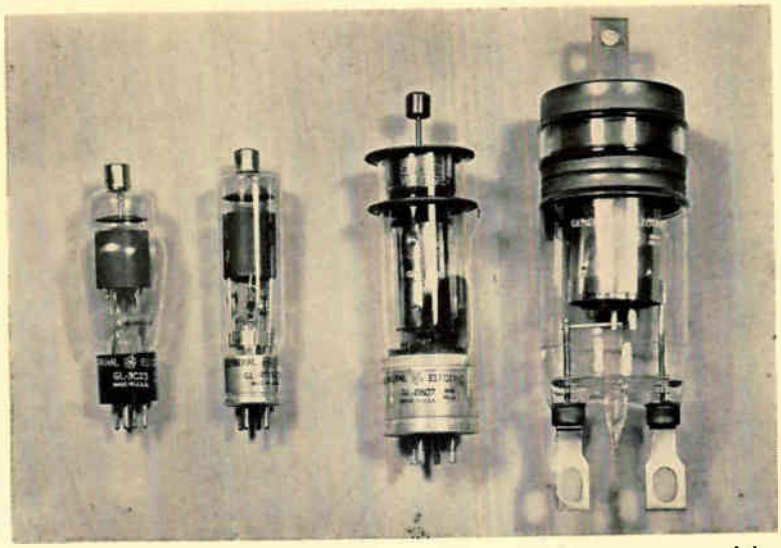


FIG. 4—Typical gas-mercury thyratrons on left, xenon-gas thyratrons on right. Current capacity ranges from 2½ to 18 amp (avg)

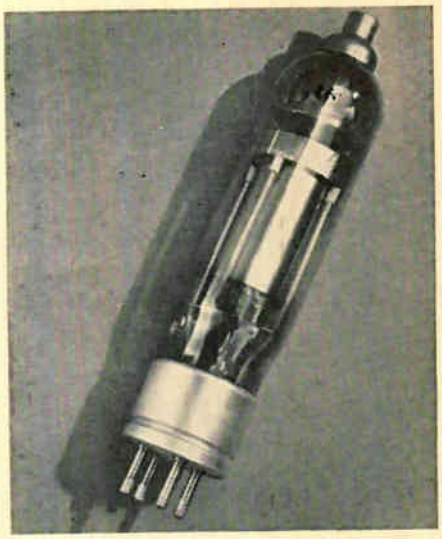


FIG. 5—Xenon-filled thyratron with nickelate filamentary cathode carries 6.4 amperes

THYRATRONS—There has been a trend in the past decade toward fast-heating filamentary cathodes and inert gas, or combinations of gas and mercury in place of mercury vapor alone for the plasma medium. Figure 4 shows a group of gas and gas-mercury vapor thyratrons with peak inverse voltages rating of 1000-1500 volts.

Mercury-vapor thyratrons, particularly those with the slow-heating unipotential cathodes, provide extremely stable operation and long life in applications where the tube is in continuous service. Tubes with shielded grid design operate through 10 megohm to 100-megohm grid resistors while still controlling amperes in the output.

The slow heating (3-5 minutes) cathodes minimize heating power requirements and permit large active emitting areas to be incorporated with resulting low emission densities. Starting difficulties tend to occur at too low mercury temperatures (10 C and below) while loss of control and arc back may occur at temperatures in excess of 90-100 C, depending somewhat on the anode voltage.

Inert gas tubes such as the 5828/C6L (Fig. 5) are essentially immune to ambient temperature changes since the density of the gas determines the tube characteristics and the density does not change with temperature after initially loading. The cathodes are usually of the filamentary type for fast heating and the barium nickelate coating has proved satisfactory in performance. Initially, clean up of the inert gas was a problem in applications having highly inductive loads and with the rectifier operating at large angles of phase control. Under such conditions the current at the end of conduction decreases rapidly and the initial inverse voltage rises rapidly and to relative high magnitudes. Reduction in the commutation factor ($di/dt \times de/dt$) either by slowing down the rate at which the inverse voltage appears across the tube with R-C snubber circuits or decreasing the rate of current change with commutating reactors provides satisfactory control. In another approach the space between the grid and anode is reduced thereby minimizing the volume of ionized gas that must be collected at the end of each conducting period. Gas cleanup is correspondingly reduced.

The combination of an inert gas, such as argon, with mercury seeks to remove the low temperature limitation of mercury vapor by the addition of the inert gas and to retain the practically inexhaustible supply of vapor that is present in even small drops of mercury. Argon, with an ionization potential of 15.7 volts, is usually added so that the mercury vapor (ionization potential 10.4 volts) will provide the gaseous medium for most conduction. The upper temperature limit is not seriously lowered since the pressure of mercury increases so rapidly at temperatures above 90 C that it quickly becomes the determining factor.

HYDROGEN THYRATRONS—Hydrogen thyratrons were developed during World War II to provide pulse modulation for magnetron tubes in radar systems. Activity languished at the end of the war and remained dormant until the increasing evidence of the cold war and the increasing speed of planes sharply focused attention on the need for improved devices. As a result the Services initiated an active development program that resulted in improvement in both performance and life of the hydrogen thyratron tubes.

Hydrogen thyratrons in pulse modulator service are high-speed switches which must conduct high peak currents for durations of 1 to 2 microseconds and at repetition rates of a few hundred to a few thousand pulses per second. It is essential that full conduction be established in a fraction of a microsecond and that the tube regain control in a few microseconds at the end of the conduction period. Average current is low and the peak current high. Typical values for the type 5948 are 1 ampere average, and 1,000 amperes peak. At 25 Kv charge on the pulse forming network the tube controls a discharge of 25 megawatts. Useful power output, the usual basis for designating the tube size, is 12½ megawatts since in normal applications the line and load are approximately matched in surge impedance and half of the voltage appears across each portion.

The design of hydrogen thyratron tubes requires spe-

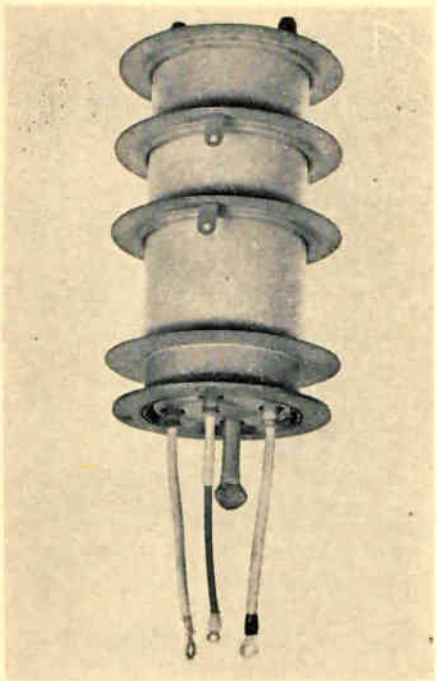


FIG. 6—Forty-eight megawatt GE ceramic hydrogen thyratron

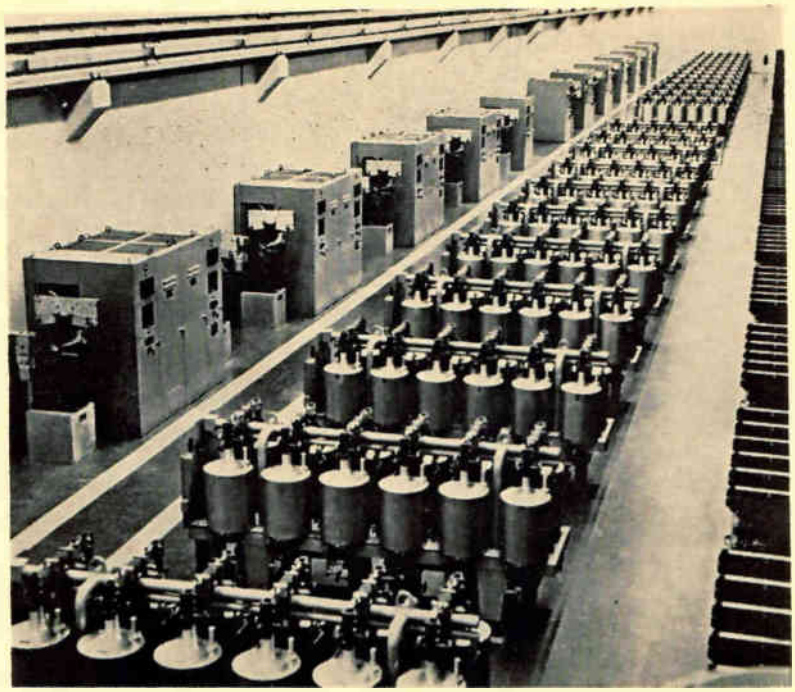


FIG. 7—Bank of G-E pumpless rectifiers which supply aluminum smelting pot line at Aluminum Company of America's Rockdale, Texas plant

cial attention to spacings, gradients and gas density. The tubes are designed to operate with positive grid pulses and without the usual negative grid bias desired in most industrial thyratron applications. The grid encloses the anode completely and the arc passages are devious. As a result the arc-drop is higher than in negative grid tubes and the gas density must be higher. Arc losses in the anode and grid regions are much higher than in industrial thyratrons and reach magnitudes of several hundred volts. An appreciable contributing factor is the time to ionize during the starting period. In spite of the fact that ionization is established in a small fraction of a microsecond, the loss during the anode potential fall from line voltage to arc drop is appreciable as the plasma is forming and current begins to flow. An anode-dissipation-factor is recognized in the ratings to control this loss. It is defined as the product of the peak voltage, peak current and repetition rate.

Hydrogen reservoirs have been provided in the larger hydrogen thyratrons to maintain the desired gas density. Hydrides, such as those of zirconium or titanium, are used to store the gas. These materials have the property of being self regulating—that is, the hydride will release or absorb hydrogen depending on whether the gas density is above or below the equilibrium pressure corresponding to the temperature at which the reservoir is operating. Relatively large volumes of gas may be stored—with the result that hydrogen cleanup is not a critical factor in the life or performance of the tube.

With the need for radar equipment having greater range and higher definition, larger hydrogen thyratrons are needed. Development work funded by the U. S. Signal Corps and U. S. Air Force is still in progress but the more compact designs and the performance of the tubes presently developed amply justify using ceramic construction. Figure 6 shows one of these tubes.

MERCURY POOL TUBES—The extremely high emission capabilities of cathode spots on a mercury pool have made mercury pool tubes a favorite for high current applications. Glass bulb rectifier designs with 3 to 6 anodes in side arms reached capacities of the order of 400 amperes, d-c, at 600 volts output. Metal tank designs with 12 to 24 anodes attained capacities of several thousand amperes. The continuous presence of the load current and the resulting high ionization present dictated that the nonconducting, negative anodes be withdrawn from the high ionization region. Anodes and grids were, therefore, shielded in extended arms or tubes, and the relative long arc path resulted in arc-drops of 24 volts or more.

Rectifier ignitrons of the types shown in Fig. 7 have found extensive application in the conversion of a-c into d-c for the electrolytic formation of aluminum from aluminum oxide (bauxite ore), for the electrolytic separation of gases such as chlorine oxygen and hydrogen, and for variable-speed motor drives in steel mills as well as for general d-c shop supplies.

Reversing steel mill drives are becoming increasingly important in the rebuilt steel mills of Europe and in the constant improvement programs in the United States. The ability of such rectifiers to reverse rapidly the direction of the roll motors during ingot-reduction permits rolling operations to be completed without time-consuming ingot reheating cycles.

Special designs of ignitrons have been developed for locomotive rectifier service. Motivating influences for the use of such rectifiers are that they permit standardization of the traction motors with the types used on diesel-electric locomotives; the high-torque response of the d-c motor at standstill; and the possibility of securing trolley power directly from existing 60 cycle utility systems.

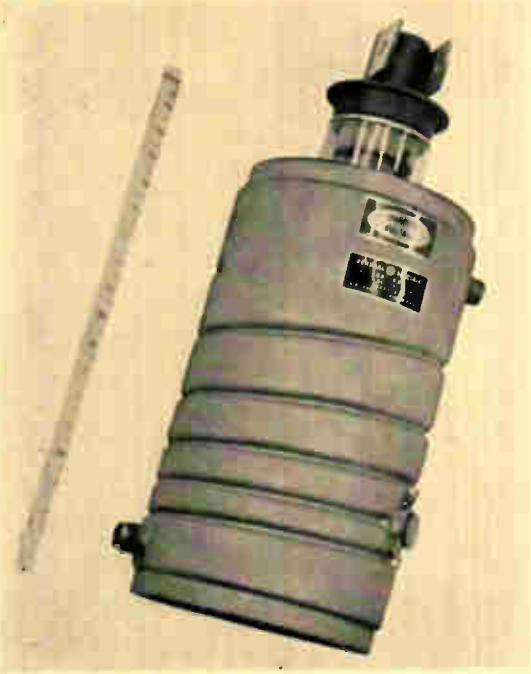


FIG. 8—Ignitron 7151 con switch 4,800 Kva (two tubes in inverse parallel) at potentials of 250 to 600 v

WELDING CONTROL IGNITRONS—In resistance welding two ignitron tubes are assembled in a back to back connection to form a nearly inertialess switch to control the primary current to the welding transformer. Primary currents during the weld reach magnitudes of 1,000 to 10,000 amperes. These currents are conducted from 1 to 20 or 30 cycles depending on the material being welded. Precise control of the number of cycles in each weld is extremely important, particularly when thin materials are being joined and each weld is of a few cycles duration. Additional controls in the thyratron circuits permit preheat, heat variation during the weld, and finally annealing functions to be planned in the weld cycle. The precision and weld quality that these controls give plus the low maintenance of the ignitron switch have made this system the standard for resistance welding equipment.

Early in the development of the welding ignitron tubes size standards were established on a preferred-series basis in which the Kva capacity for two tubes doubled for each successive increase. The latest and largest tube to be added to the series is in Fig. 8.

Temperature controlled ignitrons were introduced recently for this service. Temperature control prevents over heating of the ignitron tubes in case the cooling water is not turned on or the supply is inadequate. Equally important it permits appreciable water saving. Older protection schemes incorporated special water relays that were designed to provide protection against inadequate water flow. Inadequate water flow and the resulting overheating can cause the ignitron tubes to lose control and conduct continuously. Continuous conduction causes burning of the work and the electrodes. Two forms of control have been developed—the Zehner integral bowed-strip thermostat system and the clamp-on thermostat system. Each system has its unique advantages.

In the bowed-strip system the expansion of the inner cylinder of the ignitron with increase in temperature is compared to a slightly bowed strip of a low-expansion alloy attached to the outer cylinder. As the inner and outer cylinders expand the bowed strip moves closer to the outer cylinder, and, at a predetermined setting activates one or two microswitches. Usually, one switch is adjusted to turn on an electromagetically operated water valve and the other is adjusted to a slightly higher temperature to sound an alarm or shut down the equipment. The system will protect against the extreme condition of full load through the tubes and no water flow.

In the clamp-on thermostat system a separate bimetal thermostat is attached to a pad (shown in Fig. 8) that indicates the temperature of the inner cylinder and the cooling water. The response of this system is fully satisfactory. Separate thermostats are available to perform water-saving and over-temperature protection functions. When both functions are needed, one thermostat of each type is mounted on each of the two ignitrons customarily used in the welding control. In many cases, only over-temperature protection is used.

Coaxial return of the cathode current is becoming an increasingly important design consideration for pulse welding ignitrons, thermonuclear ignitrons, locomotive ignitrons and radar. Generally the cathode current is conducted coaxially along tube-enclosing cylinders. This minimizes external magnetic field and prevents distortion of the arc path from fields of associated buses.

NUCLEAR STUDIES—Ignitron tubes of existing and modified designs as well as some designs specially developed for particular functions have found application in this interesting field. In particle accelerators of the Synchrotron and Bevatron types the charged electron or porton particles are accelerated to velocities approaching the speed of light before being diverted to impinge on the target material under study The acceleration takes place in machines of the Bevatron type in an evacuated tube shaped in the form of a doughnut. The doughnut varies from several feet in diameter in the lower energy accelerators to hundreds of feet in high energy machines.

The particles are maintained in their circular orbit by magnetic fields which must increase as the speed of the particles increase. Energy for the magnetic fields is usually stored in static capacitors in the smaller machines, and in rotating fly-wheel generators in the larger machines. The stored energy is discharged into the orbit magnetic coils through ignitron tubes which serve to initiate the start of the current at a precise instant and to conduct the high peak currents required.

Special, high-voltage, high-current ignitrons have been developed for the Project Sherwood thermonuclear fusion studies previously discussed under "Research". The GL-7171, rated at 10 Kv and 35,000 peak amperes, and the Z-5385 capable of operation at 20 Kv and 60,000 peak amperes, are typical of these new developments.

IGNITRONS IN RADAR SERVICE—High-power, long-range radars such as the BMEWS system are necessary for tracking satellites and missiles. High-voltage, pentode ignitrons are used in pulse modulators for switching and for crowbar protection of the output tubes.

LINEAR-BEAM MICROWAVE TUBES

Klystrons and traveling-wave tubes and beam-type parametric amplifiers provide high gains, wide bandwidths and high power outputs. New traveling-wave tubes afford gains up to 60 db. Tubes with liquid-cooled helices may handle 10 Kw at S-band. Some high-power klystrons for radar can produce up to 25 Mw peak power. Other klystrons can deliver 10 Kw continuous power at S-band

By VINCENT R. LEARNED, Director of Research and Development, Electronic Tube Division, Sperry Gyroscope Co., Great Neck, N. Y.

LINEAR BEAM MICROWAVE TUBES, exemplified by klystrons and traveling wave tubes (twt's) provide new forms of amplifiers, oscillators, mixers and frequency multipliers capable of performing a wide variety of functions useful to system designers. High gains (over 60 db), wide bandwidths (one octave), and exceptionally high power outputs (megawatts) are available in these tube types. They lend themselves to a variety of modulation methods, and find an increasing variety of applications both in c-w and pulse systems.

Linear beam microwave tubes are characterized by an electric field circuit that interacts longitudinally with an electron beam to extract kinetic energy from electron groups and provide useful amplification and power output. Klystrons and twt's are distinguished primarily by the nature of their interaction circuits. The twt circuit is nonresonant and continues along the beam; in the klystron the circuits are resonant and spaced at intervals along the beam.

The basic varieties of klystrons and twt devices are distinguished by the focusing systems used to obtain long, dense electron beams of controlled diameter. There are five principle systems in use.

ION FOCUSING—A fortuitous ion phenomenon used in early klystrons neutralizes the heavy space charge of the electron beam to allow its travel through several resonant cavities. This simple approach prohibits pulsing because of delay in ion build-up and is limited in power by interaction grids which intercept the beam.

SPACE CHARGE FOCUSING—A convergent electron gun forms trajectories that squeeze electrons together so that the beam converges into a neck sufficient for passage through the interaction structures. Axial electric fields in the structures help extend the neck through the interaction region. This is useful for relatively short, pulsed beams and eliminates focusing magnets.

MAGNETIC FOCUSING—(Called Brillouin focusing in early theory.) In the modern system developed ten years ago by Wang, the cathode and collector structures are external to a longitudinal field in the interaction region, permitting very large cathode surfaces for tremendous current densities in the beam (1,000 amps per sq cm). This method is basic to megawatt tubes.

PERMANENT PERIODIC MAGNETIC (PPM) FOCUSING—Small thin disk permanent magnets interleaved with pole pieces provide periodically reversing magnetic fields along the axis of the tube. See Fig. 1. The beam can be controlled over long distances with a structure much lighter than solenoids or solid magnets.

ELECTROSTATIC FOCUSING (ESF)—More recently, a periodically reversing electric field along the beam is being applied in the manner of magnetic fields. The system is undergoing considerable laboratory development and only a few tubes with this system are available.

TRAVELING WAVE TUBES—The traveling wave tube is characterized by a helix, loaded waveguide, or other slow-wave structure which interacts with a long narrow

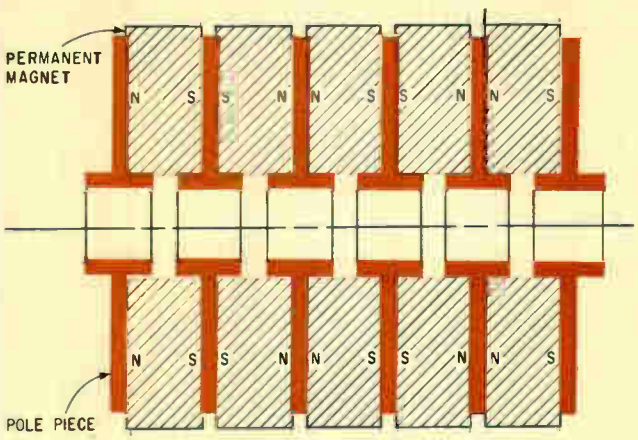


FIG. 1—Arrangement of several sections of permanent periodic focusing magnets for a traveling-wave tube

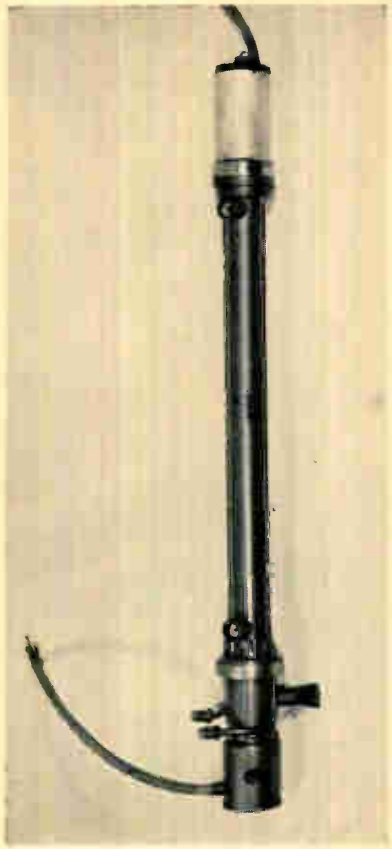


FIG. 2—Traveling-wave tube delivers 200 watts continuous power at 7,000 to 11,000 Mc

electron beam. Available power and gain depend generally upon the density and length of the beam and its degree of coupling with the interaction structure. Since slow-wave structures can be nonresonant, bandwidths of an octave or more are often obtained.

Earlier twt's employed glass, helix slow-wave structures, external matching structures, and focused the beam by immersing it in the field of a solenoidal electromagnet. They exhibited low gain and power, high noise figure and considerable variation in gain over the band. Up to five years ago, few twt's were sufficiently rugged for the severe environments of modern systems.

Some recent developments have brought twt's into a growing number of system applications.

Improved focusing systems permit high power handling—hundreds of watts c-w and megawatts peak.

Metal-ceramic construction has been developed for severely exposed temperature, vibration and shock environments.

Improved integral attenuators and matching circuits within the tube provide uniformly high gain over an octave band.

Improved shielding of all-metal structures produces gains over 60 db. Gain over an octave band can now be large enough to produce large amounts of noise power.

Metal-ceramic structures enabling operation at near incandescent helix temperatures now yield as much as 550 watts c-w in the 2,000- to 4,000-Mc band.

As a result of these developments, a wide variety of reliable twt's are now available for high-gain c-w, high-power c-w, and high peak pulse power service. See Fig. 2.

PERIODIC FOCUSED TWT—Currently, most high-gain low-power twt amplifiers have been converted to ppm focusing to make neat, lightweight packages as shown in Fig. 3. These are suitable for a wide variety of system applications. Esf focusing has been applied to high-gain twt's at low microwave frequencies. A bifilar helix with separate voltages on each helix provides the periodic focusing. The present limits of insulators and field emission limit these tubes to frequencies below 4,000 Mc. For wideband helix tubes, present esf tubes are primarily low power amplifiers. Potentially the techniques can yield power tubes in the less than 2,000 Mc range.

The low-frequency higher-power traveling wave tube is also adaptable to ppm focusing to reduce magnet weight and power. However, as frequency and power are increased beyond the range of one kilowatt pulse at C-band, the tube designer must resort to solenoid focusing for a broadband helix type tube. For narrow bands the development of periodic and electrostatic focused tubes with loaded waveguide structures looks promising through the higher frequency bands.

WIDEBAND TWT APPLICATIONS—The wideband twt's are capable of octave bandwidths and are useful in electronic countermeasures and reconnaissance or navigational systems requiring large bandwidths. They serve as driver amplifiers for radar transmitter chains and also provide the extreme bandwidths needed for multiplier or mixer service in these amplifier chains. Typical octave-bandwidth tubes will multiply seven or eight times with a net conversion gain. For mixer

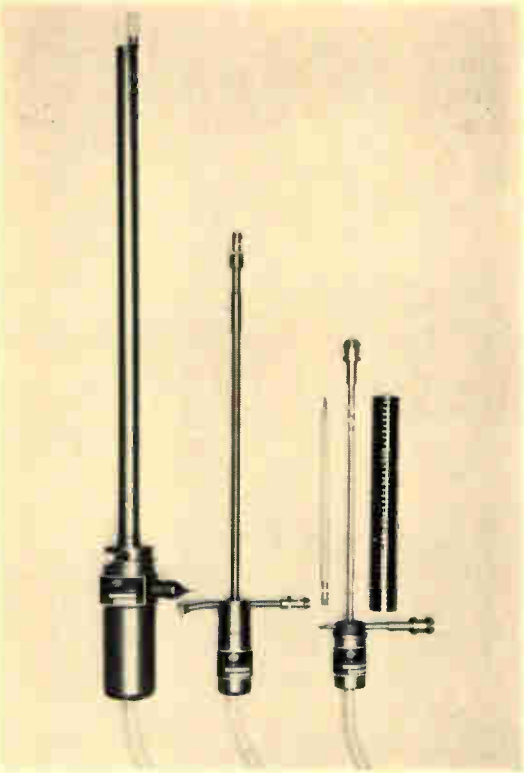


FIG. 3—Permanent periodic magnetic (ppm) focused traveling-wave tubes have gains of about 60 db. Tubes are available in 6 octaves from 240 to 11,000 Mc

operation, the beam voltage can be modulated directly or through a cavity on the beam ahead of the helix interaction structure. This voltage modulation develops sidebands useful for wide-frequency range mixing. Up to now little use has been made of the twt's broad-band capability to amplify very wideband signal spectra.

NARROW BAND TWT—The narrow-band twt has ben developed for point-to-point communications systems where constant amplitude or gain and linear phase performance is required over a small band. Typically, the tube is made with a glass envelope and external coupling circuits and is adjusted to meet the needs of each frequency band. Since fixed station operation needs only moderately rugged construction, glass makes an ideal structure for low manufacturing cost.

PULSE HELIX TWT—Current helix twt's provide pulse power outputs up to 10 kilowatts. This represents a peak power limit for helix traveling wave tubes. As synchronous velocity becomes greater with power, the helix structure becomes so coarse that it develops strong space harmonic fields that make the tube a better backward-wave oscillator than forward-wave amplifier.

Most commercially available pulse helix tubes require full beam-voltage pulse modulation and solenoid focusing.

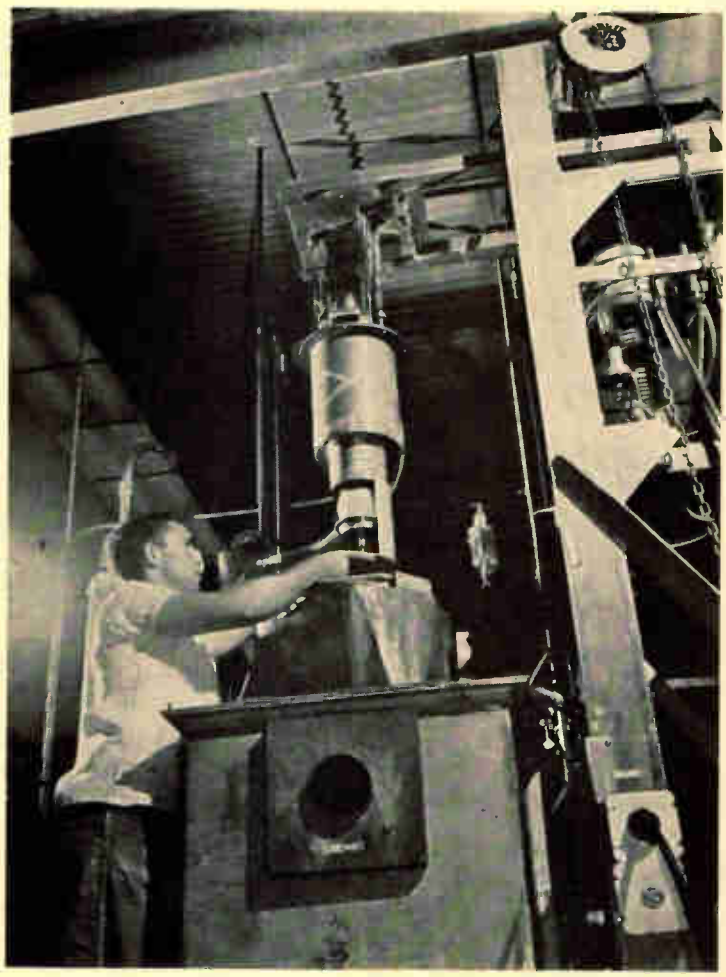
Newer kilowatt twt's now becoming available use ppm focusing at lower frequencies and have a control grid for beam modulation. This fine mesh grid at the cathode usually requires only 5 percent of the full beam voltage for full on and off control of the tube. Grid control affords great savings in modulator power for high repetition rate applications.

HELIX COOLING—Present twt's utilizing conduction and radiation cooled helices have achieved average power outputs of one watt at 55 Gc (Bell Labs experimental) and 550 watts at 3 Gc (Sperry production). This technique holds further promise in the 10- to 100-Gc range with the power output scaling roughly as the square of frequency. Variation of structures may increase the power of this type of tube by as much as a factor of ten for relatively narrow band amplification.

Future twt's may achieve somewhat greater average output power through the development of helix cooling methods using high thermal conductivity ceramics such as beryllium oxide. Liquid-cooled helices for frequencies below 20 Gc show promise of obtaining kilowatts of average tower at X-band and more than ten kilowatts at S-band with broad amplification bands.

LOW-NOISE AMPLIFIERS—Five years ago the helix twt had a noise figure of 7 to 10 db at S-band. Through a series of developmental achievements, the noise figure is now in the 3-db range for laboratory tubes, with commercially available tubes now around 6 db. These

FIG. 4—Megawatt pulsed klystron for C-band. Similar tubes generate up to 10 megawatts peak with much higher peak powers obtainable in the future



improvements may continue below this noise figure.

Another form of the low-noise tube is the tunable backward-wave amplifier, which uses two or more sections of helix adjusted to verge on backward wave oscillation. This provides a selective band-pass amplifier which can be voltage-tuned. These tubes also show good low-noise characteristics and provide image suppression for tunable radar receiver front ends.

BEAM PARAMETRIC AMPLIFIER—Another recent form of low-noise amplifier tube is the beam parametric amplifier, which employs transverse interaction, contrasting to the longitudinal form. As with all parametric amplifiers, this tube must be driven by a higher frequency pump source. It can achieve less than 1 db but noise figures of 3 to 4 db prevail where idler channel noise common to parametric amplifiers is present. By employing a much higher pump frequency, a reduction in idler noise may be possible. Beam parametric amplifiers offer gain stability despite pump power variations, and provide large isolation between output and input. They should be available soon in broadband versions over the usual microwave frequency range. With the concept of d-c pumping, the parametric amplifier may also have a future as a power tube.

BACKWARD-WAVE OSCILLATORS—The backward-wave oscillator tube is a self-oscillating twt which is electronically tunable over a wide range. In the early helix form it was bulky, required solenoid focusing magnets and was noisy. The noise was caused by ions trapped in the beam of the helix. New interdigital circuits which yield a much higher space harmonic impedance now make the tube much shorter, and permit ions to be drained for good low-noise performance. Backward-wave oscillators with a permanent magnet package are now available over the full microwave frequency range. The tubes are used mostly as high-speed, wide-frequency range swept-signal sources for testing. They can be used as master oscillators in wide band radar and close-range f-m altimeter transmitters.

HIGH PEAK POWER TWT—Since the helix traveling wave tube is limited to approximately 10 kilowatts of power output, other forms of circuits have evolved which make possible interaction at the higher beam velocities required for high-power tubes. These circuits include several forms of the ring and bar and the loaded waveguide structure. At the 100-watt power level, loaded waveguide has been successfully used up to about 1.3 to 1 bandwidth with some sacrifice in efficiency.

The loaded waveguide form of high-power twt was pioneered by Nalos, Graig and Chodorow at Stanford University achieving performance with 5- to 10-percent bandwidth. For higher power levels, staggered circuit techniques applied recently to experimental loaded waveguide tubes have shown a solid 10 percent bandwidth in the 100-Kw to megawatt range. The pulsed high-power loaded waveguide tube is still in a developmental stage and many improved versions are forthcoming.

KLYSTRONS—Klystrons are characterized by one or more resonators and a drift space or similar region to allow bunching of beam electrons in their passage between resonators. Available power, gain, and stability largely depend on beam performance and the number and characteristics of the resonators.

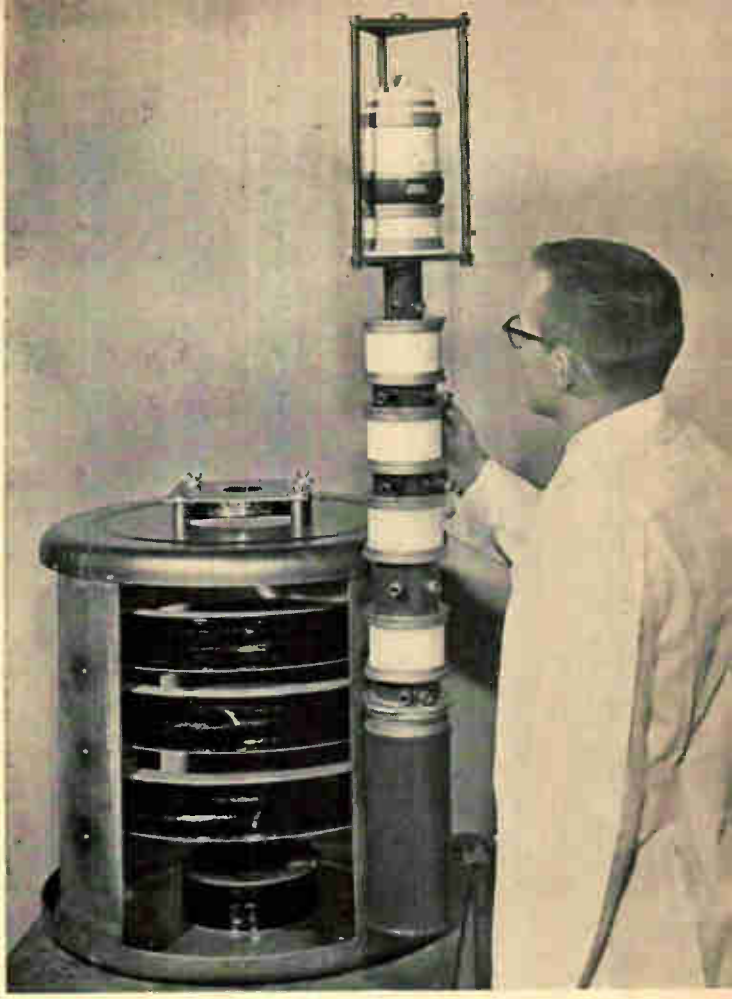


FIG. 5—Eimac klystron generates 10-Kw continuous power in 620 to 985 Mc band

Little more than a decade ago, klystrons were considered limited to low-power narrow band devices. Recent developments have produced astonishing strides in both power and bandwidth with the result that much advanced development of sophisticated super-power systems is predicated on the klystron's rapidly advancing capabilities.

MEGAWATT KLYSTRONS—Spectacular advances among recent electronic tube developments have been in megawatt klystrons (Fig. 4) designed for major radar bands, including X-band. These tubes, which employ very high beam densities and multiple resonators (three to six), can now produce one to 25 million watts peak power and the ultimate power limitations are not yet in sight. Equally remarkable improvements have been made in bandwidth, gain, pulse length and average power output.

With high powers, beam impedance is low and the effective capacitive reactance of the coupling-gap circuit is high enough to allow low operating Q's for significantly broad bandwidth. Tubes with 5-percent bandwidth are now on the market and 10-percent bandwidth tubes will become available soon. Many extra cavities added along the beam have produced large gain-bandwidth products. Experimental tubes with synchronously tuned

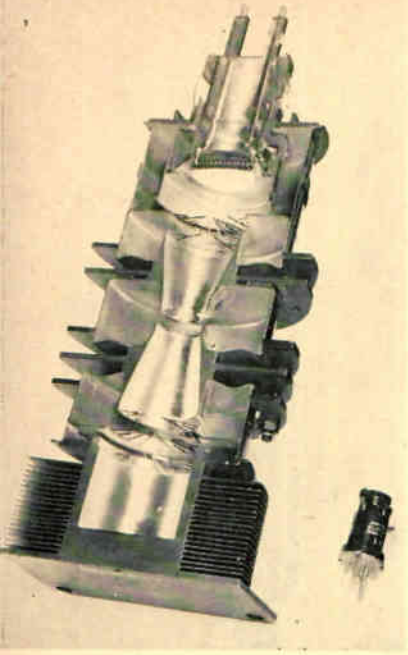


FIG. 6—Cross section of spoce chorge-focused klystron

FIG. 7 — Reflex klystron for 34,000 to 37,000 Mc

resonators have yielded stable gains as high as 110 db. With staggered tuning, bandwidths over 10 percent at 10 megawatts can be achieved with 40 db gain.

Efficiencies as high as 50 percent are obtained on some designs, and 40 percent is consistently obtained in good designs. Improvements in both control and interaction should yield tubes that consistently give 50 percent efficiency within the next few years.

There has been little change in the peak power output capabilities of tubes built within the last five years. This is not due to any inherent limitation of the megawatt klystron, but more a limitation in its application. Peak power can be easily increased as system requirements demand.

The average power output capabilities of megawatt tubes have in the past been somewhat limited by problems of output windows. Current progress, now at the 10 Kw level, indicates that large jumps in average power will be achieved within the next few years.

Great strides have been made in increasing the megawatt pulse lengths which now run as high as 2,000 μsec with 2,000 joules per pulse at the lower frequencies. A high order of beam control must be achieved to prevent internal vaporization of the tube parts by residual interception of the high-energy electron beam. Collector heat dissipation is not a serious problem because beam tubes can be built large enough to dissipate the high density electron beam energy.

Long pulses are the result of improvements in emission characteristics of cathodes. Recent advances in vacuum technology have significantly improved tube processing to yield better cathode environments. It is now possible to achieve more nearly the ultimate performance characteristics of the oxide emitter. Also, highly convergent focusing systems greatly reduce the current density at the cathode surface and permit beam densities of the order of 1,000 amperes/cm^2. The large cathode area available also minimizes ion damage.

All megawatt klystrons employ solenoids for focusing, but because of the high average beam power this does not significantly compromise weight and efficiency. It is also feasible to employ a form of periodic permanent magnet focusing, which would reduce the weight and power drain, but this development has not received much emphasis to date in system requirements.

HIGH POWER C-W KLYSTRONS—Along with rapid advance of the megawatt klystron, the high power c-w klystron has become commercially available. See Fig. 5. It is now possible to obtain 10 kilowatts of continuous power at S-band and lower frequencies, and as much as 2 kilowatts at X-band, and 10 watts at 8 mm. C-w klystrons take advantage of the inherent quality of the highly-convergent cathode-focusing system and the divergent characteristics of a large collector to dissipate the high average power. Because the beam power and voltage level is much less than in a megawatt pulse tube, the high power c-w klystron is a narrow-band device and requires mechanical tuners. It is usually built with a number of cavities and can have typical gains of over 40 db. Present forms of this tube usually employ a focusing solenoid.

High power c-w klystrons serve as rugged work horses both in long-range scatter communication systems and in uhf tv transmitters. Pulsed forms of high power c-w klystrons take advantage of the inherent quality radar systems. These tubes generate high average powers but can be pulsed at peak powers with a duty cycle in the 10 percent range. Nonintercepting control electrodes switch large amounts of power on and off rapidly. These tubes have stable amplitude and frequency modulation characteristics required in doppler application.

The c-w klystron is inherently capable of large amounts of average power and the next few years shall see much higher average power than the 10 Kw now available at S-band. Powers approaching 10 or more times greater than those now being achieved are forthcoming.

SPACE-CHARGE FOCUSED KLYSTRONS—Another form of klystron which has come into wide use in recent years is the space-charge-focused klystron amplifier shown in Fig. 6. This is a pulsed amplifier tube in which beam trajectories are allowed to travel through the tube with natural space-charge repulsion forces. A series of cavities placed along the beam yield the required gain and power output characteristics. These are usually grid controlled and, for pulse power outputs of 30 kilowatts peak and 1 kilowatt average at L-band, only a small amount of pulse drive is required to obtain highly shaped pulses for minimum spurious side-band radiation. Space-charge-focused klystrons power Tacan and other navigation systems. Similar tubes developed for higher frequency bands are used as drivers for radar chains.

REFLEX KLYSTRONS—Recent developments in ion-focused klystrons have been limited almost exclusively to new reflex klystrons with the exception of one small 1-watt two-cavity oscillator for rugged transmitter oscillator and amplifier service in missile beacons. See Fig. 7. Most reflex klystron developmental efforts have been directed towards making the tube rugged and keeping spurious frequency and amplitude modulation components low under severe vibration and shock conditions. Typical specifications for an X-band tube are 1.5-Mc frequency deviation under 150-g shock, and 0.2-Mc peak to peak frequency modulation under 10-g vibration between 20 and 1,000 cps.

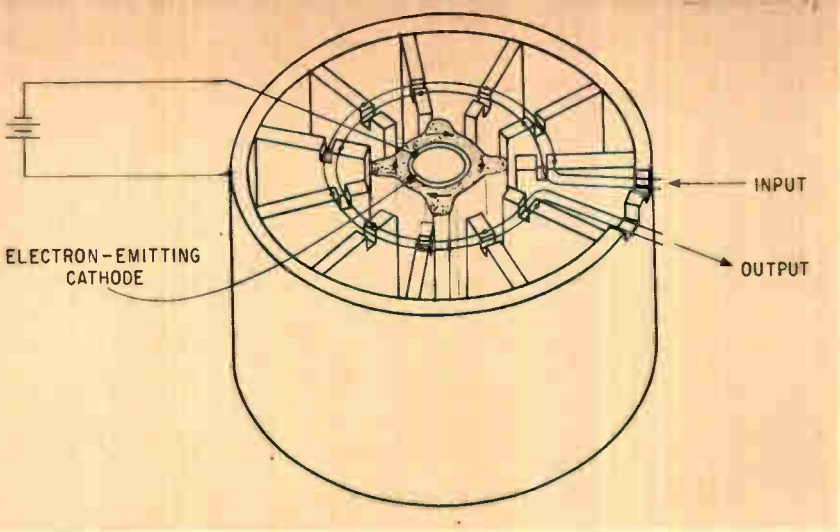


FIG. 1—Schematic diagram of Amplitron

CROSSED-FIELD MICROWAVE TUBES

Since 1950, *the conventional magnetron has been joined by several other cross-field devices that behave as amplifiers of high efficiency and power-handling capacity. In addition, significant advances have been made in crossed-field oscillators*

By WILLIAM C. BROWN, Associate Director of Engineering, Crossed-Field Devices, Raytheon Company, Waltham, Mass.

A NUMBER OF ADVANTAGES of the crossed-field device, such as efficiency and high power handling capability, stem directly from the feature of the tube which most distinguishes it from the other general class of microwave tubes known as the colinear beam class which includes the klystron and conventional traveling wave tube. This distinguishing feature is the method by which it converts the energy of the power supply into useful r-f energy. Colinear beam devices such as the klystron and traveling wave tube convert all the power supply energy into kinetic energy by imparting velocity to electrons; these then surrender a portion of their kinetic energy when they interact with the r-f field. The crossed-field device avoids this intermediate step by providing a mechanism for direct conversion of the energy of the power supply into useful r-f energy. Many of the desirable properties of the crossed-field device such as high efficiency and low x-ray generation are directly attributable to this unique energy conversion system. In the crossed-field device, the magnetic field is indispensable to the process of converting the applied energy of the power supply to r-f energy, as distinguished from its function in the colinear type tube where the purpose of the magnetic field is to help focus the beam.

Crossed-field microwave tubes may be classed in several different ways. From the user's point of view the most obvious division is into self-excited oscillators and amplifier classes. To the oscillator class belong the conventional magnetron oscillator, the coaxial magnetron oscillator, the Stabilotron, and the electronically tunable backward-wave oscillator. To the amplifier class belong the Amplitron and the injected beam magnetron amplifier, which represent two different approaches to crossed-field amplification. The injected beam forward wave magnetron amplifier reflects the influence of the conventional traveling wave tube, whereas the Amplitron reflects the influence of the magnetron oscillator.

AMPLITRONS—The Amplitron, introduced in 1955 by Raytheon, is of popular interest not only because it functions effectively as a broad-band amplifier but because it combines many other properties such as compact size, high operating efficiency, economy of construction, low phase pushing, and high power handling capability.

Referring to Fig. 1, the Amplitron consists of an electron-emitting cathode surrounded by an anode circuit. The anode circuit has the dual function of a slow-wave r-f circuit with which the electrons interact and an electrode for the collection of electrons. A magnetic field whose direction is parallel to the axis of the cathode is also pro-

wave mode. In the first case, both electron beam and energy of the wave are propagated in one direction, while in the case of the carcinotron, energy flow is in the opposite direction from the beam. In the carcinotron the power flowing on the line is largest near the output which is in the region of entrance of the electron beam. The electron beam then tends to bunch rapidly, and delivers power to the r-f network which then flows back toward the tube output and beam input. An electronic feedback path is thus established. Efficient interaction between beam and circuit can only be established when velocity of beam and phase velocity of the network are approximately synchronous. The frequency of oscillation is therefore established when the phase velocity corresponding to that frequency is synchronous with the velocity of the electron beam. If the phase velocity is a function of frequency, as it is in the carcinotron r-f circuit, changing the beam velocity will affect the frequency. The beam velocity is changed by adjusting the electric field between the sole and anode circuit.

Typical of the state of the art of carcinotron development is the QK634A shown in Fig. 7. The characteristics of this tube are shown in Fig. 8.

CONVENTIONAL MAGNETRON OSCILLATOR—The conventional magnetron oscillator is still in wide use today in radar. It is finding additional use in microwave heating applications. The attributes which have given this device its staying power are high efficiency (35 to 60 percent), economy of manufacture, relative compact size and light weight, relatively low anode potential, lack of need of auxiliary equipment such as electromagnets or extensive x-ray shielding, and ability to be mechanically tuned with simple modifications.

The magnetron consists of a cathode which emits electrons, an r-f circuit surrounding the cathode with which the emitted electrons interact, an external coupling to this circuit, and a magnetic field parallel to the axis of the cathode. When packaged with a permanent magnet, as most modern magnetrons are, it is necessary only to apply heater power and anode potential to operate the device.

Magnetron performance data are usually available in the form of a performance chart and a load diagram. The performance chart indicates how efficiency and r-f power output vary as a function of modulator input, and also how the anode voltage is related to the magnetic field and anode current. Figure 9 shows a performance chart for the QK624, a one megawatt, X-band pulsed magnetron.

Table I—Performance Comparisons of Coaxial and Conventional Magnetrons

Electrical Characteristics	Coaxial Magnetron	Conventional Magnetron
Peak Power	250 Kw	250 Kw
Circuit Efficiency	85 Percent	70 Percent
Electronic Efficiency	65 Percent	60 Percent
Tuning Range	20 Percent	15 Percent
Pulling Figure	3 Mc	14 Mc
Pushing Figure	0.08 Mc/amp	0.4 Mc/amp

COAXIAL MAGNETRON OSCILLATOR—The coaxial magnetron, a development of the Bell Telephone Laboratories, and the Stabilotron, a Raytheon development, have made possible an improvement in the frequency stability of crossed-field oscillators by a factor of approximately ten while still retaining the high efficiency and power handling capability of conventional magnetrons.

The coaxial magnetron, so denoted because of a stabilizing cavity which is built around the magnetron proper, is shown in Fig. 10. Not only does the cavity make possible high-frequency stability, but also allows simple mechanical tuning by the movement of one end of the cavity itself. No ganged tuning is necessary. The device has low frequency pulling and pushing figures, about one-fifth those of a conventional magnetron oscillator, and in general the spectrum quality is good.

Addition of the cavity to the tube provides a high degree of frequency stabilization and at the same time, surprisingly, increases overall efficiency. The increase in efficiency is brought about by improvements in both the circuit and electronic efficiency. The improvements which this tube concept makes possible are perhaps best illustrated by comparison of an X-band coaxial magnetron with a conventional magnetron oscillator. See Table I.

STABILOTRON—The Stabilotron represents another de-

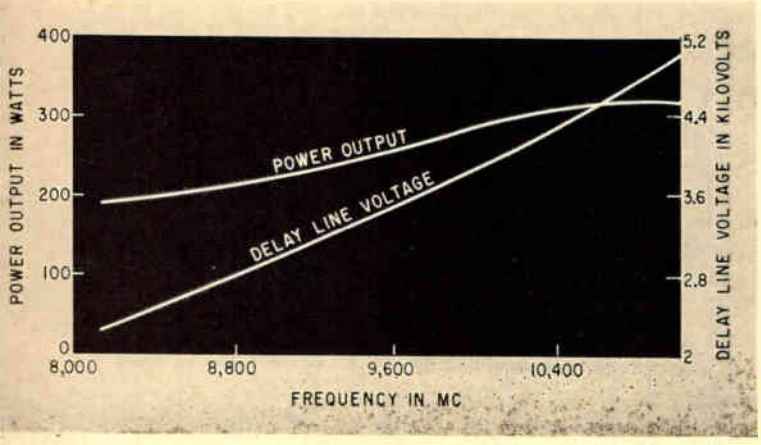


FIG. 8—Power output as function of frequency and frequency as function of delay-line voltage for QK 634A carcinotron

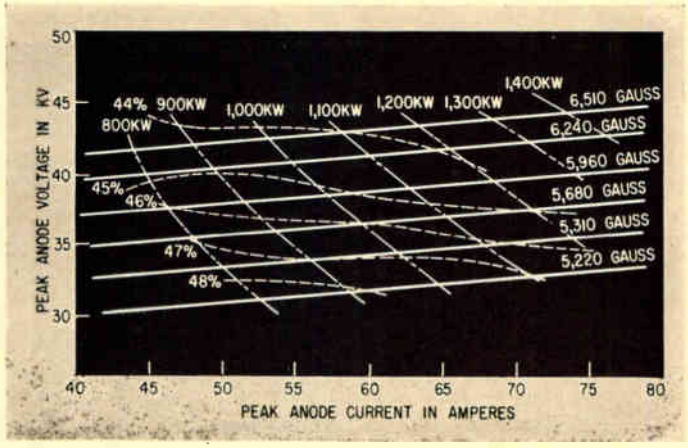


FIG. 9—Performance chart for QK 624, a one megawatt X-band conventional magnetron

Table II—Comparison of Stabilotron and Conventional Magnetron

	5J26 Magnetron	QK630–629 Stabilotron
Pulling Figure in Mc	2–2.5	0.4–0.6
Pushing Figure in Kc per amp	50–100	1–4
Peak operating current in amperes	46	40
Operating magnetic field in gauss	1,400	1,150
Operating voltage in Kv	28.2	36
Typical efficiency in percent	42	52
Peak power output in Kw	550	650
Average power output in watts	550	1,560
Spectrum sensitivity to heater power	Sensitive	Not sensitive
Tuning range in Mc	1,220–1,350	1,260–1,350

velopment in frequency-stable oscillators. When used as a pulsed device, its frequency pushing and pulling figures are about the same as that for the coaxial magnetron, and its starting time jitter is extremely low, permitting cancellation ratios of over 40 db with nominal pulse durations in mti radar. When used as a c-w device, even smaller pushing and pulling figures may be realized.

Like the coaxial magnetron, the Stabilotron is capable of being tuned over an appreciable range (from 5 to 12 percent), but it is necessary to gang a line stretcher to the tuning of the cavity if tuning is to exceed more than half of one percent. However, at the lower frequencies it is possible to incorporate the tunable cavity, line stretcher, and damping resistor as permanent parts of the equipment, and the Stabilotron vacuum tube itself is mechanically and electrically little more complex than a fixed-frequency conventional magnetron oscillator. Moreover, in some applications it is desirable to have the tuning cavity separate from the tube.

The Stabilotron consists of a platinotron with the addition of suitable r-f feedback and stabilizing circuits. The platinotron device is described to some degree under the Amplitron heading, since the Amplitron device is merely the platinotron used as an amplifier. The platinotron device has a number of desirable properties from the viewpoint of designing a highly stabilized oscillator around it. These properties are: small effect of anode current change on phase shift through the device; directional properties of the device which permit making a feedback path through the device itself; and the excellent match of the device to external circuits over a wide frequency range. When these properties are coupled with a stabilizing system having a stabilizing factor of fifty or more, an extremely stable device results.

The method of using a platinotron in conjunction with other circuit elements to form a highly frequency-stabilized oscillator is shown in Fig. 11. Where tuning is not required, the line stretcher is omitted. A portion of the output power is reflected from the reference plane *ll'*. This reflected power travels back through the platinotron anode circuit with little or no attenuation or reflection and out to reference plane *rr'*. Here most of it is again reflected, the phase of the reflection depending upon the frequency of the incident power and the resonant frequency of the stabilizing cavity. This rereflected power is then amplified by the backward-wave interaction principle and arrives at the reference plane *ll'* at full output level.

Steady oscillations can occur only if the loop phase shift from plane *ll'* to plane *rr'* and return is an integral multiple of 360 degrees. The phase shift-versus-frequency characteristic of the stabilizing cavity has a slope many times greater than that of any other element in the circuit. A slight change in frequency thus permits the cavity to correct for substantial phase shift which might be introduced by such factors as a change in the antenna load or frequency pushing of the electron stream.

Some perspective as to the performance of the Stabilotron may be obtained by comparing it with a standard magnetron oscillator of similar frequency and power. See Table II.

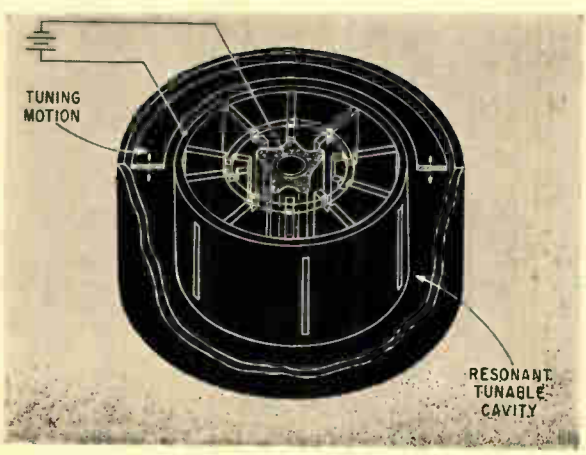


FIG. 10—Schematic diagram of the coaxial magnetron. Addition of cavity improves overall efficiency

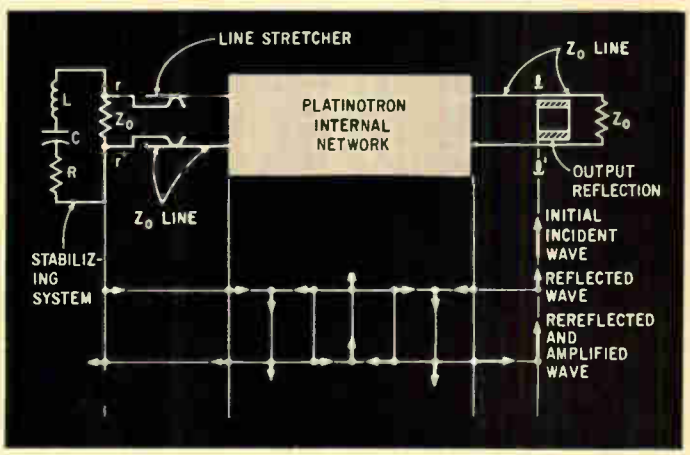


FIG. 11—Schematic diagram showing operation of the Stabilotron as a stable oscillator

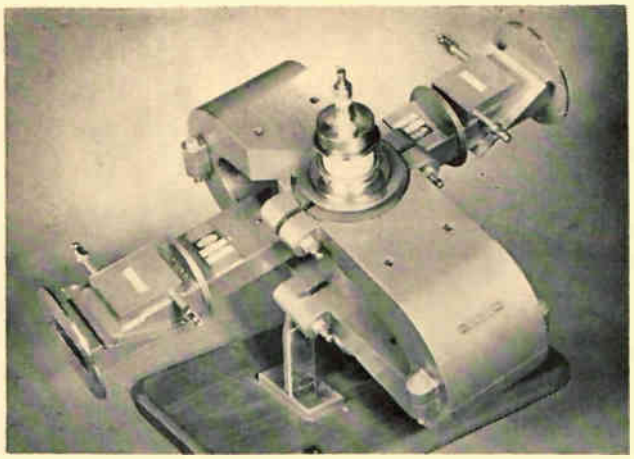


FIG. 2—Completely packaged QK 622 S-band Amplitron handles 3 Mw peak power

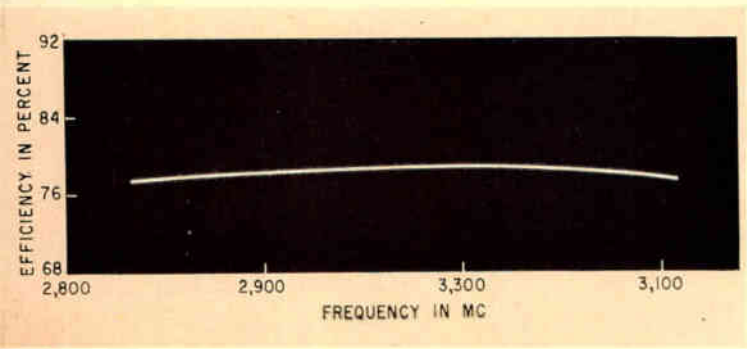


FIG. 3—Efficency of QK 622 plotted against frequency

vided. At one end of the r-f slow-wave circuit an input connection is attached and at the other end an output connection is attached. The characteristic impedances of the anode slow-wave structure and the input and output lines are matched over a broad range of frequencies. To place the Amplitron into operation, r-f power is applied at the r-f input terminals and a potential is applied between the cathode and anode. Under the influence of the electric field which this potential creates, electrons leave the cathode and because of the magnetic field, move around the cathode in concentric paths. As the d-c potential between cathode and anode is further increased, the electrons move in circular orbits of ever larger diameter and with increasing speed until their speed becomes synchronous with the r-f wave in the anode circuit. When synchronism is reached, the electrons then begin to interact with the r-f field and deliver energy to the r-f field, losing potential energy as they do so and drifting closer to the anode where they are collected after delivering as much as 80 percent of their original potential energy directly to the r-f field. The electrons then surrender the balance of their original energy as heat when they strike and are collected by the anode. The r-f energy which is generated by the interaction process flows out of the output connection. As the frequency of the r-f input is changed, the frequency of the generated power immediately follows.

EQUIVALENT CIRCUIT—As a circuit element, the Amplitron may be described as an active two-terminal-pair network with directional properties. When an r-f signal is injected into the first set of terminals, the r-f level is greatly increased at the second set of terminals. On the other hand, if the r-f signal is injected into the second set of terminals, the r-f level is neither increased nor decreased at the first set of terminals. To a first approximation there is the same phase shift of the r-f signal as it traverses the device, regardless of direction. If the direction of the magnetic field is reversed, then the directional properties of the device are also reversed.

The completely packaged QK622 is shown in Fig. 2. The weight of this tube is 125 lb. As Fig. 3 indicates, this tube is capable of producing full rated output of 15 Kw over an 8-percent bandwidth with efficiencies which exceed 70 percent over the entire band and which approach or even exceed 80 percent at some frequencies. This high efficiency is of great importance in making it possible to operate Amplitrons at high power levels.

One of the interesting relationships in Amplitrons is that between the r-f input and r-f output, particularly over a wide range of power levels. This relationship has been examined in the QK520 with the results given in Fig. 4. The device behaves as a saturated amplifier. For a given d-c input power level the r-f output is relatively independent of the r-f drive level, departing from this independence as the magnitude of the r-f drive level becomes comparable to the r-f output level. If the r-f drive level becomes too low at a given d-c input power level, it loses control over the frequency of the r-f output. In the region in which the r-f input does not control the r-f output, the r-f output is noisy, poorly defined, and at some other frequency than the driving signal. The transition region between the controlled and uncontrolled areas is well defined and of negligible width. Figure 4 indicates that the operation of the QK520 Amplitron has been explored with r-f drive levels as low as 2 Kw and as high as 2,000 Kw. Power gains as high as 20 db have been obtained at the higher drive levels. In general, Amplitrons are operated at a level where the gain is about 10 db.

PHASE SHIFT—A highly desirable property of the Amplitron, of increasing importance as radars with pulse-compression characteristics are coming into being, is its

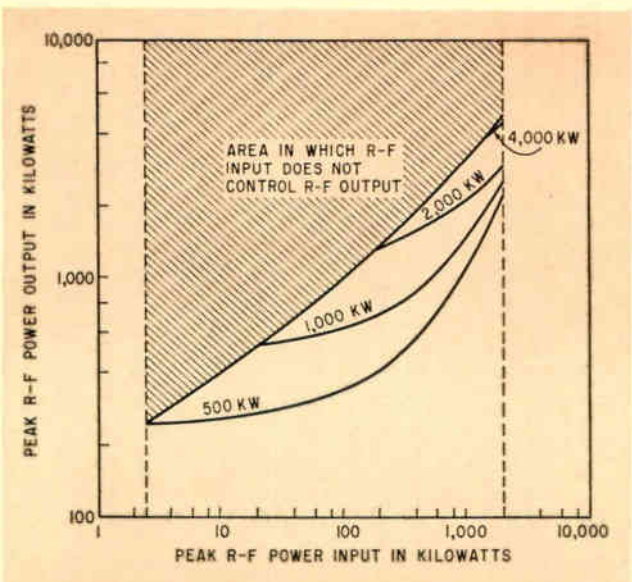


FIG. 4—Performance chart for Amplitron. Contours show constant modulator input

high degree of linearity of phase as a function of frequency, and the small dependence of phase shift upon operating current, particularly near the value of operating current. Figure 5 shows the phase shift characteristic between the input and output terminals of an Amplitron as a function of frequency for a zero value of anode current and for the operating value of the current. In the region of the operating current the incremental change in phase shift for a small incremental change in current amounts to about a 0.2-deg phase change for a 1 percent variation in current. Such a small dependence of phase shift upon current makes for both better radar performance as well as for a more economical power supply.

INJECTED BEAM FORWARD WAVE AMPLIFIER—The injected beam forward wave amplifier represents another approach to a crossed-field amplifier. Such an amplifier is closely related to the conventional traveling wave tube. The development laboratories of the Compagnie General de Telegraphie Sans Fil demonstrated the operation of such a device. This French company has chosen to call their device the TPOM which stands for *le Tube a Propagacion d'Onde a champ Magnetique.*

As seen in Fig. 6, the injected beam magnetron amplifier consists of a beam-forming arrangement, an r-f network in juxtaposition with a sole, and a magnetic field normal to the direction of travel of the beam and normal to the electric fields established between sole and anode. The cathode and accelerator electrode are so positioned and operated at such potentials as to inject the beam between the anode circuit and the sole region at the proper point with the proper initial velocity. This initial velocity must be the same as the phase velocity of the r-f wave propagating down the network. In the absence of an r-f signal, the beam is held at its initial velocity and prevented from hitting the anode or sole as it travels down the tube by adjusting both the potential between the anode and sole and the magnetic field so that the initial velocity equals E/B, where E is the electric field between the plates and B is the magnetic field. In the presence of an r-f signal, bunching of the electron stream occurs and

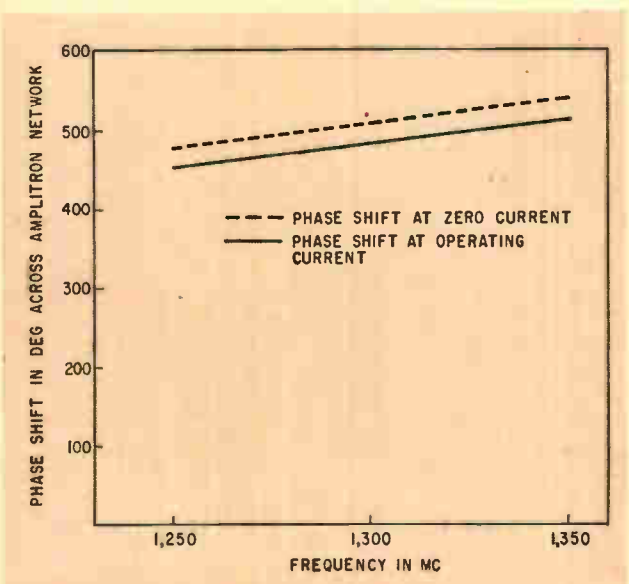


FIG. 5—Phase shift across Amplitron plotted against frequency. Tube exhibits little phase shift with current change

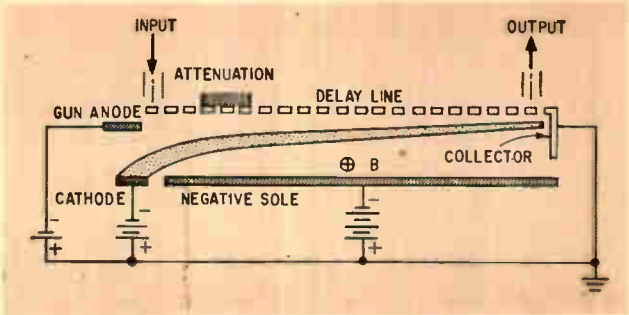


FIG. 6—Mode of operation of injected-beam forward-wave magnetron amplifier

FIG. 7—Injected-beam backward-wave electronically tunable oscillator type QK 634A

these bunches move to the anode circuit, converting their potential energy to r-f energy as they do so.

In the design of the magnetron amplifier r-f circuit, an attempt is made to hold the phase velocity of the r-f circuit as constant as possible over a wide frequency band to keep the beam velocity constant. In turn, this permits operation over a band of frequencies without adjustment of the potentials on the beam injection mechanism.

Typical of the state of the art of the injected beam forward wave magnetron amplifier is the QR806 which provides c-w operation at the 300-watt level with a gain of about 23 db.

Interest in the injected beam magnetron amplifier has recently been raised by the design of better beam-forming electrodes and by a better understanding of the noise producing mechanisms in crossed-field devices.

INJECTED BEAM, BACKWARD-WAVE ELECTRONICALLY TUNABLE OSCILLATOR—Passing now to crossed-field oscillators, it may be desirable to first discuss the injected beam, backward-wave electronically tunable device because of its constructional similarity to the magnetron amplifier just discussed. This device is frequently referred to as the M-type carcinotron in recognition of the early work of the Compagnie General de Telegraphie Sans Fil in this area. As indicated, the construction of the carcinotron resembles closely that of the construction of the magnetron amplifier. The distinction between the carcinotron and the magnetron amplifier is that the magnetron amplifier operates in a forward-wave mode, whereas the carcinotron operates in a backward-

CATHODE-RAY TUBES

Advances in television picture tubes in last decade include shortening the tube, improving faceplate design, aluminizing screens, electrostatic focusing and improved manufacturing techniques for color tubes. New instrument cathode-ray tubes have smaller spot sizes. Electroluminescent devices are coming along for electronic display uses

DURING THE PAST TEN YEARS well over 100 million television picture tubes have been manufactured in a wide variety of shapes, sizes, deflection angles, screen variations and electron-gun structures. Sales of specialized cathode-ray tubes for use in closed-circuit television, industrial electronics, data processing, navigation, education, medicine and national defense have also totaled in the millions of dollars.

During the 1950's there was broad progress in monochrome television picture tubes aimed at producing improved tubes selling at lower prices. Notable trends were associated with the envelopes or bulbs of which the tubes are made. Television receiver production started in the mid 1940's with the 10-inch round glass bulb which was manufactured by hand methods. Gradually bulb manufacturing methods were mechanized. A recent advance has been the 23-inch implosion-proof tube with squared corners introduced by tube manufacturers early in 1959 and already incorporated into the 1960 lines of several television set manufacturers.

TUBE SHORTENING—In spite of steady increases in viewing area of the tube screen, tube lengths have decreased steadily. Early rectangular tubes had beam deflection angles across the diagonal of about 70 deg. Improvement of deflection yokes and increase in efficiency of deflection circuits permitted increase to 90 deg deflection, with consequent reduction in tube body length from 15½ in. to 12½ in. for a 21-in. tube. In 1956, another step increased the deflection angle to 110 deg. This change reduced the 21-in. tube body length to about 9 in., and necessitated reduction in tube neck diameter and modification of the contour of the funnel-neck, over which the deflection yoke seated, to allow use of more effective and efficient yokes.

Table I shows the increase in television picture tube area and accompanying reduction in length of typical tubes manufactured in quantity in 1950 and 1960.

FACEPLATE IMPROVEMENT—Other developments in television picture tubes during the 50's have improved the quality of the television picture. Faceplate glass quality has improved steadily. The size and number of blisters (bubbles) and inclusions in the glass have been reduced substantially, and faceplate surface defects have been almost eliminated.

Along with projects to overcome the effect of reflective surfaces, developments have been undertaken to improve safety. Until 1959, all television receivers had been equipped with protective windows designed to contain possible tube implosions. Both glass and plastic windows had been used, and they degraded the television picture by interposing surfaces for reflection and collection of dust, as well as occasionally by surface defects.

In 1959, a tube improvement appeared, consisting of a form-fitting glass shield cemented to the tube face with a layer of synthetic resin, making the face essen-

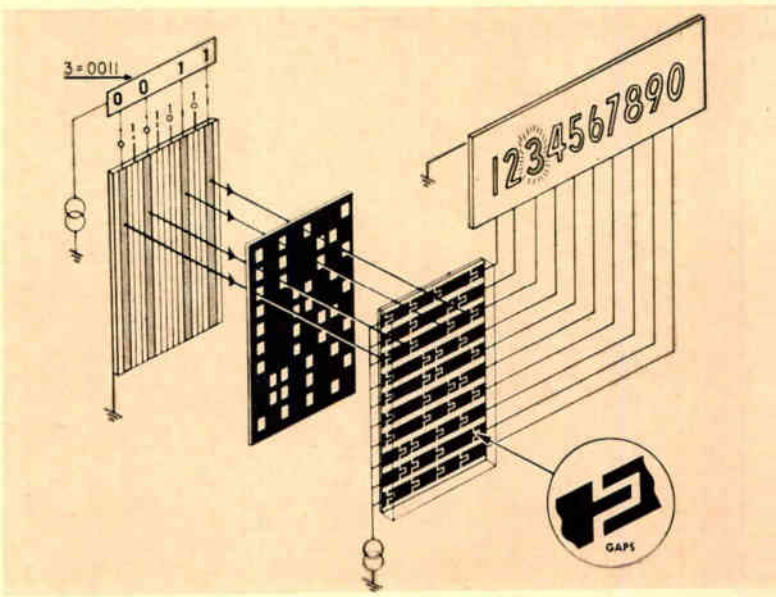
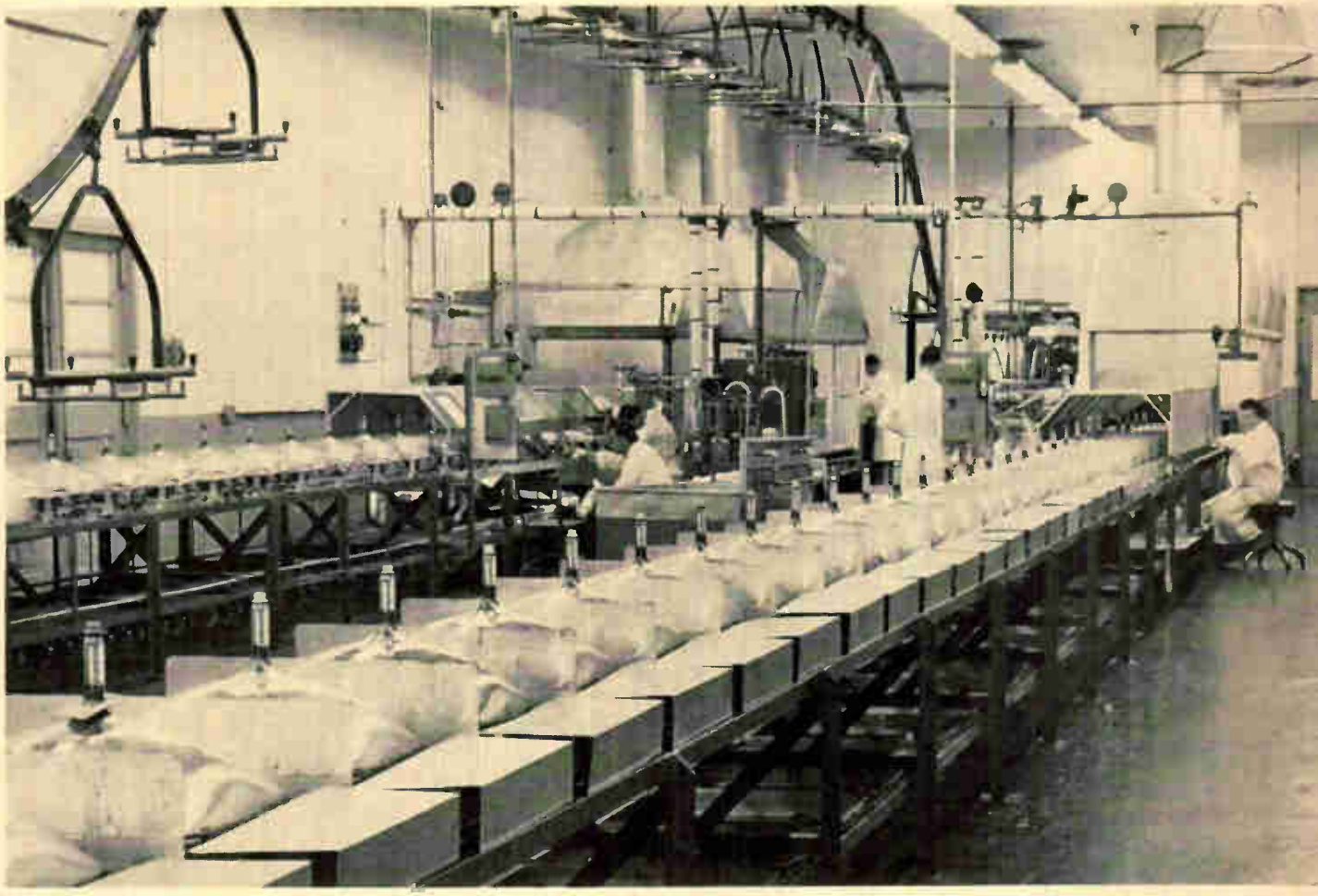


FIG. 1—Binary-to-decimal decoder

By ROSS K. GESSFORD, SR. Chief Engineer
WILLIAM A. DICKINSON Section Head—Design
JOSEPH H. LOUGHLIN Coordinator of Engineering

Electronic Tubes Div., Picture Tube Operations, Sylvania Electric Products, a subsidiary of General Telephone & Electronics Corp., Seneca Falls, N. Y.



MANUFACTURING line for laminating improved-type cathode-ray-tube faceplates. Tube has integral ears on coverplate to simplify mounting in receiver; design permits tube face to project well forward in receiver

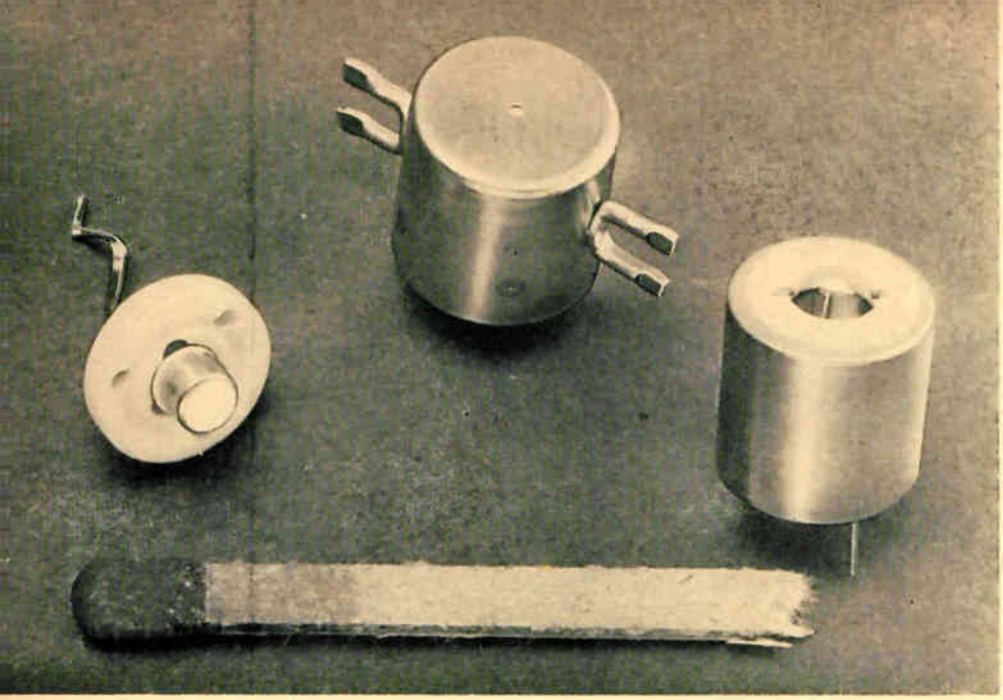
tially a thick, laminated safety glass. It is practically impossible to make a tube of this construction implode, and the coverplate will withstand very heavy blows without damage to itself or to the tube.

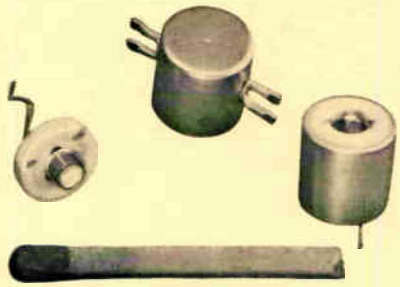
At present, the tubes are being made in 23-in. diagonal size in a more rectangular shape. A 19-in. tube for portables will be available this year. Further development of this principle can be expected in the direction of reducing tube weight and improving picture quality.

ALUMINIZED SCREENS—Before 1950, only a few tube types used aluminized screens, but the advantages obtainable by this process are so great that since about 1953 practically all picture tubes have been aluminized. In a nonaluminized tube, a high percentage of the light from the fluorescent screen is radiated back into the bulb. Some of this wasted light returns to the face by reflection from the internal surface and reduces contrast by falling on the dark areas of the picture. Aluminizing provides a thin, bright, optically reflective, electron-permeable aluminum film just behind the fluorescent screen, which increases screen brightness by reflecting the back-emitted light out toward the viewer. It also nearly eliminates the back lighting which degrades contrast. Aluminizing maintains the screen at essential anode potential at high anode operating conditions, and since it protects the screen from developing ion blemish, it has allowed the omission of ion traps from electron guns currently being used. Removal of the ion trap eliminates the need for an external ion trap magnet, making tubes easier to adjust on receiver lines,

Table I—How Television Picture Tubes Have Increased in Area and Decreased in Length From 1950 to 1960

1950			1960		
Type	Area	Length	Type	Area	Length
17BP4	149 sq in.	19 1/4 in.	17DKP4	155 sq in.	10 11/16 in.
			21EQP4	262 sq in.	12 9/16 in.
20CP4	220 sq in.	21 7/16 in.	23CP4	282 sq in.	15 3/16 in.
			24AVP4	332 sq in.	14 13/16 in.





Actual size

LEFT TO RIGHT: conventional cathode assembly, conventional control-grid assembly and new 0.2-watt heater-cathode assembly for portable tv tubes

and contributes to shortening the tube neck.

ELECTROSTATIC FOCUSING—Another major gun change has been the switch from magnetic to electrostatic focusing. This change required considerable industry effort to attain uniformity in focusing characteristics, and to prevent leakage and arcing within the tube.

Electrostatic focus tube design has improved steadily. Voltage ratings have increased, and guns have been shortened without sacrifice of the resolution capability. New fabrication techniques and automation have improved uniformity of tube characteristics. Electrostatic focus guns are particularly suitable for wide deflection angle tubes, since, as compared with magnetic focus guns, they have smaller beam diameter in the deflecting field, resulting in less defocusing of the beam at the extremes of deflection.

BUILT-IN CAPACITOR—An array of picture tube types is now available, consisting of combinations of the various features listed above, plus many others that have been produced to satisfy the desires of the receiver designers. Most tubes are now rated for series heater string operation, and 300, 450 and 600-ma types are available. Some progress has been made in reducing video drive voltage, and several types are now available which operate at 50 to 100 volts on the accelerating grid (grid No. 2) versus 300 to 450 volts on conventional types. Types are available with anode voltage ratings as low as 8 Kv min. and others as high as 22 Kv max. Most picture tubes have an external conductive coating over the funnel which together with the internal conductive coating on the bulb walls forms a high voltage capacitor, which is used as a filter capacitor in the high voltage supply. This external coating also shields the receiver from electrical disturbances present on the internal coating of the tube.

No survey of television display devices would be complete without mentioning projection television tubes. Seven-in.-diameter tubes, rated at 80 Kv anode voltage and having screen brightness up to 30,000 ftL are available for theater projection systems. A few projection tubes have been built for custom installation in homes and clubs.

TUBES FOR PORTABLE TV—Late in the decade, a great deal of work was done toward developing truly portable television receivers with self-contained power supplies. The requirements on the picture tubes for such a receiver are stringent. Tubes must be conservative of power—particularly the heater and the scanning system—and must operate with the low video signal voltage available from transistors. Picture brightness and contrast must be high since the receivers will be expected to operate satisfactorily outdoors in bright sunlight.

One portable receiver has appeared that uses a 2-in. diameter picture tube in a spherical mirror viewing system. Development is proceeding on big-picture portable sets. A heater-cathode design requiring only about 0.2-watt heater power, about 5 percent of customary value, has been demonstrated. Several methods of reducing video signal requirements to less than 10 volts have been described. Post-deflection accelerators and scan magnifying lenses have been proposed for reducing scan power requirements.

COLOR PICTURE TUBES—The metal color tube was developed into a commercially mass-produced form in the 1950's by a succession of developments in tube design.

The shadow mask color tube features a viewing panel or screen composed of triangular groups of three small phosphor dots, each a different color (green, blue and red), placed in front of specific holes in a mask. Three electron guns are used, one for each of the three phosphor dot colors, with the dot configurations arranged so that they are excited individually upon impingement by the electrons emitted from the corresponding electron gun.

In forming the fluorescent color array on the internal surface of the faceplate, the glass faceplate was covered with a coating of a photosensitive substance and a fluorescent material. The coating was dried and the

Table II—Characteristics of EIA-Registered Standard Phosphors

Phosphor	Emission Color: Fluorescence	Emission Color: Phosphorescence	Persistence	Application
P-1	Yellowish green	Yellowish green	Medium	Cathode-ray oscillographs and radar
P-2	Yellowish green	Yellowish green	Medium	Cathode-ray oscillographs
P-3	Yellowish orange	Yellowish orange	Medium	
P-4	White	White	Medium to medium short	Monochrome television picture tubes
P-5	Blue	Blue	Medium short	Photographic recording
P-6	White	White	Short	Obsolete—originally used in television receivers
P-7	White	Yellowish green	Blue, med. short Yellow, long	Radar
P-8	Obsolete	Replaced by P-7		
P-9	Obsolete			
P-10			Dark trace, very long	Outside source of light is used for observation; persistence from seconds to several months
P-11	Blue	Blue	Medium short	Photographic recording
P-12	Orange	Orange	Long	Radar
P-13	Reddish orange	Reddish orange	Medium	
P-14	Purplish blue	Yellowish orange	Blue, medium short Greenish Yellow, medium	Military displays where repetition rate is 2 to 4 seconds after excitation is removed
P-15	Green	Green	Visible, short Ultraviolet, very short	Television pick-up of photographs by flying spot scanning
P-16	Bluish purple	Bluish purple	Very short	Television pick-up of photographs by flying spot scanning
P-17	Yellow white to blue white	Yellow	Blue, short Yellow, long	Military displays
P-18	White	White	Medium	Low frame rate television
P-19	Orange	Orange	Long	Radar indicators
P-20	Green to yellow green	Green to yellow green	Medium to medium short	High visibility displays
P-21	Reddish orange	Reddish orange	Medium	
P-22	Tricolor phosphor screen		Medium	Color television
P-23	White	White	Medium	Low temperature white—(Sepia) interchangeable with P-4
P-24	Green	Green	Short	Flying spot scanner tubes
P-25	Orange	Orange	Medium	Military displays where repetition rate is 10 seconds, to 2 minutes after excitation is removed
P-26	Orange	Orange	Very long	Radar display
P-27	Reddish orange	Reddish orange	Medium	Color television monitor service
P-28	Yellow green	Yellow green	Long	Radar display
P-29	Two-color phosphor screen		Medium	Indicator in aircraft instruments

coated faceplate was then jig-assembled with its shadow mask which had over 300,000 circular openings. One opening in the mask was associated with each triad of colored fluorescent dots in the finished tube. The faceplate and mask were properly positioned with a collimated light source electron optically corrected and the coating was exposed to light rays radiating from this source. Those portions of coating that were exposed to light became hardened. After exposure, those portions of coating that were not exposed to light were removed by development. This process was done three separate times using a zinc sulfide blue phosphor, a zinc ortho-silicate green phosphor and a zinc phosphate red phosphor. For each exposure operation, the light source was offset a predetermined distance so that the colored phosphor dots in each triad were separated and properly oriented with respect to the gun and the shadow mask.

In the second half of the decade, the 21-in. round glass shadow mask color tube was introduced to mass production. This tube required new production assembly techniques, particularly in joining the screened panel section to the bulb cone section. While early glass bulbs had metal flanges attached to each section and welded together to unite the sections, this welding operation was soon superseded by a frit-sealing operation in which the cone and panel were sealed together with a devitrifying glass frit. Registration of the electron beams on the phosphor dots was improved through the use of more sophisticated optics in exposing or printing the screen as well as improvements in the control of phosphor dot size. This 21-in. glass color tube superceded the 21-in. metal type in production during the late 1950's.

TUBES FOR OSCILLOGRAPHY—While the preceding discussion deals with the development of display devices for their largest single application, television, the past 10 years also have seen the development of a great variety of widely differing cathode-ray display tubes for a host of specialized applications, many of them new.

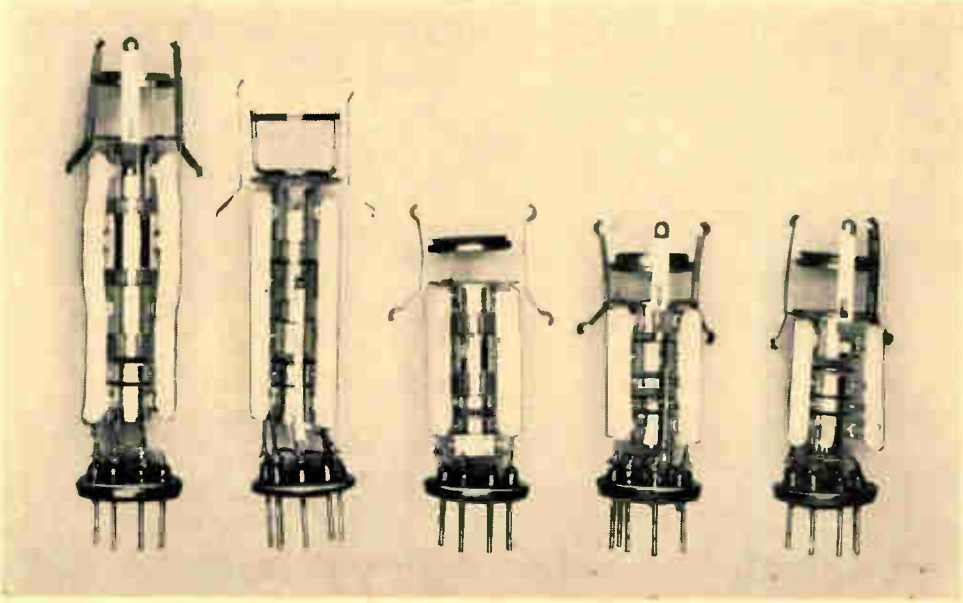
As the requirements on oscilloscopes for testing electronic equipment became more stringent, they were reflected in tighter requirements on the cathode-ray tubes used in this equipment.

New types appeared with reduced spot size, improved deflection sensitivity, improved deflection linearity and reduced pattern distortion. Notable among these were the helical anode post accelerator types, in which a post-deflection beam accelerating field is distributed along the length of the tube by a conducting helix on the inner bulb wall. These tubes are capable of 6:1 post-acceleration ratios, and combine the optimum in deflection sensitivity, deflection linearity resolution and brightness.

For particular applications, a number of multigun tubes having from 2 to 5 guns were introduced commercially, as were tubes with flat faceplates, tubes with rectangular screens, tubes with deflection plate connections brought out through the bulb walls to reduce capacitance and inductance in their circuits, high accuracy nonaccelerator types and many other variations. Tube manufacturers supply most of their types with any of a variety of fluorescent screens. (See Table II.)

Radar indicator tubes and cathode-ray tubes for other military gear became more specialized and were built to closer tolerances and with improved quality, especially the quality of the glass bulbs and the fluorescent screens. Direct view storage tubes have been developed for high brightness radar displays, taking the place of tubes with long persistence fluorescent screens. Several ultrahigh resolution tubes having trace widths less than 0.001 in. have been developed for photographic recording of high-definition radar information.

The emergence of electronic computers has required developing high-accuracy scope tubes for display of analog information and other tubes for storage and for readout of digital information. Several tubes were introduced which form alphanumeric characters by passing the beam through appropriately shaped apertures. The



GUNS for 110-deg picture tubes. Left to right: conventional double-ended anode, conventional single-ended anode, semiflat, short conventional gun and tripotential focus structures

Charactron, used in Sage situation displays, can write up to 64 different characters at any point on its screen and also present analog data. The Typotron is a character display device uniting tube with storage so that alphanumeric information can be written on the screen and held as long as desired.

TRAVELING-WAVE CRT—An interesting new type of display tube, the Wamoscope, was declassified in 1956. The Wamoscope incorporated most of the features of a microwave receiver in a single envelope. The tube consisted of three parts: a traveling wave tube section, a velocity-sorting detector and a cathode-ray screen. This special tube allowed the direct display of microwave frequency radar information and the like.

A development of the late 1950's that promises much future usefulness is the Videograph, or high speed electronic printer, the heart of which is a cathode-ray tube having a target consisting of an array of many fine wire conductors sealed through the bulb face. Charge patterns written on the target by the beam are transferred to sensitized paper outside the tube face where they are developed by the Xerography process. The system can presently print the equivalent of three 8½ by 11 in. pages of typing a second.

PHOSPHORS—Phosphors for cathode-ray tubes are inorganic crystalline materials capable of converting electron energy into luminescence. The fluorescence and the phosphorescence (persistence) characterize the useful properties of these phosphors. The physical and chemical aspects of a phosphor determine the nature (color, brightness and persistence) of the luminescence. Most cathode-ray and television picture tube screens are composed of phosphor particles whose particle size usually lies between 2 and 20 microns. Most of the phosphors listed in the table were developed or improved in brightness and/or color uniformity in the last 10 years.

SCREENS—Higher resolution cathode-ray tubes have been made possible by reduced electron beam diameters and by improved phosphor and screening techniques which allow less apparent spot size growth.. Actual spot size measured on the face of a regular cathode-ray tube always appears larger than the actual electron beam. This effect can be attributed to light scattering by the phosphor particles adjacent to the particles actually excited by the electron beam. By preparing screens of much smaller particle size phosphors and using tighter control of the screening techniques, this increase in spot size due to light scattering is minimized. Such screens are known as fine grain screens and have produced from 3,000 to 6,000 lines resolution on a 5-in. tube.

Another approach to producing an idealized screen for fine spot or high resolution tubes is the so-called transparent screen. Phosphors can be evaporated inside a glass envelope in the same manner as aluminum films. Vapor kinetic processes may also be used. Extremely thin evaporated screens are transparent and are composed of crystals so minute as to be invisible at very high magnification. When an electron beam strikes such a screen, resulting spot size is nearly a direct measure of the electron beam diameter. These transparent screens have been produced commercially.

ELECTROLUMINESCENT DEVICES—The last decade marked the commercial development of a light-producing display device known as the electroluminescent lamp. The light source for this lamp is the result of the phenomenon called electroluminescence which specifically defines the conversion of electricity into light within a phosphor. The electroluminescent lamp is a planar or area solid-state device. Because it has no filament, catastrophic failure is not a problem.

The electroluminescent lamp is a flat plate luminous capacitor activated by an alternating current. In early construction, it consisted of a sheet of glass rendered conductive on one side by the application of a transparent conductive film. This film, in turn, was coated with a thin layer of a special phosphor (electroluminescent) dispersed throughout a solid or liquid organic dielectric. In turn, the phosphor-dielectric layer was coated with a metallic conductor. Lead wires, attached to the conductive film on the glass and to the metal foil, completed the capacitor.

Further development led to the replacement of the organic dielectric by a glass dielectric and to the replacement of the glass base with a metal plate. This metal sheet serves as one conductor and provides mechanical strength and physical rigidity to the completed lamp. A ground coat layer of solid ceramic material to act as an insulator and reflector is fired onto this base sheet. Next, the ceramic dielectric containing suspended electroluminescent phosphor is applied. This is the light-emitting layer. A transparent electrically conducting layer is then applied to the dielectric-phosphor coating and serves as the other plate of the capacitor. One electrical connection is made to the metal and the other to the transparent conductive layer. Finally, a finish layer of transparent glass is applied over the conducting layer to protect the lamp from mechanical damage and to provide a protective insulating outer surface.

This electroluminescent light source can also be employed to create dynamic solid-state panel display devices since light is emitted where, and only where, there is capacitive coupling. By approximate patterning of the top or bottom conductive films in given areas any shape, configuration or group of areas may be made to light individually or in unison. Numeric and alphanumeric panels developed late in the 1950's are examples of the use of electroluminescence.

Electroluminescence can be used in combination with other phenomena, such as photoconduction, to produce many useful devices. A photoconductive material serves as a resistor as long as it is in the dark, and becomes a conductor when light shines on it. Actually, a film of photoconductive material is a light-sensitive switch.

The capability of adding a photoconductive control or switch element to the electroluminescent sandwich produces a tool that can be used as a solid-state switching device. This basic photoconductive-electroluminescent switch makes it possible to build circuits to process complex logical functions. (See Fig. 1). These circuits are capable of converting information without the need of mechanical switches or diode networks.

Storage, Counting and Phototubes

Developments include multiplier phototubes with low electron transit-time spread, ruggedized vidicons, low-noise image orthicons, improved image converters, high-resolution storage tubes, faster output counting tubes and beta counters with cosmic-ray guard assemblies

THIS SECTION covers multiplier phototubes camera tubes, storage tubes, counting tubes and radiation detecting tubes. There has been a great deal of work done on new developments for certain of these types.

MULTIPLIER PHOTOTUBES—An important requirement of a multiplier phototube intended for high definition work is that differences of the transit times of the electrons through the tube (transit-time spread) must be negligible; otherwise, the tube will not accurately resolve extremely short signals received in quick succession.

One approach to this problem is to use a spherical photocathode. DuMont, RCA, and Mullard have done this. The RCA 7264 features a photocathode on the inner surface of the spherical face end of the bulb, a focusing electrode for shaping the field which directs photoelectrons from photocathode to first dynode, and an accelerating electrode for minimizing space charge. Transit-time spread for this tube is of the order of 0.5 nanosecond.

Mullard also uses a spherical photocathode in their 56 AVP. In addition, they have improved the input electron-optical system to include a focusing electrode, an accelerator and a deflector plate. By this means, transit-time spread has been reduced to approximately 0.3 nanosecond.

Dark-current fluctuations and electron shot effect are two of the main sources of noise in multiplier phototubes. In the ITT type 6836, a 16-stage tube of the end-window type, cathode shot-effect noise is minimized by reducing size of the active cathode to a central area of approximately ⅛ in. in diameter.

Solar-blind tubes are intended for upper atmosphere probe work and related tasks. By use of synthetic sapphire glass windows, a selective response maximized to the far-ultraviolet portion of the spectrum is obtained. Response to white light is low. Both DuMont and CBS are active in this field. The DuMont K1932 is now being used by several government agencies.

In ultrasensitive tubes, RCA has recently introduced the type 7029. It is a dormer-window type with a median cathode sensitivity of 125 microamperes per lumen. It is a ten-stage tube and can be used for startracking. The schematic arrangement is given in Fig. 1. DuMont has produced some experimental models with cathode sensitivities ranging from 100 to 200 microamperes per lumen.

Research is being done by RCA on further improvement of copper-beryllium dynode surfaces. The material is intended for high-current-density applications, and has been found to be superior to silver-magnesium for this application. However, the tube gain using copper-beryllium dynodes is lower than when cesium-antimony is used.

PHOTOCATHODE MATERIALS—Trialkali photocathode surfaces are currently being studied at DuMont, and one result has been to make tubes having a high value of cathode sensitivity.

The RCA 7326 is equipped with a newly developed multialkali semi-transparent photocathode and features high sensitivity, low thermionic dark current, and high conductivity even at low temperatures. This photocathode may be cooled to liquid-air temperature to reduce the dark current without sacrificing conductivity to such an extent that current-carrying capacity is impaired.

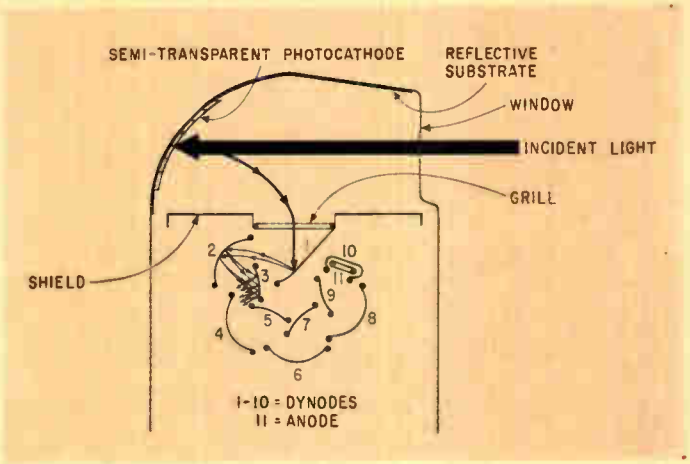


FIG. 1—Ultrasensitive ten-stage phototube can be used in star-trackers (RCA type 7029)

By ARTHUR S. KRAMER,
Senior Technical Specialist, Research Division,
Allen B. DuMont Laboratories, Inc., East Paterson, N. J.

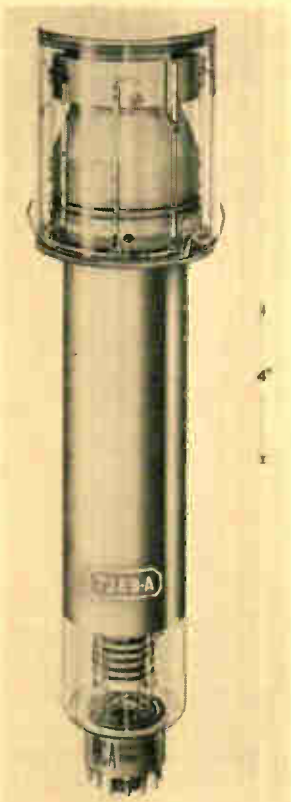


FIG. 2—RCA 7389A has improved signal-to-noise ratio

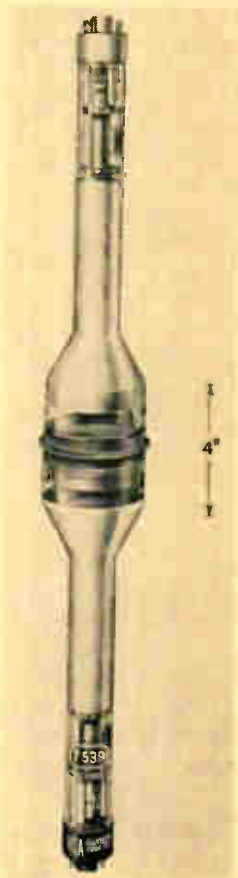


FIG. 3 — Double-ended scan-converter tube (RCA type 7539)

Three small developmental tubes primarily designed to withstand shock and vibration as encountered in rockets and missile space probes have been produced by RCA. Electrically, they are similar to the type 6199, with high spectral sensitivity to blue-rich light and low sensitivity to red radiation. These types, known as C7151C, C7151D, and C7151E, are identical except for base connections.

Some time ago, DuMont introduced a multiplier phototube with a built-in voltage divider for the dynode circuits. This made it possible to reduce the number of leads to the tube from 12 to 3, and helped to reduce pickup between long leads. DuMont has now taken a step further and has developed a multiplier phototube with an encapsulated power supply and voltage divider in the tube base. The power supply operates from 6 or 12 volts d-c.

ITT is developing a tube with a special S20 photocathode on solid substrate with lower resistance. This arrangement is suitable for pulse operation.

CAMERA TUBES—Vidicon tubes are playing more important roles in medical and biological research each year. The RCA developmental type C-73439 ultraviolet-sensitive vidicon is said to be the first camera tube of its kind ever constructed with a fused-quartz faceplate. This tube permits the observation of living-cell specimens irradiated with such low values of ultraviolet radiation that cell damage is minimized.

Two vidicons, the Machlett 7038A and the RCA 7262, featuring precision of construction and uniformity of characteristics, have recently been introduced. Both obtain substantially equivalent sensitivity over the entire scanned area by utilizing a uniformly-thick photoconductive surface. Matched characteristics from tube to tube make it possible to obtain good color uniformity and balance when used in three-vidicon color cameras.

The struggle to reduce the physical size of transistorized industrial and military tv cameras was given a boost when the General Electrodynamic Corp. (GEC) electrostatic vidicon type 7522 was made available. Deflection and focusing coils are no longer needed. Resolution and sensitivity are comparable to magnetic-deflection types.

The GEC type 1300.26 storage vidicon has been de-

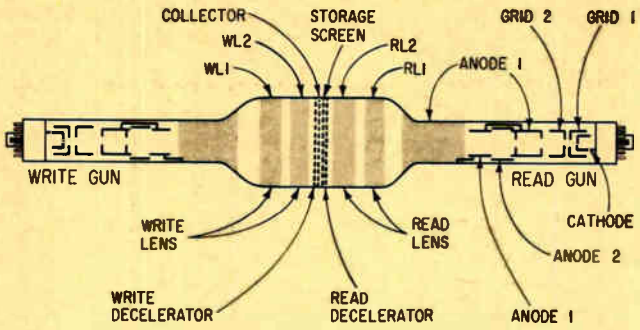


FIG. 4—Raytheon two-gun storage tube or scan converter (type QK 787). Highest direct potential is 3,500 v

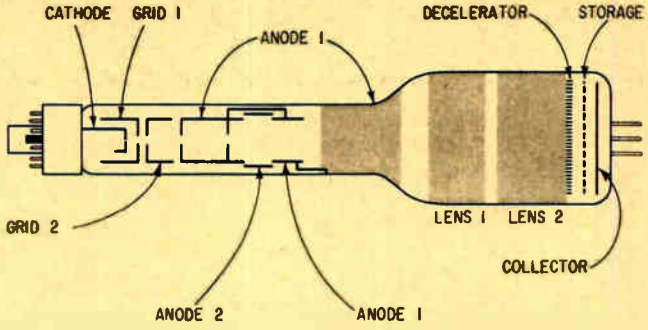


FIG. 5—Single-gun recording storage tube (Raythean type QK 685) is 14½ in. long

signed to store optical images for extended or delayed electrical readout. Typical applications include radarscope and oscilloscope pickup to retain the crt trace for improved visual interpretation. Sensitivity is 0.2 microampere for uniform 2,870 K tungsten illumination on faceplate. Grid 2 has a maximum rating of 750 v d-c, which is somewhat higher than most other vidicons can tolerate. Under typical operating conditions, grid 2 is set at 300 v d-c.

Westinghouse has introduced a pickup-storage tube type WL-7383 (Permachon), which can be operated in a standard vidicon camera with certain modifications. Besides possessing signal integrating properties, the tube offers a gray scale rendition comparable to conventional pickup tubes. It has been used successfully in reduced-bandwidth transmission applications not requiring storage by employing scan frame times of approximately 25 seconds.

Grimson Color, Inc., has recently introduced a process in which any vidicon, (or image orthicon), may be equipped with internal reticle markings. Faceplates of blemish-free, optically-polished glass are etched with one-mil-width lines in the design specified by the customer. By filling the lines with inert substances, reticle markings will be reproduced on the monitor screen in either black or white lines. The face plate can then be fused to a standard vidicon and tested. The markings show up as well-defined permanent lines on the monitor screen.

There is an increasing demand for ruggedized vidicons to satisfy such requirements as tv reconnaissance drones, upper atmosphere probes, moon probes, missiles and satellites. The GEC 7226A and the RCA 7263 have been developed to meet this need.

IMAGE ORTHICONS—Considerable attention has been given to ruggedizing several of the image orthicon types; the RCA type 7198 and the GE developmental type Z-5358 are typical.

Both tubes are same size as other orthicons and voltage requirements are similar. Sensitivity of the 7198, however, is somewhat higher.

The search for methods to improve the signal-to-noise ratio of orthicons has led to the introduction of the RCA 7389A (Fig. 2) and the English Electric Valve Co. (EEV) P822. Both these tubes have diameters of 4½ in. as compared to 3 in. for other orthicons. The high capacitance of the target assembly results from the increased area of the target and enables these tubes to have an extended linear portion on their light transfer characteristics and larger output signals. This higher output signal results in an improved signal-to-noise ratio. The 7389A has an overall length of 19⅜ in.

The demand for an image orthicon built to close manufacturing tolerances has resulted in the RCA 7513, which features precision construction for improved registration of images in color cameras. To achieve preciseness of construction, each section of the tube is accurately aligned with respect to the main axis. The result is that the three images produced within a color camera can be practically identical in geometry, and registration over the entire picture area is very good.

The type P825 image orthicon manufactured by EEV has recently been applied in a new way to an old problem. X-ray equipment has been developed by which 11 by 11 in. fluoroscopic images suitable for examination by normal lighting are presented on one or more monitor screens. After passage through the patient, the x-ray beam impinges on a fluorescent screen and the resultant image is reflected through 90 degrees by a mirror into a lens system, and then to the photocathode of the 4½-in. orthicon. At this stage, the picture is converted from light into electronic form, so that it can be amplified and reproduced on tv-style screen. A remote recording unit can also be connected to the electronic rack for making spot film records. Image amplification enables the x-ray dosage to the patient to be reduced.

IMAGE CONVERTERS—The ITT FW-113 is a developmental two-stage cascaded image converter tube using an S-11 photocathode and magnetic focusing. The tube consists of two image-converter tubes cascaded in a single glass envelope. Output of the first converter communicates with the input of the second through a thin transparent window, thus greatly increasing gain. The output image is a greatly intensified replica of the input. Either permanent or electromagnets can be used for focusing. The two sections of the tube are diodes, with one electrode common, and only three electrical connections are necessary for operation.

STORAGE TUBES—Four models of double-ended scan-converter tubes have been recently brought out: the Raytheon QK787, the GEC 1300.32, the Intec TMA-403X, and the RCA 7539 (Fig. 3). The major function of this type of tube is to convert from one type or speed of scan to another type or speed of scan, such as from

FIG. 6—Burroughs Beam-X decimal electronic switch and one of its transistorized circuit modules

ppi to tv raster or tv at high speed to tv at lower speed.

The Raytheon QK787 is equipped to give 1,000 tv lines resolution per diameter, and can be operated so that ppi pictures can be written continuously and the storage decayed at a controllable rate, thereby producing target trails for moving objects. Degree of control is good enough so that, at one extreme, trails can extend across the complete diameter of the tube; at the other extreme, stored picture can be decayed to 50 percent of its original amplitude in less time than is required for a single antenna rotation. Complete erasure is possible in two seconds or less. Tube uses magnetic deflection on both guns and either electrostatic or magnetic focusing is available. Magnetic focusing gives better resolution. The QK787 is 24 in. long by 3 in. diameter in center section. Highest d-c voltage required is about 3,500 volts. A cross-sectional view of the QK787 is shown in Fig. 4.

The GEC 1300.32 scan converter, a storage device with variable erase time, is capable of simultaneous reading and writing. It utilizes magnetic deflection and focus on both sides with provision for electrostatic focus and electrostatic dynamic focus. Resolution is 1,000 lines. Reading and writing signals are available on two terminals in proper phase relationship to make signal separation possible with simple cancellation circuits and no r-f modulation is needed to differentiate between input and output.

The Intec TMA-403X video transformation tube is a semiconductor type memory tube employing two axially opposed electron guns in a physical arrangement that allows instantaneous transformation of video signals from one coordinate to another through simultaneous scanning of the two side of a target membrane. Resolution is 1,000 tv lines.

RCA has introduced the 7539 scan converter tube, which has a resolution capability of 150 range rings per display radius with a response of 50 percent or better. The tv monitor system which works with this tube must have a resolution in excess of 1,000 tv lines.

A new type of storage phosphor has recently been introduced by Ferranti, Ltd., of England. Designated as Y phosphor, its purpose is to delay the observation of a signal until such time as is convenient to the observer. This is a special class of zinc sulphide phosphor which has the ability to store electron energy and release it under the influence of infrared illumination. Advantages claimed for the new Y phosphor are that the entire display can be stored and released only when required; rate of decay is completely under control of the operator and that conventional crt's can be given better storage properties.

Any tube equipped with this new phosphor must be reasonably well-shielded from ambient white light and must also be illuminated by a source which is high in short and medium infrared energy and quite low in visible energy. In operation, the image is stored until released by illuminating the tube phosphor with the infrared energy.

Several other high-resolution tubes have been introduced recently. The RCA developmental type C73959 is a high-resolution 5-in. display storage tube designed for applications where it is desired to have a bright, nonflickering display of stored information for relatively long periods after writing has ceased. With 5,000 volts on the screen, a 3.8-in. diameter display with saturated brightness of 200 foot-lamberts is obtained. Typical writing speed is 3,000 in. per sec.

Another high-resolution tube, the Raytheon QK685, can provide 1,000 tv lines resolution per diameter at 50 percent modulation level. This is an electrical output recording storage tube capable of repeating information stored for several hours up to 20,000 times without serious deterioration of signal strength or quality. Overall length of QK685 is 14½ in. by 3⅛ in. maximum diameter. Highest d-c supply voltage required is about 3,500 volts. A cross-sectional view is given in Fig. 5.

RCA has introduced the type 7448 5-in. display storage tube designed so that it can be made on a mass-production basis, with resulting reduction in cost. The tube is built with only one neck for both guns, the axes of which are parallel. This type of construction makes the tube very useful for applications where space is scarce, such as in fighter-plane cockpits. The 7448 has resolution of 50 lines per in. and writing speed of 300,000 in./sec.

A storage tube capable of writing a tv raster and ppi scan simultaneously has been introduced by DuMont. This model, the K 1878, is a 10-inch direct-view type capable of storing signals for several hours and of giving highlight brilliance of 500 foot-lamberts. One novel way to use this tube is to have one gun integrate the echoes from a radar and display them while the second gun writes in information from other sources, such as a fire-control computer, a second radar, or a past history source. Minimum resolution is 50 lines/in.

Machlett has introduced their ML-6577, a storage tube for displaying printed data rapidly. Any one or a combination of 63 alphanumeric characters, approximately ⅛ in. in height, can be written sequentially and displayed continuously until erased at speeds up to 25,000 characters per second. Tube is 30¼ in. overall length by 5⅝ in. max. diameter. Highest d-c voltage required is 3,000 volts.

COUNTING TUBES—Mullard of England have made available a Trochotron high-speed decimal stepping tube, for use as a counter or selector at speeds up to 1 Mc. This tube, the ET51, is switched by a negative signal, and provides a constant-current output of 5.5 ma, sufficient to drive a cold-cathode decimal indicator. Ad-

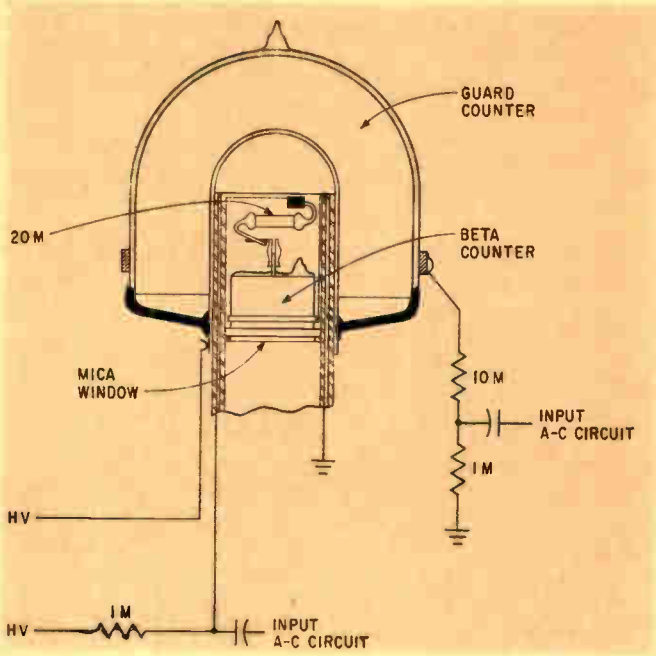


FIG. 7—Amperex beta counter assembly

vantage of the ET51 is that it can replace several tubes or transistors with associated components. Tube is a vacuum device which makes use of crossed electric and magnetic fields to form a beam of electrons between a thermionic cathode and any of ten groups of three electrodes mounted radially about the cathode. The electric field is provided by the interelectrode potentials within the tube and the magnetic field by a cylindrical magnet fitted externally around the glass envelope. Maximum d-c supply voltage is 100 v d-c.

EZ108 by Elesta AG, Bad Ragaz, Switzerland, is a miniature gas-filled decade stepping tube and consists of a cylindrical anode surrounded by 20 cathodes. A negative pulse input steps the glow from cathode to cathode. Maximum counting speed is 1 Mc. Successive negative input pulses step the glow to successive main cathodes. The voltages which appear across the cathode resistors may be used in computing and control applications.

The Burroughs Beam-X, a decimal electronic switch, is designed using small rod magnets within a vacuum to control the position of an electron beam to any one of ten output positions. A photo of the new Beam-X is shown in Fig. 6. The module in the photo is designed for counting applications up to 110 Kc, and provides 10 electrical outputs. In a typical ten-position switching application, the switch eliminates a total of 90 transistors, diodes, and resistors which are used with binary logic to achieve the same results.

An improvement has recently been made in the Sylvania types 6476, 6476A, and 6802. These decade counter tubes are gas-filled devices employing 30 pin-like cathodes which surround a disk-shaped anode, and can now stand by on one pin for much longer than 100 hours without sticking. Counting rate has also been increased to 5 Kc.

The new Mullard Z302 decade stepping tube is so sensitive that interstage coupling amplifiers can be eliminated. Use of this tube permits complete counter chains to be built with considerable simplification. The tube consists of a circular anode surrounded by 30 rod cathodes which are connected to form 10 repeated groups of three electrodes each. With suitable circuit conditions, a discharge is formed between the anode and one of the main cathodes. Its position is shown by a visible glow on the tip of the cathode, which remains in position until the discharge is moved to the next main cathode by a suitable input signal. Counting speeds up to 1,000 pulses per second can be attained.

Baird-Atomic has introduced a line of miniature Digitrons, which are cold-cathode glow tubes designed to display a glowing numeral on the envelope side when a voltage is applied between the common anode and the chosen cathode. When packed side by side, the row of glowing digits resembles a printed number.

A long-life Nixie indicator tube has been developed and made available by Burroughs. These are gas-filled, ten-digit numerical indicator tubes with a common anode. They are viewed from the top, and contain stacked elements in the form of metallic numerals. Application of a negative voltage to the selected character with respect to a common anode results in its becoming the cathode of a simple gas discharge diode.

RADIATION DETECTING TUBES—Western Radiation Laboratory has developed several highly special and small Geiger-Muller tubes for medical and biological research using radioisotopes. Diameters are of magnitude 1 to 6 mm, and lengths are of magnitude 5 mm to 30 mm. Operating voltage is 500 to 600 volts, positive on anode. Tubes are self-quenching and nonphotosensitive. Maximum counting speed is approximately 100 counts per sec and life in counts is approximately 10^7. Tubes can be used in cystoscopic manipulators, or mounted on special catheters.

The problem of measuring the beta activity of low-intensity radioactive samples has been greatly simplified with the introduction of the Amperex type 18515/18517 low-level beta counter tube configuration. Among the most important factors governing the lower limit of beta detection is the background counting rate of the detector, which is the count in the tube caused by any outside agency. Among causes of such spurious counts are: gamma radiation from surroundings, mesons of cosmic radiation and beta and gamma radiation from impurities in detecting tube.

Using the new Amperex beta counter assembly, a single counter tube, the Amperex 18517, serves as the entire cosmic-ray guard assembly. The Amperex type 18515 fits inside the guard tube, as shown in Fig. 7. The resulting structure requires only 400 pounds of lead shielding to achieve backgrounds of the order of one count per minute.

Boron trifluoride neutron detectors are used to detect slow neutrons. When surrounded by paraffin or other moderators, they will detect fast neutrons. Nuclear-Chicago has introduced a line with long plateaus which discriminate well against gamma radiation. Model NC-210 is useful where low fluxes are to be measured over large areas. It consists of detectors commonly joined by a brass base, and measures 4 in. by 10 in.

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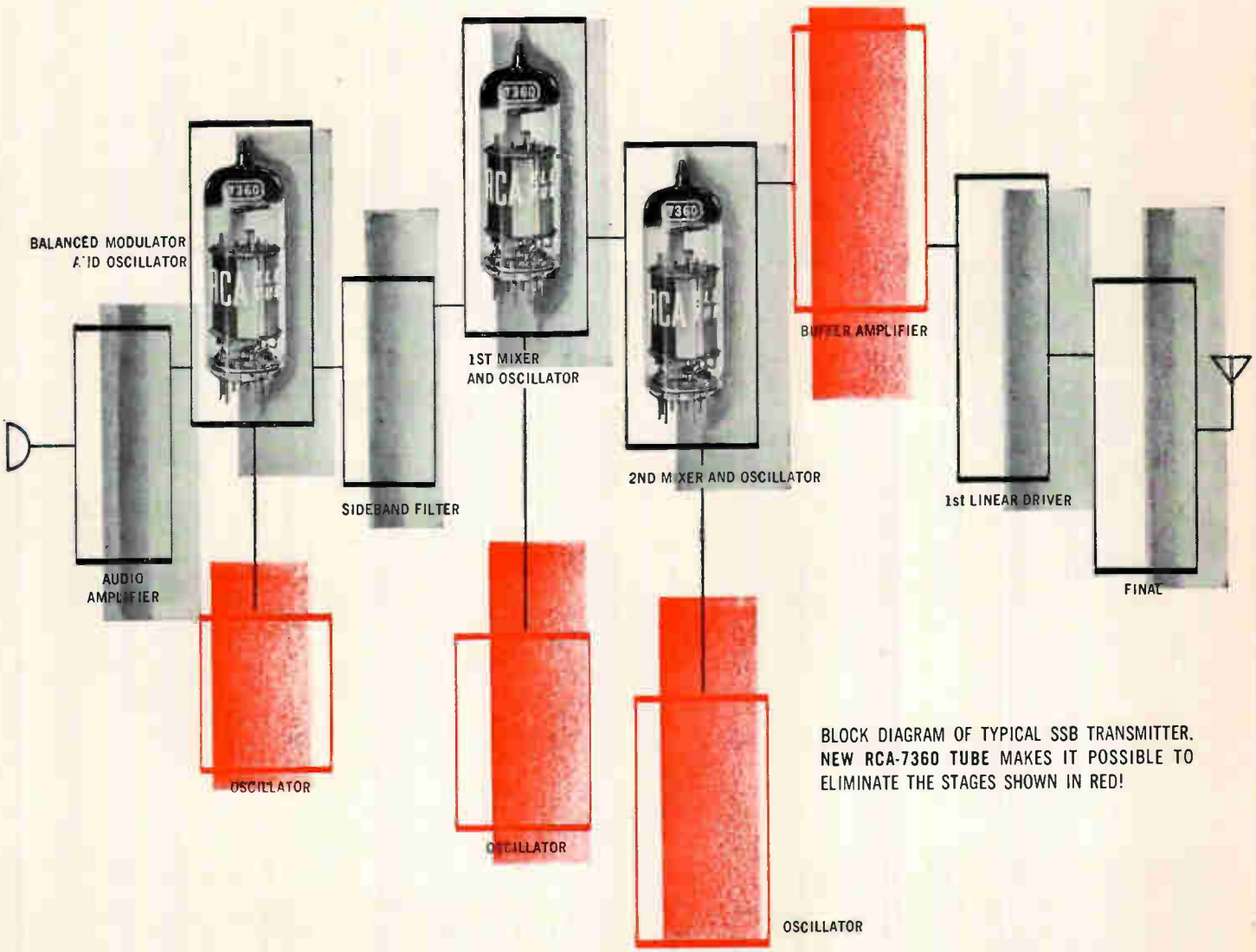

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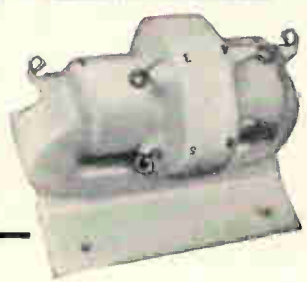

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12 KV test at 30,000 feet

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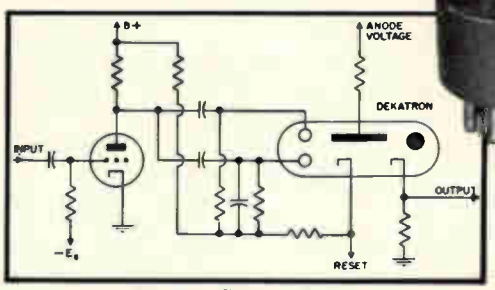

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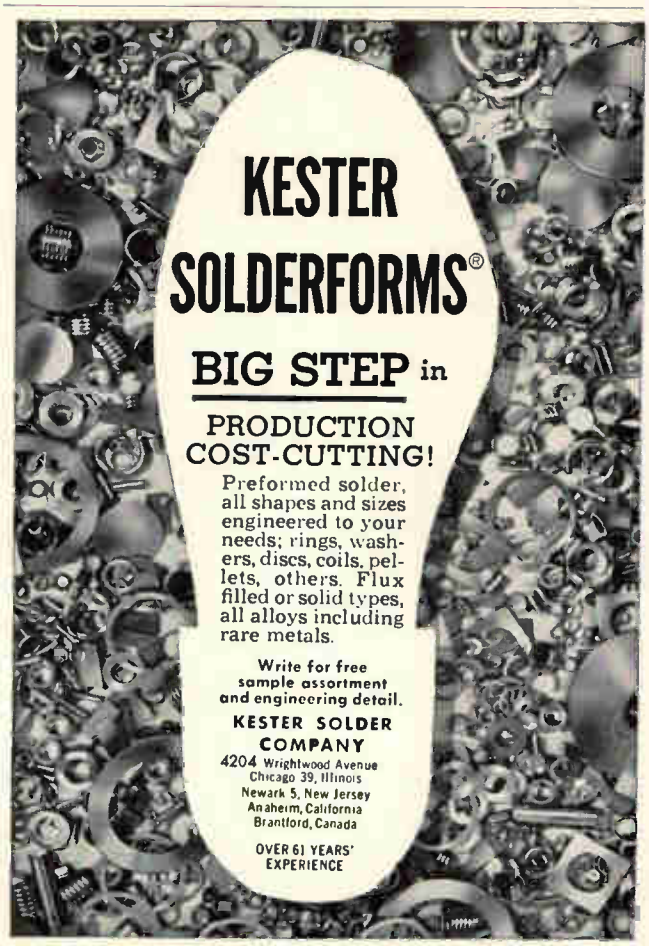

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- fast recovery time—.15 μsecs max*
- high rectification efficiency
- high-frequency operation—to 500 Mc
- 1000-hours operating life guaranteed
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- uniformity of electrical characteristics
- exceptionally low reverse-leakage
- ruggedness inherent in structure
- withstand severe environment
- miniature size

*proven in Jan 256 circuit.

Excellent recovery time makes SYLVANIA silicon-bonded DIODES especially well suited to switching service in logic circuitry. High frequency cutoff and excellent rectification efficiencies make them the designer's choice for detector and discriminator service. Reliability under stresses of environment is assured by the bonded point-contact structure and the minimal mass of the package. Careful control of material purity and surface cleanliness guarantees low leakage initially and throughout the long operating life of SYLVANIA SILICON-BONDED DIODES.

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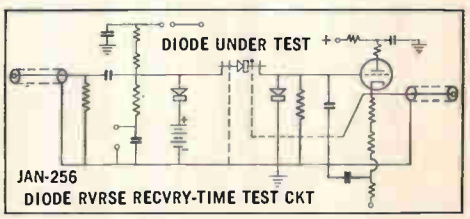

ELECTRICAL CHARACTERISTICS	1N251	1N252	1N997
Reverse Recovery Time (Jan 256 circuit)	0.15 μsec to 500 μA max. (+5 mA to −10 V)	0.15 μsec to 250 μA max. (+5 mA to −10 V)	0.15 μsec to 250 μA max. (+5 mA to −10 V)
Peak Forward Current	120 mA	120 mA	120 mA
Forward Current (minimum)	2.0 mA @ 1.0 V	10.0 mA @ 1.0 V	10.0 mA @ 1.0 V
Reverse Current (max @ 25° C)	0.20 μA @ −10 V	0.10 μA @ −5 V	0.025 μA @ −12 V
Reverse Current (max @ 100° C)	10.0 μA @ −10 V		
Reverse Current (max @ 125° C)		10.0 μA @ −5 V	
Reverse Current (max @ 150° C)			5.0 μA @ −12 V
Peak Inverse Voltage (minimum)	40 V @ 125 mW	40 V @ 100 μA	40 V @ 100 μA

For complete technical data, write Semiconductor Division, Sylvania Electric Products Inc., Dept. 224B, Woburn, Mass.

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

STAMPING: RMC—Capacity—Z5U

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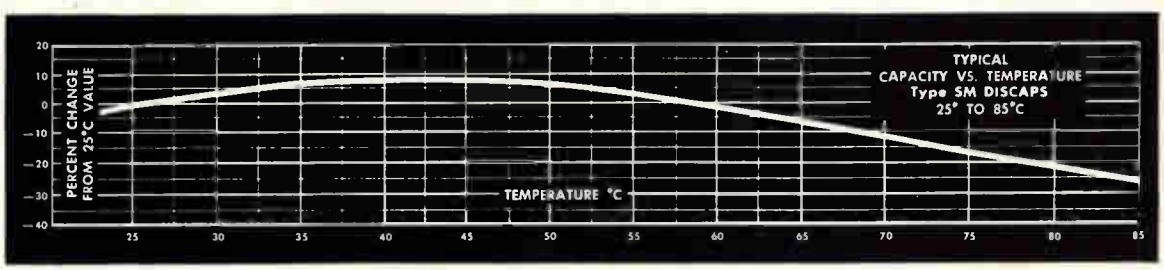
RMC Type SM DISCAPS are designed for applications in compact radios, testing products, communication equipment and other products where space is of prime importance. These DISCAPS are rated at a working voltage of 500 volts and exhibit a minimum capacity change between +10° and +85° C. Type SM DISCAPS can be specified with the complete assurance of quality and reliability that is inherent in all RMC DISCAPS.



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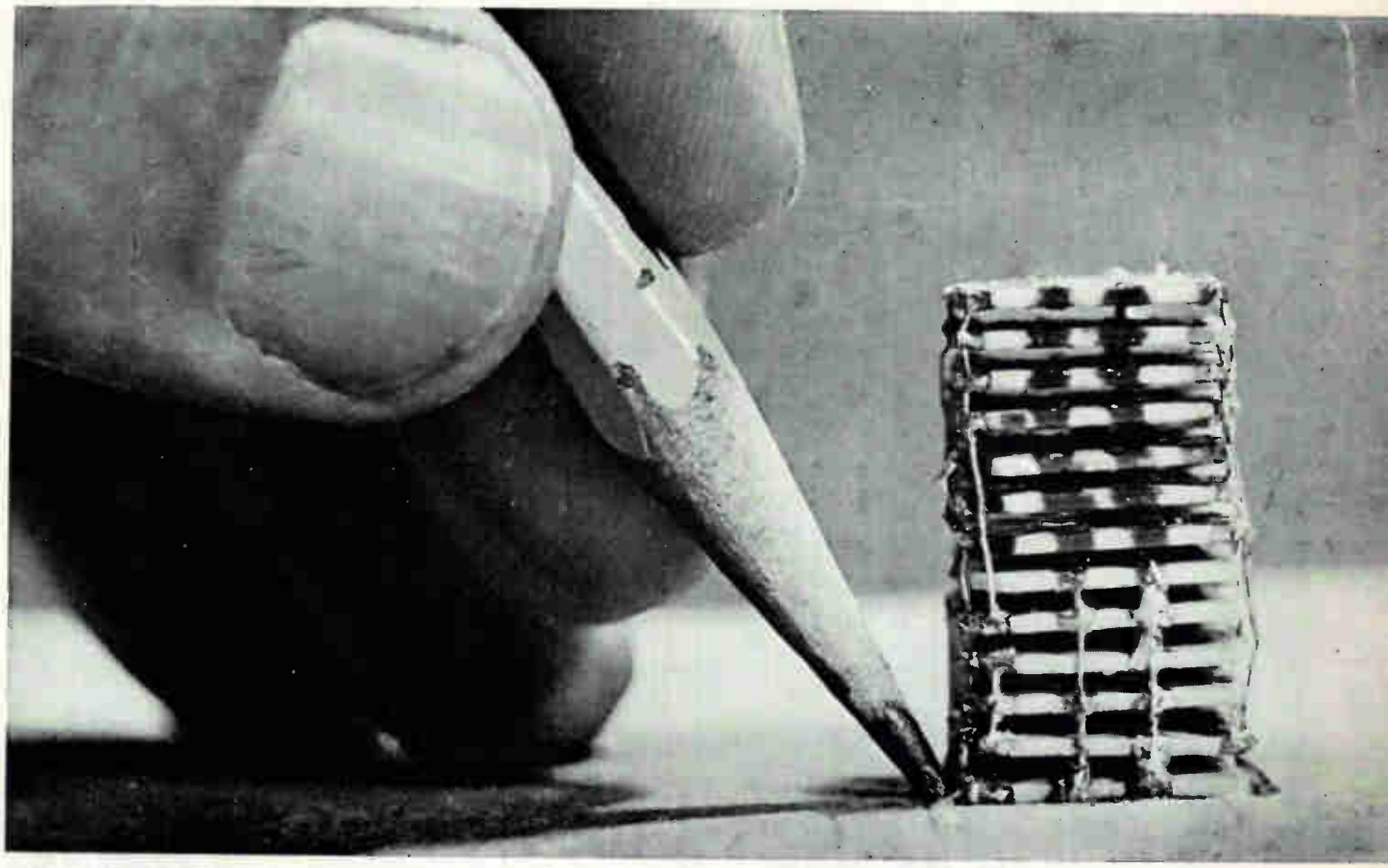


FIG. 1—This full-adder assembly consists of 18 wire-supported and wire-interconnected wafers

MICROMINIATURIZING A Space Vehicle Computer

One present-day approach to design and fabrication of a microminiaturized digital computer for space

By EDWARD KEONJIAN,

Sr. Engineer, Arma Div.,
American Bosch Arma Corp.,
Garden City, N. Y.

ALL space vehicle electronic equipments must be reliable, consume little power, weigh little, and be small. This article describes approaches to decreasing the size of digital computers comprising tens of thousands of components.

The microminiaturizing technique used is the 2-D or two dimensional approach. This technique puts an entire functional circuit on a thin wafer substrate, which may be either an insulator, a conductor, or a semiconductor.

By depositing a large number of components on a single thin substrate, a high parts density can be attained. Doing this also simplifies the problem of interconnecting components.

Figure 1 and Fig. 2A shows a 2-D type full-adder. Individual circuits are shown in Fig. 2B. This logic-circuit block functions in the NRZ (non-return to zero) mode, operating on the trailing edge of a 140-Kc clock pulse that is 1.4-μsec wide. In operation, the adder dissipates very little heat. Natural convection within the adder transfers this heat.

Seven amplifiers, eight AND circuits, and one flip-flop comprise 17 individual circuits which are fabri-

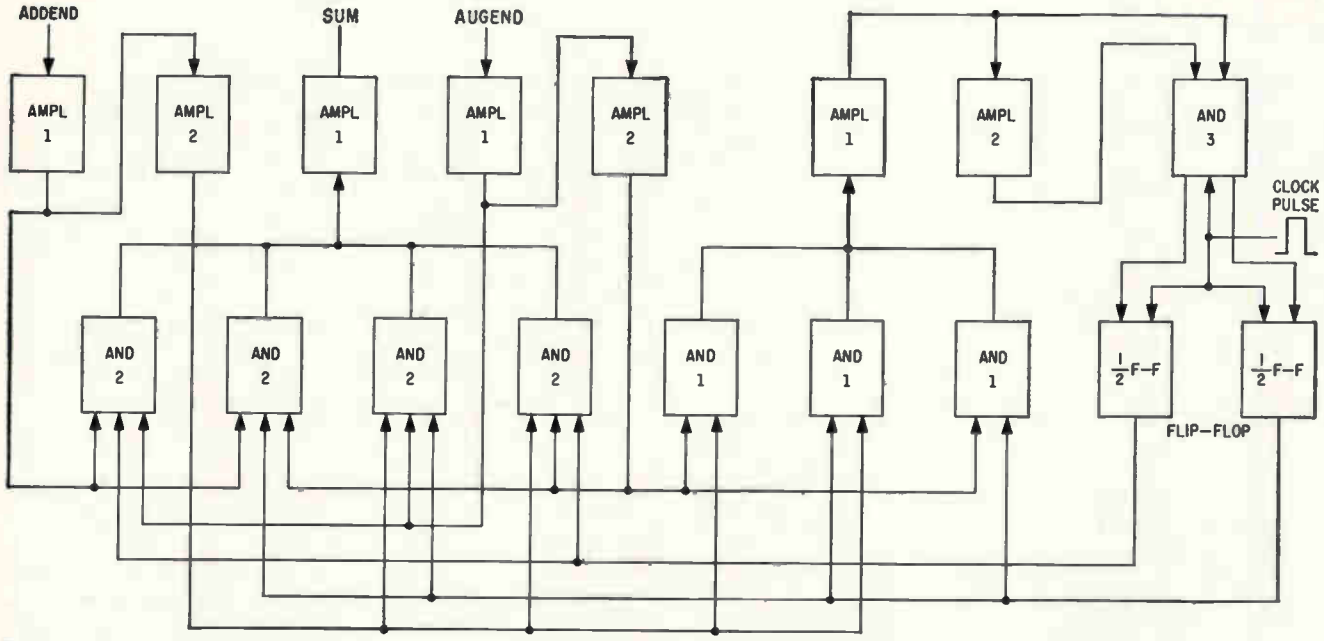


FIG. 2A—Block diagram of the full adder. Individual blocks are composed of basic circuits shown in Fig. 2B

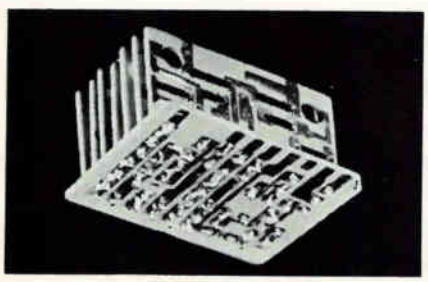


FIG. 3—Interconnections of assembly (above) are by circuit board; of other assembly (below), by strip

cated on 13 wafers. Each wafer is 0.5 by 0.5 by 0.03 inch.

A flip-flop wafer (two such wafers comprise a flip-flop) is shown in Fig. 2C. Printed resistors, barium-titanate capacitors and unencapsulated silicon semiconductors are used. The insert shows, in crosssection, details of transistor placement in an 0.1-in.-diam. hole in the wafer. (The active element of a diffused-junction transistor is generally used.) Diodes are similarly placed, in 0.06-in.-diam holes. A silicone varnish coats the surfaces of the semiconductors.

Several assembly techniques have been used. Figure 1 shows one full-adder assembly. The volume of the entire circuit, including all interconnections, is about ¼ cu in. This volume corresponds to a final circuit parts density of about 600,000 parts per cu ft. The wires between wafers provide mechanical supports as well as electrical connections.

Figure 3 (top) shows another version of the full adder. This version consists of seven circuit wafers, which are interconnected by the printed-wire board on the bottom.

Assembly of another version of the full adder is indicated in Fig. 3 (bottom). In constructing this adder, the wafers are mounted to the flexible interconnection strip (top). The strip is then folded in accordion fashion, thus forming the wafers in two columns of equal height. Strip and wafers are placed in a thin plastic housing whose volume is ½ cu in. Seventeen circuit wafers comprise the strip-assembled full adder. Base material for the wafers is an aluminum ceramic. Linework is fired on the wafers. Resistors are of the printed-carbon type; diodes, transistors and capacitors are mounted into the wafer.

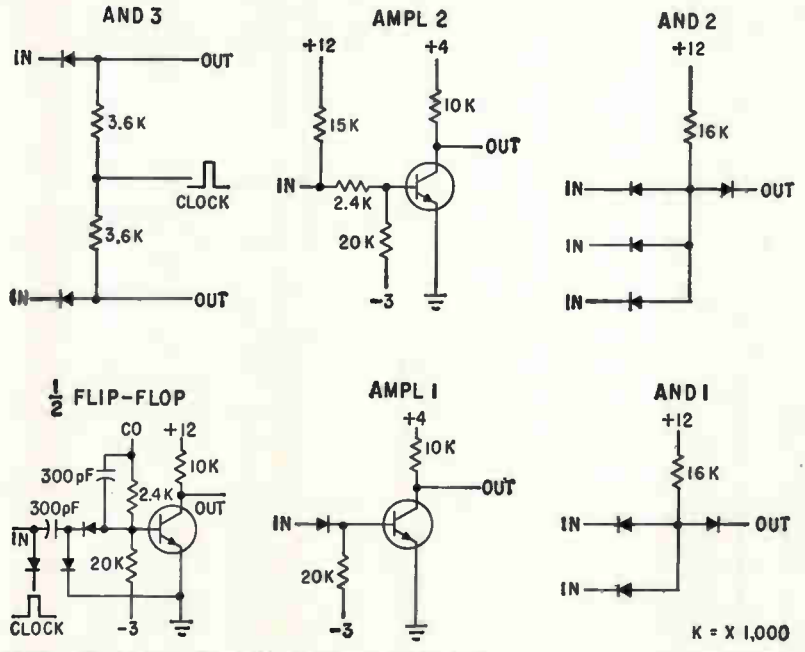


FIG. 2B—Basic circuits used in full adder

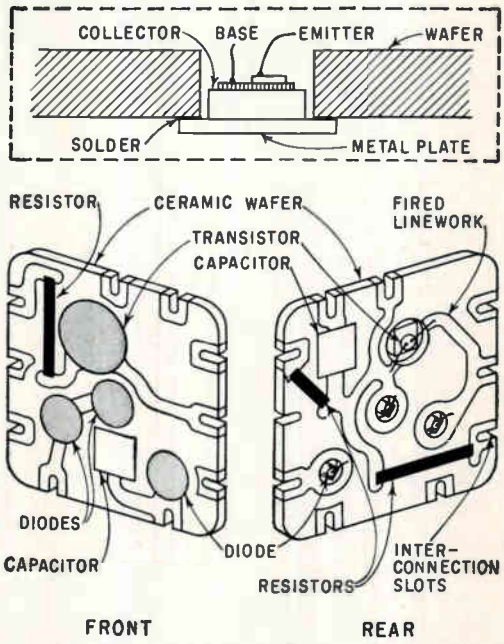


FIG. 2C—Flip-flop wafer construction

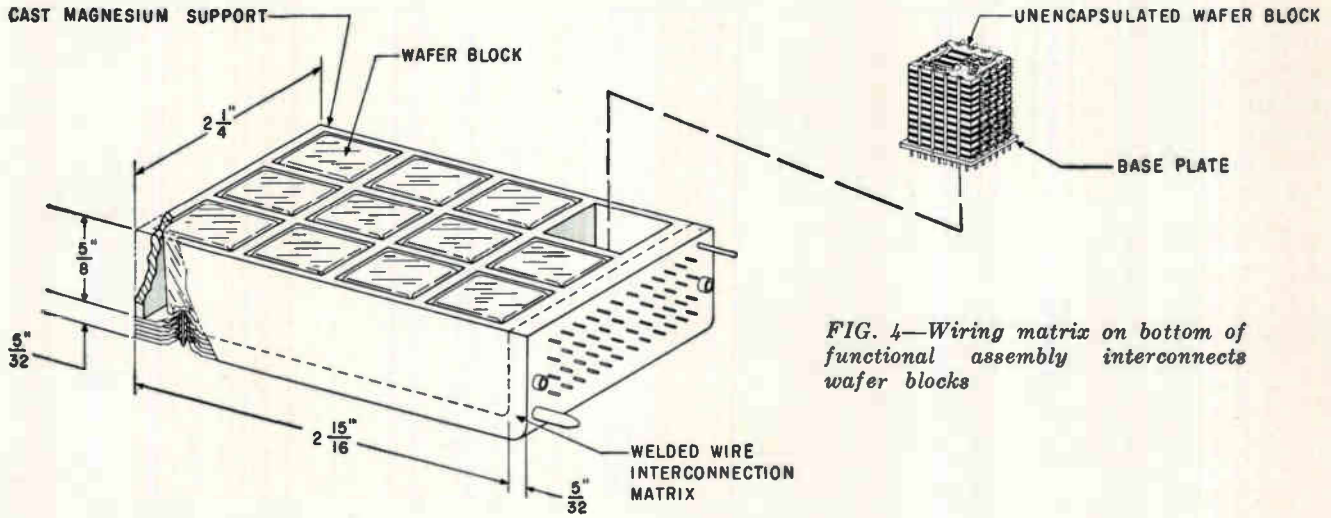
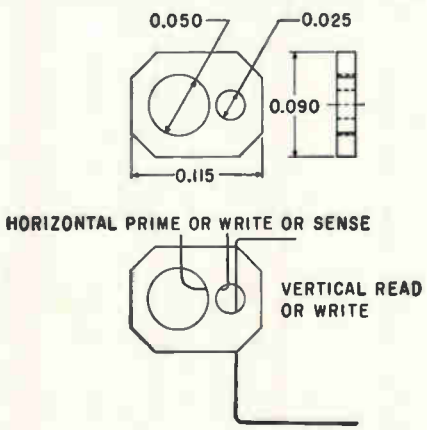


FIG. 4—Wiring matrix on bottom of functional assembly interconnects wafer blocks



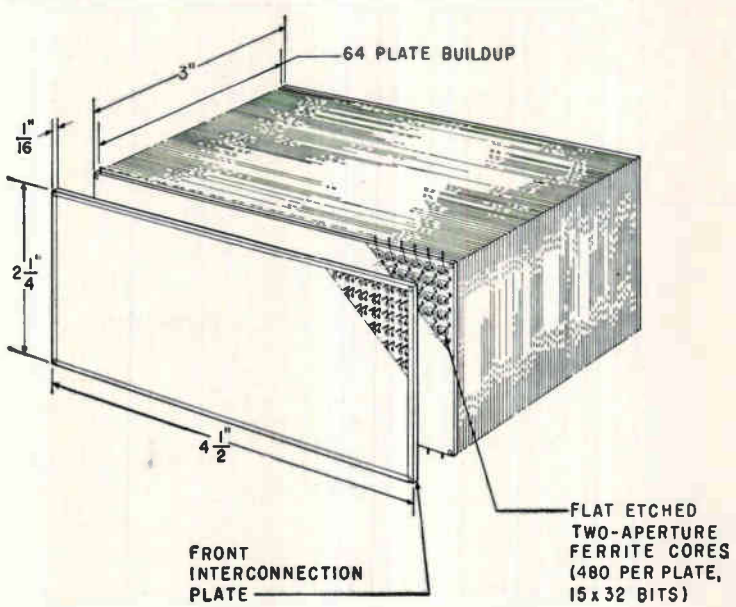


FIG. 5 — Subminiature transfluxor cores (above) form a 30,000-bit storage (right)

SOME PROBLEMS IN REDUCING COMPUTER SIZE

Selecting components, particularly semiconductors, and protecting them from environmental extremes.

Producing and assembling economical and reliable components, component wafers, wafer subassemblies.

Interconnecting wafers comprising sub-assemblies. So far, vertical wires, printed-wiring boards or flexible strips have been used as the interconnecting means—as well as to furnish mechanical support. Usual joining methods are spot welding, dip soldering or both.

Heat transfer in a small, parts-packed volume. Expected computer heat dissipation of about 50 w will be handled by cooling gas.

Preventing interference as the number of circuits and interconnections increases

At the edge of the wafer, short, bent leads for interconnection are soldered to the pads.

The interconnection strip consists of a 2-mil-thick Teflon film with 1-mil copper bonded or plated on both sides of the Teflon and etched to form the interconnecting lines. Plated-through holes are used for crossovers. Mounting of wafer rows alternates from side to side of the interconnection strip to permit a bend radius of 15 mils. To permit a large number of bend cycles without unduly fatiguing material, only one side of the Teflon has copper at the bend. A Mylar film above the wafers prevents shorting.

The assembled strip is housed in its plastic container to effect a compression-tension type of packaging. One end of the interconnection strip projects outside of the container, thus providing external-connection terminals.

Protection of individual circuit wafers forming subassemblies such as the full adder is obtained by enclosing the subassemblies in a thin-walled hermetically-sealed container. The container is filled with an inert high-heat-conducting gas.

So far, attempts to coat circuit components with a suitable protective substance have not given entirely satisfactory results. A special treatment (pacification) of semiconductor surfaces, to make them invulnerable to their environment, is still experimental.

The basic problem in computer packaging is to combine a great number of circuit subassemblies in a minimum volume, keeping weight low and reliability high. Figure 4 shows an assembly of logic-circuit subassemblies. A high-density welded-wiring matrix interconnects the subassemblies.

The storage section of a computer contributes much to its volume and weight. Thin-film techniques, which permit storage of a large amount of information in a small amount of space, are still experimental. Present plans involve use of subminiature transfluxors of about 0.1-in. external diameter. Figure 5 shows the approach to wiring and packaging a transfluxor storage matrix for a memory with about 30,000 bits.

Figure 6 indicates interassembly interconnections of the computer.

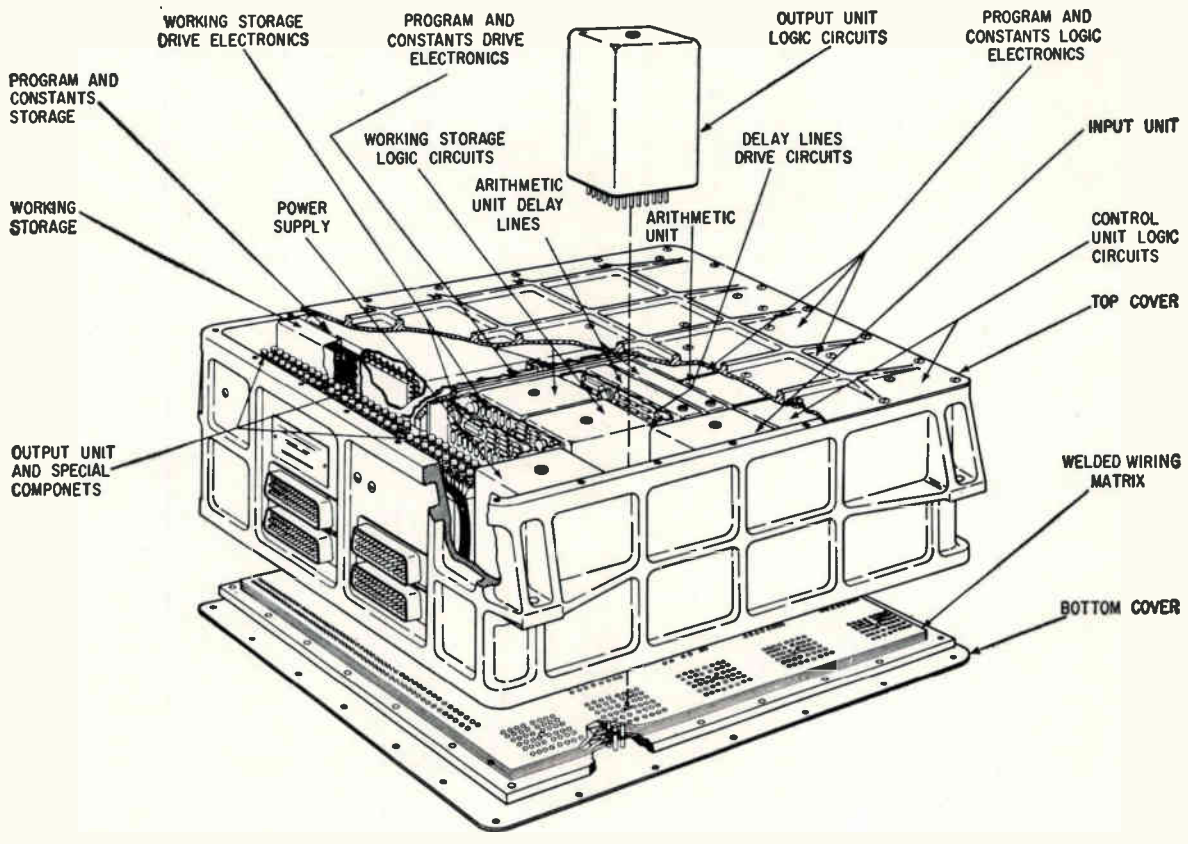
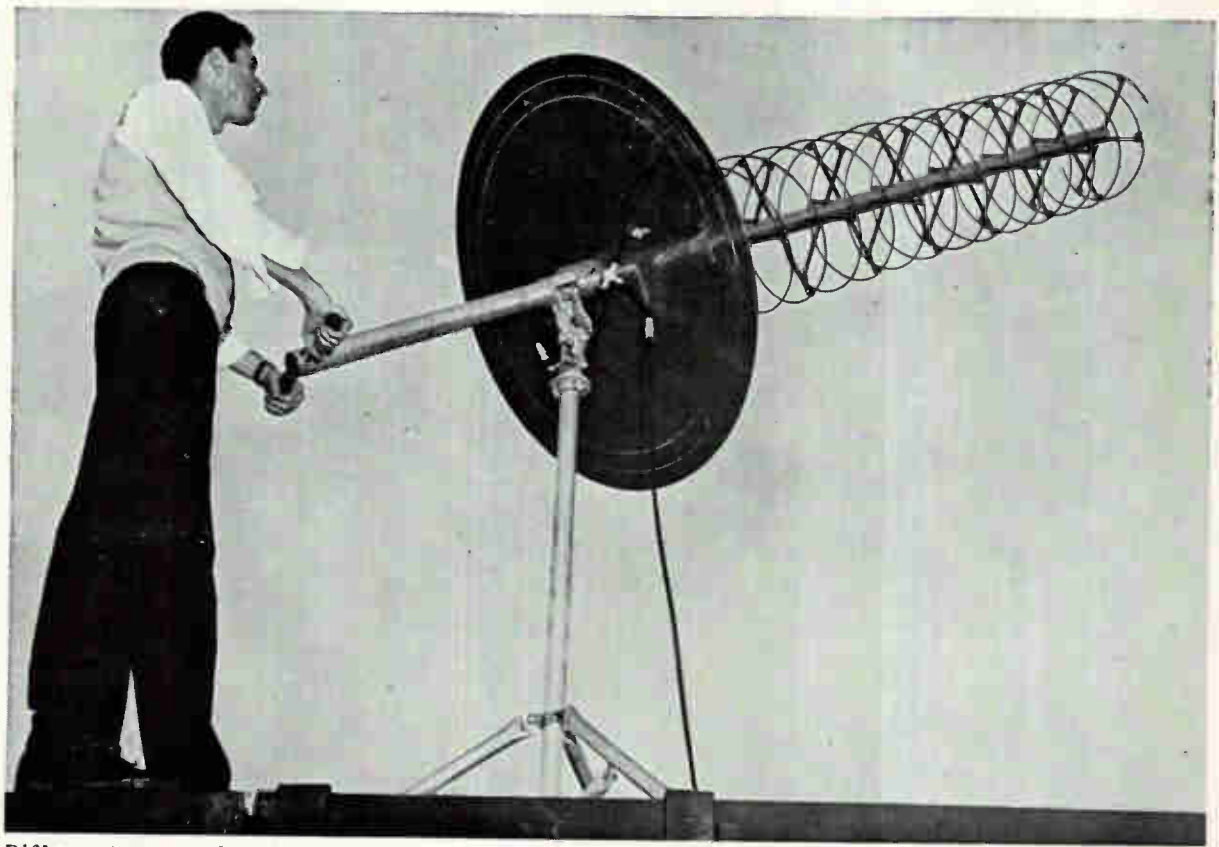


FIG. 6—Exploded view of proposed computer indicates techniques for interconnecting assemblies

IMPROVING THE

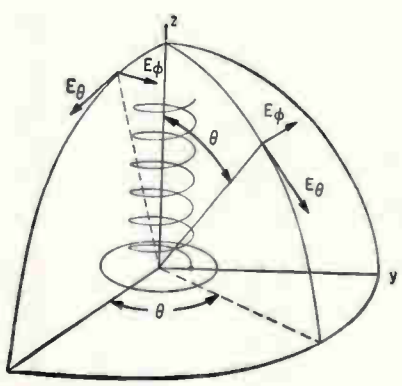
Helical Beam Antenna

By interlacing two helical antennas, the overall radiation pattern is improved, side lobes are reduced and the result is a significant improvement over a single helix



Bifilar antenna used in making measurements discussed in article

By A. G. HOLTUM, Jr., Chief Engineer, Andrew California Corp., Claremont, California



Coordinate system used

THE RADIATION characteristics and directivity of a single helix operating in its axial mode are limited by the relationship between the velocity of the traveling wave on the conductor and the spacing between turns. This limitation can be overcome by using a bifilar or interlaced helical construction. This article describes experiments performed on a bifilar antenna with two feeds and a phasing harness. A simple expression for the radiation pattern is derived and compared with measurements made over a bandwidth of approximately 1.5 to 1.

Results of these measurements indicate improved directivity and sidelobe structure for the new configuration.

Operation of the helical antenna in its axial or beam mode has been described[1, 2]. This configuration has proven to be a practical method for producing a circularly-polarized radiation pattern of desirable characteristics over a fairly wide frequency band with desirable imped-

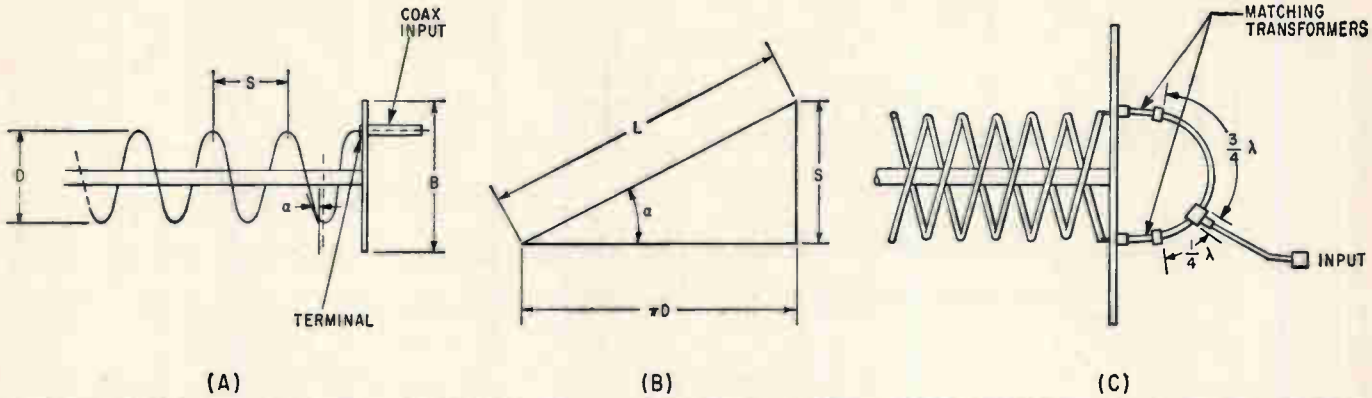


FIG. 1—Relationship of helix dimensions (A), helix geometry (B); (C) bifilar helical antenna arrangement, (D) relation

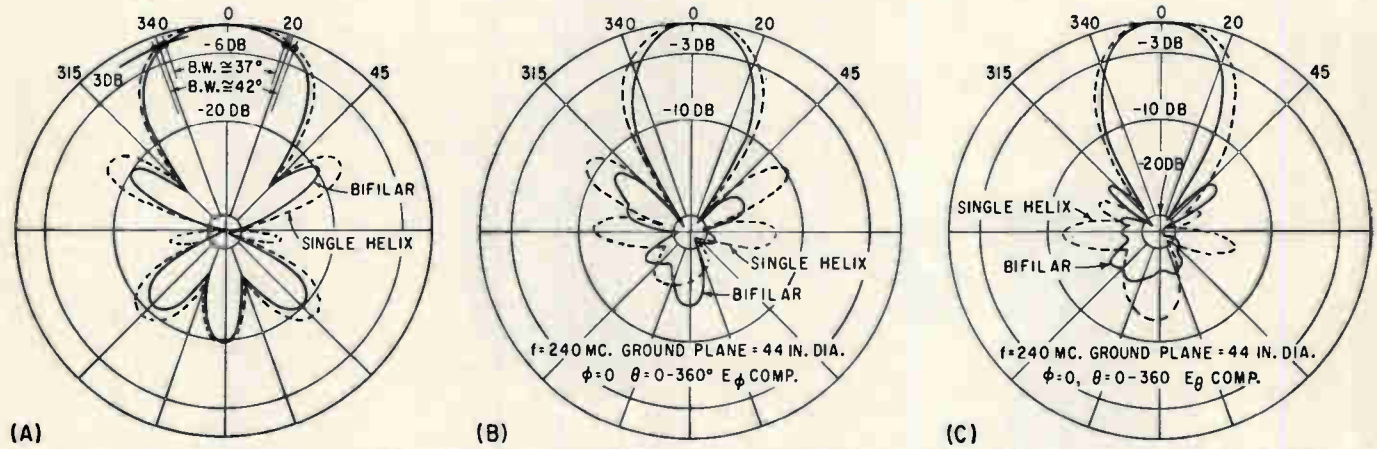


FIG. 2—Comparison of antennas: (A) both antennas, (B) pattern measured at 240 Mc, (C) comparison for the E-plane,

ance characteristics. It is used for tracking and telemetry applications in the forms of single elements of a few to many turns and as an array of two or more elements for increased directivity or interferometer applications.

In the analysis of the radiation characteristics of a single helix the approximate pattern may be computed as an array of n turns by taking the product of the pattern for a single turn and for the array[3].

Kraus' has shown that the optimum value of the pitch angle for the helical operating in the axial mode is between 12 degrees and 14 degrees and that the 14 degree type tends to have slightly better impedance characteristics while the 12 degree type tends to have slightly better patterns. This indicates that if the distance between the elements in the array were to be closer together the pattern might be improved. Because the traveling wave on the conductor would not be phased properly the spacing is limited.

Preservation of the proper phase together with an increase in the number of elements in the array suggests the use of a double wound or bifilar helix. It is the purpose of this article to discuss such a configuration and to describe experiments which were performed on an antenna so constructed.

Figure 1A and B shows the relation of helix dimensions as suggested by Kraus and Fig. 1C illustrates the bifilar antenna in a configuration utilizing two separate feeds together with a phasing harness for adjusting the phase of one helix with respect to the other. As indicated in the figures, a coaxial transmission line and ground plane are used for excitation. This article will be limited to a discussion of operation in the axial or beam mode.

There are several ways in which a mathematical structure could be set up to predict phase velocity of wave propagation on helices and their radiation patterns. Consider the simple first approximation as suggested by Kraus' which assumes that a helical antenna radiating in the axial mode has a single traveling wave of uniform amplitude along its conductor. Using the principle of pattern multiplication, the radiation function for the Fraunhofer region of a single helix can be considered to be a product of the pattern for one turn and the pattern for an array of n isotropic point sources as shown in Fig. 1D. Here n is equal to the number of turns and S is equal to the spacing between turns. When the helix is long that is, when $nS\lambda$ is > 1 the array pattern largely determines the shape of the radiation function. The array pattern for an array of n isotropic point sources may be expressed then by:

$$E \sim \sin(n\psi/2)/\sin(\psi/2) \qquad (1)$$

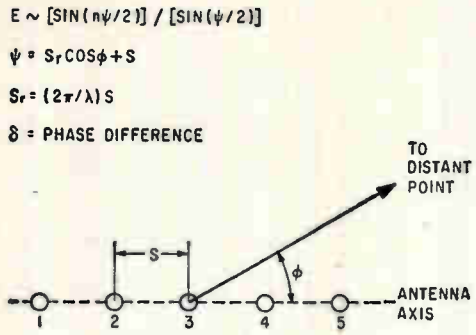
Where n is equal to the number of sources and

$$\psi = Sr\cos\phi + \delta \qquad (2)$$

where $Sr = 2\pi S/\lambda$ and δ = change in phase/turn.

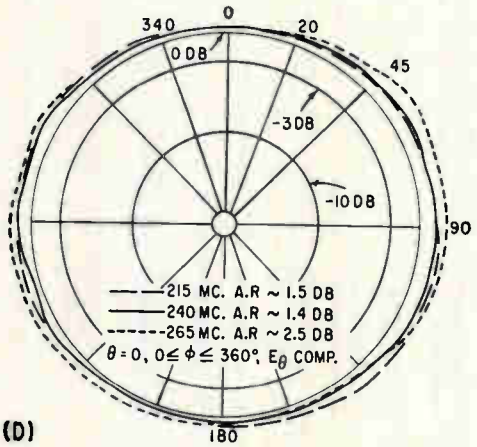
We can express ψ also as

$$\psi = 2\pi\,[S_\lambda \cos\phi - (L_\lambda/\rho)] \qquad (3)$$



(D)

ship for array of isotropic sources



(D)

(D) bifilar axial ratio

where L_λ is the single-turn length and ρ is the relative phase velocity of wave propagation along the helical conductor. The subscript λ means the unit of measurement is in wavelength. For the fields to be phased requires

$$\psi = 2\pi m \quad \text{where } m = 0, 1, 2, 3, \ldots \quad (4)$$

Assuming that the increased directivity condition of Hansen and Woodyard[5] exists, this expression becomes

$$\psi = -[2\pi m + (\pi/n)] \quad (5)$$

Equating Eq. 5 and Eq. 3 and setting the direction of the helix axis $\phi = 0$, we have

$$\rho = L_\lambda/[S_\lambda + m + (1/2n)] \quad (6)$$

Equation 6 is an expression of relative phase velocity in terms of the geometry of the helix assuming the existence of the Hansen-Woodyard condition. If we now substitute Eq. 5, set $m = 1$, and simplify, we have

$$\psi = 2\pi [S_\lambda (\cos\phi - 1) + (1/2n)] \quad (7)$$

Assuming that the single turn pattern may be expressed by the function $\cos\phi$, we have

$$E \sim [\sin (n\psi/2)/\sin (\psi/2)] \cos\phi \quad (8)$$

Equation 8 is an approximate expression for the radiation function of the single helical[4]. By replacing the function $\cos\phi$ with the function $\cos^2\phi$ to approximate a double turn, we have

$$E \sim [\sin (n\psi/2)/\sin (\psi/2)] \cos^2\phi \quad (9)$$

Equation 9 is the approximate expression derived from pattern multiplication of a double turn and the array factor for n isotropic point sources. Note that these approximate expressions neglect the effect of the ground screen. A comparison of the two plots are shown in Fig. 2A. The solid line represents a single helix of 8 turns while the dotted line represents the bifilar helical of 8 turns each. The sidelobe level and beamwidth at half-power points have both improved. The expression above assumes a phase relationship of 180 degrees.

To determine the significance of any improvement that might be attained on an actual model, two antennas were constructed, one a single helix and one a bifilar helix, each utilizing a ground plane measuring 44 in. in diameter. Other parameters are $D = 17.04$ in., $S = 12.31$ in., $\alpha = 13$ degrees, $n = 8$ and $B = 44$ in.

The photograph shows the bifilar helical antenna on which antenna patterns were measured.

Figure 2B is a pattern measured at 240 Mc of the bifilar and single helical antenna in the H-plane. Here H-plane designates the $E\phi$ component (vertical with the plane of rotation of the antenna under test). The solid line shows the pattern of the bifilar antenna while the dotted line is the superimposed plot of the single helical. Notice that the side lobes for the bifilar also measures a lower value with respect to the maximum signal. Figure 2C is the same comparison for the E-plane pattern which represents the E_θ component (in the plane of rotation of the antenna under test).

To determine the effect of changing relative phase, a number of antenna patterns were measured at various phases of signal fed to one feed with respect to the other. Results of these measurements indicates that there is no gradual deterioration of the pattern as the phase deviates from 180 degrees, but rather a sudden explosion as we approach zero degrees. One may also, however, the wide latitude in the phasing of the two feeds which means that a given phasing harness will operate over a wide frequency band. Experiments with a line stretcher indicated that there is no sharp peak at the optimum point of operation but rather a broad maximum around the 180 degrees phasing center.

Other characteristics of the bifilar antenna as measured over the band are the axial ratio plots shown in Fig. 2D and the vswr measurements shown in Fig. 3.

Other experiments performed were the measurements of radiation patterns using various relative phases of the signal feed to the two feed points. These experiments indicated that a given phasing harness would operate well over a wide frequency band; this was corroborated by measurements over a wide band with the same harness.

The author acknowledges assistance of Arnold Wright, Geza Dienes and David Angle for fabrication, computation and measurement.

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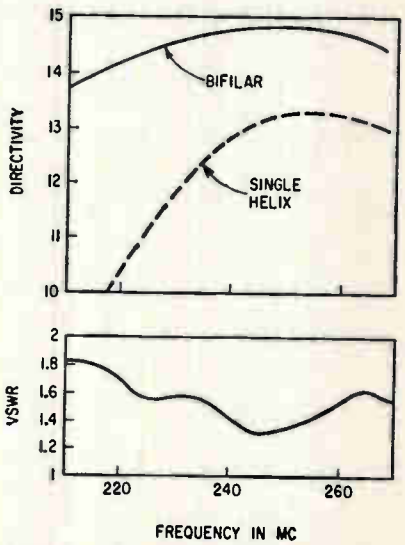


FIG. 3—Directivity and vswr measurements of antenna

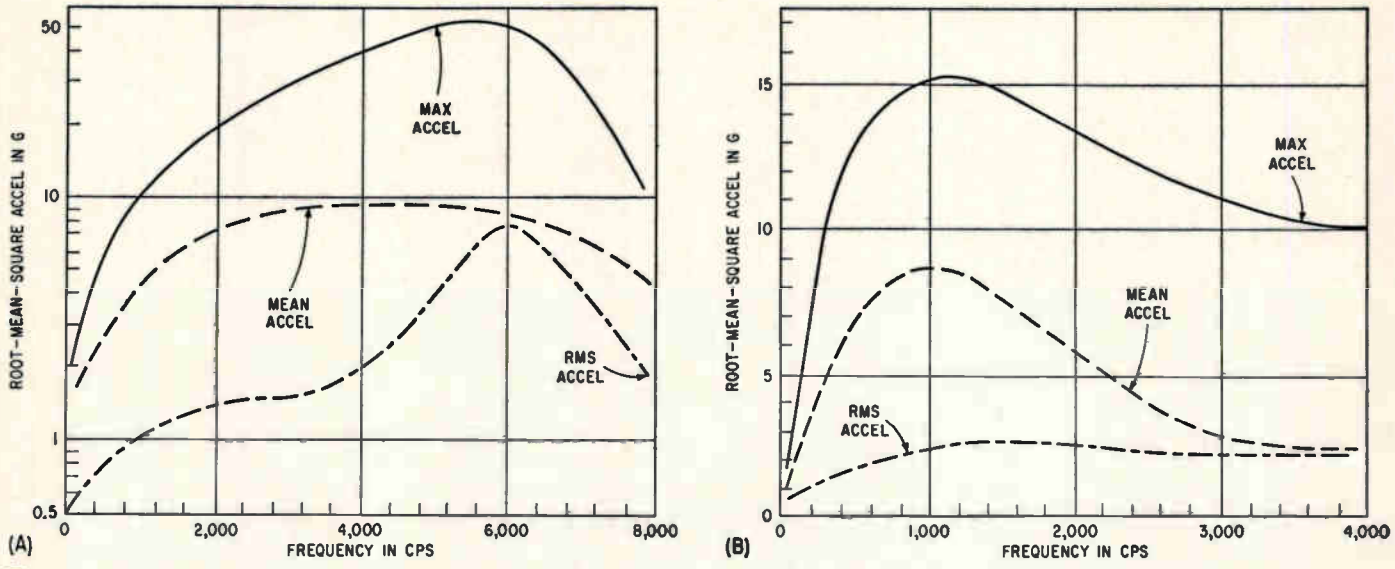


FIG. 1—Typical accelerations during missile launch and boost along three major axes (A); and typical accelerations during sustained flight (B)

What Designers Should Know

Missile components differ widely in their resistance to shock and vibration. This rundown on the different effects of the missile dynamic environment will be useful to the designer of components and installations

By HAROLD C. LAWRENCE,
Assistant Chief Engineer,
Robinson Technical Products, Inc.,
Teterboro, N. J.

BECAUSE environment is presently the greatest barrier to increased performance and accuracy of missile guidance systems, the effects of this environment must be minimized. This article summarizes some of the factors which the components designer must consider.

Vibration failures far outweigh shock and impulsive acceleration failures on missile equipment—this is typified by the 4 to 1 ratio of vibration to shock failures in communications equipment. Elements which can withstand 50 to 75 g transient (shock) impulses frequently can tolerate only a maximum of 2 to 3 g of sustained vibratory environment. For the missile component designer, numerical magnitude of g is of little significance without subsequent definition of pulse time, shape and continuity.

The missile dynamic environment can be categorized in four general areas: mechanical shock, transient vibration, sinusoidal vibration and random vibration. Shock occurs during ground handling and transit, at launch, during boost and at engine cutout. Acceleration loads of various magnitudes also result from buffeting, wind loadings and maneuvers. The most severe vibration exists at launch, and shortly after, reaching instantaneous high frequency peaks of 400 g and sustained magnitudes of 10 g. A preponderance of missile field data indicates that most vibration is random and complex. Typical records from several operational missiles have been integrated into curves as shown in Fig. 1 and 2A.

Most of the missile vibration data has been taken at from four to six stations within the missiles, usually on bulkheads, shelves, or longerons, and with various kinds and qualities of instrumentation. It is suggested, therefore, that the data be used as order of magnitude rather than as specific. Unfortunately the limited number of pickup points precludes the interesting and useful possibility of evaluating the mechanical impedance of the skin and various other substructural elements. Figure 2B represents the maximum values recorded along the three major axes of an electronic chassis during a missile flight.

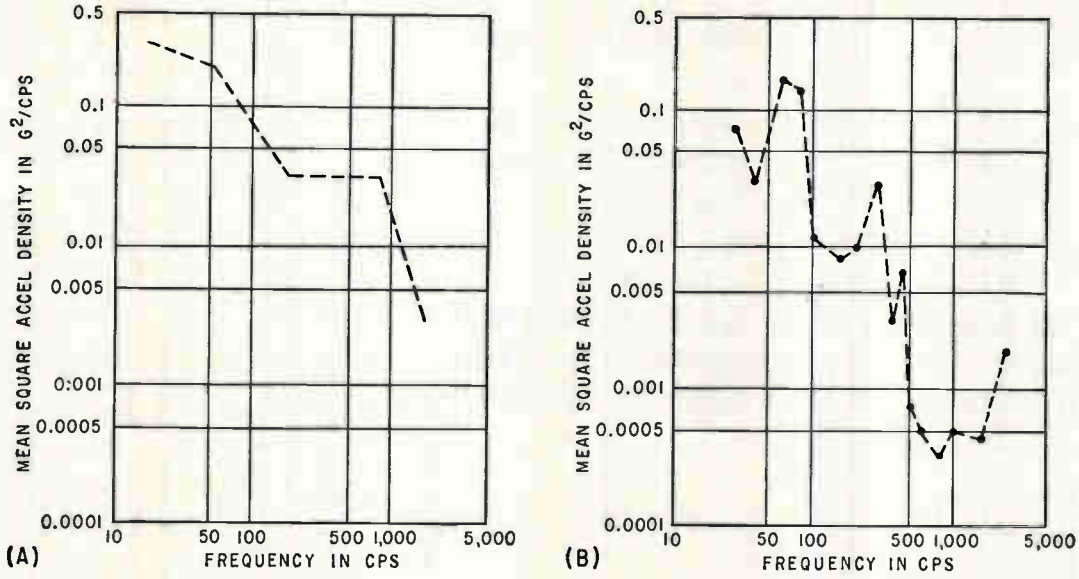


FIG. 2—Typical envelope of maximum values of mean square acceleration along three major axes of an electronic chassis (A); and maximum values measured during missile flight (B)

About Missile Components

Acoustical vibration is commonly manifested in missiles as a result of turbine scream or rocket nozzle exhaust noise. On the skin adjacent to a rocket nozzle, noise generated vibration has been measured at 175 decibels. This, then, must also be considered in the efforts to mitigate the missile environment. The magnitude of missile vibrations is, generally, minimum at the nose, increasing towards the aft end, and is especially severe adjacent to the engine compartment where the combined effects of engine vibration and acoustical impingement are felt. A common sequential arrangement of components from missile fore to aft is: payload, guidance, control, fuel, oxidizer, pressurization system, engine accessories and engine. Thus, the components most subject to vibrational damage are located in forward region where the vibration is relatively less severe.

Missile flight gust loads of 4 g are common, and longitudinal launch accelerations of up to 10 g can be expected. Serious loads also result from change of missile course at high speed. Probably the most severe shocks occur during transit on ground vehicles and during associated handling. At frequencies up to 300 cps, maximum shock to be anticipated by truck transport is 7 g and by rail, because of switching, 25 to 30 g. These values are infrequent and obviously do not take into account mass relationships and the missile location on, and attachment to, the transporting vehicles.

The concern of the missile component designer is the fragility of typical equipments and the tolerance of these equipments to the missile dynamic generation. In the mechanical area the most critical equipment is the guidance system which generally consists of gyros, gimbal frames and bearings, plus electronic sensing and correcting devices. The gyro mass is inherently rigid and well balanced. The gimbal frames are preferably low mass elements and are flexible by the nature of their support and pivot points. This flexibility must be tolerated but it makes the guidance system especially susceptible to vibration failures and reduction of accuracy. The pivot bearings are designed to be nearly frictionless and are of minimal mass, often being fabricated from brittle jewels. The danger of shock or vibratory environment relative to the bearings is obvious, particularly when considering that the pivot drag produced by a bearing failure would destroy the guidance system accuracy. Other mechanical elements in the missile, such as control linkages, structural elements, power plants, and fuel systems, can either be ruggedized or reoriented so as to best tolerate the dynamic environment. The major penalty here is usually one of weight.

Electronic equipments and components constitute the greatest area of susceptibility to the dynamic environment. Electronic equipments cover the field from guidance and fuel control to detection and countermeasures. It is useful to analyze the fragility of the basic components which make up these equipments.

Wright Air Development Center reported a series of shock and vibration tests which were conducted

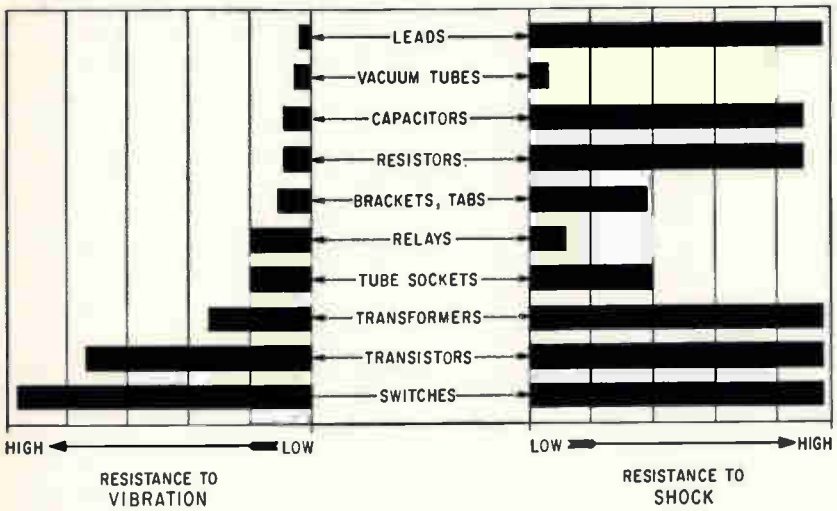


FIG. 3—Relative vibration and shock resistance of chassis components

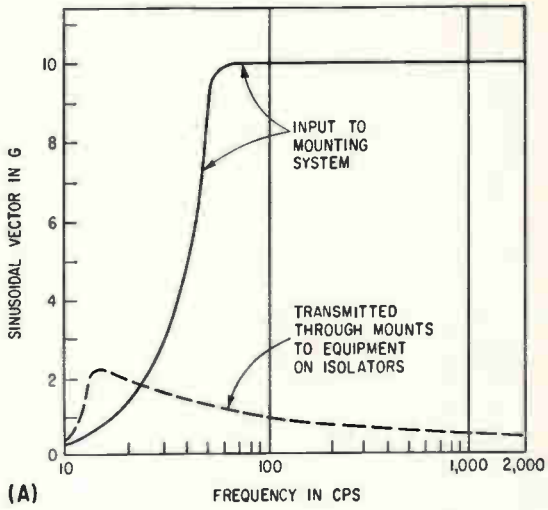


FIG. 4—Performance of component test mount

on several receivers, transmitters, compasses and dynamotors, weighing from 2 to 35 pounds. These tests revealed a distinct pattern of failures. At from 2 to 5 g, sustained sinusoidal vibratory input, and at frequencies up to 2,000 cps, all chassis exhibited failures, generally in leads and tubes. Shock tests of the same equipments produced no failures below 50 g—6 millisecond input. The shock failures ultimately obtained were primarily of relays, or interference due to chassis deformation. Several failures were attributed to tubes and shields which loosened in, or fell from, their sockets but which were still functionally sound. The preceding, and evidence from other sources, strongly supports the conclusion that low mass items tend to fail due to vibration while high mass items are more susceptible to shock failures.

The general fragility of electronic and electrical components is summarized in the following paragraphs and in Fig. 3.

Electrical Leads: Surveys show that roughly half of all vibratory failures are due to flexure of electrical leads, particularly those which support capacitors and resistors.

Vacuum Tubes and Relays: Relays and tubes are next most susceptible to vibratory failure. Tubes short-circuit, loosen, fall out, or exhibit microphonics. Relays fail mechanically, and gradually, first showing erratic function and finally complete malfunction. Relays of newer design can tolerate from 10 to 15 g in the range 10 to 2,000 cps, while most electron tubes cannot withstand more than 10 g in the same frequency spectrum. Good progress has been made on the design of relays capable of withstanding 100 g vibrational environment. Most relay failures occur above 500 cps vibratory with inputs from 2 to 12 g. It is noteworthy that clapper relays are most delicate, rotary are next; plunger relays are most rugged. Relay orientation with respect to expected direction of severe input disturbance is a simple but often critical chassis design decision.

Cabling: Electrical connectors, cables and wires, as such, are not susceptible to shock or vibration failure. If unsupported, however, cables and wires may fail due to flexure fatigue when subject to sustained vibration. Flexing coaxial cable can also generate noise voltages in high impedance circuits. A source of trouble is wearing of insulation due to rubbing action on unsupported lengths of cable. Conversely, care must be exercised not to support the cable so rigidly as to undermine the effect of vibration isolators on mounted equipments.

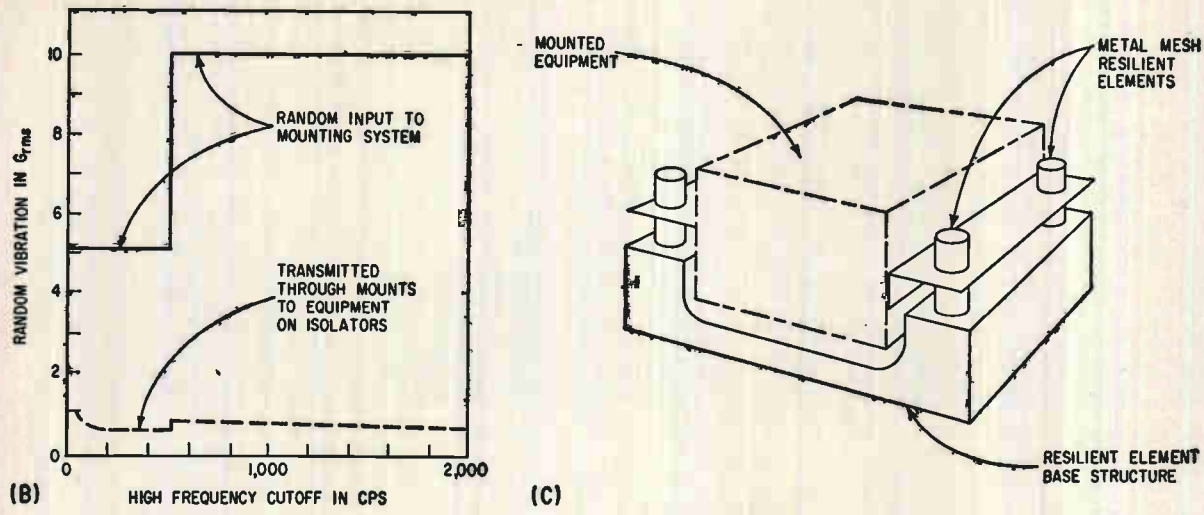
Transistors: Transistors are of low mass and good rigidity and thus, when properly supported, are resistant to both shock and vibration. Many available transistors can withstand sustained 15 g vibration up to 2,000 cps.

Transformers: Transformers are inherently rugged and resistant to the dynamic environment physically and functionally. Possibly the two most serious problems related to dynamic tolerance of transformers are poorly designed tabs, or feet, and careless location of the transformer within a chassis. These high mass items are often found flimsily cantilevered off a flexible sheet metal panel.

Capacitors and Resistors: Capacitors and resistors are of low mass and as a rule fail in a vibration field due to lead flexure fatigue. Thus, failure is due more to the method of mounting than to any inherent weakness of the component.

Switches, Circuit Breakers, Terminals: Switches, circuit breakers and terminals are generally tolerant of dynamic disturbance and can be reliable provided due consideration is given to orientation, low stressed installation, firm support, and proper component selection. All these elements should be trouble free if given reasonable mechanical analysis prior to selection and installation. Many of the problems related to leads can be circumvented by using printed circuit boards, taking care that the boards are firmly supported so as not to chatter electrically or resonate mechanically.

Mechanical components are usually more conducive to physical proportions suitable to good dynamic tolerance. Electronic designers should not neglect to have a chassis design subjected to rigorous mechanical analysis before it is finalized and fabricated. Most mechanical failures observed in dy-



subject to sinusoidal vibration (A) and random vibration (B); and center of gravity type of test mount used (C)

namic surveys suggest poor judgment in this respect.

Common pitfalls include the use of improper size fasteners (No. 6 and smaller screws can crack during screw driver installation), massive elements on cantilever shelves and brackets, flimsy tabs and feet, and nonrigid structures. Sharp corners and bends, notches, cutouts, cracks, scratches, point loads and other stress raisers should be avoided. The same stress raisers that hasten fatigue failures also hasten failures in shock and vibration environments. Stress relief should be designed into formed sheet metal items and, where possible, bends should be made across the material fiber lines rather than parallel to them.

On pivoting masses and linkages, the use of counterbalancing and spring loading should be considered, as should orientation and axes of dynamic severity. It is also advisable to assure utilization of structure stiffness by using the correct number and size of installation bolts. Selflocking nuts are preferable to lock washers and plain nuts. The former, even if not fully tightened down, will not unscrew and become disengaged from the screw.

The most straightforward approach to ameliorating the dynamic environment is to use vibration isolation and shock absorption systems for whole chassis or for fragile components within the chassis. Properly designed isolation alters the environment to one tolerable to the mounted equipment. The isolation system often weighs as little as 5 percent of the mounted component and, when considered in the early design stage, can result in little or no additional volume. An overall weight saving is often possible. Possibly the decisive factor in the use of isolation is that accurate dynamic environment descriptions and equipment fragility ratings are rare and the only reasonable approach, therefore, is to use isolation to favorably bias the disturbing environment.

Isolation systems can be effective in both sinusoidal and random fields. Figures 4A and 4B illustrate the performance of a missile component mounting system subject to both types of disturbance. The mounting (Fig. 4C) is a center of gravity type using knitted stainless steel wire mesh resilient elements which exhibit excellent damping characteristics (note the low amplification at sinusoidal resonance) and nonlinear spring rate. This well-damped mounting showed little tendency to sustain impressed motion in a random field, even when the random input was filtered to a narrow band of frequencies which closely bracketed the natural frequency of the mounting. The sinusoidal performance curve (Fig. 4A) is in terms of the sinusoidal g vector since this illustrates the input acceleration force reduction commonly achieved by using isolators.

Many types of vibration isolators are commercially available using materials ranging from simple natural rubber to knitted stainless steel wire mesh. Each has its place in the isolation field and selection of isolators is contingent upon specification requirements and tolerance to the environment in which they must operate. Disregarding other factors, a natural rubber isolator, for example, is not tolerant to an environment of petroleum products, while a stainless steel mesh isolator offers exceptional resistance to temperature extremes. Naturally, the optimum combination of characteristics is to be sought for any isolation problem. Good damping gives reduced acceleration for transmissibility at resonance, and good nonlinear damping produces low amplitude resonance plus high quality isolation beyond resonance. Nonlinear spring rate isolators permit substantial load variation without appreciable change in performance, and this type isolator also effectively lends itself to successful combination of some of the more desirable characteristics of shock absorbers and vibration isolators.

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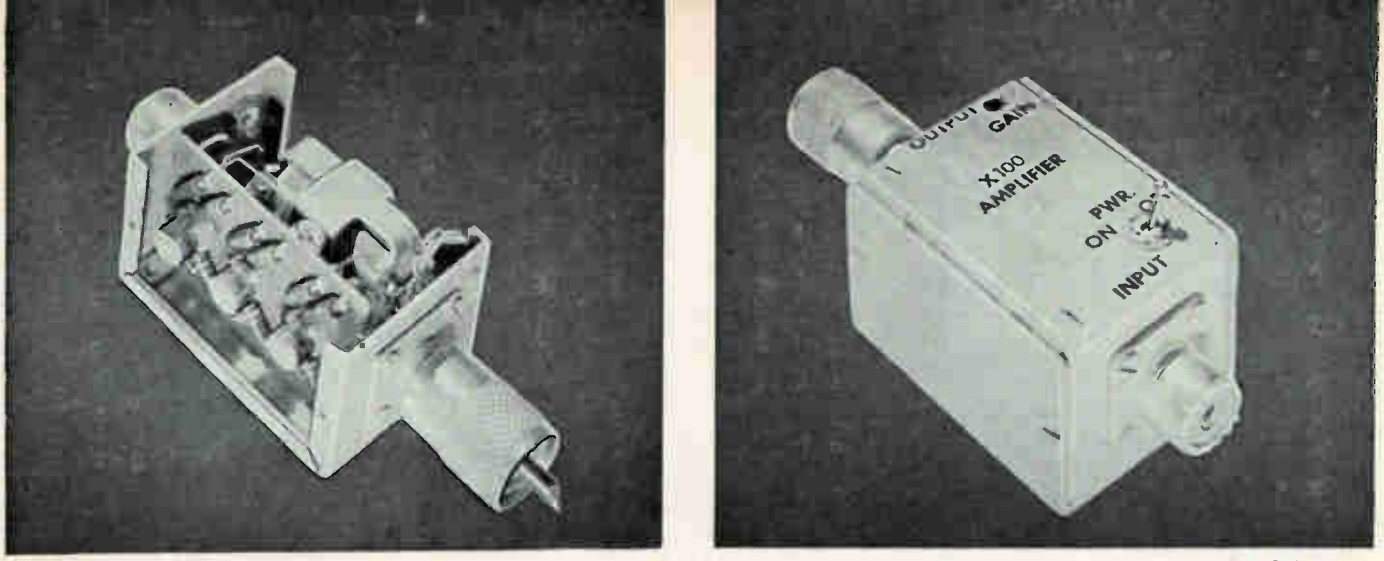


This compact chassis layout includes an amplifier and a battery (left); unit assembled for operation (right)

PREAMPLIFIER DESIGNED FOR

Minimum Power Consumption

Silicon transistors used in conjunction with high-value circuit resistances allow this three-stage amplifier to operate with a battery drain of less than one milliwatt

By CARL D. TODD Hughes Semiconductor Division, Newport Beach, California

OCCASIONS arise in which it is desirable to operate a piece of electronic apparatus from a minimum amount of power to extend battery usefulness. This may be done by designing the circuit to operate at low voltage, low current or a combination of both.

Low power applications of germanium transistors usually have a low-voltage supply but the current cannot be greatly reduced because of collector-base leakage current I_{CBO}. This current at room temperatures is in the neighborhood of 1 to 5 microamperes. In the common emitter amplifier, the effect of I_{CBO} is multiplied by a factor which is determined by the circuit resistances and the current gain of the transistor. Also, as the temperature rises, the value of I_{CBO} increases rapidly.

If operation of small-signal amplifiers using germanium transistors were attempted at low currents the operation would be unsatisfactory because of the large shifts in the transistor operating points.

Silicon transistors, on the other hand, have a value of I_{CBO} which is much lower than that for germanium transistors. A typical value might be 10 nano amperes. Thus, silicon transistors can be used at low currents without the problems associated with germanium transistors.

Another difficulty which arises is the decrease in gain which occurs as the operating bias current is decreased. Some transistors have a usable gain down to a bias current of some 10 microamperes.

The amplifier circuit of Fig. 1 illustrates the operation of silicon fused junction transistors at low operating currents.

The first two common emitter stages operate at a collector current of approximately 10 microamperes and the output stage is biased at approximately 20 microamperes. Thus the total drain including that for the bias stabilization networks is only some 50 microamperes or a total battery power requirement of only 750 microwatts. A lower collector voltage supply could have been used with even lower power requirements but this circuit was designed to be operated from an available 15-volt battery.

Open loop gain for the three stages is typically 5,000 though this may vary somewhat depending on the exact parameters of the transistors used. Negative feedback is injected to give a stabilized voltage gain of 100. Also, by adjusting the potentiometer R_{13}, the gain may be set to any value between 20 and the open-loop gain. Low gain values are more stable and have a better frequency response due to the larger amount of feedback.

The values of resistors used in this amplifier circuit are much higher than normally used in transistor circuits—in fact, they are in the same range as those used in vacuum-tube applications. Coupling capacitors, while somewhat higher than the values used in

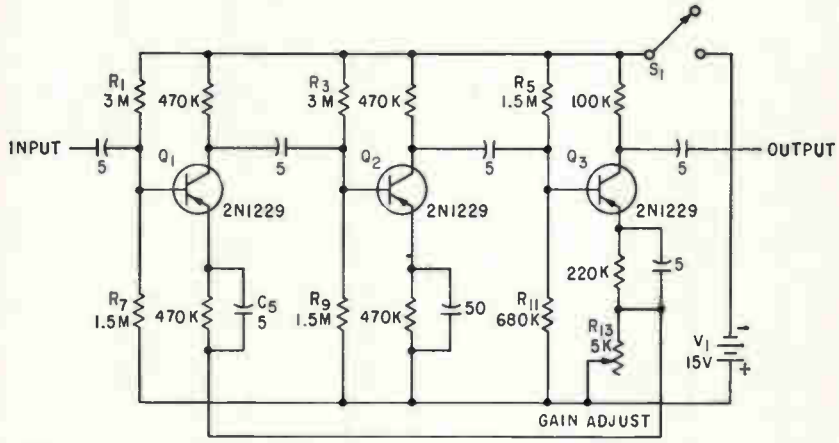


FIG. 1—Resistance levels comparable with those in tube circuits contribute to high input impedance, as well as low power consumption

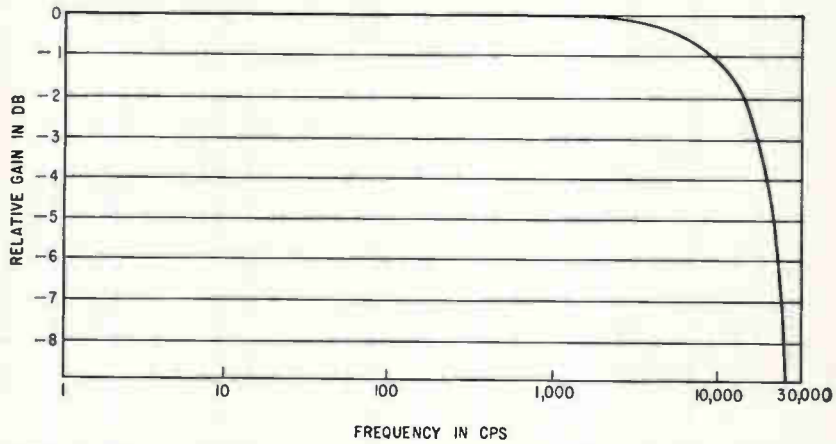


FIG. 2—Frequency response constant to about 18 Kc. Actual gain is set by feedback adjustment, potentiometer R_{13}

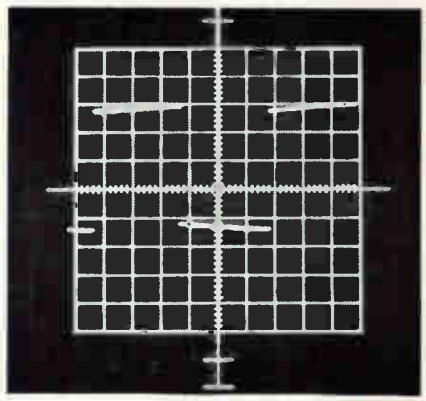


FIG. 3—5-cps square wave illustrates low-frequency performance

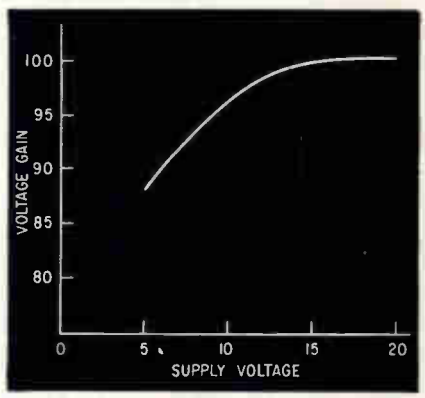


FIG. 4—Gain is not critically dependent upon stability of supply

vacuum-tube circuits, are much lower than the values used with transistors where low frequency response is required.

The input resistance of the amplifier is approximately 500,000 ohms. This is due mainly to the negative feedback but is partially due to the increased levels of resistance caused by low current operation.

Frequency response is indicated in Fig. 2. As shown, the 3-db bandwidth is roughly 18 kilocycles for a gain of 100. Bandwidth could have been raised by proper compensating techniques but for simplicity, was not done in this case. Low frequency response is excellent as indicated both by Fig. 2 and Fig. 3. Figure 3 shows the output waveform for a 5 cycle per second square wave input signal. Maximum output is 2.5 volts peak-to-peak, a value more than ample for most applications of the preamplifier.

Reasonable performance is obtained even when the battery voltage has dropped to some 5 volts as shown in Fig. 4. Increasing the supply voltage to 22½ volts would have little effect except to increase the open loop gain and hence the stability. Operating the amplifier with only 5 volts allows the bias currents for the transistors to drop to roughly 3 microamperes and 6 microamperes for the two input stages and the output stage respectively.

One of the problems in low level preamplifiers is that of noise. Especially does this present a problem where high input-impedance levels are necessary. In the prototype model, with a generator resistance of 50,000 ohms the equivalent noise input was only 2 microvolts. Even with a generator resistance of 500,000 ohms, the equivalent noise input was only 8 microvolts. This allows the amplifier to be used at low levels of signal.

As constructed in a 1½ by 1¾ by 2½ inch chassis complete with internal battery, the amplifier serves as an addition to the laboratory oscilloscope or audio millivoltmeter, allowing measurement and study at a low voltage level. Hum pickup is minimized by the screening effect of the chassis.

The amplifier, as described, is primarily intended for use at room temperature. If elevated temperature operation is necessary, bias stabilization resistors R_1, R_3, R_5, R_7, R_9 and R_{11} may each be reduced to one third of their original value. This will give increased stability with temperature which must be paid for by a slight increase in battery drain.

The author wishes to acknowledge the considerable technical assistance rendered by M. Morishita in the construction and performance testing of the prototype model.

Selective Calling

Demodulating and decoding equipment identifies 100 percent of messages

By A. I. PERLIN

Bendix Radio Division,
Bendix Aviation Corp.,
Baltimore, Md.

AS THE INPUT load to the sensory perception of an aircraft pilot increases, any means of reducing this loading becomes important in improving pilot performance. In the case of radio equipment, a significant improvement is made by simply removing the necessity for continuously monitoring a communication channel. This is accomplished by the Selective Calling (SELCAL) equipment described in this article.

Selective calling may be used either to alert the pilot to the arrival of a call or to automatically activate his headphones or cabin loudspeaker. Other applications include remote control or monitoring of airborne equipment by a ground-based operator, selective use of distance-measuring equipment in high-density traffic, and basic data link operation. Figure 1 is a block diagram of the SELCAL system.

The equipment was designed with a view to creating a device that could use conventional commercial-grade components in a commercial model as well as the more costly military components required in typical military specifications. The unit can thus be used for a variety of applications and cost is dictated only by the severity of the customer's environmental requirements and not by the design itself.

Standardized modules are employed wherever possible. The circuit of Fig. 2A demonstrates one approach to this end. This circuit is a conventional transistor bistable device with auxiliary input gating to allow a packaged unit to serve in a variety of applications.

The device shown in Fig. 2A is used as a conventional flip-flop by connecting terminals 1 and 7 and terminals 4 and 8 and using terminals 2 and 5 as inputs (8 and 7 being the corresponding outputs). The same arrangement, if terminals 2 and 5 are tied together, becomes a binary counter stage. If resistor R_1 is omitted, the circuit becomes a one-shot multivibrator and is used as a pulse generator.

In the conventional flip-flop configuration, terminals 7 and 8 may be connected to terminals 1 and 4 of a succeeding stage to make a shift register and if the flip-flop gating is disregarded, a sinusoidal input to terminal 3 or 6 will generate a square-wave output, and the device serves as a clipper.

To reduce the amount of equipment in the receiving unit, the message structure has been made as simple as possible. No parity bit is employed because the gain realized in performance is too small to be of value, however the fifth bit in the word structure is retained as a timing bit.

A single word in this system consists of a ONE followed by a four-bit binary representation of the decimal value of the number being transmitted, making a total of five bits in all. The first bit (in time) is always a ONE. Data are transmitted in bursts of audio tones, one tone representing a ZERO and a second representing a ONE.

A message is made up of a synchronizing interval (of eight bit intervals duration) followed by the five words of the address. The synchronizing interval exists only for clearing the system since timing synchronization is actually a continuing process. The interval contains only the ZERO tone frequency.

The transmitting station need be only a long serial shift register with provision for presetting values, and tone gating by the output stage. This is the type of ground station built for this system. Making a call with such a transmitting station requires only switch (or dial) selection of a five-digit call, and then actuation by a pushbutton. This actuating signal transfers the five-digit address to the serial shift register and transmits the twenty-five bit message to all receivers.

The operator at a receiving station selects the address to which his station will respond by setting five 10-position switches to indicate a five-digit address. This may be a permanently wired connection in some equipments or a monthly (or more frequent) selection in other applications. However, the operator sees only an indicator light which informs him of an incoming message, and a pushbutton for turning the indicator off.

The signal derived from a conventional receiver is applied to the input terminal and drives two amplifiers which, in turn, deliver their outputs to two filters. (See Fig. 1.) These filters separate the ZERO and ONE tones and each filter provides rejections of the other tone of more than 35 db at all input signal levels within the normal range (0.5 to 5 v peak-to-peak).

The tone bursts are then separately rectified and filtered to produce envelopes of opposing polarity which are added algebraically. The resulting signal is nearly sinusoidal for alternating ONE and ZERO signals. Distortion and noise in the system can deteriorate the signal. Thus, to provide more effective detection, the signal is squared by clipping near the zero-crossing points. This allows the system to be operated successfully in noisy conditions down to that point at which the distortion becomes so severe that extraneous zero-cross-

for Data Link Systems

sent over a communications link with noise-to-signal ratio of 6 db

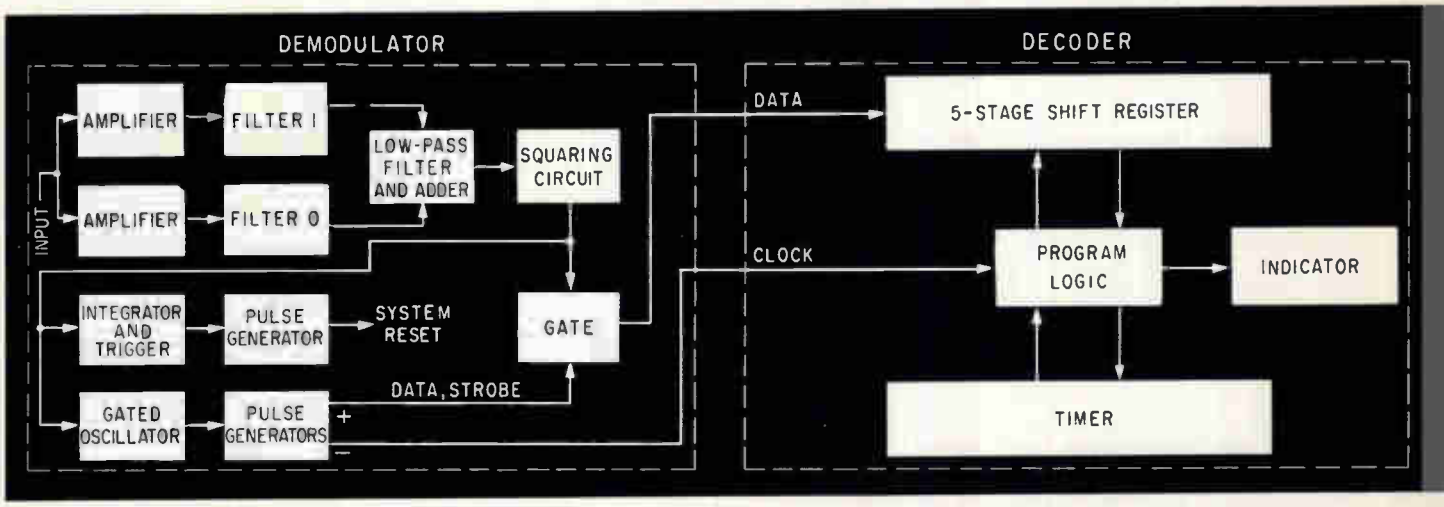


FIG. 1—Selective calling system provides indication to pilot when five correct words are received in a single message

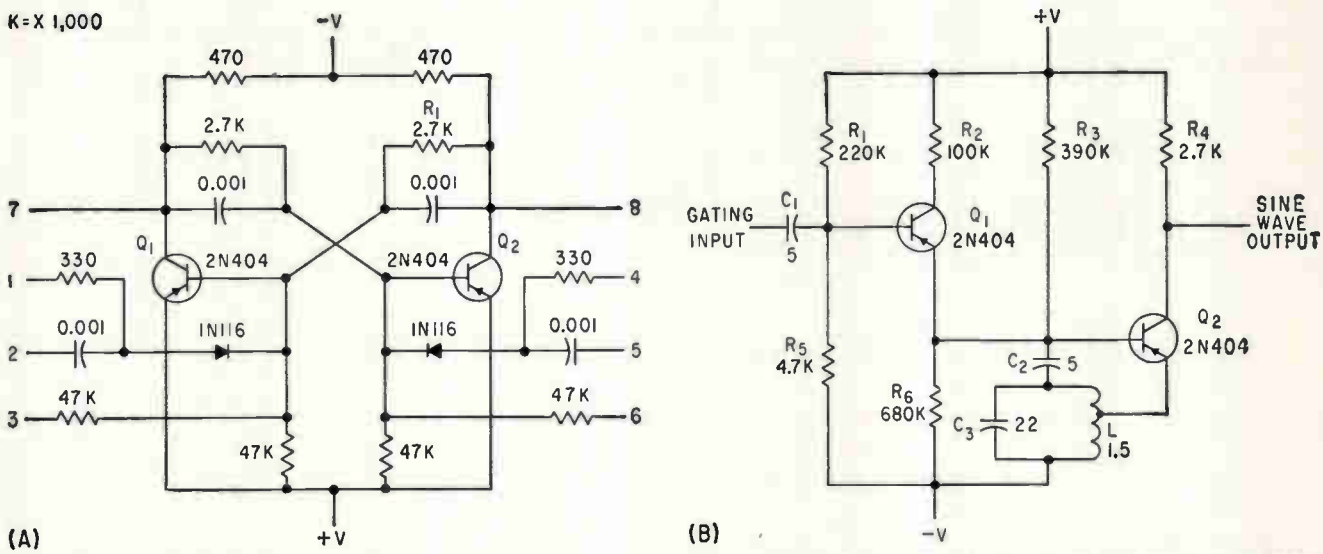


FIG. 2—Basic bistable module (A) can be used as a flip-flop, shift stage or clipper. Gated sinusoidal oscillator (B) drives pair of pulse generators

ings appear during the bit interval. This occurs at a signal-to-noise ratio of approximately −8 db.

The gated oscillator, shown in Fig. 2B, drives a pair of pulse generators. There are two pulses for each oscillator cycle, the one generated at the negative-going zero-crossing is the system clock, and the pulse generated at the positive-going time is used to sample a gate which, in turn, is enabled or inhibited by the squared data signal. There is an input to the oscillator which is also derived from the squaring circuit. This signal is the synchronizing device for the oscillator, always maintaining synchronization of new data.

The circuit components are selected so that the oscillator formed by the C_3-L tank in association with Q_2, R_3, R_4, R_6 and coupling capacitor C_2 will operate at the system bit rate within a tolerance of ±2 percent (maximum).

When a gating input arrives, in

the form of a positive-going output from the clipper, a positive pulse enters the base of Q_1, transferring it from its normal (cutoff) state to a state of saturation. This places the emitter-collector impedance of Q_1 and the series resistor R_2 in the base circuit of Q_2, saturating Q_2 and preventing further oscillation. The parameters of the oscillator tank are such that clamping occurs quickly, and the output rises to the most positive point in the sine wave excursion.

For practical systems operating up to 1 Kc, turn-off has been accomplished in a negligibly small fraction of one cycle and oscillation restarts within 0.1 ms of the end of the gating pulse trailing edge. Thus, the receiver clock is always kept in step with the incoming signal.

A reset signal is also made available to prepare the system to accept data. To generate this signal, an integrator and trigger (Fig. 1) are included which examine the output of the squaring circuit and cause the trigger to be actuated whenever the output of the squaring circuit is DOWN (in a zero or no data state) for more than six intervals.

Because the longest group of zeros in a message is only four bits, these cannot cause spurious resets during a message; only a noise-free period or the presence of a synchronizing signal can operate the integrator and trigger circuit. This will, in turn, cause the pulse generator to produce a system reset signal.

The remaining signals entering the decoder require only a brief discussion. The clock signal introduces each bit interval, which may or may not contain a data pulse depending on the gate input at that time. All data enter a 5-stage shift register, and a set of program logic and a timer process the full message. If a five-word address arrives which corresponds to the address of the receiving station, the indicator will be actuated.

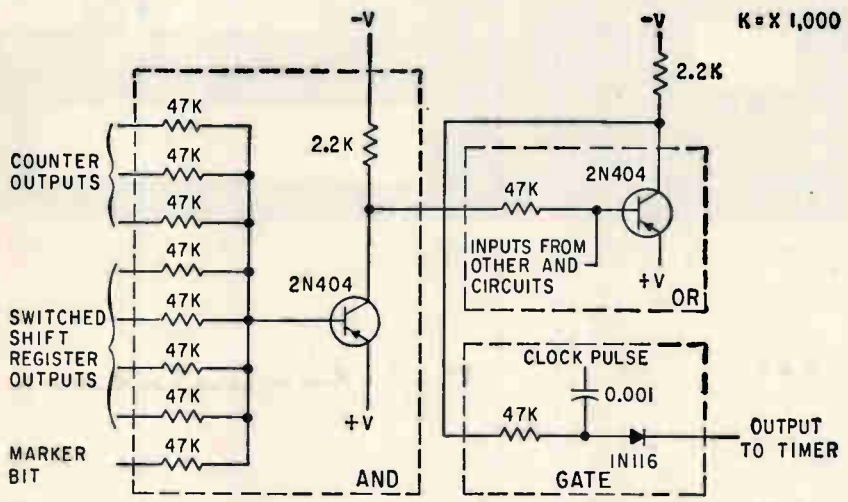


FIG. 3—Schematic indicates path of signal through commutation logic

One five-bit shift register is used for an entire 25-bit message. There are five AND circuits; the first is partially enabled at a count of 000, the second at 001, and so forth. There are also inputs from the shift register which are directed through the five switches which set the address for this unit. These switches connect the correct ZERO or ONE outputs of the four data-bearing stages to each of the five ANDS in a manner that partially enables AND 1 only when the correct first word is present, AND 2 for the second word only, and so forth.

The output from a marker bit delivers another enabling input to every one of the five ANDS during the last bit of each word. There are, then, eight inputs to each AND in this group, and the inputs are set so that only if a correct word is in storage at the proper time position can the presence of the marker bit cause the AND to generate an output.

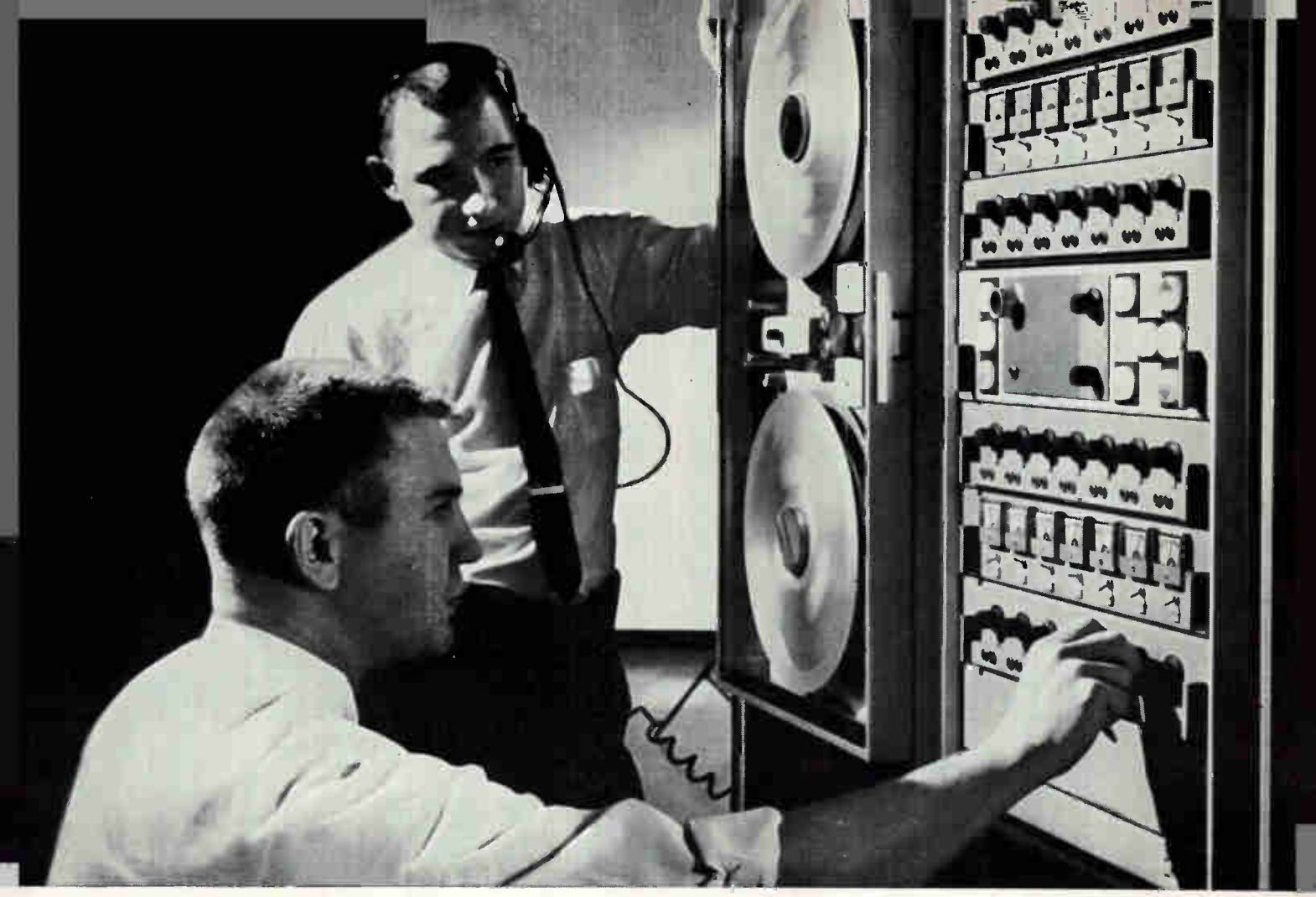
Figure 3 shows how this logical process is created. The AND circuit shown is one of the five in the program logic. When all three selected counter outputs, the four switch-selected shift register outputs and the marker bit are all in the UP (or binary ONE) condition, the output of the AND is DOWN. Any other input configuration will cause the output to be UP.

The OR is a similar circuit, and will have an UP output if any input is DOWN. Thus, if any one of the five AND circuits passes through a satisfied condition, such an input will be received by the OR and an UP output will be provided to the pulse gate.

The diode shown is biased so that it will allow a clock pulse to pass only if the voltage level into the gate is UP. The output of the gate then operates a three-stage counter which must reach a count of 101 (binary 5) in order to operate the indicator. Such an indication is thus possible only if five correct words are received in a single message.

The SELCAL unit described is being employed as a building-block element in other equipments. A small circuit addition, for example, will produce an automatic reply, either with or without data exchange, and since the processing equipment already exists, the alteration necessary to create a data link is so small that all additional elements required can be packaged as part of the data display itself.

Signal-to-noise performance has been measured in noise having a relatively constant rms value and produced by a noise generator. All measurements were made with the minimum specified input signal (0.5 v peak-to-peak) and the following results obtained: The system will correctly identify 100 percent of messages sent over a communications link having a noise-to-signal ratio of 6 db. There will be correct identification of over 90 percent of all messages at 8 db and no false alarms are present below 10 db.



AMPEX specifies Tung-Sol transistors for FR-600 analog tape recorder

The Ampex FR-600 records the same bandwidth at half the tape speed previously required. It's the first Ampex laboratory-type instrumentation recorder to offer all solid-state electronics. Frequencies as high as 250 kc can be handled (at a tape speed of 60 ips). FM, pulse-duration modulation, direct and digital recording modes are available through plug-in amplifier modules. FM response from d-c to 20 kc within ½ db is double that previously available. The FR-600 is already handling data recording in the new Minuteman missile project.

With reliability the keyword, the choice of components for the FR-600 had to be an exacting one. Tung-Sol germanium power and switching transistors were specified for several major assignments. Tung-Sol's high stability 2N379 transistors deliver reliable power to the motor drive amplifier, the FR-600 control unit, and each bay power supply of the recorder. Tung-Sol's precision 2N414 germanium switching transistors handle important switching functions in the direct record amplifier, direct reproduce amplifier, FM record, FM reproduce, pre-amplifier and frequency standard.

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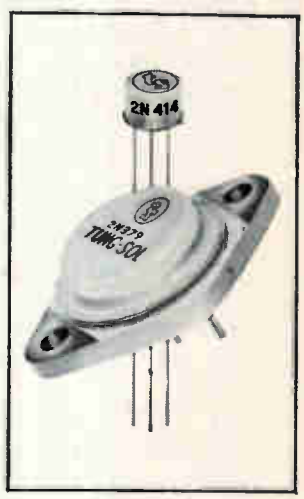

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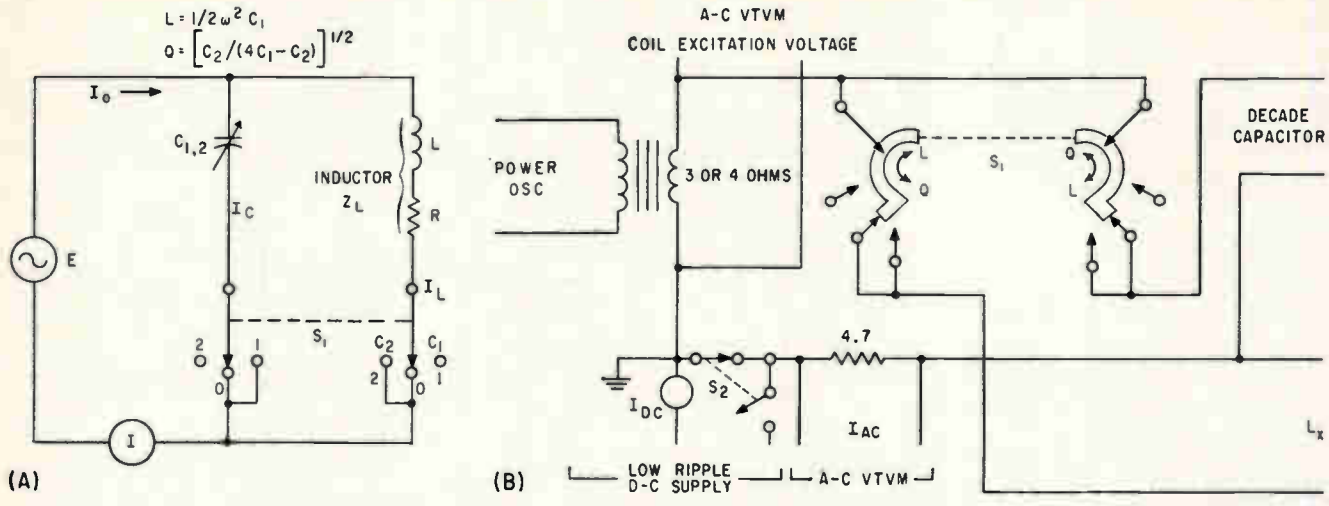


FIG. 1—Basic (A) and practical (B) circuits for measuring low Q's. Switch S_2 is in no d-c current position

Low-Q Coil Measurements

By R. E. LAFFERTY,*
Assistant Chief Engineer,
The Daven Company, Livingston, N. J.

A SIMPLE AND effective means of measuring inductance that is particularly suited for the measurement of iron core chokes was proposed by H. M. Turner in 1928.[1] When necessary, this measuring circuit will support a d-c magnetizing current for the measurement of incremental inductance. An extension of Turner's method can also be used to measure the Q of an inductor, provided the Q is less than 10. This is of interest because many measuring circuits require Q to be greater than 10, while all too often Q is below 10, particularly at low frequencies.

The basic measuring circuit is shown in Fig. 1A. The inductor is alternately switched in (position 0 of S_1) and out (position 1 of S_1) of the circuit while a decade capacitor is adjusted until the current is the same for both switch positions.

The current, I_c, through the parallel impedance is $E/|Z|$ amperes, where $|Z|$ equals

$$\left(\frac{R^2 + \omega^2 L^2}{\omega^2 C_1^2 R^2 + (1 - \omega^2 L C_1)^2}\right)^{1/2}$$

*Now with Boonton Electronics Corp.

The adjusted current, I_c, through the capacitor when the inductor is out of the circuit is $E\omega C_1$. Because C_1 is adjusted to make I_c equal I_c, we can write

$$(1 - \omega^2 L C_1)^2 + \omega^2 C_1 R^2 = \omega^4 L^2 C_1^2 + \omega^2 C_1^2 R^2.$$

Rewriting the expression for L, we have

$$L = 1/2\omega^2 C_1 \qquad (1)$$

It should be observed that the measured value of L is not in any way influenced by the resistance of the inductor.

Leaving the inductor in the circuit and disconnecting the capacitor (S_1 in position 2) a new current I_L of $E/|Z_L|$ amperes flows. With the capacitor reconnected across the coil, the capacitance is increased until this new value of current (I_L) is again obtained. Calling this increased value of capacitance C_2, we can then write: $E/|Z_L| = E/|Z|$, or

$$(R^2 + \omega^2 L^2)^{1/2} = (R^2 + \omega^2 L^2)^{1/2}/[(1 - \omega^2 L C_2)^2 + \omega^2 C_2^2 R^2]^{1/2}$$

From this

$$(1 - \omega^2 L C_2)^2 + \omega^2 C_2^2 R^2 = 1 \qquad (2)$$

If we solve this equation for L, unless the term $\omega^2 C_2^2 R^2$ is negligible ($Q > 10$), the resistance of the coil will be a determining factor. Thus, we have the condition of C_1 in Eq. 1 being a measure of the coil's inductance, irrespective of the Q, while C_2 in Eq. 2 is a measure of both the inductance and Q. From Eq. 2

$$R^2 = (2\omega^2 L C_2 - \omega^4 L^2 C_2^2)/\omega^2 C_2^2$$

Dividing by $\omega^2 L^2$ and defining Q^2 as $\omega^2 L^2/R^2$, we have

$$Q^2 = \omega^2 L C_2/(2 - \omega^2 L C_2)$$

Substituting Eq. 1 for L yields

$$Q = [C_2/(4C_1 - C_2)]^{1/2} \qquad (3)$$

Best accuracy is obtained when measuring a Q of unity. Values of Q from about 0.5 to 5 can be measured with a fair degree of accuracy and good approximations made for Q's of from 0.1 up to 10.

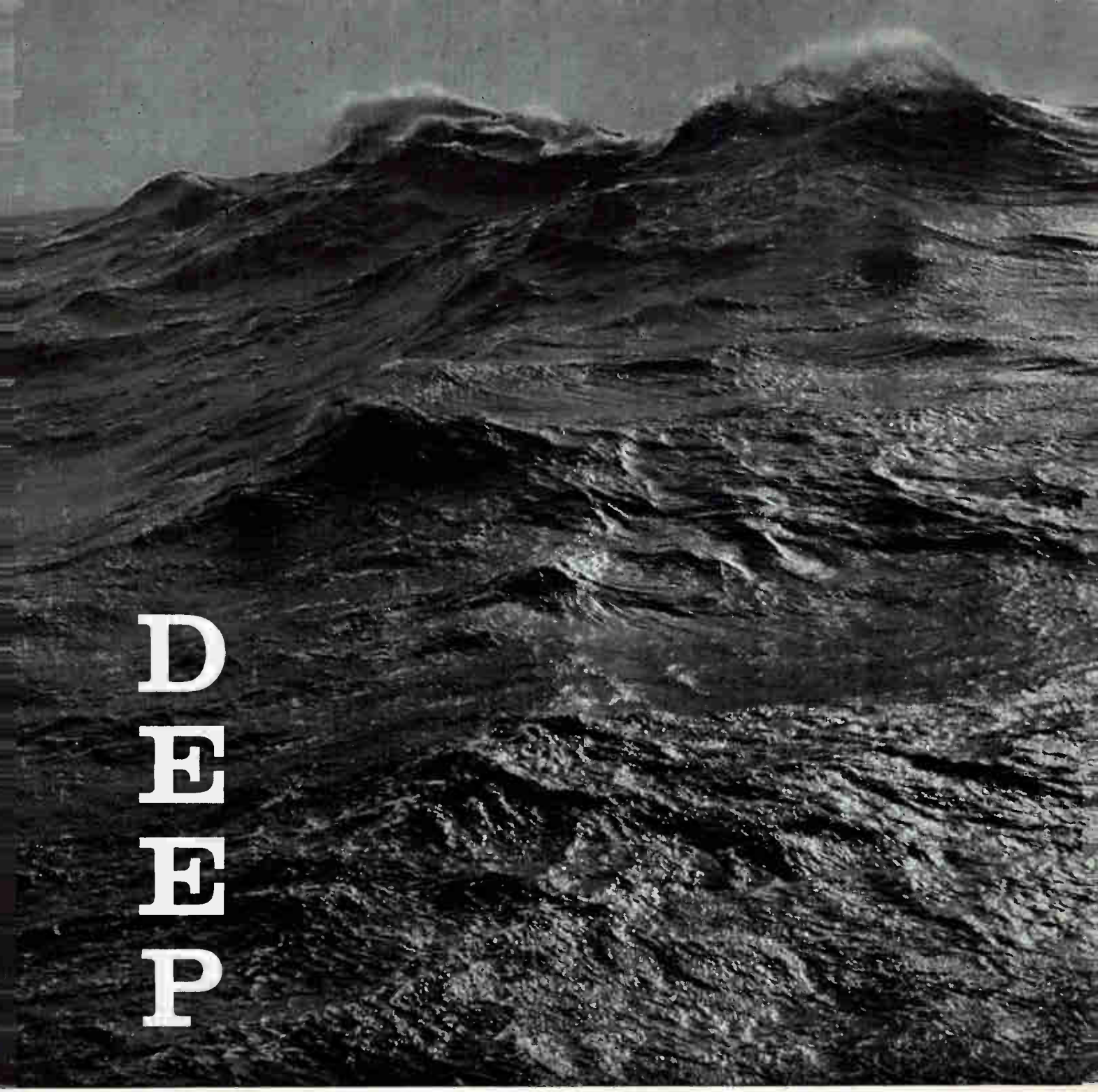
The complete circuit of a simple measuring instrument is given in Fig. 1B. Inductances ranging from about 500 h to 0.5 mh can be measured with decade capacitors of from 0.01 μf to 10 μf over a frequency range of 50 cps to 10 Kc.

Measurements with and without d-c current can be made. Switch S_2 controls the d-c.

This technique has been used for six months to measure Q's of coils at lower audio frequencies.

REFERENCES

(1) H. M. Turner, The Constant Impedance Method for Measuring Inductance of Choke Coils, *Proc IRE*, 15, p 1559, Nov. 1928.



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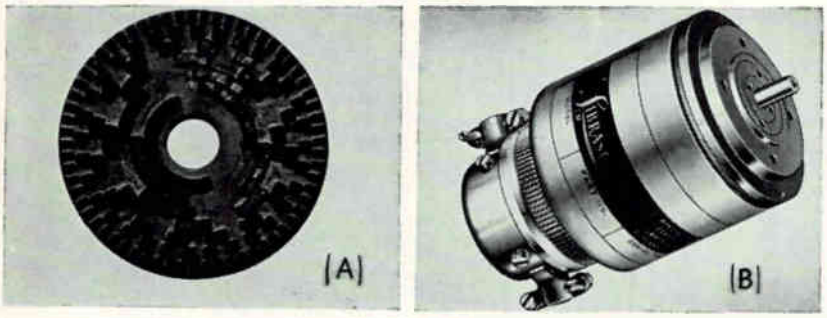
Magnetic Shaft-Position Encoders



Raised and depressed portions on ferrite disk (A) alter flux in magnetic encoder (B) to produce digital output of shaft position or rotation

MAGNETIC technique for shaft-position encoders offers high rotation speeds and high reliability for computer, control and data-logging systems. The new noncontact technique was developed by Librascope division, General Precision, Inc.

Shaft-position encoders deliver a set of two-level signals representing a binary expression of input shaft position or rotation. They provide a link between analog and digital data-processing systems. As digitizers, they change a varying function into discrete values.

Magnetic Encoders

The magnetic technique uses changes in magnetic induction of toroidal ferrite readout cores to generate two-level voltage signals that can arbitrarily be designated as binary ONES or ZEROS. The signals are generated in response to the rotation past the readout cores of raised and depressed portions of a ferrite disk driven by the input shaft. The raised and depressed portions of the ferrite disk form a coded pattern that is a binary representation of the angular position of the disk.

Toroidal ferrite cores are about 0.1 inch in outside diameter and 0.07 inch in inside diameter. An alternating current source drives the core. The driving current and number of turns of the winding are fixed at values required to drive the core to magnetic saturation just before the completion of each half cycle of the driving signal to assure reliable core switching. The driving circuit consists of the alternating current source, a fixed resistor and the core.

The pattern on the surface of the coded disk is machined ultrasonically to obtain concentric tracks of raised and depressed portions to correspond to the binary bits used in the digital representation of shaft position. In a 7-bit encoder that can resolve a shaft revolution to one part in 128, seven concentric tracks are required. One or more readout cores, depending on the binary code used, monitor each bit track.

The readout cores and the code disk are positioned in a fixed magnetic field. This field is generated by a field coil fixed to one end of the magnetic housing. This disk occupies the air gap between the ends of the magnetic housing. The magnetic circuit path is from the field coil through the code disk, the readout core, and the related air gaps and back through the magnetic housing.

Total flux density within the readout core results from the flux generated by its own excitation current and the flux resulting from the core-encompassing magnetic circuit. However, flux density of the fixed field is a function of reluctance along the total magnetic path of the field. Altering thickness of the code disk changes air gap between the rotary disk and the readout cores, resulting in a change in flux density of the magnetic circuit.

The change in flux density alters total magnetic induction of the core, which is directly reflected as a change in core impedance. The voltage drop across the readout core follows the impedance change, producing a bivalued voltage output measured across the core.

Thus voltage across the core varies in accordance with the raised and depressed portions of the code disk. The new technique provides voltage ratios between ONE and ZERO of 20:1 or more. These high ratios permit use of a wide range of readout circuits with the encoders.

Performance

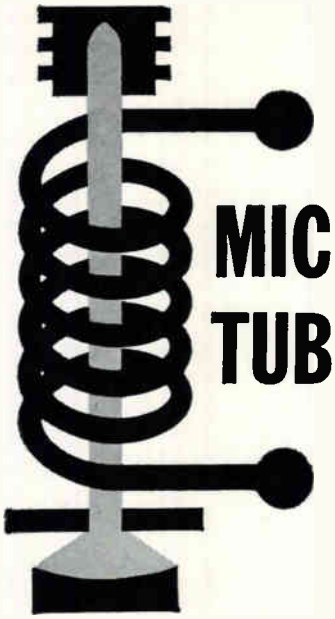
The basic 7-bit encoder can be operated at 10,000 rpm when the readout cores are driven by a 125-Kc source. The large capacity encoders are restricted to speeds of about 4,000 rpm by mechanical factors such as gear lubrication. Because the electrical elements are not subject to wear, life of the magnetic encoder is limited only by the mechanical elements, such as the input shaft bearings. These magnetic encoders have operated successfully for over 20 million revolutions at 1,000 rpm in Navy fire-control systems. Results of these tests indicate a life expectancy of over 20,000 hours.

The new encoders are immune to other adverse environmental factors. They can be operated over a temperature range of −20 to 100 C and are resistant to vibration and shock. The noncontact magnetic technique eliminates need for mechanical adjustment of encoder elements during entire operating life.

Readout

A wide variety of reliable readout circuits is possible with the high ONE to ZERO voltage ratios. Both serial and parallel readouts are possible, depending on the system requirements.

Choice of readout circuit configuration is dictated by the system application. Driving oscillator frequency can be chosen to meet slew-



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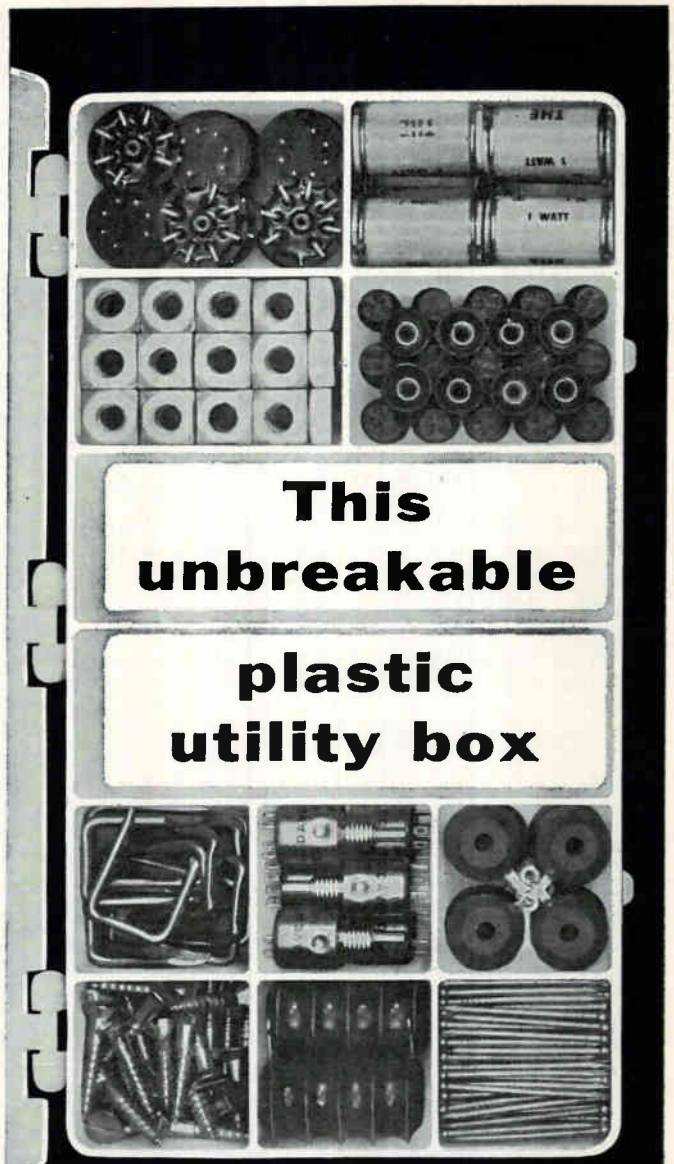

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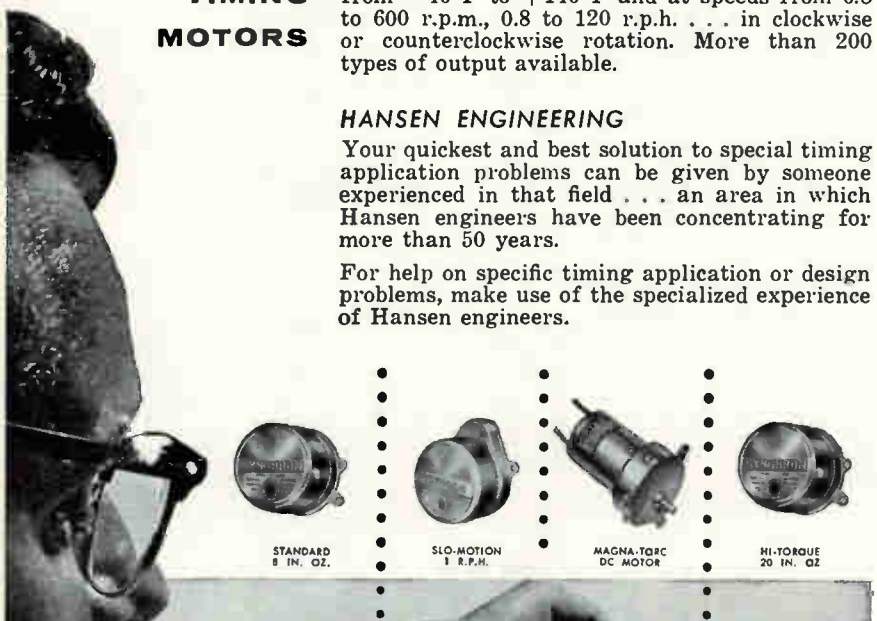

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ing speed requirements. Solid-state isolation diodes can be used within the encoders to permit as many as 20 encoders to be interrogated by a single decoding unit along a single-harness transmission system.

Many specialized applications are possible with the addition of proper circuits. Magnetic encoders can also be incorporated into standard data-processing equipment or as sources of digital information in computer and automatic control facilities. For example, they can be used as the source of the integrated information required for aircraft engine thrust measurements. In such an application, input shaft position and resulting digital output would be proportional to engine thrust. Plotted against time, these data can be used to determine engine thrust as a function of time or any other time-dependent parameter.

Magnetic shaft encoders are also suited for automatic production of intricate parts requiring accurate machining. Machine tools are often computer controlled. Shaft-position to digital encoders are used to feed back directly into the computer logic needed information on table positions, traversing and tool feed rates, and similar data.

In many complex guidance and control systems, operations on some data inputs are best performed by analog computers. However, subsequent operations on the processed data require digital computation. Magnetic encoders can receive analog information in the form of shaft position from the analog computer and translate it into digital form for the digital computer.

Parametric Amplifier Increases Radar Range

PARAMETRIC amplifier increases range of a tracking radar about 50 percent. It was developed at MIT Lincoln Laboratory under Air Force contract with support from ARPA. The low-noise amplifier is used in an experimental S-band radar that has been installed near Wallops Island, Va., to track reentry vehicles.

The negative-resistance amplifier is a non-degenerate type that oper-

ates at 2,800 Mc. Pump frequency is 8,400 Mc. A Hughes HP 2800 germanium varactor operated at liquid nitrogen temperature is used as the reactive element.

Noise figure of the amplifier alone is about 0.8 db, equivalent to a noise temperature of 65 K. Minimum detectable signal of the radar is about −116 dbm, representing an improvement of 7 to 8 db over conventional receivers.

Installation of an X-band maser at the Virginia site is also planned by Lincoln Laboratory. It has bandwidth of 8 Mc and gain of over 20 db. It operates at liquid helium temperature and at atmospheric pressure.

Atomic Fuel Gage for Missiles and Aircraft

RADIOACTIVITY is used in a fuel gage developed for aircraft and missiles. High accuracy and reliability are claimed for the instrument, which was developed for the U.S. Navy by Atomics International division of North American Aviation.

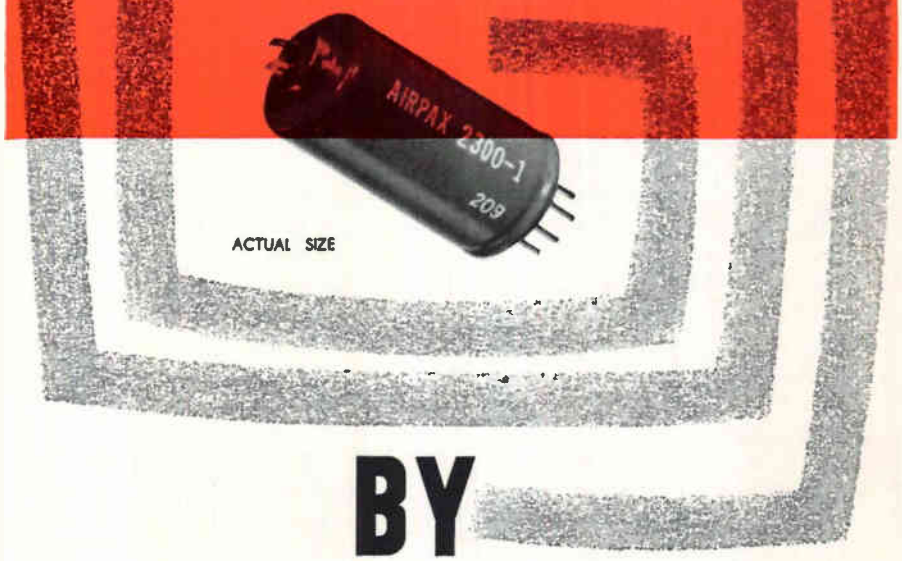
The gage is undergoing tests in a twin-engine jet bomber at altitudes to 38,000 ft. Changes in altitude or cosmic radiation did not affect performance of the light-weight fuel gage. Additional tests are scheduled by the Navy.

All types of solid and liquid propellants can be measured by the gage. Performance is not affected by impurities in the fuel. It measures all fuel, is easily installed and automatically compensates differences in hydrocarbon or petroleum-based fuel.

The gage consists of gamma radiation sources, such as cobalt-60, scintillation detectors containing a ratemeter and pulse amplifier, a power supply and an indicator. Radiation sources and detectors are mounted on the sides of each fuel tank. The rays decrease in intensity as they pass through the fuel.

The amount of fuel is determined by the intensity of gamma rays reaching the detectors. The ratemeter converts pulses picked up by the detectors into d-c voltage and the quantity of fuel is recorded in pounds on the indicator.

LOW NOISE *miniature* CHOPPERS



BY AIRPAX

Airpax low noise choppers have been developed for use where exceedingly low level signals in low impedance circuits would be lost in the background noise attendant with normal chopper operation. Designed after exhaustive tests for optimum electrostatic and electromagnetic shielding, Series 2300 choppers, using a drive frequency of 400 CPS, have found wide acceptance where the noise level must be kept in the 1 microvolt region.

Illustrated is the type 2300-1, with top solder lug terminals. Also available with plug-in top terminals and external mu-metal shield.

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CIRCLE 117 ON READER SERVICE CARD 117

Materials Hold Key To Improved Tubes

ELECTRON TUBES capable of reliable performance at high ambient temperatures are impaired by limitations of conventional getters.* In a report from the Electronic Material Sciences Laboratory, Air Force Cambridge Research Center, U. S. A. F., Bedford, Mass., R. L. Phipps calls attention to a cerium aluminum and thorium getter material called CER ALLOY 400, developed by Cerium Metals and Alloys Division of Ronson Metals Corp., Newark, N. J. This material acts as a continuous getter through the 200 to 1,000 C range and is well suited to meeting needs between 300 C and 600 C.

Initial studies of coating and sintering techniques peculiar to CER ALLOY 400 have met with a reasonable degree of success. At the Material Sciences Laboratory in Bedford equipment was set up last week to study and evaluate adsorption characteristics of the gettering surface, compare CER ALLOY 400 with other getters and to study the effect of sealing operations on getters. Initial experiments indicated the need for this evaluation.

Base emission phenomena, including the development of new materials for obtaining increased emission with resultant long life are also under investigation. According to A. Matthewson, the use of all-ceramic directly-heated cathode is still being investigated. This ceramic, titanium dioxide, when properly processed, can be made conductive to the desired degree. Used as a base material for the conventional oxide coating, this cathode exhibits the same properties as the conventional nickel-based oxide cathode. It has several advantages over the conventional indirectly heated oxide cathode. No separate heater is required, heater cathode leakage currents are eliminated, it is rugged, shock resistant and can be made to have any operating voltage-current characteristics for a given temperature. However, it is more difficult to fabricate and requires more rigid processing control. These cathodes show warm-up characteristics similar to the indirectly-heated nickel base oxide cathode, but this warm up time can be reduced.

Applications in an electron tube as a directly heated cathode or grid are based on the fact that conductivity of TiO_2 may be varied by the firing schedule which is followed. The problems of joining TiO_2 to itself or other materials and of controlling the final conductivity are being investigated.

As reported by Tandy, titanium oxide pieces are available commercially as ALSIMAG 192 or they may be formed from titanium oxide powders by pressing in the proper dies with a hydraulic press and sintering. Both type pieces may be machined using an ultrasonic drill.

Techniques have been developed for brazing TiO_2 to itself or to other metals. Twelve percent titanium-cored silver-copper eutetic solder has been used to braze the compound to itself. Liquid bright platinum painting of the brazing area appears to help the strength. Titanium hydroxide and nickel powder is used to make the tungsten lead and molybdenum end cap braze to the TiO_2 cathode rods. The attachment of leads to the titanium dioxide cathods involves ceramic-to-metal sealing techniques in addition to the drilling of holes into the ends of the fired components. Both of these techniques are being investigated.

Tandy reports that several tubes have been made and tested using triple carbonate emitting material sprayed on TiO_2 rods. These tubes have operated up to 7,000 hours with a maximum of approximately 8.5 ma/cm^2 emission. Although this emission is one-fourth that resulting from a nickel base cathode control tube, the results are promising.

Three tubes have been made with TiO_2 grids. One tube had some grid emission when heated and this may have been due to thermionic, secondary or photoelectric emission. Only 5μA of thermionic emission was measured from a TiO_2 cathode when heated to 990 C (brightness) with 2.1 kv acceleration. Higher temperature brazes and better compacts are future objectives. Revised processing techniques may obtain better emission and longer life.

Since many rare-earth oxides, particularly neodynium and gadolinium oxide lead one to believe that they might make good thermionic emitters, a Battelle Memorial In-

* A volatile metal, vaporized inside a vacuum tube, which obtains initial high vacuum by absorbing gas within the tube. Choice of getter is important especially for tubes that perform at high ambients. When hot, getters may give out gas they have absorbed.

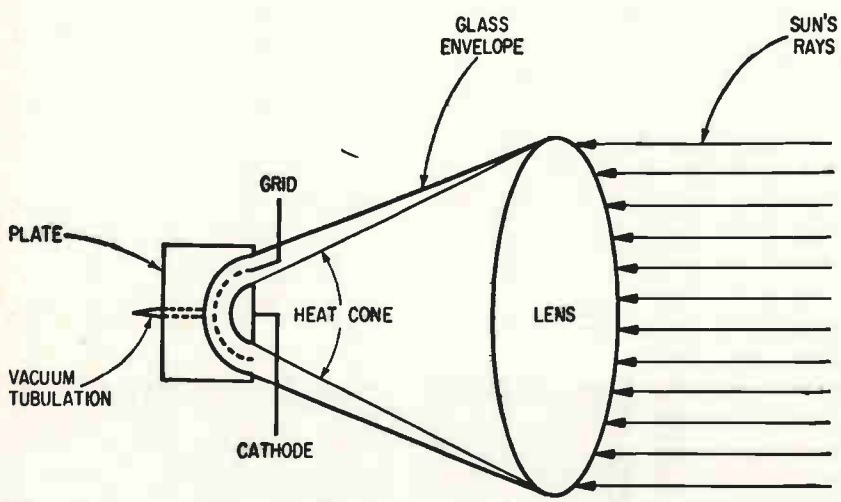

FIG. 1—Diagram shows configuration of solar powered electron tubes now in experimental stages. Design works on paper, awaits fabrication

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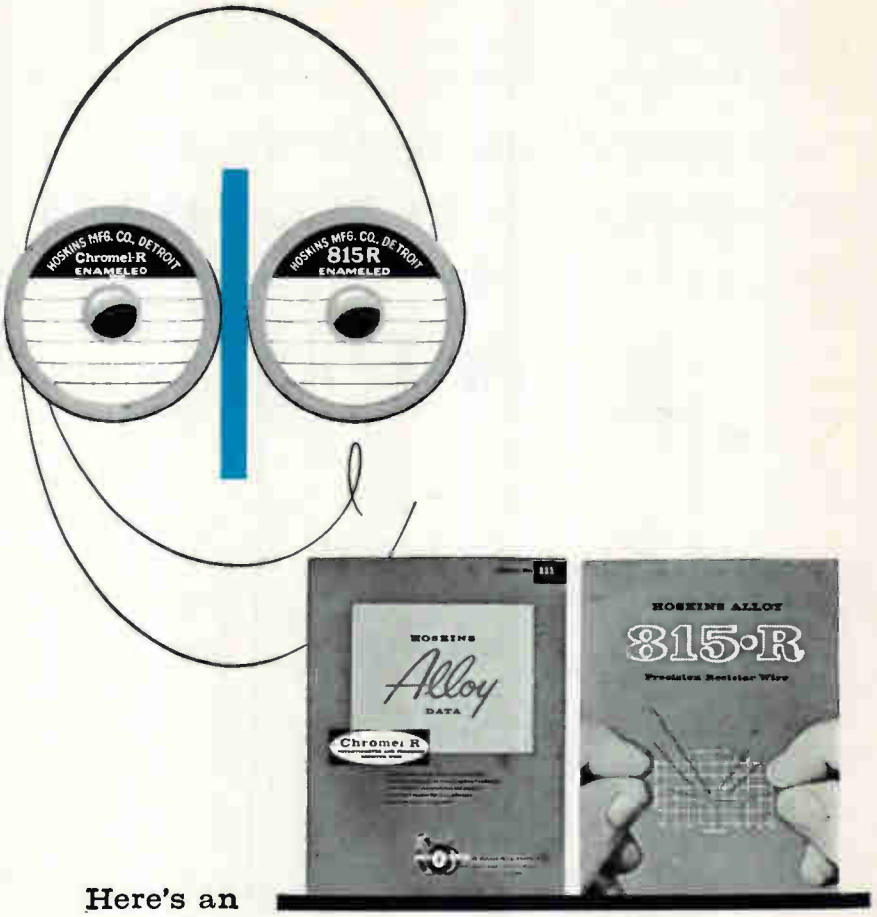

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stitute contract is exploring various oxide combinations with base metals and reducing agents.

Another AFCRC project, reported by G. P. Ploetz, R. F. Trimble and H. F. Cox considers the application of solar energy to power electron tubes. Designs have been worked out on paper and fabrication techniques may be forthcoming. According to some sources it is believed that patents are held on spherical tubes but not much has been reported in this area. Hemispheric-shaped cathode, grids and plate configurations are suggested in Fig. 1. A lens is used to concentrate the sun's energy onto the inner surface of the hemispheric cathode. A single grid and external plate are shown with vacuum envelope and tubulation and it is suggested that such devices can be processed in any of the thermal imaging techniques developed with precision solar and carbon arc imagers. An analysis of imaging techniques was made by D. D. Foster. Analysis of spherical surface areas was used in designing various types of grid meshes for the hemispheric shape.

Reports from the Radiochemistry Branch of AFCRC reiterate what has been mentioned in this column on several occasions: "Improvements in existing electronic equipment, using available materials, have for the most part been pushed nearly to their limits. If greater reliability of function, new and desirable functions and major breakthroughs are to be realized, they must for the most part come from new and improved materials."

Through basic and applied research programs, the Radiochemistry Branch seeks materials that can form the building blocks of the active components of electronic equipment. It is expected that these investigations will provide information useful to engineering physicists in fashioning materials into reliable electronic components.

A specific material that is being studied is the single-crystal growth of silicon carbide. This is an area now being closely watched by transistor people.

Nuclear environmental effects on electronic materials are being studied along the lines of what happens

to the chemistry of surfaces as a function of irradiation and how the nuclear environment can be measured. Turner reports that an interesting and unique development has occurred in the study of the bombardment of platinum and silicon specimens with Kr^{85}. Indications are that a significant portion of the trapped atoms remain even after prolonged annealing at high temperature.

More extensive work along these lines will be possible using the MIT reactor which is now in full operation. This facility will study radiation effects on electronic materials.

Dice-Sized Modules

Cube of electronics in engineer's right hand fits on modular card that does as much work as all 23 conventional printed circuit boards spread out on table

THE GUIDANCE system of the AN/USD-4 Swallow reconnaisance drone built by Republic Aviation will use half-inch cube modules, each holding from 12 to 18 components and weighing about two grams. This packaging allows the building up of an extensive logic capability for a computer at reduced size.

Use of the module technique is familiar, but this seems to be one of the most compact units designed for off-the-shelf components. The module is suitable for use in any all-purpose digital computer whether for military or commercial use.

The units are arranged on modular cards at the rate of 44-50 per card. Uniform units can be stacked, and can be made economically.

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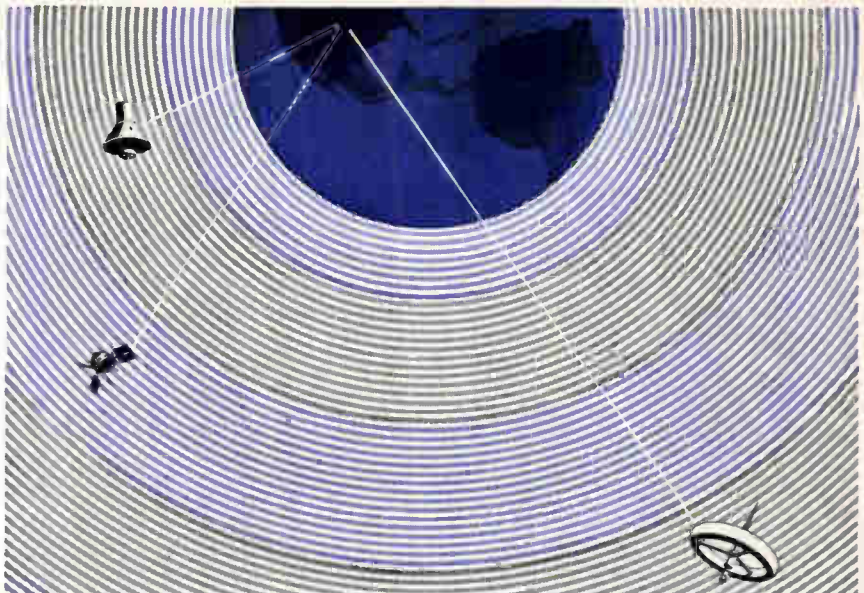

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Correcting Rhodium Plating Defects

By J. NEWTON PERHAM, Metals and Controls Division, Texas Instruments Incorporated, Attleboro, Mass.

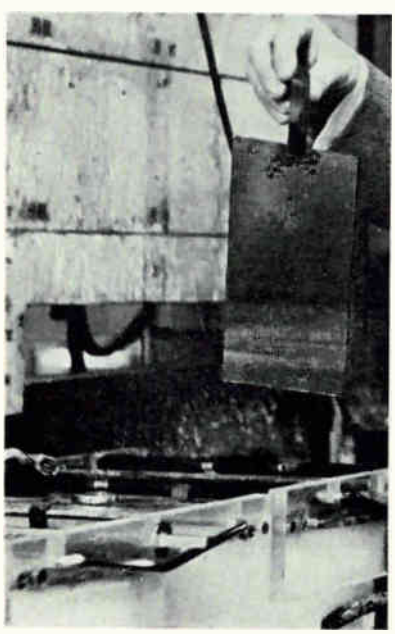
RHODIUM PLATING is a relatively simple process since no brighteners, wetting agents or other additives are involved. The anodes are inert. As the acid bath (pH approximately 1.5) is worked, only rhodium concentrate is added to maintain proper metal content.

It is most important to maintain strict preparation and rinsing procedures prior to rhodium plating. Inorganics cannot be removed economically from the rhodium solution. Organics may be removed by carbon treatment. By thorough rinsing, contaminates can be held to a minimum. Plate only gold, silver or nickel surfaces. Nickel is preferred. The quality of the plated rhodium surface is only as good as the undercoat.

For decorative applications, coatings up to 0.000008-inch, use rhodium phosphate solution with either sulphuric or phosphoric acid. The straight phosphate bath gives the whitest and brightest coat. The phosphate sulphuric acid combination possesses higher efficiency and throwing power. Electronic applications use rhodium sulphate solution with sulphuric acid. Plating speed is much greater and the deposit has lower internal stress.

The plating bath container is externally water-heated to 110 F. to 120 F. Do not heat the plating solution by an internal submerged heater as the hot metal surface could cause a breakdown in the solution, forming rhodium oxide on the heater walls. Rhodium tank material may be Pyrex, Lucite, vinyl or Koroseal coated steel. Rhodium plating barrels are made of Lucite, vinyl or Teflon.

The ratio of anode area to work



Typical rhodium plating setup using expanded anode

PLATING DEFECTS, CAUSES AND CURES

Plating Defects and Causes	*Corrections*
Dark greyish plate. Due to: metallic contamination of the bath usually due to improper rinsing of work prior to rhodium plating	Make up new bath, have old solution refined, add rinse tanks; rinse more thoroughly in existing tank, use alternate hot and cold running water rinses
Bluish, brown dark streaky plating; coating is sometimes much softer than normal. Due to: organics in rhodium solution	Carbon treat solution as follows: transfer rhodium to clean, suitable tank; stir in activated charcoal, approx. 1 oz. per gal. of solution; stir constantly for ½ hr. minimum; solution should be 120 F approx, filter solution back into cleaned plating tank
Rough plate. Due to: carbon particles in bath; too high current; work shorted in tank	Filter solution; reduce voltage
Plating peels. Due to: (1) dirty work surface; (2) nickel base not activated properly	(1) Check cleaning methods; use soak cleaner prior to electro cleaner; (2) use 10% sulphuric acid rinse between nickel and rhodium plating operations
Brown spots and nonuniform plate. Due to: too great a work area in proportion to anode surface	Increase anode area or decrease work area
Anodes turn black. Due to: too large a work load causing excessive current on anode surface; formation of rhodium oxide	Increase anode surface 1 to 2 ratio with work area
Sludge forms in bottom of bath; slow action at anode and work surface. Due to: acidity of bath is too low	Add acid diluted in distilled water, bring Baume hydrometer reading up to 6° Be
Black, sometimes sooty deposit forms on plating tank walls. Due to: (1) organics in rhodium solution; (2) too high voltage being used	(1) Carbon treat solution and clean tank; (2) reduce voltage to 6
Too slow buildup of required rhodium thickness. Due to: (1) metal concentration too low; (2) too low current; lack of agitation	(1) Increase rhodium concentration to 14 grams per gal. for 0.000050-inch plate and 20 grams per gal for 0.0002-inch plate (2) Increase voltage; mechanically agitate the work rod

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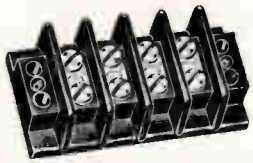

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For more information about the Model 7508 and other Bryant Standard Magnetic Storage Devices, from 7500 to 75,000,000 Bits, write to Bryant Computer Products Division, P.O. Box 620, Springfield, Vermont.

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NEW Couch Relay isolates Contacts from Contamination

Organic material can't contaminate the contacts in the new Couch Type 2M micro-miniature relay. They're hermetically sealed in a separate chamber — and without rosin flux.

Also contributing to reliability is Couch's patented rotary armature, pivoted on two sapphire jewels and virtually immune to present day levels of shock and vibration.

Designs like this, produced within an unusually narrow range of manufacturing tolerances, help explain why Couch relays are being called on to provide reliability in many complex systems.

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ENGINEERING DATA:

Shock	50G Min.
Vibration	30G's to 2,000 CPS
Dielectric Strength	1000 Volts RMS Min.
Height	.875" max.
Width	.800" max.
Thickness	.400" max.
Weight	18 ± 1 gram
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RHODIUM THICKNESSES

Application	*Thickness* (microns)
Decorative Purposes	0.025 to 0.125
Tarnish Protection	0.125 to 0.25
Corrosion Protection	0.25 and more
Corrosion Protection (severe)	0.5
Electrical Contacts (light load)	0.37 to 0.5
Electrical Contacts (heavy load)	2.5
Electrical Contacts (severe friction)	6.2 and more

(Fisher, Leonhard, *Metall*). 1956, 608)

area should be kept to 1-to-2. Expanded platinum on tantalum anodes or solid platinum anodes are structurally much stronger, cost less and permit constant circulation of the rhodium solution through their surface.

Work should be agitated, particularly when the heavier industrial coatings are being deposited. Agitation permits the deposition of less porous coatings due to the reduction of hydrogen bubbles forming on the plated surface. It also improves the current efficiency of the bath.

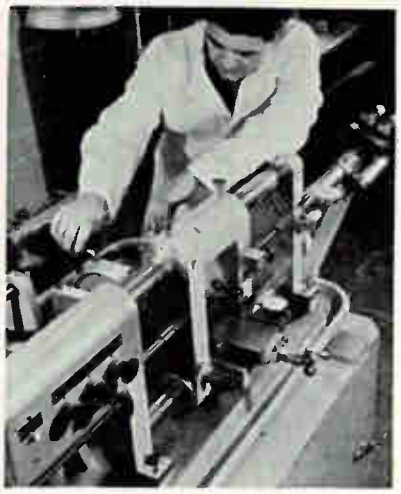
Rhodium is expensive. It costs approximately 21 cents per square foot of surface 0.000001-inch thick. Design plating racks accordingly. Use plastisol or rubber coated racks with a minimum of contact surface exposed to hold the work.

The accompanying table reports some of the more frequent difficulties experienced when operating a rhodium bath and how they can be corrected.

Turns Computer Memory Drums

PRECISION TURNING device, built on a drill press table, will machine to a tolerance of plus 0.000050 inch, minus 0.000000. The machine was devised by Librascope Division, General Precision, Inc., Glendale, Calif., to finish the outer diameters of memory drums.

The table, from a 24-by-36-inch Delta drill press, was scraped and hand-lapped to provide an accurate mounting surface for the fixtures. Fixturing on the table can be changed to accommodate various types of drums. The table is



Pneumatic-hydraulic feed drives tool across rotating drum face

anchored in a 1-ton cement block and is used in an air-conditioned area.

Drums are rotated by thin belts driven by a 1-horsepower, 220-volt enclosed motor. The driving speed range is 600 to 5,850 rpm, which permits certain drums to be turned at their designed operating speeds.

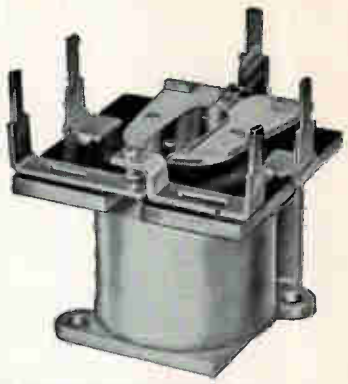
Cutting tool feed speeds can vary from 0.25 inch to 5 inches a minute. The tool holder is driven by a pneumatic cylinder. Control of the oil flow from a hydrocheck cylinder, against which the pneumatic cylinder works, regulates the speed of tool holder traverse. Diamond tools and the evenness of speed provided by the pneumatic-hydraulic tool feed yield a finish of 8 microinches or less, the company reports.

A precision lathe and saddle fixture formerly used hampered quantity production because of its complicated construction and the difficulty in changing drum types. The new machine was designed by Roy W. Van Holm, prototype shop foreman.

Germanium Used in New Brazing Alloy

Recent AEC patent available to industry (2,901,347, assigned by J. A. McGurty and E. S. Funston) describes a new alloy for brazing stainless steel. The alloy consists of 27 to 65 percent by weight of nickel, 5 to 40 percent chromium and 15 to 40 percent germanium.

For Printed Circuitry



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The Style 1005 Relay is a single-pole, double-throw relay, light in weight yet capable of withstanding severe operating conditions and rough handling.

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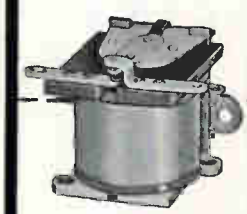
MAXIMUM COIL RESISTANCE	13,000 ohms
SENSITIVITY	0.05 watt at standard contact rating; 0.3 watt at maximum contact rating
CONTACT COMBINATION	SPDT
CONTACT RATING	Standard 1 amp.; optional ratings, with special construction, to 3 amps. Ratings apply to resistive loads to 26.5 VDC or 115 VAC
MECHANICAL LIFE EXPECTANCY	10,000,000 operations minimum
DIELECTRIC STRENGTH	500 VRMS minimum



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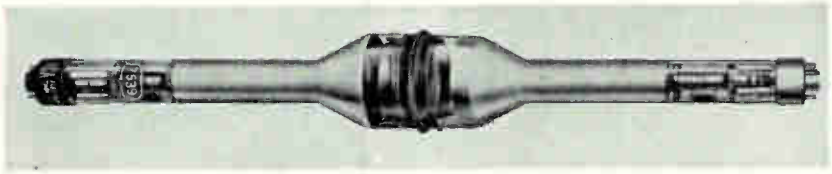


Scan Converter for Large-Screen Radar

PERMITS PINPOINTING AIRCRAFT LOCATIONS

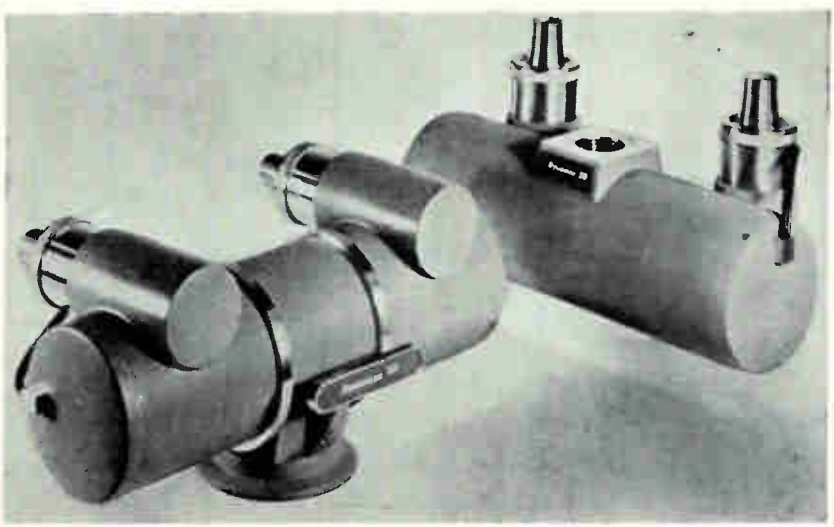
LARGE-SCREEN radar display in brightly lighted rooms is possible with a new scan conversion tube developed by the Radio Corporation of America, 30 Rockefeller Plaza, New York, New York. The tube can continuously transform signal information from one radar time base to another enabling radar operators to pinpoint aircraft.

For example, plan position information generated by a conventional radar system can be processed by this tube for brighter and larger air-traffic control display on a large-screen television monitor or for transmission by television circuits to remote locations.

The tube employs two coaxial electron guns on either side of a central target section. One of the electron guns operates as the gun of a conventional radar oscillograph tube placing the radar scan signal on the central target section. This is called the writing gun. The electron beam from the second gun, called the reading gun, is deflected by a television scanning system and releases information from target.

The tube, designated the RCA-7539, has a resolution capability of 150 range rings per display radius with a response of 50 percent or better. The tv monitor must be designed for resolution better than 1,000 lines. The tube is about 26 in. long and 3½ in. in diameter at its widest part.

CIRCLE 301 ON READER SERVICE CARD



New Tube Reduces X-Ray Dosage

ONE INSERT TUBE IS GRID CONTROLLED

USE OF ADVANCED x-ray diagnostic techniques while using substantially less radiation is the advantage claimed for a 150,000-volt tube developed by Machlett Laboratories, a subsidiary of Raytheon Company, located in Waltham, Mass.

The Dynamax 50 makes possible high-definition pictures using either conventional techniques or image amplifying systems. It can be used with three different insert tubes.

The first insert tube provides precise exposure control by a grid-like structure similar to those used in triode vacuum tubes. Exposures in the millisecond range are possible to minimize blurring due to patient motion.

Another insert tube has its anode rotating at 11,000 rpm. This insert tube permits high-energy short-time exposures.

A conventional double focus insert tube may also be used. This tube has high heat storage and heat dissipating characteristics.

CIRCLE 302 ON READER SERVICE CARD

Tiny Binary Encoder

FOR MISSILE USE

WELL SUITED FOR missile applications is a new shaft-position to digital encoder packaged in a size 8 casing only 0.75 in. in diameter by 1.25 long. The 13-bit unit is a product of Librascope Division, General

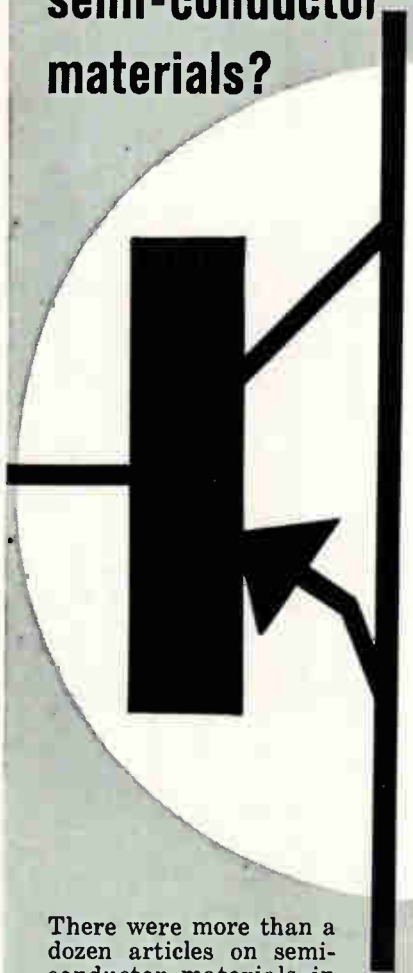
Precision, Inc., 808 Western Ave., Glendale, Calif.

Known as the model 793M, the encoder has a resolution of 128 counts per input shaft revolution and a total capacity of 8,192 binary counts. A combination of two cascaded disks and 25 contact pickups is used to provide serial or parallel binary readout of shaft position or rotation.

The readout circuit uses the V-scan technique; accuracy can never be less than the least significant bit in 2^{13} counts. Counting speeds of 0 to 200 rpm are possible. Tests indicate a potential life of 2×10^6 revolutions at 200 rpm, equivalent to 167 hours of continuous operation.

The unit requires potential of 6 to 60 v d-c with a maximum of 2 milliamp. Starting and running

do you know what's expected from semi-conductor materials?



There were more than a dozen articles on semiconductor materials in **electronics** in recent months. Each was specially edited to give you all key facts, ideas or trends—and there's more coming! Accurate **electronics**' reporting tells you what's happening now . . . what's *expected* in materials and components. Don't miss dozens of articles on basic subjects edited to keep you informed, help make your research, development, sales and marketing plans pay off. It pays to subscribe to **electronics** (or renew). Fill in box on Reader Service Card now. Easy to use. Postage free.

FIND WHAT YOU NEED IN electronics

Measures 1mv to 1000v from 10 cps to 250 kc

BALLANTINE ELECTRONIC VOLTMETER

Model 300-D
Price $255.

Note these outstanding features:

★ **Top Accuracy:**
better than 2% throughout voltage and frequency ranges and *at all points on the meter scale.*

★ **High Input Impedance:**
2 megohms shunted by 15 pf, except 25 pf on lowest range.

★ **Excellent Stability:**
less than ½% change with power supply voltage from 105 to 125 volts.

★ **Long Life:**
several thousands of hours of operation without servicing or recalibration.

★ **Five Inch, Mirror-Backed, Easy-to-Read Meter:**
logarithmic voltage scale reading from 1 to 10 with 10% overlap at both ends; auxiliary linear scale in decibels from 0 to 20.

Also available in 9½ and 19 inch relay rack models

This instrument is an improved version of Ballantine's original Model 300, famous for its accuracy, sensitivity, and reliability for more than 20 years.

Write for brochure giving many more details
— Since 1932 —

BALLANTINE LABORATORIES INC.
Boonton, New Jersey

CHECK WITH BALLANTINE FIRST FOR LABORATORY AC VACUUM TUBE VOLTMETERS, REGARDLESS OF YOUR REQUIREMENTS FOR AMPLITUDE, FREQUENCY, OR WAVEFORM. WE HAVE A LARGE LINE, WITH ADDITIONS EACH YEAR. ALSO AC/DC AND DC/AC INVERTERS, CALIBRATORS, CALIBRATED WIDE BAND AF AMPLIFIER, DIRECT-READING CAPACITANCE METER, OTHER ACCESSORIES.

torques are both below 0.5 in.-oz. The encoder is designed for ambient temperatures from −18 to 100 deg C under severe vibration and high-g loads.

CIRCLE 303 ON READER SERVICE CARD

Low Level Beta Counting System

USES COSMIC-RAY-GUARD COUNTER TUBE

INCREASE IN SYSTEM reliability is achieved with a new low-level beta counting system developed by Technical Associates, 140 West Providencia Ave., Burbank, Calif. The system uses the Amperex beta counter tube and cosmic ray guard. The single tube replaces an array of up to 30 guard tubes used before. This permits shielding for backgrounds of 1 count per minute or less with a sizable reduction in the amount of shielding required.

The model LLB-40 system includes the model LS-41 lead and mercury shield, either Amperex type 18515/18517 or type 18516/18518 counter tube and guard, and ACS-42 anticoincidence scaler.

CIRCLE 304 ON READER SERVICE CARD

Atomic Frequency Standard

EXTREMELY STABLE

FREQUENCY STABILITY of better than one part in a billion is achieved under airborne conditions by an airborne atomic frequency standard delivered to Wright Air Development Division by the National Company, Malden, Mass.

The unit is an outgrowth of National's Atomichron model NC-1001 but is only one tenth its size and weight.

The new frequency standard weighs only 65 lb and occupies 1½ cu. ft. Under laboratory conditions, frequency stability is improved tenfold over service conditions.

The standard is expected to be used as a general-purpose portable frequency standard. It will also be used as a test instrument in working on advanced guidance systems and other airborne applications.

CIRCLE 305 ON READER SERVICE CARD

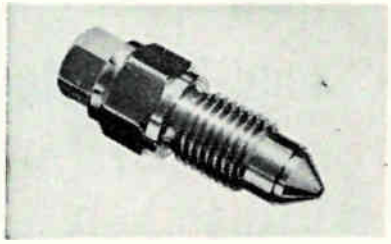
Miniature Quartz Pickup

MEASURES BALLISTIC PRESSURE TO 200,000 PSI

BALLISTIC PRESSURES to 200,000 psi can be measured with a miniature natural quartz crystal pickup that measures only 1⅛ in. long by ⅜ in. in diameter. The 601/633 pickup is manufactured by Kistler Instrument Corp., 15 Webster St., North Tonawanda, New York.

The semicircular crystal element is mounted in a rigid column. The pickup has a natural frequency of 100,000 cps, a rise time of 5 microseconds and mounts in a ⅜-in. threaded hole.

A special piston and cylinder insert extends the pressure range to 200,000 psi. Other inserts permit the pickup to operate in ranges from 35,000 to 300,000 psi. A special version of the pickup measures pressure directly to 15,000 psi with future 50,000-psi capability planned.



To display pressure signals on an oscilloscope, a Kistler 655 amplifier calibrator and 672 low-noise cable may be used.

CIRCLE 306 ON READER SERVICE CARD

Detector Capsules

PHOTOVOLTAIC

HOFFMAN ELECTRONICS CORP., 1001 Arden Drive, El Monte, Calif., announces types EA7E1, EA7E3 and EA7E5 silicon photovoltaic detector capsules. Primary applications are in light detection, infrared sensing programming circuits, counting devices, and reading holes in punched cards. The solar cell light sensitive unit is hermetically sealed in a glass capsule and has an operating temperature range of −65 C to +150 C. Response time is less than 10 μsec. The subminiature capsule is 0.5 in. long and 0.08 in. in diameter. EA7E1 has current output of 300 μa at 1,250 ft-candles of tungsten illumination; a dark reverse current of 5 μa maximum at a reverse voltage of 1 v. EA7E3 has a current output of 250 μa and a dark reverse current of 10 μa. EA7E5 has a current output of 200 μa and a maximum dark reverse current of 20 μa.

CIRCLE 307 ON READER SERVICE CARD

Silicon Rectifiers

DOUBLE-DIFFUSED

TRANS-SIL CORP., 55 Honeck St., Englewood, N. J. Type MR series of double-diffused junction silicon rectifiers will deliver up to 3.0 amperes, half wave, with proper heat sink, in ambients up to 150 C. In

Custom-electronic cables shielded or jacketed in seconds!

SHIELDED ZIPPERTUBING®

Zippertubing® lets you make custom cables anywhere, any time without the aid of machinery or other equipment. You get 100% shielding coverage of wires, cables, and branch-out cable assemblies. One inexperienced man can do the job in one easy, timesaving operation! Cables can be permanently sealed or simply zipped closed for easy re-accessibility to conductors.

ZIPPERTUBING® NOW AVAILABLE IN MATERIALS TO MEET EXTREME TEMPERATURE AND USE CONDITIONS . . . Zippertubing is available in aluminum, copper, or co-netic steel. These conductive metals are combined with vinyl, Teflon, Mylar, Nylon or fiberglass for abrasion resistance. There is also Zippertubing to stand up against nuclear rays and Thermazip for the extreme temperatures of missile blast.

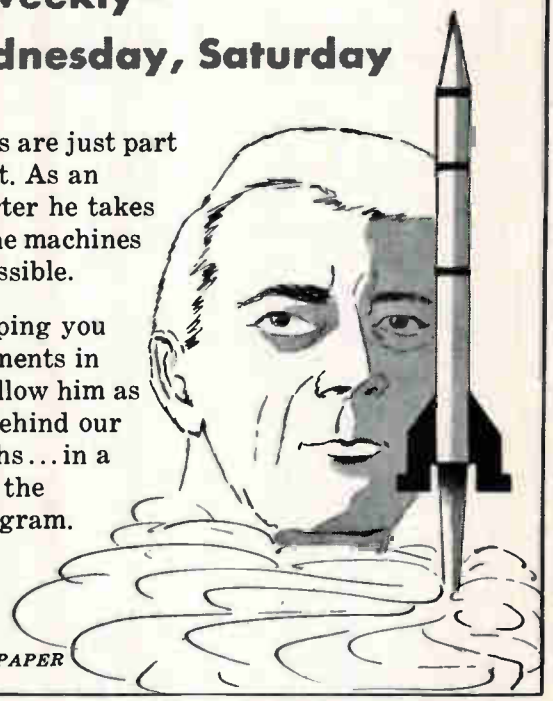
ZIPPERTUBING® MEETS MIL SPECS. If you design or work with electronic cables, it will pay you to investigate Zippertubing. Send for free literature and the name of your closest field representative.

Pat. and Pat. App. For

THE Zippertubing® CO.
752 S. San Pedro St., Los Angeles 14, Calif.

CIRCLE 209 ON READER SERVICE CARD

An engineer talks shop in the New York World-Telegram three times weekly– Monday, Wednesday, Saturday



Rockets and computers are just part of Dick Slawsky's beat. As an engineer turned reporter he takes a lot of time to cover the machines that make miracles possible.

But his big job is keeping you posted on the developments in engineering today. Follow him as he reviews the facts behind our scientific breakthroughs . . . in a terse, timely column in the New York World-Telegram.

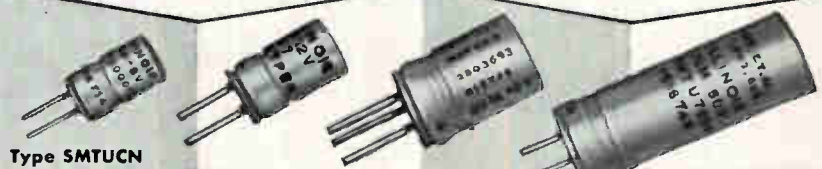
A SCRIPPS-HOWARD NEWSPAPER

CIRCLE 208 ON READER SERVICE CARD

ILLINOIS *UP-RIGHT* Miniature Electrolytic Capacitors . . . *Type SMTU finest for* TRANSISTORIZED CIRCUITRY

Time Tested Quality

Aluminum cased, with exclusive patented hermetic sealing. Stable under temperature extremes — stable to shock and vibration. Guaranteed long life. Fully tested and approved. Millions now in use.



Type SMTUCN
Dual Common Negative Separate Anodes

Compact construction permits exceptional space savings and economy which is highly desirable in modern transistor circuitry. One capacitor saves space where normally two individual capacitors were previously needed. These dual units are ideal for bypass, filtering or coupling where a common ground exists.

Type SMTUCP
Dual Common Positive Separate Cathodes

These dual section common anode constructed capacitors have cathodes which are electrically separated and isolated. Unique construction with "floating" cathodes makes these ideal for coupling, filter and bypass circuits for "above ground" applications.

Temperature Range: −40 to +65°C; also available −30 to +85°C
Voltage Range: 3 to 250 volts

ILLINOIS CONDENSER COMPANY
1616 NORTH THROOP STREET
CHICAGO 22, ILL. EV 4-1300

Write for complete technical literature

Export Department: 15 Moore Street, New York 4, New York

CIRCLE 131 ON READER SERVICE CARD

full wave circuits, currents up to 9.0 amperes can be realized. The rectifiers are hermetically sealed cells particularly suited for power supply and magnetic amplifier applications. Designed for conduction cooling by mounting directly onto the chassis, the stud-mounted units may also be installed with electrical insulating mica washers supplied with each. The double diffusion process assures uniform forward an reverse characteristics over the entire operating temperature range.

CIRCLE 308 ON READER SERVICE CARD

Wirewound Pot
SINGLE TURN

NEW ENGLAND INSTRUMENT CO., 1334 Main St., Waltham, Mass. Designed for panel trimmer control and servo applications in low and high torque models, the model 55W precision, single turn wirewound pot with ½-in. o-d, is available with stops or in continuous rotation. Unit, with all-metal construction, meets MIL5272A and applicable portions of JAN R-19 specifications. It is designed and developed to operate under extreme environmental conditions and has been fully laboratory and field tested.

CIRCLE 309 ON READER SERVICE CARD

Thermistor Kit
8 BEAD ITEMS

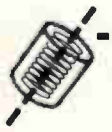
VICTORY ENGINEERING CORP., 524 Springfield Road, Union, N. J., announces a glass coated bead thermistor kit for designers and experimenters. The KTB1 kit contains 8 bead thermistors, covering a complete decade of resistance values from 100 ohms to 1 megohm. Supplied with each kit are technical data, curves, characteristics, and a pair of tweezers to facilitate handling of the thermistor beads. Kit is priced at $19.50.

CIRCLE 310 ON READER SERVICE CARD

Low Pass Filter
CARRIES HIGH POWER

CONTROL ELECTRONICS CO., INC., 10 Stepar Place, Huntington Station, L. I., N. Y., has developed a low pass filter for use in the output stage of a personal page transmitter operating on a 60 Kc carrier frequency. The LF-122 was designed to provide a minimum attenuation of 40 db throughout the aircraft and citizen band frequencies. It was designed to carry high power in the order of 75 w peak and 25 w normal. It can be driven from source impedances of

SPECTROL PRECISION POTENTIOMETERS



Two valid reasons why SPECTROL delivers better non-linear pots *faster!*

REASON 1 COMPUTER DESIGNED

Spectrol uses an IBM 610 computer to turn out complex non-linear precision pots in record time, both single-turn and multi-turn. This in itself saves weeks of time, assures more accurate performance. Spectrol alone maintains a computer on the premises for this purpose.

How It Works. Design information in the form of X and Y coordinates or mathematical equations describing the particular parameters of a given non-linear function is entered in the computer. Previously programmed general equations automatically compute from these data points manufacturing directions in terms of winding equipment settings, cam angle and radii. An electric typewriter prints out winding machine set-up information on a form which is sent to production. Simultaneously, a punched tape is made to store data for repeat requirements.

between 5 to 10 ohms and output is to the transmitter's loop antenna. Attenuation is 50 db down at the 3rd harmonic. Attenuation is held to less than 1 db up to 60 Kc and less than 3 db at 65 Kc.

CIRCLE 311 ON READER SERVICE CARD

Power Supply
RACK MOUNTED

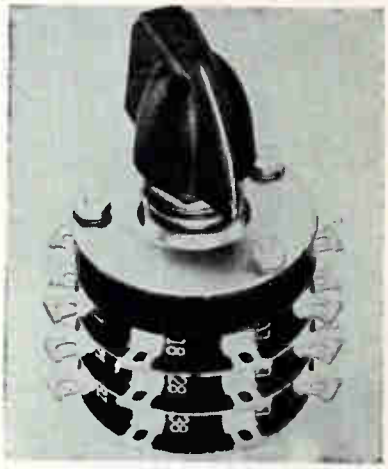
TRANS ELECTRONICS, INC., 7349 Canoga Ave., Canoga Park, Calif. Output for model RR303 is 0-300 v d-c at 0-500 ma; input, 105-125 v a-c 55-400 cps; line regulation, 0.1 percent; ripple and noise, 1.5 mv rms maximum; filament output, 6.3 v CT at 15 amperes; vernier voltage control; polarity either positive or negative may be grounded; output superior binding posts on front panel; barrier strip on rear; dimensions, 5¼ in. high, 19 in. wide, 14¾ in. deep. Price of the RR303 (without meters) is $320; the RM303 (with meters), $360.

CIRCLE 312 ON READER SERVICE CARD

Reference Diodes
IN GLASS PACKAGE

MOTOROLA INC., Semiconductor Products Division, 5005 E. McDowell Road, Phoenix, Ariz., announces a series of ½ w temperature-compensated reference diodes in a glass package providing a stable 9.0 v reference source. They measure about ⅓ in. by $\frac{1}{10}$ in. The diodes are suitable for ultrastable voltage reference applications in digital voltmeters, precision high stability oscillators, frequency meters, analog to digital converters, d-c power supplies and similar communications and industrial control applications. Types 1N935 through 1N939 serve as stable 9.0 v reference sources over a temperature range of − 65 to 175 C, with stability limits as low as ± 0.0005 percent per deg C. They meet MIL-E-1 and MIL-S-19500.

CIRCLE 313 ON READER SERVICE CARD



Rotary Switch
SOLDER-LUG TERMINALS

ELECTRO SWITCH CORP., King Ave., Weymouth, Boston 88, Mass. To simplify wiring the type A rotary multipole switch is now available with solder-lug terminals instead of screw terminals. The silver-

REASON 2 LIBRARY OF TAPES

Spectrol also maintains an extensive library of tapes with programs for the solution of general non-linear potentiometer design equations, saving hours of calculation time and providing error free results. Again, you receive a superior product sooner.

Let us know your design requirements. With Spectrol's time-saving techniques, you can expect a quote within a few days.

Contact your Spectrol representative for more details about Spectrol linear and non-linear precision potentiometers, or write direct. A 4-page specifications brochure is yours for the asking. Please address Dept. 42

SPECTROL ELECTRONICS CORPORATION

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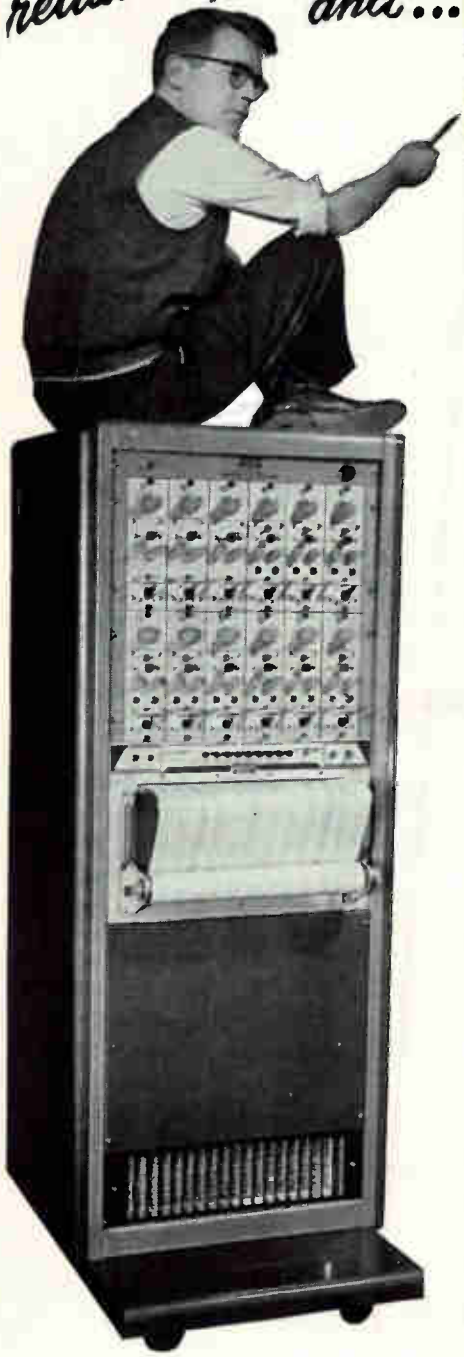
22

When you specify MASSA you specify reliability versatility and...

12 CHANNEL
DIRECT INK OR ELECTRIC RECTILINEAR RECORDING SYSTEM

MORE DATA

PER DOLLAR



This new Recording System, Model BSA-1200, combines all the advantages of rectilinear recording with the economy of ink writing in ⅓ less space than any comparable system. At an average chart speed of 50 mm/sec., for example, you save $10,000 every 200 hours in chart costs alone when compared to other rectilinear recording systems. In addition, this system is designed to accept a wide choice of different interchangeable plug-in preamplifiers for each of the 12 recording channels.

ADDITIONAL FEATURES

- **High Speed Rectilinear Recording with *Ink*. Unique pen design provides splatterproof writing to 200 cycles.**
- **Wide Frequency Range reproduces signals from DC to 200 cps on rectangular coordinate chart paper**
- **Interchangeable Plug-in Preamplifiers — Low, Medium, High Gain DC, AC, Chopper, Carrier, and Servo**
- **Automatic one second timer and manual EVENT MARKER**
- **18 Speeds — Push-button Controls (Remote control optional)**
- **Individual Power Supplies and Transistorized Driver Amplifiers for *each* channel. Prevents cross-talk between channels**
- **Pen Motor Overload protection**
- **Interchangeable pens for either Ink or Electric Writing**
- **Micrometer Pen Motor Adjustments for accurate pen alignment**
- **Plug-in provisions for remote or centralized control of all functions**
- **Modular Design throughout for ease of servicing**

Write for complete information on High Speed Recording Systems

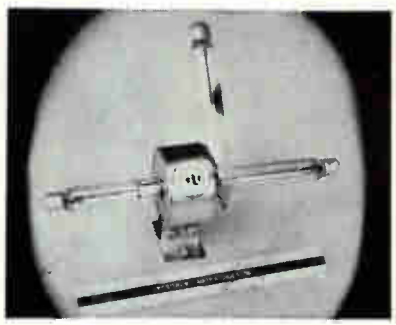
OTHER MASSA PRODUCTS
TRANSDUCERS
Sonar, Ultrasonic
ACCELEROMETERS
MICROPHONES
HYDROPHONES
AMPLIFIERS
COMPLETE LINE OF MULTI-CHANNEL AND PORTABLE RECORDING SYSTEMS

MASSA
A DIVISION OF
COHU
ELECTRONICS INC

6 FOTTLER ROAD
HINGHAM, MASSACHUSETTS

plated terminals have elongated holes that will accommodate up to three No. 16 wires. Switch has a maximum interrupting rate of 5 amperes 125 v a-c and a continuous-current rating of 10 amperes. It can be furnished in a wide variety of contact arrangements, and from one to ten sections. It is designed for single-hole panel mounting, is $2\frac{3}{32}$ in. in diameter and extends $1\frac{1}{16}$ to $5\frac{1}{4}$ in. behind panel.

CIRCLE 314 ON READER SERVICE CARD



High Voltage Relay
HAS VARIED USES

RESITRON LABORATORIES, INC., 2908 Nebraska Ave., Santa Monica, Calif. Model 35 high voltage, high vacuum relay is capable of switching up to 35 Kv peak, a-c or d-c in air and is ideally suited for switching high-powered radar pulse networks, dielectric testers, h-v power supplies, x-ray apparatus, etc. Standard model is supplied with a 24 v d-c actuating coil. Actuating coils with other voltage requirements can be supplied in this model on special order.

CIRCLE 315 ON READER SERVICE CARD

Power Transistors
HIGH RELIABILITY

TEXAS INSTRUMENTS INC., Semiconductor-Components Division, P. O. Box 312, Dallas, Texas. The 2N1046 series alloy-diffused germanium power transistors are especially suited for core drivers, tv deflec-

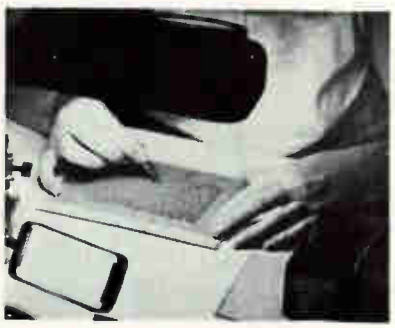
tion circuits, hi-fi amplification and other high frequency power applications being able to switch 3 to 4 amperes in 10 μsec. Featuring 30-w dissipation, the high current devices have an operating temperature of 100 C.

CIRCLE 316 ON READER SERVICE CARD

Magnet Wire
50-GAGE AWG

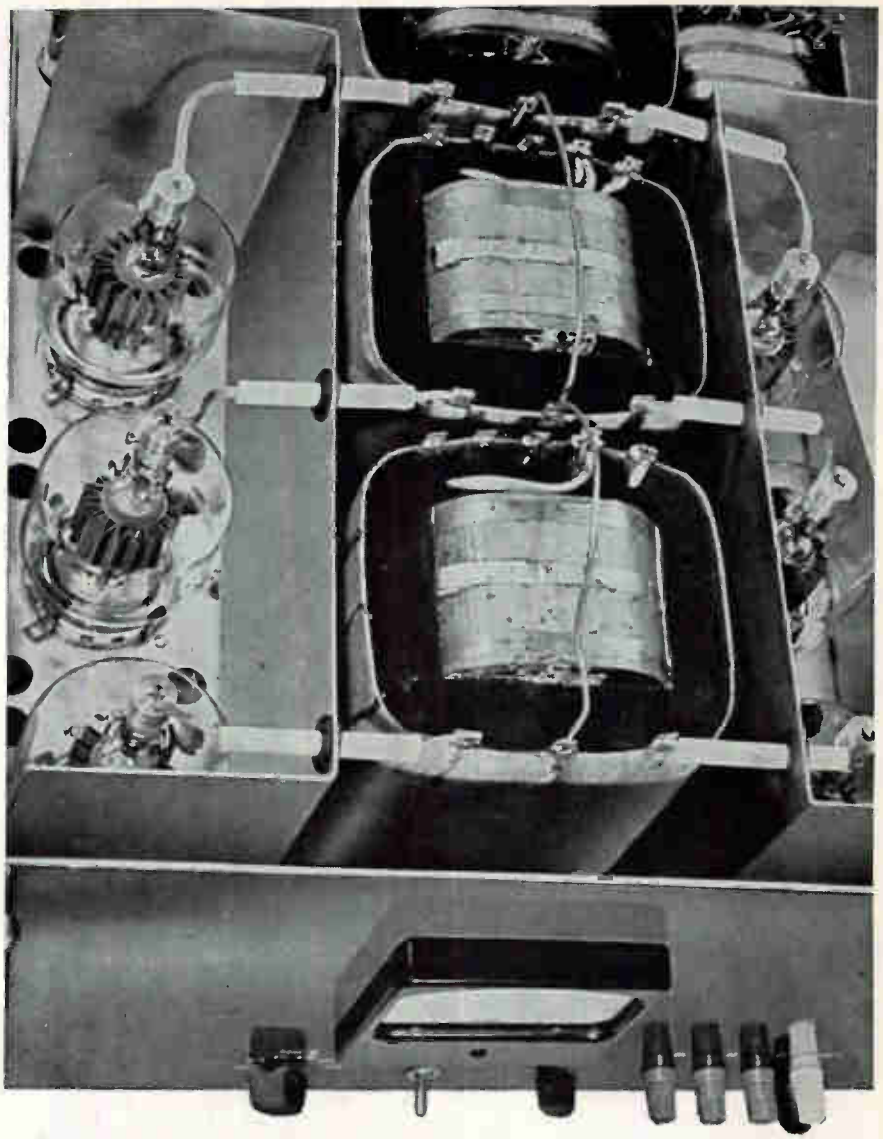
VIKING WIRE CO., INC., P. O. Box 104, Danbury, Conn., has introduced a 50-gage Awg (0.001) single enamel film insulated magnet wire. It is designed for use in hearing aid transformers, subminiature relays, for missiles, rockets, computers, and syncro-motors. A 1-lb spool has 335,000 continuous feet of wire. This is approximately 65 miles of the hair-thin magnet wire. This size is also manufactured with coatings of polyurethane, Formvar, Isonel, F. Bondall, P. Bondall, and nylon.

CIRCLE 317 ON READER SERVICE CARD



Alumina Ceramic Parts
MINIATURIZED

DIAMONITE PRODUCTS MFG. CO., Shreve, Ohio, is now delivering miniaturized alumina ceramic parts and components on a full production basis for the electronic and related industries. The company's product developments staff will work with the customer in engineering the particular requirements for structure and manufacturing best suited for the application. With new processing facilities, it is possible to offer improved physical and dielectric strengths and low loss factors in a material that is easily metallized and vacuum tight. Photograph illustrates inspection of ac-



"When we get reports from a large customer that the Penta power tubes in our Invertron last about 10,000 hours at full power and give the highest reliability, you can see why we use them," says Behlman Engineering Company, Burbank, Calif.

Penta power tubes are used in the majority of the many models of the Invertron AC power supplies, which cover the range from milliwatts to kilowatts. Like every other Invertron component, they were chosen after the most rigorous competitive testing.

'PENTA POWER TUBES GIVE US LONG LIFE AND RELIABILITY'

...THAT'S WHY THEY'RE USED IN BEHLMAN ENGINEERING'S INVERTRON®

The same Penta tubes, proved through use by major manufacturers, are available to you right off the shelf. Whether you're a volume manufacturer or a ham building a rig, you'll find Penta power tubes unsurpassed for long life and reliability. Call or write now for full information.

Featuring frequency accuracy, exceptional regulation, and low noise, Invertrons use either Penta PL-177A, PL-4D21, PL-4D21A, PL-4-400A or PL-5D22 power tubes, depending on the output.

Penta PL-177A Power Tube

Penta PL-4D21A Power Tube

Penta PL-4-400A Power Tube

Penta PL-5D22 Power Tube

PENTA LABORATORIES INC.

312 N. Nopal St. Santa Barbara, Calif. WOodland 5-4581

Faced with the problem of transmitting rotating power and control signals, D. S. Kennedy & Company, a leading manufacturer of radar and tracking antennas, called upon the leading producer of slip ring assemblies — ELECTRO-TEC!

Electro-Tec engineers developed a completely self-contained, prealigned, easily mounted slip ring "package" for the giant 60' dish type antenna Kennedy was producing for a tracking radar.

Fitting into a 4' high by 20" diameter housing, the slip ring assembly contains 118 circuits — 8 sixty amp., and 110 twenty amp. of which 40 are shielded for ultra-low noise.

This is typical of the many successful design and manufacturing applications which Electro-Tec performs for leading manufacturers of radar, gyros, inertial guidance, instruments, and switching.

*Pat. No. 2,696,570 and other patents pending

Write for illustrated literature

ELECTRO-TEC CORP. SLIP RINGS • SWITCHES RELAYS

P. O. BOX 37R, SOUTH HACKENSACK, N. J. • BLACKSBURG, VA., ORMOND BEACH, FLA.

curately produced intricate parts typical of those mass produced to fulfill the need of the electronic miniaturization program. One hundred percent inspection to military standards is usual procedure.

CIRCLE 318 ON READER SERVICE CARD

Silicon Rectifier
AXIAL TYPE

SOLITRON DEVICES, INC., 67 South Lexington Ave., White Plains, N. Y. These diffused silicon rectifiers are pressure molded, under heat and vacuum, by a new method, insuring a true hermetic seal. Units are available from 50 v piv to 1,000 v piv at 100 ma to 750 ma. They are only $\frac{3}{8}$ in. long, 0.200 in. o-d, $1\frac{1}{4}$ in. gold plated leads, with the chamfered edge always cathode. Prices range from 40 cents each to $3 according to piv.

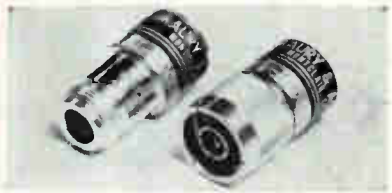
CIRCLE 319 ON READER SERVICE CARD

Servo Data Printer
DIGITAL UNIT

MORAN INSTRUMENT CORP., 170 E. Orange Grove Blvd., Pasadena, Calif. Series B, P and V Digiprinter is a self-balancing potentiometer which, when used in conjunction with standard transducers such as strain gages, load cells, thermocouples, etc., provides a visual digital readout of weight, pressure, position, voltage, current, temperature, and resistance measurements, as well as a printed readout similar to that of an adding ma-

chine. Unit operates on 115 v a-c, 60 cycle power, and consists of a plug-in servo amplifier, power supply, servo motor, potentiometer, precision gear train, and a printing counter.

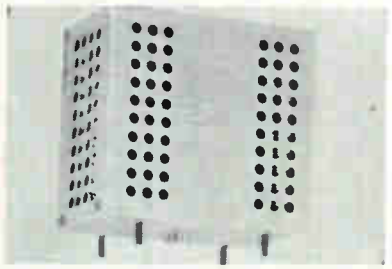
CIRCLE 320 ON READER SERVICE CARD



Matched Load
COAXIAL

MAURY & ASSOCIATES, 10373 Mills Ave, Montclair, Calif. New series of coaxial type N terminations are very small, rugged, and manufactured to exacting standards. Units were designed for numerous applications where a low reflection coaxial load is required. They feature very low vswr 1.05 maximum from d-c to 1,000 Mc; impedance is 50 ohms nominal and power handling is 1 w c-w. Units are not affected by humidity or temperature changes, and are supplied with individual calibration charts.

CIRCLE 321 ON READER SERVICE CARD



Power Supply
CHASSIS-MOUNTING

HARRISON LABORATORIES, INC., 45 Industrial Road, Berkeley Heights, N. J. Model 860 highly regulated transistor power supply is adjustable from 0 to 36 v at any output current from 0 to 500 ma. An octal plug is used for all input and output connections to the supply, including remote programming (333 ohms/volt) and remote sensing. Regulation is better than 3 mv; ripple, less than 500 μv for any combination of line or load. No voltage

plan ahead!

To be *really* sure of getting your pot deliveries on time, you *could* assemble your own! But just when you're counting on sub-contractors to deliver the necessary parts — you *might* find they're tied-up on someone *else's* job! So if you *must* be sure, lay in a good supply of raw materials in quantity lots — metals, glass, wire, plastics, bearings — the works!

But before you load up the living-room with bar stock, check with Ace. You'll find, to your relief, that Ace abundantly warehouses all their own raw materials — just for the express purpose of being able to *make* everything they need — when it's needed, for controlled delivery! So if *delivery* of precision pots is a prime consideration, talk to the company that does its *own* sub-assembly manufacture — see your Acerep!

From raw materials to completed pot — within the plant — our servo-mount A.I.A. size ⅞" ACEPOT®. As with all the others, from ½" to 6".

ACE ELECTRONICS ASSOCIATES, INC.
99 Dover Street, Somerville 44, Mass.
SOmerset 6-5130 TMX SMVL 181 West. Union WUX

Acepot® Acetrim® Aceset® Aceohm® ®Reg. Appl. for

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CUT COST & TIME OF COMPONENT TESTING 5 WAYS

Engineers who know where a component will "give", and test *there* first... plus complete evaluation facilities... all mean low cost component testing... high reliability... and quick service at United States Testing Company. Here's what you get:

Automated Reliability Testing— machine-recorded, error-free readings of 0.1% accuracy, every 3 seconds.

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Experienced Evaluation Engineers— who spot weakness and potential failure.

Economical Handling of Your Peak Loads— quick take-over; costs you less than adding permanent staff.

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overshoot can occur at turn-on or turn-off, and supply is fully protected for all overload conditions including a direct short across the output (no fuses employed). Unit measures 6½ in. by 3 7/16 in. wide by 6 in. high. Price is $197.

CIRCLE 322 ON READER SERVICE CARD

Converter
VOLTAGE-TO-FREQUENCY

VIDAR CORP., 2107 El Camino Real, Palo Alto, Calif. Fully transistorized circuitry develops a frequency precisely proportional to input voltage with 0.1 percent long-term accuracy in the model 240 A. Frequency range is 0-100 Kc. Full-scale sensitivity can be switched from 0.1 v through 1,000 v in five steps. Input polarity is indicated automatically. Typical applications include analog-to-digital conversion (used with a counter), precise integration, and telemetry.

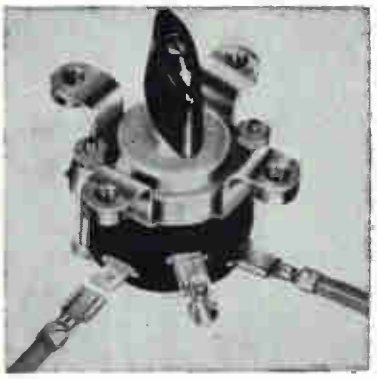
CIRCLE 323 ON READER SERVICE CARD

Resolver Test Set
SEMIAUTOMATIC

THETA INSTRUMENT CORP., 520 Victor St., Saddle Brook, N. J. Model MST-5RSA resolver test set

is announced. Each parameter value is read directly without the use of charts or tables. Specifications: measures electrical error, electrical zero, phasing, fundamental null, and total null. Resolver types: transmitter, differential, and control transformer. Accuracy: better than 30 sec-of-arc total error. Size: 24 in. wide by 25 in. high by 16 in. deep. Price: $4,500.

CIRCLE 324 ON READER SERVICE CARD



Rotary Switch
10-AMPERE DEVICE

ELECTRO SWITCH CORP., King Ave., Weymouth, Boston 88, Mass. To permit rapid wiring with snap-on connectors, the 10-ampere type P rotary snap switch is now available with male quick-connect terminals. These terminals, which are integral with the stationary contacts, can be furnished on any of the side-connected switches having either make-before-break or break-before-make contacts.

CIRCLE 325 ON READER SERVICE CARD

Coax Attenuator
VARIABLE UNIT

RADAR DESIGN CORP., Syracuse, N. Y. Model RDA-971 variable attenuator has BNC connectors and a variation range of 0-25 db (minimum) with less than 1 db frequency sensitivity over the entire 0-1,000 Mc range. Attenuation is varied

THIRTEEN INDISPENSABLE CHARACTERISTICS FOR *Precision* SERVO POTS

PRECISION SERVO POTENTIOMETERS HAVE ALL 13 FEATURES

Your Assurance of Superior System Performance

1 High Reliability
2 Low Torque
3 High Accuracy
4 Low Inertia
5 High Resolution (or Infinite in Film Type)
6 Wide Resistance Range
7 Low Phase Shift Over Wide Frequency Range
8 Low Noise Level
9 Highly Precise Non Linear Functions
10 Can Be Ganged
11 Long Life
12 Close Mechanical Tolerances
13 Withstand Extreme Environmental Conditions

A few of the many applications of TIC Precision Servo Potentiometers are as input-output transducers in servo systems for airborne navigation and flight control, fire control, fuel control, shipboard gun directors, missile aiming and flight control, analog computing, air traffic control and telemetering.

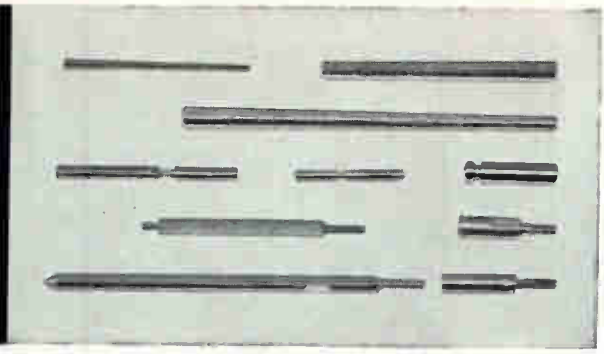
TIC Precision Servo Potentiometers are available in 21 types with diameters from ½" to 3", giving design engineers a wide range from which to select. Included are single and multi-turn types with either wirewound or infinite resolution metallic film resistance elements, as well as types designed for ganging without a shaft. And TIC Precision Servo Potentiometers are engineered to withstand the severe environmental conditions imposed by military equipment operation.

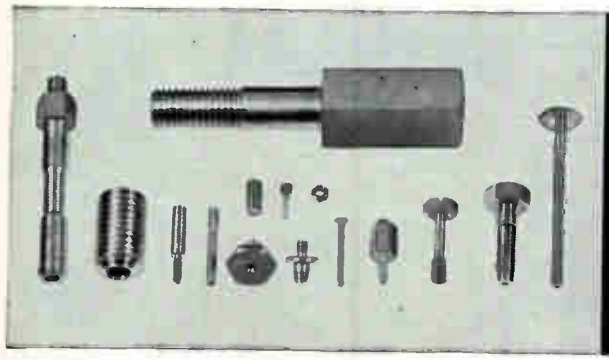
Write or call for this new catalog on the TIC line of Precision Potentiometers - the most complete line on the market.

TECHNOLOGY INSTRUMENT CORP.
569 MAIN STREET, ACTON, MASS.

SUBSIDIARIES: ACTON LABORATORIES, INC., ACTON, MASS. • ALTOMAC CORP., CANTON, MASS.
TECHNOLOGY INSTRUMENT CORP. OF ARIZONA, TUCSON, ARIZ.
TECHNOLOGY INSTRUMENT CORP. OF ILLINOIS, FRANKLIN PARK, ILL.
TECHNOLOGY INSTRUMENT CORP. OF CALIFORNIA, NEWBURY PARK, CALIF.

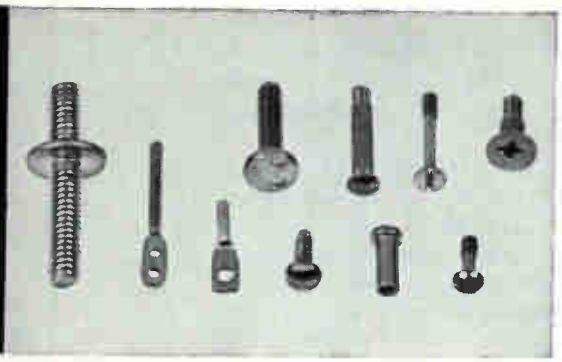
LOOK TO ALLMETAL® FOR—





SCREW MACHINE WORK AND SPECIAL PARTS

IN ALL METALS



You can look to Allmetal for fine screw machine work in all metals...plus cold heading and hot forging. Complete secondary operations. Prompt production on long or short runs. Intricate shapes, precision tolerances, large, small miniature sizes.

- 30 YEARS OF KNOW-HOW • RIGID QUALITY CONTROL
- SINGLE AND MULTIPLE SPINDLE AUTOMATICS
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For standard stainless steel fasteners, you can depend on Allmetal to provide immediate shipment from "the world's largest stock of stainless fasteners."

REQUEST 132-page catalog #60 (on your letterhead). Packed with helpful fastener data plus stock list.

MANUFACTURERS OF STAINLESS STEEL FASTENERS SINCE 1929

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CULVER CITY, CAL. WE 3-9595

821 STEWART AVENUE, GARDEN CITY, NEW YORK

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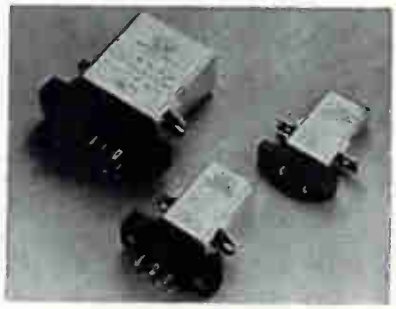
WEST COAST OFFICE & WAREHOUSE
5822 West Washington Blvd., Culver City, Calif.

by rotating the ¼ in. shaft and maximum insertion loss and vswr are 0.5 db and 1.3, respectively. Price and delivery, for small lots, are $280 and 4-6 weeks, respectively. Calibrated dial, different input-output orientation and different connectors (from among N, C, HN, TNC) can be supplied to special order.

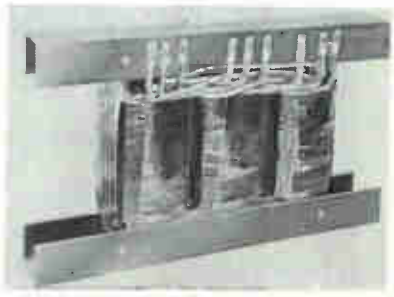
CIRCLE 326 ON READER SERVICE CARD



Miniature Relays
PLUG-IN TYPE

ELECTRONIC SPECIALTY CO., 5121 San Fernando Rd., Los Angeles 39, Calif. These highly reliable contact-type relays are available in the following ratings: spdt—5 ampere, dpdt—10 ampere, and 6 pdt—10 ampere. Sockets are of a space saving design with outside dimensions no greater than the size of the relay, exclusive of the mounting points. Sockets are designed for top or bottom chassis mounting and provisions are made for locking the plug-in relay to the socket and the chassis. The hermetically sealed relays meet requirements of MIL-R-25018, MIL-R-6106C, and MIL-E-5272.

CIRCLE 327 ON READER SERVICE CARD



Transformers
1 TO 600 KVA

PERKIN ENGINEERING CORP., 345 Kansas St., El Segundo, Calif., has

available a transformer line with ratings of from 1 to 600 Kva. The single- or three-phase 60-cycle units are dry-type and meet NEMA and MIL-T-27A specifications. Further information may be obtained by requesting bulletin T360.

Transistor Test Set
DIRECT READING

DYNATRAN ELECTRONICS CORP., 178 Herricks Road, Mineola, N. Y. Model 1802 transistor test set is designed to measure the important r-f parameters of both *npn* and *pnp* transistors. Set provides direct readings of the alpha cut-off frequency and gain bandwidth product for junction transistors up to 50 Mc. It also provides direct readings of the r'_bC_c product and the collector output capacity. Instrument is complete in itself, requires no auxiliary equipment. It is power line operated and contains no batteries.

CIRCLE 328 ON READER SERVICE CARD

Silicon Glass Diodes
HERMETICALLY SEALED

MOTOROLA INC., 5005 E. McDowell Road, Phoenix, Ariz. Glass package ¼ w silicon Zener diodes are especially suited for computer and general applications because of their small physical dimensions. The diffused junction devices will find many applications in oscillators, d-c coupled amplifiers, switching circuits, multivibrators, level-shifters, clamps, subtractors and references. The entire series of standard types ¼ M6.8Z through ¼ M200Z, offers some 43 separate voltages, from 6.8 through 200 v, in tolerances of 20, 10 and 5 percent. They are also available in series or parallel matched sets with tolerances as close as 1 percent.

CIRCLE 329 ON READER SERVICE CARD

FROM: Army Ballistics Missile Agency

TO: Fenwal Electronics

SUBJECT: Taking the temperature of EXPLORER VII

Gentlemen:

In connection with the Explorer VII satellite launching in October . . . the heat balance experiment conducted by Dr. V. E. Soumi provided 5 extra information channels for use by the Army Ballistic Missile Agency

The channels were used for temperature measurements on: a) a portion of the skin of the satellite, b) the solar cells, c) the 20 mc transmitter, d) the storage batteries, and e) the Geiger-Muller tube in the Van Allen experiment.

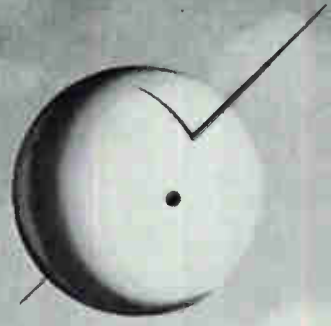
The sensing device used for all five measurements was a thermistor probe manufactured by Fenwal Electronics, Inc. (Type G-188). All probes matched one another so closely that only one calibration curve was required for all measurements and for all spares . . .

Sincerely,

Gordon L. Harris

GORDON L. HARRIS

Public Information Officer

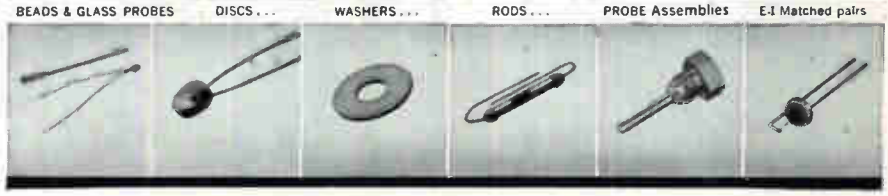


MORAL: *Investigate Fenwal Electronics Thermistors.* Their "new applications ceiling" is virtually unlimited — temperature or liquid level measurement, time delay, remote control, switching — you name the problem, Fenwal Electronics can help. For new Thermistor Catalog EMC3 and complete information, write

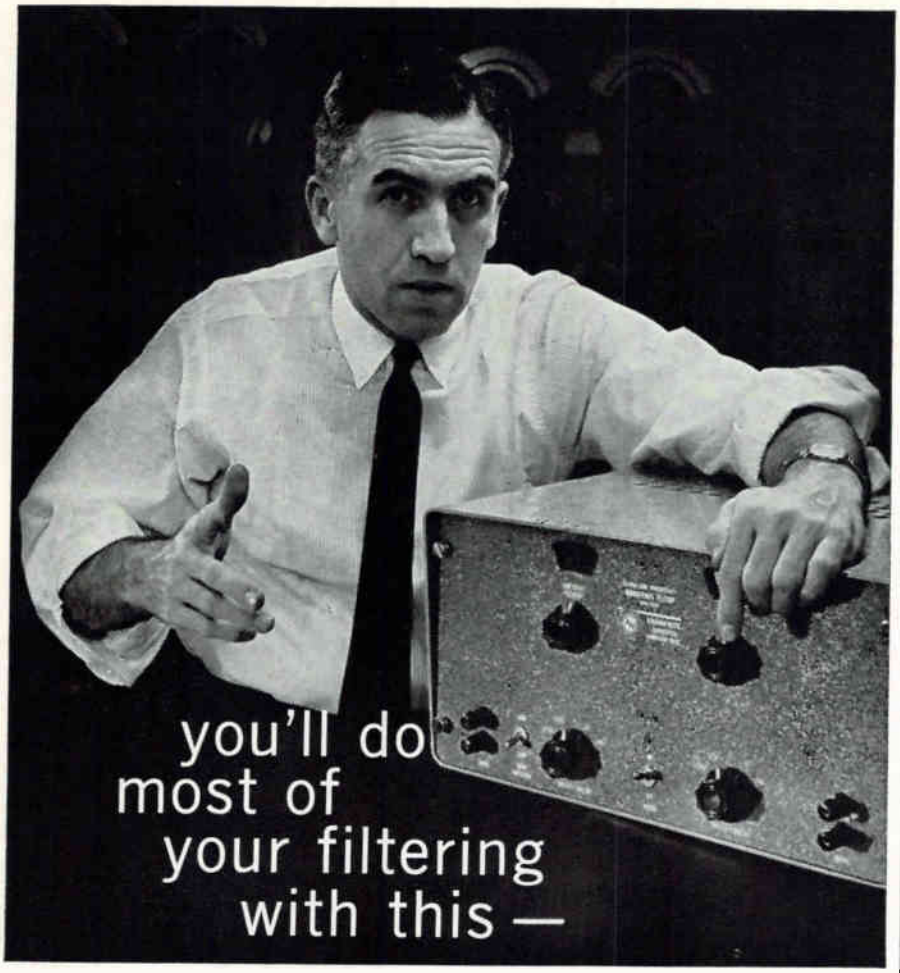
Fenwal Electronics

51 MELLEN ST., FRAMINGHAM, MASS.

BEADS & GLASS PROBES | DISCS... | WASHERS... | RODS... | PROBE Assemblies | E-I Matched pairs



CIRCLE 143 ON READER SERVICE CARD



because only the 330-M is continuously variable from 0.2 cps to 20 kc!

Now you can cover the complete frequency range from sub-audio through audio with one convenient variable electronic filter! Its bandwidth covers the most widely used frequencies in circuitry design, testing, measurement and research. The 330-M can replace — in a 17" x 8" x 12" size — banks of fixed filters, and massive inductors and capacitors.

More than this most frequently used bandwidth, the 330-M band-pass filter offers rapid attenuation beyond the cut-offs. Unwanted signals are attenuated up to 80 db, and maximum attenuation is *maintained* at all frequencies beyond cut-off. Low cut-off, high cut-off and center frequency are all continuously variable. Cut-off frequency dials are single log-scale, direct reading. Band switches give frequency ranges in five decades. Attenuation is 24 db per octave outside the pass-band, reaching 70 db in less than three octaves. Signal-to-noise ratio is greater than 80 db.

Write for full information on this wide-band, light-weight band-pass filter. Its convenient coverage of low frequencies through audio, and direct reading, continuously variable cut-offs give you real work-load flexibility. Other Krohn-Hite band-pass filters include Models 330-A (0.02 to 2,000 cps), 310-AB (20 to 200,000 cps); and rejection filters as well. *Also, Krohn-Hite Oscillators, Amplifiers and Power Supplies.*

KROHN-HITE CORPORATION
580 Massachusetts Avenue • Cambridge 39, Mass.
Pioneering in Quality Electronic Instruments

Literature of

POWER DIODES United Electronics Co., a subsidiary of Ling-Altec, Inc., 42 Spring St., Newark 4, N. J., has available bulletin CDB-1, a new technical brochure describing a complete family of miniaturized power diodes.
CIRCLE 380 ON READER SERVICE CARD

PRECISION CAPACITORS Component Research Co., Inc., 3019 S. Orange Drive, Los Angeles 16, Calif. Bulletin 2C describes stable, low temperature coefficient capacitors designed to meet critical requirements.
CIRCLE 381 ON READER SERVICE CARD

UNIVERSAL WAVEGUIDE STAND Polytechnic Research & Development Co., Inc., 202 Tillary St., Brooklyn 1, N.Y., has published a bulletin on the type 370 universal stand which accommodates all waveguide sizes used in the frequency range of 2,600 to 40,000 Mc.
CIRCLE 382 ON READER SERVICE CARD

DIGITAL SWITCHES Chicago Dynamic Industries, Inc., 1725 W. Diversey Blvd., Chicago 14, Ill., has released a catalog sheet on ½ in. wide modular digital thumbwheel switches with instant positive readout.
CIRCLE 383 ON READER SERVICE CARD

SHAFT POSITION ENCODER ASCOP Division of Electro-Mechanical Research, Inc., P.O. Box 44, Princeton, N. J. A 12-page brochure, "Shaft Position Digital Encoders With Magnetic Readout," is now available.
CIRCLE 384 ON READER SERVICE CARD

FLIGHT LABORATORY SERVICES RCA Flight Laboratory, P.O. Box 1507, Wilmington, Del., has available a 16-page illustrated color brochure describing full services for testing airborne equipment quantitatively and qualitatively in flight.
CIRCLE 385 ON READER SERVICE CARD

METAL FILM RESISTORS Daystrom, Inc., Weston Instruments Division, 614 Frelinghuysen Ave., Newark 12, N. J. Bulletin 04-101-A gives technical data on the Vamis-

tor, a precision metal film resistor which combines the best features of both wire wound and film types and meets every requirement where either type is specified.

CIRCLE 386 ON READER SERVICE CARD

TEMPERATURE TEST CHAMBERS The Electric Hotpack Co., Inc., Cottman Ave. at Melrose St., Philadelphia 35, Pa. A four-page folder illustrates and describes five models of high-low temperature test chambers.

CIRCLE 387 ON READER SERVICE CARD

PULSE GENERATOR Rese Engineering, Inc., 731 Arch St., Philadelphia 6, Pa. Technical bulletin 59-G describes model 1051 nsec current pulse generator.

CIRCLE 388 ON READER SERVICE CARD

PHOTOELECTRIC SCANNER Farmer Electric Products Co., Inc., 2300 Washington St., Newton Lower Falls, Mass. Type SA-IR miniature infrared photoelectric scanner (proximity sensor), that contains both the light source and the pickup head in one small housing, is described in bulletin 260.

CIRCLE 389 ON READER SERVICE CARD

VOLTMETERS Metronix, Inc., Chesterland, Ohio. Panel-mounting electronic voltmeters, expressly designed for continuous monitoring of critical parameters in systems and consoles, are described in a new folder of data sheets.

CIRCLE 390 ON READER SERVICE CARD

GROUND SUPPORT EQUIPMENT Adler Electronics, Inc., One LeFevre Lane, New Rochelle, N. Y. An illustrated 4-page brochure describes the company's capabilities for the design and manufacture of production-line to preflight missile and satellite check-out systems.

CIRCLE 391 ON READER SERVICE CARD

DIGITAL COMPUTER General Mills, Inc., 1620 Central Ave., Minneapolis 13, Minn. Model 2003 completely transistorized digital computer is described in a two-color folder.

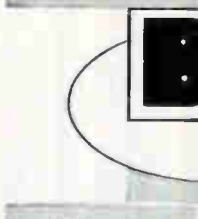
CIRCLE 392 ON READER SERVICE CARD

FOR ADVANCED TECHNIQUES IN:

Test Equipment
- Audio Oscillators
- Distortion Meters
- Audio Frequency Meters
- R-F Signal Generators
- Grid Dip Meters

Components
- Filters—Low & High Frequency
  - Low Pass
  - High Pass
  - Band Pass
  - Band Rejection
- Toroidal Coils
- I-F and R-F Transformer Assemblies
- T-R Switches
- R-F Filament Chokes
- Audio Phase Shift Networks
- Band Switching Pi-Networks
- Cyclometer-type Counters
- Oscillator Coils
- R-F and Audio Filters
- R-F Chokes
- Air Wound Inductors
- Transmitting Condensers (Variable Air)
- Frequency Multipliers
- Band Switching Turrets
- Rotary Coils
- Antenna Tuning Networks
- Baluns

Special Equipment
- Mobile Radio Teletype Equipment
- AM-SSB Transmitters and Receivers



- Filters
- Toroidal Transformers
- Phase Split Networks
- Coils
- Baluns

. . . B&W's specialized facilities and experience in design, engineering and production are ready to solve your unique problems in these fields. You are assured immediate action and short delivery on special components, assemblies and equipment.
We invite you to ask for bulletins or better yet, drop us specs covering your specific requirements.

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Canal Street & Beaver Dam Road • Bristol, Penna.
CIRCLE 145 ON READER SERVICE CARD

NEW IDEAS FOR SALE!

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Completes $1-Million R&D Lab

ELECTRO-OPTICAL SYSTEMS, INC., recently announced completion of a new $1-million R&D laboratory in Pasadena, Calif. This 50,000-sq-ft brick facility will house three of the company's technical divisions, as well as corporate headquarters and administrative offices.

Designed to expand significantly EOS' R&D capabilities for space, military weaponry and industry, the new building accommodates more than 250 people. Completely air-conditioned, it will provide approximately 45,000 sq ft of laboratory and technical office space and 5,000 sq ft for administrative offices.

A principal activity in the new facility will be the development of an ion propulsion engine for space vehicles and satellite control mechanisms. Other technical programs will feature work in areas of molecular electronics, optical homing and guidance systems, high speed switching techniques, solid state transducer development, and space defense systems.

Interior arrangements of the building is in the shape of an "H". Laboratories are in the center portion, with engineering and scientific office space located around the perimeters. Administrative offices of the company are located in the front of the building.

Laboratories will contain a wide range of environmental test equipment and other specialized instrumentation. Soon to be completed is a large 9-by-3-ft vacuum facility capable of simulating near-space environment. Already in operation is a high temperature (3,000 C), high-pressure (5,000 psi) furnace for material studies under environmental extremes; a dust-free room for work on delicate instrumentation; optical lab providing an uninterrupted optical path of 250 ft, an x-ray metallurgical facility, and a high vacuum crystal growing furnace.

Technical divisions occupying the new laboratory include Solid State, Electronic Systems, and Fluid Physics.

Super-Temp Names Two Vice Presidents

AMERICAN SUPER-TEMPERATURE WIRES, INC., Winooski, Vt., recently appointed Richard D. Hoyt as vice president in charge of sales and Oakley F. Hoyt as vice president in charge of market research and advertising. The Hoyts have jointly supervised sales for the company since it was organized in 1955 and in addition have served in engineering capacities as well.

Both men have been engaged in the industry for over 20 years, and, during the past decade they have specialized in high temperature wires, employing Teflon, silicone rubber, etc., as insulating compounds.

Richard Hoyt, in his new position, will continue to promote the Super-Temp line on a national basis, while Oakley Hoyt will be engaged in the investigation of new product possibilities and broadening the application of the company's present high temperature wire line in the military, industrial and consumer fields.

Moskowitz Joins LFE Division

LABORATORY FOR ELECTRONICS, Boston, announces the appointment of Fred Moskowitz as assistant director of the newly established Advanced Development Division. He will assist the director of the division in the direction of, and engage in, research and development of new techniques, systems, components and products in the areas of advanced communications systems and techniques, navigation of space vehicles, reliability, and data retrieval and recognition.

Prior to this appointment, Moskowitz was senior scientist at the Advanced Studies Office, Rome Air Development Center. He was also branch chief of a long-range navi-

Hermetic Seal Corp. Glass-to-Metal and Ceramic-to-Metal Seals for EVERY Electronic Use!

- Crystal Bases
- Vac-Tite Connectors
- Multiple Headers
- Diode Closures
- Transistor Stems
- Single Lead Terminals
- Refrigerant Seals

Hermetic Seal Corporation is your prime source for seals in all sizes, terminations and shapes to fit your specifications. Hermetic is the pioneer in this specialized field and the originator of more than 10,000 different seals. Precision quality-control from design, manufacture and precious metal plating is assured.

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43 River Road, North Arlington, N. J.

CIRCLE 211 ON READER SERVICE CARD

TEST RELAYS FASTER, MORE ACCURATELY, WITH EECo's ALL-NEW

RELAY TESTER

Where knowledge of relay performance is important to your operations, here's one of the most valuable aids ever devised.

It's EECo's Model RT-905, latest improvement on the most successful line of relay testers ever made available.

Measures voltage and current simultaneously, both pull-in and drop-out. Measures contact resistance, coil resistance, insulation resistance, pull-in and drop-out time, contact bounce. Automatic relay driving circuitry. Oscilloscope connections and appropriate circuitry.

Write for data sheet, and turn over your relay troubles to an EECo RT-905.

Anaheim Electronics Division
Electronic Engineering Company *of California*
1601 East Chestnut Ave. • Santa Ana, Calif. • KImberly 7-5501 • TWX: S ANA 5263
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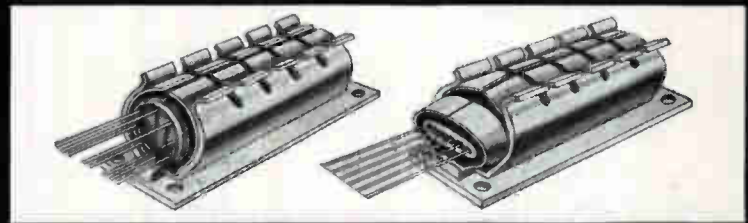
CIRCLE 210 ON READER SERVICE CARD

AUGAT'S REVOLUTIONARY

ELASTACLAMP*

The answer to more effective cooling of subminiature tubes!

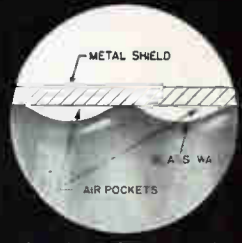


Heat-dissipating subminiature tube shield with elastic thermal conductor

Enlarged section of Elastaclamp's inner cartridge.

Resilient elastomer will completely conform to pronounced irregularities of glass surface thus reducing dangerous hot spots.

Tubes protected from severe shock and vibration by rubber-like elastomer which cushions glass.



Enlarged section conventional heat-dissipating tube shield.

For additional information write for bulletin No. 559.

AUGAT BROS., INC.

*Trademark

31 Perry Avenue • Attleboro, Mass.

CIRCLE 147 ON READER SERVICE CARD

MINIATURE AND SUB-MINIATURE CAPACITORS

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TANTALUM CAPACITORS

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ALUMINUM CAPACITORS

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iei, originator of miniature aluminum foil electrolytic capacitors, now offers a full range of miniature and sub-miniature types and sizes:

Polar and non-polar

Plain foil and etched foil tantalums

Multi-section aluminum types

Reliable over a wide temperature range

Tantalum capacitors are made in accordance with Military Specs. High capacities, low DC leakage deal far transistorized circuits. Write for bulletins 81558 and 41858.

International Electronic Industries, Inc.
Box 9036-B, Nashville, Tennessee.

iei

AN SPS COMPANY

where reliability replaces probability

gation project at Watson Laboratories, Eatontown, N. J.

Houston Fearless Corp. Names Horkey V-P

HOUSTON FEARLESS CORPORATION, Los Angeles, Calif., has named Edward J. Horkey vice president, engineering. He will also remain as president and chief executive officer of Horkey-Moore Associates, a Houston Fearless subsidiary.

Prior to organizing the Torrance, Calif., research, engineering, and manufacturing firm in 1953, Horkey was a vice president of Pastushin Aviation Corp. He was with North American Aviation, Inc., for 15 years and held the position of chief technical engineer.

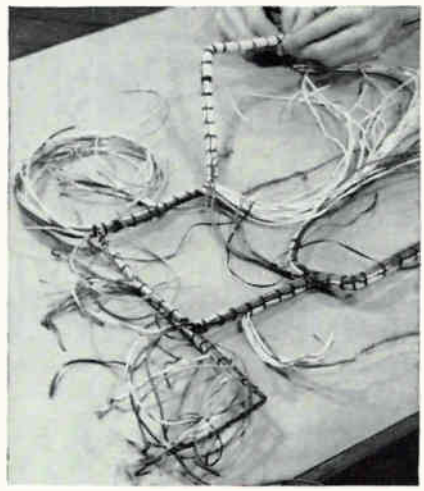
Horkey-Moore became a subsidiary of Houston Fearless late in 1959.

ADVAC Doubles Its Stamford Plant Size

ADVANCED VACUUM PRODUCTS, INC., a wholly-owned subsidiary of Indiana General Corp., has doubled manufacturing space and production facilities from 5,000 to 10,000 sq ft in its plant in Stamford, Conn.

ADVAC manufactures and markets ceramic-to-metal hermetic seals, terminals and related products. Its primary markets are the semiconductor and electronic tube fields. The parent company makes permanent magnets and ferrite magnetic materials.

GUDELACE is engineered for problem-free lacing



It's no accident that Gudelace is the best lacing tape you can buy. Excellence is *engineered* into Gudelace. A sturdy nylon mesh is meticulously combined with the optimum amount of special microcrystalline wax. Careful selection of raw materials and superior methods of combining them give Gudelace outstanding strength, toughness, and stability. Gudelace is the original *flat* lacing tape which distributes stress evenly over a wide area. It is engineered to stay flat; it will not stretch out of shape when pulled. Gudelace's nonskid surface prevents slipping, eliminating the too-tight pull that causes strangulation and cold flow. Durability and dependability make Gudelace your most economic buy—with no cut insulation, fingers, or feelings.

Write for Data Book with specifications on Gudelace and Gudebrod's complete line of braided lacing tapes and dial cords—Temp-Lace, Stur-D-Lace, and Gude-Glass.

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Executive Offices
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PIG-TAILORING eliminates: • Diagonal cutters • Long nose pliers • Operator judgment • 90% operator training time • Broken components • Broken leads • Short circuits from clippings • 65% chassis handling • Excessive lead tautness • Haphazard assembly methods.

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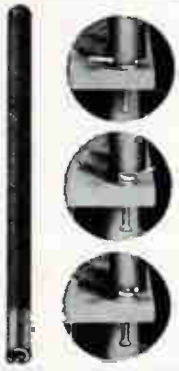

Write for illustrated book to Dept. E-4

BRUNO-NEW YORK INDUSTRIES CORP.

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C.E.C. Hires New Division Head

BERTRAM MAGENHEIM has joined Control Electronics Co., Inc., Huntington Station, N. Y., as microwave Division head.

In his new capacity, he will be responsible for the overall design, development and manufacture of all C.E.C. microwave components and instruments.

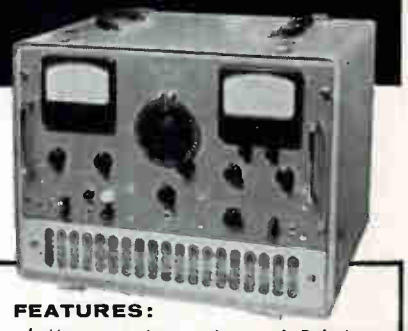
From 1957 until joining C.E.C. Magenheim was senior project member of the technical staff at RCA where, among his duties, he had responsibility for the advanced development of the microwave subsystem for a long haul high capacity microwave radio relay system. Prior to that he was microwave signal generator group leader at Polarad Electronics Corp., Long Island City, N. Y.

S-C Division Appoints William F. Conway

APPOINTMENT of William F. Conway as manager of production engineering in Stromberg-Carlson's Commercial Products Division, Rochester, N. Y., is announced. Stromberg-Carlson is a division of General Dynamics Corp.

Prior to joining Stromberg-Carlson, Conway served seven years as an industrial engineer for the Aeronautical Division of the Minneapolis-Honeywell Regulator Co., advancing to the position of senior production engineer.

NEW...COMPACT... TRANSMISSION & DELAY MEASURING SET TYPE 453-A



FEATURES:

- √ Measures Attenuation and Relative Delay Characteristics of Transmission Systems with Impedances of 600 ohms
- √ 500 cps to 50 kc Carrier Frequency Range
- √ Accuracy = ± 5 microseconds

TYPE 453-A MEASURES DELAY

. . . by comparing the time relationship between the transmitted and received signals. The transmitter generates an amplitude modulated signal consisting of a variable carrier modulated at a constant 62.5 cycle rate. The receiver measures the change in relative phase of the 62.5 cycle envelope of the transmitted signal with respect to a common reference derived from the source which generates the 62.5 cycle modulation. Provisions are also made to measure the levels of the transmitted and received signals.

SPECIFICATIONS:

Carrier Frequency: Adjustable in two ranges from 500 cps to 40 kc.

Modulation Frequency: 62.5 cps derived through frequency dividing circuits from a tuning fork controlled oscillator.

Transmitter Output: Two output levels 0 dbm and −4 dbm, floating and balanced. Output impedance 600 ohms ±30 ohms over range 500 cps to 50 kc. Frequency characteristics of output signal flat to ±.5 db.

Receiver Input: Balanced and floating with an input impedance of 600 ohms ±20 ohms from 500 cps to 50 kc.

Delay Measurements: Indicated on a relative basis. Always read on the 0 to 0.2 M.S. full scale range. Coarse and Fine Delay switches and Fine Phase Control for precise adjustments.

Amplitude to Phase Conversion: With 10 db change in Receiver Input amplitude, output delay indicator will not change more than ±5 microseconds.

Power: 117 volts, 60 cps, single phase, 60 watts.

Dimensions of Cabinet: 22" long, 15" deep, 14" high.

Dimensions for Rack Mounting: 19" long, 14" deep, 13½" high.

For complete details write for catalog

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For an up-to-date listing of such equipment see Searchlight Section of April 8th

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Our Annual Checkup

ONCE A YEAR we go out of our way to talk face-to-face with a substantial number of our subscribers, ex-subscribers and even non-subscribers.

We ask hundreds of questions, getting many answers on such divergent subjects as educational level, time spent reading an issue, number of individuals who read a given copy, opinion of editorial content and buying influence for various products and services.

If you spent an hour or more with one of our interviewers, sincere thanks. Whether you did or not, be assured we are hard at work planning ahead, making improvements, trying to keep you informed and up-to-date even before you alone recognize the need. Your opinions, plus those of many others, give us the cross-section we need to serve you better.

A typical subscriber

A typical ELECTRONICS subscriber is in his early thirties. The chances are better than two to one he holds a college degree, often in electrical engineering or physics. He probably reads his copy of ELECTRONICS at home, and then shares it with 2.5 other people. He spends an hour and twenty minutes reading an issue. He frequently has other engineers reporting to him or working under his supervision, and he is not at all bashful in criticizing our performance if it doesn't consistently satisfy him.

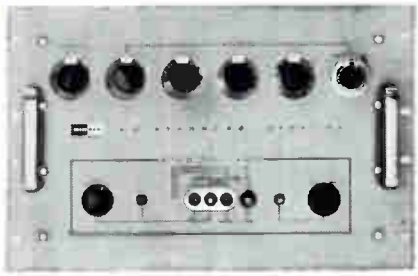
Of course, there is no such animal as an "average" reader. He's a mix of a lot of individuals with some points in common and some differences.

That's what keeps our job so fascinatingly difficult. No one kind of article or issue can hope to please everyone. That's one reason we have added more and more editorial pages in each of the past three years. It is also the reason why ELECTRONICS is now a weekly publication.

James Hildwood

PUBLISHER

This is a DC standard cell



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For complete information about either RCA-7735 or RCA-7262-A get in touch with the RCA Field Office nearest you, or write RCA Electron Tube Division, Commercial Engineering, Section D-19-Q-5, Harrison, N. J.

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