September 15, 1961

electronics

A McGraw-Hill Publication 75 Cents

Photo at right

THERMIONIC CONVERTER

for space vehicles will use sun's rays
see p 76

How to design

LOGIC CIRCUITS

with thin films and tunnel diodes, p 59

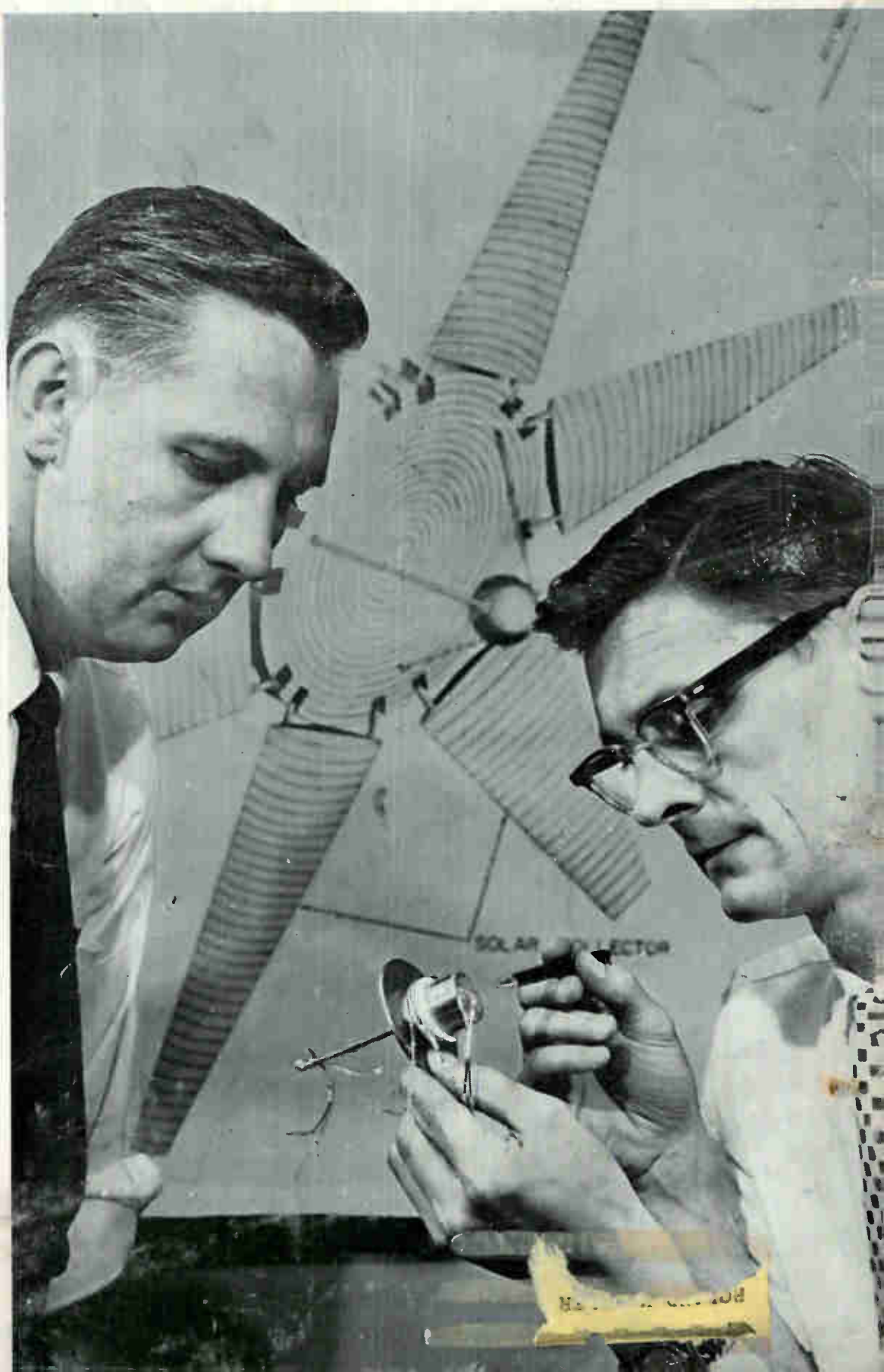
INSPECTING METALS

with new electroluminescent x-ray converters, p 56

Unconventional

DETECTORS

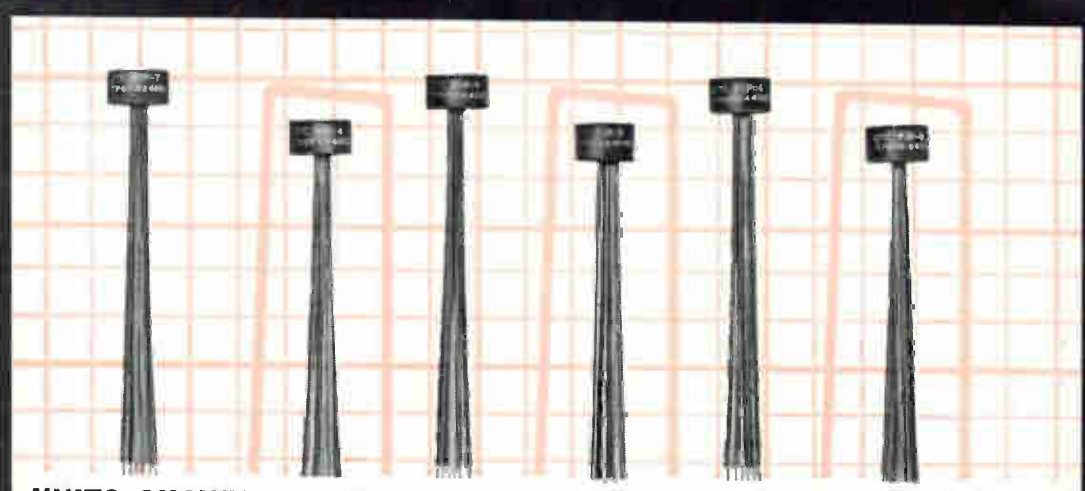
for surveillance and communications
see p 49



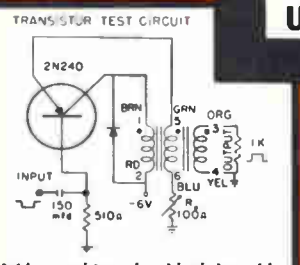
NEW PIP SERIES

ULTRAMINIATURE TRANSISTOR PULSE TRANSFORMERS

PIONEERS IN MINIATURIZATION



UNITS SHOWN ACTUAL SIZE—IMMEDIATE DELIVERY FROM STOCK



All units individually checked and adjusted, in transistor circuit illustrated, to parameters in table.

DEFINITIONS

Amplitude: Intersection of leading pulse edge with smooth curve approximating top of pulse.
Pulse width: Microseconds between 50% amplitude points on leading and trailing pulse edges.
Rise Time: Microseconds required to increase from 10% to 90% amplitude.
Overshoot: Percentage by which first excursion of pulse exceeds 100% amplitude.
Droop: Percentage reduction from 100% amplitude a specified time after 100% amplitude point.
Backswing: Negative swing after trailing edge as percentage of 100% amplitude.

- MIL type TP6RX4410CZ — METAL CASED
- Manufactured & Guaranteed to MIL-T-21038
- 5/16" Dia. x 3/16" Ht.; Wt. 1/20 oz.
- Ratio 4:4:1
- Anchored leads, withstands 10 lb. pull test
- Printed circuit use, plastic insulated leads
- Can be suspended by leads or clip mounted

	APPROX. DCR, OHMS			BLOCKING OSCILLATOR PULSE					COUPLING CIRCUIT CHARACTERISTICS						
Type No.	1-Brn 2-Rd	3-Org 4-Yel	5-Grn 6-Blu	Width μSec.	Rise Time	% Over Shoot	Droop %	% Back Swing	P Width μSec.	Volt Out	Rise Time	% Over Shoot	Droop %	Back Swing	Imp. in, out,
PIP-1	.18	.20	.07	.05	.02	0	0	37	.05	9	.018	0	0	12	50
PIP-2	.47	.56	.17	.1	.025	0	0	25	.1	8	.02	0	0	5	50
PIP-3	1.01	1.25	.37	.2	.030	2	0	15	.2	7	.035	0	0	5	100
PIP-4	1.5	1.85	.54	.5	.05	0	0	15	.5	7	.06	0	0	0	100
PIP-5	2.45	3.1	.9	1	.08	0	0	14	1	6.8	.15	0	0	5	100
PIP-6	3.0	3.7	1.1	2	.10	0	0	15	2	6.6	.18	0	2	10	100
PIP-7	4.9	6.05	1.8	3	.20	0	0	14	3	6.8	.20	0	2	10	100
PIP-8	8.0	9.7	2.9	5	.30	0	0	3	5	7.9	.22	0	13	25	200
PIP-9	13.1	15.9	4.7	10	.35	0	5	12	10	6.5	.4	0	15	20	200
PIP-100	Transistor pulse transformer kit, consisting of PIP-1 thru PIP-9 in plastic case.														

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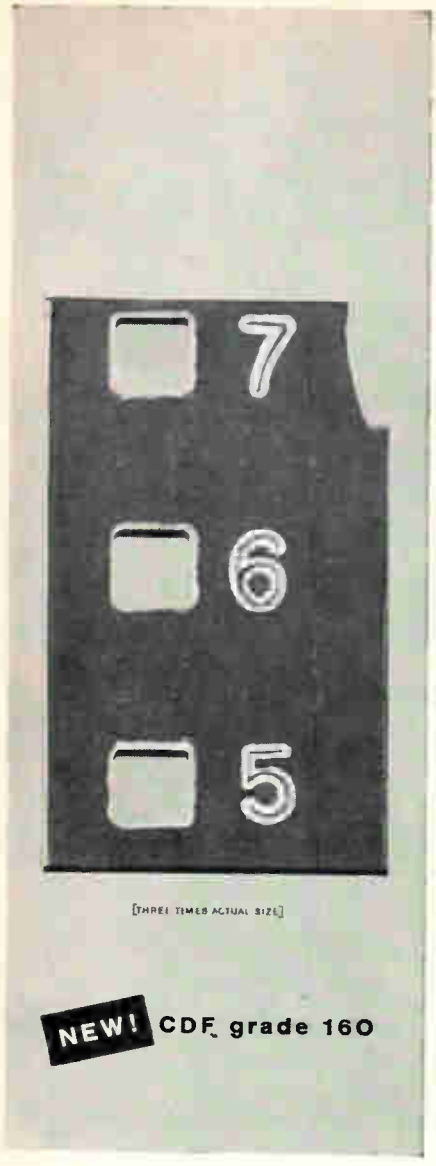
September 15, 1961

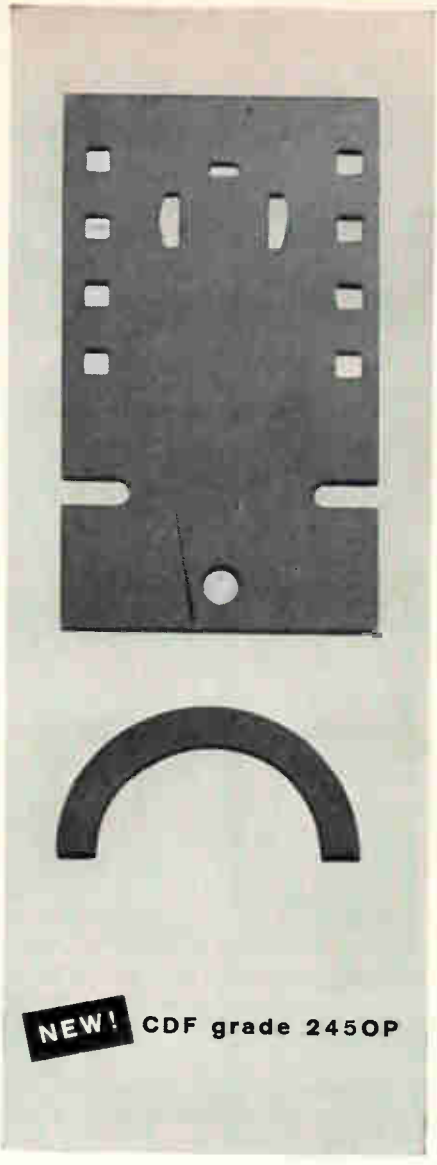
electronics

A McGraw-Hill Publication *75 Cents*

W. W. MacDONALD, Editor



NEW! CDF grade 160



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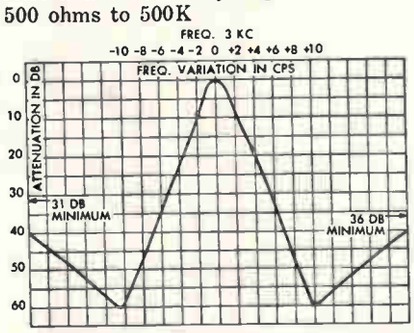
Only a Bird in a Gilded Cage

As succeeding generations of missiles penetrate the curtain of space that separates Earth from other planets, the importance of electronic guidance, control and airborne telemetry systems becomes obvious. For, without new engineering design techniques to provide reliable communication and control, the most advanced missile is but a bird in a gilded and very expensive cage.

As typical examples of what can be accomplished to insure maximum performance in missile telemetering, communication, data processing and other applications, Burnell & Co. has developed two new filters—a miniature 3 kc crystal filter and, employing modern synthesis techniques, a miniature 500 kc LC toroidal filter possessing low transient distortion characteristics.

TECHNICAL DATA
3 kc Crystal Filter

Attenuation—3 db B/W—2 cps
Shape Factor—30/3—5:1
Impedance—500K in and out
Temp. Coeff.—.021 cps °C
Size—3½ x 2 5/16 x 1 1/16
Insertion Loss—3½ db
Also available in any impedance from 500 ohms to 500K

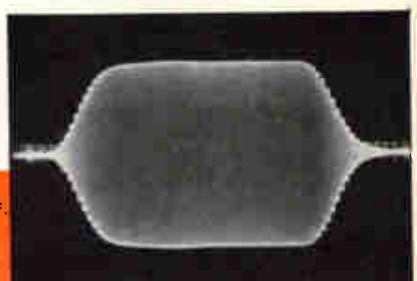


TECHNICAL DATA
500 kc LC Toroidal Filter

Attenuation—B/W 40 kc at 3 db
—200 kc at 50 db
Impedance—50 ohms in and out
Insertion Loss—4.5 db
Over and undershoot—
(for a step modulated 500 kc carrier)—less than 1%
Size—⅞ x 3 x 1½

Other Burnell filters are available in frequencies up to 30 mcs over a wide range of impedances.

Write for new catalog.



Filter response to step modulated 500 kc carrier

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September 15, 1961

CIRCLE 3 ON READER SERVICE CARD 3

September 15, 1961

CIRCLE 5 ON READER SERVICE CARD 5

September 15, 1961

CIRCLE 7 ON READER SERVICE CARD 7

WASHINGTON OUTLOOK

PLANS FOR ANOTHER step-up in defense spending are being developed. The emphasis, once more, will be on bolstering conventional forces, with heavier deployment of forces in Western Europe. Stimuli for the new moves are the sealing-off of East Berlin and resumption of nuclear testing.

Already, the Pentagon has scheduled $46.6 billion in spending this year —about $4 billion over last year. Size of the new step-up has yet to be fixed, but one high-level Defense Department official says it "will not be on a scale to change the economic picture". So far, there's no plan to seek a fourth supplemental defense appropriation. Officials believe they may be able to shift funds around in the existing budget to handle the new increase.

Very little of the new military speedup would go for expansion of strategic bomber and missile forces, as plans now shape up. But Pentagon officials concede that the "general psychological situation will make it harder not to spend" some of the $700 million Congress added for bombers.

MILITARY PROCUREMENT of common-use electronic parts will be centralized in the Defense Supply Agency, a new Pentagon unit just set up to consolidate as much as possible military buying, storage, and distribution of common-use goods bought in quantity by the armed forces.

When plans have been detailed within the next few months, field offices of the new inter-service group will be buying resistors, capacitors, antennas, and some 650,000 different common-use parts. It's not clear whether electron tubes, which the Air Force now buys for all the services, will be included. The services will continue to procure the bulk of the weapons and specialized equipment not widely purchased by other agencies.

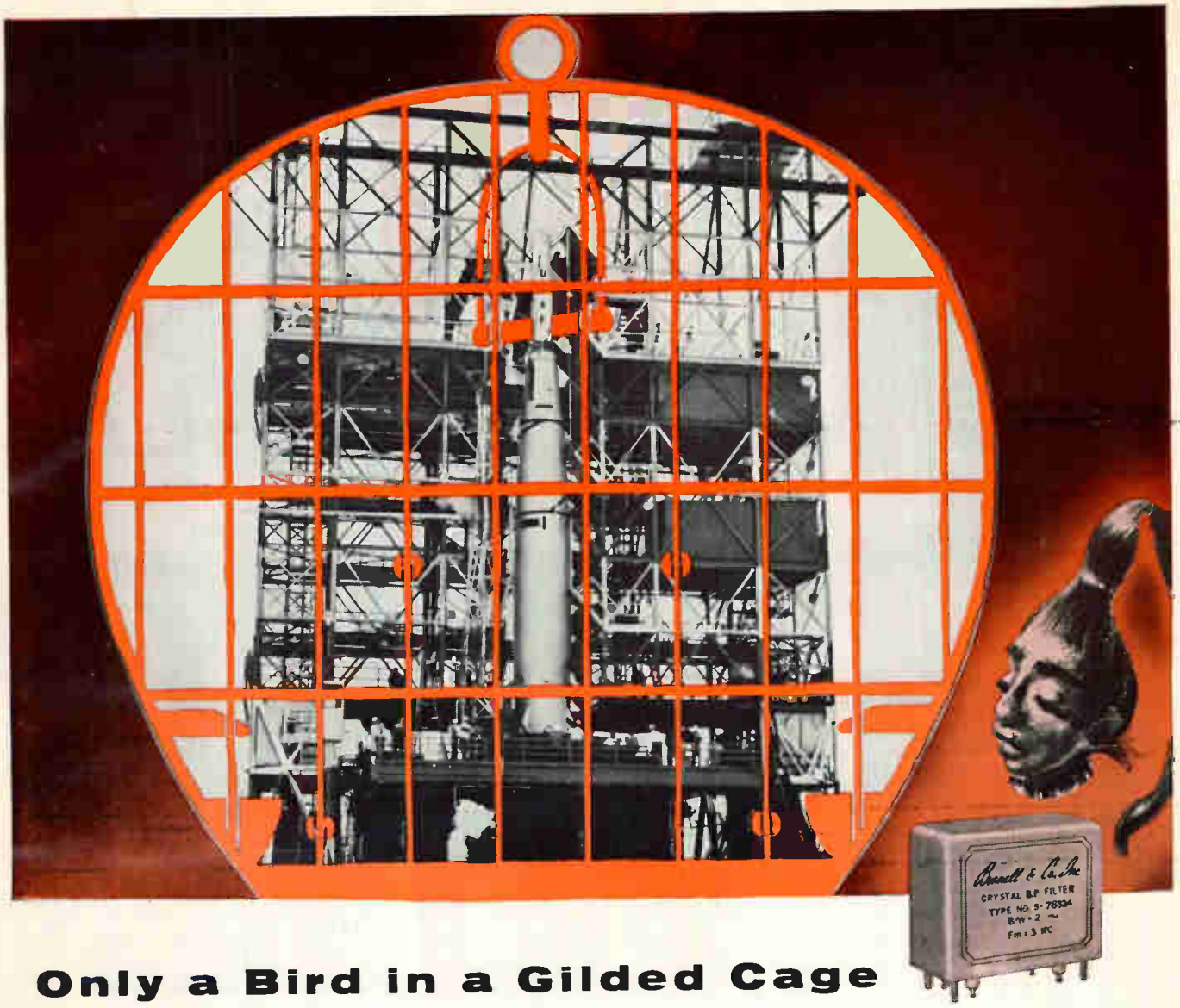
RESUMPTION OF NUCLEAR TESTING by the Soviets and the U. S. will have a direct effect on electronics. Miniaturization of a wide range of new tactical weapons and instrumentation for our tests and detection of Soviet tests will be needed.

The U. S. has long wanted to reduce the size of its field nuclear weapons to make them lighter in weight, more rugged in design, and simpler to operate. The test ban placed on nuclear testing in October, 1958, froze many weapons programs. Scientists and engineers could only go so far in the interim period without more testing.

Smallest of the U. S. nuclear field weapons is the bazooka-type Davy Crockett with a fraction of a kiloton yield. But even this requires two men to fire. The Army wants to cut the size of this and other weapons. The Navy wants to make nuclear anti-submarine weapons more compact so that more can be carried by aircraft, helicopters and drones.

NEW INSTRUMENTATION will be required for underground nuclear testing. Testing underground is far more difficult than exploding devices in the atmosphere. The big difference lies in getting suitable instrumentation to measure the explosions. With the U. S. committed to do the bulk of its nuclear testing below the surface—as plans stand now—a push for better measuring instruments is sure to come.

Detecting Soviet nuclear explosions will get U. S. attention, too. Project Vela was to detect Soviet tests if agreement could have been reached on a nuclear test ban. Some $66 million was spent on Vela by the start of the current fiscal year. Resumption of Soviet tests does not lessen the need for information. The effort to detect Soviet testing will most affect underground instrumentation. Atmospheric tests are relatively easy to detect. But at present there is no sure way to detect underground explosions.



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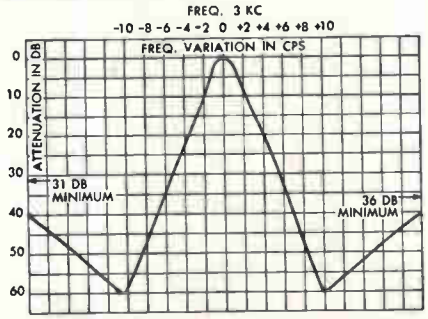
Insertion Loss—3½ db
Also available in any impedance from 500 ohms to 500K



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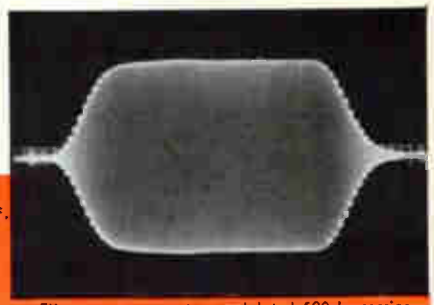

Filter response to step modulated 500 kc carrier

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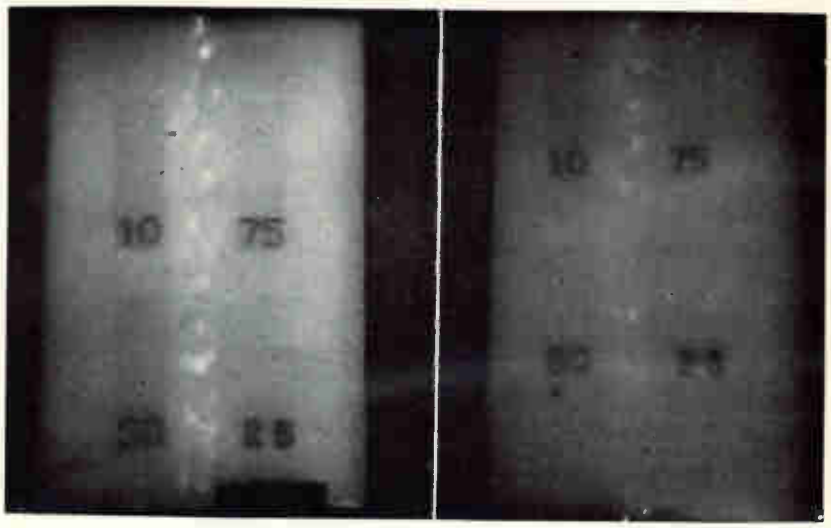
CROSSTALK

LASER RESEARCH is rapidly reaching the stage where developers can talk with confidence about practical communications systems. One recent development in this exciting field is that the combination of a laser and a traveling-wave tube results in heterodyning of components of the laser's optical spectrum, indicating the feasibility of optical superheterodyne receivers. In another field, also reported on page 20, Stanford scientists showed how electrochemical cells may be combined into neuron memories that can be trained to respond to stimuli. Such memories are potentially more versatile and less expensive than conventional memories and can lead to trainable computers or even machines that act animal-like in response to physical stimuli.



ELECTROLUMINESCENT-PHOTOCONDUCTIVE panels can be used to convert x-rays to visible light with an attendant increase in image intensity. This is illustrated by the fluorographs above, which compare the performance of the EL-PC panel amplifier (left) and a conventional fluorescent screen (right) for a ¼-inch-thick steel plate. Patchy white vertical marks indicate the weld in the plate, which shows up here as a third-order reproduction. For a discussion of inspecting metals with electroluminescent x-ray converters, turn to the article by D. K. Wilburn of the Detroit Arsenal beginning on p 56.

SYSTEMS AND DEVICES for detecting electromagnetic radiation are receiving increasing attention. In this issue J. Q. Burgess of Ohio State University presents a survey of unconventional detectors for weak signals. In addition to comparing known detectors, Burgess describes possibilities for improving detection techniques, such as using the high sensitivity of natural sensors more effectively. An optical Faraday-rotation/paramagnetic-resonance detector is among a variety of detection devices described on p 49.

Coming In Our September 22 Issue

FEATURE MATERIAL to appear next week includes: modern uhf and microwave ferrite devices, by J. C. Cacheris and N. G. Sakiotis of Motorola; infrared electronics in Tiros II, by F. Schwarz of Barnes Engineering Co; and a hot-switching surge current nomograph, by W. Austin of RCA.

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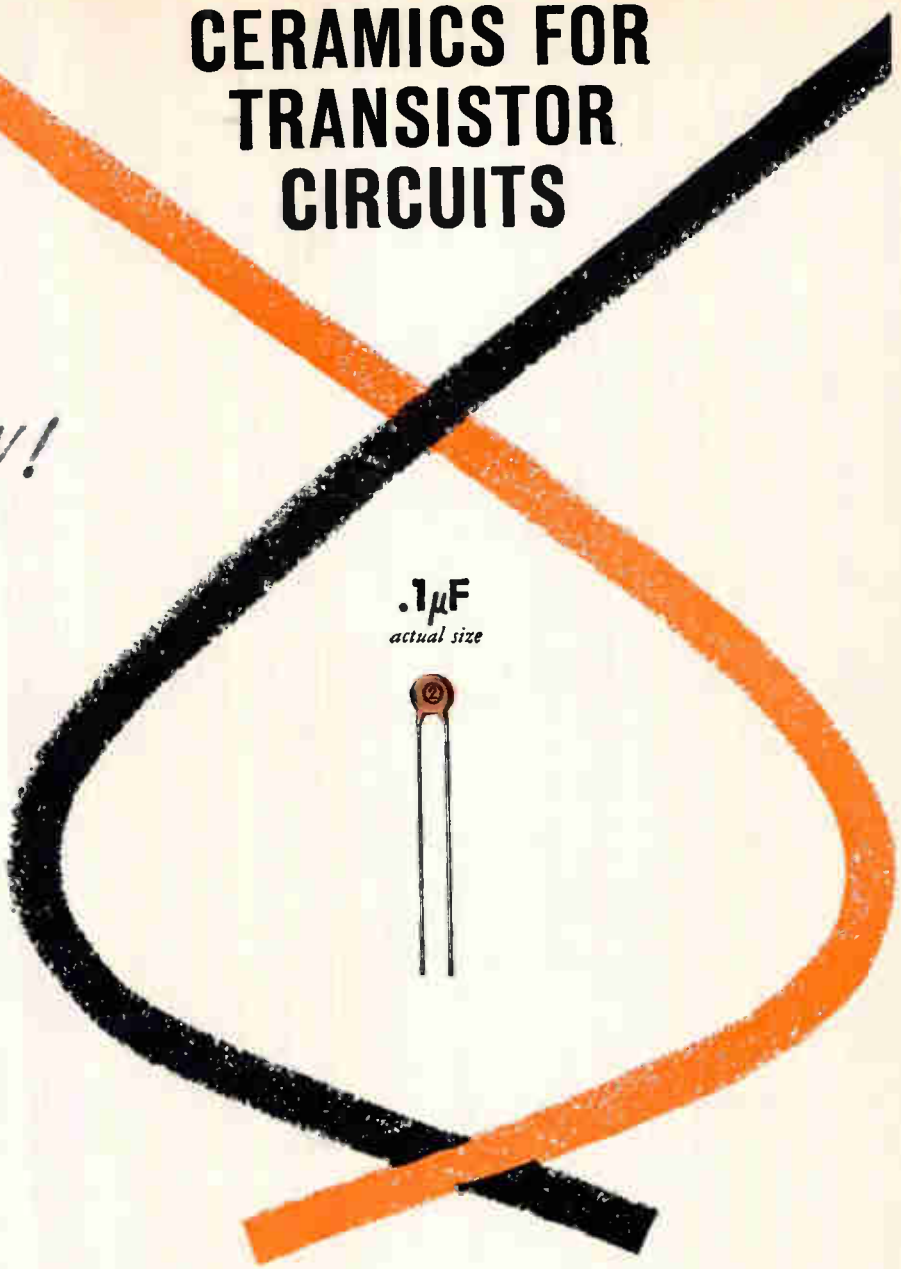

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μF	Diameter in inches	μF	Diameter in inches	μF	Diameter in inches
.1	.225	.047	.275	.01	.275
.22	.275	.1	.400	.022	.350
.47	.400	.22	.550	.033	.400
1.0	.595	.33	.660	.047	.490
2.2	.840	.47	.840	.1	.660

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COMMENT

Vendor Analysis

Your article in the May 19 issue of ELECTRONICS on "How Do You Rate As A Vendor" (p 26) has been read by us with a great deal of interest. We are in the process of forming a department within the purchasing division to handle vendor analysis. Would it be possible to obtain from the various companies mentioned in your article any data pertaining to the systems used, together with forms, etc? Any help you can give us will be greatly appreciated.

PAUL S. FALCONE
CHATHAM ELETRONICS DIVISION,
TUNG-SOL ELECTRIC
LIVINGSTON, NEW JERSEY

Reader Falcone's interest in this engineering-oriented field has been made known to appropriate personnel at the companies mentioned.

Proprietary Rights

Certainly, the government is spending millions of tax dollars for research and development. Private industry is also spending millions of private and stockholder's dollars to further the national race for technical supremacy.

Regardless of who finances the research and development work, the end result is up-to-date know-how in the form of manufacturing drawings, novel processes, techniques, etc. Exclusive possession of superior know-how gives a tremendous competitive advantage to any company operating under our free-enterprise system. Therefore, the matter of ownership with the right to withhold or restrict the commercial use of this data becomes a deadly serious matter.

Industry no longer can claim right and title to everything nor can government. There are areas that are 100-percent government-financed and those that are 100 percent industry-financed — either black or white. Gray areas represent the big problem where contractor and government funds have become hopelessly mixed, for instance, by the acceptance of a product-improvement contract following a company-financed project. The government has a right to free use of the part which resulted from expenditure of government funds. However, the contractor should have complete commercial rights in return for his contribution, which included supplying his investment in facilities, skills and a wealth of specialized background of technical knowledge. The contractor is in business to capitalize on these investments.

In most cases the government should not ask for unlimited rights to drawings developed at private expense. It should instead be willing to agree that such data as are actually required for miscellaneous support functions will not be used for competitive procurement purposes.

Present policy and practices have produced a tragic state of disharmony wherein small business, big business, and the procuring services negotiate with each other in an atmosphere of distrust.

DENHAM S. SCOTT
THE GARRETT CORP.
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High Speed Analysis

[Regarding "High-Speed Analysis of Electronic Circuits by Geometry", page R50 July 20, 1961 ELECTRONICS BUYERS' GUIDE] I suggest correction of the expression *negative impedance* as used throughout the article. Also I would like to see a nomogram for parallel components included in the approach presented to make it more complete. I call [a geometric construction I have prepared] "a nomogram for parallel connection of identical components."

ALEXANDER N. LANDYSHEV
CALIFORNIA STATE
POLYTECHNIC COLLEGE
SAN LUIS OBISPO, CALIF.

Author's reply:

More conventionally, I could have used the longer terms "negative phase angle impedance" or "positive phase angle impedance", or even "impedance with capacitive phase angle", etc. I was not aware that I was creating a new term in an already complex electronic literature as my purpose was in the interest of brevity only.

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Milo Electronics Corp.
Sun Radio & Electronics Co., Inc.
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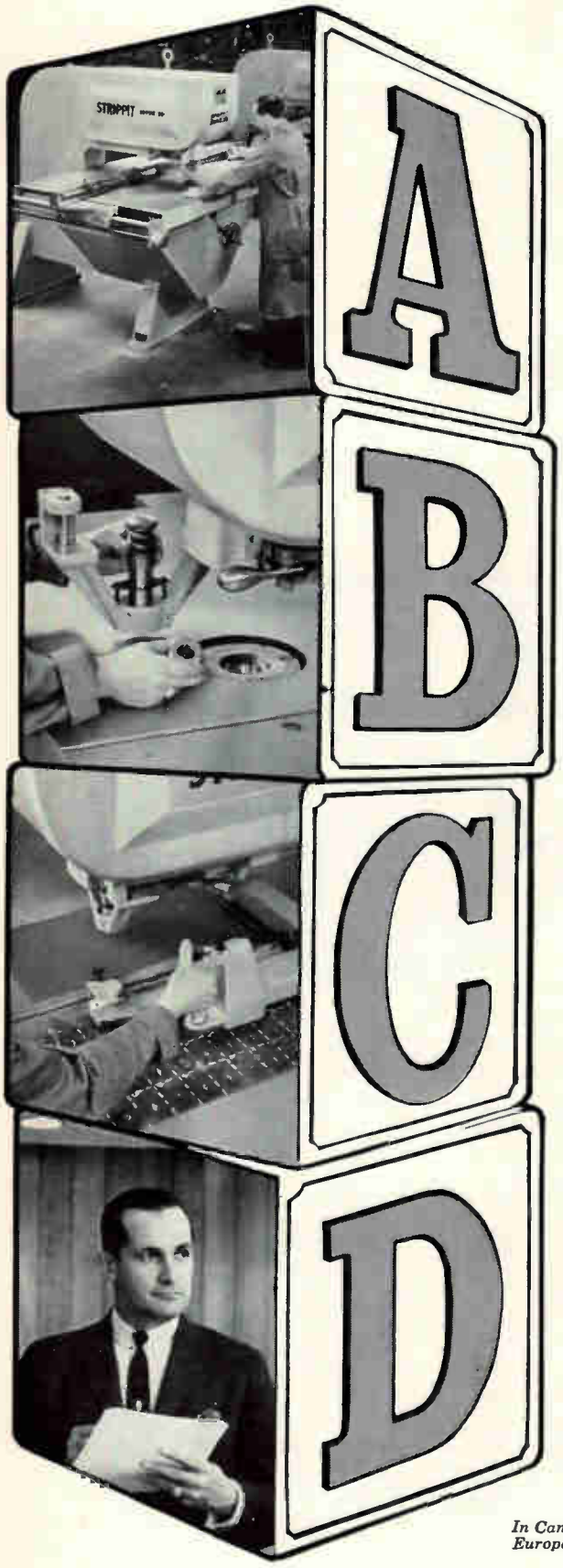

A versatile, multi-purpose, single station sheet metalworking machine, the STRIPPIT Super 30 Fabricator punches round and shaped holes in workpieces up to 60″ wide...any length. Will also punch close-centered hole clusters in any material up to ¼″ thick... nibbles straight or contour lines in ⅛″ material...notches 90° corners, radii and special edge notches to meet most production requirements in material up to ⅛″ thick.

Big savings in time are standard! Change tools in *seconds!* STRIPPIT's Swing-Shift Punch Holders permit you to change punches from either right or left. One size punch and die can be substituted for another in 20 seconds. Workpieces can be positioned rapidly for precise hole location thanks to STRIPPIT'S Micrometric Back and End Gaging System. Set dimensions directly to thousandths.

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ELECTRONICS NEWSLETTER

Sonar Beacons May Guide Submarines

NAVY BUREAU OF SHIPS has awarded The Martin Company, Baltimore, a six-month, $99,000 study contract to design an advanced navigation aid for submerged submarines. The system will be installed in the Navy's Atlantic Underseas Test and Evaluation Center.

Both passive and active navigational aids will be considered. The final system is to include submarine-borne and fixed undersea units. The system will probably use a "bottom bounce" method of projecting underwater sound. Sound projected to the bottom bounces to the surface and back to the bottom again. Direct acoustic propagation will also be investigated.

System design will follow studies of sound behavior in the bottom bounce method. Under consideration as power sources are Snap-1A and Snap-3 small nuclear power units. Portions of the system will be installed in the ocean at depths that will make retrieval difficult.

While Martin was not specific about the purpose of the system, the description indicates that the end result would yield an underseas network of numerous position indicators, or sonar beacons. Such beacons would allow Polaris-type submarines to obtain exact position fixes prior to missile launches.

Satellite Display Tube Shows Tracks in Advance

SATELLITE DISPLAY system which defines present and predicted paths on 20-inch cathode ray tube is under final test at National Space Surveillance Control Center at Bedford, Mass. Poesid system (Position Of Earth Satellites In Digital Display) uses mercator projection overlay of the earth to identify tracks.

Six satellite tracks may be presented simultaneously. Real-time positions of satellites are displayed as intensified spots on their respective tracks. Satellite information stored in computer is converted to punched teletype tape which is then used as input to Poesid system. Predicted positions up to nine days in advance can be displayed.

System developed by Fred Slack of Air Force Cambridge Research Laboratories uses light gun to identify specific satellite from multiple tracks. Operator points light gun at displayed target of interest and additional information is displayed, including identification number, distance of apogee and perigee, type of scientific or military information transmitted from satellite, date of launching and altitude.

Corkscrew Field Might Harness Fusion Plasma

EIGHT-FOOT MODEL of a new type of "magnetic bottle" to contain plasma during thermonuclear fusion power experiments (ELECTRONICS, p 29, Sept. 1, 1961) will be built at MIT. Unlike conventional fusion "bottles", which consist of a pipe-like field stoppered by mirror fields at the end, the new machine will try out a corkscrew field.

Theory is that as the plasma beam travels in the corkscrew, some of the longitudinal energy of the particles would be transformed to perpendicular energy. This would make it easier for the mirror fields to contain the particles long enough for fusion and the release of thermonuclear energy.

The model will operate with electrons, which are lighter than the ionic charged particles normally used in thermonuclear machines. A full-scale machine would be 50 to 100 feet long. The theory, proposed by an MIT graduate student, Air Force Capt. R. C. Wingerson, is also being investigated at Los Alamos Scientific Laboratory.

To Cut Red Tape?

ANOTHER TRY at reducing the "vast and expensive" amount of paperwork involved in military contracting is being attempted, this time by joint effort of the Aerospace Industries Association and Department of Defense.

A task force is reviewing specific weapons projects in an effort to eliminate obsolete documents, consolidate specifications and eliminate requirements which unduly limit design without contributing to system development or performance evaluation.

AIA points out that specifications may hamper advances since many are obsolete. AIA wants performance specs used more than detailed material and design specs, which frequently hamper progress, the association says.

One-Gun Color Tube May Give $350 Tv Receiver

SYLVANIA-THORN laboratories in England are developing a one-gun color television tube which generates primary colors by indexing the electron beam across alternate stripes of red, green and blue phosphors. Experimental 14 and 21-inch tubes carry 1,100 of these stripes. The beam and color signals are synchronized by separate index strips which generate a position signal as they are scanned by the beam.

The tube is compatible with monochrome transmission. Future goal in the Sylvania Electric Products-Thorn Electrical Industries joint project is reduction in tube production costs. A set made now with the tube would cost as much as a set with a shadow mask tube, according to the report. The tube is less expensive, but additional circuitry is required for indexing the beam. Aim is cost reductions which would permit sets to be built for around $350.

Semiconductor Plastics Point to New Devices

SEMICONDUCTION has been observed in more than 200 types of polymers, a Princeton University researcher reported last week at the 140th National Meeting of the American Chemical Society, in Chicago.

Further research can lead to plastic electronic components and high

temperature devices, Herbert Pohl said. Current-carrying ability is helped by special molecular arrangement of unsaturated units within the plastics. Studies of the current-carrying process are expected to provide additional fundamental information about biological processes which involve semiconduction, such as photosynthesis, enzyme reactions and vision. Large-scale chemical transformations may be made possible by taking advantage of the large surface area of polymers, their semiconducting properties and reactive chemical sites along chain-like molecules. The material would be regenerated by electric current.

Insensitivity to small amounts of impurities indicates that semiconduction within the new materials is fundamentally different from that in commonly used semiconductors, Pohl said.

Modulation Method Sends 150 Messages on a Wire

GENERAL DYNAMICS/ELECTRONICS says it has developed a phase modulation technique which will permit 15,000 words a minute or 150 teletype messages to be sent over a telephone line. Alphanumeric characters, including computer language frames, are coded into phase relationships along simultaneously transmitted tones. An almost unlimited number of symbols can be generated, readily permitting character recognition without dynamic logic or storage circuitry, the company reports. The technique is said to be exceptionally resistant to jamming. Technique is called DEFT, for Dynamic Error-Free Transmission.

Medium-Scale Computers Program Machine Tools

PROGRAMMING SYSTEM which permits a general-purpose, medium-scale computer to prepare instructions for numerically controlled machine tools has been developed by Remington Rand's Univac division and Rohr Aircraft Corp. It uses a Univac Solid-State 80 or 90 computer with card handling and printing accessories.

The companies say the system is versatile and low in cost, allowing smaller metalworking concerns to use automatic rather than manual tool programming. The programs, which will be made generally available to Univac customers, have been used by Rohr to prepare instructions for nine machines. The machines use Cincinnati, Numericord, ECS, Bendix and Thompson Ramo Wooldridge controls.

Univac also announced that another system in development will permit the Aerospace Industries Association's APT III (Automatically Programmed Tool) programs to be handled by its new thin-film memory computer, the 1107. APT III covers advanced techniques of programming complex three-dimensional parts.

CBS Electronics Sells Its Semiconductor Plant

THREE MONTHS after going out of the tube business, Columbia Broadcasting System is folding its semiconductor operations in Lowell, Mass. The $5 million, 200,000-square foot plant is being sold to Raytheon. CBS Laboratories in Stamford, Conn., is not affected.

Cryogenic Temperature Is Refrigeration Aim

CYCLE REFRIGERATION in the liquid helium range is target of concentrated efforts in industrial firms and laboratories, for application to masers, superconducting magnets and cryogenic computing devices.

Refrigeration built by Air Products will be installed soon at MIT Lincoln Laboratory. It is estimated machine will provide required cooling for 1,000 hours without interruption. Before applying it to operational maser, researchers will run laboratory life-tests on refrigerator and experiment on additional refinements for field use.

Meanwhile, low-temperature laboratory at MIT is working on new technique for cyclic refrigerator. Machine would use conventional method of expanding a compressed gas against piston, but employ a multi-stage system confined within a single cylinder.

In Brief . . .

FCC has extended deadline for comment on its uhf tv proposal, from Oct. 2 to Dec. 4. Station representatives had asked for six months more.

FEASIBILITY of 4-10 Gc amplifiers, mixers or harmonic generators using transistors will be determined at Hughes Aircraft under a $125,000 Navy study contract.

MILITARY PRODUCTION contract awards include $2.3 million to Raytheon Canada, from Canadian Army, for counter-mortar radar; $2 million to General Instrument, from Navy, for long-range sonar transducers; $300,000 to United Telecontrol Electronics, from Army Signal Corps, for drone transponders.

FRENCH ballistic missile program will get an American computer-controlled checkout system. Société pour l'Etude et Realization d'Engines Balistiques will buy the system from Packard-Bell for $350,000.

BELL LABS gave Avco-Everett Research Lab a $1.6 million contract to develop identification techniques for the Nike-Zeus anti-missile system.

MATERIALS for cesium plasma thermionic converters will be researched by Thermo Electron Engineering Corp. under a $200,000 Navy contract.

WESTINGHOUSE ELECTRIC and Remington Rand plan joint development of industrial control systems using computers.

HELICOPTER airlines in New York, Chicago and Los Angeles have selected Lear flight control equipment for new helicopters being supplied by Boeing and Sikorsky.

ELEMENTARY PARTICLE called the omega meson has been discovered at University of California's Lawrence Radiation Lab. About 40 picopicoseconds after omega is created, it splits into three pi mesons.

Special Pliers for the Highly Specialized Electronics Field

When the early transmission lines were strung in this country a century ago, it was Klein Pliers in the hands of linemen that helped do the job.

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Shown here are a few of the many highly specialized Klein Pliers carried in stock to meet the needs of electrical and electronics manufacturers.

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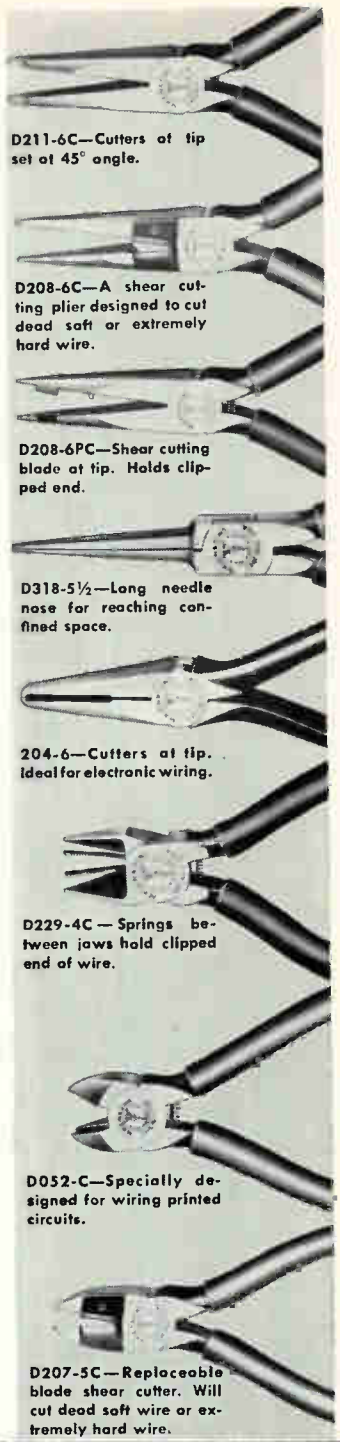

D211-6C—Cutters at tip set at 45° angle.

D208-6C—A shear cutting plier designed to cut dead soft or extremely hard wire.

D208-6PC—Shear cutting blade at tip. Holds clipped end.

D318-5½—Long needle nose for reaching confined space.

204-6—Cutters at tip. Ideal for electronic wiring.

D229-4C — Springs between jaws hold clipped end of wire.

D052-C—Specially designed for wiring printed circuits.

D207-5C—Replaceable blade shear cutter. Will cut dead soft wire or extremely hard wire.

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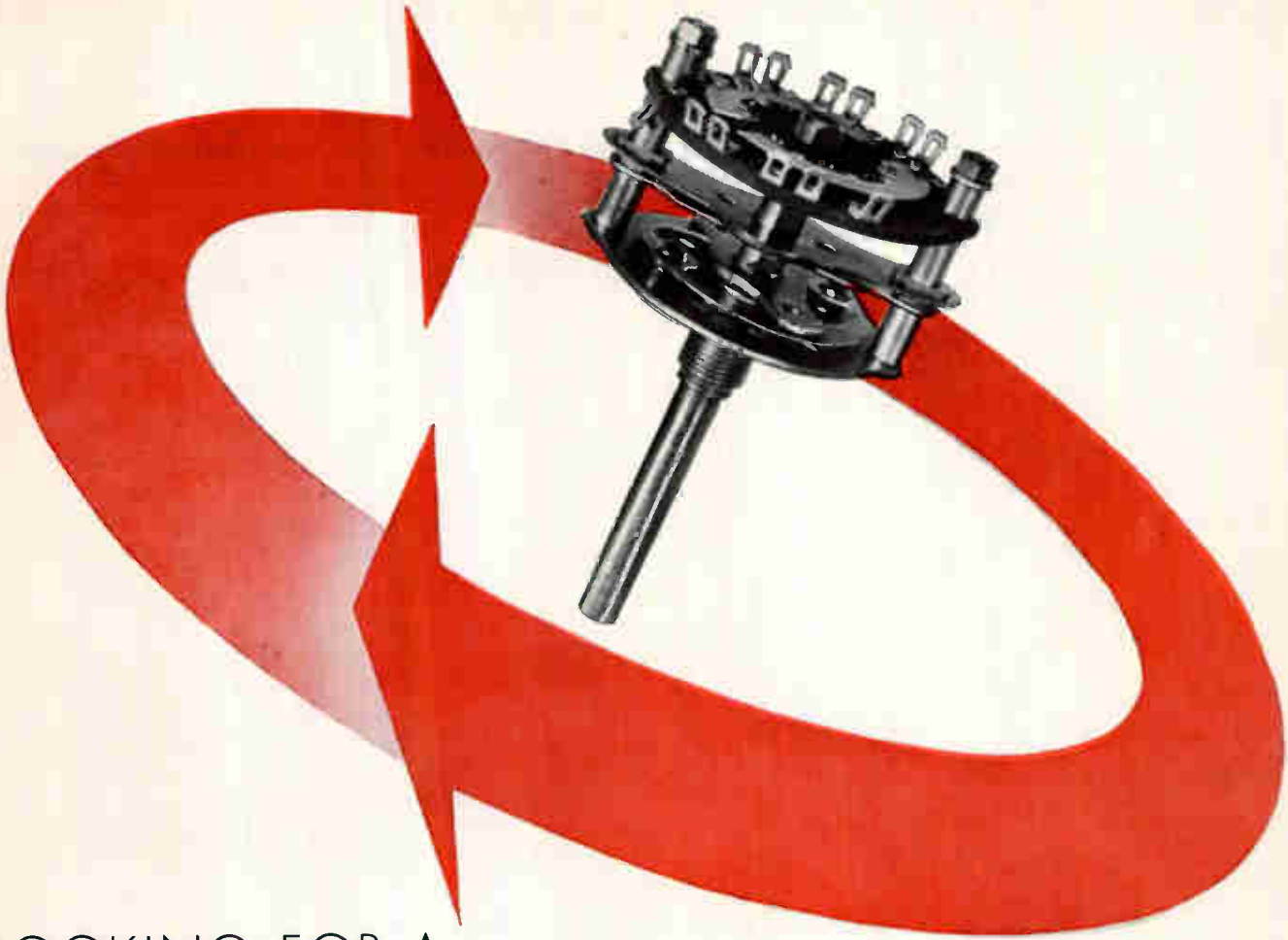
Now available: Eimac's 4KM100LA, a new 25KW klystron designed for UHF-TV transmitters. It provides the lowest operating cost ever with its low unit price, long life, non-critical focusing and high gain of 30 db to replace three tetrode stages! What's more, it's a complete amplifier unit and needs no RF design work, water filters, expensive maintenance. The 4KM100LA has all this and low noise too—more than 60db below black level. No wonder Eimac klystrons are used in almost 90% of all European UHF-TV stations! And now Eimac anticipates *your* needs with this modern, cost-cutting tube. For more data write: Power Klystron Division, Eitel-McCullough, Inc., San Carlos, Calif.

Eimac 4KM100LA Klystron Simultaneous Operating Characteristics. Beam voltage: 16KV; Beam Current: 3.8A; Power Output, peak sync.: 25KW; Bandwidth: 8mc, 1db; AM Noise: greater than 60db down.

Eimac



LOOKING FOR A ONE WAY SWITCH?

OAK UNI-DIRECTIONAL SWITCH MECHANISM—There are relatively few times when you need a switch in your circuit that won't turn back. When you do run into this occasional design problem, you usually need your switch "right now." Oak designers have come up with a simple, sturdy uni-directional detent mechanism that will withstand more than 25 inch-lbs. of reverse torque. A formed spring brass plate provides positive ratcheting action when travelling in a perforated bronze detent plate.

Uni-directional mechanisms are available on the following Oak rotary switch types: Type BH, 36° Throw; Type H, 30° Throw; Type L, 20° Throw; Type MF, 15° Throw; and Type F, 30° Throw. If you'd like more information on these, or other special Oak switches, contact your local Oak sales representative or write our Applications Engineering department. The applications in which you'll find these one-way switches useful are as unlimited as your imagination.

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WASHINGTON OUTLOOK

PLANS FOR ANOTHER step-up in defense spending are being developed. The emphasis, once more, will be on bolstering conventional forces, with heavier deployment of forces in Western Europe. Stimuli for the new moves are the sealing-off of East Berlin and resumption of nuclear testing.

Already, the Pentagon has scheduled $46.6 billion in spending this year —about $4 billion over last year. Size of the new step-up has yet to be fixed, but one high-level Defense Department official says it "will not be on a scale to change the economic picture". So far, there's no plan to seek a fourth supplemental defense appropriation. Officials believe they may be able to shift funds around in the existing budget to handle the new increase.

Very little of the new military speedup would go for expansion of strategic bomber and missile forces, as plans now shape up. But Pentagon officials concede that the "general psychological situation will make it harder not to spend" some of the $700 million Congress added for bombers.

MILITARY PROCUREMENT of common-use electronic parts will be centralized in the Defense Supply Agency, a new Pentagon unit just set up to consolidate as much as possible military buying, storage, and distribution of common-use goods bought in quantity by the armed forces.

When plans have been detailed within the next few months, field offices of the new inter-service group will be buying resistors, capacitors, antennas, and some 650,000 different common-use parts. It's not clear whether electron tubes, which the Air Force now buys for all the services, will be included. The services will continue to procure the bulk of the weapons and specialized equipment not widely purchased by other agencies.

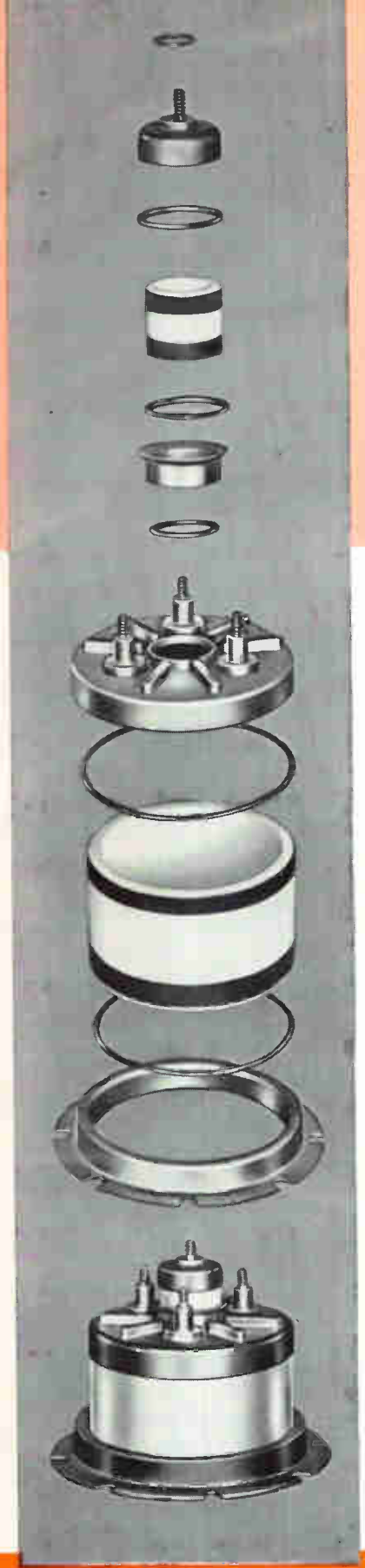
RESUMPTION OF NUCLEAR TESTING by the Soviets and the U. S. will have a direct effect on electronics. Miniaturization of a wide range of new tactical weapons and instrumentation for our tests and detection of Soviet tests will be needed.

The U. S. has long wanted to reduce the size of its field-nuclear weapons to make them lighter in weight, more rugged in design, and simpler to operate. The test ban placed on nuclear testing in October, 1958, froze many weapons programs. Scientists and engineers could only go so far in the interim period without more testing.

Smallest of the U. S. nuclear field weapons is the bazooka-type Davy Crockett with a fraction of a kiloton yield. But even this requires two men to fire. The Army wants to cut the size of this and other weapons. The Navy wants to make nuclear anti-submarine weapons more compact so that more can be carried by aircraft, helicopters and drones.

NEW INSTRUMENTATION will be required for underground nuclear testing. Testing underground is far more difficult than exploding devices in the atmosphere. The big difference lies in getting suitable instrumentation to measure the explosions. With the U. S. committed to do the bulk of its nuclear testing below the surface—as plans stand now—a push for better measuring instruments is sure to come.

Detecting Soviet nuclear explosions will get U. S. attention, too. Project Vela was to detect Soviet tests if agreement could have been reached on a nuclear test ban. Some $66 million was spent on Vela by the start of the current fiscal year. Resumption of Soviet tests does not lessen the need for information. The effort to detect Soviet testing will most affect underground instrumentation. Atmospheric tests are relatively easy to detect. But at present there is no sure way to detect underground explosions.



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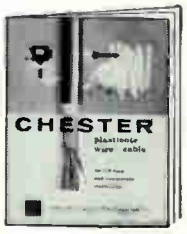

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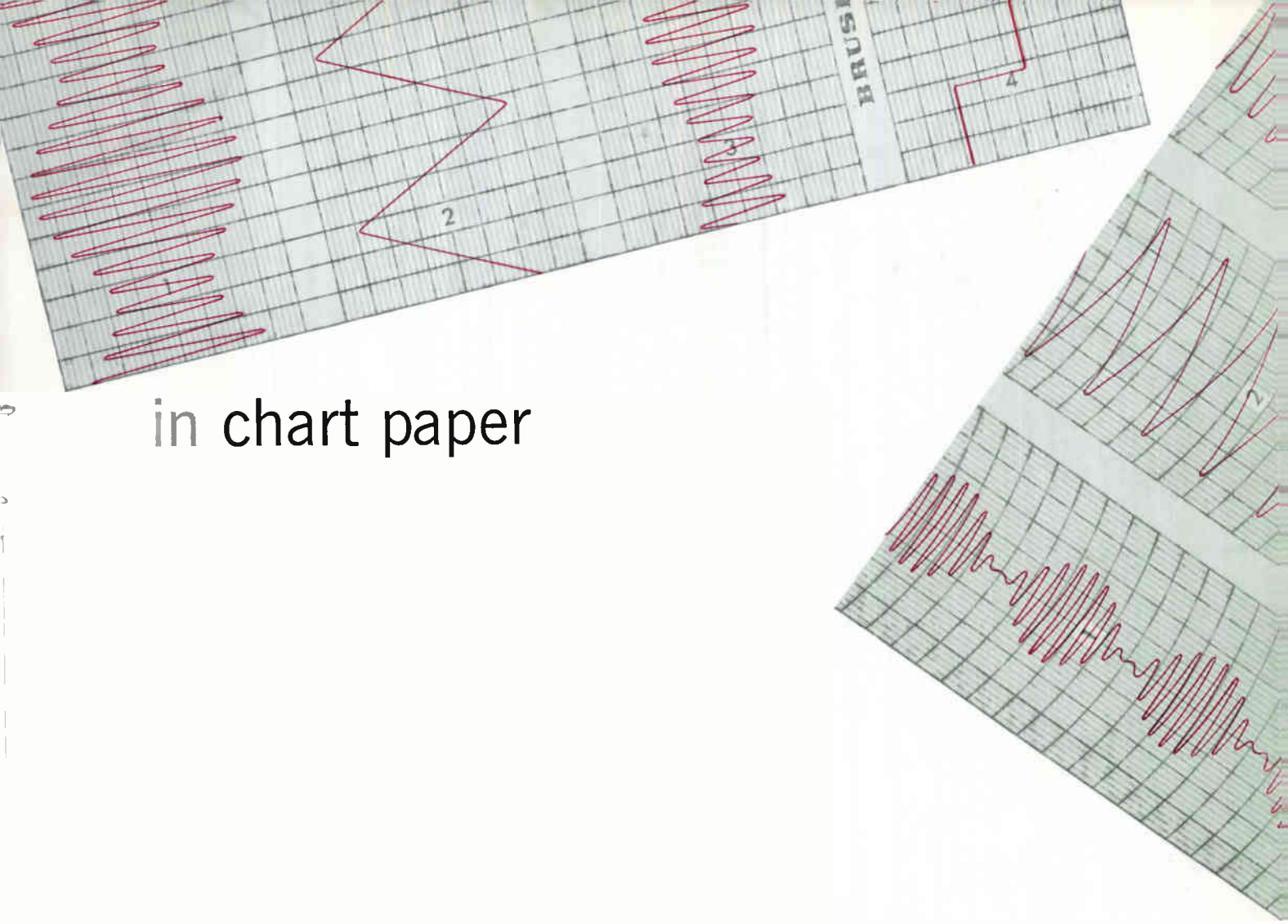

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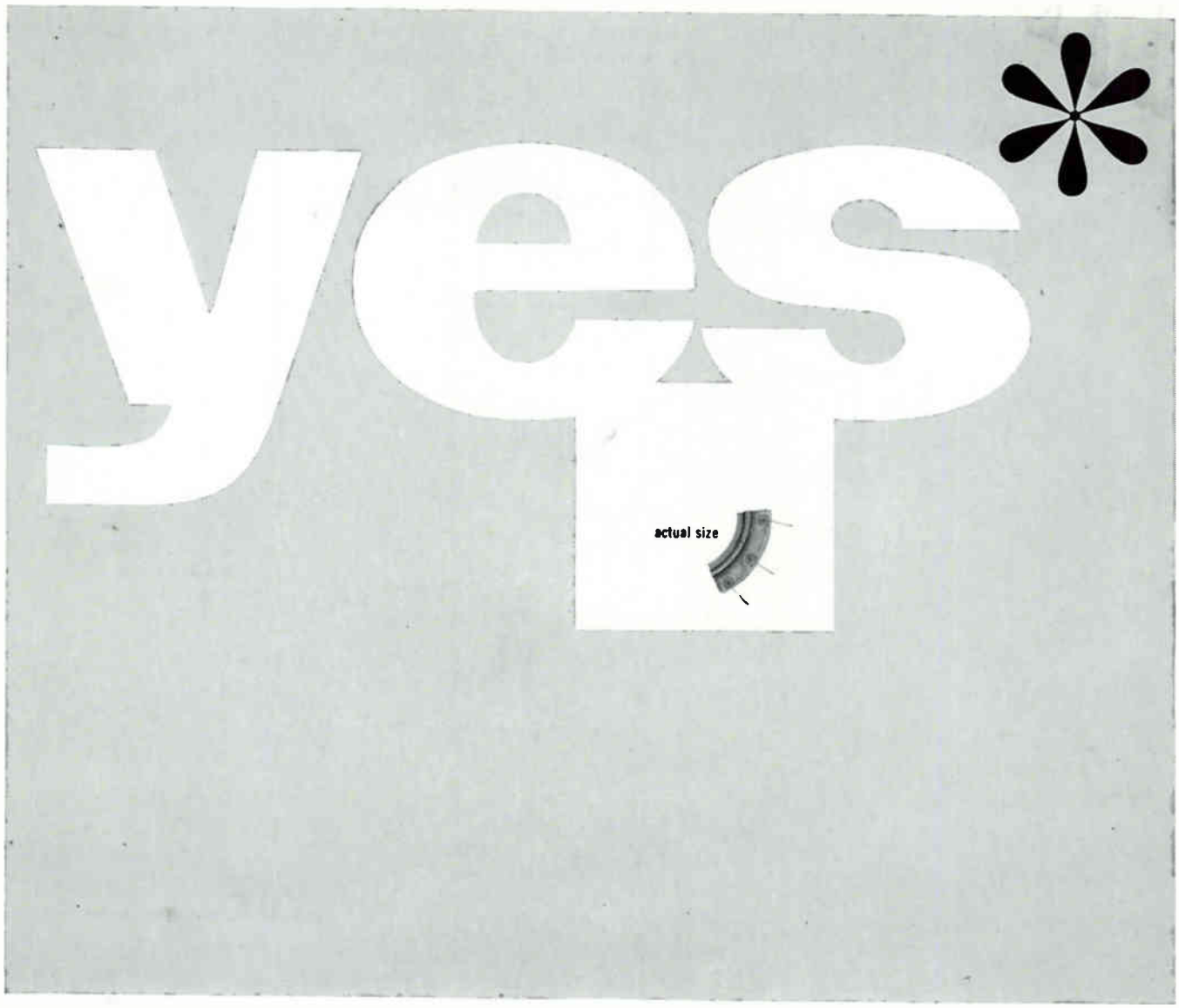

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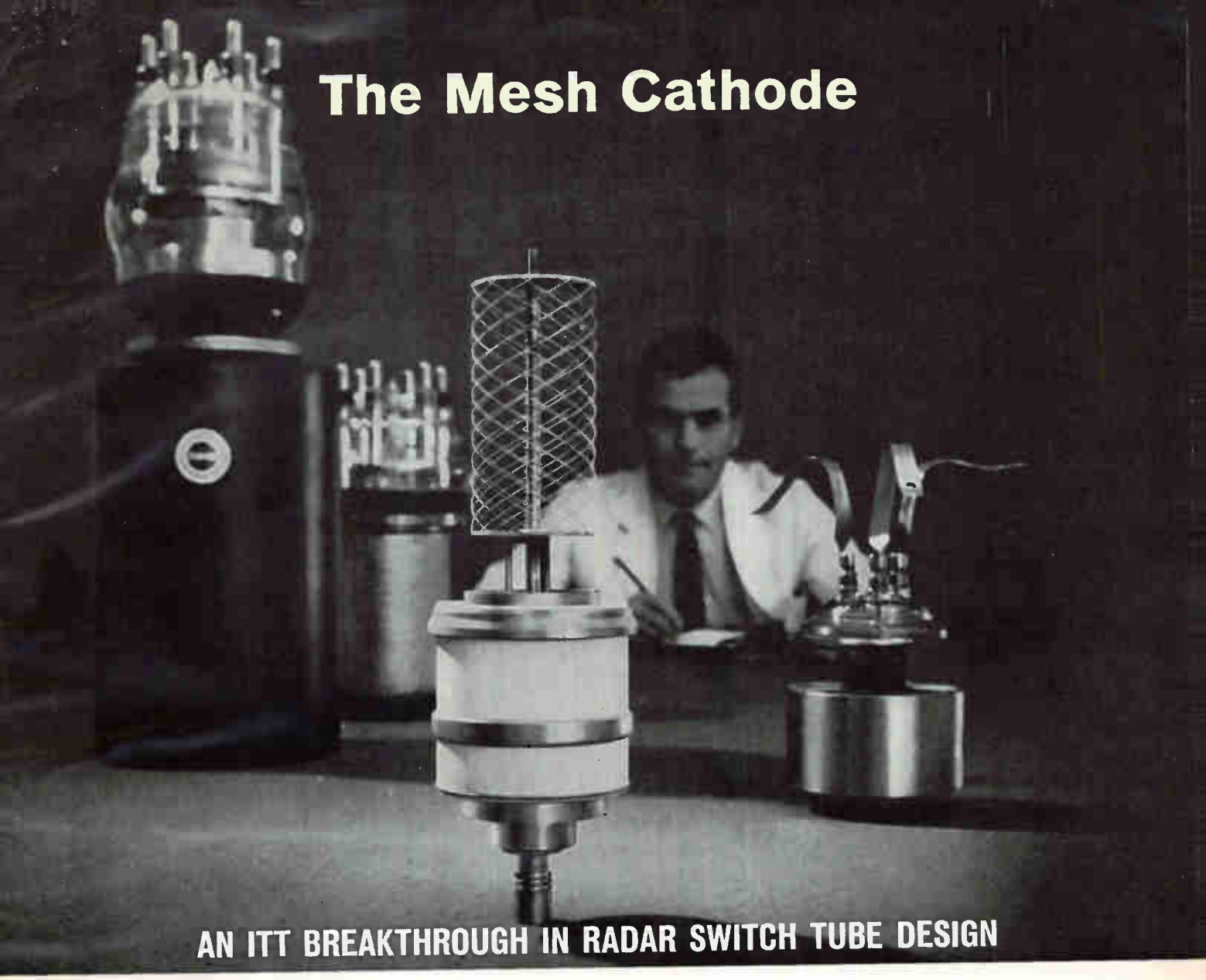

The Mesh Cathode

AN ITT BREAKTHROUGH IN RADAR SWITCH TUBE DESIGN

This seemingly delicate web of wire is actually the most rugged and structurally stable construction ever developed for power tube cathodes. Consisting of a fine cylindrical mesh instead of the usual filament configuration, the exclusive ITT mesh cathode is now available in a number of high-performance pulse triodes and power diodes. The triodes are specifically designed for radar switching applications; the diodes are ideally suited for rectifier, clipper and charging service.

Mesh cathode construction, in addition to its mechanical advantages, offers improved emission per watt in comparison with conventional cathodes, as well as quick heating and superior temperature stabilization. The cylindrical design results in an emission pattern that uses more of the available grid surface and thus reduces grid emission problems. This latest ITT power tube "first" is probably the closest existing approximation of a theoretically ideal "physicist's cathode."

Write for information on the complete line of ITT pulsed modulator triodes and power diodes. Application assistance is available for your specific requirements.

MODULATOR TRIODES – PULSED OPERATION

TYPE	PULSE POWER OUTPUT [1] (kw)	D-C PLATE VOLTAGE (kv)	PULSE CURRENT [1] (amperes)	PULSE CURRENT [2] (amperes)
F-7206	2200	18	220	350
F-7328	900	20	100	160
F-7839	7800	65	160	230
D-1037	30000	65	650	1000
F-6920	4100	35	140	200
F-7012	90	18	40	65

[1] At rated filament voltage
[2] At elevated filament voltage

HIGH VACUUM POWER DIODES

TYPE	APPLICATION	PEAK INVERSE VOLTAGE (kv)	PEAK CURRENT (amperes)	AVERAGE CURRENT (amperes)
D-1033	Rectifier	60	36	12
	Shunt or Charging	60	150	–
D-1034	Rectifier	50	45	15
	Shunt or Charging	50	200	–
D-1038	Rectifier	40	18	6
	Shunt or Charging	40	100	–
D-1039	Rectifier	65	21	7
	Shunt or Charging	65	100	–

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CIRCLE 19 ON READER SERVICE CARD

Stanford Reveals Progress in Laser

PRODUCTION OF MICROWAVE signals by photomixing near-neighbor axial mode components of the output spectrum of a ruby optical maser (laser) is reported by a Stanford Electronics Laboratory research team. Photomixing is possible up to at least 3,600 Mc. The achievement has significant implications for communications systems employing microwave-modulated light.

The photomixing procedures and parallel work in laser modulators and microwave phototubes were described during a recent four-day conference at Stanford University. The meeting, which also covered work on other research activities, was aimed at cross-fertilizing ideas. Industrial scientists and representatives of government contracting agencies attended.

Among other projects reported were:

• Liquid-state adaptive memory unit called the memistor. It was demonstrated in a neuron device called Adaline, for Adaptive Linear Classification Machine. Further development of Adalines and Madalines (for Many Adalines) may lead to analog memories and to computers which can be "trained" rather than programmed in detail, or which would respond physically to stimuli.

• Successful operation of equipment for epitaxial deposit of thin film silicon crystals on silicon substrates. Negative or positive type films can be grown at thicknesses ranging from 1,000 Angstroms to 20 microns with resistivity from 40 ohm-cm to 0.01 ohm-cm. Grown layers are unaffected by the substrate's conductivity, permitting fabrication of lightly-doped layers on heavily-doped substrates. The technique makes possible two devices under study, a negative resistance diode and a high frequency metal oxide-silicon capacitor.

• Systematic study of round-the-world propagation, at 12 Mc to 30 Mc, with a cooperating transmitter and receiver at the same location. Such propagation can be achieved during sunrise and sunset hours, except during strong magnetic disturbances.

• Pulsed ferrite microwave power generator, using small garnets subjected to pulsed magnetic fields. Experiments aimed at eliminating the need for an r-f input signal were reported successful.

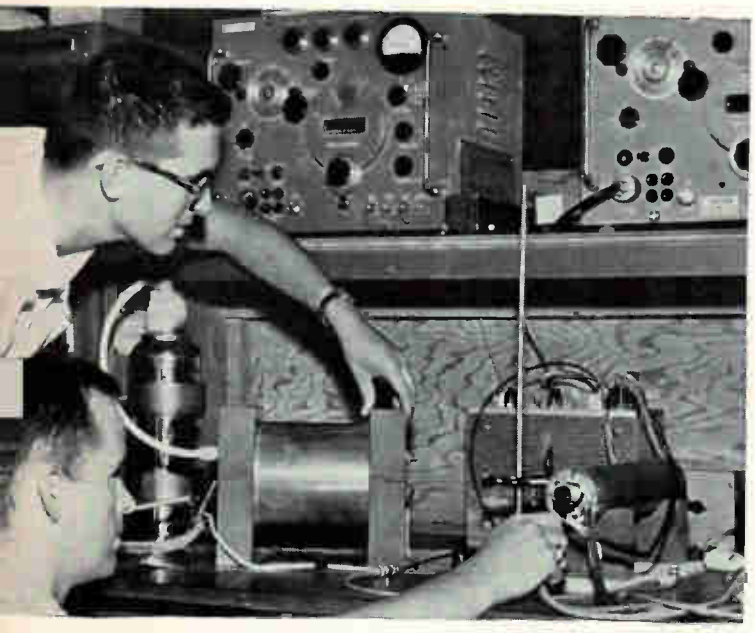
• Far infrared, submillimeter grating spectrometer for studying rare earth crystals and other far-infrared maser materials. It uses a helium-cooled GeSb photodetector sensitive in the range of 60 to 160 microns, or 2,000 to 5,000 Gc.

The investigations of laser modulation-demodulation were reported by A. E. Siegman, B. J. McMurty, S. A. Harris and W. W. Anderson.

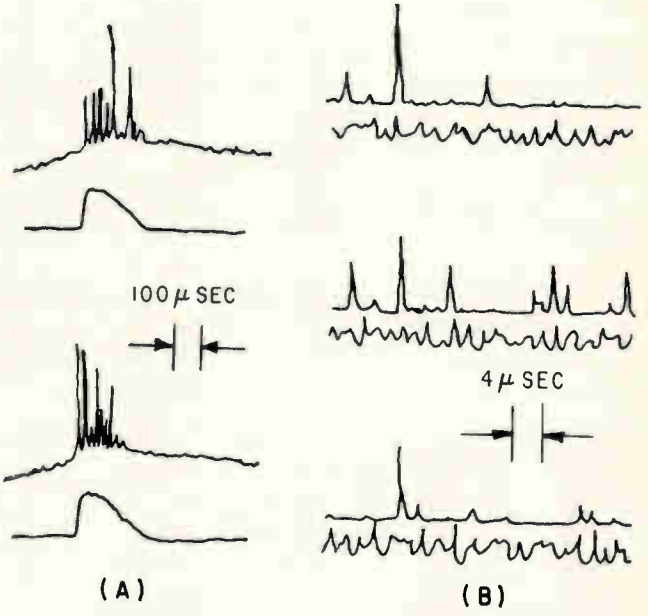
Output of a pulsed ruby optical maser is a short, intense burst of semicoherent light at wavelengths centered about 6,943 Angstroms. To be useful for communications, the burst must be modulated at the transmitter and demodulated at the receiver to recover transmitted information.

Microwave light modulation may be accomplished by shifting the optical absorption edge of a semiconducting crystal with a strong electric field. It may be possible to modulate the optical absorption and transmission characteristics of the crystal at frequencies beyond microwave. Semiconductor materials under study include amorphous selenium, cadmium selenide and selenium tellurium mixtures.

On the receiver end, the problems



Professor A. E. Siegman, of Stanford University's electrical engineering department (above), B. J. McMurty and their optical superheterodyne receiver. Elements are laser, lens mounted on stand and twt in a housing



Dual-beam oscilloscope traces at left (A) show twt's r-f output (upper traces) and cathode photocurrent. At right (B), are r-f output at 2,410 Mc, as detected by superheterodyne receiver (upper traces), and laser light output

Communications and Neuron Memories

include detecting and demodulating the arriving light signals. A microwave-modulated light beam striking a photocathode will cause the emission of a correspondingly modulated beam of photoelectrons. At microwave frequencies, however, conventional techniques of electron multiplication are not effective.

Stanford's approach is to combine phototube and microwave amplifier techniques to produce microwave phototubes. Such a tube might act as the front end of an optical superheterodyne receiver. When two light beams of different frequencies impinge on a photocathode, photomixing occurs, producing amplitude modulation of the emitted beam of photoelectrons at the sum and difference frequencies.

The Stanford team has observed a microwave difference signal when the output from a ruby laser was focused on the oxide cathode of a traveling wave tube (a modified Sylvania type 530 with a 2,500 to 4,000-Mc range; the cathode was exposed to the laser output).

Adjacent axial modes (optical resonances between which the number of axial nodes along the laser rod increases by one) are spaced at about 602 Mc in the laser used. Within the twt bandwidth were observed discrete signals centering at 1,800, 2,410, 3,000 and 3,600 Mc, representing "photo-beats" between third- through sixth-nearest neighbors in the laser-mode spectrum.

Heterodyning between the simultaneous discrete optical frequencies in the laser output took place in the twt cathode, according to the report, producing microwave amplitude modulation of the beam current.

Operational receivers would use a laser as a local oscillator and focus its output and incoming signal simultaneously on the cathode. If a twt were used, the helix would serve as an i-f amplifier for the difference signal.

Photomixing was also described as a promising tool for the study of laser. Line widths of individual components in the output spectra can be measured to accuracies two magnitudes greater than by high resolution spectrographic methods.

Reports on Adaline and its memistors were given by Bernard Widrow and P. R. Low. Memistors are small electrochemical cells. Memory is based on resistivity, which can be varied and set quickly by electroplating copper on a tin oxide coated rod. Each memistor has a conductivity ratio of 100:1, with infinite resolution. A current of 2 ma can put a cell through an entire conductivity change in 15 seconds.

Adaline has 16 memistors and inputs and a single output. The operator determines what response he wants—plus or minus—from a given set of inputs and sets up this response for the neuron by varying the resistance of the memistors. By repeating such a training process, a memory is created which stores information in a diffuse manner. The memory can then produce reasonable responses to stimuli close to those on which memory was trained.

Widrow compared possible neuron memories with a core memory with a capacity of 65,000 words 32 bits long. A bank of 32 Adalines would be trained on 1,000 to 5,000 experiences while the core memory would require 65,000 experiences to be filled. The cost of the neuron memory, he said, would probably be less than 1/1,000th of the core memory.

It has been shown, he said, that Adaline can be trained to recognize geometric patterns, perform logical functions and store digital information. Input is mechanically triggered at present. Eventually, photocells and other transducers will be used. "Photocells will give us a real eyeball, able to distinguish one visible object from another," Widrow commented. Certain light patterns would elicit definite responses. Responses could be expressed through servos in physical actions, simulating a complete psychological-type process.

Other possible applications for Adaline include solving multistage decision problems such as air photo interpretation, translating writing to speech and speech to writing, and visual identification and classification of different objects.

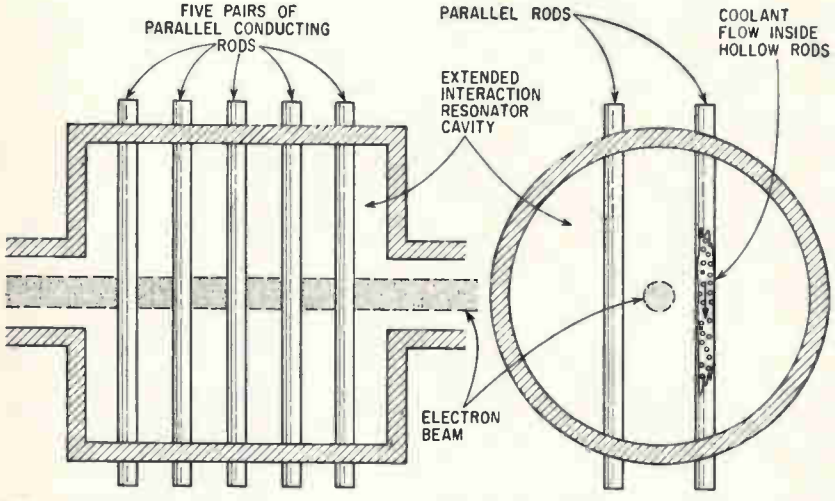
Bernard Widrow shows a conceptual version of Adaline called "Knobby Adaline". It uses rheostats instead of memistors. Plus or minus voltage settings of the knobs are quantized on the meter

Stanford has signed a contract with IBM to experiment on tieing Madeline in with a 1620 computer. The computer's core memory could act as a "cold storage" for thousands of patterns learned by the fication of different objects.

Transceivers Permit Two-Way Interpretation

POCKET F-M transceivers helped 16 Venezuelan students crack the language barrier during a University of Michigan seminar this summer. Stethescope-like earphones and microphones allow teacher and interpreter to carry on a running conversation without two-way switching. The interpreter relays questions and answers between teacher and students, who hear only the interpreter. The transceivers transmit up to 100 feet, allowing conversation on field trips or in noisy surroundings.

Resonators Step Up Klystron Power



Side view (left) and end view of extended interaction klystron resonator cavity

Sperry scientist adjusts new tube

KLYSTRON MICROWAVE amplifiers under test at Sperry Electronic Tube division of Sperry Rand are reported by the company to boost power, efficiency and bandwidth beyond the limits of conventional klystrons. The tubes are expected to inaugurate a new family of power amplifiers for such applications as space communications, satellite tracking and radar astronomy.

Called extended interaction klystrons, the tubes use an adaptation of a circuit originally devised for electron accelerators. The extended interaction circuit, or resonator (see sketch) allows modulation or demodulation to take place over a longer effective distance than the distance offered by a conventional cavity gap.

Five pairs of parallel, hollow cylindrical rods make up a transmission line that propagates a standing wave. Electrons are accelerated along this wave as the electron beam moves in synchronism with the forward-wave component.

The circuit has an effective length some eight times longer than the conventional klystron gap, but does not increase the physical length of the tube. Since the rods are hollow, they may be used to circulate coolant within the tubes.

Small size of gaps used in klystrons that operate on the bunching principle (electron velocity is altered as the electrons pass gaps in a series of cavities), has restricted power output, Sperry says. It claims average power limitations of such conventional tubes designed for communications systems are now approximately 250,000 watts at 1,000 Mc or 25,000 watts at 10,000 Mc.

Extended interaction circuits are expected to quadruple power limits while doubling frequency bandwidth. The basic circuit is reported to be a Stanford University design.

India Spurs Its Electronics Industry

INDIA IS GETTING its first transistor manufacturing plant. Establishment of the company, coming at a time when the Indian government is seeking to spur electronics manufacturing, may provide the catalyst for rapid growth of the electronics industry in that nation of more than 400 million people.

B. H. Wadia discusses crystal processing at New England plant

Semiconductors Private, Ltd., is building the plant in Poona, 120 miles southeast of Bombay. An industrialized area, India's military headquarters and site of one of the subcontinent's largest schools, Poona is considered by some as the focal point for electronics industry growth.

American production equipment is now en route to Poona. The company hopes to begin producing alloy type, germanium entertainment grade transistors next June. It plans to expand into more sophisticated semiconductor operations and possibly other electronics fields. Initial employment will be 100.

The company's engineering nucleus has been trained at Raytheon plants in the U. S. Raytheon, which holds a one-third interest in the company, will continue to supply capital equipment, training and eigineering information. The remaining interest is held by two Indian businessmen, Indersen T. Mirchandani and Taru J. Lalvani.

Technical manager is Behrman H. Wadia, an alumnus of the University of Bombay at Poona. He holds graduate degrees from Stanford, has worked at Machlett Laboratories, headed a research laboratory in India and taught at the Indian Institute of Technology.

Semiconductors Private expects to find a ready market for transistors in the Indian radio industry, which produces about one million sets a year. The industry has been gradually going into transistor sets during the past three years. Other mass markets are anticipated in recording equipment and television. Tv is still in the experimental broadcast stage in India.

Fewer than 10 percent of its radio component requirements are made in India. Transistors sell at several times the free market price. A chronic shortage of foreign currencies has resulted in severe import limitations. Prices are boosted by import duty, licensing and allocations and transportation and distribution costs.

The Indian government is encouraging foreign investment in electronics and has given electronics high priority in its five-year development plan. Military electronics equipment is largely imported, but Wadia and other native engineers are hoping to convince the government that a domestic capability for military production is in sight. Government encouragement of industrial process control development is expected to add to the growing demand for India-made instrumentation.

In the last 10 years, says Wadia, Indian officials and business leaders have come to realize that electronics must become one of the nation's major industries.

"The back-pressure is there—dependence on imports, the currency exchange problem, the need for in-

(continued on p 24)

. . . India Spurs

dustrialization, the tremendous, almost untouched market," Wadia says. "A catalyst is needed to touch off the growth explosion and we think our company will provide that catalyst."

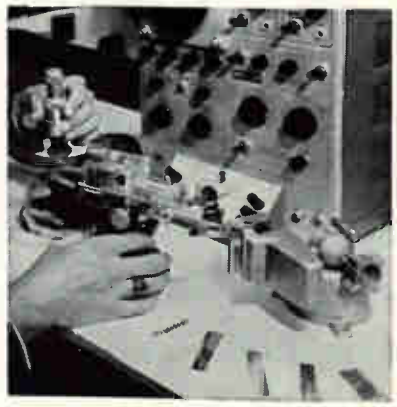
Wadia points out that engineering talent provides the principal ingredient of a domestic industry. Indian students anxious to return to their homeland after technical education abroad have had scanty prospects. Since formation of the transistor company, he has received inquiries from some 120 U. S.-trained engineers and students.

Tunnel Devices Seen as Next Microcircuit Step

DEVELOPMENT of thin-film tunnel-emission devices for use in high-performance microcircuits is reported by the solid-state physics laboratory of Lear, Inc. The company expects such devices to follow transistors and diodes as the next generation of active devices.

At present, Lear is working on techniques for evaporating conventional transistors and diodes, based on previously developed methods of depositing single-crystal films.

Tunnel-emission elements will be easy to make, economical, have high operating speed, substantial power capability and will be resistant to nuclear radiation damage, says the report. Both active and passive microcircuit components can be vacuum deposited. The active elements will be dielectric films 50 to 100 angstroms thick.



Tunnel-emission thin-film devices are tested with this setup by Lear

AEC Renews Food Irradiation Studies

ATOMIC ENERGY COMMISSION has begun a new program of research in radiation processing of perishable foods. Emphasis has been shifted from sterilization of food for long-term storage. Current aim is to develop low-dose methods akin to pasteurization, which would inhibit microbe growth for days or weeks as an alternative to freezing while foods are shipped to remote markets.

Low-dose processing is believed to have an early chance for commercial success, particularly for seafoods and fruits. Meanwhile, the Army Quartermaster Corps will continue research into sterilization by high-dose irradiation. The Army is constructing a laboratory at Natick, Mass. It will include an 18-kilowatt variable linear accelerator capable of providing 24 million electron volts, and a 1.1 megacurie cobalt source.

For the low-dose program, three research irradiators have been completed. Each uses about 25,000 curies of cobalt-60 and is equipped with auxiliary controls and equipment to permit experimental food processing under widely varied conditions. The atmosphere is controllable, temperature may be varied from 10 F to 150 F and gamma flux is approximately 250,000 rads per hour.

Two irradiators have been installed, at MIT and the University of California; the third will be located at the University of Washington. These irradiators are transportable. Irradiators able to go to the harvest site are believed necessary for commercial application. A market survey of the fisheries industry, for example, showed that 70 percent of potential users would prefer the irradiator located on the fishing vessels.

In addition, an in-plant irradiator is being designed at Brookhaven National Laboratory. It will require approximately 300,000 curies of cobalt-60. Its irradiation chamber would contain 72 food packages, conveyed through shielding walls by a conveyor in a labyrinth.

The low-dose research program also includes several parallel programs, including sprout inhibition in vegetables, disinfestation of grain and insect control. Canada and Russia have approved consumption of sprout-inhibited potatoes and France is readying such approval.

Swiss Help Indians Start New Radar Plant

NEW DELHI—Swiss electronics manufacturer, Contraves, A.G., of Zurich, is collaborating with the Indian Defense Ministry to set up a plant at Bangalore in southern India close to the government's Bharat Electronics. The new facility will manufacture specialized radar equipment.

Initial plans call for production of fire-control radar for tanks and antiaircraft installations. The Swiss firm will provide technical know-how in return for lump-sum payment and a ten percent royalty.

Future plans call for manufacturing a variety of radar equipment. Indian observers say, however, that security wraps have been placed on further production details. Financial details have also been withheld but it is understood that over the next five years the joint project will involve an investment of some $20 million.

Big Wheels, Small Tubes

RCA employees are framed by wheels used to load lead wires for nuvistor tubes. More than a million of the tubes have been produced

Extra quality at no extra cost with Bendix Semiconductors

Bendix Bulletin

HOW TO GET IMPROVED PERFORMANCE IN SWITCHING CIRCUITS

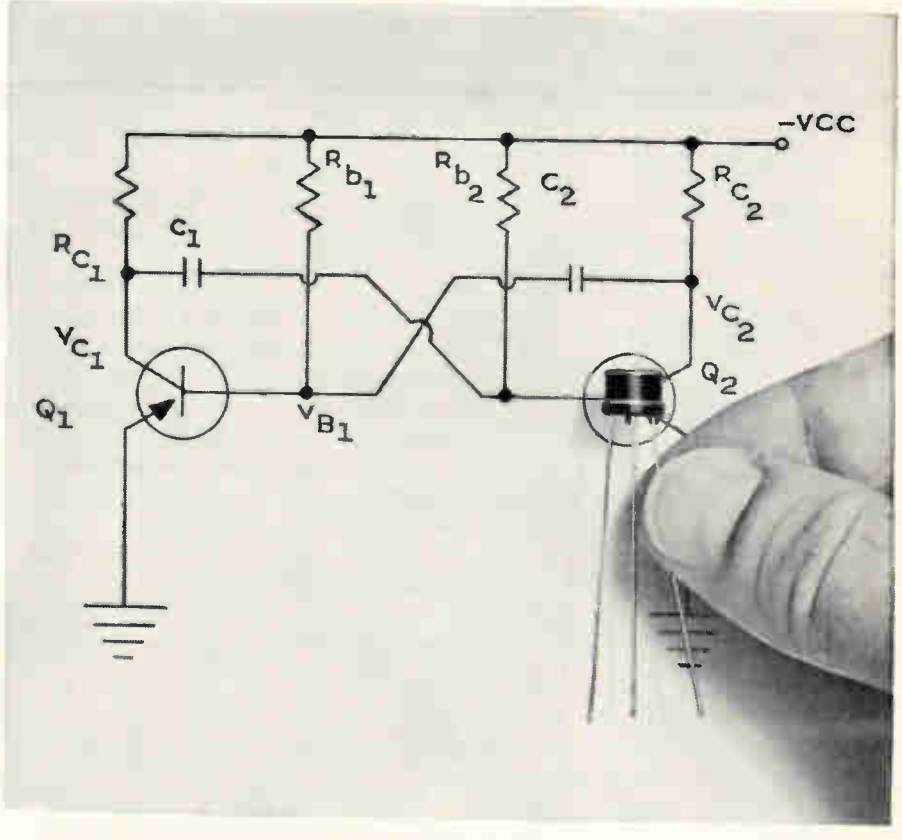
Bendix 2N1008 medium-power, medium-speed series solving design problems on wide front

Called the "workhorse of the transistor industry," the new Bendix* Driver Transistor series is winning the nod from more and more engineers daily. These men find it the answer to audio frequency and switching applications requiring extra performance.

The Bendix units combine higher voltage rating and high current gain with more linear current gain characteristics for low distortion and more efficient switching.

It is this kind of *extra* quality—combined with exceptional dependability and versatility—that's making these special Bendix devices the choice of more and more design engineers every day in answering audio frequency and switching application needs. Further advantages: Cost is low, and delivery in JEDEC TO-5 packages is *fast*.

For full details, write BENDIX SEMICONDUCTOR PRODUCTS, HOLMDEL, NEW JERSEY. *TRADEMARK



Typical Bendix 2N1008-equipped multivibrator circuit used in digital computers as a frequency divider, and in other medium-speed triggering applications.

APPLICATION, PERFORMANCE DATA INDICATE BROAD USAGE

TYPE NUMBERS	MAXIMUM RATINGS					TYPICAL OPERATION		
	Vce	Ic	Pc	Tj	T storage	hfe	fαb	Vce (Sat)
	Vdc	mAdc	mW	°C	°C	Ic=10 mAdc		Ic=100 mAdc Ib= 10 mAdc
2N1008	−20	300	400	85	−65 to +85	90	1.2 mc	0.15 Vdc
2N1008A	−40	300	400	85	−65 to +85	90	1.2 mc	0.15 Vdc
2N1008B	−60	300	400	85	−65 to +85	90	1.2 mc	0.15 Vdc
2N1176	−15	300	300	85	−65 to +85	65	1.2 mc	0.15 Vdc
2N1176A	−40	300	300	85	−65 to +85	65	1.2 mc	0.15 Vdc
2N1176B	−60	300	300	85	−65 to +85	65	1.2 mc	0.15 Vdc

Ideal for such applications as:

TRANSISTOR DRIVER • AUDIO AMPLIFIER (CLASS A OR B)
POWER SUPPLY • SERVO CONTROL • AUDIO OSCILLATOR
MOTOR CONTROL • RELAY DRIVER • POWER SWITCH

BENDIX SEMICONDUCTOR DIVISION

HOLMDEL, NEW JERSEY

THE Bendix CORPORATION

Main Office: South Street, Holmdel, N. J.—Ph: SH 7-5400 • New England Office: 114 Waltham, Lexington, Mass.—Ph: VO 2-7650 • Detroit Office: 12950 West 8 Mile Road, Detroit 37, Mich.—Ph: JO 6-1420 • Midwest Office: 2N565 York Rd., Elmhurst, Ill.—Ph: BR 9-5050 • West Coast Office: 117 E. Providencia Ave., Burbank, Calif.—Ph: VI 9-3961 • Canadian Affiliate: Computing Devices of Canada, P.O. Box 508, Ottawa 4, Ont. • Export Office: Bendix International, 205 E. 42nd Street, New York 17, N.Y.

How Five Engineers Became Executives

WHAT COMBINATION of experience, drive and talent jells into the right mixture so one engineer will be chosen to fill a higher-paying, more responsible position, while another —his counterpart—lags behind?

William A. Hertan, president of Executive Manpower Corp., New York and Washington, D. C., cites five case histories of electronics engineers his firm has recruited for clients over the past two years.

"These case histories are not unique—they're typical, and we've purposely selected those that prove a point," Hertan said.

Case number one, broad experience: A 43-year-old electronics engineer (BSEE) is now divisional vice president of a communications organization at a salary of $35,000. His responsibilities include supervision of sales, accounting, research, credit and production. Seven years ago he was a plant manager for a controls manufacturer earning $14,000.

To acquire broader and more diversified experience, he joined a management consultant firm and spent the next five years as a specialist in manufacturing studies, procedures and programming. He succeeded because he expanded his experience. This reflects sound career planning.

Case number two, technical paper: Two years ago, we recruited a young—(age 34)—engineer (BSEE, MSEE) who specialized in loudspeaker, amplifier and transformer design, and placed him with a high fidelity equipment manufacturer at a salary of $12,000. We understand he is now assistant research director at approximately $20,000 a year.

He was formerly employed by a smaller manufacturer of high fidelity equipment at $9,500 a year. He gained attention by publishing a technical paper that was well received throughout the industry.

Case number three, self-educated executive: This man is now chief engineer in charge of research for an electronic defense systems firm. He is 36 years old and makes $24,000 a year.

He does not hold a college degree, yet his record of self-education is outstanding. After serving as a technical sergeant in the Signal Corps during World War II, he worked as an electronics technician.

He knew lack of higher education could hold him back, so he took night school courses, university extension courses and every course offered by his company, an aircraft manufacturer. He participated whenever possible in seminars and conferences. Promotions followed. Three years ago, he became assistant chief engineer in the electronics defense division of the aircraft manufacturer, at $18,000. A year ago, he went to his new position.

Case number four, the "lucky break": This young man became a project leader at a salary of $16,000 a year. He first came to our attention because his fiance's engagement notice in a newspaper listed his name, position and education. We were looking for a man with his background in servo-mechanisms.

Although we call this the "lucky break," in reality he would sooner or later have advanced because of his overall good record. Before winning his new post, he was thoroughly checked out on education and knowledge in his specialty.

Case number five, promotion from within: In some instances, we are responsible for electronics engineers receiving promotions from their own companies. In about five percent of our assignments this situation occurs: after we narrow the selection of candidates to two or three people, one will tell his present employer that he is considering a new job. The employer offers our candidates more money or more money and a promotion to stay. We lose our candidate, but we know that we have contributed to his success.

Perhaps the employer will evaluate his present staff for the next vacancy to be filled.

MEETINGS AHEAD

Sept. 20-21: Industrial Electronics Symposium, PGIE of IRE, ISA, AIEE; Bradford Hotel, Boston, Mass.

Oct. 1-6: Suppression of Radio Interference, International Comm., CISPR, ASA, PGRFI of IRE; Univ. of Pa., Philadelphia.

Oct. 2-4: Communications Symposium, PGCS of IRE; Utica, N. Y.

Oct. 2-4: IRE Canadian Convention, Region 8, Automotive Bldg., Exhibition Park, Toronto, Canada.

Oct. 2-7 Astronautical Congress, International, IAE, ARS; Wash., D. C.

Oct. 3-12: British Computer Exhibition & Symposium, Electronic Engineering Assoc., Office Appliance, Trades; National Hall, Olympia, London.

Oct. 6-7: Broadcast Symposium, PGB of IRE; Willard Hotel, Wash., D. C.

Oct. 9-11: National Electronics Conf., IRE, AIEE, EIA, SMPTE; Int. Amphitheatre, Chicago.

Oct. 9-13: 13th Annual Audio Engineering Society Convention and Exhibit; Hotel New Yorker, New York City.

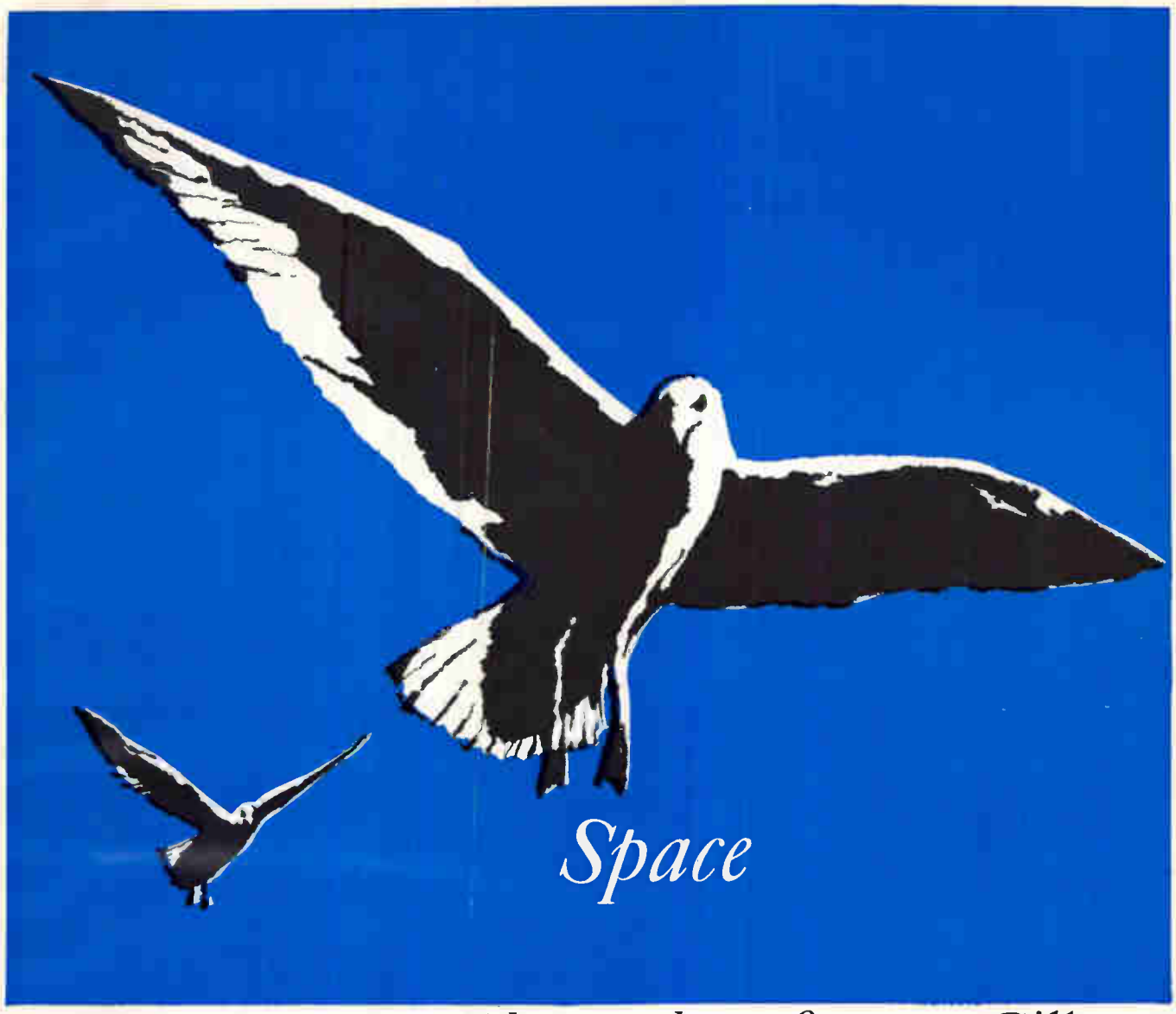
Oct. 11-13: Application of Digital Computers to Automated Instructions, ONR, Systems Devel. Corp.; Dept. of Interior Audit., C St., Wash., D. C.

Nov. 14-16: Northeast Research & Engineering Meeting, NEREM; Commonwealth Armory and Somerset Hotel, Boston.

Mar. 26-29, 1962: IRE International Convention, Coliseum & Waldorf Astoria Hotel, New York City.

ADVANCE REPORT

May 22-24, 1962: Microwave Theory and Techniques Symposium, PGMTT of IRE; Boulder, Colorado. Papers will be concerned with research, development, and applications in all areas of the microwave field. Prospective authors will submit, prior to Dec. 18, both 50-100 word abstracts and 500-1,000 word summaries accompanied by up to 6 figures suitable for reproduction to: R. W. Beatty, Chairman, Technical Program committee, 1962 PGMTT National Symposium, National Bureau of Standards, Boulder, Colo.



...roll on through pathless realms of space...Gilbert

The Range Planning Department of Pan Am's Guided Missiles Range Division is increasing its technical staff to meet the demands of the accelerated space progress, as a part of a well-organized systematic expansion program.

GMRD's Range Planning engineers plan the instrumentation, facilities and logistics necessary to support tests of the nation's most advanced aerospace systems on the Atlantic Missile Range. Plans are developed for specific programs such as DYNASOAR and CENTAUR, as well as for general expansion and improvement of the range. Major planning areas are in logistics, data acquisition systems, data support and facilities.

The Range Planning Department offers men with creative ability and initiative the opportunity to proceed from concept to hardware. The programs are important . . . the funds are available . . . the tools are at hand. The need is for technically respected people with leadership ability to carry out these programs.

New career positions are also available in engineering and operations. Physicists, engineers and mathematicians with B.S., M.S. and Ph.D. degrees are invited to submit resumes in confidence. Address Professional Employment Manager, Guided Missiles Range Division, PAN AMERICAN WORLD AIRWAYS, INC., Dept. W-42, P. O. Box 4336, MU 113, Patrick Air Force Base, Florida. Inquiries will receive prompt replies and all qualified applicants will be considered for employment without regard to race, creed, color or national origin.

PAN AM

GUIDED MISSILES RANGE DIVISION

PATRICK AIR FORCE BASE, FLORIDA

BE THE FIRST IN YOUR BLOCK TO DRIVE A 1937 PACKARD

WIN this fine Classic Car

A 1937 Packard–12 cylinder Coupe in mint condition and, to pick it up, a weekend flight for 2 to Southern California on a new first class, non-classic airplane.

If you miss narrowly you get $1,000
Third place is worth $300

Settle this bet for us– ## WHICH PSI AD IS BEST?

Three different PSI ads appear on the pages following this spread. Our switchboard operator has money riding on one. The Assistant Quality Assurance Control Chief likes another. Our Advertising Manager thinks they're all nice. It's a problem – for you to decide. And easy. All you have to do is –

1. Read the 3 ads (carefully, please, the ad manager is sensitive) and rate them 1-2-3. Use ESP, Ouiji Board, or just guess.
2. Then guess how many first place votes each ad in your 1-2-3 order will get.
3. Write your answers on one of the entry cards bound into this magazine following the last PSI ad and mail it *fast.* The closing date of the contest is October 15, 1961.

Now wasn't that easy? And that's all you have to do. We'll do the rest . . . counting and judging . . . which is certainly no reference to your honesty. It's just that we'll have all the cards. Which seems fair.

First prize will go to the entry which comes closest to picking the number of votes for the top-rated ad, and, naturally, the correct order. Second and third prizes will go to folks who get next nearest and next, next nearest.

Here are some more rules and hints. It might help you win if you'll read them.

HELPFUL HINTS FOR CONTESTANTS

It is not necessary for you to be an expert. Our own preliminary investigation reveals some pretty hairy sounding guesses. You are welcome to use psychology, a digital computer, even zoology if you think it'll help.

However, here are a couple of small hints that might get you started. The 2 magazines in which the contest appears have a combined paid and controlled circulation of 96,000. Some people read both magazines, which is one reason why we chose them in the first place. But nobody knows how many.

And then there's "pass-along", which is not a cowboy show, but is the result of some generous fellows letting others read their magazines, which we think is nice. Multiply by 3.4 for this factor.

Then you have to figure that some people won't enter, which is the only thing about it that seems unfair to us.

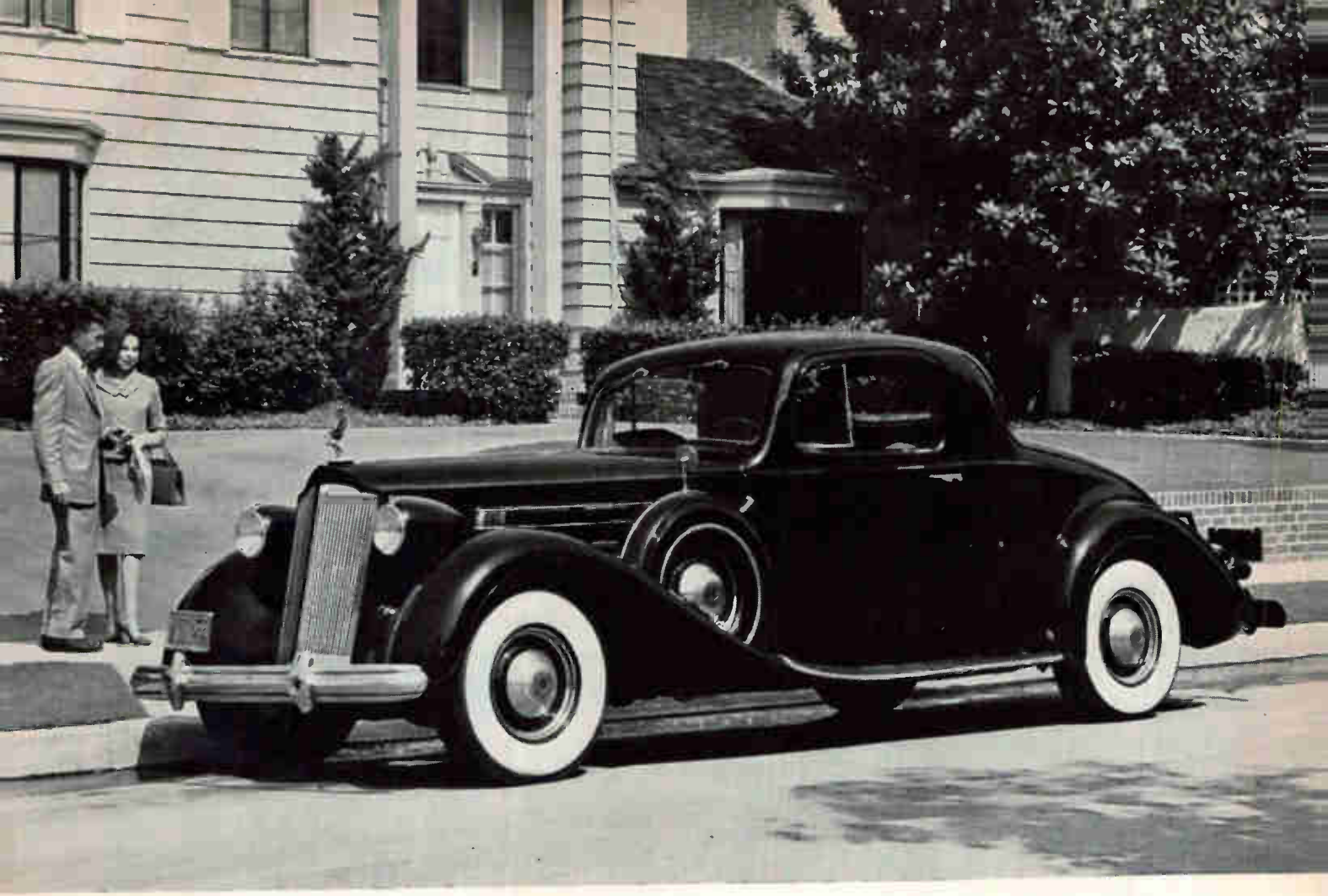
The total number of first place votes for any of the 3 ads could range anywhere from 2,000 to 75,000. Now, doesn't that offer plenty of room for your guesses?

OFFICIAL CONTEST RULES

1. Read 3 ads (A, B and C) on following pages. Indicate on one of the official entry blanks (bound in following ad C) your opinion of how contest entrants will rate each ad in order of advertising effectiveness. Then estimate number of contestants who will select each of the ads as being the most effective. There is nothing to buy.
2. Winners will be chosen on basis of accuracy in guessing:
   a. Order in which most entrants in contest will rate 3 ads.
   b. Total number who will vote for top-rated ad.

   In event of ties, entries most closely guessing number of votes for second-rated ad (or, if necessary, third-rated) will win.

   If further ties exist, entrants will be required to write a statement in 25 words or less telling why they selected top ad. In case of ties after statements have been submitted, duplicate prizes will be awarded.
3. First prize winner will get 1937 Packard 12-cylinder coupe (see picture)—Engine #906495-B; California License VJU 966. Winner, if living over 100 mi. from Los Angeles, will also get a one-way first-class air line flight for 2 persons from his home town to Los Angeles. They will be week-end guests of PSI for car presentation and title transfer at PSI plant. Winner will also receive fuel and oil for return trip to winner's home together with $100.00 deductible collision insurance and comprehensive. (PL and PD to be supplied by winner through own insurance broker.) In event winner elects to ship car by public carrier, PSI will reimburse expense to extent of distance covered, based on 8 mi.-per-gal. of fuel and an engine oil change every 1,000 mi. Second prize, a check for $1,000.00 (one thousand dollars) will be mailed to second prize winner's business address. Third prize winner will receive a check for $300.00 (three hundred dollars) mailed to his business address.
4. Contest is open only to persons actively engaged in electronic field in the 50 U.S. states, D.C. and in Canada. Employees of Thompson Ramo Wooldridge Inc., its divisions, affiliates, subsidiaries, distributors, advertising agencies and The Reuben H. Donnelley Corporation (judging firm) are not eligible.
5. All entries must be on official entry postcards (in present issue, this magazine) or obtained from Pacific Semiconductors, Inc. by writing: Advertising Dept., 12955 Chadron Ave., Hawthorne, Calif.
6. All entries must be postmarked no later than Oct. 15, 1961, and received in Los Angeles by Oct. 25, 1961. Only one entry per person and one prize per family. All entries will be mailed to: PO Box 16, Los Angeles 51, Calif.
7. Winners will be notified by mail about 30 days after contest's close. No entries returned; all become property of sponsor.



MOVE SEVEN STALLS UP IN THE COMPANY PARKING LOT

If you have ever suffered the indignity of a second class parking space—had to stand by while protocol usurped your rightful place—then you know frustration. If you have ever sneaked past a Vice President in the company cafeteria line, you know the meaning of one-upsmanship, and the fiendish glee which accompanies it.

Now, with a victory in this PSI contest, you can accomplish both. End that deep frustration, because your Classic 1937 Packard-12 rightfully belongs next to the President's common carriage. And just think of all the competitors you'll be one up on—for this automobile wasn't even ordinary in 1937.

You'll have great fun dropping your wallet in strategic meetings, careful that it falls open to your membership card in a Classic Car Club. Idly, you can mention the Concourse d'Elegance at Pebble Beach, the Polo Club in Darien, Connecticut, or the joys of Boca Raton in winter.

Not to mention the sheer pleasure of driving this marvelous machine, waving casually, or grandly, as the mood assails you, to folks who knew you when. Think of the opportunities to smile quietly, cast your eyes down with some modesty, as friends exclaim in admiration over the virginal appearance of the upholstery, its discreet use of chrome, its obvious good taste. To them, you are a man among men, a master of the art of gracious living.

And there will be your own feelings to consider. The sense of belonging with the uncommon, those who understand the elegance of the past. The feeling of command as you wheel through traffic, all eyes on you. The knowledge of smooth, quiet power, accompanied by size and weight adhering to the philosophy that these are the factors to provide comfort and safety in motoring.

There will be those who will be awestruck by the gleaming black finish of your automobile. And times when you can quietly mention your Packard-12 engine has a displacement of 473 cubic inches, a bore of 3 - 7/16 inches, a stroke of 4¼ inches, a wheel base of 134 inches, 5,255 pounds of massive strength and comfort. Such information may be all you'll need to bring tears to your sports car afficianado friends. You can even squash the miles-per-gallon type with the quiet disclaimer that your classic car runs beautifully on regular gasoline.

And think of the joy of inviting a golfing companion to place his bag in one of the locked hatches on either side. Or perhaps insisting you drive to a meeting with two vice presidents in the rumble seat.

Lest you believe our generosity ends with this magnificent automobile, let us hasten to add right here, the trip for 2 to pick it up in Lawndale, California. Right there is something to talk about. How many people do you know who have had a free flight to Lawndale?

Do enter the contest right now. It may be a way to alter your life, your hopes, your dreams considerably—to gain prestige—to shake empire builders at their very cores.

PSI®

Pacific Semiconductors, Inc.

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TURN PAGE

AD A

The Logical Logic Switch

for your Computer Design!

PSI 2N920 - 2N919

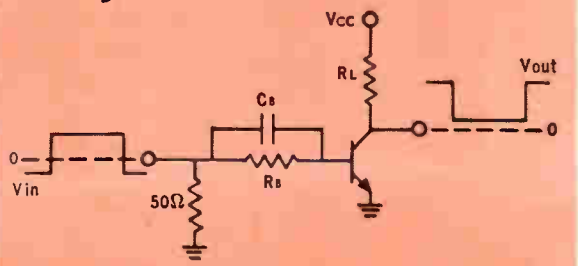
(high h_{FE}) (medium h_{FE})

FAST SWITCHING · LOW V_{CE} (Sat) · LINEAR h_{FE} versus I_C and V_{CE}

TRIPLE DIFFUSED SILICON PLANAR TRANSISTORS

Look what happens in fast switching circuitry...

TRANSISTOR TYPE	t_{ON}	t_{OFF}	t_{TOTAL}
PSI Laminar™ (Triple diffused planar)	5	5	10 NSec
Micro-Alloy Diffused	5	7	12
Epitaxial	6	8	14
Mesa (double diffused)	10	11	21
Planar (double diffused)	12	13	25



(SCHEMATIC – CIRCUIT B)

It's logical to specify PSI Logic Transistors

* **ADDED ADVANTAGES** of *low leakage, better stability under varying environmental conditions* and inherent *greater reliability* – as well as switching performance competitive in all aspects with germanium logic transistors!

* **PRICE PARITY** with germanium switches of competitive speeds is rapidly being reached. Volume in 1962 will wipe away any remaining differential.

* When epitaxial transistors have come of age and are *proved* reliable they will provide a ready second source to the *production-proved* PSI Triple Diffused Planar transistors.

EXPERT FIELD ENGINEERING SERVICE is immediately available. There are PSI field offices from coast to coast. Call one of them now!

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AD B

Why PSI is ONE of America's TOP TWO IN SILICON TRANSISTORS

Pacific Semiconductors, Inc. was first to make silicon computer diodes commercially available, and is the industry's number one diode source.

Until early 1960, PSI's transistor development was largely concentrated on providing certain vital transistors for satellite communication programs and developing broad technology in basic transistor techniques. Since that time this work has led to explosive growth in silicon switching transistor capability. Why?

it's simple as

A *dvanced R&D*

Original PSI research led to the first Triple Diffused Silicon Mesa Transistors nearly four years ago. Its objective was to attain large volume production of devices with extraordinary electrical characteristics—very fast switching, extremely low saturation, superior high current and small signal beta and broad VHF versatility. Products of that research are the now-famous 2N1505 - 2N1506 VHF communication transistors, the 2N1899 high frequency power transistors, the 2N1837 premium switch, the 2N920 logic switch and the PT601 core driver transistors—along with scores of less glamorous but equally important "work horse" transistors for every application in today's and tomorrow's design.

B *usinesslike engineering*

including product services, quality control and applications engineering in its framework—is a completely self-sufficient and dynamically-growing PSI operation. PSI triple diffused, isolated base (planar) production technology is turning out medium and low power core drivers and switches which are equal to or better than any specifications available in the industry These devices are available in TO-5, TO-8, TO-18 and the new TO-46 and TO-51 packages.

C *oordinated marketing*

The PSI transistor operation happily teams the theoretical and the practical—all the way from R&D to the field engineers. The ultimate selling price of a new device is considered just as realistically as the exciting electrical characteristics of the device itself—in the PSI Coordinated Marketing philosophy.

When your problem requires Advanced R&D—Businesslike Engineering—Coordinated Marketing—we'd like to have the privilege of talking it over with you. Phone, wire or write a PSI field engineering office near you!

PSI® *Pacific Semiconductors, Inc.*

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12955 CHADRON AVENUE • HAWTHORNE, CALIFORNIA

AD C

72 reasons why YOU SHOULD SPECIFY PSI TRIPLE DIFFUSED SILICON PLANAR TRANSISTORS

HIGH SPEED SWITCHING TRANSISTORS

TYPE	Total Power @25°C Case Watts	V_{CBO} Min.	V_{CER} Min.	V_{EBO} Min.	f_t mc Typ.	h_{FE}*	$V_{CE\ sat}$* Max.	Pkg.
2N706	1.0	25	20	3	350	20 min	.60	TO-18
2N706A	1.0	25	20	5	350	20-60	.60	TO-18
2N706B	1.0	25	20	5	350	20-60	.40	TO-18
2N753	1.0	25	20	5	350	40-120	.60	TO-18
2N834	1.0	40	30	5	350	25 min	.25	TO-18
2N919	1.2	25	20	5	400	20-60	.20	TO-18
2N920	1.2	25	20	5	400	40-120	.20	TO-18
2N921	1.2	50	30	5	400	20-60	.30	TO-18
2N922	1.2	50	30	5	400	40-120	.30	TO-18
2N1252	2.0	30	20	5	210	15-45	1.5	TO-5
2N1253	2.0	30	20	5	210	30-90	1.5	TO-5

PREMIUM SWITCHING TRANSISTORS

2N1837	2.0	80	50	8	210	40-120	.80	TO-5
2N1837A	2.8	80	50	8	210	40-120	.80	TO-5
2N1409	2.0	30	25	4	235	15- 45	.80	TO-5
2N1409A	2.8	30	25	4	230	15- 45	.80	TO-5
2N1410	2.0	45	30	4	235	30- 90	.80	TO-5
2N1410A	2.8	45	30	4	230	30- 90	.80	TO-5
PT850	2.0	120	80	5	200	40-120	2.0	TO-5
PT850A	2.8	120	80	5	200	40-120	2.0	TO-5

SPECIAL PURPOSE SWITCHING TRANSISTORS

2N1340	2.8	150	150	5	220	5 min	0.7	TO-5
PT601	13.0	60	45	4	210	30-90	1.0	TO-8
PT600	13.0	60	45	4	210	15-45	1.0	TO-8
2N1900	125.0	140	100	5	50 min	10-20	2.0	Single End
2N1901	125.0	140	100	5	50 min	15-40	2.0	Single End

*SEE DATA SHEETS FOR CONDITIONS

STANDARD SWITCHING TRANSISTORS

TYPE	Total Power @25°C Case Watts	V_{CBO} Min.	V_{CEO} Min.	V_{EBO} Min.	f_t mc Typ.	h_{FE}*	$V_{CE\ sat}$* Max.	Pkg.
2N497	4.0	60	60	8	190	12-36	5.0V	TO-5
2N498	4.0	100	100	8	190	12-36	5.0V	TO-5
2N656	4.0	60	60	8	190	30-90	5.0V	TO-5
2N657	4.0	100	100	8	190	30-90	5.0V	TO-5

TYPE	Total Power @25°C Case Watts	V_{CBO} Min.	V_{CER} Min.	V_{EBO} Min.	f_t mc Typ.	h_{FE}*	$V_{CE\ sat}$* Max.	Pkg.
2N696	2.0	60	40	5	200	20-60	1.5	TO-5
2N697★	2.0	60	40	5	200	40-120	1.5	TO-5
2N698	2.0	120	80	5	190	20 min	5.0	TO-5
2N699	2.0	120	80	5	190	40-120	5.0	TO-5
2N708	1.2	40	20	5	—	30-120	.4	TO-18
2N717	1.5	60	40	5	200	20 min	1.5	TO-18
2N718	1.5	60	40	5	200	40-120	1.5	TO-18
2N719	1.5	120	80	5	190	20 min	5.0	TO-18
2N720	1.5	120	80	5	190	40-120	5.0	TO-18
2N717A	1.8	75	50	7	200	20-60	1.5	TO-18
2N718A	1.8	75	50	7	200	40-120	1.5	TO-18
2N719A	1.8	120	80	7	190	20-60	5.0	TO-18
2N720A	1.8	120	80	7	190	40-120	5.0	TO-18
1420	2.0	60	30	5	170	100-300	1.5	TO-5
2N1613	3.0	75	50	7	200	40-120	1.5	TO-5
2N1711	3.0	75	50	7	170	100-300	1.5	TO-5
2N1893	3.0	120	80	7	190	40-120	5.0	TO-5

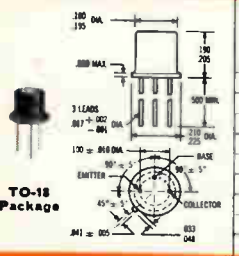
★ MIL-S-19500B/99A (Sig C)

GENERAL PURPOSE SWITCHING TRANSISTORS

2N1336	2.8	40	25	3	190	—	—	TO-5
2N1838	2.0	45	30	4.5	190	40-150	1.4	TO-5
2N1839	2.0	45	30	4.5	170	12- 50	1.4	TO-5
2N1840	2.0	25	20	5	150	10 min	1.4	TO-5

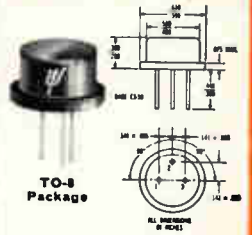
*SEE DATA SHEETS FOR CONDITIONS

VERY HIGH FREQUENCY TRANSISTORS

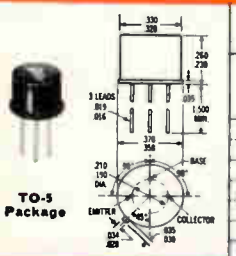


TO-18 Package

TYPE	Total Power @25°C Case Watts	V_{CBO} Min.	V_{CER} Min.	V_{EBO} Min.	Power Gain @ f=30mc Typ.	Power Gain @ f=70mc Typ.	Power Gain @ f=100mc Typ.	Pkg.
PT729	1.2	25	15	5	—	—	15db P_o=.2W	TO-18
2N707	1.0	56	28	4	—	—	8db P_o=.2W	TO-18
2N1338	2.8	80	50	3	18db P_o=0.35W	10.5db P_o=0.35W	7db P_o=0.35W	TO-5
2N1342	2.8	150	125	5	—	13db P_o=0.4W	10db P_o=0.3W	TO-5
2N1505	3.0	50	40	3	10db P_o=1.8W	8db P_o=1.2W	6db P_o=1W	TO-5
2N1506	3.0	60	40	4	12db P_o=1.8W	10db P_o=1.2W	8.5db P_o=1W	TO-5
2N1710	13.0	60	45	3	10db P_o=5W	6db P_o=6W	5db P_o=6W	TO-8
2N1709	13.0	75	60	4	12db P_o=5W	8db P_o=7W	6db P_o=7W	TO-8
PT531	13.0	—	80	4	—	10db P_o=3W	—	TO-8



TO-8 Package

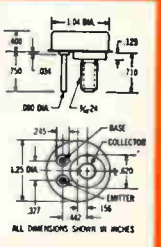


TO-5 Package

HF HIGH POWER TRANSISTORS

TYPE	V_{CBO} Min.	V_{CER} Min.	V_{EBO} Min.	h_{FE}	10mc h_{FE}	f_t mc	5 mc Class C Amplifier Power Out	5 mc Class C Amplifier Power Gain	Pkg.
2N1899	140	100	5	10 min	3	50 min	125W	10db	Single End
2N1900	140	100	5	10-20	3	50 min	125W	10db	Single End
2N1901	140	100	5	15-40	3	50 min	125W	10db	Single End
2N1902	140	100	5	10 min	3	50 min	125W	10db	Double End
2N1903	140	100	5	10-20	3	50 min	125W	10db	Double End
2N1904	140	100	5	15-40	3	50 min	125W	10db	Double End
PT900	80	50	5	10 min	3	50 min	125W	10db	Single End

PSI "Single-Ended" Power Package



ALL DIMENSIONS SHOWN IN INCHES

(SEE PSI TRANSISTOR LITERATURE FOR TECHNICAL DETAILS)

PSI®

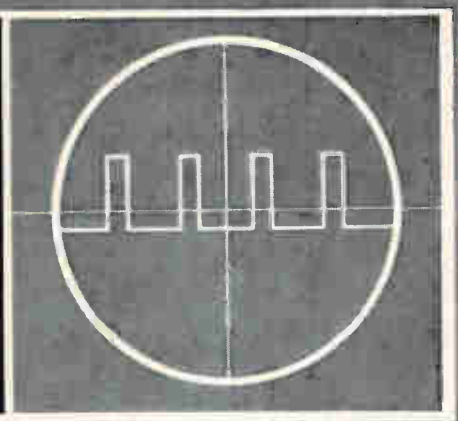
Pacific Semiconductors, Inc.

TRW A SUBSIDIARY OF THOMPSON RAMO WOOLDRIDGE INC.

12955 CHADRON AVENUE, HAWTHORNE, CALIFORNIA

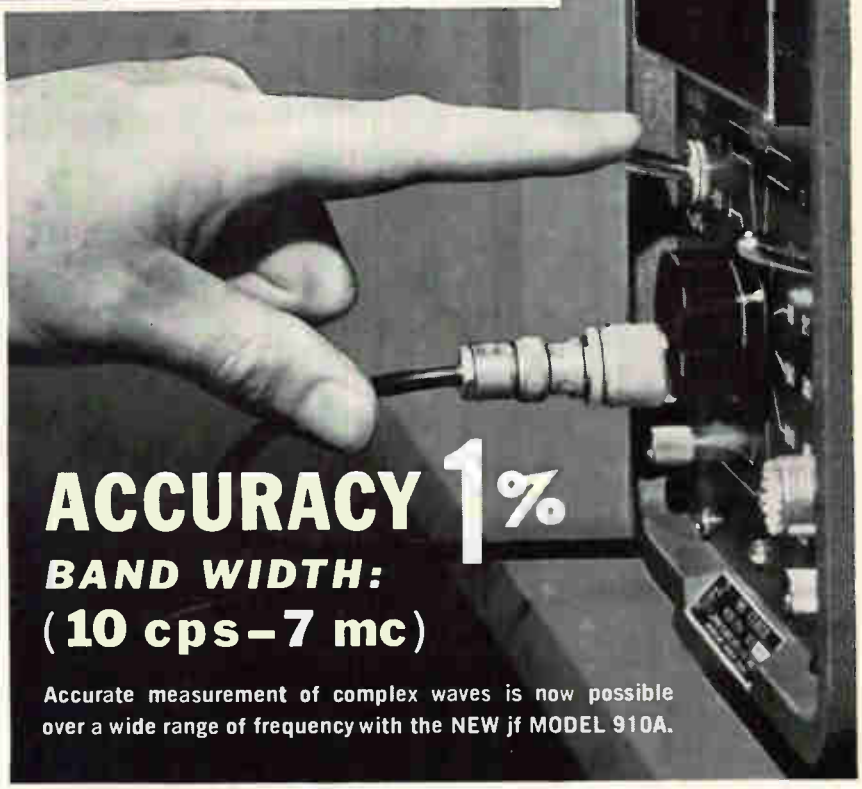
ALL-NEW... TRUE RMS VOLTMETER

now . . . measure true RMS value of virtually all waveforms



FLUKE

MODEL 910A



ACCURACY 1%

BAND WIDTH:

(10 cps–7 mc)

Accurate measurement of complex waves is now possible over a wide range of frequency with the NEW jf MODEL 910A.

For the *first time* one instrument provides 1% midband accuracy, 10 cps to 7mc bandwidth, plus 100 u v sensitivity. For added versatility an amplifier output is provided for simultaneous oscilloscope or recorder monitoring.

Model 910A employs a thermocouple located in the feedback loop of a sensitive DC amplifier to measure the actual heating effect of the input waveform. This circuit arrangement is the key to the rapid response and high calibration accuracy of the Model 910A and also prevents any error in reading due to ambient temperature variation. Isolation of the thermocouple from the input terminals by a high gain, ultra stable AC amplifier provides high input impedance and completely protects the thermocouple from burnout under any condition of overload.

Model 910A is ideal for measuring AC currents in non linear devices, total harmonic content of distorted waveforms, noise, average power of pulse trains, and other measurements that involve waveforms which are not necessarily pure sinusoids.

Partial Specifications–jf MODEL 910A

Voltage Range:	1 MV to 300V (full scale readings)
Decibel Range:	−72 to +52 dbm
Frequency Response:	10 cps to 7Mc
Accuracy:	± 1% of full scale 50 cps to 800 KC ± 2% of full scale 20 cps to 2Mc ± 3% of full scale 20 cps to 3.5 Mc ± 5% of full scale 10 cps to 7 Mc
Input Impedance:	10 megohms shunted by 30 pf for 0.3 volt range and below. 10 megohms shunted by 15 pf for 1.0 volt range and above.
Crest Factor:	3 at full scale, proportionately higher for readings less than full scale.
Price:	Cabinet Model—$545.00 Rack Model—$565.00 Prices f.o.b. factory.

Prices and data subject to change without notice.

A more complete description will be sent to you upon request.

FLUKE

JOHN FLUKE MFG. CO., INC.

P. O. Box 7428 Seattle 33, Washington

IT'S NEW IT'S FROM BRUNING

Five Hundred TRACING PAPER

Here is a new drawing medium truly worthy of your attention. Bruning's Five Hundred is a tracing paper *engineered* for draftsmen—developed after a decade of testing and proving by America's leading supplier to the engineering profession.

Five Hundred tracing paper has all the qualities that valuable drawings need and deserve. More, it has them in outstanding degree: the translucency, the permanence, the surface texture (each side slightly different for individual preference).

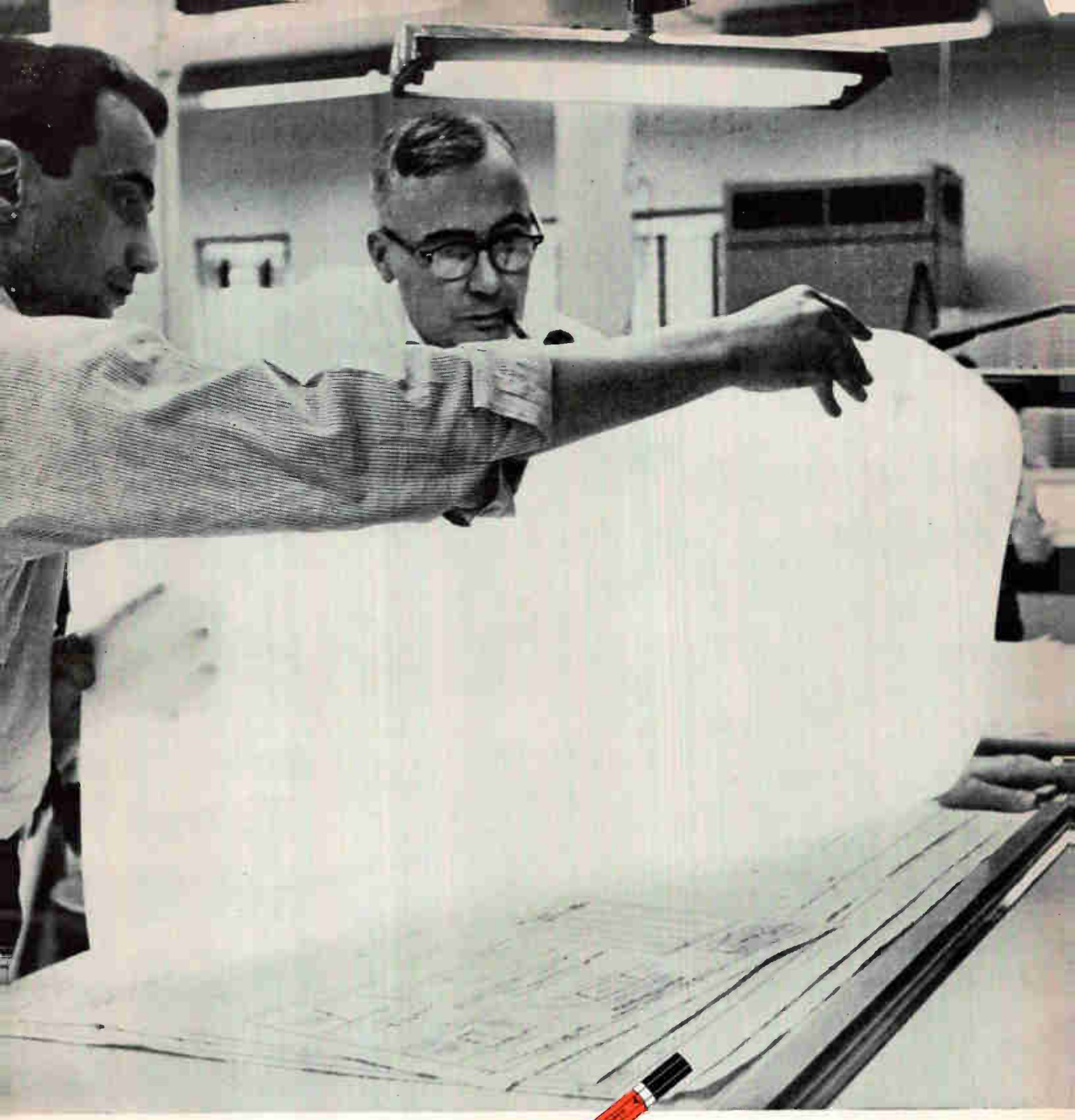
Today, with the costs of engineering drawings higher than ever before, the paper on which they're made should be the best obtainable—and the best is Bruning Five Hundred. Yet, this new drawing medium costs no more than conventional tracing papers.

TRY IT...PROVE IT

The real proof of this new tracing paper is, of course, your own test. So confident are we that Five Hundred will meet your highest expectations, we offer a large trial supply well below our cost. You have your choice of roll or sheets: simply mark the coupon.

BRUNING

CIRCLE 38 ON READER SERVICE CARD



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- JUST ONE DOLLAR brings you the new Five Hundred in your choice of a 10-yard roll (36" wide) or 100 sheets of 8½ x 11—each sells for approximately $3.00.
- AND YOUR FREE BOOKLET! In the course of developing the new Five Hundred, Bruning researchers turned up many facts of real importance to all who use tracing paper. These helpful pointers are yours in a handy guidebook, *"Tracing Paper Characteristics, and What They Mean to You."* It makes interesting reading. Check the box for your free copy.

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Please send materials I have checked below. My dollar (s) is enclosed.

- ☐ 100 sheets Five Hundred tracing paper, 8½ x 11 ($1.00)
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HERE'S ECONOMICAL, SIMPLE ANALOG/DIGITAL CONVERSION *for accurate systems measurements*

DYMEC VOLTAGE-TO-FREQUENCY CONVERTERS—

building-block instruments for high-accuracy voltage measurement, independent of noise or hum

Dymec Models 2210 and 2211A/B Voltage-to-Frequency Converters average out noise and hum to obtain high-accuracy voltage measurement. This is especially advantageous in systems applications. You get higher useful measurement accuracies than with other conversion techniques.

Models 2210 and 2211A/B convert an input dc voltage to a proportional frequency of constant amplitude which is applied to a gated electronic counter to produce a direct digital reading of the input analog voltage. With a longer counter gate time you also can obtain the integral of the input voltage. The DY 5207-1 Converter permits similar measurement of ac input voltages and is programmable for both dc and ac voltage measurements.

In addition to flexible systems use, especially effective in the presence of ac input interference, the Dymec Converter/Counter combination provides an inexpensive digital voltmeter for lab or factory.

Models 2210 and 2211A provide four-digit resolution when used with a 1 second counter gate or three-digit resolution with a 0.1 second gate. Model 2211B provides up to 5 digits of resolution.

Here are brief specifications of Dymec Voltage/Frequency Converters. Call your Dymec/Hewlett-Packard representative or contact Dymec direct for detailed data sheet and application information.

	Dymec 2210/2210R	Dymec 2211AR/BR	Dymec 5207-1
Ranges: (VDC, ±, full scale)	±1 ±.1 ±10 ±1 ±100 ±10 ±1000 ±100 } *	* { ±1 ±.1* ±10 ±1 ±100 ±10 ±1000 ±100 } *	DC { ±.1 1 ±1 10 ±10 100 ±100 750 ±1000 } AC volts, rms, 20 to 100,000 cps
Output Frequency:	0-10 KC	2211AR, 0-10 KC 2211BR, 0-100 KC	0-10 KC
Accuracy:**	±0.06%	2211AR, ±0.02% 2211BR, ±0.03%	±0.06% dc ±0.5%, 50-10,000 cps ±0.75%, 20-100,000 cps
Stability:***	±0.03%	±0.02%	±0.03% dc
Price:	DY 2210, $660.00 (cabinet) DY 2210R, $650.00 (rack)	$1,250.00 (rack)	$1,850.00 (rack)

*Available at extra cost. **Accuracy includes stability, is given in per cent of full scale and is affected by frequency and accuracy of calibration, line voltage variations, temperature changes and accuracy of multi-range input attenuators. Figures given are those attained under normal operating conditions. ***Given as per cent of full scale per 24-hour day.

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

DYMEC

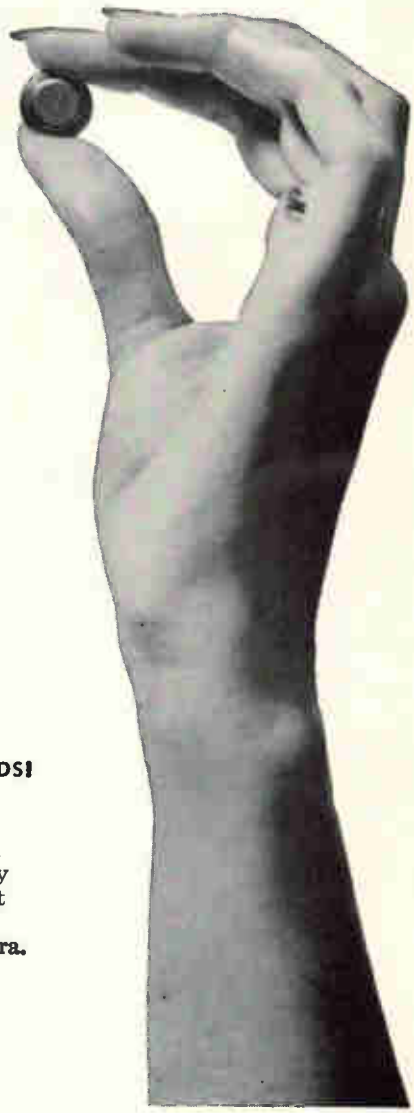
A Division of Hewlett-Packard Company

Dept. E-9, 395 Page Mill Road, Palo Alto, California • DAvenport 6-1755 (Area Code 415)

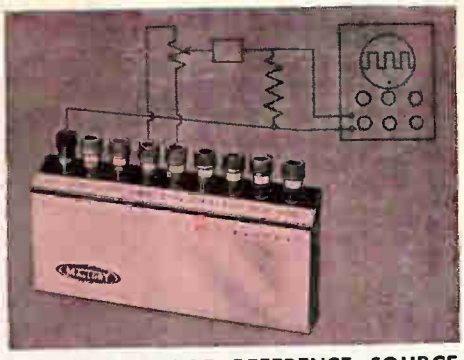
TWX-117-U

PUT EXTRA
SALES PUNCH IN
NEW PRODUCTS WITH –

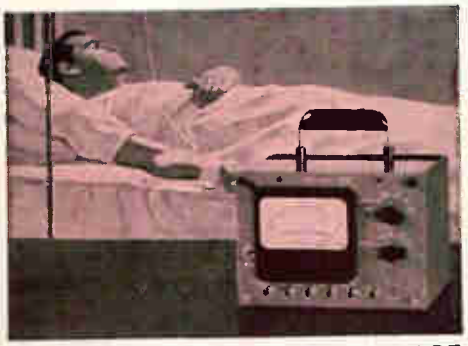
MALLORY MERCURY BATTERIES



FOOLPROOF PICTURES IN 10 SECONDS!
The new Polaroid Electric Eye Land Camera automatically adjusts lens opening and shutter speed. Photo cell circuit is powered by long life Mallory Mercury Batteries, capable of at least one year's service. No chance of corrosive leaks endangering the camera.



PRECISE VOLTAGE REFERENCE SOURCE for instrument calibration and lab tests, Mallory Mercury Reference Battery is accurate within ± ½% of stated voltage. Glass-free, rugged construction. Can't be damaged by overloads. Eight voltage outputs, 0 to 10.8 volts, in 1.35 volt steps.



HYPOTHERMIA PRECEDING HEART SURGERY involves remote measuring of temperatures. The Tele-Thermometer from Yellow Springs Instrument Co., Inc. does this exacting work, with Mallory Mercury Batteries providing needed high electrical capacity per unit size. (2.5 volt cells, .66″ dia. by 1.3″, rated 1000 milliamp-hours.)

FIRST ELECTRONIC TIME PIECE ACCUTRON, by Bulova, guaranteed accurate to one minute per month, is designed to run a full year without battery change. To power the mechanism, Mallory Mercury Batteries assure long life, constant voltage discharge and freedom from gassing and leakage.

Miniaturization . . . portability . . . extra long life . . . name the extra sales factor, and Mallory Mercury Batteries can add it! Want fewer battery changes, longer storage life, fade-free service? Mallory offers far longer life, far higher capacity per unit size than conventional batteries! Batteries must have wide temperature range? Mustn't leak? Make yours Mallory! Their constant discharge voltage is ideal for transistor circuitry, too.

There's a wide availability on a broad line of single or multiple voltage cells. Custom power packs developed on request. Write Mallory, the mercury battery pioneers, for consultation and engineering data.

Mallory Battery Company
North Tarrytown, N.Y.
a division of

P.R. MALLORY & CO. Inc.
MALLORY

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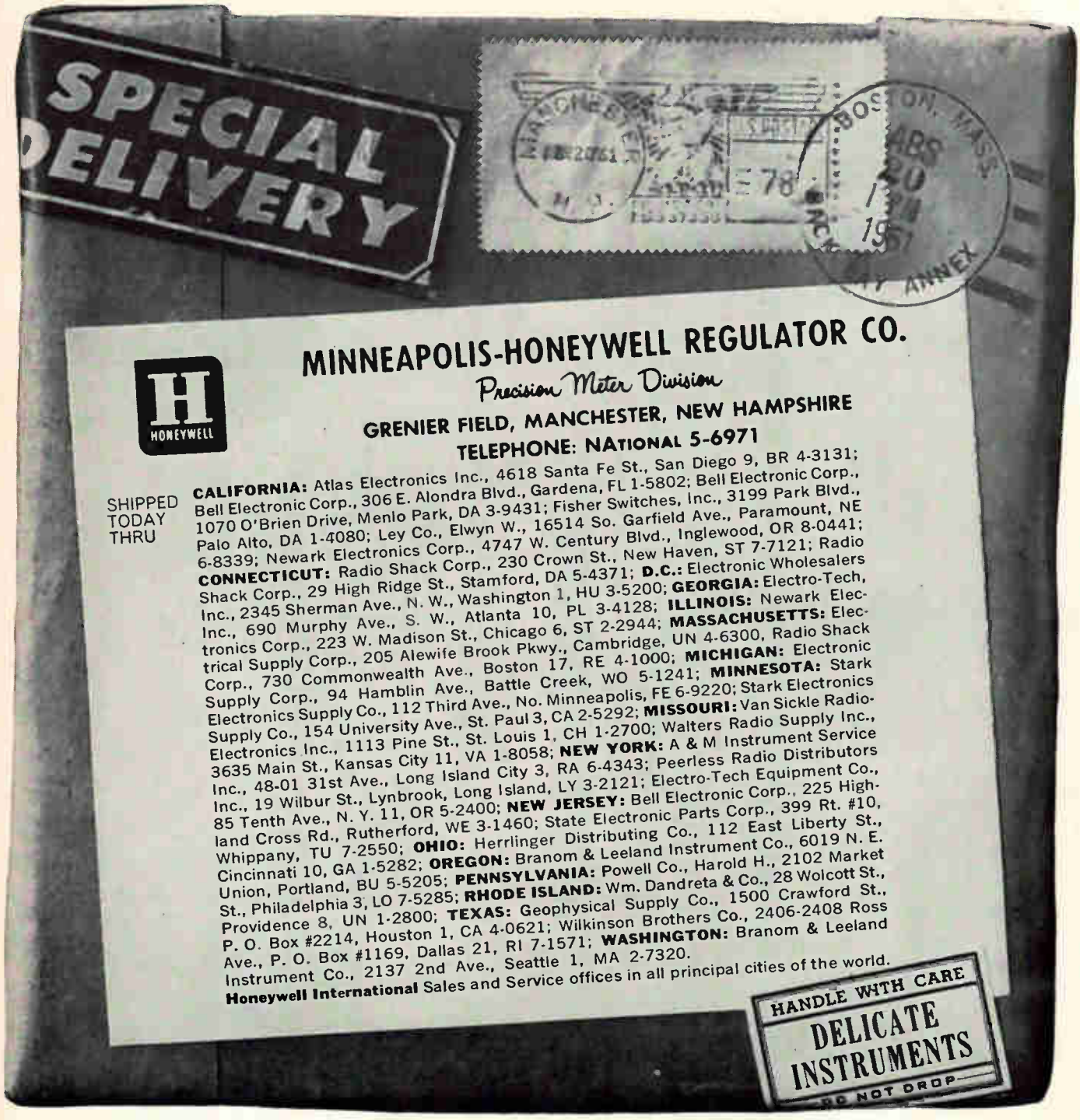

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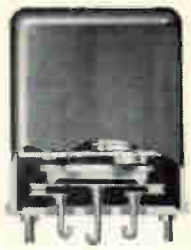

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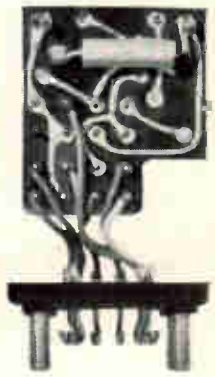

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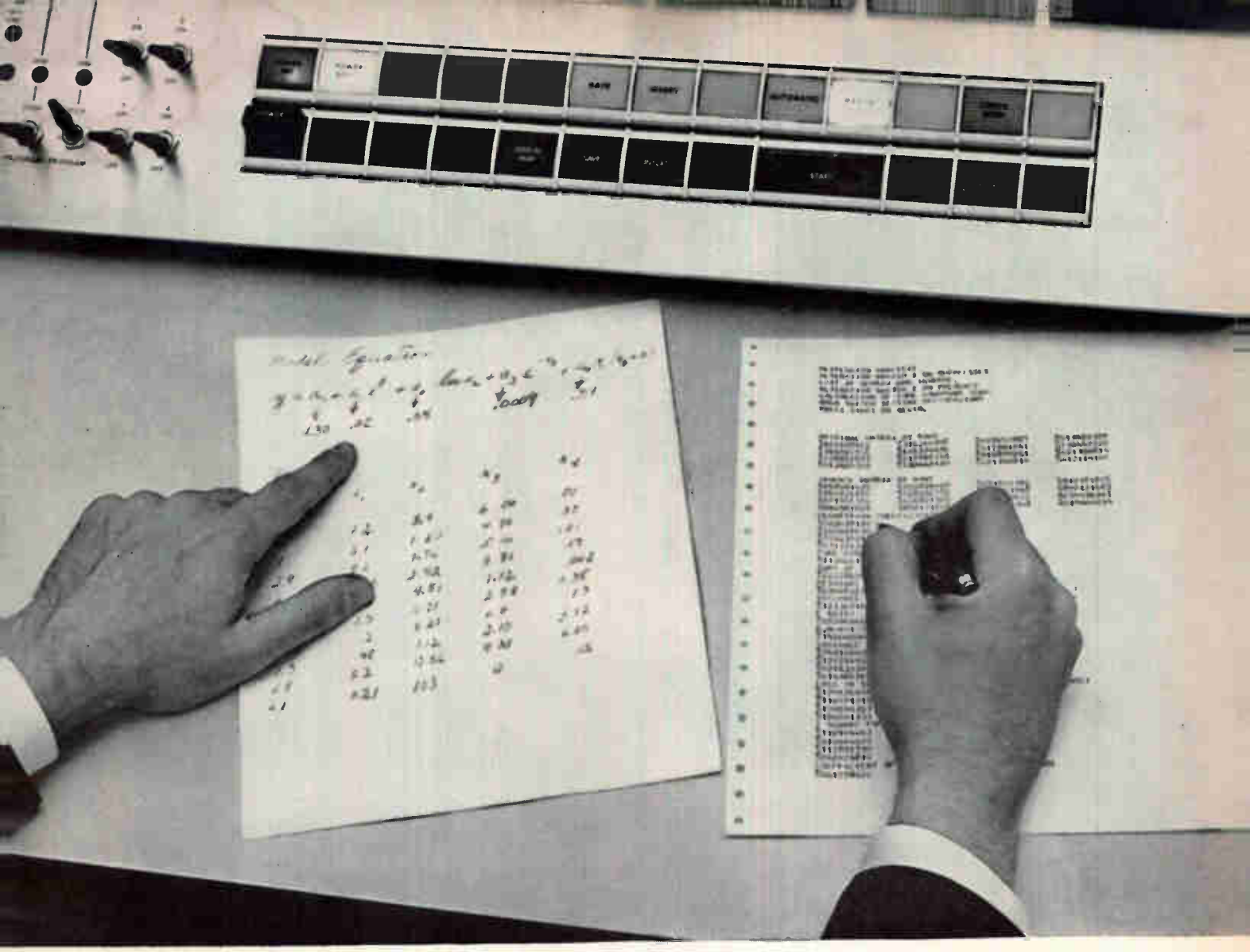

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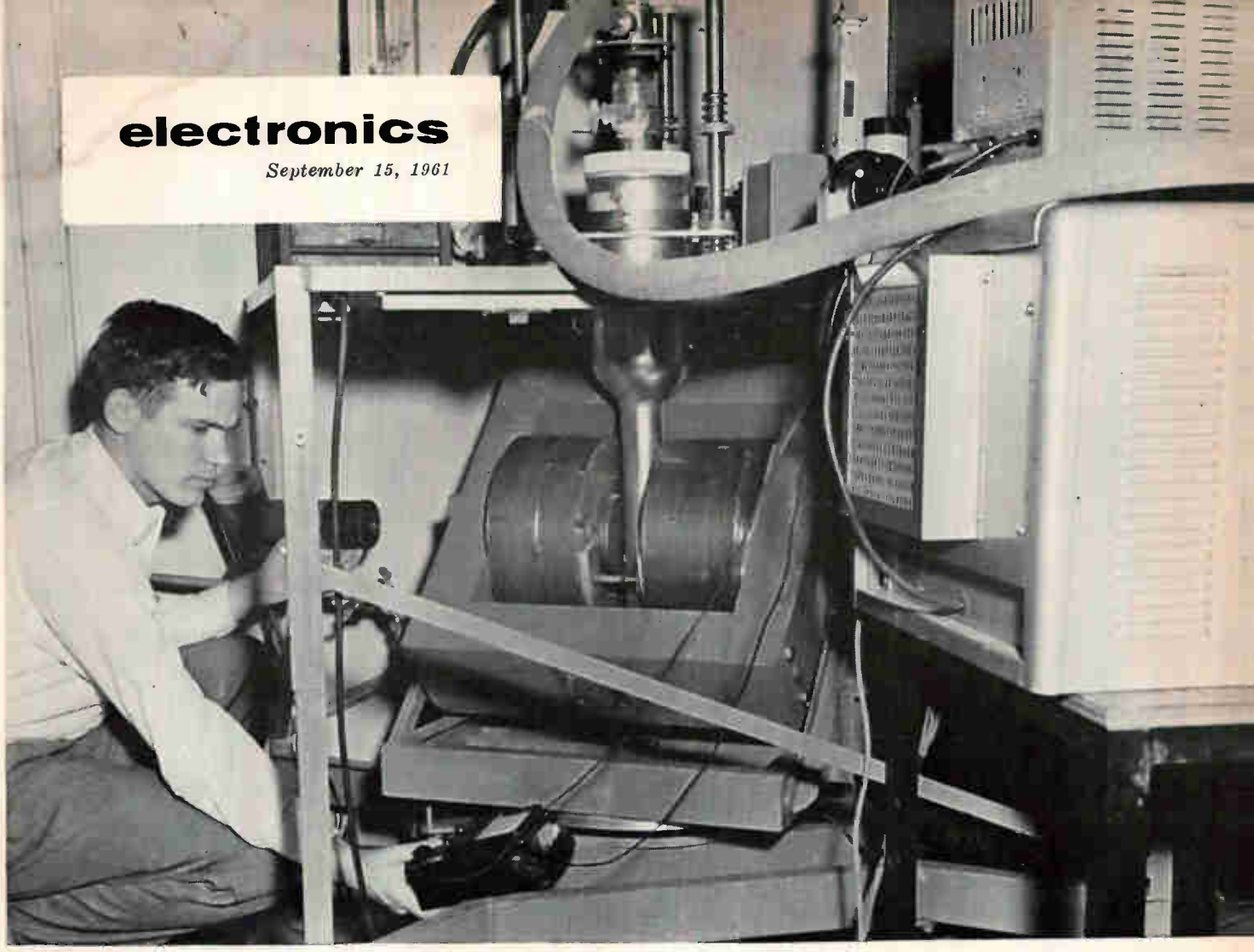

Experimental optical Faraday-rotation/paramagnetic-resonance detector

New Concepts in Detecting Weak Electromagnetic Signals

The weakest signal that can be detected has an energy of one quanta. Scintillation counters, for the X-ray band, are close to the limit of absolute sensitivity

By JAMES Q. BURGESS,*
Antenna Laboratory
Ohio State University,
Columbus, Ohio

IN SCIENCE AND TECHNOLOGY the detection of signals is a primary requirement. The signals may be electromagnetic radiations, sound or pressure waves, chemical changes and particle or vapor emissions. Man's fundamental detectors of signals originating at a distance are sight and sound, with smell playing a smaller role. To the fundamental detectors man has added radar, radio monitoring, ir detectors, sonar, and similar aids, with the output of such devices usually being a visible or audible signal.

Specialized detectors have been developed by plants and animals for detecting other than visible and audible radiations. These mechanisms are of current interest because of their high sensitivity and compactness. Examples include: echo-

* Now with RCA, Cambridge, Ohio.

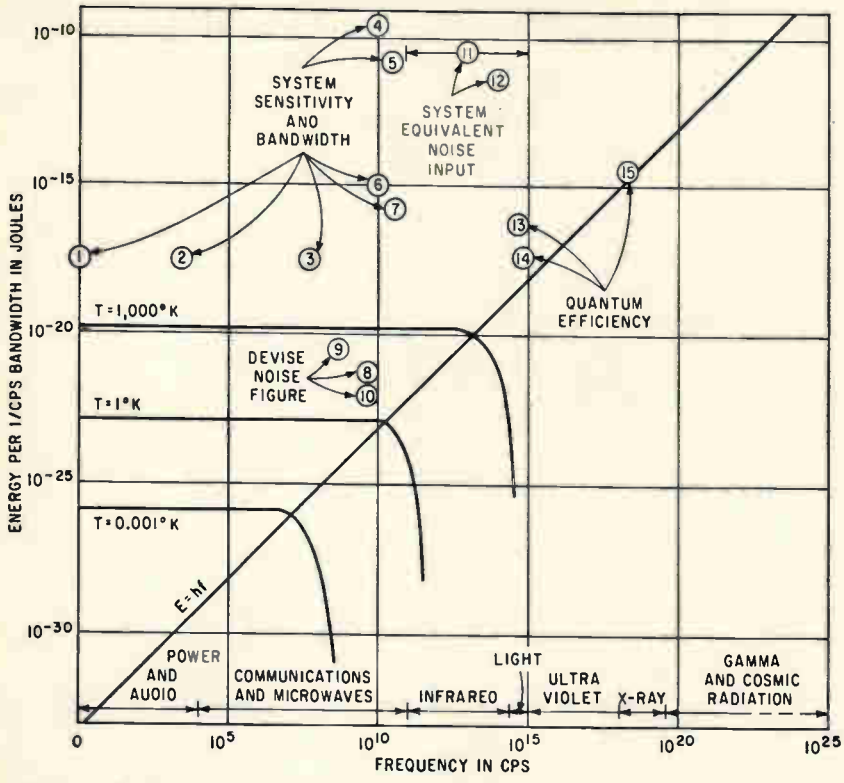

FIG. 1—Systems and devices for detecting electromagnetic radiation are identified in accompanying table. The lines of constant temperature represent equivalent noise power, and place a lower limit on detection

location in bats and dolphins, infrared sensing in the rattlesnake,[1-2] pressure sensing in the venus flytrap, honeybee navigation by polarized skylight, odor sensitivity in dogs and some moths, celestial navigation by the homing pigeon, electric field anomoly detection by electric eels.

In addition to these specialized external sensors, animals possess large numbers of internal sensors such as pressurereceptors, chemoreceptors, thermoreceptors and kinereceptors. Biophysicists since Galvani have known that the central nervous system is organized on electrochemical principles and (more recently) that the transmitted information consisted of electrical impulses. The advent of electronic amplifiers permitted Adrian and Bronk (in the 1920's) to connect a loudspeaker to the optic nerve of an anaesthetized cat and listen to these transmitted impulses. Since then electrosensory physiology has largely been concerned with the stimulus/response characteristics of nerve tissue. In all known cases the mode of information transmission is the same, though the speed may vary widely depending on whether the nerve sheath is insulated or not. For these cases a local response is triggered whenever threshold stimulus is reached. These properties appear to reside in the outer covering of the nerve fiber so that once it is triggered the local response can travel in either direction along the nerve fiber. This behavior suggests that nerve fiber can be represented by an equivalent distributed transmission line consisting of series R, shunt C and a negative shunt R. The negative resistance is explained by the selective permeability of the nerve membrane to Na^+ and K^+ ions and can be used to explain the dual nature of nerve tissue both as a transmission line and as a highly sensitive detector at nerve endings. This negative resistance has been measured by Moore[3] on the giant axon of the squid: the volt-ampere characteristic is similar to that of the tunnel diode.

The negative resistance characteristic is important because it allows the application of theory already worked out for several man-made relaxation detectors such as: superregenerators (vacuum tube, parametric amplifier, maser), bubble and cloud chambers, G-M counters and some solid-state ir counters. These devices go through cyclical energy density fluctuations in which, over some portion of the cycle, the stored energy density has the characteristic.

$$E_{(t)} = E_{(t_0)} \exp [A_{(t,\ E)}\ t] \qquad (1)$$

where $E_{(t)}$ is instantaneous energy density and $E_{(t_0)}$ is energy density at $t = 0$. Term A is a periodic function of t or E, both with an average negative value; A is positive during the active portion of the cycle and negative during relaxation. The large amplification (E_t/E_{t_0}) possible in such detectors depends on the magnitude of the exponent. For large gains ($e^{At} \approx 10^{10}$), slight variations in the exponent may cause undesirably large fluctuations in gain. In biological systems this problem is minimized by using many detectors and correlating their outputs.

As the information is ultimately to be presented to the brain, the problem of detection is primarily one of sensing. For those emanations where man's natural sensors can be used, the problem is simplified. When natural sensors are not available, a chain of detecting devices are used: the input is the desired emanation and the output is one that can excite a natural sensor. This leads to several methods of finding new detection techniques. The first is the historic method in which a successful detection chain is modified through the use of some physical effect (magnetic resonance, Mossbauer Effect, Edison Effect, Faraday Effect) to give an output dependent on the desired input. An example of this is furnished by the present efforts to devise imaging detectors for ir by adding an image converter tube to a television camera. One of the objections to this method of attack is that the overall reliability is less than the reliability of the worst detector in the chain.

A second possibility for improving detection techniques is to use the high sensitivity of natural sensors more effectively. Both the eye and ear have maximum sensitivities in excess of 10^{-15} watt—equal to

or better than any man-made detector except the maser or cooled parametric amplifier. Therefore it should be possible to devise simple detectors whose power gain is as low as −20 db, and still obtain improvement over presently available systems. Examples of work in this direction are the scintillation screen used to view x-rays, and the earphone, used to sensitize the ear to audio signals. In both cases the device is passive (no power gain) and only modifies the original stimulus.

A third possibility is that new ways can be devised to couple presently available detectors to the brain. Of the five senses, only two, sight and hearing, are used for anything other than their original purpose. While no experimental evidence either supports or disproves it, the operation of smell and taste sensors is apparently dependent on chemoreceptors whose impulse frequency is dependent on their local ionic environment. Based on this it might be possible to build a device to slip into the nostrils to detect the presence of radioactive fallout, in much the same way that an electrical arc can be detected by the odor of ozone. On the other hand, beneath the surface of the skin are large numbers of both heat-sensitive and pressure-sensitive nerve endings capable of being stimulated electrically. Because of

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TABLE OF SYSTEMS AND DEVICES PLOTTED IN FIG. 1

1. Chopper-amplifier, Hewlett Packard Model 425A, can detect better than 10^{-6} volt across 10^6 ohms with 0.2 cps bandwidth using optical chopper.
2. Human ear at 2,500 cps. Best reported sensitivity is 5×10^{-17} watt. (Stevens and Davis, *Hearing*, p. 344, Wiley, 1938.) Bandwidth taken as ½ of lowest frequency (24 cps) of action potential in auditory nerve in cat. (O. Glasser, ed., *Medical Physics*, I, p 1,659, Yearbook Publishers, 1950.)
3. Ionospheric scatter-propagation receiver operated at 49.8 Mc with indicated bandwidth of 100 cps can detect 1/10 μvolt across 52 ohm load. (Ta-Shing Chu, Ionospheric Scatter Propagation at Large Scatter Angles, Antenna Laboratory, Department of Electrical Engineering, The Ohio State University, M. S. Thesis, 1 July 1957, AD 245 126.)
4. Barretter operated at 10 Gc followed by 1 Kc center frequency, 4 cps bandwidth amplifier gives −90 dbw sensitivity using Narda 814 bolometer. (Reference given under detector 7.)
5. 1N26 crystal diode operated at 25 Gc followed by 1 Kc amplifier with 4 cps bandwidth. Sensitivity of −100 dbw is reported. (Reference listed with detector 7.)
6. Synchronous detection with hybrid tee and narrow band audio amplifier gave −144 dbw, 4 cps bandwidth. (Reference listed with detector 7.)
7. D. Yaw, A K-Band Superhetrodyne System Using a Rotating Guide Phase Shifter, Report 444–19, Antenna Laboratory, Department of Electrical Engineering, The Ohio State University, 15 Feb. 1955. (Describes 25 Gc system with 4 cps bandwidth whose maximum expected sensitivity is −150 dbw.)
8. M. Uenohara and W. M. Sharpless, An Extremely Low-Noise 6-KMc Parametric Amplifier Using Point-Contact Diodes, *Proc IRE*, 47, p 2,114. (The device noise figure measured at 90 degrees K for double-sideband operation was 0.3 db; this represents an excess noise figure of 21 degrees K.)
9. Wade, Low-Noise Amplifiers for Centimeter and Shorter Wavelengths, *Proc IRE*, 49, p 883 May 1961. (S-Band twt's reported with noise temperatures as low as 250 degrees K.)
10. R. W. DeGrasse, H. E. D. Scovil, Noise Temperature Measurement on a Traveling-Wave Maser, Appl Phys 31, p 443. (Device noise temperature of 10.7 K at 5.81 Gc averaged over 37 measurements in 30 minutes.)
11. *Proc IRE*, 47, p 9–64A, Sept. 1959. (Advertisement for Eppley Laboratories Inc., Newport, R. I. states Golay cell sensitivity of 6×10^{-11} watt rms equivalent noise input flat from microwaves to ultraviolet. Time constant 1.6 sec.)
12. *Proc IRE*, 47, 9–53A, Sept. 1959. (Advertisement for Honeywell Military Products Group, Hopkins, Minnesota describing PbTe detector coupled to 77 degrees K operated at wavelength of 4.3 microns with 1 cps bandwidth whose sensitivity for unity s/n ratio is 7×10^{-12} watt.)
13. O. Glasser ed., Medical Physics, 1, p 1,659, Yearbook Publishers, 1950. ("human eye . . . energy for visual excitation has repeatedly yielded results of the order of 100 quanta, varying between 58 and 148, using blue-green light . . . Due to scattering and losses in the eye . . . the actual effective number is 5–14".)
14. Sproull, "*Modern Physics*", John Wiley and Sons, p 449, 1956. (". . . photocathode efficiency of about 1/20 electron per photon.") Condon and Odishaw, eds., "Handbook of Physics," p 8, p 66, McGraw-Hill Book Co., 1958. (Multiplier phototube photocathode efficiency approaches 10^{-1}.)
15. J. Taylor and W. Parrish, Absorption and Counting Efficiency Data for X-Ray Detectors, *Rev Sci Inst*, 26, p 367, April, 1955. (presents data on relative efficiencies of G-M, proportional, and scintillation counters to show that scintillation counters are best detectors of X-rays with 90–99 percent efficiency.)

Cryostat of superconducting bolometer is in the foreground

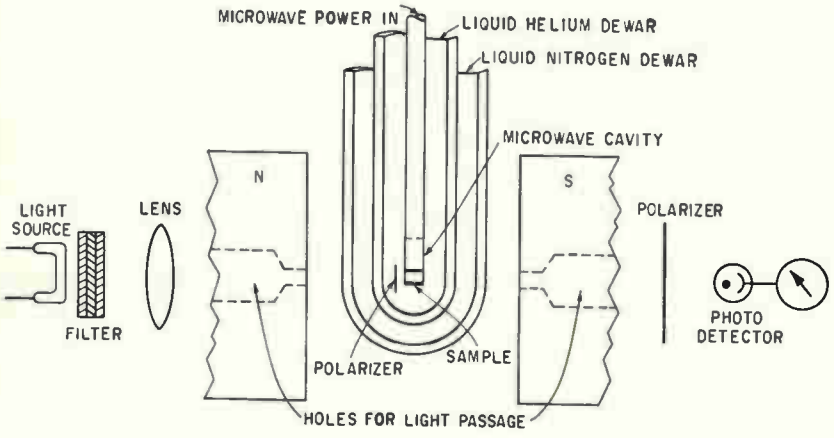

FIG. 2—Optical Faraday-rotation/paramagnetic-resonance detector has narrow-band resonance, no frequency restriction below ultraviolet, estimated initial sensitivity of 10^{-10} watt

this it may be possible to sensitize the observer to a wide variety of external stimulii by placing detecting electrodes on the skin.

The chart shown in Fig. 1 compares known detectors with known limits of detection. The limits of detection are considered to be set either by the impossibility of detecting energy in units smaller than one quanta or by the black body radiation falling on the primary detector. This black body radiation $[E = hf/(e^{hf/kT} - 1)]$ is obtained from the part of the Planck radiation equation dealing with linearly polarized radiation in a single mode from a quantized harmonic oscillator and reduces to the familiar $E = kT$ where $kT >> hf$. The slant line in Fig. 1, $E = hf$, represents the energy due to one quanta per second of intercepted radiation, and provides the lowest possible energy to which a detector with a 1 cps bandwidth could respond. The quantum efficiency of a particular detector is obtained from the ratio of the energy sensitivity per unit bandwidth to hf, or from the length of the ordinate separating the $E = hf$ line and the point representing the detector.

Energy sensitivity of various detectors have been plotted by four different methods, depending on the available data. Some detectors are plotted from system sensitivity and bandwidth; others use system equivalent noise input, device noise figure, or the quantum efficiency.

When overall systems are involved, the maximum sensitivity both for biologic detectors and man-made detectors seems to be between 10^{-17} and 10^{-18} watt. The three detectors appearing below this level are plotted on the basis of the device noise figure, so their apparent superiority depends on their outputs being passed through noise-free channels. Over the interval between 10^{11} to 10^{14} cps (ir), the available detectors are less sensitive than those above and below by as much as seven orders of magnitude. Even the ir sensors in rattlesnakes appear to be appreciably less sensitive than other natural detectors such as the eye and ear. This frequency band is important because it contains most of the thermal radiation of man and machines.

Several devices or schemes have received some attention in the laboratory because they involve either a new physical principle, extreme simplicity, or extreme sensitivity.

The schematic of an optical Faraday rotation versus paramagnetic resonance detector is shown in Fig. 2. A photograph of the apparatus is also shown. The detector was adapted from a method used by J. M. Daniels and his coworkers[4] at the University of British Columbia for measuring the spin lattice relaxation time in neodymium ethylsulphate. Its attractiveness is primarily due to its lack of frequency restriction below ultraviolet, while retaining narrow band resonance. Its initial sensitivity has been estimated at 10^{-10} watts but this can probably be improved.

The physical principle involved is the dependency of the rotation of plane-polarized light on the average magnetic moment of the crystal. This may be described as

$$\theta = A_1 \tanh \frac{\mu H_a}{k T_s} + B_1 H_a \qquad (2)$$

where H_a is the applied magnetic field, A_1 and B_1 are constants, μ is the electron spin magnetic moment, k is Boltzmann's constant (1.38×10^{-23} joules per degree K), T_s is the effective temperature of the spin system and θ is the optical rotation in degrees per mm. The first term describes the paramagnetic contribution to rotation, the second term describes the dimagnetic contribu-

tion. In the detector the magitude of the first term is altered by making T_s dependent on the microwave input power.

If the electronic spin states of the crystal are Boltzmann distributed as in Fig. 3A, T_s describes the equivalent temperature of the spin system. By adjusting the magnetic field for microwave resonance between a pair of levels, microwave power is absorbed and the upper state population is increased at the expense of the lower state. This pumping action increases the average spin temperature of the crystal, causing a net change in magnetic moment and thereby a net rotation of the plane of optical polarization. The limit to this process occurs when no more energy can be absorbed so that these levels (2-3 in Fig. 3B) are said to be saturated. For a two level spin system, saturation corresponds to infinity spin temperature and a population inversion corresponds to negative spin temperature, which is the necessary condition for a maser.

The Faraday-rotation/paramagnetic-resonance detector, Fig. 2, can be considered as the combination of an electron paramagnetic resonance spectrometer and an optical polarimeter. The polarimeter consists of an incandescent source, collimating lens, Polaroid polarizer, paramagnetic crystal with its c axis parallel to the optic axis, a Polaroid analyzer and a multiplier phototube detector. That portion of the dewar flasks in the optical path is left unsilvered. The paramagnetic spectrometer consists of a microwave cavity with the crystal at a point of H_{r-f} max immersed in a liquid helium bath and a strong magnetic field. In operation, the microwave power reflected from the cavity is measured as a function of the external magnetic field, H_{d-c}. The electron spin resonance appears as a change in the cavity absorption for critical values of H_{d-c}.

Figure 3C shows the typical optical rotation as a function of H_{d-c} to be expected with the microwave input power as a parameter, using a two level crystal. For a CaF_2 crystal using 0.67 percent Eu^{++} doping, rotations as large as 17 degrees have been measured at 1.6 degree K with a relaxation time of $\approx$ 200 milliseconds. Using dark ruby (1.5 percent Cr^{+++}) the results are 2 degrees and 200 milliseconds.[6]

A microwave radiation pressure detector is shown in Fig. 4; the pencil in the photograph is pointing at the flexible cavity wall. The microwave energy entering the cavity has its E field parallel to the b dimension of the waveguide. By enclosing the end of the guide in a cavity the electric field is intensified by the Q of the cavity. The coulomb force due to this field then distorts the piezoelectric cavity-wall so that the voltage between the piezoelectric plates becomes a measure of the microwave power. Assuming a wall deflection $<<b$, the total force on the cavity face is given by

$$F_y = \frac{QP}{\omega b} \qquad (3)$$

where Q is the unloaded cavity Q, P is microwave input power, ω is microwave angular velocity, and b is the cavity dimension parallel to E vector.

For 1 mw of 10 Gc power incident on a cavity whose Q is 10^4 using 1 × ½ inch waveguide, the force is approximately 10^{-8} newtons. While this force is small and difficult to detect by d-c means, it can be detected by making it vary in resonance with the piezoelectric plate. In this scheme the motion of the cavity wall produces only second order detuning of the cavity because its movement is along the noncritical dimension. An estimate of the ultimate sensitivity is obtained by assuming crystal and cavity Qs are equal, thus the power dissipated in the crystal is equal to that dissipated in the cavity. With present techniques it is possible to detect energy levels in piezoelectric crystals as low as 10^{-17} watt, so it should be possible to detect microwave signals as low as 10^{-18} watt.

The microwave radiation pressure detector has been operated with aluminum foil diaphragm (shown in Fig. 4) instead of a piezoelectric crystal. With approximately 20 milliwatts of 10 Gc radiation modulated near 1 Kc, feeble sounds could be heard coming from the foil surface. When the modulation frequency was varied the sound simultaneously varied in pitch. This demonstrates only the physical effect, not the practicability of such a scheme. Other variations of this scheme are possible. One of these, shown in Fig. 5A, uses the torque induced in a dielectric rotor by a circularly polarized wave to operate a torsion galvanometer. Another scheme[7] involves a shift in the frequency of a torsional pendulum whose rotating mass consists of a metallic ellipsoid making small excursions about the equilibrium position where the ellipsoid axis and

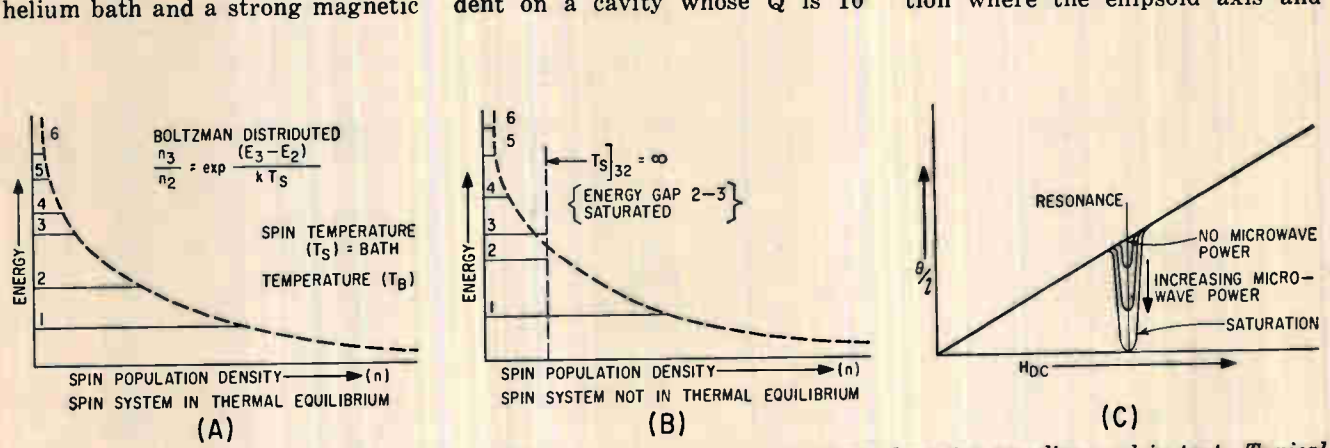

FIG. 3—Electron spin population (A) and (B) and its relation to microwave detection are discussed in text. Typical optical rotation of a 2-level crystal as a function of applied d-c field (C)

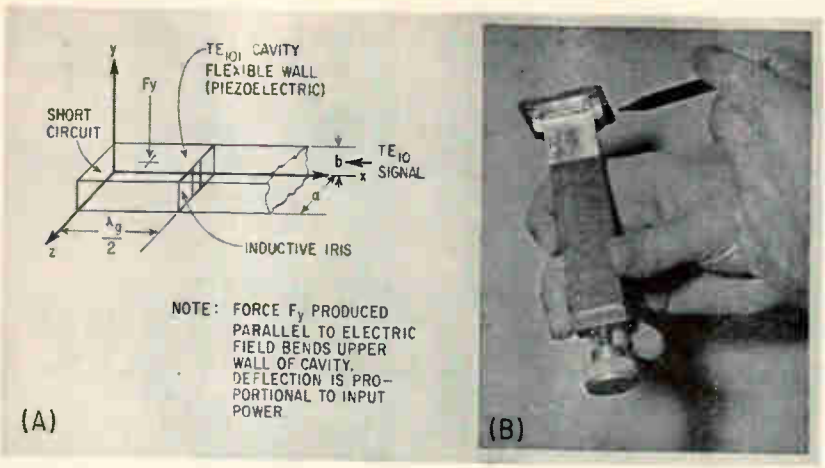

FIG. 4—Microwave radiation pressure detector (A). Aluminum foil wall in experimental unit (B) detected 1-Kc modulation on 10-Gc signal

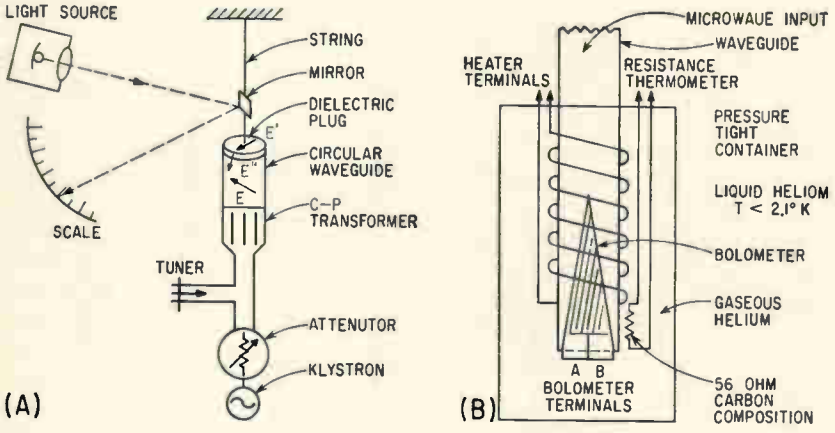

FIG. 5—String galvanometer detects microwaves by developing torque in dielectric rotor (A). Cryogenic bolometer (B) has theoretical possibility of detecting microwaves at 10^{-15} watt

the E field are parallel. Cullen and Stephenson[8] devised a mocrowave wattmeter using the tendency of a conducting vane to align itself with the microwave E field. This device is commercially available with a minimum detectable power level of 1/10 watt.

The change in conductivity of certain materials due to the influence of radiation heating has long been used for the detection of such radiation. Since the sensitivity of such a device depends on the ratio of conductivity change per unit heat input, the use of superconducting materials with their small specific heats and large temperature coefficient of resistance can greatly increase the sensitivity of a bolometer detector.

Figure 5B shows a schematic of this type device for detecting microwaves. The heater is used to keep the temperature of the superconducting element at the point of maximum sensitivity. The photograph of the experimental bolometer shows the cryostat containing the liquid helium in the foreground and various components of a resistance bridge in the background. Experimental sensitivity of this device so far has not exceeded 10^{-10} watt, although its predicted maximum sensitivity is 10^{-15} watt.[9]

In general, these are other schemes and devices whose unusual properties may be of value in constructing new or unusual detectors.

It has been suggested that if gravitational waves could be generated they would propagate through all known materials, including the earth. Figure 6 represents a hypothetical mechanism, based on Newtonian mechanics, for producing such radiation. Two masses m_1 and m_2 are arranged to oscillate along a line joining their centers. The point p, located at some distance from the center of mass, will be in the gravitational fields of both m_1 and m_2. If these fields travel at a finite velocity there should be a lowest frequency of vibration for which the gravitational field at point p will have a time varying component along the axis at the vibration frequency, even though the center of mass remains fixed. This scheme is based on Cavendish's experiment in which the gravitational constant is determined by the frequency shift of a torsional pendulum when the average distance between large masses is varied.

The property of some crystals to emit light or heat in proportion to their previous x and γ radiation dosage is called thermoluminescence. It is interesting because of its passive nature and long memory. Because energy is needed only during readout, this effect could be used as a remote sensor for periodic readout.

In connection with recent work on optically pumped atomic resonance devices, several workers have proposed a scheme that in effect allows the one-to-one exchange of a low energy radio frequency photon for a high energy optical photon, with an energy gain dependent on their frequency ratio.[10] If optical pumping is used to populate level 6 (see energy level diagram, Fig. 3A) at the expense of level 1, and the relaxation time between levels 1-2 is much longer than the relaxation time of levels 2-6, the amount of pumping energy absorbed will depend on the stimulated emission of levels 2-1. An alternate method is to measure the absorption of pumping energy between levels 2-6 as a function of the radiation impinging on levels 1-2. For this scheme level 2 is depopulated by the pumping radiation and repopulated by the radiation to be detected and by the relaxation process.

The secondary emission process is of interest because of the possibility of building devices with large

gain-bandwidth products and moderate power consumption. Photo multiplier tubes commonly have current gains of 10^6 and quantum detection efficiencies as high as 20 percent, while requiring less than one watt of d-c power. In conventional vacuum tube video amplifiers the upper frequency limit is set by the equivalent R-C product in the plate circuit. In secondary emission devices the R-C product is negative, so the gain tends to rise with frequency.

Almost without exception man-made sensors channel their information through either the eye or ear. For work in potentially dangerous environments (nuclear reactors, gas producing mines, intense microwave fields, etc.), for which natural sensors are unresponsive and conventional man-made detectors are cumbersome, it may be possible to devise small detectors which couple to the nerves in the skin. Such detectors would have a pulsed electrical output—similar to nerve action current—thereby eliminating the weight and bulk of transducers such as headphones, loudspeakers, bells, flashing lights, galvanometers and cathode-ray tubes.

Conventional bolometer circuits generally detect the change in resistance of the bolometer element as a function of the amount of radiation falling on the detector, by using a bridge circuit nulled at zero radiation. It appears that a simple relaxation detector could be built using a bolometer as the sensitive element. During excitation, thermal energy is added in proportion to the increase in thermal energy over ambient; during relaxation the bolometer element is allowed to cool back to ambient temperature. Such a scheme has the exponentially increasing sensitivity

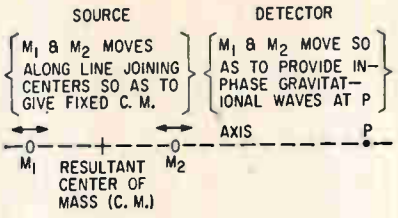

FIG. 6—Gravitational waves, if they can be produced and detected, would travel through all known materials

function discussed in connection with Eq. 1, and could be considered as a superregenerative thermometer.

Since the introduction of the superregenerator by Armstrong[11] in the 1920's, there have been no fundamental changes in this simple yet highly sensitive detector. Its limited use at present is due to its poor selectivity, high noise figure, fluctuating gain and re-radiation. All these effects except re-radiation are attributable in some way to the net circuit resistance as a function of time. It is possible that some of the newer low-noise devices such as masers, tunnel diodes and parametric amplifiers could be used to minimize the noise figure, while the poor selectivity and fluctuating gain could be improved by careful selection of the net circuit losses as a function of time. Finally, operation at d-c is possible, as in nerve tissue, if the LCR equivalent circuit of the superregenerator is replaced by an L-R or R-C circuit alone. For this case the net resistance is composed of both a negative and positive resistance, in varying amounts, and the energy stored in the reactance follows Eq. 1.

Some gases, such as NH_3, have microwave absorption lines that show a marked pressure change under the influence of this radiation. It is possible that this effect may have application in the detection of these frequencies.[12]

The purpose of this work has been the investigation of new or unusual detection techniques. As a consequence, a general survey of detection techniques, including biological techniques, and detector sensitivities was made. Of the possibilities that have been explored, the Faraday-rotation / paramagnetic-resonance detector appears the most promising. Its special interest is that it appears to be the forerunner of a class of detectors based on atomic resonance which can cover the gap between near ir and the upper microwave frequencies. The far ir is especially important because the thermal radiation emitted by man and man-made devices falls in this range. The piezoelectric radiation-pressure device can probably be made to operate in their region but may be difficult to tune. In general, radiation pressure offers an alternative method of detecting electromagnetic waves when no other means are available.

But when a system combining extreme simplicity and high gain is required, detectors of the relaxation type can be surprisingly effective. Use of the relaxation methods is especially effective in nerve nets, and these nerve nets can serve as excellent models and examples for the construction of small lightweight detectors. In this view it might be concluded that the combination of relaxation detection with atomic resonance techniques could provide a sensor for electromagnetic radiation that would closely approximate the ideal detector in terms of sensitivity, simplicity, selectivity, small size and efficiency.

The work was supported by Air Force Contract 33 (616)6849, Aeronautical Systems Div.

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Industrial Fluoroscopic Inspection By

Electroluminescent X-ray converter gives higher brightness than conventional fluorescent screens, or alternatively, permits lower intensity X-rays to be used for the same brightness

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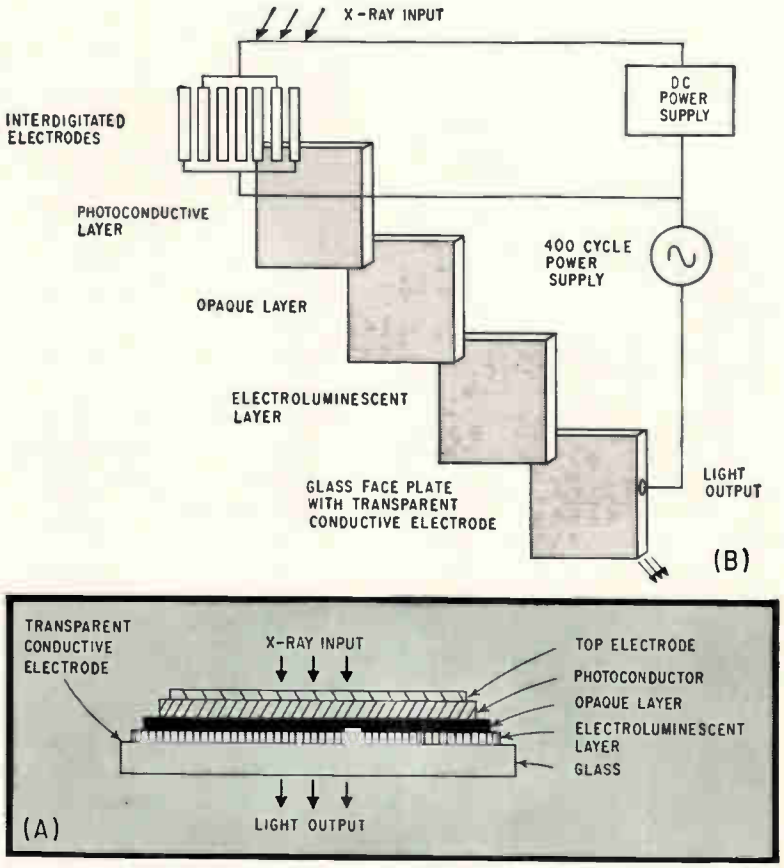

FIG. 1—Arrangement of layers in basic converter (A) and schematic of the converter and its power supply, using interdigitated electrodes for erasing latent image (B)

ELECTROLUMINISCENT light panels are used as character and numeric readouts in computer devices, as self-luminous dials and indicators in instrumentation and as diffuse illumination sources for general lighting. In addition, electroluminescent layers have found application as a solid state amplifier for the visual display of X-ray images.[1, 2]

One disadvantage of common fluoroscopic X-ray screens is low output brightness. To overcome this defect, higher X-ray excitation energies may be used, but they then affect the ability of the eye to perceive minute image detail. In comparison, the electroluminescent X-ray intensifier offers increased output brightness of several orders of magnitude, together with improved resolution and contrast, at operating energies in the 150 to 500 Kvp X-ray range.

Some of the earliest work in the field of X-ray intensification using solid state elements was done by White in the 1930's. However, development of the first practical electroluminescent imaging device was first reported in 1955 when Diemer, Klasens and Van Santen described an X-ray amplificon, which consisted of an input layer of cadmium sulfide in conjunction with a zinc sulfide electroluminescent surface.[3] The basic features of the e-l X-ray intensifier as it is known today were developed by Kazan and Nicoll.[4] Figure 1 shows the constructional and schematic arrangement of the sandwich and interdigitated electrode type intensifiers.

FIG. 2—The 6 inch by 6 inch electroluminescent converter panel and viewing screen

Early in 1958, development of the sandwich type intensifier into an industrial device for use in X-ray

Electroluminescent X-Ray Converters

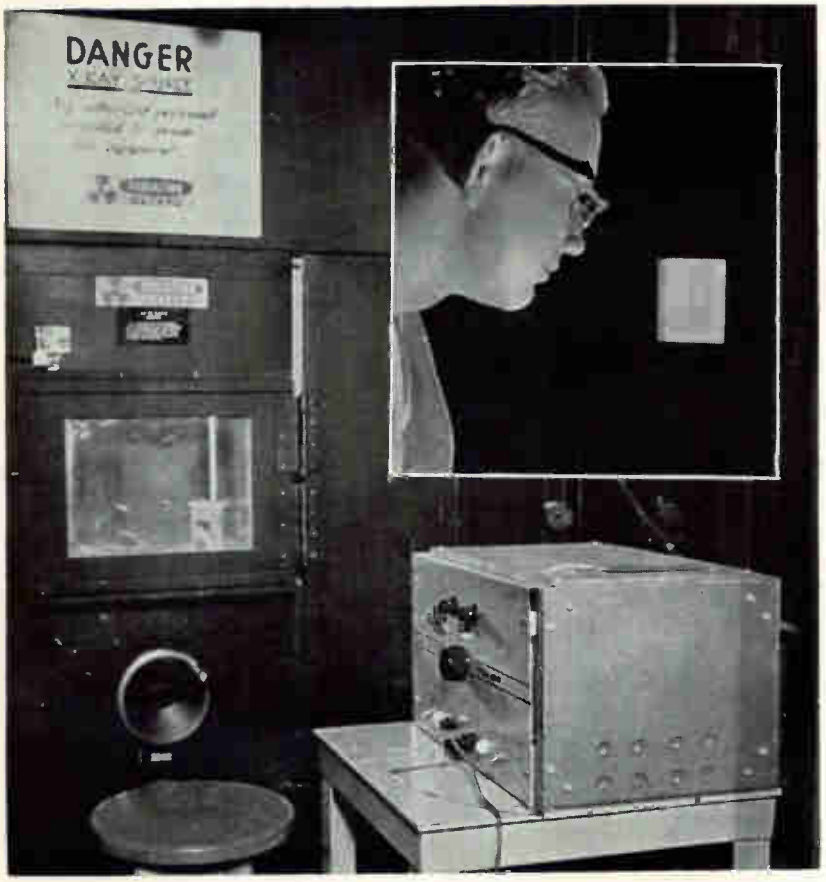

FIG. 3—Lead cabinet containing X-ray sources is fitted with lead-glass viewing window. Inset shows engineer viewing the electroluminescent screen, with an image just discernible in its center

fluoroscopy was started and has resulted in a high resolution thin profile X-ray intensifier. Figure 2 pictures a 6 inch × 6 inch version of the new industrial intensifier, encapsulated in a thin bakelite case. A modification of this design incorporates a thin sheet of lead as a secondary intensifier. This type device has also been constructed in a 12 × 12 inch size for larger inspection jobs.

In a broad sense, the phenomenon of electroluminescence is not basically different from the luminescence observed in fluorescent materials.[5] For electroluminescent sources the exciting agent is an alternating electric field. In a simple configuration, the phosphor is embedded in an insulating layer positioned between two conductive electrodes. When an alternating voltage is applied between the conducting electrodes, it sets up an electric field, and excites the phosphor layer, resulting in light emission. In the electroluminescent X-ray intensifier, a stratum of photoconductive cadmium sulfide is sandwiched between the e-l layer and the top electrode (Fig. 1A), while an opaque film over the e-l layer eliminates excitation from visible light.

Photoconductive material is nonconducting in the dark but conducts when exposed to X-rays. When conducting, the photoconductor applies a voltage to the e-l layer, which in turn emits visible light. Another important property of the photoconductor is its ability to absorb X-ray photons. For cadmium sulfide, the mass absorption coefficient is 12.9 for a 30-Kvp X-ray source. This compares with a coefficient of 25.4 for cadmium selenide using the same X-ray sources. Cadmium selenide, however, has only been used on an experimental basis due to problems of formulation and application. The high resolution intensifier uses a sprayed photoconductive film 0.0085-inch thick. Theoretically, an increase in thickness results in greater X-ray absorption and subsequent conversion.[6] Difficulties encountered in curing and uniformity have optimized this thickness at about 8 mils for the present state of the art.

The interdigitated electrode intensifier, shown schematically in Fig. 1B has been investigated for its ability to eliminate latent images that degrade the resolution of the sandwich type intensifier under dynamic conditions of operation. The image persists when the photoconductor is driven to an excessive state of excitation by large doses of X-rays; latent images are then displayed after the excitation is removed, and are due to this prolonged state of excitation. Erasure is accomplished by a d-c clearing voltage, applied across the interdigitated grid and bottom electrode as shown in Fig. 1B. The clearing voltage, in effect, drives the photoconductor to a state of non-conduction, removing any persistent display of light.

Perhaps the best known use of fluorescent screens is in the field of medical therapy. In the energy range from 30 to 110 Kvp, the conventional medical fluorescent screen offers advantages of time and material economy. Film techniques, however, are still relied upon for the ultimate in critical examinations. Use of experimental electroluminescent X-ray intensifiers in medical radiology has been reported and found useful under certain conditions.[7] Factors that limit application of conventional fluorescent screens using X-ray energies above

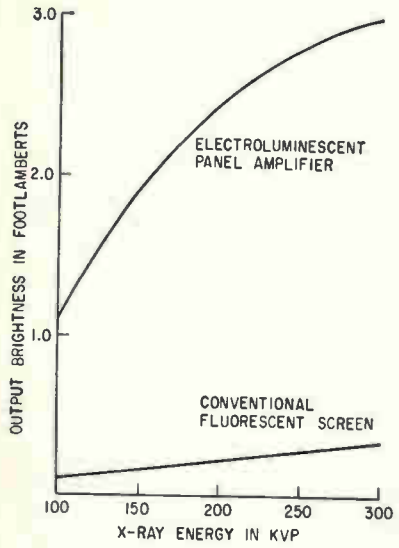

FIG. 4—Characteristics of the electroluminescent viewing method compared with the conventional fluorescent screen

110 Kvp are generally considered to be insufficient output brightness, with subsequent reduction in resolution and sensitivity.[8] (See Fig. 4.) At X-ray energies in the 150 to 500 Kvp energy range the electroluminescent X-ray intensifier offers definite advantages over the standard fluorescent screen. Among these advantages are greater output brightness, operator control of image brightness to suit viewing conditions, and high gamma-in-increased image contrast. The e-l panel amplifier also affords the greatest potential advantage of future development, especially with respect to forthcoming improvements in the photoconductor.

Practical use of industrial fluoroscopic image devices has been investigated in general by the Physical Sciences Laboratory of the U. S. Army Ordnance Tank-Automotive Command.[9] An arrangement for direct viewing fluorographic images is shown in Fig. 3. A lead cabinet houses X-ray tubes that provide safe operation up to 300 Kvp. An attached observation booth with a protective lead-glass window gives the operator a direct view of the specimen under test.

The operational performance of the electroluminescent X-ray image intensifier in the 50 to 300 Kvp energy range is evaluated in terms of the following factors. Output brightness, resolution, contrast, unsharpness or blurring, sensitivity, and dynamic fluctuation, or speed. Resolution, contrast, and sensitivity are measured with the standard radiographic penetrameter, which is a small metal plate material radiographically similar to the specimen itself, and which is usually perforated. Its thickness is a definite proportion, say 2 percent of the specimen thickness, while the hole diameters are $2T$, $3T$, and $4T$, where T is the penetrameter thickness. Radiographic penetrameters can therefore be used to measure: contrast—differences in densities; sensitivity—recognition of detail; and definition—sharpness of outline.

Although the industrial electroluminescent X-ray intensifier is most useful in the 150 to 500 Kvp energy range, panel potentialities above 500 Kvp will be presented in a detailed report of remote high energy X-ray fluoroscopy.[10]

To determine user interest and individual requirements, several high resolution X-ray intensifiers are being evaluated in industry on a practical basis. One application is in the inspection of hermetically sealed relays. Figure 5 shows the internal arrangement of components within the relay housing; the photographs are taken with el-pc and fluorescent viewing methods respectively. These techniques provide inspection of contacts, pivot assembly, stop mechanism, and coil, without disassembly of housing.

The electroluminescent X-ray image intensifier has been developed to a sufficient degree to warrant its limited use in industry. Practical observations of penetrameter performance indicate 2 percent contrast and 4 percent detail sensitivity at X-ray intensities of 150 Kvp for a ½-inch thick steel sample. The e-l panel amplifier also affords operator control over output brightness and contrast.

New photoconductive materials promise improvements in X-ray conversion and subsequent resolution. Although the eraser type panel can eliminate the problem of latent images, the development of faster screens is seen as a more feasible solution. As interest in the electroluminescent X-ray amplifier develops, along with improved technical performance, this new fluoroscopic device should find a definite application in nondestructive testing.

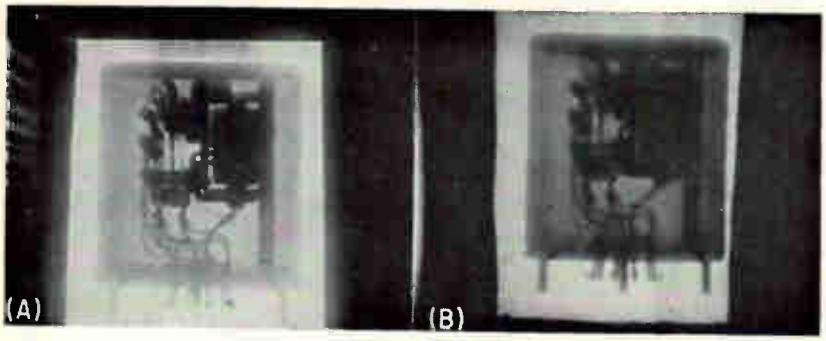

FIG. 5—Examining hermetically sealed relay. Photograph of electroluminescent viewer (A) received 15 seconds exposure time while fluorescent screen photograph (B) was exposed for 90 seconds owing to its lower brightness. Both photographs are now third order reproductions

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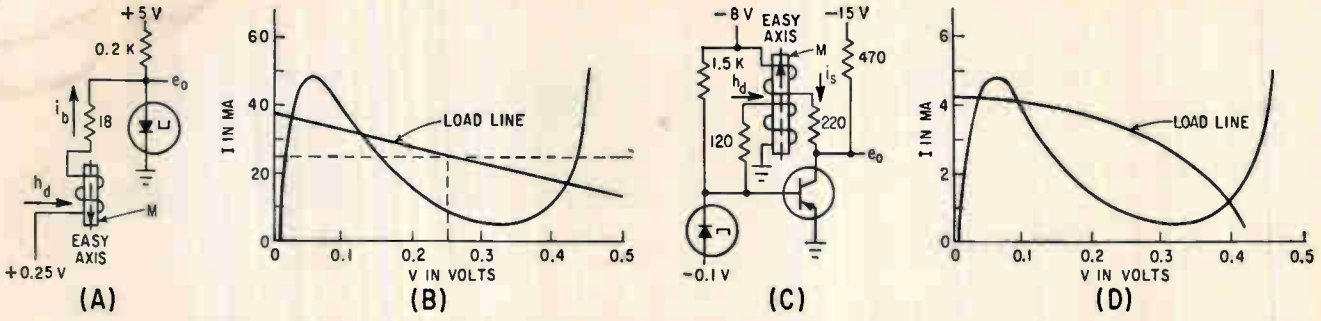

FIG. 1—Simple toggling circuit (A); tunnel diode characteristics (B) and (D); and single transistor toggle (C)

Design of Logic Circuits Using Thin Films and Tunnel Diodes

Two types of toggling circuits have been built and successfully operated using thin films and tunnel diodes. Possibility for thin-film, tunnel-diode logic arrays appears promising

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BOTH tunnel diodes and thin ferromagnetic films have bistable characteristics that make them adaptable to digital computer circuits. Because of its negative resistance characteristic, the tunnel diode can be biased to operate at two stable voltage levels for a given current condition, while the single-domain ferromagnetic film has two stable magnetization orientations in the absence of external fields.

Since both these elements operate at low voltage and moderate current levels, and since both have high switching speeds, their combination into digital computer logical devices offers benefits. This article gives examples both of circuits that have been successfully operated with good results and of circuits that have not yet been built, but appear feasible and indicate a broad range of logical functions.

Figure 1A shows a toggling circuit. The tunnel diode characteristic is shown in Fig. 1B. The 5-volt supply biases the film-diode combination at a constant 25 ma, which is about the mean of the peak and valley currents. The static load line for the diode is shown in the figure. The two stable diode voltages are thus about 0.05 and 0.4 volt, which means the bias current i_b through the film winding will flow in either of the two directions, depending on the state of the diode.

Assume the diode to be in its low-voltage state, which means that the film-winding current is in the direction shown and will set the film into one of its two stable states. Now let a pulsed transverse field h_d be applied. This causes the magnetization vector M to swing away from its rest direction toward the perpendicular, which induces a voltage in the winding of such polarity as to raise the load line of Fig. 1B above equilibrium. If this voltage is of sufficient magnitude, the diode switches to its high-voltage state, causing i_b to reverse, so that the film will be biased in the opposite direction when h_d is removed. Thus the application of a transverse drive field causes both the film and the diode to switch to opposite states. A subsequent h_d pulse induces a film-winding voltage of opposite polarity, which switches the diode back to its original state, in turn switching the film. Thus the circuit functions as a high-speed toggle.

Switching waveforms for this circuit are shown in Fig. 2A. The film is of 80-20 Permalloy about 2,000 A thick, with an anisotropy field H_k of about 4 oe. The drive field h_d was a 10 oe, 0.3 μs pulse with rise and fall times of 20 ns, and the diode switch times are also about 20 ns. The long exponential decay of the film output is due to the excessive 3 microhenry leakage inductance of the film winding, which consisted of 80 closely spaced

turns of No. 40 wire.

The short switching time and simplicity of this circuit are attractive, but it suffers from limitations. Unless the leakage inductance of the film winding is greatly reduced, the long exponential decay of the film output severely limits the toggling repetition rate. The low-level diode output is not sufficient to drive a subsequent stage, and an additional transistor stage might be necessary. Also, the necessity for using rather high-current tunnel diodes and the 0.25-volt supply are troublesome.

The single-transistor toggle, Fig. 1C, somewhat obviates these difficulties. Since a transistor stage is necessary if circuits are to be cascaded, as in a counter, such a stage has been added, with certain benefits.

The tunnel diode, whose characteristic is shown in Fig. 1D, controls the conducting state of the transistor. The −0.1 volt supply ensures transistor saturation, but would not have been necessary if either silicon or gallium arsenide tunnel diodes had been available. The current-voltage characteristic of the germanium tunnel diode above the valley voltage is about the same as the base-emitter characteristic of the germanium transistor it controls. Thus, additional bias is necessary to ensure transistor saturation. Since silicon and GaAs tunnel diodes have higher forward voltage drops, no bias is necessary to ensure transistor saturation.

The tunnel diode is biased as in the previous circuit, with stable output voltages of 0.05 and 0.4 volt. Assume it to be in its low-voltage state. The transistor is then turned off and the film winding current i_s flows as indicated, setting the film into a stable state. A transverse pulse field h_d once again rotates the magnetization vector M, inducing voltages in both longitudinal film windings. The additional winding is necessary because of the phase reversal introduced by the transistor. The voltage induced in the second winding is fed back to the tunnel diode, causing it to change to its high-voltage state, turning on the transistor, and reversing the direction of i_s and the preferred state of the film. Once again a subsequent field pulse causes the circuit to revert to its original state.

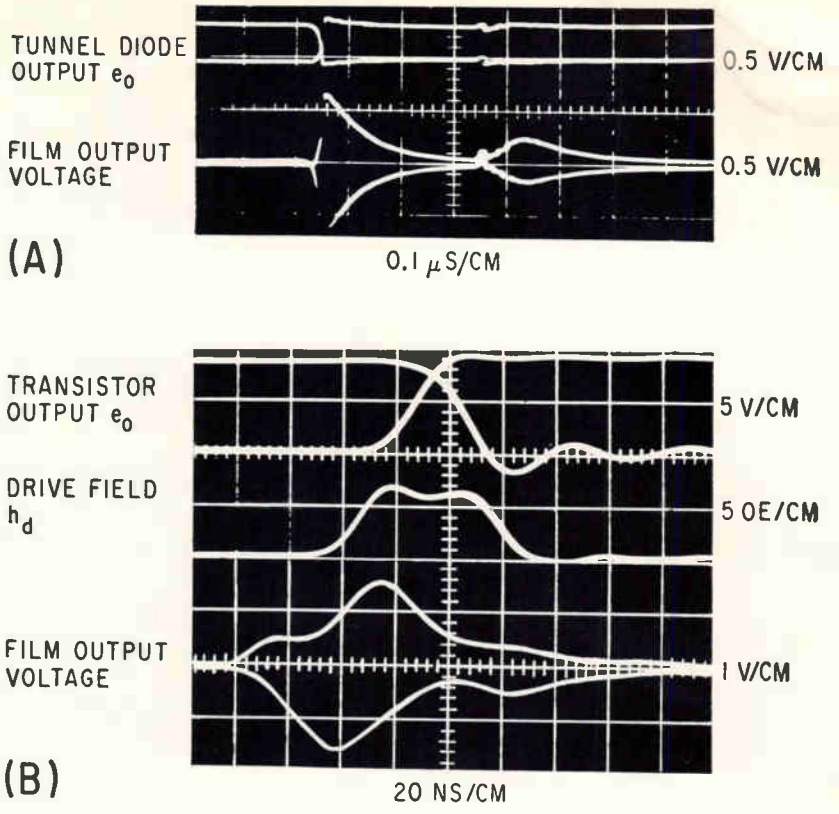

FIG. 2—Switching waveforms for simple toggling circuit (A), and waveforms for single-transistor toggle (B)

The circuit was successfully operated with waveforms shown in Fig. 2B. The film was the same as the one previously described, the collector winding had 15 turns, the feedback winding 25 turns, although it appears that fewer turns were necessary. A Western Electric mesa transistor similar to the 2N559 with measured rise and fall times shorter than 20 ns was used.

This circuit shows several advantages over the previous one. It has a considerably larger output signal, uses a low-current tunnel diode, and would not require an extremely low-voltage supply if silicon diodes were used. It also permits higher repitition rates, since a combination of lower winding inductance and higher series resistance reduces the time constant, as shown in Fig. 2B. A more careful winding arrangement would have given even more improvement. In comparison with tunnel diode-transistor logic, the thin film-tunnel diode-transistor circuit of Fig. 1C accepts input pulses of random polarity to achieve toggling. A tunnel diode-transistor combination would require set and reset pulses of opposite polarity.

It appears most feasible to use magnetic films with tunnel diodes and transistors in single, logically complex devices as in the previous circuit, or in logical arrays. Since magnetic film logical elements are usually inefficient energy transfer devices, they are advantageous when the inefficient transfer of energy is either desirable or tolerable. As an example of the use of a logical array device, consider the case in which the output from one of n registers is to be gated to an input of another device. For simplicity, an embodiment using small ferrite memory cores is shown in Fig 3A. The single-turn bias and drive current requirements for the ferrite memory cores would obviously be large.

Each core is used as an AND circuit and the outputs are ORed together simply by stringing a winding through them as is done in a memory. Each core replaces the two diodes that would be required in a diode equivalent of the circuit. Since both a film core equivalent and the ferrite core arrangement shown would require more complex

gating pulses and more output amplification than the diode arrangement, they would be most feasible when the number of inputs and the number of gating elements are large.

If a bias current were applied through the gate pulse winding to bias the core to point 3 in Fig 3B, the output of the gate would be complemented. Thus, by changing the bias on the core, the gate can be changed from a noncomplementing to a complementing gate. Assume that the bit stored in the left-hand transistor is to be transferred out. If this transistor is conducting, the core is biased to point 2 on the B-H loop of Fig. 3B and, when the drive pulse is applied, no switching occurs and no output is obtained along the sense line going to the threshold amplifier. If the transistor is nonconducting, the core is unbiased, operating at point 1 of the B-H loop, and a gating pulse will produce an output.

If the complement is desired, enough steady-state bias current is applied at the gate input to cancel the transistor current and bias the core to point 4 for a conducting transistor and to point 3 for a nonconducting transistor, so that drive pulses produce outputs for the opposite condition to that described above. For the arrangement shown a large transient would exist while the bias was reversed.

To make simple, high-speed film logical elements, it is necessary to use the rotational switching properties of films[1], to use thin dielectric and conductor fabrication techniques such as those suggested by Broadbent[2], and to make the current requirements modest (20-200 ma) by use of small elements.

Film arrays or matrices hold promise as powerful high-speed logical communication links. That is, the contents of a computer word are used to generate bias currents along the columns of the matrix, transfer pulses are applied to any of the rows of the matrix, and a set of outputs is obtained from appropriate sense windings which represent the original word which has been logically altered. By pulsing different row lines, different logical alterations are obtained. An example is a shift matrix[3] in which the input word biases the columns, the transfer pulses are applied to the rows, and the sense windings run diagonally along the matrix elements. A transfer pulse along the nth row thus outputs the original word shifted by n places. Another simple example would be a masking matrix, in which the portion of the input word transferred would depend on the number of films along a given row that were switched, which in turn would depend on the row selected.

Film elements also can be used as simple AND, OR, and majority decision elements in much the same way as the cores in Fig. 3A. By adjusting bias currents, a film will be permitted to switch for only the proper combination of inputs. If, for a given element, all its input currents must be present to cancel the bias and permit switching upon the application of a transfer pulse, an AND function is performed. If only one input permits switching, an OR function is performed. If switching is permitted when more than half the inputs are present, a majority-decision operation is performed. Large arrays with appropriate interconnecting windings could perform a variety of logical operations using logical elements of this type.

The primary difficulty at present is the amount of amplification required to bring the sense winding signal up to a usable level. This is the result of using films mounted on relatively thick glass which cuts down the degree of coupling achieved. It is anticipated that using the multiple-layer deposition techniques of Broadbent[2] much better coupling could be obtained with correspondingly greater energy transfer.

Film uniformity is not as important here as in film memories. In memories, the films must retain information in the absence of biases, so that stray-field and demagnetization problems are severe. Here the films are coupling elements always operated in the presence of external bias fields, so that demagnetization problems are not so severe.

The authors thank Western Electric for supplying the transistors used and IBM for supplying the tunnel diodes. The work reported here was supported by a National Science Foundation Grant.

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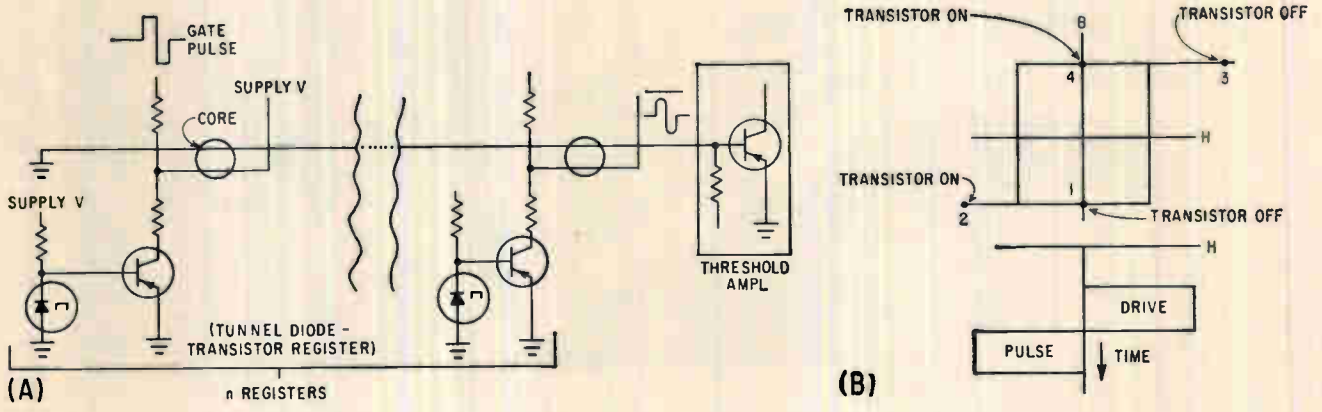
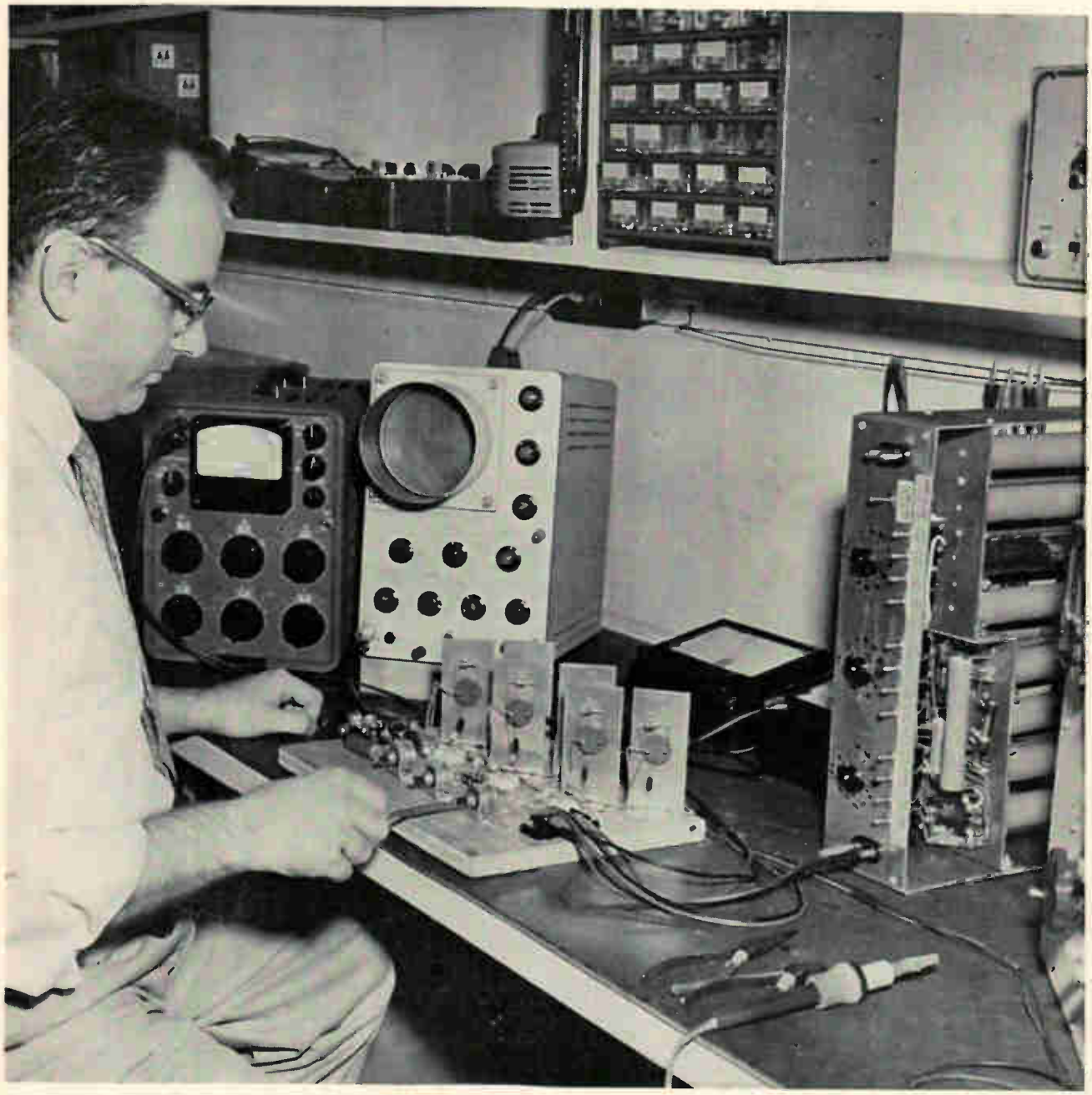


FIG. 3—Gating core array device using small ferrite cores, tunnel diodes and transistors (A), and illustration of how changes of bias on core will change the gate

Half-Bridge Inverter Provides

Analogous to the full-wave voltage doubler, circuit uses only two three-phase applications. Basic circuits can be connected in



Author adjusts controls on three-phase half-bridge inverter

Economical Three-Phase Power

transistors; is suitable for two-phase as well as

series for high-voltage operation

By ALLAN G. LLOYD,
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MOST STATIC INVERTERS have been based on one of two basic circuits: the parallel inverter[1] or the bridge inverter[2]. The configuration shown in Fig. 1 is the self-excited half-bridge inverter. It is the inverter analog of the full-wave voltage doubler, just as the parallel inverter is the analog of the full-wave center-tapped rectifier, and the bridge inverter is the analog of the full-wave bridge rectifier.

The circuit works as follows: Capacitors C_1 $(=C_2)$ are assumed large enough to maintain the potential E_1 constant during the half-cycle. Voltage E_2 is switched in a square-wave mode from minus battery with Q_1 ON to plus battery with Q_2 ON. Each base-drive winding is wound for 2.5 v to 5 v peak, and resistors R_1 and R_2 selected for proper drive current at the required collector current in Q_1 and Q_2. Switching is caused by magnetic saturation of T_1, as in other inverter circuits. Output voltage is square only if C_1 and C_2 are infinite; in practical circuits, the output waveform is tilted in proportion to the output current, since C_1 and C_2 in parallel are effectively in series with the primary. The table shows voltage and current relations for each of these circuits. Maximum transistor OFF voltage equals the input voltage in the half-bridge circuit so that a two-transistor, 80-v inverter is practical in germanium, and 150-v inverters have been constructed in silicon. Input voltage and current are transformed to $E/2$ and $2I$ at the transformer primary, just as in a voltage doubler. The half-bridge inverter maintains transformer efficiency because there is no increase in primary volt-amperes due to a 50-percent duty cycle of primary current as in the parallel inverter.

Like the bridge inverter, this circuit is easy to de-spike, and requires only a diode across each transistor to give complete protection against voltage spikes. It is particularly advantageous for high input-voltage inverters from the standpoint of cost, since two capacitors are usually much cheaper than the transistors they replace, and one capacitor is usually required across the line in any case.

The circuit operates in a symmetrical mode only if $E_1 = E_{in}/2$. Since nothing in the basic circuit of Fig. 1 establishes this condition, the circuit will oscillate with E_1 anywhere between 0.1 E_{in} and 0.9 E_{in}. Practical limits on the value of E_1 are set by the loss of ON drive to Q_1 when E_1 approaches E_{in}, and to Q_2 when E_1 approaches zero.

A practical inverter circuit is shown in Fig. 2A. N_s, D_3 and D_4 constitute a symmetry-forcing circuit. N_s is wound to be about 1 volt more than N_p to make up for the conduction voltage of D_3 or D_4. The only current in N_s is the small amount of peak charging current in D_3, or D_4, required to keep E_1 ex-

*Now with Bread Boards Inc., Newark, N. J.

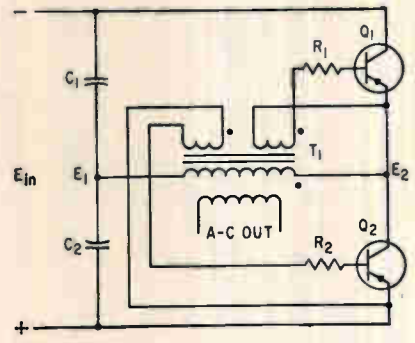

FIG. 1—Basic circuit of half-bridge inverter. Only two transistors are used, with two capacitors and a specially wound transformer

Voltage—Current Relations for Different Inverter Types

	Parallel	Bridge	Half-Bridge
Input voltage	E	E	E
Input current	I	I	I
Input power	EI	EI	EI
Transistor ON current (Peak)	I	I	$2I$
Transistor OFF voltage	$2E$	E	E
Primary voltage* (end to end)	$2E$	E	$E/2$
Primary current, rms	$0.707I$	I	$2I$
Primary VA*	$1.414EI$	EI	EI

* Must be multiplied by 1.1 to obtain equivalent sine wave value.

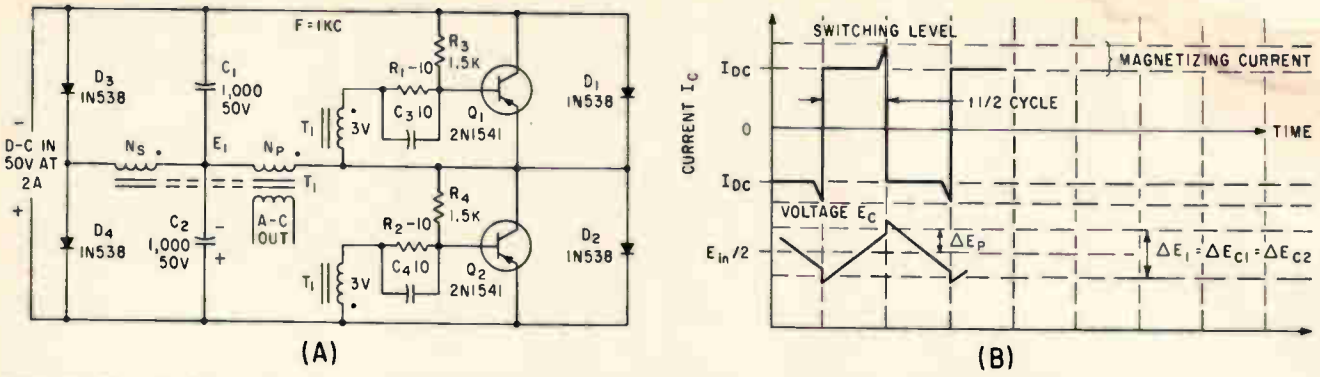

FIG. 2—Practical inverter circuit, (A); instantaneous waveforms of capacitor current and voltage, (B)

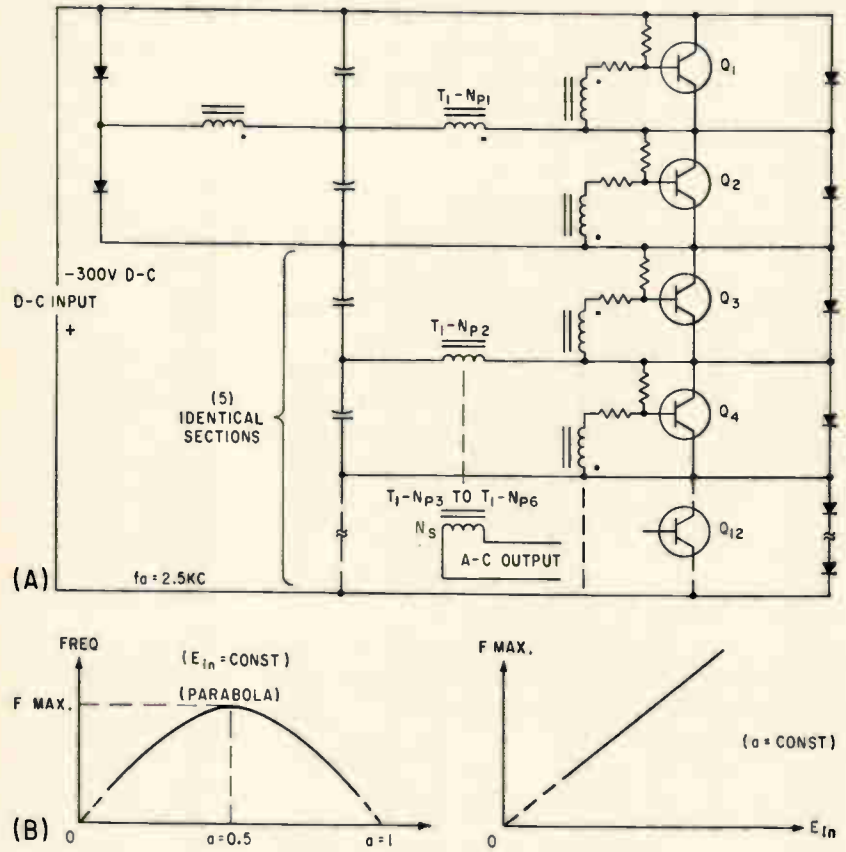

FIG. 3—Series of interconnected sections form a high d-c input voltage inverter, (A); parabolic plot of frequency in (B) shows circuit can be used as squaring circuit

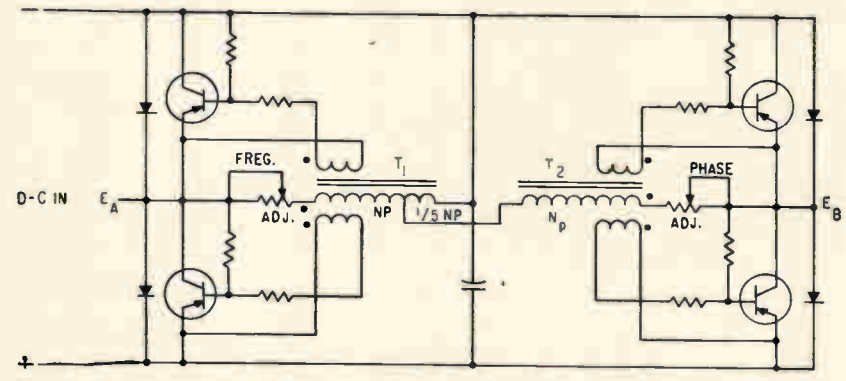

FIG. 4—Half-bridge principle applied to a two-phase inverter

actly halfway between plus and minus battery. N_s therefore can be wound with fine wire. Transformer T_1 is otherwise calculated exacly as a normal inverter-transformer, remembering that $E_{Np} = \frac{1}{2} E_{dc}$ and $I_{Np} = 2I_{dc}$. C_3 and C_4 are speed-up capacitors, and may not be required. R_3 and R_4 are starting resistors, and are determined experimentally. D_1 and D_2 are the de-spiking diodes for Q_2 and Q_1 respectively. The value of C_1 $(=C_2)$ is a compromise between waveform squareness and capacitor size, but can be quickly estimated as follows. Instantaneous capacitor current and voltage waveforms are shown in Fig. 2B. If it is assumed that C_1 and C_2 are large enough to make ΔE_1 small in comparison with E_{dc}, then each capacitor current waveform will be a square wave with a value of I_{dc}, and the capacitor a-c voltage waveform will be triangular with a peak value of

$$\Delta E_p = I_{dc}\,(t_{\frac{1}{2}\ \text{cycle}})/2C$$

For example: assume $I_{dc} = 2a$, f = 1 Kc and $E_p = 0.5$ volt. Then $(t_{1/2\ \text{cycle}}) = 500\mu$ sec and $C_1 = C_2 = I_{dc}\ (t_{1/2\ \text{cycle}})/2E_p = (2a \times 500\ \mu\text{sec})/(2 \times 0.5\text{v}) = 1{,}000\ \mu\text{f}$.

Any number of these sections can be connected in series to yield a high d-c input-voltage inverter. Figure 3A shows the pattern for a 300-v inverter. Six identical primary windings are wound on transformer T_1, along with 12 base windings, one symmetry forcing winding, and a-c output windings as required. By using enough sections in series, it should be possible to build a 10,000-v d-c input atomic battery inverter of 85 percent efficiency. Transformer T_1 could be arranged in the form of a large toroidal ring, with a secondary wound first and

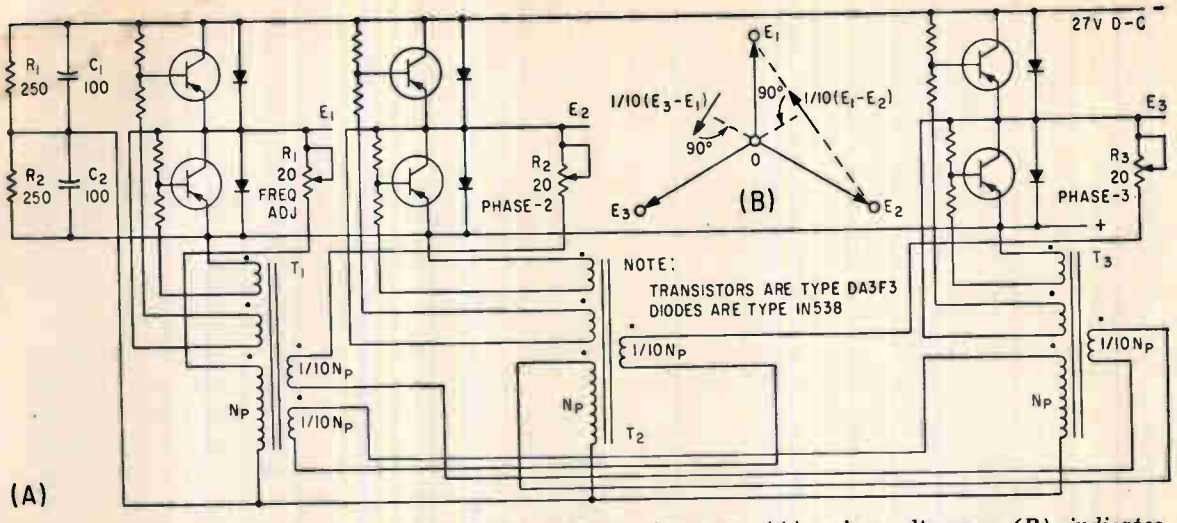

FIG. 5—Self-excited three-phase non-ambiguous bridge inverter, (A); phase diagram (B) indicates derivation of synchronizing voltages

insulated to withstand the end-to-end primary circuit voltage.

The half-bridge inverter has applications which utilize the non-symmetrical mode of operation. Since there can be no average d-c voltage component across the primary of T_1, Fig. 1, the potential at E_2 averaged over the cycle equals E_1. Programming (driving) E_1 from an external a-c or d-c source and filtering E_2 directly to remove the switching waveform results in a high-power, high-current, unity-voltage-gain switching-type voltage follower. E_2 (average) depends only on E_1 and is independent of E_{in}, so that there is a ripple reduction factor going from the input at E_{in} to output at E_2.

Basic circuit operation results in constant volt-seconds per half-cycle of transformer excitation. Half-cycle peak induced voltages and periods vary such that $(E_{peak}) \times (t_{1/2\ cycle}) = K =$ constant. This leads to the formula for frequency

$$f = \frac{1}{t} = \frac{1}{t_1 + t_2} = 1 \Big/ \left(\frac{K}{E_{in} - E_1} + \frac{K}{E} \right) \quad (1)$$

which normalizes to

$$f = 4a(1 - a) \times f_{max} \quad (2)$$

where

$$a = E_1/E_{in} \quad (3)$$

and

$$f_{max} = K_1 E_{in} \quad (4)$$

Equation 2 is an inverted parabola, as plotted in Fig. 3B. The parabolic form of frequency against a indicates that this circuit could be used as a simple voltage-to-frequency squaring circuit in some applications. Equation 4 shows that output frequency is directly proportional to input voltage for a fixed a.

Sections can also be connected in parallel for two-phase and three-phase operation. For these applications, it is convenient to use the separate switching core configuration[3]. Figure 4 shows a two-phase inverter, adapted to the half-bridge circuit from published material.[4] The application of $\frac{1}{3}(E_A)$ in series with the primary voltage of T_2 causes E_B to switch at 90 deg. lagging if the transformers are otherwise equal. Quasi-square-wave output free of third harmonic can be obtained by bridging a single-phase load from E_A to E_B, and adjusting the phase control for 120 deg. instead of 90 deg. lag.

Figure 5A and the photo show a self-excited, three-phase, non-phase-ambiguous bridge inverter, each oscillating section of which is a half-bridge inverter operating in the square-wave mode. Phase diagram, Fig. 5B, shows that the 90-degree signal required to synchronize E_3 is derived from $(E_1 - E_2)$ while E_2 in turn is synchronized by $(E_3 - E_1)$. Only one pair of capacitors is required for the entire inverter. Each capacitor current waveform is square and equals $\frac{1}{2}$ the primary current in any one of the switching transformers (magnetizing current plus reflected base load) at three times the inverter frequency.

Variable resistor R_1 is the master frequency controlling element, while variable resistors R_2 and R_3 are used to adjust the phases of E_2 and E_3 respectively. Although there is a 50 percent interaction in these two phase adjustments, the usual 120 degree relationship can be easily obtained. Delta-connected three-phase transformers can be directly connected to E_1, E_2 and E_3, since $(E_1 - E_2) + (E_2 - E_3) + (E_3 - E_1) = 0$ at every instant. Wye-delta connected transformers cannot be used unless the neutral is floating. Each voltage $(E_1 - E_2)$, $(E_2 - E_3)$ and $(E_3 - E_1)$ is a quasi-square-wave equal to E_{in} for $\frac{2}{3}$ of a half-cycle and zero for $\frac{1}{3}$ of a half-cycle. This waveform has no 3rd, 9th, etc., harmonics, and is easier to filter than square waves. T_1, T_2 and T_3 are small switching cores. R_1 and R_2 establish equal voltage division for symmetrical operation.[5]

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Radar Boxcar Circuits Using Nuvistors,

Single-stage, low-noise circuits combine nuvistor triode with transistors and Zener diode

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THE BOXCAR CIRCUIT is a waveform-sampling device that provides time selection and storage. Boxcar circuits are widely used in military radar as moving-target detectors, as sensing elements of tracking radars and as gated (time selection) agc.

The essential elements of any boxcar are an electronic switch, storage capacitor and isolator. The isolator is usually a vacuum-tube cathode follower.

The electronic switch momentarily connects the storage capacitor to the input waveform, thus charging the capacitor to the instantaneous value of the waveform at the time of switching. Ideally, the capacitor retains this voltage until the electronic switch again conducts, thus storing a new sample. The isolator permits reading the capacitor voltage without disturbing it.

A low-noise, high-performance boxcar design demands that leakage resistance across the capacitor be as high as possible and that the resistance of the electronic switch, when conducting, be as low as possible. In this last point, low switch resistance, Zener diode biasing is superior to the usual R-C biasing.

Previous boxcars using conventional vacuum-tube circuits required bulky power supplies, used transistors in cascaded boxcars, or compromised high-frequency response to achieve a satisfactory noise level in single-stage transistor circuits. The new hybrid circuit combines both tubes and transistors, so as to achieve low-voltage operation and high signal-to-noise ratio without losing high-frequency performance.

The vacuum tube has a high input resistance, but cannot produce a high load current at low plate voltage. The transistor is current operated, and has a low input resistance and highly temperature-sensitive input leakage current. The transistor is however an excellent current amplifier whose output is only slightly affected by collector voltage. This boxcar isolator uses a nuvistor triode in the input circuit, followed by a transistor current amplifier.

Maximum nuvistor plate current is approximately 0.1 ma at a plate voltage as low as 15. An output signal of up to 10 volts appears across the load resistor.

Two versions of the hybrid circuit were built, and both performed satisfactorily up to 70 deg. C. One used germanium transistors while the other used a single silicon transistor. Signal-to-noise ratio of the silicon hybrid was 1 or 2 db better at all temperatures. Simplicity is another advantage of the silicon hybrid over its germanium counterpart; one additional transistor and several resistors are needed to provide high-temperature stability in the germanium transistor hybrid. Figures 1A and 1B illustrate the two circuits. The boxcar signal input should be driven from a 150-ohm source.

Power drain is negligible except for the nuvistor filament power of approximately 1 watt. Only 100 microamperes is required of the negative supply.

The most stringent requirement on a boxcar circuit is the reproduction of input waveform modulation having a frequency of $prf/2$ where prf is the sampling rate. To detect accurately such modulation, the electronic switch must completely change the capacitor charge, by the magnitude of the modulation envelope, in a single sampling interval. If the modulation frequency were low compared to the sampling rate, the requirements would be less severe. The capacitor would be charged to the maximum modulation voltage in many small increments. It is desirable to make the storage capacitor as small as possible; however, leakage resistance sets a lower practical limit on capacitor size, since loss of capacitor

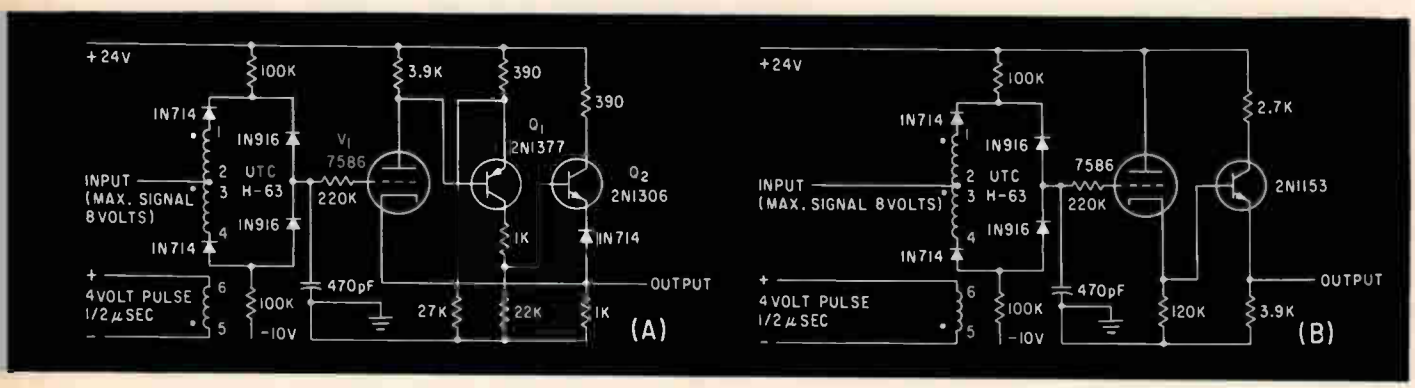

FIG. 1—Circuit of the germanium-transistor hybrid boxcar (A); a similar unit using a single silicon transistor (B)

Transistors and Zeners

biasing to achieve 60 db signal-to-noise ratio

voltage between samples produces a noise component in the output. Any reduction in switch resistance improves performance. The substitution of Zener diode biasing reduces this resistance by a factor of approximately five over R-C biasing. This reduction is most apparent for small signals.

The factors relating to switch resistance may best be considered by examining the two circuits shown in Fig. 2A and 2B.

Resistance of the electronic switch will depend upon how hard the diodes are made to conduct by the switching pulse. High diode current will result in low switch resistance. The current versus voltage characteristic of a typical diode, Fig. 3A, shows why this is true.

The curve shows that the slope decreases as diode current approaches zero. Since the diode dynamic resistance is the reciprocal of this slope, low diode current results in high diode resistance.

Because of its self biasing characteristic, the conventional boxcar switch is forced to operate at low diode current levels near point A of the curve. Any increase in switching pulse amplitude will raise the bias across C_1 and C_2 rather than significantly raise the current. Attempts have been made to increase the peak diode current by bleeding off a fraction of the bias voltage between switching pulses. Adjustment of the R-C bias network was so critical as to make this approach impractical.

This difficulty does not exist with Zener biasing. The Zener diode, as used in the switch, is equivalent to battery biasing of the switch diodes and is independent of switching pulse amplitude. The switching pulse amplitude should be chosen to exceed the bias. Under these conditions it is possible to operate the diodes at a reasonable slope such as point B on the diode characteristic.

Since there is little change in the slope except near the origin, the switching pulse amplitude is noncritical. An amplitude change of 2 to 1 is tolerable.

Zener diode biasing is especially suitable for a random *prf* boxcar since bias remains constant and the switch stays open even for zero *prf*.

Signal-to-noise ratio for the germanium-transistor hybrid circuit was measured to be about 60 db for d-c input signal between 2 and 6 volts at room temperature. The signal-to-noise ratio for this circuit varied with ambient temperature from 63 db at 30 C to 48 db at 70 C. Both tests were made with a *prf* of 2 Kc. Optimum signal level is approximately 4.5 volts.

A constant input d-c level was sampled by the boxcar, to evaluate only that noise introduced in the boxcar circuit. The diode and storage capacitances form a voltage divider which produces a highly attenuated replica of the sampled waveform at the output. This effect usually contributes negligible power at the output. If in some applications it becomes significant, a video phase inverter and neutralizing circuit such as shown in Fig. 3B may be used to suppress it.

An HP200-AB oscillator and a Tektronix type 581 oscilloscope were connected at the boxcar input and output respectively to check high modulation frequency performance. The hybrid boxcar circuit response at 1 Kc ($prf/2$) was down less than one db from the 100-cps case. The *prf* used in all boxcar measurements was 2 Kc.

The RCA nuvistor vacuum tube type 7586 was chosen because of its ruggedness, small size, low power requirements and its promise of high input grid resistance. Because this factor is so critical in a low-noise boxcar, a detailed study of nuvistor grid current was made as a function of plate voltage, filament voltage and plate current. Nearly optimum conditions, with low grid current and a reasonable output load resistance as the criteria, are obtained at a plate voltage of 50 volts, a plate current of 0.1 ma and a filament voltage of 5 volts. An increase in any of these parameters increases grid current. Although not optimum, a nuvistor plate supply of +24 volts proved satisfactory in the hybrid boxcar. Operation of conventional vacuum-tube filaments below their rated voltages may reduce tube life; the nuvistor cathode, however, is made of chemically passive material.

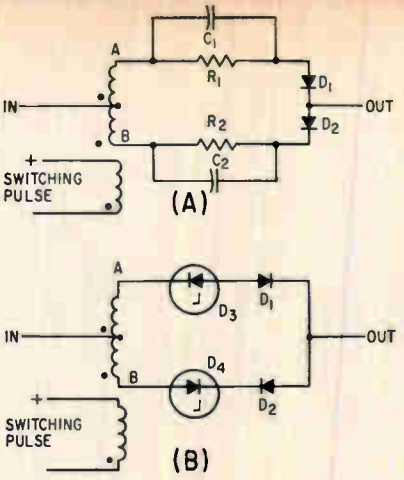

FIG. 2—Conventional boxcar switch using diodes (A); the improved Zener-diode boxcar switch (B)

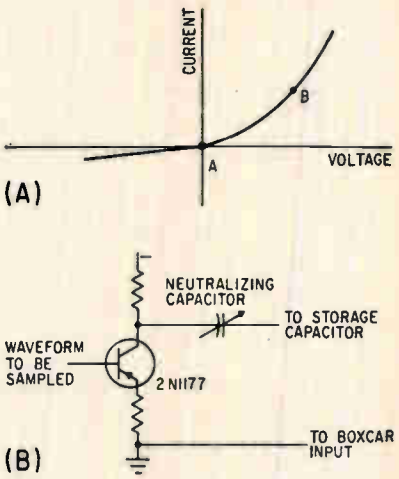

FIG. 3—Typical diode characteristic (A), illustrates circuit operation; transistor neutralizing phase inverter circuit (B)

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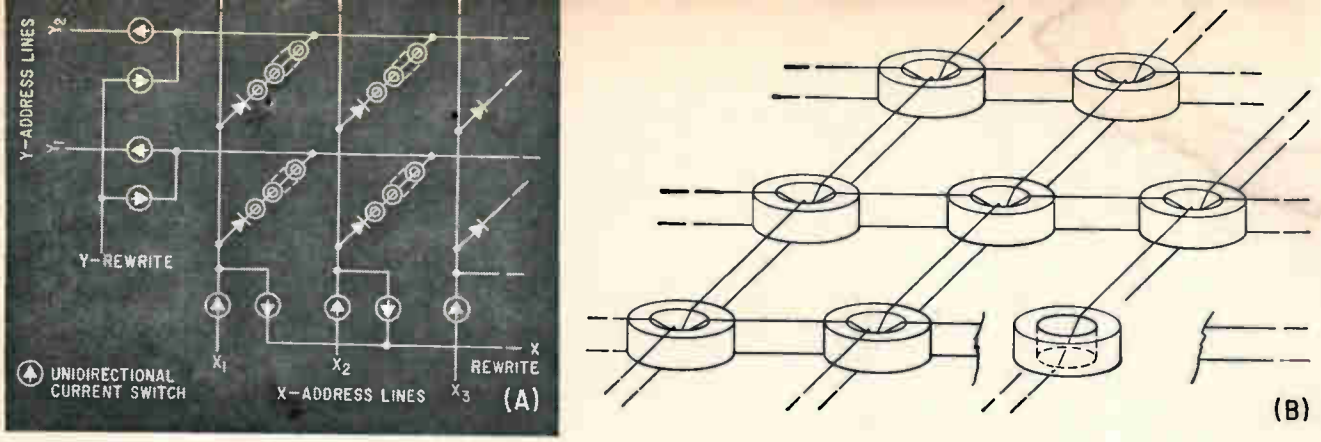

FIG. 1—Schematic illustrates diode-steered selection system for word-arranged memory, (A); detail of wiring of memory core plane is shown in (B)

Diode Steering Increases Speed of Magnetic Memories

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MAGNETIC-CORE memory with a 4,096-word capacity, operating with a three-microsecond cycle time, is connected to the main frame of Maniac III, a general-purpose digital computer built by the Institute for Computer Research at the University of Chicago.

High operating speed of this memory is due to novel core interconnection practices.[1]

A junction diode is used as the steering element for word selection in a word-organized core memory. Its recovery current is used to half-select the same word during the second half of a READ or STORE operation. Furthermore digit lines are wired with a pair of wires that engage every core with two turns, so that each digit line resembles a twisted pair transmission line with a core at every intersection.

Diode steering reduces the problems raised by partially selected word lines. It leaves control over the word-line parameters external to the core stack, so that the difficulty introduced by variation in line impedance with digit content may be overcome. The advantage of this selection system over the more conventional twin-diode scheme lies in conversion of the formerly wasteful diode recovery time into useful operation time.

The system is illustrated in Fig. 1A. It uses germanium junction diodes because of their generally slow recovery time. Thick bases store relatively larger numbers of minority carriers. Each core is threaded by two function lines. The word line threads cores of the same word, and the digit line (not shown) threads cores in the same bit position of every word.

In the first phase of READ, one X-address-line and one Y-address-line current switch are simultaneously alerted, and supply full core-switching current to the associated word line. All cores of the one word threaded by that line are driven towards ZERO, and the alerted sense amplifiers detect any signals induced on the digit lines. In a STORE, this same operation erases the contents of the word selected; that is, it leaves all cores of that word in ZERO.

In either case, the current pulse on the word line is of the same amplitude and time duration, and fully loads the base of the steering diode (a leaky bucket) with minority carriers. At the end of this current pulse the diode starts its recovery to high back resistance.

In the second phase of a READ, all X-rewrite and Y-rewrite current switches are immmediately alerted, but supply half-amplitude core switching current only to the word line with the unrecovered diode, every other word line presenting a high-impedance path because of its fully recovered diode. This half-amplitude current pulse half-selects all cores on the tagged word line, and simultaneously, sweeps the base of the unrecovered diode free of minority carriers, restoring it to its fully recovered state and pre-

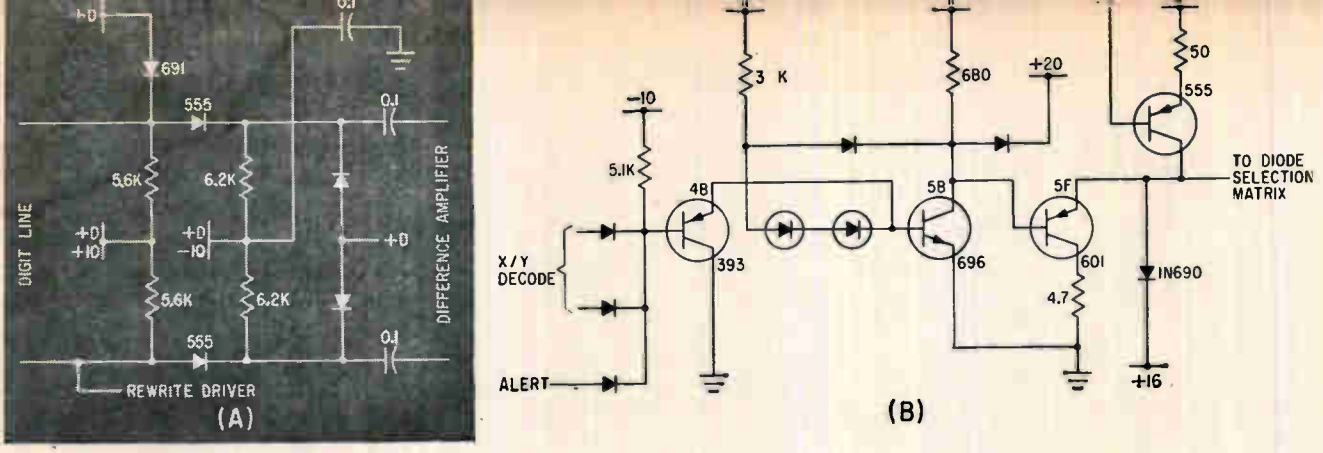

FIG. 2—Digit line decoupling circuit, (A); X- or Y- line driver circuit schematic (B)

paring the memory for another operation.

The signals previously on the digit lines control the digit line drivers so as to rewrite only those cores previously in ONE. The second phase of a STORE is identical, except that the digit line drivers are controlled by the contents of the new entry to the memory.

A principal factor extending the total cycle time in all core memories is the post-write disturb signal on the digit or sense line. By replacing the customary ground plane return for each digit line with a second wire adjacent to the first, each digit line can be converted into a two-wire transmission line and terminated in its characteristic impedance.

The half core-switching current pulse supplied by a digit line driver now propagates down the line at a rate determined by the line constants, and is absorbed at the receiving end. This prevents starting a new READ or STORE operation for a time equal to the transmission time of the line, since the digit and word line currents are of opposite sense in switching a core.

However, this time is much shorter than that of the post-write disturb signal. Since both wires of the twisted pair are threaded through each core, the amplitude of the current pulse required of the digit line driver is reduced by half, and the twisted-pair transmission line is virtually impervious to stray fields. In the Maniac III core memory, the word lines are treated in the same way, but only to reduce the word-line current requirements. The lines terminate in a short circuit; see Fig. 1B.

The fabrication of core planes with twisted-pair wiring requires different techniques from those used in conventional core arrays.

A sheet of phenolic the same thickness as the cores is provided, with perforations 0.056 in. in diameter, spaced 0.093 in. apart. One side is covered with a thin membrane of the type used for decalcomanias. The area that is to contain the cores is outlined with a mask, and the cores are shaken in. A second membrane seals them in. The membranes are then punctured at each hole with a plastic needle, and the plane is ready for threading. A nylon bristle is spliced to the end of a wire to ease the job of stitching.

When the core plane is completely threaded, the phenolic sheet is trimmed, leaving a border of about 3 in. around the area occupied by the cores, and the wire ends are taped to the edge of this border. The membranes are then dissolved, leaving the cores freely suspended, unstressed, and accessible to ventilation.

The planes are then framed by cementing strips of epoxy glass to either side of the phenolic sheet, leaving some 2½ inches of wire exposed between the frame and the edge of the sheet.

For assembly of the stack, the wires are freed from the edge of the phenolic sheet and most of the border trimmed away. The planes are mounted side by side on an assembly fixture and connections are made between adjacent planes by twisting the wires together and soldering. All interconnections of the digit lines are made in this way. The word lines from the ends of the plane are soldered to edge connectors, which will hold circuit cards containing the selector diodes.

After testing, the group of planes is removed from the fixture, and folded accordion-fashion.

The stack for Maniac III consists of 64 planes, each with 64 word lines and 108 digit lines. The digit lines form two 48-bit computer words, the remainder being available as spares, or for parity checking. A word line in this memory therefore threads two words, and a READ operation makes access to both simultaneously. Either one, or both, may be used by the computer.

The memory can be regarded as consisting of 4,096 words of 108 digits each, or 442,368 cores. This requires 108 each of reading amplifiers, digit registers, input gates, output gates, and rewrite current switches. All these circuits are contained on one printed circuit card for each digit; in all, 14 transistors and 18 diodes.

To test each group of planes, the computer was used to scan the word lines while an operator scanned the digit lines. Faults were displayed by the computer and were repaired on the spot.

The cores develop a ONE signal of about 60 millivolts. The impedance of the loaded twisted-paid transmission line is about 300 ohms. The sense amplifier is a capacitor-coupled differential amplifier with heavy feedback for d-c stabilization, with a gain of approximately 30 for difference signals and 0.1 for common-mode signals.

The same twisted-pair digit line from which the input signal is taken also transmits the half core-switching current for rewriting the digit. A diode switch and biasing network disconnects the sense amplifier and allows a common mode signal of approximately 1 volt into the amplifier. This signal is almost

completely rejected at the output, and the amplifier is ready for the next cycle 0.5 microsecond after the end of rewriting. See Fig. 2A and 3.

The rewriting current through the double-turn digit winding is approximately 100 milliamps. The potential of the quiescent line is maintained by the diode-resistor network at the amplifier input. When rewrite current is to be applied, one side of the line is switched to a fixed negative voltage by an npn high-current silicon mesa transistor, type 2N697. The other side of the line is clamped to a positive regulated voltage slightly below the quiescent voltage of the line. The magnitude of the current is established by the line impedance and terminating resistor. It can be adjusted by varying the difference between these voltages. A second npn switch and dummy load resistor absorb the current when it is not switched onto the line.

For the word-selection system, a twelve-digit binary address from the computer must be decoded to select one of the 4,096 possible word lines. This selection is done over three logical levels. The first level treats the digits in groups of three, by a diode matrix, with eight output lines on each of the four groups. The output of these lines is amplified and transmitted to a second level of logic, also composed of diodes. This level treats pairs of the groups of eight and combines them with an alerting signal. Two of the groups of eight form 64 outputs that drive the word-selection switches called the X group. The other two groups of eight drive the switches of the Y group, Fig. 2B.

The switches are connected to the word lines in the core stack through the 1N91 junction diodes so that, for any X and any Y, only one of the 4,096 selection diodes will be forward biased and apply current to the line.

The diodes are mounted in printed-circuit cards, 32 per card, held at the ends of the core planes. The base ends of the diodes of each plane are in common and are connected to a Y switch, and to a constant-current source equal to half core-switching current. The Y switches are normally biased off, and diode clamps absorb the current from the current source.

Each word-line wire coming from a selection diode has its opposite end connected to one of 64 buses that pass along the entire stack and pick up the corresponding line for each plane. These buses are connected to the X switches and to constant-current sources supplying a current in excess of core-switching current. The X switches are normally biased on, and the source currents are absorbed through these switches.

When a signal appears from the decoder, one X switch will be switched off. The current source associated with this X line is connected through a word line and diode to a Y switch, which is now connected to a voltage source. Thus, full switching current is applied to a word of cores, and readout signals are picked up.

After readout, the alerting signal to the decoder is dropped, and the switches return to normal. However, the selected diode, due to stored carriers and external control of circuit parameters, will conduct one-half switching current through the Y-switch constant-current source, and through the word line, in the inverse sense, to the X switch. This current, in combination with equal currents on the digit lines, accomplishes rewriting of the cores. See Fig. 3.

Currents for both reading and rewriting depend on provisions made in the current sources. They may be altered independently for best operation of the system. The clamp-line voltage may be adjusted to accommodate the maximum back voltage from the cores, and excess current may be used for fast readout, with normal currents for rewriting. As the cores are not used here to establish the usual 2 to 1 switching criterion, their coercive properties are not critical and low-drive small-aperture cores were chosen for greatest circuit economy.

The switches are 2N601 transistors, with collectors grounded, emitters connected to the word-selection circuits, and bases driven by 2N697 transistors as grounded-emitter nonsaturating amplifiers. The current sources are 2N1042 transistors, with currents fixed by emitter resistors, bases connected to a regulated voltage, and collectors used as the current sources.

The selection system contains 512 transistors and 864 diodes, exclusive of the junction diodes for word selection. The power dissipation is 720 watts. The power dissipation for the entire memory system (8^k words) is 1,500 watts.

Four thousand words of memory is operating reliably with cycle time adjusted to 3 microseconds. The diode recovery detection system, which will maintain a lockout of the computer until diode recovery is complete, has not been placed in operation, so the cycle time must be adjusted to accommodate the slowest diodes in the system. The diodes were installed without sorting for recovery time. When this has been done, and recovery detection is installed, the system will be self-timing and is expected to operate with an average cycle time of 2.5 microseconds.

The task of providing this memory was a joint effort of the A. E. C. Applied Mathematics and Computing Center of New York University and the Institute for Computer Research, University of Chicago. Underlying development work[2], was performed at the Computing Center.

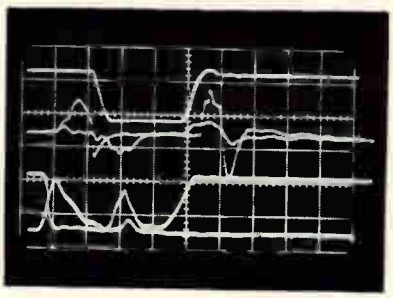

FIG. 3—Memory operating signals. Repetitive reading and rewriting to a single memory address—14 zeros, 84 ones. Sweep speed is 0.5 microsecond per cm. Upper trace shows digit rewrite signal, 20 volts per cm, second trace is amplifier output signal, ONES *and* ZEROS, *2 volts per cm, third trace shows word line driver Y, normally positive, 10 volts per cm, bottom trace shows word line driver X, normally negative, 10 volts per cm*

REFERENCES

(1) A. Melmed and R. Shevlin, Diode-Steered Magnetic-Core Memory, *IRE Trans. on Electronic Computers*, EC-8, No. 4, Dec 1959.

(2) This work was supported by the AEC Computing and Applied Mathematics Center, Institute of Mathematical sciences, New York University, under contract AT(30-1)-1480 with the U. S. Atomic Energy Commission.

ANOTHER MULLARD FRAME-GRID TUBE

Increased gain, reduced microphonics, and better controlled characteristics–these are the advantages you get when you specify Mullard frame-grid television tubes.

EF183 VARIABLE MU RF PENTODE

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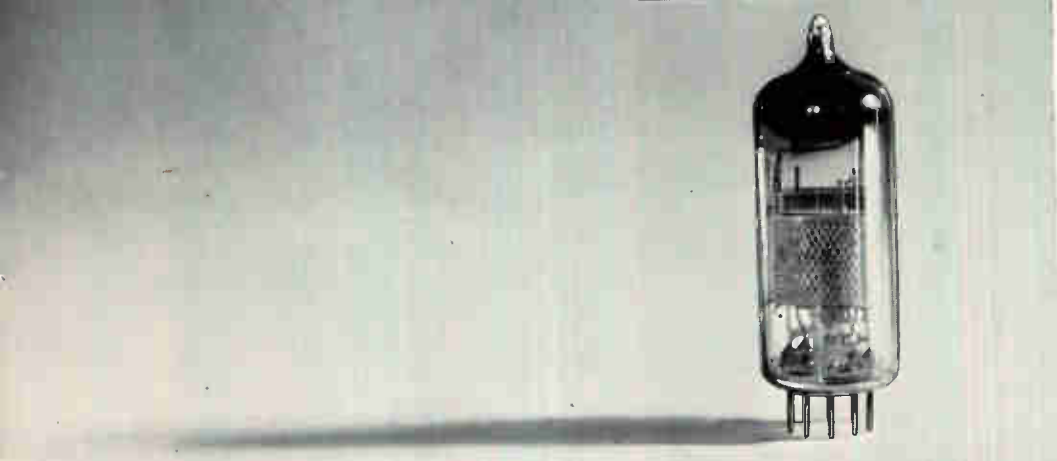

Frame-grid variable-mu r.f. pentode for use as an automatic gain controlled i.f. amplifier in television receivers.

CHARACTERISTICS

V_a	170	200	230	V
V_{g2}	90	90	90	V
V_{g3}	0	0	0	V
I_a	14	12	10.5	mA
I_{g2}	5.3	4.5	3.6	mA
V_{g1}	-1.8	-2.0	-2.1	V
g_m	14	12.5	10.6	mA/V
r_a	350	500	650	kΩ
r_{g1} (f -40Mc s)	11.6	13	15.3	kΩ

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Moon-Reflected Propagation Path Is Tested

USEFULNESS of the moon as a reflector for radio communications is limited by low coherent bandwidth. Tests indicate that the constantly changing multipath structure causes several types of distortion, although voice transmissions have been made successfully using a suppressed carrier.

The experiments were reported to the National Electronics Conference in a paper by R. E. Anderson and B. H. Claxton. Double-sideband carrier-suppressed transmissions at 915 Mc were used, and amplitudes of each sideband at different separations were recorded and their cross-correlation coefficients computed.

With high quality standards, coherent bandwidth of the lunar path is less than 1,000 cps. Comparison tests with tropospheric scatter and the Echo satellite indicate that the poor sideband correlation and signal degradation are peculiar to the moon.

Signals were transmitted from Air Force Cambridge Research Laboratories, Bedford, Mass., and received at the GE Radio-Optical Observatory near Schenectady, N. Y. The 10-Kw transmitter used feeds a linearly polarized signal to a 28-ft parabaloid. Another 28-ft parabaloid receives the reflections, which are fed to a parametric amplifier and then converted in a crystal mixer to 30 Mc.

Amplified mixer output is supplied to two communications receivers set at 100-cps bandwidth and tuned individually to each sideband. To compensate Doppler shift and ensure that sideband signals stay in the pass band, i-f output from one receiver drives a carrier phase-lock system that controls local oscillator frequency.

The agc delay was removed so that the agc responds to any signal above noise level. Agc response is set for a time constant of 0.3 sec, which follows amplitude fluctuations as fast as 3 cps, and the agc voltages are recorded.

Lunar signals are greatly attenuated primarily because of the two-way distance but also because of equipment losses and because the moon is neither a perfect reflector or scatterer. In addition, several mechanisms in the path cause distortion.

Multipath delay distortion occurs because signals reflected over the shorter two-way distance to the center of the moon arrive 11.6 milliseconds before those reflected from the outer rim. Also scattered components are apparently added to signals reflected from areas other than the center of the moon.

There are several sources of Doppler frequency shifts, which contribute to distortion. A maximum shift of about 400 cps in the two-way path results from orbital motion of the moon relative to the earth. Rotation of the earth causes a maximum Doppler frequency shift of about 2,000 cps at the latitude where the tests were made. Because all components of the signal are affected equally by these frequency shifts, they can be eliminated by techniques such as that used in the phase-lock receiver.

Libration of the moon causes distortion because signals reflected from the side rotating toward the earth undergo a Doppler shift different from those reflected from the side rotating away from the earth. Although the frequency spread is not more than 30 cps, libration of the moon also causes more serious distortion. The continuously varying reflecting surface causes a constantly changing multipath structure.

Topographical variations of the moon are quite large compared to a wavelength at 915 Mc so that amplitude of a reflected c-w signal has a noisy, deep-fade structure like tropospheric scatter signals. However, dimensions of the moon are of the same order of magnitude as audio frequencies. Two c-w signals separated by as little as 1,000 cps have poorly correlated amplitudes. By studying amplitude correlations at different frequency separations, coherent bandwidth can be determined and predictions made regarding distortion.

In the tests, amplitudes were recorded of the sidebands of tropospheric scatter signals with 80-Kc separation. Correlation was high even though some fades were quite deep. Bell Labs used a 10-Kw transmitter feeding a 60-inch parabaloid to illuminate Echo. Sideband separations up to 20 Kc were used with 960 Mc carrier frequency.

With 20-Kc separation, fading rate had a period of about 5 seconds, which is much longer than that of lunar signals and apparently results from structure of the rotating balloon. Even with 1-Mc separation, fading correlation is high. Neither the rapid fading experienced with moon reflections nor the marked lack of correlation between sidebands was observed, suggesting that perturbations of lunar reflections result from the moon itself rather than the atmosphere or particularly its ionosphere.

The recorded amplitudes of two lunar signals separated by 500 cps are not nearly as highly correlated as tropospheric scatter signals with 80-Kc separation or Echo signals with 20-Kc separation. Correlation with separations of 1, 2, 4 and 8 Kc become progressively worse.

The narrow bandwidths do not preclude voice communications by lunar reflection, however. Several successful voice transmissions were made from Bell Labs to GE using an amplitude-modulated single-sideband suppressed carrier. In several attempts to use a transmitted carrier, however, the signal was completely unintelligible.

Although test results indicate that the lunar path might not accommodate the 3,500 cps used for voice transmission, speech intelligence is contained in the spectral energy distribution and phase relationships of the frequency components are not important. Because of the slow changes in spectral energy distribution at the syllabic rate of about 10 cps, the moon re-

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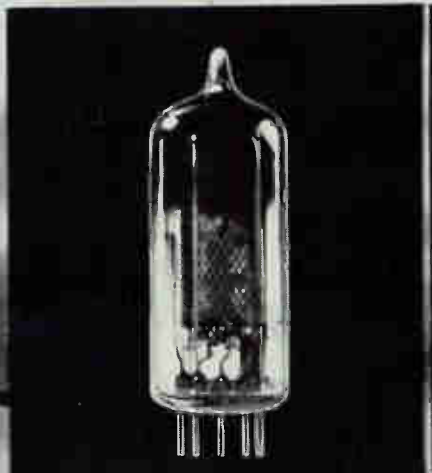
EF184 RF PENTODE



ANOTHER MULLARD FRAME GRID TUBE

Increased gain, reduced microphonics, and better controlled characteristics—these are the advantages you get when you specify Mullard frame – grid television tubes.

Frame-grid sharp cut-off pentode for use as i.f. amplifier in television receivers.

CHARACTERISTICS			
V_a	170	200	V
V_{g2}	170	200	V
V_{g3}	0	0	V
I_a	10	10	mA
I_{g2}	4.1	4.1	mA
V_{g1}	-2.0	-2.5	V
g_m	15.6	15	mA/V
r_a	330	380	kΩ
μ_{g1-g2}	60	60	
r_{g1} (f = 40Mc/s)	9.5	11	kΩ

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flection path is quite satisfactory for speech.

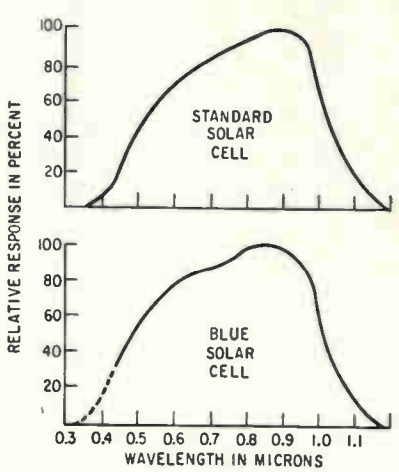
Changing Response Ups Space Solar Cell Power

INCREASE in power of fifteen to twenty percent is expected from a solar cell for space applications that has greater response in the blue region of the spectrum. Development of a solar simulator to duplicate sunlight outside the earth's atmosphere is credited with making the improved cell possible. (See ELECTRONICS, Aug. 11, p. 11.)

Output from the cell, developed by Hoffman Electronics, is 9.5 to 10 watts per square foot of panel surface exposed to the sun in space. Comparable output from older types is 8.5 watts. The cell is expected to be even more valuable for space exploration at greater distances from the sun where solar energy will be diminished.

Called the blue cell because of its response characteristics, the new power source is expected to have a longer useful life in space. Better response in the blue region was obtained by making a thinner diffused surface, which increases resistance to nuclear radiation.

The basic criterion for evaluating the performance of solar cells has been the tungsten standard lamp. Although the tungsten lamp is satisfactory for cells that will be exposed to the sun after it has passed through the atmosphere, most of the energy from this source is concentrated in the red area of



Better response at shorter wavelengths permits blue cell to use more of the solar energy in space

the spectrum. Because most of the solar energy in space is in the blue region of the spectrum, a different standard was believed necessary for solar cells destined for space applications.

Two light sources are used in the simulator. A tungsten lamp emitting light largely in the red region is combined with a xenon lamp that produces light with a heavy blue content. Light beams from the two sources, after passing through a series of filters, are mixed and focused on a test platform where the solar cells are mounted.

Accuracy and consistency of the energy content provided by the simulator is attributed to a pyrheliometer, which senses the amount of energy in a light beam regardless of color. The light sources are directed at the pyrheliometer individually and together while adjustments are made to yield the same amount of energy that the solar cells would encounter from the sun in space. When the color from the simulator has been verified by a spectrometer, it is then ready for use.

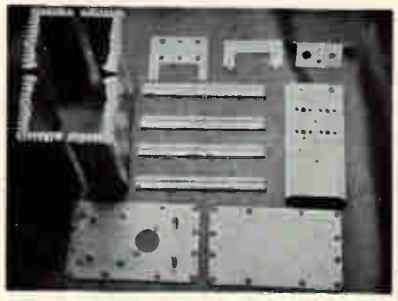
It had been believed theoretically that solar cells could be improved by making the top layer thinner, which in effect moves the active junction closer to the surface. The conditions in the cell would be altered so that the shorter wavelengths of blue light would contribute a larger portion of the total converted energy. Practical tests with the simulator verified the theory.

Spectral response of the blue cell and a standard solar cell, both chosen randomly, are shown in the figure. Peak response of both cells occurs at about 0.85 microns. However, response of the new cell drops to 50 percent at 1.03 microns at the red end and 0.48 microns at the blue end. Response of the standard solar cell also drops to 50 percent at 1.03 microns at the red end but at the blue end it drops to this level at 0.53 microns.

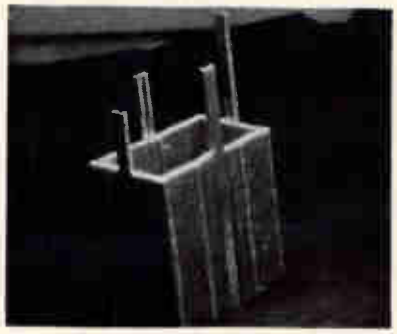
Response range of the new cell appears to be about 10 percent better than the standard cell, but the actual improvement is considerably better. Because there is much more solar energy in the region between 0.45 and 0.5 microns, power output is expected to be as much as 15 to 20 percent greater in space.

are finned on the outside for heat dissipation and are grooved in the inside for mounting printed circuit boards. Power transistors are mounted on the center partition. End slots in the partition fit tightly over keys on the corner pieces.

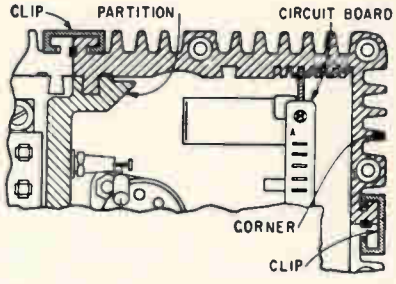
To assemble a unit, the bottom plate, which carries the connector, is wired to the harness. The transformer is mounted on the bottom plate and the two corners which fit around the transformer are



Mechanical parts of package



Corner and clip extrusions



Cross-section through one corner of an assembly

fastened to the bottom and clipped together. The other components are added and the remaining two corners and their clips are attached. The corner pieces are fastened to the top and bottom plates with neoprene gaskets and screws. If the unit is to be waterproof, Silastic compound is added at the junctions of the corners and on the interiors of the clips.

This packaging method has resulted in a 60 percent reduction in

the spectrum. Because most of the solar energy in space is in the blue region of the spectrum, a different standard was believed necessary for solar cells destined for space applications.

Two light sources are used in the simulator. A tungsten lamp emitting light largely in the red region is combined with a xenon lamp that produces light with a heavy blue content. Light beams from the two sources, after passing through a series of filters, are mixed and focused on a test platform where the solar cells are mounted.

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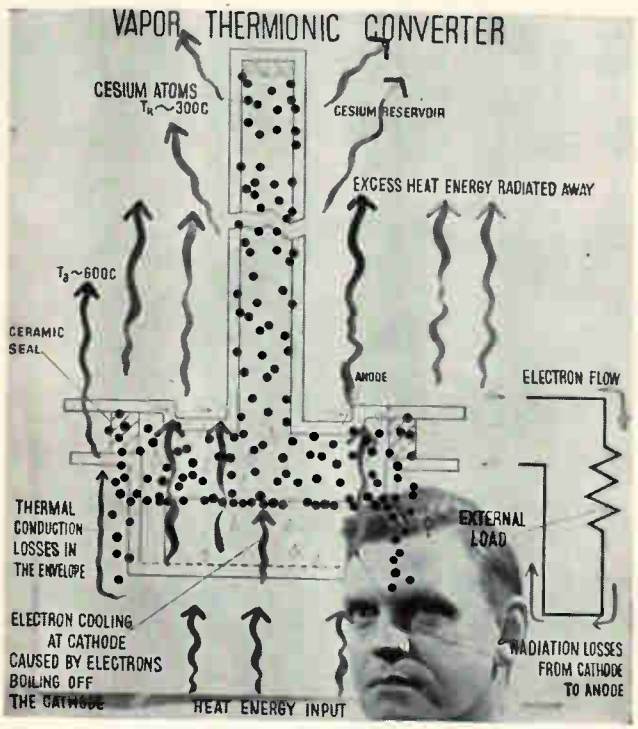

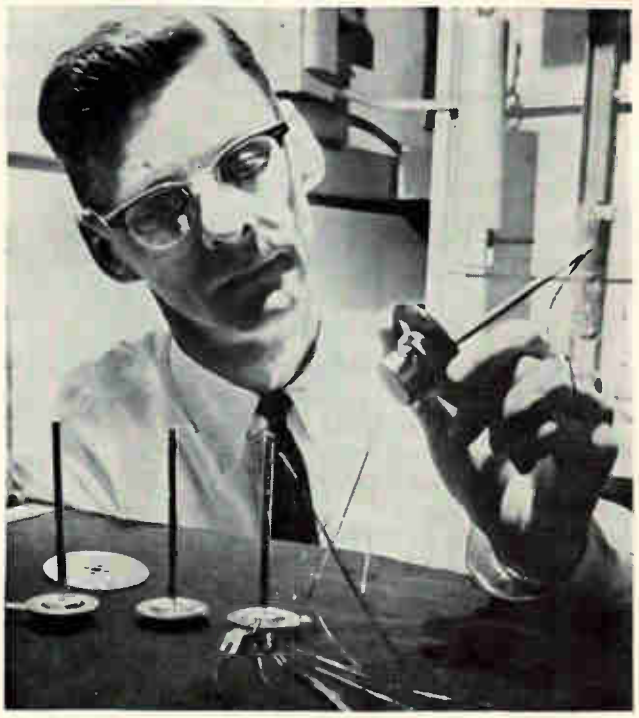

Diagram (left) shows how cesium vapor breaks down space charge to increase flow of electrons from cathode to anode. Thermionic converter held by A. O. Jensen of General Electric (right) produces enough power for a radio to transmit millions of miles through space

Generating Power From the Sun

INCREASED ELECTRICAL power requirements of missile and space vehicles planned for the future are creating the need for a power source that is both light weight and reliable (see ELECTRONICS, Sept 1, p 32).

Recent technological advances have made thermionic converters, which convert heat directly into usable electricity, a promising answer to this need. These advances include improvements in sealing techniques and developments in materials technology, as well as power output[1]. The continuing technical problem associated with thermionic converters is the achievement of a practical life. This life problem is directly related to the materials area. A lesser problem involves a reliable, sensitive, simple method of cesium pressure control under varying conditions of vapor converter operation.

Thermionic converters will permit power systems producing thousands of watts of power. Such power levels are predicted based on data obtained from heat converters which were designed and fabricated to meet specific requirements for solar thermionic generator systems.

Back in October last year, General Electric placed vacuum thermionic converters into commercial production. Operating at a cathode temperature of 1,150 C, these vacuum devices had a power density of 0.4 watts per sq cm for a total output of 2 watts and an efficiency of 3 to 4 percent. To achieve this power output and efficiency, this type of converter must have extremely close anode-cathode spacings, about 0.5 mil or less, primarily to minimize the effect of space charge.

Since then, increases in power output, operating efficiency, and life have been obtained with another type of thermionic converter, a vapor device. These G. E. vapor thermionic converters use cesium contained in a reservoir to adjust the work functions of the anode and cathode surfaces, and a vehicle for creating a plasma in the interaction space between the anode and cathode. These converters have integral radiators and reservoirs and can operate in a vacuum or inert atmosphere without auxiliary cooling or typical laboratory control, both of which would be impractical for space applications.

Operating at cathode temperatures of 1,530 C, one type of vapor thermionic converter has produced 4.6 watts per sq cm for a total power output of 23 watts at an operating efficiency of about 16 percent. Vapor converters operate within a cathode temperature range from about 1,500 C down to about 1,200 C. At cathode temperatures of around 1,300 C, for instance, they generate 2.4 watts per sq centimeter with 11 percent efficiency.

General Electric has concentrated its efforts in the 1,500 C range and

This 24" diameter coil wound with 18 pounds of #.064x.130CCHEP rectangular magnet wire, is entirely self-supporting because it's made of Anaconda's new cement-coated epoxy magnet wire. The outstanding bond strength of this wire is stable at high temperatures, too, so coils can be removed from the oven and handled while still hot without danger of deforming.

new CEMENT COATED EPOXY magnet wire makes possible coils that hold their shape without support, hot (200 C) or cold

The secret's in the bond strength. Anaconda's new 130 C (Class B) cement-coated epoxy magnet wire forms a bond so strong that the coil is completely self-supporting.

No ties or braces are needed at any temperature up to 200 C. In fact, it can be removed from the oven at 200 C and dipped in encapsulating materials without losing its shape. Both ways you save on production costs.

The unique Anaconda epoxy cement coating softens just enough to bond each wire firmly to adjacent wires. The higher the temperature (to 200 C) the stronger the bond. It's a contact bond with minimum flow.

And the inherent dielectric properties and limited flow of the epoxy cement actually contribute to the electric strength of windings. Thus you can use cement-coated epoxy wire with little or no increase in overall diameter of the wire.

More advantages: Anaconda cement-coated epoxy magnet wire won't hydrolize in enclosed systems; it's completely compatible with standard transformer oils, varnishes, insulation and encapsulating materials; it's available in all sizes of round, square and rectangular, in spools, reels, pails or drums.

For more information about Anaconda cement-coated epoxy magnet wire, contact Anaconda Wire and Cable Company, 25 Broadway, New York 4, New York, Department EFL-1-E.

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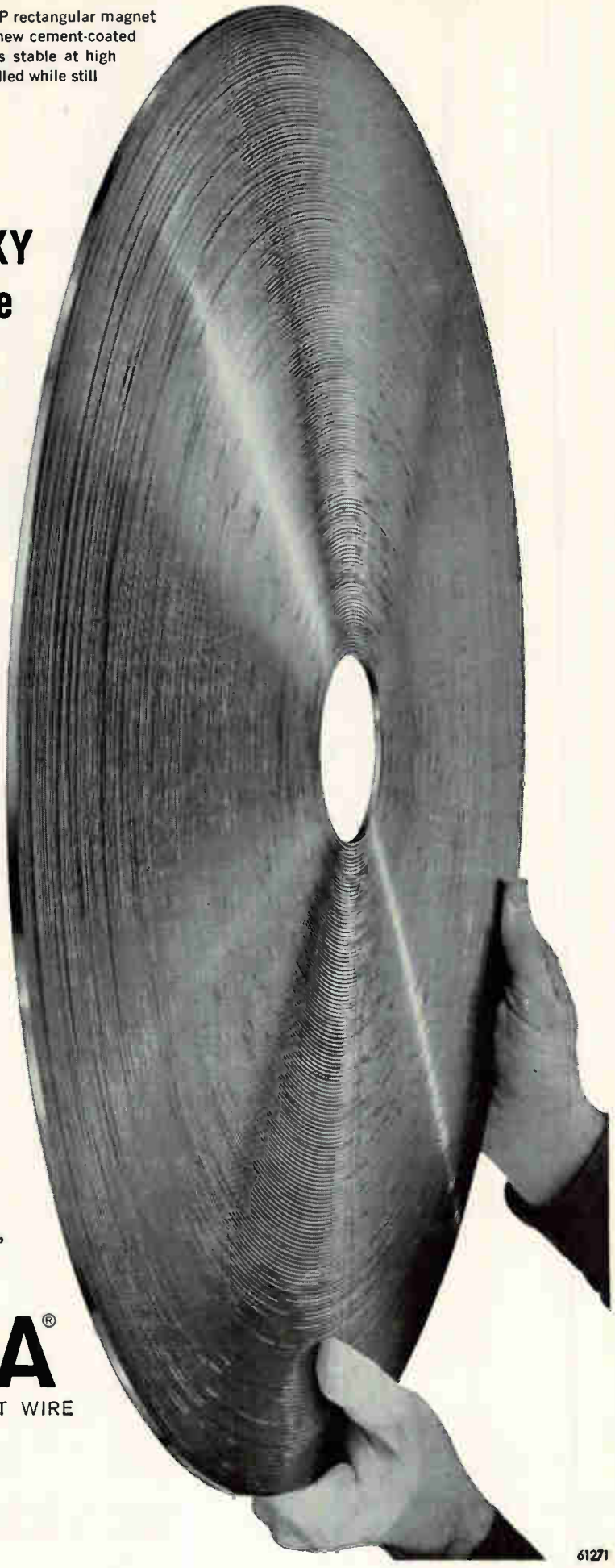

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below, because lower operating temperatures usually indicate optimum solar thermionic system design. Consideration, however, is also being given to selected applications at higher temperatures.

Below 1,500 C, G. E. engineers already see a useful life of 1,000 to 10,000 hours of steady operation. And where particular applications allow the metal-ceramic seal temperature to be kept below approximately 500 C, this magnitude of life is possible now in properly fabricated devices.

The high temperature metal-to-ceramic seal and its compatibility with cesium vapor is the major, continuing materials problem. However, one program, aimed at a 1,000 C metal-ceramic seal already has yielded a ceramic seal that is compatible with cesium vapor at 700 C.

G. E.'s experience indicates that vacuum thermionic converters may have reached their maximum performance, at least with the materials and techniques currently available. Their belief is that a power density of about half-a-watt per sq cm and an efficiency of approximately four percent is the most that can now be achieved in production-type devices having a reasonable life.

The same is true of simple vapor diode converters; meaning a reasonable, practical limit has been reached with diode converters operating with cesiated surfaces in the lower temperature region.

Although some small improvements in the reduction of the anode work function may be expected, power density and efficiency figures are not expected to change significantly for simple diode converters.

In the near future, the power output and efficiency of thermionic converters will be increased. One design, a triode vapor converter, promises to almost double present output power and efficiency in the cathode temperature region below 1,300 C.

Triode converters will be based on an electron injection principle with a grid located within the cathode sheath. Vapor triode converters appear to make feasible a power density of four watts per sq cm and an efficiency of about 20 percent at a cathode temperature of about 1,300 C. As noted above, diode

converters at a comparable temperature have produced 2.4 watts per sq cm at an 11 percent efficiency.

The gain in power density and efficiency accrues mainly through a reduction in cathode fall bought about by injecting a portion of the cathode emitted electrons into the grid-anode region with a kinetic energy of a few electron volts.

Apart from using solar heat, work is going on to use thermionic converters imbedded in atomic piles to convert nuclear heat directly into electrical power. Additional heat sources for thermionic converters include rocket engines as well as conventional chemical and fossil fuels.

In addition to a triode converter, G. E.'s Power Tube Department is working on two new types of thermionic converters. One type will be an integral thermal storage converter containing a material that would be able to store up enough heat while a satellite is within sight of the sun to allow continuous generation of power in the satellite system as it passes behind the earth's shadow.

This type of converter would be useful in low-orbit satellite missions, within 300 to 500 miles of the earth.

The other type, in early stages of development, is a ceramic-coated thermionic converter being designed for use in portable power generators.

REFERENCE

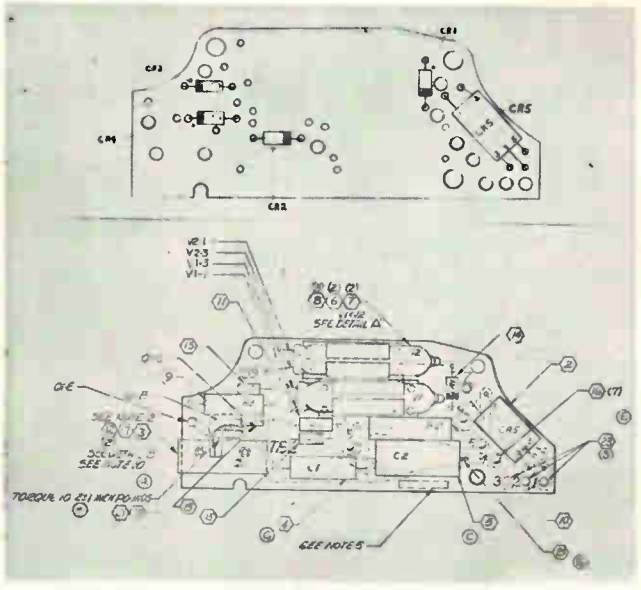
(1) E. A. Baum and A. O. Jensen, Thermionic Converter—Design Status and Forecast, General Electric Power Tube Department, paper presented at Power Sources Conf., Atlantic City, May 1961.

New Molding Methods

IMPROVED molding techniques, developed at Mycalex Corp., permit reductions in the cost of electronic parts molded from Mycalex or Supermica ceramoplastics, according to Jerome Taishoff, president of the company.

The newly perfected techniques are most valuable in producing such dielectric parts as relay spacers and motor end plates. Parts with a small amount of contouring, or with small male and female excursions in topology, can also be produced on presses using the new method.

Savings on some parts run as high as 84 percent.



Plastic overlay is used by assembler (left) to check progress. Components to be added at each step are outlined in full size on the template; component polarity markings are indicated; wires, etc., are shown in color. Typical plastic overlay (right) for installing five diodes, and a drawing of the complete circuit

Transparent Overlays Speed Circuit Assembly

TRANSPARENT overlays can speed the fabrication of etched circuit boards. Not only is assembly faster, but reworks are fewer and inspection is more efficient. The plastic overlays are being used by General Dynamics/Pomona, Div. of General Dynamics Corp., to give step-by-step information necessary for accurate fabrication of the etched circuit boards. Intricate drawings, —often a source of error because of multiple call-outs and many lines —are not needed.

Each of the overlays shows an outline—to exact size—of the circuit board to which it applies. The specific location of each part to be installed is also shown. An assembler responsible for mounting resistors, for example, can find the exact location of each resistor by placing the proper overlay over the circuit board and matching the outline of the board to the overlay outline. Colored parts, such as resistors or lead wires, are reproduced in their proper colors on the overlays. Part values and polarity are also noted. An inspector, using the same overlay, can quickly make a visual check on accuracy after the assembler has completed each step.

The mass of detail typical of drawings is eliminated. Multiple callouts, the maze of lines, and tightly packed or distorted illustrations are all unnecessary with the overlay technique. It has been well established that too much information not only confuses the assembler but makes the inspector's job more difficult.

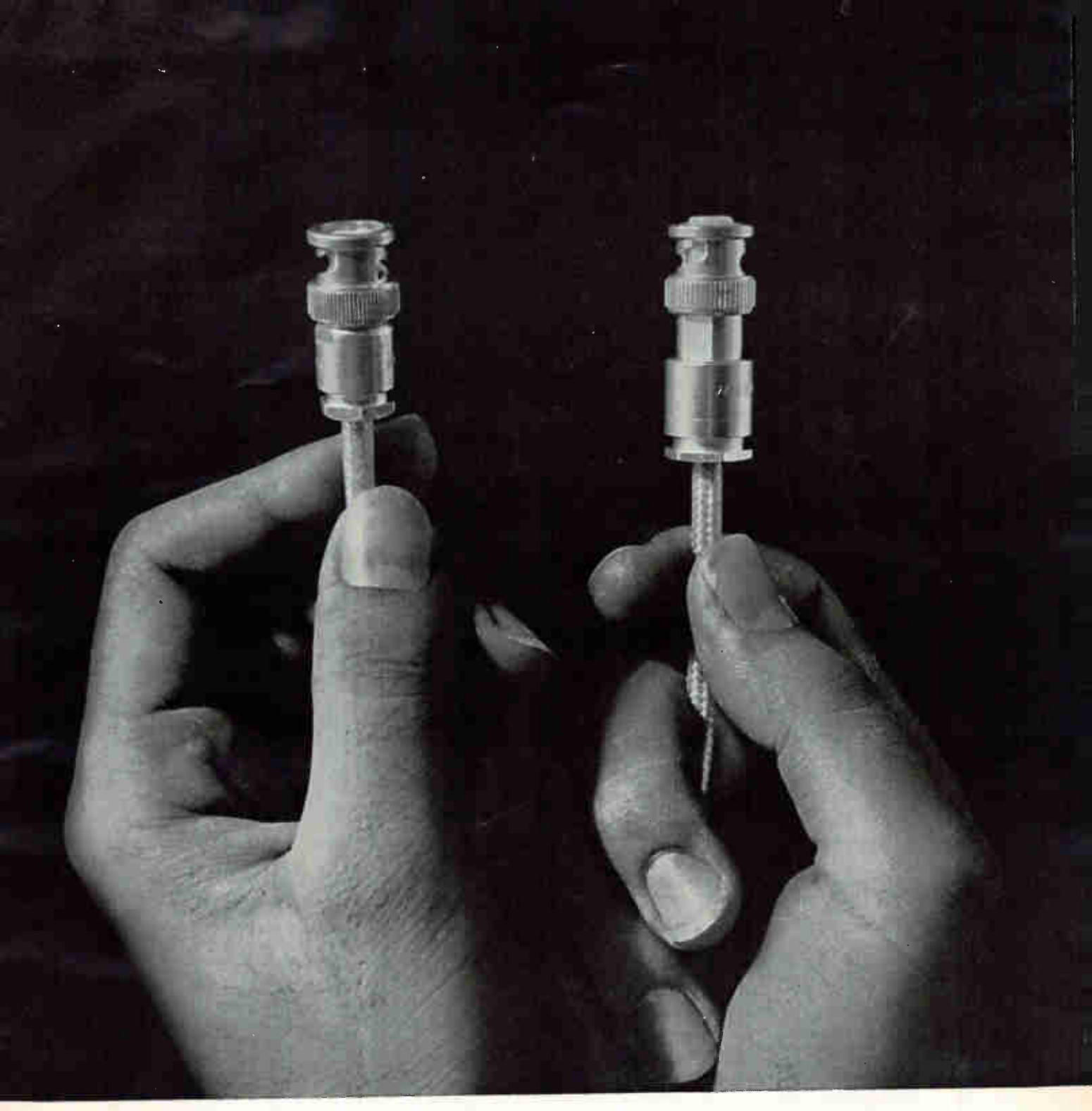
Although cost of the plastic overlays is slightly higher than paper drawings, the cost savings in other areas more than make up for it. The technique greatly reduces rework caused by errors in assembly. Efficiency of assemblers using overlays has been substantially increased. The process also eliminates the need for the inspector to serve as a foreman. The assembler can use the overlay to check his own work and does not need to ask the inspector. As a result, one inspector can check twice as many assemblies as previously.

Extrusions Form Efficient Housing

By L. C. OAKLEY,
Vice President,
Mid-Eastern Electronics, Inc.,
Springfield, N.J.

ALUMINUM EXTRUSIONS in three basic shapes provide efficient, attractive housings for a series of compact, high-output d-c power sources designed for missile ground support and industrial equipment. The package can be assembled, or disassembled for maintenance, in a few minutes.

The extrusions are finned corner pieces, gold-anodized clip sections and a center partition. These are cut to length (package height) on a cutoff machine. The corner pieces



How would you choose between these two coaxial connectors?

The answer depends on your circuit requirements. The *ipc*® connector on the right was specially designed for a customer who needed a BNC-type connector for high voltage operation. We designed this connector for use up to 5000 vdc. It looks like the AMPHENOL® connector on the left, a standard BNC rated at the usual 500v.

This is typical of the differences between *ipc* and AMPHENOL connectors. Approximately 60 per cent of the *ipc* connectors we market each year are special designs to meet individual customer's requirements.

The AMPHENOL connector line, on the other hand, offers you the most complete selection of UG-types available from a single manufacturer as well as *Push-On*®, *Quick-Crimp*®, and *Subminax*® connectors.

So, you see, you really don't have to choose between the two. RF Products offers you industry's most complete line of standard coaxial connectors—AMPHENOL—as well as the custom engineered line—*ipc*. Together, they can solve all your connector problems.

You can get full details by writing for Catalog D3 which presents the AMPHENOL line in detail, and Catalog 11 which describes the *ipc* connector line. If you don't find the connector you want in these catalogs, call your nearest RF Products representative. He'll be happy to work with you to develop exactly the connector you need. *Registered Trademark*

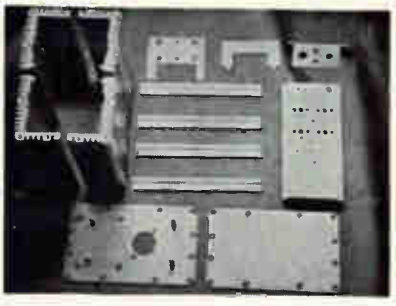
RF PRODUCTS | ipc DX AMPHENOL

Division of Amphenol-Borg Electronics Corporation • 33 East Franklin St., Danbury, Conn.

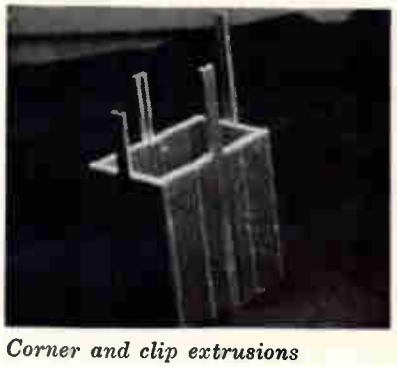
CIRCLE 81 ON READER SERVICE CARD

are finned on the outside for heat dissipation and are grooved in the inside for mounting printed circuit boards. Power transistors are mounted on the center partition. End slots in the partition fit tightly over keys on the corner pieces.

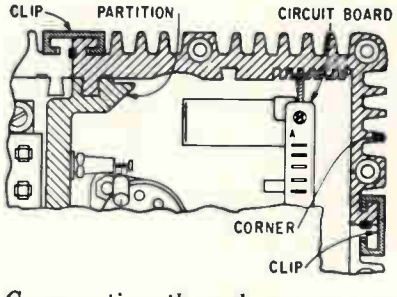
To assemble a unit, the bottom plate, which carries the connector, is wired to the harness. The transformer is mounted on the bottom plate and the two corners which fit around the transformer are



Mechanical parts of package



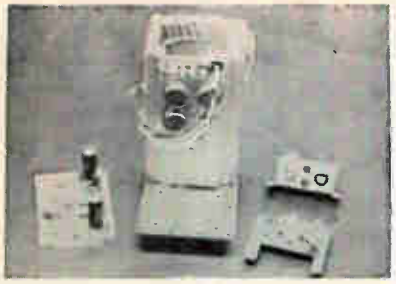
Corner and clip extrusions



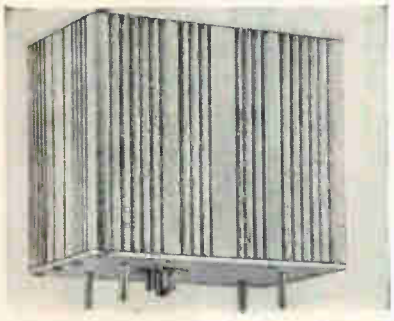
Cross-section through one corner of an assembly

fastened to the bottom and clipped together. The other components are added and the remaining two corners and their clips are attached. The corner pieces are fastened to the top and bottom plates with neoprene gaskets and screws. If the unit is to be waterproof, Silastic compound is added at the junctions of the corners and on the interiors of the clips.

This packaging method has resulted in a 60 percent reduction in



Partially assembled power supply



Completed unit, ready for use

cost. Labor cost is lower and inspection and adjustment is easier. The unit can be completely disassembled in less than five minutes and the printed circuit board can be replaced in one minute. All components are reliably fixed in position.

Improved heat dissipation permitted a 33 percent increase in power output. The unit can operate in still air without an external heat sink. Tests indicate excellent heat transfer from the center partition to outer surfaces with practically no temperature differential between any two points on the unit.

The initial unit in this series was a 12-volt, 3-ampere d-c unit for Atlas missile support equipment. The first approach, quickly discarded, had all components potted inside a transformer can. It required an external heat sink and was not maintainable.

Units were then housed in finned sand castings. Capacitors and circuit boards were supported in foam rubber above potted transformers and rectifiers. Transistors were mounted externally in recesses machined in the housings. This design was produced for more than a year, but machining and assembly were costly, maintainability was limited, external transistors reduced reliability and components might slowly migrate in location in shock and vibration environments.

New On The Market

Dual-Gun Storage Tube

FOR SATELLITE AND MISSILE TRACKING

ALLEN B. DUMONT LABORATORIES, 750 Bloomfield Ave., Clifton, N. J. Dual-gun 10-in. storage tube has high accuracy for satellite and missile tracking. It utilizes a patented gun structure to achieve deflection linearity within 1 percent (no deflection plate current). Advantages are the ability to track from two separate antennas or two angles or points. Storage time of the tube is from 3 to 10 min. Writing speed is 200,000 ips at 40 lines per in. resolution and 50 foot lamberts light output.

CIRCLE 301 ON READER SERVICE CARD

Television Comparator

MAGNIFICATION UP TO 300 TIMES

GPL DIVISION, General Precision, Inc., 63 Bedford Road, Pleasantville, N. Y. Specially designed c-c tv system enables an operator to inspect, in minute detail, components such as transistors, resistors, microminiature wafers, and subassemblies. Unit can also be used to examine and study live biological specimens and standard lab slides. Using a control stick, an operator can position the image on the screen, and change its magnification through the entire range without loss of focus.

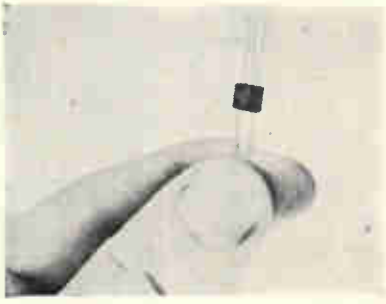
CIRCLE 302 ON READER SERVICE CARD

Tantalum Capacitors

HIGH-RELIABILITY

FANSTEEL METALLURGICAL CORP., North Chicago, Ill., announces tantalum capacitors with a 99.997 percent reliability per 1,000 hr. Units are offered in ratings from 1.5 to 560 μf for temperatures ranging from −55 to +125 C. They will withstand 40 g shock and 2,000 cps vibration at 20 g. Ratings are available at maximum d-c working voltages from 4 to 125 v.

CIRCLE 303 ON READER SERVICE CARD



Tiny Silicon Chopper

ENCAPSULATED PACKAGE

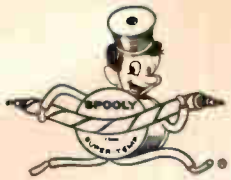
SOLID STATE ELECTRONICS CO., 15321 Raven St., Sepulveda, Calif. Model 6 rugged solid state Microchopper will connect and disconnect a load from a signal source. It may also be used as a synchronous demodulator to convert an a-c signal to d-c. Linear switching or chopping of voltages can be accomplished over a range extending down to ± 20 μv and up to ± 20 v. Chopper is an inertialess device that can be driven from d-c to 100 Kc.

CIRCLE 304 ON READER SERVICE CARD

Varactor Diodes

MICROETCH TYPE

PHILCO CORP., Lansdale, Pa. Types L-4110, L-4111, and L-4112 varactor diodes provide simultaneous operation at max frequency and max voltage. They have very high cutoff frequency and increased ca-



HOTTEST NEWS *in the industry*

Super-Temps new versatile wire and cable with an operating temperature of 1000°F.... flexibility...moisture resistant properties is bringing a new high standard of quality to today's most demanding industries.

New design potentials with MGT are literally unlimited and new economies and more efficient operations are being obtained in present equipment.

MGT wires are ideally suited for incorporation in cables of single or multi-conductor constructions. Braided wide shielding of various metals including stainless steel can be used. Jackets of Glass Fiber Braids or other materials compatible with high temperature usage are obtainable.

Below is a test chart showing results from our own and other laboratories.

MGT WIRE AND CABLE

Specimen #1–#24 (AWG) 7/32 N.P.C. Specimen #2–#20 (AWG) 7/28 N.P.C.

TEST	SPECIMEN #1	SPECIMEN #2
Dielectric 1.5 KV 1 Min. 5% Salt Solution Test #1	Passed	Passed
1000°F. for 30 Minutes Dielectric	1500 for 20 sec.	1500 for 60 sec. 1550 Breakdown
Insul. Res.	6000 Megohms	12,000 Megohms
Cycle Test		
4.1 800°F. for 30 Minutes Cool to Room Temp. Insul. Res.	infinite	infinite
4.2 Saltwater Bath 1 Hr. Insul. Res.	infinite	infinite
4.3 800°F. for 30 Minutes Cool to Room Temp. Insul. Res.	infinite	infinite
4.4 Hi-Pot 1 KV for 1 Min	Passed	Passed
4.5 Breakdown	4.8 KV	2.7 KV
Cycle Test (conducted on single specimen)		
5.1 1000°F. for 30 Minutes Cool to Room Temp. Insul. Res.	infinite	infinite
5.3 1000°F. for 30 Minutes Insul. Res.	infinite	infinite
5.4 Hi-Pot 1 KV for 1 Min	Passed	Passed
5.5 Insul. Resist.	300,000 Megohms	infinite
5.6 Breakdown	2 KV	2.2 KV

INSULATION RESISTANCE CHECKED AT 500 VOLTS D.C. EXCEPT WHERE NOTED ABRASION TEST–(JANCO) Specimen #1–39.8 Inches; Specimen #2–61.3 Inches.

Super-Temp has the largest line of wire and cable, the best production facilities, and a nationwide network of engineering representatives ready to serve you at a moment's notice ...good reasons to always specify Super-Temp.

For information on availability and prices of amazing new MGT wire and cable write, wire or phone...your inquiry will receive prompt attention.

Super-Temp

AMERICAN SUPER-TEMPERATURE WIRES, INC.

A Subsidiary of Haveg Industries, Inc.

8 West Canal Street, Winoski, Vermont—UNiversity 2-9636

General Sales Office: 195 Nassau St., Princeton, N. J.—WAlnut 4-4450

Keep Ahead with HAVEG

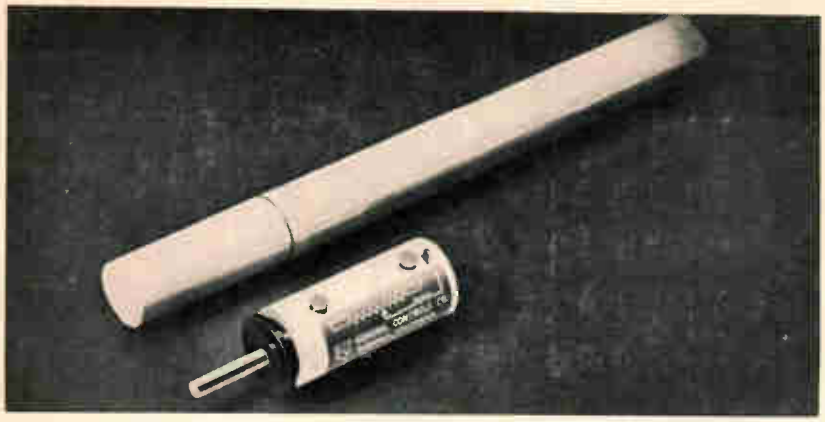
FIRST IN *Engineered* PLASTICS

Super-Temp is a specialist in Teflon and Silicone Rubber Insulations. Products include: Magnet Wire, Airframe Wire, Hook-up Wire, Coaxial Cables, Miniature & Jumbo Cables and Tapes.*

*Dupont's TFE FEP Resins

pacitance variation promoting unusual efficiency. Units are designed for use as harmonic generators at frequencies up to 3 Gc, 6 Gc and 10 Gc. They may also be used as parametric amplifiers or r-f tuning devices.

CIRCLE 305 ON READER SERVICE CARD

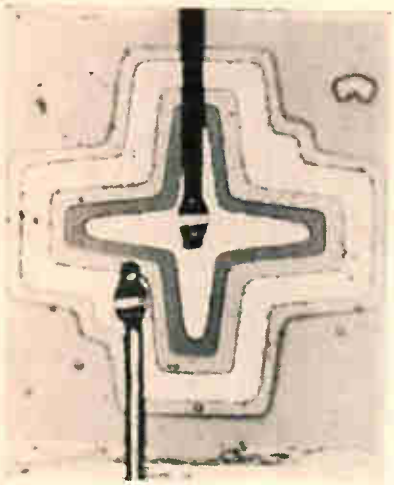


Multiturn Potentiometer

FOR MISSILE MANUFACTURERS

GENERAL CONTROLS CO., 1320 So. Flower St., Burbank, Calif. The PM305 10-turn pot measures ⅜ in. in diameter and weighs 5 grams. It features a molded body, which contributes to its reliability in temperatures ranging up to 150 C. Rotation of the wire-wound pot is 3,600 deg, plus 20 deg, minus 0 deg, with an active coil length of 8 in. Torque is 0.5 oz in. max. Resistance range is 50 to 100,000 ohms; resistance tolerance, ±3 percent with the best practical being ±1 percent; power rating, 1 w at 85 C.

CIRCLE 306 ON READER SERVICE CARD



Planar Transistor

STAR GEOMETRY

MOTOROLA SEMICONDUCTOR PRODUCTS INC., 5005 E. McDowell Road, Phoenix, Ariz. Silicon transistor combines advantages of epitaxial growth and surface passivation with internal star geometry optimized for highly efficient operation in circuits ranging from d-c to 100 Mc. Star configuration is said to provide the greatest emitter and base perimeter-to-area ratio obtainable, thereby increasing the frequency response of the unit without affecting its current-handling capability. Switching speed at 0.5 amp is 10 nsec.

CIRCLE 307 ON READER SERVICE CARD

Transistor Cooler

THERMOELECTRIC

GENERAL THERMOELECTRIC CORP., P.O. Box 253, Princeton, N. J. The F-3TC Frigistor, a thermoelectric cooling module of high pumping capacity, is intended for use with

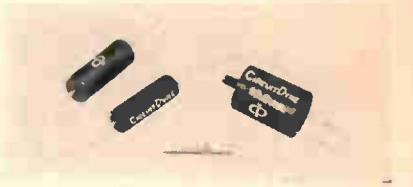
TO-3 and TO-41 transistor cases. It has three TE couples, the cold sides of which extract heat from the case. The heat is pumped out to the other side of the transistor cooler and rejected to a chassis, fins, or heat sink. The F-3TC provides cooling at any current up to 17 amp.

CIRCLE 308 ON READER SERVICE CARD

Current Regulator

HIGH ISOLATION FACTOR

CIRCUITDYNE CORP., 480 Mermaid St., Laguna Beach, Calif., introduces a two-terminal component used for limiting current in electrical networks. The Currector is a solid-state unit, available in fixed ratings from 1 to 10 ma in 10 percent increments. Standard current



tolerance is ±5 percent. Typical admittances are as low as 1 μohm, and both polarized and nonpolarized versions are available.

CIRCLE 309 ON READER SERVICE CARD

Preset Counter

ADD-SUBTRACT

ROBOTOMICS, INC., 2422 E. Indian School Rd., Phoenix, Ariz. Dual preset quantities may be counted in add or subtract mode at speeds up to 100,000 per sec with model 3004 S predetermining counter. Counting direction is controlled manually or with automatic electronic control by supplying input pulses to one of two control lines. Relay outputs or pulse outputs initiate any desired action upon completion of each preset count.

CIRCLE 310 ON READER SERVICE CARD

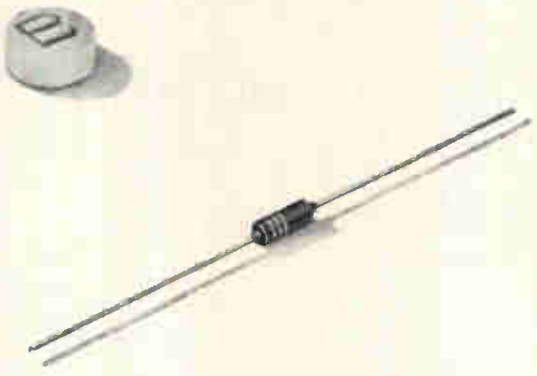
Subminiature Rectifiers

INTERNATIONAL RECTIFIER CORP., 233 Kansas St., El Segundo, Calif. One thousand to 2500 v. subminiature rectifiers for high voltage multiplier circuits provide 85 to 100 ma.

CIRCLE 311 ON READER SERVICE CARD

Coaxial Relay

OMEGA PRECISION, INC., 757 N. Coney Ave., Azusa, Calif. Operat-



No derating headaches with General Electric Subminiature Rectifiers

These silicon subminiature glass rectifiers can be operated reliably right up to the current and voltage ratings shown below . . . *no derating necessary!* And G-E transient PRV ratings provide added protection when you choose the right rectifier for your application. Another important protection: rugged design to meet military requirements.

So for outstanding reliability under all operating conditions in magnetic amplifier and other low leakage circuits, ask your Semiconductor Products District Sales Manager for complete information on G-E subminiature rectifiers. Or write to Rectifier Components Department. Section 25I31, · General Electric Company, Auburn, New York. In Canada: Canadian General Electric, 189 Dufferin Street, Toronto, Ont. Export: International General Electric, 150 E. 42nd St., N.Y. 17, N.Y.

FOR FAST DELIVERY OF SUBMINIATURE RECTIFIERS AT FACTORY-LOW PRICES, SEE YOUR AUTHORIZED G-E DISTRIBUTOR.

RATINGS AND CHARACTERISTICS

JEDEC or GE Type Number	Repetitive PRV	Transient PRV	Max. I_{DC} at 25°C Amb.	Max. I_{DC} at 150°C Amb.	Max. Full Load Voltage Drop at 25°C	Max. Oper. Temp. °C Amb.
1N645	225	275	400 ma	150 ma	1V	175°
1N646	300	360	400 ma	150 ma	1V	175°
1N647	400	480	400 ma	150 ma	1V	175°
1N648	500	600	400 ma	150 ma	1V	175°
1N649	600	720	400 ma	150 ma	1V	175°
1N676	100	120	200 ma	75 ma	1V	175°
1N677	100	120	400 ma	150 ma	1V	175°
1N678	200	240	200 ma	75 ma	1V	175°
1N679	200	240	400 ma	150 ma	1V	175°
1N681	300	360	200 ma	75 ma	1V	175°
1N682	300	360	400 ma	150 ma	1V	175°
1N683	400	480	200 ma	75 ma	1V	175°
1N684	400	480	400 ma	150 ma	1V	175°
1N685	500	600	200 ma	75 ma	1V	175°
1N686	500	600	400 ma	150 ma	1V	175°
1N687	600	720	200 ma	75 ma	1V	175°
1N689	600	720	400 ma	150 ma	1V	175°

GENERAL ELECTRIC

ing voltage is 22-32 v d-c. vswr is 1.2. Unit is less than one in. in diameter.

CIRCLE 312 ON READER SERVICE CARD

Heater Blankets
USE ETCHED FOIL

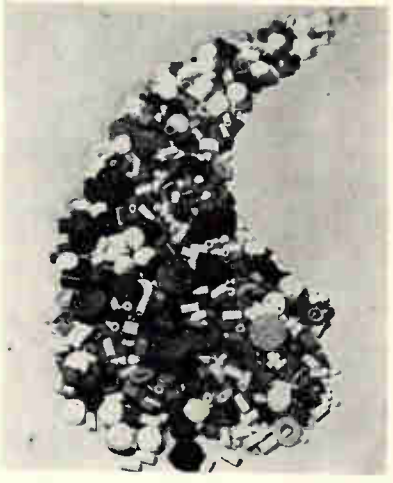
THERMAL CIRCUITS, INC., 59 Park St., Beverly, Mass. A new type of construction, utilizing resistance alloy foil etched to shape is now being used to manufacture flexible electric heater blankets. The etched circuit eliminates wire windings. Foils as small as 1 by 3 in. are etched and laminated in Teflon for very thin, high performance heaters of electronic components.

CIRCLE 313 ON READER SERVICE CARD

Beam Evaporator

ALLOYD ELECTRONIC CORP., 37 Cambridge Parkway, Cambridge, Mass. Electron beam evaporator for ultra-high purity metallic and ceramic films includes electron gun and vacuum chamber.

CIRCLE 314 ON READER SERVICE CARD



Epoxy Pellets
SIMPLIFY BONDING

EPOXY PRODUCTS, INC., 137 Coit St., Irvington, N. J. Epoxy in pellet form becomes a universal bonding material suited to production line

techniques. Pellets eliminate such drawbacks as difficulty in mixing, difficulty in metering and skin irritation. They will bond practically any kind of material to any other kind. Shear strength of a steel to steel bond is 4,700 psi.

CIRCLE 315 ON READER SERVICE CARD

Tantalum Capacitors
AXIAL LEAD

TANSITOR ELECTRONICS, INC., West Road, Bennington, Vt. The HV-type axial lead tantalum foil capacitors have single unit ratings to 300 wvdc over the temperature range −55 to +85C, and to 250 wvdc from −55 to +125 C. Units save space and weight by eliminating series connections and balance resistors formerly required for such voltages.

CIRCLE 316 ON READER SERVICE CARD

A-C Voltage Standard

TENSOR ELECTRIC DEVELOPMENT CO., INC., 1873 Eastern Parkway, Brooklyn 33, N. Y. Accuracy is ±0.1 percent at 100v output.

CIRCLE 317 ON READER SERVICE CARD

Coax Termination
WITH LOW SWR

HEWLETT-PACKARD CO., 1501 Page Mill Road, Palo Alto, Calif. A low reflection load for terminating 50-ohm coaxial systems in their

characteristic impedance is available. Model 908A has a swr of less than 1.05 from d-c to 4,000 Mc. It is useful for terminating coaxial devices during most swr measurements, or as a production line impedance standard. Power rating is ½ w average; maximum input is 1 Kw peak.

CIRCLE 318 ON READER SERVICE CARD

A-C Voltage Standard
PORTABLE UNIT

SENSITIVE RESEARCH INSTRUMENT CORP., 310 Main St., New Rochelle, N. Y. Model FLH thermocouple transfer standard measures directly in percentage of reading, the influence of frequency on the indication of voltmeters, calibrators and other transfer standards. Frequency influence is measured to an accuracy of ±0.01 percent from 1.5 v to 1,125 v over a span of 20 cps to 50,000 cps.

CIRCLE 319 ON READER SERVICE CARD

Linear Transducer
HIGHLY SENSITIVE

ASSEMBLY PRODUCTS, INC., Chesterland, O. Transducer converts a linear position to a signal that reads out on a meter. The signal need not be amplified. The transducer is best suited to measuring deviations of a few thousandths of of an inch from mechanical null. When only indication of the signal is required, a panel meter is used with the transducer. If control of an operation is also desired, the transducer may read out to a meter-relay.

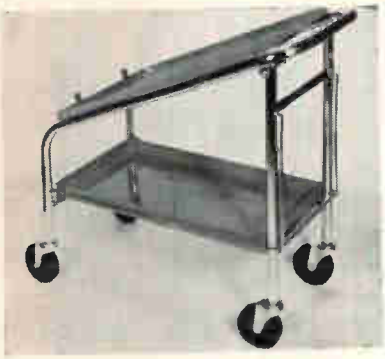
CIRCLE 320 ON READER SERVICE CARD

Shutter Switch

LITTON INDUSTRIES, Airtron Div., 200 E. Hanover Ave., Morris Plains, N. J. X-band waveguide shutter

switch is 1.65 cubic in. and weighs under 3½ ounces.

CIRCLE 323 ON READER SERVICE CARD



Oscilloscope Cart

PRICED AT $29.95

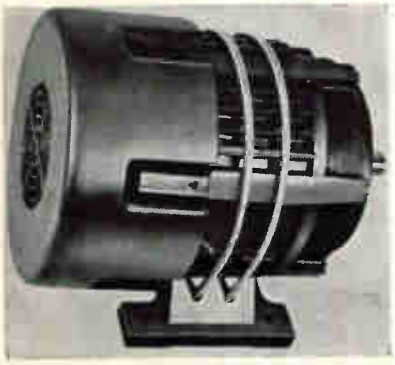
ATLANTIS METAL PRODUCTS Division of Atlantis Electronics Corp., P.O. Box 451, Garland, Texas, announces a scope cart for oscilloscopes or auxiliary equipment. Features: graduated back stop support; 4 in. swivel caster wheels; collapsible for storage. Dimensions: 29 in. high (25 deg tilt) by 15 in. wide by 27 in. long. Frame is made of 1 in. o-d steel tubing. Trays are made of heavy 20 gage cold rolled steel.

CIRCLE 324 ON READER SERVICE CARD

Time Delay Relays

ACCUTRONICS, INC., 403 N. Foothill Rd., Beverly Hills, Calif. Relays provide fixed or adjustable time delays from 100 μsec to 300 seconds. Price range is from $29 to $45.

CIRCLE 325 ON READER SERVICE CARD



Induction Motor

CONTINUOUS-DUTY

KEARFOTT DIVISION, General Precision, Inc., 1150 McBride Ave., Little Falls, N. J., announces the EF-30-1 totally enclosed, continu-

ous-duty, fan - cooled induction motor. Designed to suit a variety of military and commercial applications, the unit operates at a speed of 5,500 rpm and complies with the applicable specifications of MIL-E-16309, MIL-STD-108A, and U.S. Signal Corps Specification 72-53.

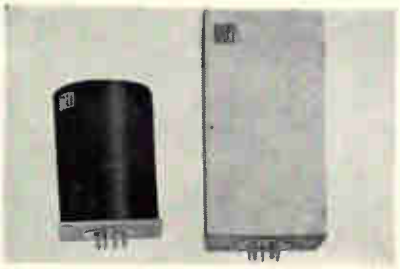
CIRCLE 326 ON READER SERVICE CARD

Power Resistors

T-C of ± 10 PPM/DEG C

OMTRONICS MFG., INC., P.O. Box 1419, Peony Park Station, Omaha 14, Neb. Miniature precision power resistors are available with a guaranteed temperature coefficient of ± 10 ppm/deg C max, over a temperature range from − 55 C to + 350 C. Identified as Code No. C-10, they are available in both inductive and noninductive windings, power ratings from ½ to 10 w, resistance range from 25 to 275,000 ohms, and tolerances to ± 0.05 percent, depending on size and type.

CIRCLE 327 ON READER SERVICE CARD



Magnetic Regulators

FOR SCR CONTROL

ORTHO FILTER CORP., 7 Paterson St., Paterson, N. J. Ortho-Trig magnetic regulators are capable of firing and controlling kilowatts of power. The self-contained magnetic control circuit is capable of controlling the leading edge of the silicon controlled rectifier gate voltage wave over a range of 0 to 180 deg. The 60 cps unit measures 1⅜ in. sq by 3½ in. high and weighs 16 oz. The 400 cps unit measures 1⅜ in. in diameter by 2¼ in. high and weighs 5 oz.

CIRCLE 328 ON READER SERVICE CARD

Tantalum Capacitors

COMPONENTS, INC., Smith St., Biddeford, Maine. Subminiature, solid electrolyte units, polarized and non-

CIRCLE 92 ON READER SERVICE CARD

CIRCLE 202 ON READER SERVICE CARD

polarized, have a hexahedral shape, are available in five sizes.

CIRCLE 329 ON READER SERVICE CARD

Terminating Arrows
AND SPEARS

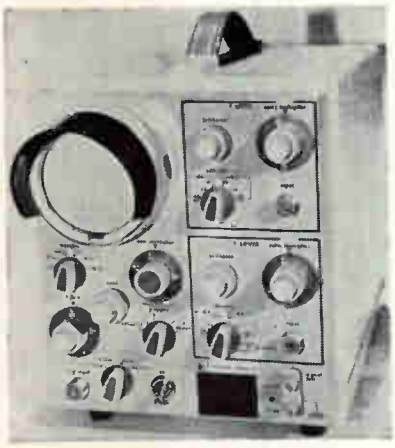
COAX DEVICES, Box V, Chelsea 50, Mass., offers to the microwave engineer a group of terminating arrows and spears each of which produces a vswr of 1.03 or less when placed in corresponding waveguide and operated over its waveguide range. They are made of Microloss type F, a material that is fungus proof, moisture resistant, and able to withstand severe temperature changes. Prices on single units range from $10-$20.

CIRCLE 330 ON READER SERVICE CARD

Film Resistors

OHMITE MANUFACTURING CO., 3677 Howard St., Skokie, Ill. Film patterns in wafer type, micromodule film resistors permit user to tailor resistance to required values.

CIRCLE 331 ON READER SERVICE CARD



Dual Gun Oscilloscope
WEIGHS 22 LB

PACKARD BELL ELECTRONICS, 12333 W. Olympic Blvd., Los Angeles 64, Calif. Dual gun, d-c to 5 Mc oscilloscope is priced at $495. With only

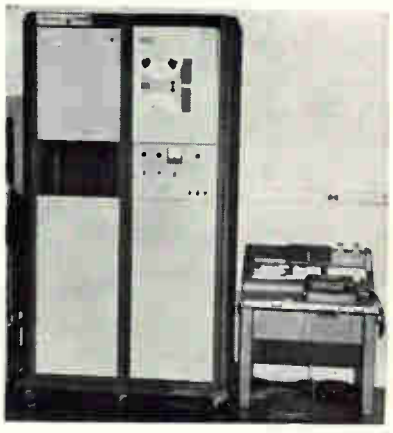
two types of vacuum tubes and the crt, the scope is designed for easy maintenance and repair. Identical amplifiers on each vertical input provide identical traces over the full screen face with no phase shift. A preamplifier is built into the lower vertical amplifier, increasing the sensitivity from 100 mv/cm to 1 mv/cm. Sweep range is from 1 μsec/cm to 1 sec/cm.

CIRCLE 332 ON READER SERVICE CARD

Magnetic Tape Certifier

CYBETRONICS, INC., 235 High St., Waltham 54, Mass. System inspects all channels simultaneously for surface dirt, creases, inclusions, etc.

CIRCLE 333 ON READER SERVICE CARD



Conversion System
ANALOG-TO-DIGITAL

ELECTRONIC DEVELOPMENT CORP., 423 W. Broadway, Boston 27, Mass. Model 8040 multichannel analog-to-digital conversion system will automatically translate up to 40 channels of varying voltage data into 13-bit 8-4-2-1 binary-coded decimal form, and then prepare this data on punched cards in IBM format.

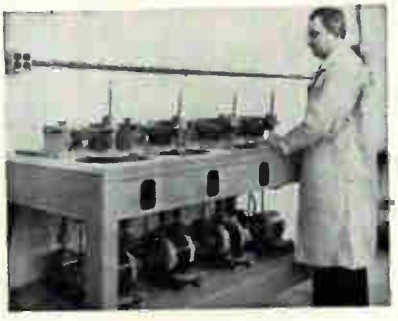
CIRCLE 334 ON READER SERVICE CARD

Thermocouples
FEATURE VERSATILITY

AERO RESEARCH INSTRUMENT CO., 315 N. Aberdeen St., Chicago 7, Ill. Temperature ranges of AirOpak thermocouples are from −400 to 3,000 F. Sheath diameters are 0.40 to 0.32. They can be bent to shapes;

weldments can be performed directly on thermocouples. They are pressure tight to 50,000 psig.

CIRCLE 335 ON READER SERVICE CARD



Lapping Machine
CAN CUT COSTS

FEDERATED ELECTRONICS, INC., 139-14 Jamaica Ave., Jamaica, N. Y. Development of a new lapping machine in the manufacture of germanium crystals could save the transistor industry millions of dollars, it is claimed. The unit, a modification of an optical industry lens grinder, will turn out germanium crystals flatter and more parallel and eliminates a number of processes in the making of the crystals.

CIRCLE 336 ON READER SERVICE CARD

Power Triodes

EITEL-MCCULLOUGH, INC., 301 Industrial Way, San Carlos, Calif. For use as zero-bias Class-B linear amplifiers, the triodes provide peak-envelope powers ranging from 500 to 20,000 w.

CIRCLE 337 ON READER SERVICE CARD

Pot Conformity
TAPE PROGRAMMED

JONATHAN ELECTRONICS CORP., 720 E. Walnut St., Fullerton, Calif., introduces a nonlinear potentiometer conformity tester with tape pro-

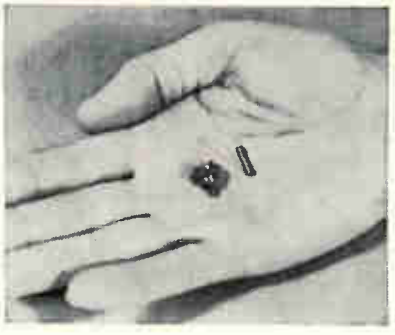
grammed function control plus display and chart readout. It offers a completely automatic means of measuring deviation from predetermined voltage transfer functions. An average pot can be tested at 36 points in less than 4 minutes, with an average of 2 minutes required for set up.

CIRCLE 338 ON READER SERVICE CARD

Radiator/Retainers

THE BIRTCHER CORP., 745 S. Monterey Pass Rd., Monterey Park, Calif. Combination radiators and retainers for mounting in flip-flop or push-pull circuits are double-ended with tapped base.

CIRCLE 339 ON READER SERVICE CARD



Cryogenic Sensors
TWO TYPES

MINNEAPOLIS-HONEYWELL REGULATOR CO., Wayne & Windrim Aves., Philadelphia 44, Pa. These tiny sensors measure cryogenic temperatures from 4 to 40 deg Kelvin (— 269 to — 233 C). One sensor measures surface temperatures, while the other device is a probe-type unit for internal applications. They can be used with conventional millivolt-type instruments.

CIRCLE 340 ON READER SERVICE CARD

Cable Assemblies

BOSTON INSULATED WIRE & CABLE CO., Bay St., Boston 25, Mass. Miniature coaxial and triaxial cables are available with connectors in 50, 75, and 95 ohm sizes.

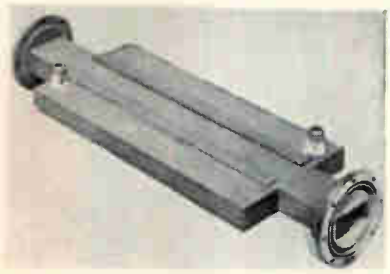
CIRCLE 341 ON READER SERVICE CARD

Angular Accelerometer

DONNER SCIENTIFIC CO., Concord, Calif. Force balance angular accelerometer, less than 4 oz., is avail-

able in ranges from ±500 rad/sec² to ±1500 rad/sec².

CIRCLE 342 ON READER SERVICE CARD



Directional Couplers
THREE CONFIGURATIONS

BOMAC LABORATORIES, INC., Salem Road, Beverly, Mass. Directional couplers are offered in three general configurations: cross guide, sidewall, and topwall coupling to meet the requirements of moderate cost, high power handling capacity and high directivity, respectively. Units are available with customer specified coupling value, power handling capacities ranging from 70 to 2,700 Kw.

CIRCLE 343 ON READER SERVICE CARD

Waterproof Plug

VECTOR MANUFACTURING, 5616 Lawndale, Houston, Tex. For use with signal circuits for offshore geophysical work, the plug can be repaired on the job because of a replaceable banana pin screw-in connection.

CIRCLE 344 ON READER SERVICE CARD

Tetrode
FOR F-M, TV

PENTA LABORATORIES, INC., 312 No. Nopal St., Santa Barbara, Calif. The 4-100A tetrode, used in f-m

broadcasting, television, and other services, can be operated at frequencies up to 110 Mc. Plate-dissipation rating is 1,000 w. Tube will provide up to 3,400 w of plate power output as a Class-C c-w or f-m amplifier, and more than 2,600 w as a Class-C amplitude-modulated amplifier.

CIRCLE 345 ON READER SERVICE CARD

Magnetic Tape Recorder

AMERICAN CONCERTONE, INC., 9449 W. Jefferson Blvd., Culver City, Calif. Recorder features a dual-differential capstan drive system and concentric reel design.

CIRCLE 346 ON READER SERVICE CARD

Encoders
ANALOG-TO-DIGITAL

NORTHERN PRECISION LABORATORIES, INC., 541 Commerce St., Franklin Lakes, N. J., announces analog-to-digital shaft position encoders based upon the Gray Code format. Units are available in ranges from 2^5 to 2^{13}. Precious metal alloy code drums are utilized in lieu of etched or plated disks. Multi-strand wipers are used on each track to increase reliability and to reduce noise.

CIRCLE 347 ON READER SERVICE CARD

Stacking Module
FOR MILITARY USES

MODULAR ELECTRONICS CO., P. O. Box 552, Santa Ana, Calif. The EM-136 module provides the system designer with a unique package design for modular subsystem circuits. Design is well suited for military electronic applications in missiles, aircraft, underwater instrumentation and sounding rockets. It allows the stacking of up to 14 units in a single system.

CIRCLE 348 ON READER SERVICE CARD

COAXIAL TYPE SWITCHES
. . . multi-position, single or multiple gang

Now you can switch coaxial line circuits quickly and without error. These handy, inexpensive units are available with "UHF", "BNC", "N" and Phono type connectors for use with either 52 or 75 ohm lines. Phono connector types are specific for Hi-Fi applications. Other types are designed to handle RF Power up to 30 MC, 1 KW input.

Stock items ready for shipment are:

Model 550A—Single gang, single pole, 5 position switch with UHF connectors. Price: $8.25 each.

Model 551A—Single gang, 2 pole, 2 position special purpose switch with UHF connectors. Ideal for switching any device in or out of series connection in coax line circuits. Price: $7.95 each.

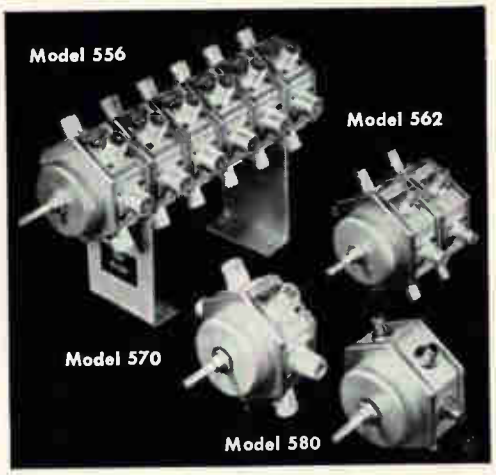
Model 560—Single gang, single pole, 5 position switch, same as Model 550A except with BNC type connectors. Price: $11.95 each.

Model 561—Single gang, 2 pole, 2 position special purpose switch, same as Model 551A except with BNC type connectors. Price: $9.95 each.

Model 570—Single gang, single pole, 5 position switch, same as Model 550A except with N type connectors. Price: $13.35 each.

Model 580—Single gang, single pole, 5 position switch, same as Model 550A except with Phono type connectors. Price: $7.35 each.

Multiple gang types, up to 6 gang for single pole—5 position switches, and as required for 2 pole—2 position switches, are made to order with any connector types listed above. Prices on request.



Barker & Williamson, Inc.

Beaver & Canal • Bristol, Penna.

Foreign Sales—Royal National Corp., 250 West 57th St., New York 19, N.Y.

OTHER B&W EQUIPMENT: Transmitters AM-CW-SSB • Transistorized Power Converters and inverters • Dip Meters • Matchmasters • Frequency Multipliers • Low Pass Filters • T-R Switches • R. F. Filament Chokes • Transmitting R. F. Plate Chokes • Band-Switching Pi-Network Inductors • Cyclometers • Antenna Coaxial Connectors • Baluns • Variable Capacitors • Toroidal Transformers • Fixed and Rotary edgewound Inductors • Plug-in Coils with fixed and variable links • Straight type air wound coils in a variety of dimensions.

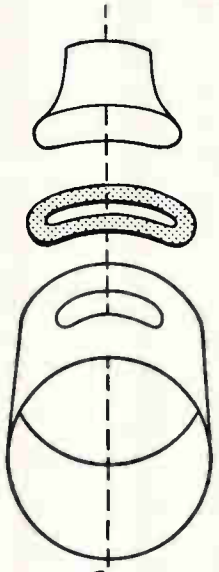
CIRCLE 211 ON READER SERVICE CARD

NEW CURVED
brazing
washers and shims

The operator no longer needs three hands to put the components together!

Applications on which one tube is radiused or saddled to fit over another are sometimes difficult to preform with a washer or shim. The stiffness of the washer may hold the radiused member away from the other tubes. By curving the washer to the curvature of the tube, the problem is minimized.

Curving a shim permits snapping of the shim onto the tube.



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LUCAS-MILHAUPT *Engineering Co.*

5051 South Lake Drive, Cudahy, Wisconsin

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Time Saving Shapes and Narrow Tape for Making Printed Circuit Master Drawings

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Black non-stain, non-smudge narrow tape in 15 or 60 yd. rolls from 1/32" wide. Also red translucent and black on white.

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Same Day Shipment is Our Usual Service

CIRCLE 99 ON READER SERVICE CARD

PRODUCT BRIEFS

GATING DEVICE for silicon controlled rectifiers. Dresser Electronics, 555 N. Fifth St., Garland, Texas. (349)

SERVO AMPLIFIER high powered. Westamp Inc., 11277 Massachusetts Ave., Los Angeles 25, Calif. (350)

CRYOGENIC THERMOMETER subminiature. Radiation Research Corp., Westbury, L. I., N. Y. (351)

REMOTE ANGLE COUNTER servo mounted unit. Theta Instrument Corp., 520 Victor St., Saddle Brook, N. J. (352)

AUTOMATIC VOLTAGE REGULATORS heavy-duty. The Superior Electric Co., Bristol, Conn. (353)

DECADE RESISTOR/DIVIDER flexible and accurate. Precision Apparatus Co., Inc., 70-31 84th St., Glendale 27, L. I., N. Y. (354)

TELEMETERING FILTERS fast response. Hisonic, Inc., P. O. Box 534, Shawnee, Kansas. (355)

DIGITAL PRINTER 4 line per sec counting rate. Northeastern Engineering, Inc., 25 South Bedford St., Manchester, N. H. (356)

MINIATURE CONNECTORS in kit form. Omega Precision, Inc., 757 N. Coney Ave., Azusa, Calif. (357)

DIGITAL OHMMETER low-cost. Non-Linear Systems, Inc., Box 728, Del Mar, Calif. (358)

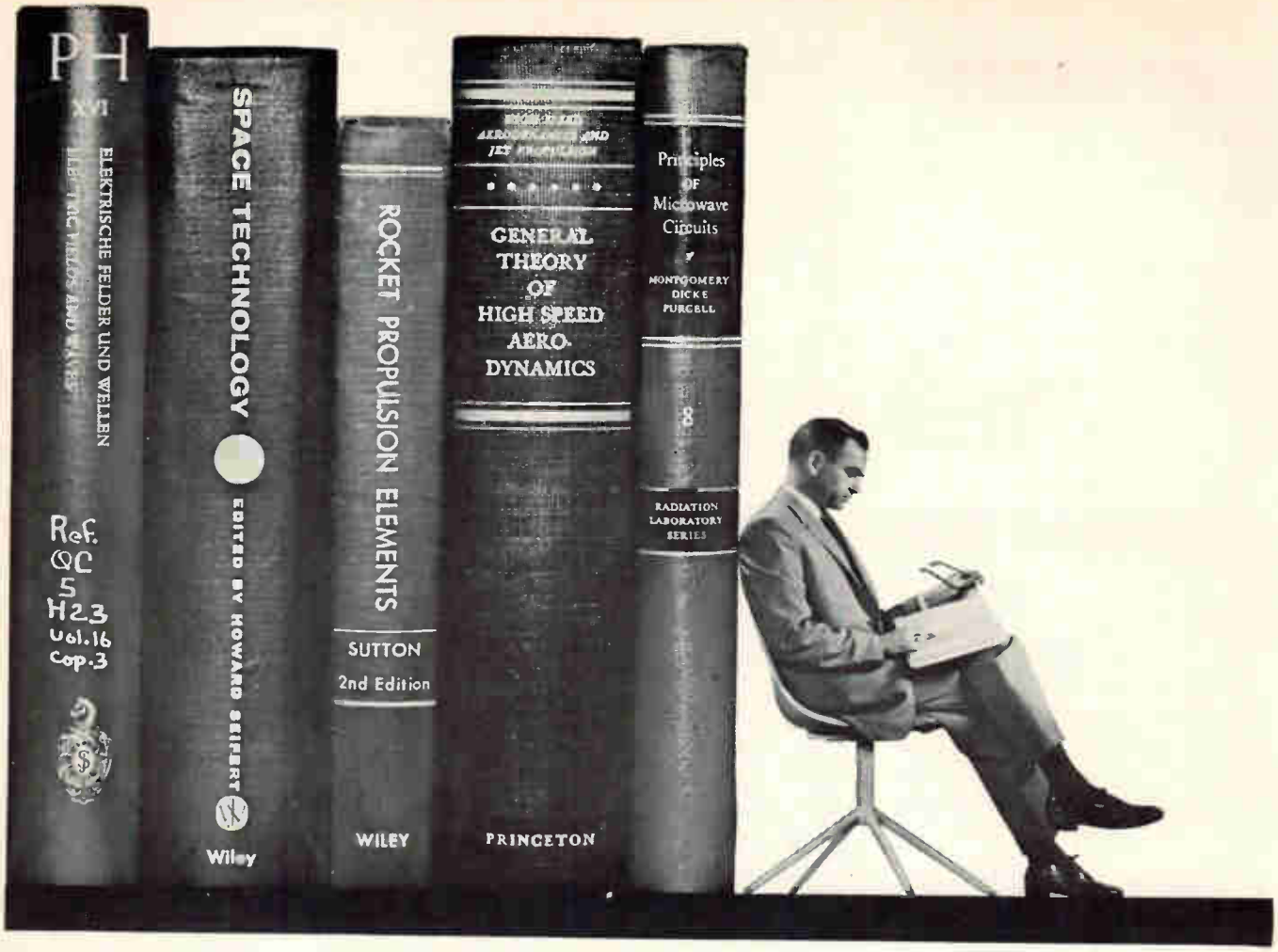
GLASS ZENER DIODES 51 subminiature types. International Rectifier Corp., 233 Kansas St., El Segundo, Calif. (359)

CRYOGENIC VALVES low leakage. Hydraulic Research & Mfg. Co., 2835 N. Naomi, Burbank, Calif. (360)

TEMPERATURE CHAMBER large volume-low gradient. Delta Design, Inc., 3163 Adams Ave., San Diego 16, Calif. (361)

ENCLOSURE seals by Koldweld process. Scully-Anthony Corp., 4707 Willow Springs Road, LaGrange, Ill. (362)

CALIBRATION INDICATOR for tension and compression loads. Baldwin-Lima-Hamilton Corp., Waltham 54, Mass. (363)



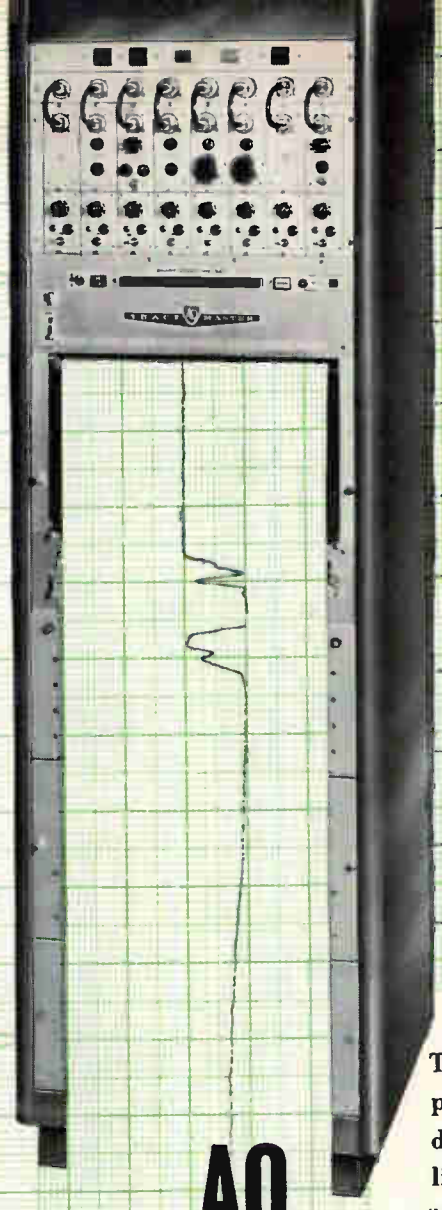
scientists and engineers in a unique leadership role

The frontiers of space science and technology are being expanded at Aerospace Corporation. The scientists and engineers of this leadership organization are the critical civilian link uniting government and the scientific-industrial team developing space systems and advanced ballistic missiles. In providing broad scientific and technical leadership to every element of this team, they are engaged in a balanced program of activities spanning the spectrum from basic research and forward planning through general systems engineering. Included in the latter are technical supervision, integration and review of the engineering, development and test operations of industry to the extent necessary to assure achievement of system concept and objectives in an economical and timely manner. These people are privileged to view both the state-of-the-art and system development in their totality. Now more men of superior ability are needed: highly motivated scientists and engineers with demonstrated achievement, maturity, and judgment, beyond the norm. Such men are urged to contact Aerospace Corporation, Room 110, P. O. Box 95081, Los Angeles 45, California.

Organized in the public interest and dedicated to providing objective leadership in the advancement and application of space science and technology for the United States Government.

AEROSPACE CORPORATION

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.



AO Trace-master provides twice the definition

The unique direct-carbon-transfer writing method produces a trace from 2 to 3 times finer than any other direct-writing technique. This allows twice as many lines per millimeter . . . twice the definition! Resolution is unsurpassed . . . each line is uniform in width and contrast, revealing the most minute variations in the phenomena measured with utmost fidelity. This writing technique combined with the advanced pen-motor design produces a wider frequency response at larger amplitudes. Continuous recording of data can be displayed simultaneously on 8 channels . . . up to 8 independent event markers can be added. Ten chart speeds — 0.1 to 500 mm/sec — provide a 5000:1 chart speed ratio.

The AO Tracemaster has become the new standard of performance for these and many other reasons . . . write now for the full story!

See the AO TRACE MASTER . . . plus other advanced direct writing recorder instrumentation at N.E.C. Booth 242 and N.E.R.E.M. Booth 804.

American Optical
COMPANY

INSTRUMENT DIVISION, BUFFALO 15, NEW YORK

Literature of

FACILITIES BROCHURE Intellux Inc., 30 S. Salsipuedes St., Santa Barbara, Calif. A 40-page brochure shows the company's facilities for R&D and production of thin film electronic devices. (364)

IR DETECTORS Block Associates, Inc., 385 Putnam Ave., Cambridge, Mass., has available a state of the art report on the capabilities of ambient temperature indium antimonide photoconductive infrared detectors. (365)

D-C POWER SUPPLIES Jordan Electronics, a div. of The Victoreen Instrument Co., 121 S. Palm Ave., Alhambra, Calif. A 12-page brochure describes a wide range of d-c power supplies. Facilities and production techniques are included. (366)

SOLID STATE TIME DELAY Shockley Transistor unit of Clevite Transistor, Stanford Industrial Park, Palo Alto, Calif. Application data sheet describes how simple, variable time delay circuits, using a small number of components, can be designed with a 4-layer diode as the active element. (367)

GLASS-TO-METAL SEALS Networks Electronic Corp., 9750 DeSoto Ave., Chatsworth, Calif., has prepared a 4-page brochure on its glass-to-metal seal facilities. (368)

TWIN POWER PENTODE Radio Corp. of America, Harrison, N.J. An application note discusses use of the 6939 uhf twin power pentode in r-f amplifier and frequency-tripler service. (369)

TRIMMING POTENTIOMETER Techno-Components Corp., 18232 Parthenia St., Northridge, Calif., has issued a two-page catalog sheet for the precision ⅜ in. sq trimming potentiometer with a resistance value up to 50,000 ohms. (370)

RATE OF DESCENT INDICATOR Gulton Industries, Inc., 212 Durham Ave., Metuchen, N.J. Bulletin contains description and specifications for a rate of descent indicator that has a range of 0-10 ft and accuracy of 0.2 ft/sec. (371)

POTENTIOMETER RECORDER Instrument Corp. of America, 516 Glenwood Ave., Baltimore 12, Md. A

the Week

four-page folder covers the Recordette-4, a portable, high performance potentiometer recorder. (372)

PRECISION CASTING Atlantic Casting and Engineering Corp., 810 Bloomfield Ave., Clifton, N. J., offers an 18-page booklet on precision alloys, containing an engineering table with specifications and properties of eight different nonferrous alloys. (373)

D-C/D-C CONVERTER Magnetic Research Corp., 3160 W. El Segundo Blvd., Hawthorne, Calif. A two-page bulletin lists operating characteristics of a 40 w d-c to d-c converter for missile computers. (374)

ELECTRON DEVICES Watkins-Johnson Co., 3333 Hillview Ave., Stanford Industrial Park, Palo Alto, Calif. A quick reference catalog covers twt's, O-type bwo's, Helitrons, and electronically tunable filters. (375)

MINIATURE CONNECTORS The Pyle-National Co., 1334 N. Kostner Ave., Chicago 51, Ill. A product bulletin gives complete information on MIL-C-26500-A miniature electrical connectors. (376)

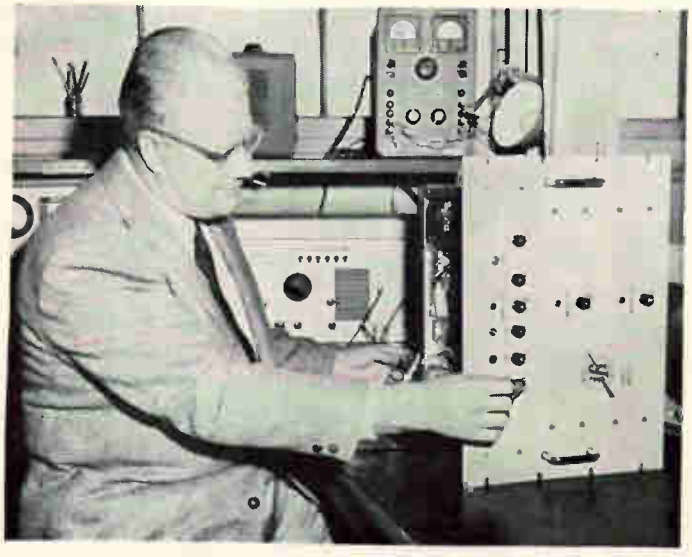
MOTOR-RUN CAPACITORS Aerovox Corp., New Bedford, Mass., has published a four-page catalog covering a complete line of a-c motor-run capacitors. (377)

TRANSISTOR NOISE Quan-Tech Laboratories, Inc., Boonton, N. J., has available a technical report dealing with the origin and nature of the various types of electrical noise generated in transistors. (378)

CAPACITORS Erie Resistor Corp., 645 W. 12th St., Erie, Pa. An 18-page bulletin covers 90 variations of resin sealed Button-Mica capacitors. (379)

POWER SUPPLY John Fluke Mfg. Co., Inc., P. O. Box 7428, Seattle 33, Wash., announces a technical data bulletin on the model 417A general purpose power supply. (380)

TEST PROBE RECEPTACLES AMP Inc., Harrisburg, Pa., has published a product information bulletin on a line of test probe receptacles for printed circuit boards. (381)



Swanson: always on the go

ONE OF THE BETTER-KNOWN young business and civic leaders of Long Island is Elston H. Swanson, president of Instruments for Industry, of Hicksville, N. Y. He gained this reputation by the ardent application of his "diverse talents and boundless energy"—to quote an associate—in furthering the growth of Long Island's industry and social services as well as the affairs of his own company.

"Mr. Swanson just can't seem to stand still," says Kay Wilhelm, his secretary. "He's always on the go."

Swanson has been on the go since he first came to New York 17 years ago as an electronics engineer in search of a job, newly graduated from the Illinois Institute of Technology. Ten years and four jobs later he bought all the stock of IFI, then a struggling young company with sales of $400,000, became its president and undertook to guide it to a respected position as a developer of electronic systems and precision potentiometers.

The philosophy that people, no matter what their role in life, should be interested in other people, their needs and their problems, is actively pursued by Swanson. Thus, largely through his efforts, the first electronics Explorer Scout troop was formed in the Metropolitan New York-Long Island area. Under the guidance of IFI engineers, the troop has built and fired a three-stage rocket, among other activities.

The IFI president was a founder of the Adelphi Research Center "to give Long Island industry a sorely needed academically-oriented, pure and basic research facility." In 1958, he founded and served as first president of the Long Island Electronic Manufacturers Council, whose aim is to advance the region's role in the electronic industry.

Swanson is currently president of the Long Island YMCA, a member of the executive committee of the Long Island Association, and chairman of the Nassau County Advisory Committee of the Salvation Army. Last year he served as county chairman for commerce and industry during the Salvation Army's fund raising drive. Also in 1960 he was chairman of the Long Island chapter of the Young Presidents' Organization, composed of men under 40 who head companies with more than $1 million of business a year.

An ardent aviation enthusiast—he is a licensed instrument pilot, flies his own Beechcraft Bonanza and has logged more than 1,800 hours—Swanson is currently chairman of Planners for Mitchel, a group of leading Long Island citizens who believe it vital to the future of Long Island to retain deactivated Mitchel Field as a limited use civilian airport.

While flying is Swanson's chief hobby, and one that gives him many opportunities to make more pleasurable business trips, he also enjoys photography, amateur radio and raising tropical fish. He is married and has two children.

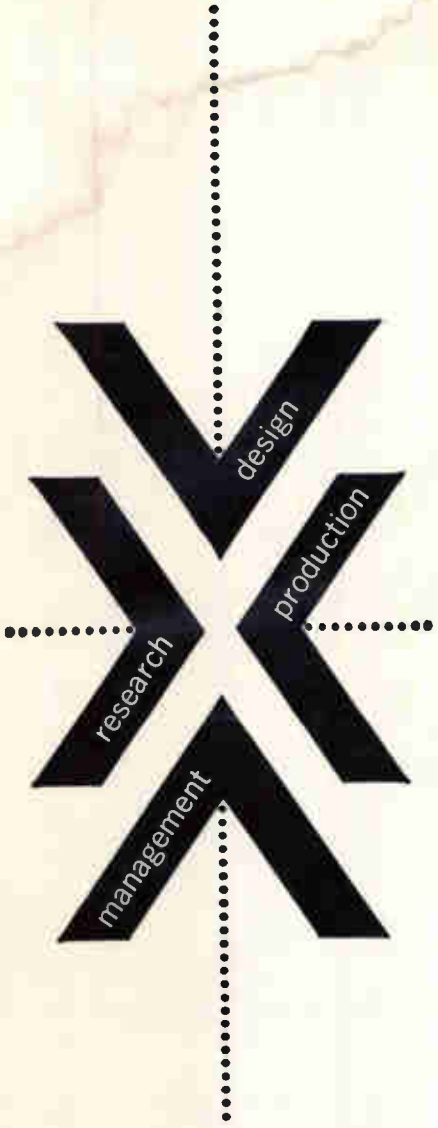
Jerrold Electronics Elects Harman

JERROLD ELECTRONICS CORP., Philadelphia, Pa., has announced the election of Sidney Harman as president and chief executive officer. He succeeds the company's founder, Milton J. Shapp, who remains chairman of the board of directors.

Harman was president of Harman-Kardon, Inc., when the company merged with Jerrold Electronics last February. He was elected executive vice president of Jerrold in April.

Establish New Electronic Lab

BURROUGHS ELECTRONICS, INC., Cos Cob, Conn., is a recently formed research and development organi-



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"The definition of a farad unfortunately makes it a unit too large for general use. More convenient are the units micro-farads and micro-microfarads."

It is said that even Michael Faraday doubted if a farad could ever be realized. But then, he hadn't been exposed to the engineering and production capabilities of Sangamo . . . the first capacitor manufacturer to produce and establish standards in the production of electrolytic energy storage capacitors.

So now the "impossible"—a farad of capacitance capable of being held in one hand—has been achieved. Rated at 1½ volts, the one-half farad Sangamo Type DCM electrolytic carries the highest capacitance per unit volume in the industry. It is the product of Sangamo engineering imagination . . . the very real result of intimate product knowledge applied to quality materials and progressive production methods. It is ready for application in missiles, computers, and a wide range of power supply applications where peak power requirements exceed the maximum output of the supply. Phone near? Discuss your applications with your Sangamo Representative.

Occasionally applications call for energy-storage capacitors to meet special requirements, including higher temperature and higher ripple current. That's a good time to turn to Sangamo, where yesterday's impossibilities become capacitor facts such as this . . .

CAPACITY = ONE FARAD

EC61-1

SANGAMO ELECTRIC COMPANY
SPRINGFIELD, ILLINOIS

zation founded by Gordon S. Burroughs. Major effort will be R&D in the fields of radio direction finding, aerial navigation, infrared, reconnaissance, surveillance, analog computers, and others primarily for the military, industrial and space agency services.

Burroughs was formerly vice president for military, industrial and advanced systems of CBS Laboratories.

Dunn Engineering Names Kravetz

ROBERT KRAVETZ, formerly quality assurance requirements and specifications manager for the Lockheed Missile and Space Division, has been named sales manager of Dunn Engineering Corp., Cambridge, Mass.

Kravetz was with Lockheed from 1956 until he resigned recently to join Dunn Engineering. Previously he was a senior engineer with Aerojet-General Corp.

Conair Elects Nestel Board Chairman

CONAIR (Consolidated Airborne Systems, Inc.) of New Hyde Park, N. Y., announces the election of John I. Nestel to chairman of the board of directors. The company is engaged in the design and manu-

facture of electronic and electromechanical airborne instrumentation and ground support equipment.

Nestel was one of the founders of the company in 1957. Prior to his interest in Conair, he held top management positions at Fairchild Associates and at Avien, Inc.

G. T. Schjeldahl Hires Arthur R. Moore

ARTHUR R. MOORE, formerly in the quality engineering department of Minneapolis Honeywell's Ordnance Division, has joined the electronics laboratory at the G. T. Schjeldahl Co., Northfield, Minn.

The Schjeldahl Co. was organized in 1955 and is active in the manufacture of a complete line of packaging machines, industrial tapes and adhesives, special plastic fabrications, high altitude research balloons, space Satelloons, and electronic telemetry systems.

Scientific Company Is Organized

A NEW scientific company, Quanta Laboratories Inc., Washington, D. C., has been formed to engage in study programs and product development in the fields of earth-space optics, photometry, infrared radiometry and heat transfer.

Emanuel Goldstein is president of the company. He was formerly

with Project Vanguard in the optics division of the Naval Research Laboratory.

Polarad Electronics Promotes Rosen

BERNARD ROSEN has been appointed to the position of general manager, equipment engineering, of Polarad Electronics Corp., Long Island City, N. Y.

He joined Polarad in 1951.

Semicon, Inc. Appoints Two Executives

SEMICON, INC. of Bedford, Mass., announces the appointments of Robert E. House as executive vice president and Herbert N. Goldman as vice president of engineering.

Before joining Semicon, both were associated with Transistor Electronic Corp., where House was manager of advanced product research and Goldman, manager of silicon diode development and pilot line production.

National Transistor Names Calandrello

NICOLA A. CALANDRELLO has been named manager, diode research and development, for National Transistor Mfg., Inc., Lawrence, Mass.

Before joining National Transistor, Calandrello was a senior development engineer with Clevite and prior to that he held a similar post with Raytheon.

Control Logic, Inc. Hires Beinhocker

GILBERT D. BEINHOCKER has been appointed director of systems engineering for Control Logic, Inc., Inc., Natick, Mass. He was formerly product manager for computers, and associate director of engineering for Epsco, Inc., of Cambridge, Mass.

Control Logic specializes in the conception, design, development, and production of advanced digital data handling and real-time control systems.

PEOPLE IN BRIEF

Conrad A. Parlanti, vice president of General Communication Co., assumes the additional post of technical director. **Charles F. McMorrow,** formerly with RCA, joins the General Mills Electronics Group, research and development dept. as associate director for engineering. **John J. O'Donnell** of RCA's electronic data processing division moves up to manager, circuit packaging and standards engineering, in the commercial systems dept. **Arthur C. Omberg** promoted to group executive by the Bendix Corp. **Richard F. Wenke** leaves International Radiant Corp. to join Tenney Engineering as development engineer. **Edward B. Moore** advances to chief engineer of Aircraft Radio Corp. **Eric B. Toulmin-Rothe,** previously with Sikorsky, appointed project engineer at Deltime, Inc. **Lewis E. Hollander, Jr.,** transfers from Lockheed Aircraft to Endevco Corp., as director of the solid state laboratory. **Paul R. Obdyke,** formerly with Intl. Research Associates, named chief engineer by Remanco, Inc. **Richard A. O'Brien** promoted to supervisor of reliability and military products for Corning Electronic Components. **Frank D. Banta,** director of program management for General Precision, Inc., chosen assistant vice president.

EMPLOYMENT OPPORTUNITIES

electronics

WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

This Qualification Form is designed to help you advance in the electronics industry. It is unique and compact. Designed with the assistance of professional personnel management, it isolates specific experience in electronics and deals only in essential background information.

The advertisers listed here are seeking professional experience. Fill in the Qualification Form below.

STRICTLY CONFIDENTIAL

Your Qualification form will be handled as "Strictly Confidential" by ELECTRONICS. Our processing system is such that your form will be forwarded within 24 hours to the proper executives in the companies you select. You will be contacted at your home by the interested companies.

WHAT TO DO

1. Review the positions in the advertisements.
2. Select those for which you qualify.
3. Notice the key numbers.
4. Circle the corresponding key number below the Qualification Form.
5. Fill out the form completely. *Please print clearly.*
6. Mail to: D. Hawksby, Classified Advertising Div., ELECTRONICS, Box 12, New York 36, N. Y. (No charge, of course).

COMPANY	SEE PAGE	KEY #
ESQUIRE PERSONNEL Chicago, Illinois	120*	1
THE GARRETT CORPORATION AiResearch Manufacturing Division Los Angeles, California	116	2
LITTON SYSTEMS INC. Guidance & Control Systems Div. Woodland Hills, California	101	3
LYCOMING Div. of Avco Corporation Stratford, Conn.	118*	4
THE MITRE CORPORATION Bedford, Mass.	113*	5
MOTOROLA, INC. Military Electronics Div. Western Center Scottsdale, Arizona	117	6
PAN AMERICAN WORLD AIRWAYS INC. Guided Missiles Range Div. Patrick AFB, Fla.	29	7
PHILCO WESTERN DEVELOPMENT LABS. Palo Alto, California	115	8
SANDERS ASSOCIATES, INC. Nashua, New Hampshire	118*	9
SIKORSKY AIRCRAFT Div. of United Aircraft Corp. Stratford, Conn.	119*	10
TELEREGISTER CORPORATION Stamford, Conn.	118	11
TROPICAL RADIO TELEGRAPH CO. Hingham, Mass.	117	12
P-7374	117	13

*These advertisements appeared in the 9/8/61 issue.

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electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

Personal Background

NAME .....

HOME ADDRESS.....

CITY..... ZONE..... STATE.....

HOME TELEPHONE.....

Education

PROFESSIONAL DEGREE(S).....

MAJOR(S) .....

UNIVERSITY .....

DATE(S) .....

FIELDS OF EXPERIENCE (Please Check) 9151

- ☐ Aerospace
- ☐ Antennas
- ☐ ASW
- ☐ Circuits
- ☐ Communications
- ☐ Components
- ☐ Computers
- ☐ ECM
- ☐ Electron Tubes
- ☐ Engineering Writing
- ☐ Fire Control
- ☐ Human Factors
- ☐ Infrared
- ☐ Instrumentation
- ☐ Medicine
- ☐ Microwave
- ☐ Navigation
- ☐ Operations Research
- ☐ Optics
- ☐ Packaging
- ☐ Radar
- ☐ Radio—TV
- ☐ Simulators
- ☐ Solid State
- ☐ Telemetry
- ☐ Transformers
- ☐ Other .....
- ☐ .....
- ☐ .....
- ☐ .....

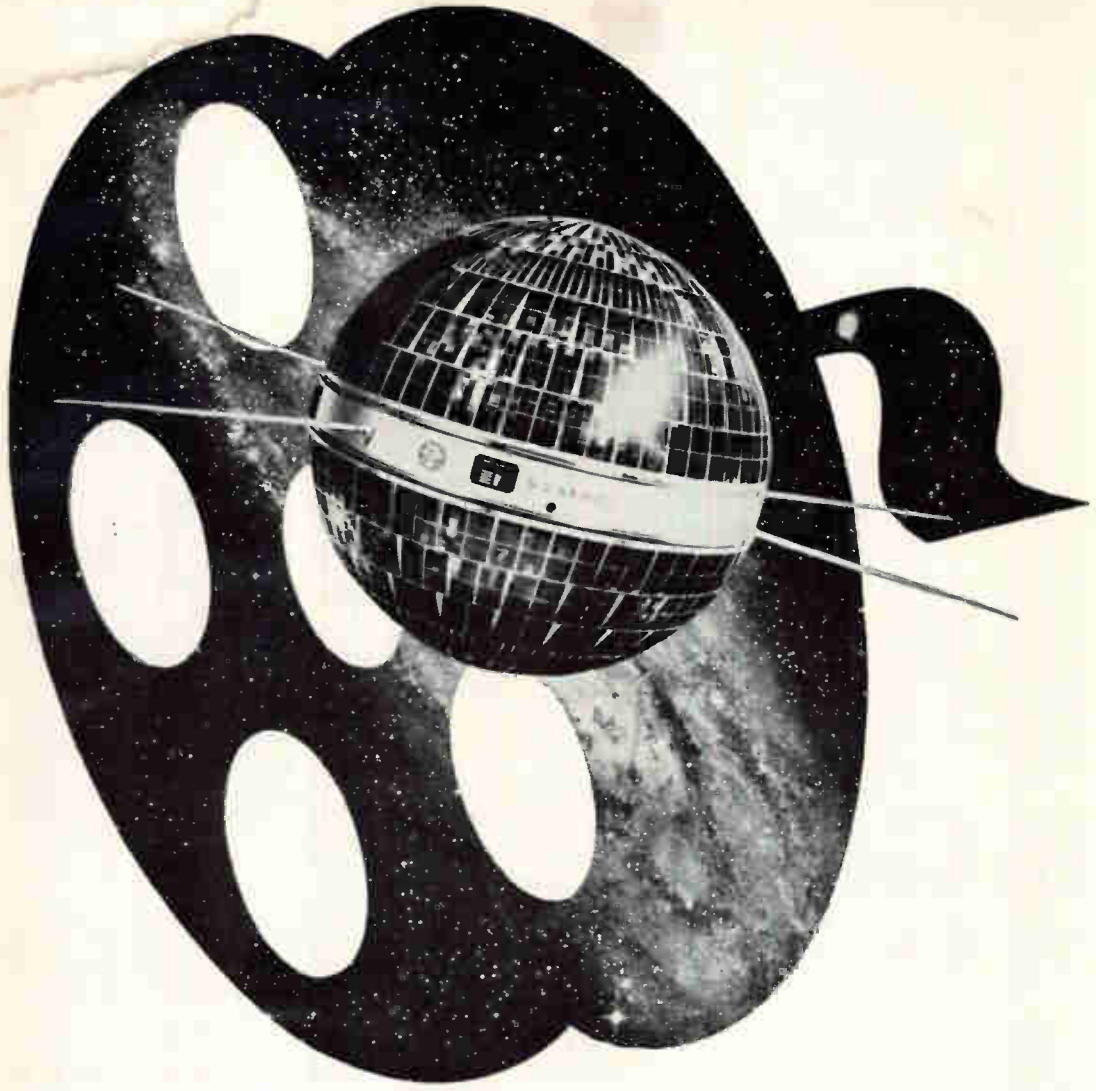
CATEGORY OF SPECIALIZATION

Please indicate number of months experience on proper lines.

	Technical Experience (Months)	Supervisory Experience (Months)
RESEARCH (pure, fundamental, basic)	.....	.....
RESEARCH (Applied)	.....	.....
SYSTEMS (New Concepts)	.....	.....
DEVELOPMENT (Model)	.....	.....
DESIGN (Product)	.....	.....
MANUFACTURING (Product)	.....	.....
FIELD (Service)	.....	.....
SALES (Proposals & Products)	.....	.....

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25



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From the earliest plans to invade space, PHILCO Western Development Laboratories has played a vital role in satellite vehicle instrumentation, still but *part* of its contribution to space communications. From this newest electronics center on the San Francisco Peninsula comes a continuing flow of advanced missile tracking, range and data processing instrumentation.

Added research projects and growing programs assure *you* a long and rewarding career as a member of the PHILCO Western Development Laboratories. What you think and what you do can be unhampered and uninhibited. Personal recognition and advancement promptly follow performance, with monetary rewards to match. Northern California provides an affluent climate for living, as PHILCO Western Development Laboratories provides a stimulating climate for working. For information on careers in electronic engineering, please write Mr. W. E. Daly, Dept. E-9.

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin; U. S. citizenship or current transferable Department of Defense clearance required.

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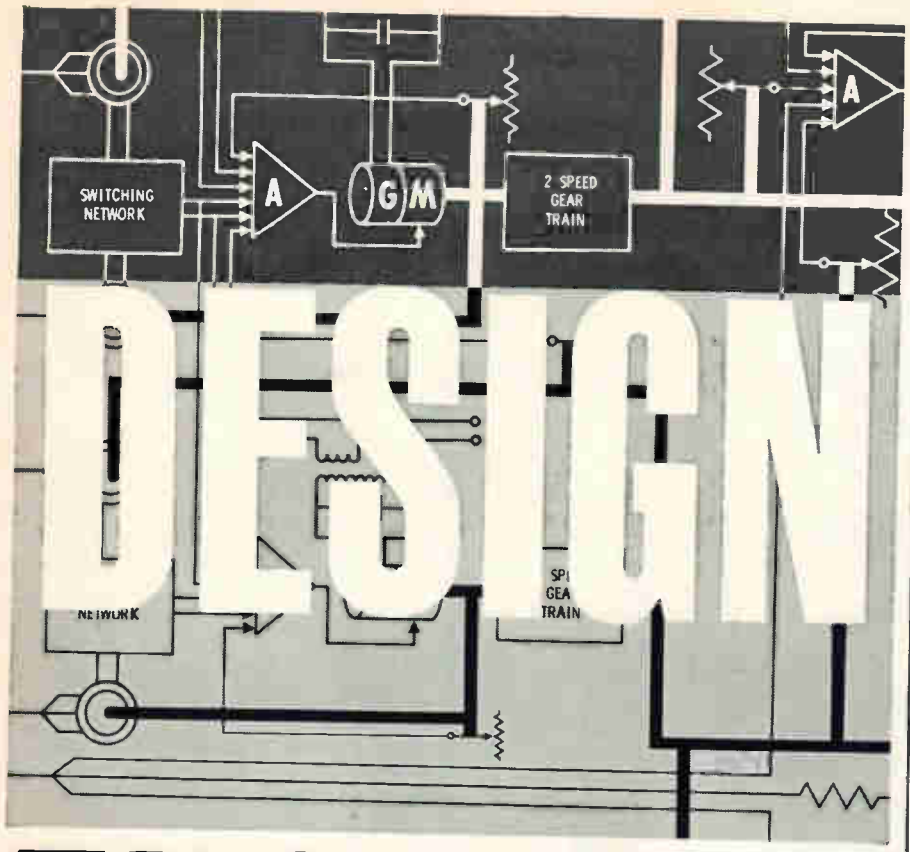


ENGINEER

An outstanding position is available for a highly creative design engineer who can work effectively with high level analytical and theoretical engineers in the development of complex electromechanical instruments for use in high speed, high altitude aircraft and space applications. At least five years experience and appropriate degree is necessary.

This responsible position requires the personal initiative and ability to render complete and concise layouts for use by designers as well as draftsmen.

The ability to evaluate equipment and systems specification is essential, and a working knowledge in several of the following areas would be highly advantageous:

pneumatic pressure mechanisms, precision sensing devices such as servoed and nonservoed force balance transducers, kinematics, flexure design, miniaturization, instrument bearing applications, fine pitch, differential and nonlinear gearing applications, anti-backlashing techniques, plate and 3-D cams and temperature compensating devices.

U.S. citizenship or previous security clearance required. Garrett is an "equal opportunity" employer. Send complete resume to Mr. Thomas Watson.

THE GARRETT CORPORATION
AiResearch Manufacturing Division
9851 So. Sepulveda Blvd., Los Angeles 45, California

SEARCHLIGHT SECTION

Classified Advertising

BUSINESS OPPORTUNITIES — EQUIPMENT - USED or RESALE

RATES

DISPLAYED

The advertising is $24.75 per inch for all advertising other than on a contract basis. AN ADVERTISING INCH is measured ⅞" vert. on a column, 3 cols.—30 inches—to a page. EQUIPMENT WANTED or FOR SALE ADVERTISEMENTS acceptable only in Displayed Style.

UNDISPLAYED

$2.40 a line, minimum 3 lines. To figure advance payment count 5 average words as a line. BOX NUMBERS count as one line additional.

DISCOUNT of 10% if full payment is made in advance for four consecutive insertions.

Send NEW ADVERTISEMENTS or Inquiries to Classified Adv. Div. of Electronics, P. O. Box 12, N. Y. 36, N. Y.

The publisher cannot accept advertising in the Searchlight Section, which lists the names of the manufacturers of resistors, capacitors, rheostats, and potentiometers or other names designed to describe such products.

INDEX TO ADVERTISERS

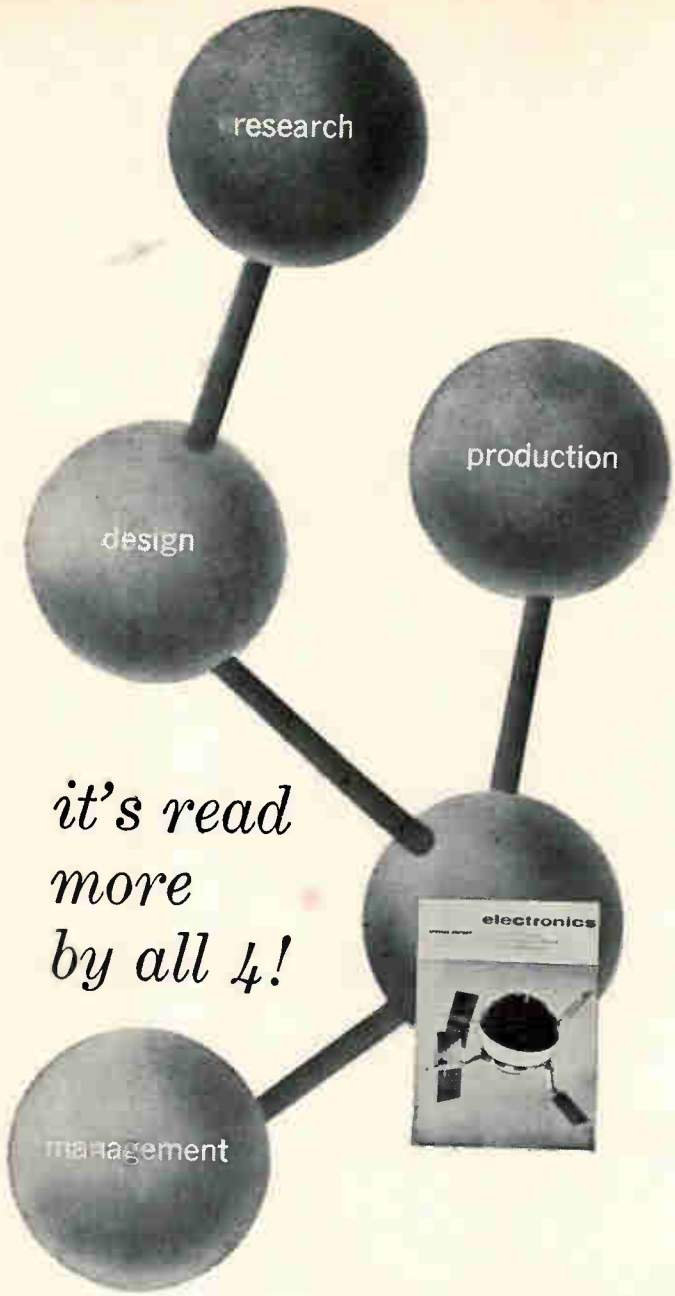
Audited Paid Circulation

■

INDEX TO CLASSIFIED ADVERTISERS

• See Advertisement in the July 20, 1961 issue of Electronics Buyers' Guide for complete line of products or services.

• See Advertisement in the July 20, 1961 issue of Electronics Buyers' Guide for complete line of products or services.



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Associated Business Publications

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at no extra cost!

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- Weldable leads, which are readily solderable, are standard on all units at no surcharge
- Exceeds MIL-R-10509D, Characteristic C specs
- Off-the-shelf delivery from your Daven distributor

Write for full details on Types DA 2 and DA 4

THE **DAVEN** COMPANY, Livingston, New Jersey

RESISTORS

A SUBSIDIARY OF GENERAL MILLS

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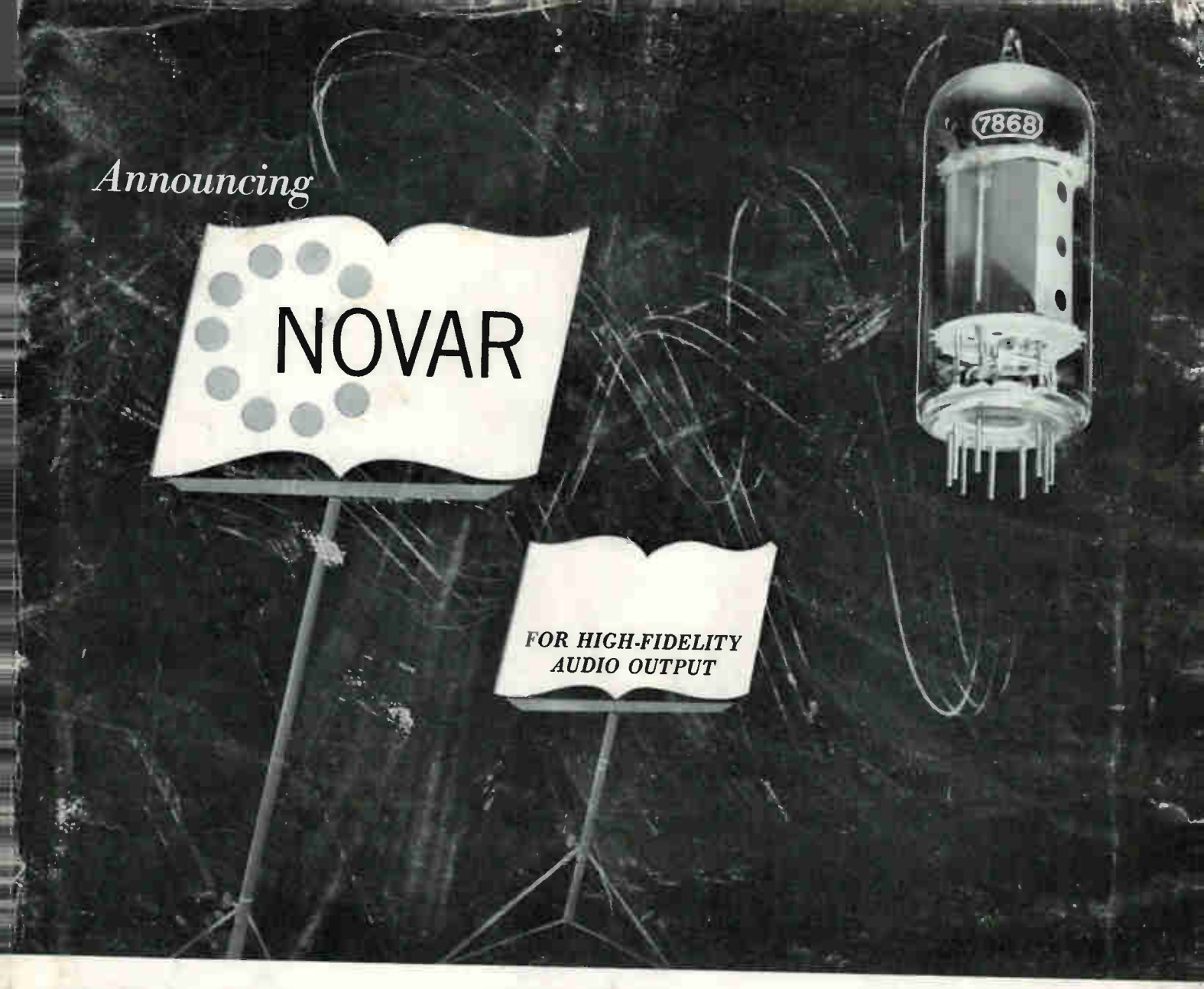

NEW RCA-7868 NOVAR POWER PENTODE OFFERS OUTSTANDING DESIGN ADVANTAGES

With this new tube RCA brings all the advantages of novar design to high-fidelity circuitry.

RCA-7868 is a high-perveance 9-pin novar power pentode for output stages of hi-fi audio amplifiers, phonographs and radio receivers. You'll get up to 44 watts of power output from a pair of them in Class AB_1 push-pull service in audio amplifiers.

RCA-7868 is the first hi-fi tube type in RCA's new novar line of large, all-glass 9-pin receiving tubes. Its cost to you is less than that of any equivalent tube regardless of base configuration.

RCA-7868 has all the advantages of novar design, the *only* all-glass, integral-base receiving tube design to offer:

Larger internal lead diameter—for strong cage support and high thermal conductivity for very effective heat dissipation.

Wider spacing between pins (0.172″)—to minimize the possibility of voltage breakdown; hence greater reliability.

Pin length of 0.335″—for firm retention of tube in socket.

Pin circle diameter of 0.687″—large enough to permit use of both T9 and T12 envelopes.

RCA Dark Heater—found exclusively in RCA receiving tubes... additional assurance of reliability.

RCA 7868 has two base-pin connections each for grids #1 and 2; special radiator on siderods of grid #2 assures cooler operation.

Take full advantage of this major contribution to audio technology. See your RCA Field Representative for full details...or write: Commercial Engineering, Section I-19-DE-3 RCA Electron Tube Division, Harrison, N. J.

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