March 17, 1961

electronics

Coordinatograph (below) checks tolerances on layouts for printed-circuit panels. For a report on present-day techniques, see p 72

Beam maser amplifier for three-millimeter wavelengths. See p 45

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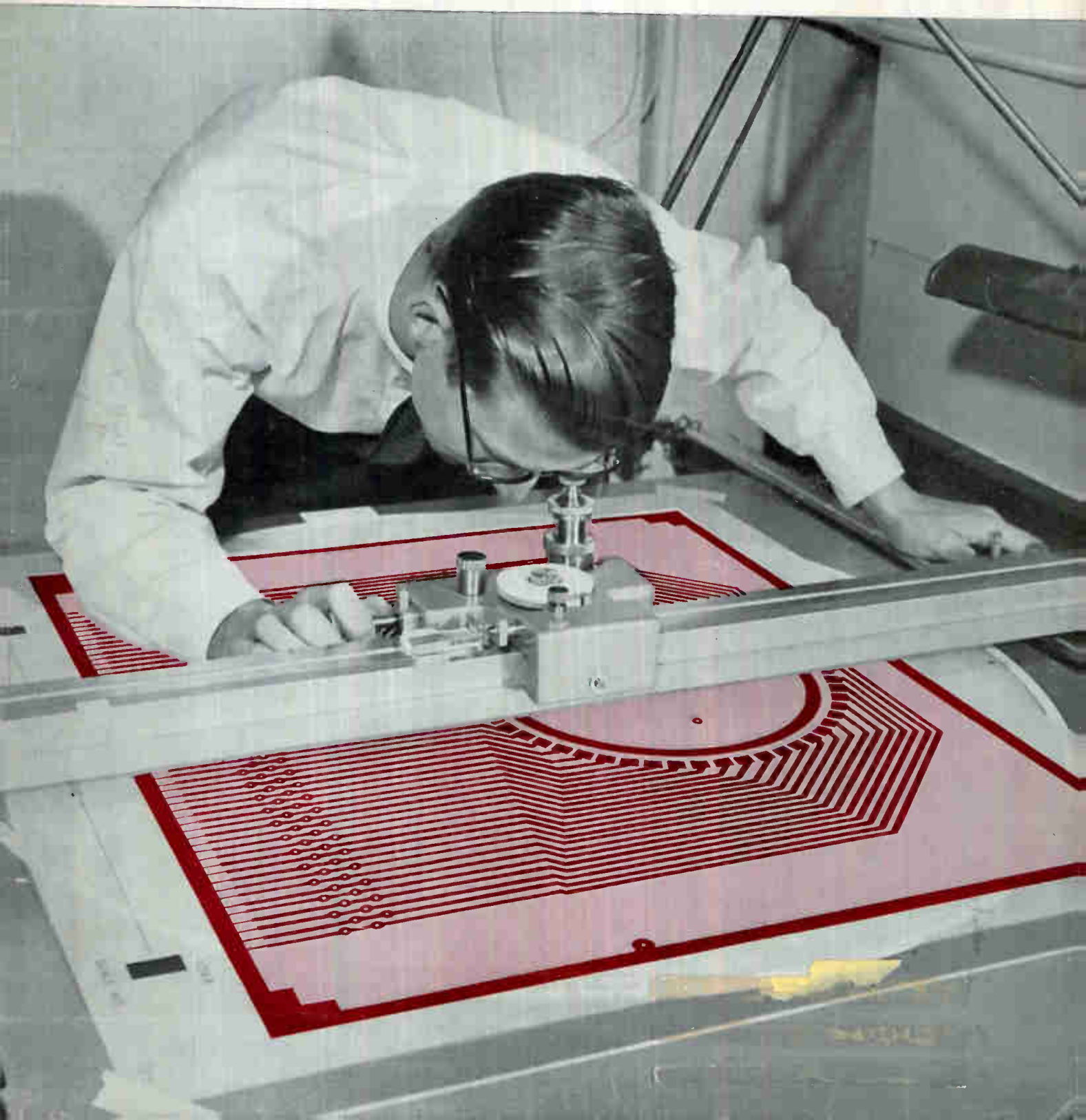
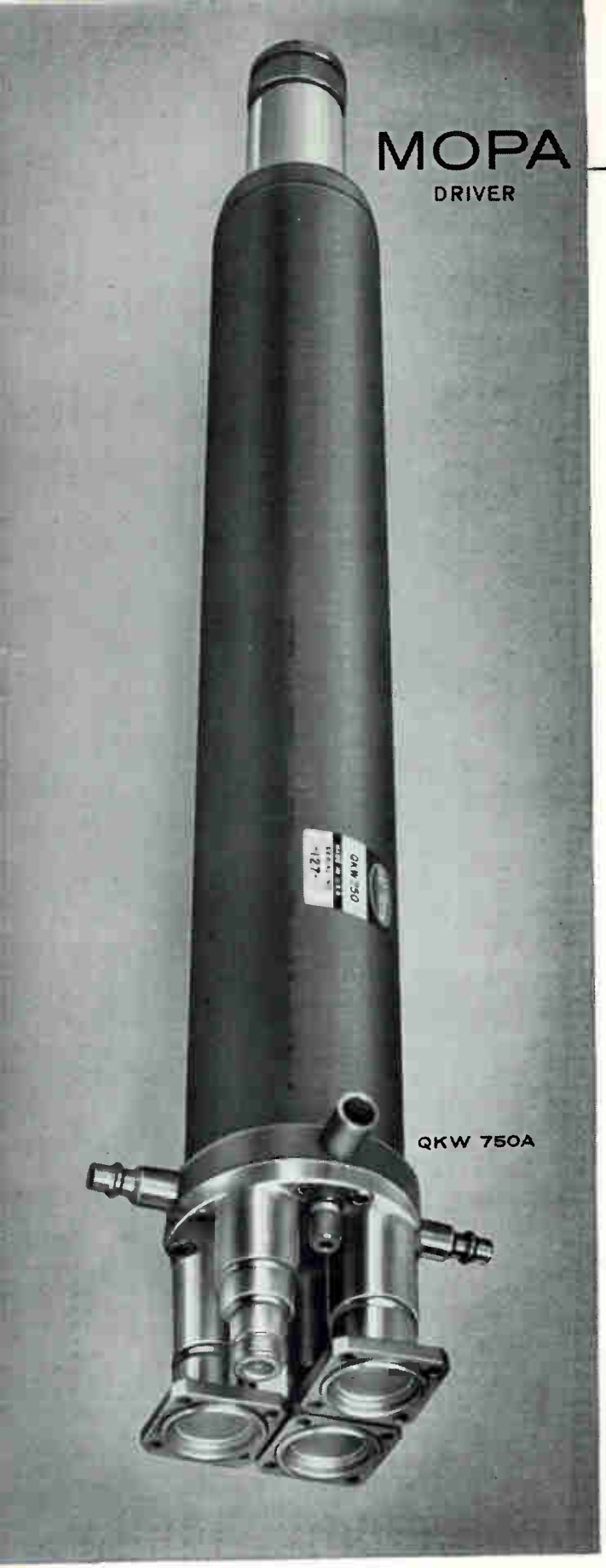
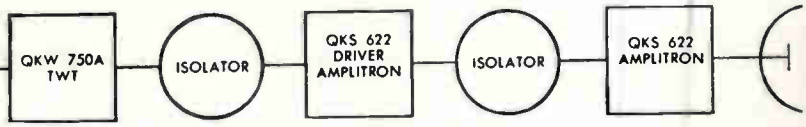


One of a series of advertisements featuring tubes for MOPA chains





MOPA chain at S-band.

New Raytheon broadband TWT drives Amplitron* in high-duty-cycle frequency-diversity applications

QKW 750A has 60 kw minimum peak power, 18 db minimum gain, and more than sufficient bandwidth to drive the QKS 622 Amplitron in S-band MOPA chain.

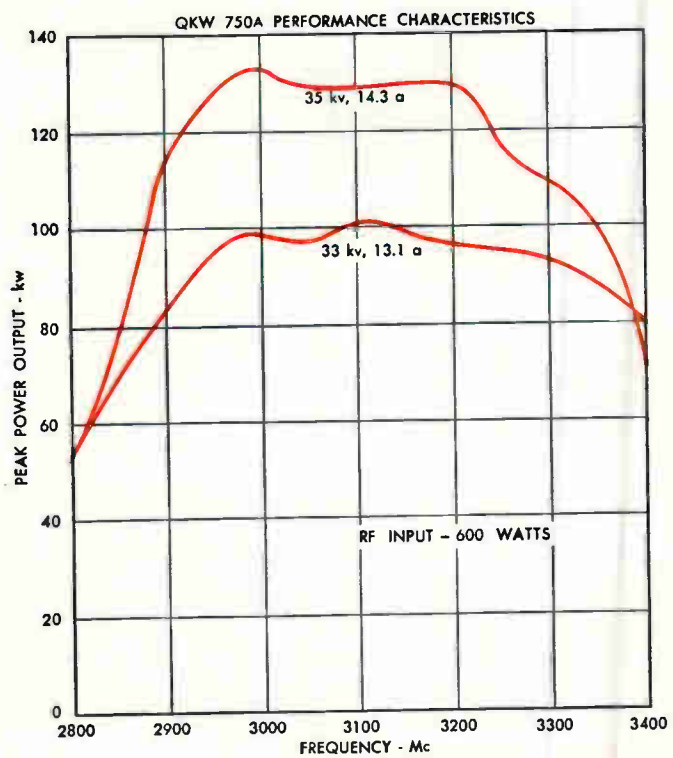
A new traveling wave tube—Raytheon's QKW 750A—now makes possible a complete broadband, high-power MOPA chain at S-band.

The tube has a duty cycle of .015 and is designed for pulsed operation over the full 2,900 to 3,100 Mc range. It provides a minimum of 18 db gain and 60 kw peak power to drive a Raytheon QKS 622 Amplitron. Output of the amplifier chain is in the megawatt range. A companion tube—the QKW 782—covers the 2,700 to 2,900 Mc range.

Microwave systems designers should note that the bandwidth, peak and average power capability, and gain characteristics of the new TWT are well above the specified values as shown in the accompanying curve. This fact lends a high degree of conservatism and reliability to system design.

Write for detailed information and application service to Microwave and Power Tube Division, Raytheon Company, Waltham 54, Massachusetts. In Canada: Waterloo, Ontario.

*Raytheon Trademark



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ENGINEERING

DEPARTMENTS

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CVQ combines exclusive transistorized shunt regulation with SOLA's inherently self-protecting, static-magnetic transformer . . . easily meets the most taxing demands of dynamic loading. Voltage holds in spite of widely fluctuating loads. The result is longer equipment life, more trouble-free operation. Contact our area representative for complete specifications and prices. Or write today for literature on CVQ.

SEE IT AT THE I.R.E. SHOW

- Standard models available at 5, 6, 10 and 12 volts d-c (100-130/181-235/200-260 volt input).
- Output regulated within ±0.04% for line voltage variations ±15%; 0.2% static-load regulation, 0 to full load.
- Excellent transient response.
- Inherent protection against output over-voltage safeguards both supply components and external circuitry.
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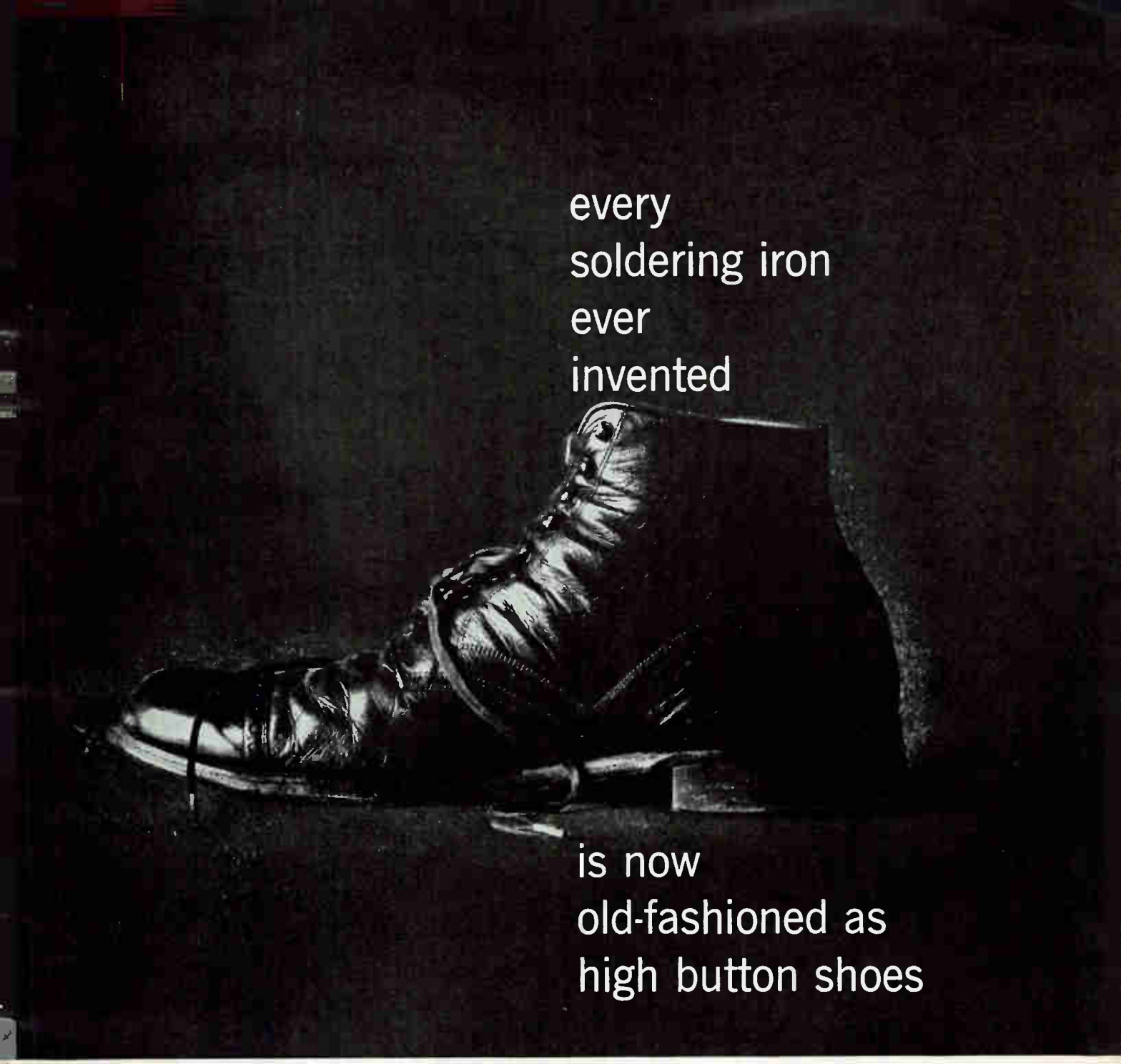

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Think of every feature, every benefit, you would design into a soldering iron if you could... and you have IMPERIAL! *Only* UNGAR experience and research could have developed this cool, lightweight, easy-handling iron. From tip to cord... the ultimate in interchangeability. There are so many revolutionary new ideas in IMPERIAL we had to put them all in an 8-page brochure. Send for your free copy now!

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electronics
Mar. 17, 1961 Volume 34 Number 11

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Executive, editorial, circulation and advertising offices McGraw-Hill Building, 330 West 42nd Street, New York 36, N. Y. Telephone Longacre 4-3000. Teletype TWX N.Y. 1-1636. Cable McGrawhill, N.Y. Printed in Albany, N. Y.; second class postage paid.

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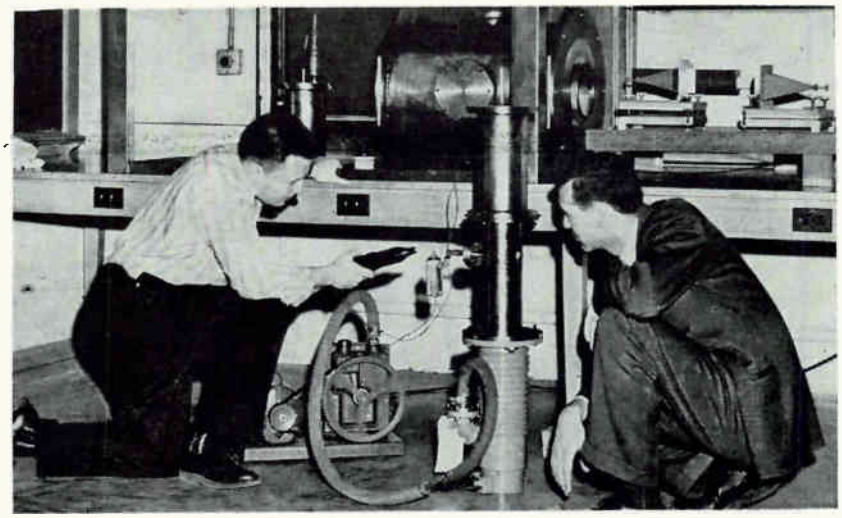
CROSSTALK



BEAM MASER. Photo above shows Dale Maley and Frank Barnes of the University of Colorado testing part of the vacuum system for a hydrogen cyanide beam maser. Their article beginning on p 45 in this issue describes the design and operation of the maser, which is built for 88 Gc.

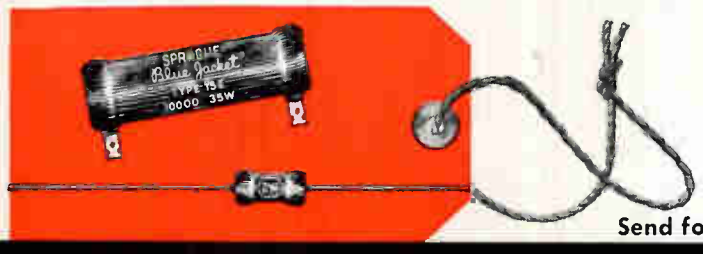
FRENCH COMPONENTS. We've an exclusive story from Paris this week (p 24), and it tells how French components are getting smaller. "More performance in smaller packages," is how the article begins. That was the most significant fact as about 400 manufacturers from France and eight other nations exhibited their latest wares recently at the Fourth International Electronics Components Show.

French component makers now are selling pinhead ceramic capacitors, carbon potentiometers that wouldn't cover a thumbnail, and transformers small enough to play dice with. And while all this is going on (the miniaturizing—not the dice-shooting), performance and frequency ranges are climbing.

PENETRATION. From our Los Angeles office, Pacific Coast Editor Hood wires a story telling how X-rays penetrate solid-fuel rocket engines (p 26). The Navy is now able to inspect large rocket engines used in missiles, thanks to a 10-million-volt X-ray machine powered by a 630-Mev electron linear accelerator. How it's done is interesting.

Coming In Our March 24 Issue

TUNNEL DIODE CIRCUIT. Pulse amplitude compressor that uses three tunnel diodes is described next week by A. A. Clark and W. H. Ko of Case Institute of Technology in Cleveland. Ability of the tunnel diode to switch rapidly from a low voltage state to a higher state is utilized to reduce the dynamic amplitude range of video pulse signals while preserving the magnitude of small signals superimposed upon large signals.



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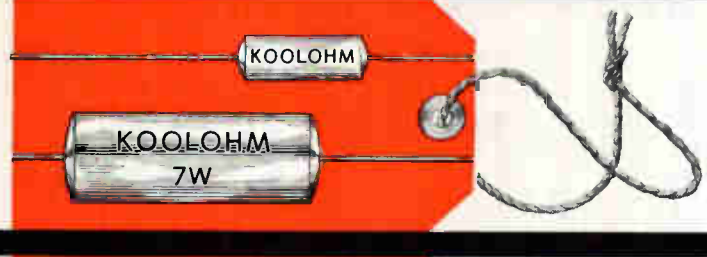

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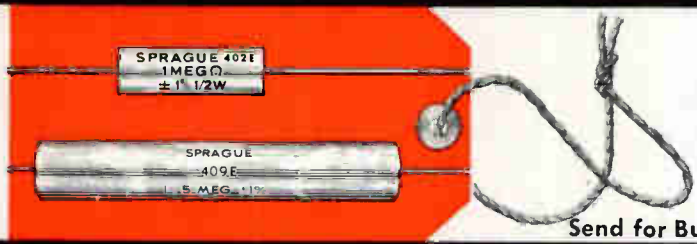

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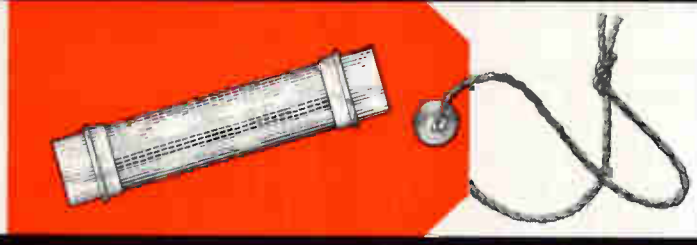

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COMMENT

Medical Electronics

(Re: your series on Medical Electronics, p 49, Jan. 20; p 46, Feb. 3; p 54, Feb. 24 . . .)

I can well appreciate the amount of legwork, research, and so forth, required to produce illuminating, informative, and well written articles such as these. My only comment of a critical nature is that I wish the articles could have been longer, going into more detail on circuitry and techniques—but we both know that "space limitation" is one of the ground rules in the magazine field.

Since the publication of my book *Medical Electronics*, I have received a great deal of correspondence from readers desiring to contact other workers in this field. Most of this correspondence falls into three broad categories: readers seeking information on commercially available electronic equipment suitable for a particular problem in medical instrumentation; readers suggesting research projects involving the use of electronics for diagnostic or therapeutic applications; and electronics engineers wishing to contact medical people (or medical researchers wishing to contact electronics engineers) with the objective of exchanging information relating to each other's fields.

My own work, both teaching and writing, is addressed primarily to the technician. Because of my limited contacts in the field, I do not feel qualified properly to direct these inquiries. I would therefore appreciate hearing from any of your readers who may know of some organization, either governmental or private, whose objectives and activities would qualify it to function in this clearinghouse capacity.

ED BUKSTEIN

MINNEAPOLIS

Ions and Health

Chiefly because of the tremendous reader response incited by your article "Ions Affect Health, Behavior" (p 45, Feb. 26 '60), a group of us here began to research the subject. So encouraged were we by the success of our pilot models in giving definite relief to asthmatics, sinus sufferers, and so forth, that we are moving to form a corporation to produce and market these machines. And what a pleasant kind of business it promises to be . . .!

PAT J. DAVID

SEAL BEACH, CALIF.

Tunnel Diodes

In returning to our research in the area of tunnel-diode logic circuits after an unfortunate delay of about nine months, it was discovered that in all samples worked with, the tunnel diodes used had degenerated during the period of inactivity. A possible explanation for this might be continued diffusion across the junction, thereby reducing the probability of quantum-mechanical tunneling to zero.

We have not run across any mention of this in the existing literature, and would like to know if anyone else has encountered this phenomenon. It would seem reasonable that the companies currently engaged in the production and research on tunnel diodes would have spent some time making life tests and made the results of these tests known. It is a source of some wonder on our part that this has not been previously noted.

CHARLES G. MASTERS
JACK E. RATHMELL

DUKE UNIVERSITY
DURHAM, N. C.

Were they gallium arsenide units? The gradual deterioration of gallium arsenide devices has been known for about ten months; the mechanism causing the deterioration is not yet understood. We have heard no word of a deterioration mechanism operating in those semiconductor materials that have been around longer. The fact that the deterioration took place while the units were inactive is especially peculiar if they were not gallium arsenide.

Kudos

Your article on ultrasonic vehicle detection covered the field accurately and was very well written. Thank you for acknowledging our part in the overall program.

MARVIN TROTT

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Now! Get premium features in a DVM priced at only $940

Cubic Corporation announces the V-45 —the first low-cost digital voltmeter with premium features. Now industrial users can buy a top-quality, precision four-digit instrument at a price they can justify—only $940. Here are the premium features you get in a V-45:

Floating Input: Both sides of the input may be floated above or below ground. The floating input circuit provides more than 80 db rejection to 60-cps common-mode signals. A grounded input is also supplied.

Extended Range: A 10% extension is incorporated in each of the V-45's three ranges. Voltages up to 10.999 may be read on the 10-volt range; voltages up to 109.99 may be read on the 100-volt range; and voltages up to 1099.9 may be read on the 1000-volt range. Therefore, the operator need not constantly shift back and forth between ranges when reading close to the normal upper limit of a range.

Transistorized Logic and Drive Circuit: The V-45 DVM uses construction techniques representing the latest state-of-the-art, with all-transistorized circuitry driving reliable stepping switches.

Cubic manufactures a complete line of quality digital instruments, including a-c and d-c voltmeters, ohmmeters, ratiometers, scanners and printer controls. Write for literature to Dept. E-102, Industrial Division, Cubic Corporation, San Diego 11, California.

SPECIFICATIONS

MODEL V-45 DIGITAL VOLTMETER

Input Impedance: 10 megohms at balance.

Ranges: Manually selected, 10% extended range

Low ±0.000 to ±10.999 vdc
Mid ±00.00 to ±109.99 vdc
High ±000.0 to ±1099.9 vdc

Sensitivity: 1 millivolt

Sensitivity Control: Continuously variable from 1 digit to standby lockout.

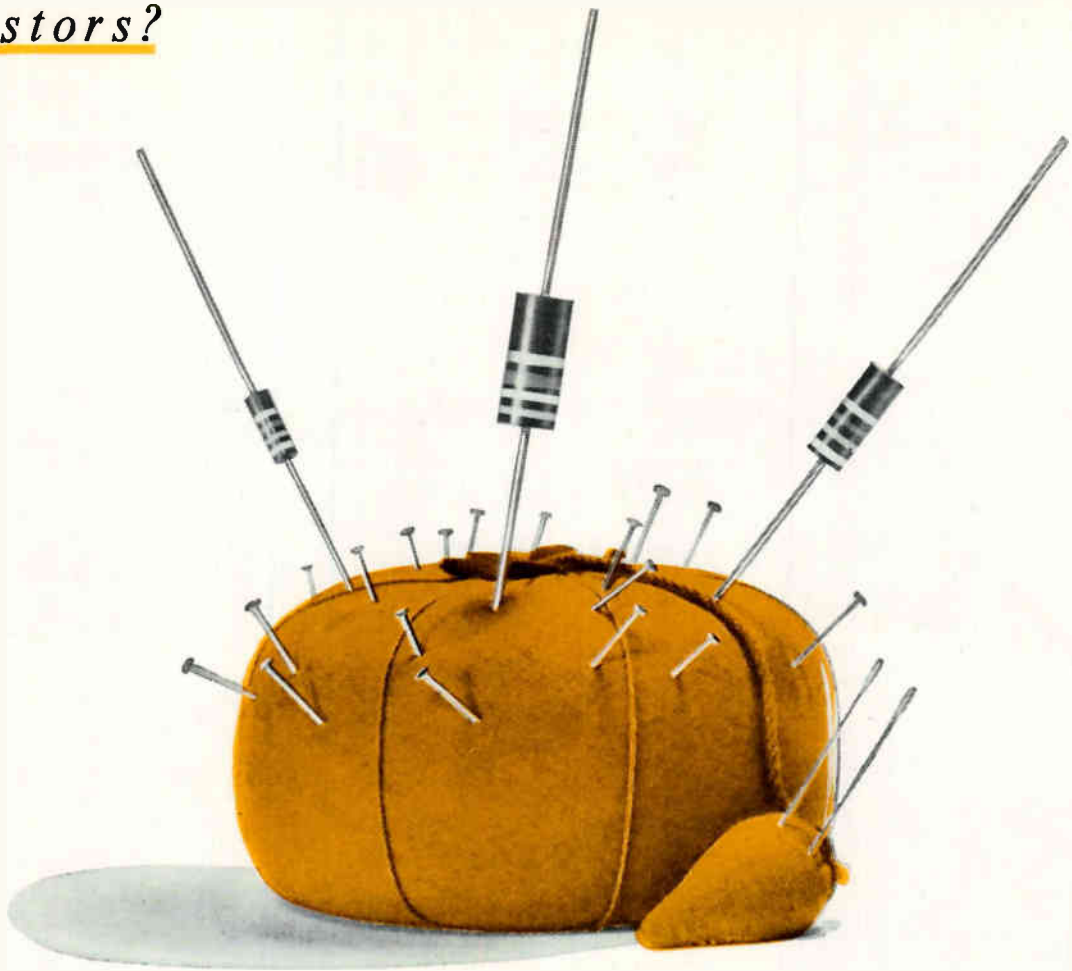
Power Input: 105-125 vac, 50-60 cps, 25 watts standby, 30 watts operating.

Dimensions: 19" wide, 5¼" high, 14" deep, rack or bench mounting with dust-proof switch and bridge section.

Average Balancing Time: Less than 2 sec.

cubic CORPORATION

Resistors?



Stick with STACKPOLE

It's a known business axiom that getting with—and sticking with—a single, dependable source of supply can reap handsome dividends. When you purchase Coldite 70+ Resistors from Stackpole you provide yourself with an *extra* cushion of dependability and quality. That's because Coldite 70+ Resistors are not only designed to exceed MIL-R-11 requirements in every respect . . . but they are also tops in load life, humidity and moisture tests.

What's more—no other resistors can match Coldite 70+ for production line efficiency because they are far and away the easiest to solder by any method . . . dip or iron. Leads stay tarnish-free and solderable even after months of storage thanks to the exclusive Stackpole extra solder coating applied after the usual tin dipping.

Coldite 70+ Resistors are available in Type RC-20 (½-watt); Type RC-32 (1-watt); and Type RC-42 (2-watts) . . . in all standard resistance values and at regular resistor prices. Write for Stackpole Resistor Bulletin giving complete specs on Coldite 70+ Resistors for MIL as well as commercial uses.

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ELECTRONICS NEWSLETTER

British Firm Expands Into U. S. Markets

BRITAIN's Electrical & Musical Industries Ltd., through its U. S. subsidiary Capitol Records, is expanding into manufacture of broadcast studio equipment, tape recorders, high-performance electron tubes and unspecified consumer electronics. Capitol has hitherto been active only in the phonograph-record field.

To launch its expansion, Capitol activated a wholly-owned subsidiary, acquired the electronics division of Voi-Shan Industries, and Hoffman Electron Tube of New York, blended them all together as EMI-U. S. Ltd. British EMI, which is a major producer of recording tape, including video and instrumentation tape, will introduce its house brand (Emitape) through the new subsidiary.

EMI does not expect to reduce its present UK-U. S. exports, although such products as klystrons may be manfactured in the U. S.

Justice Dept. Attacks Componentmakers

ELECTRONICS INDUSTRY DEFENDANTS in a federal antitrust action in Dayton, O., last week returned no-contest and not guilty pleas to Sherman Act charges. The federal grand jury in January had indicted four component manufacturers for price-fixing in sales to the armed forces and to commercial buyers. Indictments said the firms had total sales of $43 million in 1959, of which about $3 million was sales to Dayton Air Force Depot.

Justice Department attorneys indicated that the Dayton complaint will not be the last price-fixing charge to be leveled by the antitrust division against electronics manufacturers. The department also indicated it will contest pleas of *nolo contendere* (no contest) entered by Stackpole Carbon, Speer Carbon and International Resistance Co. Allen-Bradley, the fourth corporate defendant, and two individual defendants (executives of Speer and Allen-Bradley), all entered pleas of not guilty. Federal Judge C. A. Weinman took the *nolo contendere* pleas under advisement, will hear arguments on the pleas early in April.

Meanwhile, the antitrust and monopoly subcommittee of the Senate Committee on the Judiciary, under the chairmanship of Sen. Estes Kefauver (D., Tenn.), is collecting data on identical bids submitted by contractors over an 18-month period to the Defense Department. The report now being printed, includes data on electronics equipment, is expected to substantiate Kefauver's opinions about administered prices.

Grand jury indictment in the Dayton case claimed that, beginning in 1955, the companies conspired to fix and maintain uniform prices on resistors in commercial packages; fix prices in military sales; and require some distributors to adhere to prices fixed in armed forces sales. A civil suit was filed along with the criminal suit, asking for an injunction to bar the companies from continuing the alleged practices and from further intercommunication among themselves on matters of price.

Services Open Center For Frequency Analysis

TRISERVICE frequency-analysis center is being set up in Annapolis, Md., for the Defense Department's radio-frequency compatibility program. The program was authorized last July, has been more recently called the electromagnetic compatibility program. Goal of the program, in one military man's words: to ensure that "if all the electronic equipment operated by the three services were to be turned on at the same time, all would work without interference."

Air Force has management responsibility for the new center, which is located at the Naval Engineering Experimental Station. Negotiations are underway to find an industrial contractor to operate the center. One of the first jobs will be to compile a library of radar and other spectrum signatures. The center will ultimately pass on the compatibility of equipment, will where necessary initiate action for phasing out or remodeling incompatible gear.

Defense Contracts Buy Missiles, Computers

RECENT CONTRACTS announced by Defense Department have stressed increases in missile armanent and in controls and computers to handle weapons systems.

Navy last week ordered $28-million worth of Sparrow III missiles from Raytheon. The radar-guided bird, which can follow target evasions, is now operational with the Sixth and Seventh Fleets.

Navy also gave Remington Rand Univac a $5.5-million contract for more AN/USQ-20 computers. The high-speed USQ-20 is the heart of the Naval Tactical Data System, used for keeping track of complex task-group operations.

Air Force released $20 million recently to GM's AC Spark Plug division for design and development of an improved bombing-navigation system for the B-52. Production of the ASQ-48 bomb-nav system—which will incorporate radar for both high altitude bombing and low-level terrain clearance—will probably top $50 million.

Navy gave Martin Baltimore a $14-million contract for more Bullpup air-to-surface missiles, announced that the price per missile has been cut 57.3 percent since Bullpup procurement began in 1958. At the same time, a $1-million contract went to Maxson Electronics to set up a second source for assembly of Bullpup guidance and control components.

Microelectronics Receiver Demonstrated by USAF

TUNED R-F receiver made of molecular electronic functional blocks was demonstrated recently by USAF's Wright Air Development division. Westinghouse designed the experimental unit. Main parts are six silicon blocks about the size of a dime but only a fourth as thick. Each is a stage of the receiver.

The tiny set operates in the

standard broadcast band, contains a few miniature but conventional components: two pots to control volume and tune the set, five capacitors to isolate the blocks from each other, and a 2-in loudspeaker. Receiver frequency is altered by changing the voltage on the tuner stages. Two r-f amplifier stages precede the tuner; these are not tuned. Buffer, detector and a-f amplifier stages complete the set.

Navy Is Expanding Antisubmarine Efforts

RELIABILITY of electronic devices used in Navy's antisubmarine defense program will be checked out in a test range being set up at Pemaquid, Me. Vocaline Co. is industrial contractor for the test facility; the firm will work with Fleet Air Wing 3 at the Naval Air Station in Brunswick, Me. The P2V-equipped FAW3 has ASW work as its primary mission. Test facility will evaluate sonobuoys, study underwater acoustics, check out certain types of permanent hydrophone installation.

Earlier this month, Lockheed announced that the first P3V, a modification of the Electra meant to supplant the P2V in ASW work, has rolled off the lines. Testing is now underway.

Navy has developed an underwater photographic spectrophotometer which can simultaneously record light intensities across the visible spectrum at a fairly high photographic speed. Key to the speed and sensitivity is use of a wedge interference filter as the analyzing element.

The device can make direct measurement of spectral compositions at depths of 200 ft.

Electro Nuclear Systems is performing noise and radiation pattern studies of nuclear submarines for the Navy.

Japan to Remove $11 Floor On Transistor Radios

JAPAN'S Ministry of International Trade & Industry is expected to do away with the $11 floor price previously required for export of six-transistor radios. Action is expected by April. The floor-price structure, scaling upward from $11 for sets with more transistors, is one device by which MITI has kept Japan's exports from flooding overseas markets. Support for the move originated with Japanese manufacturers and exporters, who are now selling the sets in almost all but the U. S. and Canadian markets for $7 and $8. Current agreements affecting transistor-radio exports from Japan expire March 31; if the floor price is killed, quotas may be tightened.

In another action, governments of Japan and Okinawa agreed last week that Japan would loosen export of transistor-radio parts to Okinawa provided Okinawa imposed quotas on exports of sets to the U. S. and Canada. Okinawan quota is to be set at 300,000 sets, takes effect April 1. The Ryukyu Island nation is also asked to sell in all world markets, not just North America.

Meanwhile, Japan's Electronic Industry Association rejected as unfounded the charges by a Chicago local of the International Brotherhood of Electrical Workers that imports of Japanese components have caused unemployment in Chicago. The Association points out that imports amount to only 0.3 of one percent of domestic shipments. "'Buy American' drives and boycotts," JEIA says, "are irresponsible and predatory devices which will only serve to create ill will and divert attention from the real cause of the malaise."

Soviets Lose Venus Probe, Recover Test Spacecraft

SOVIET NEWS AGENCY Tass announces that radio contact with the Venus probe could not be established during the scheduled interrogation on Feb. 27. Efforts to reestablish contact since then have not been successful. Processing of telemetered data shows the various systems on the probe worked within the established limits. The solar orientation system apparently operated reliably, at least at first: solar cells recharged the chemical batteries after prior drains for transmission of data.

Last Thursday, Soviet scientists launched and recovered a 5-ton space ship containing a dog named Chernushka (Blackie) and "other biological subjects." Launch was to prove out new cabin designs for spacecraft; the cabin was recovered undamaged. The recent launch carried telemetering and television systems, a radio beacon for trajectory measurement, and radio communications gear.

Chinese Reds Modernize Radio Manufacturing

MODERNIZATION of radio manufacturing in the Chinese Peoples Republic is progressing with great vigor, according to Business & Defense Services Administration. Modernization includes use of automatic techniques in production. BDSA reports forecast resultant savings in manpower, sharp increases in production. Nanking electron-tube factory and Hua Pei radio works are among factories automated and mechanized. Standardization of radio receivers preceded the modernizing effort.

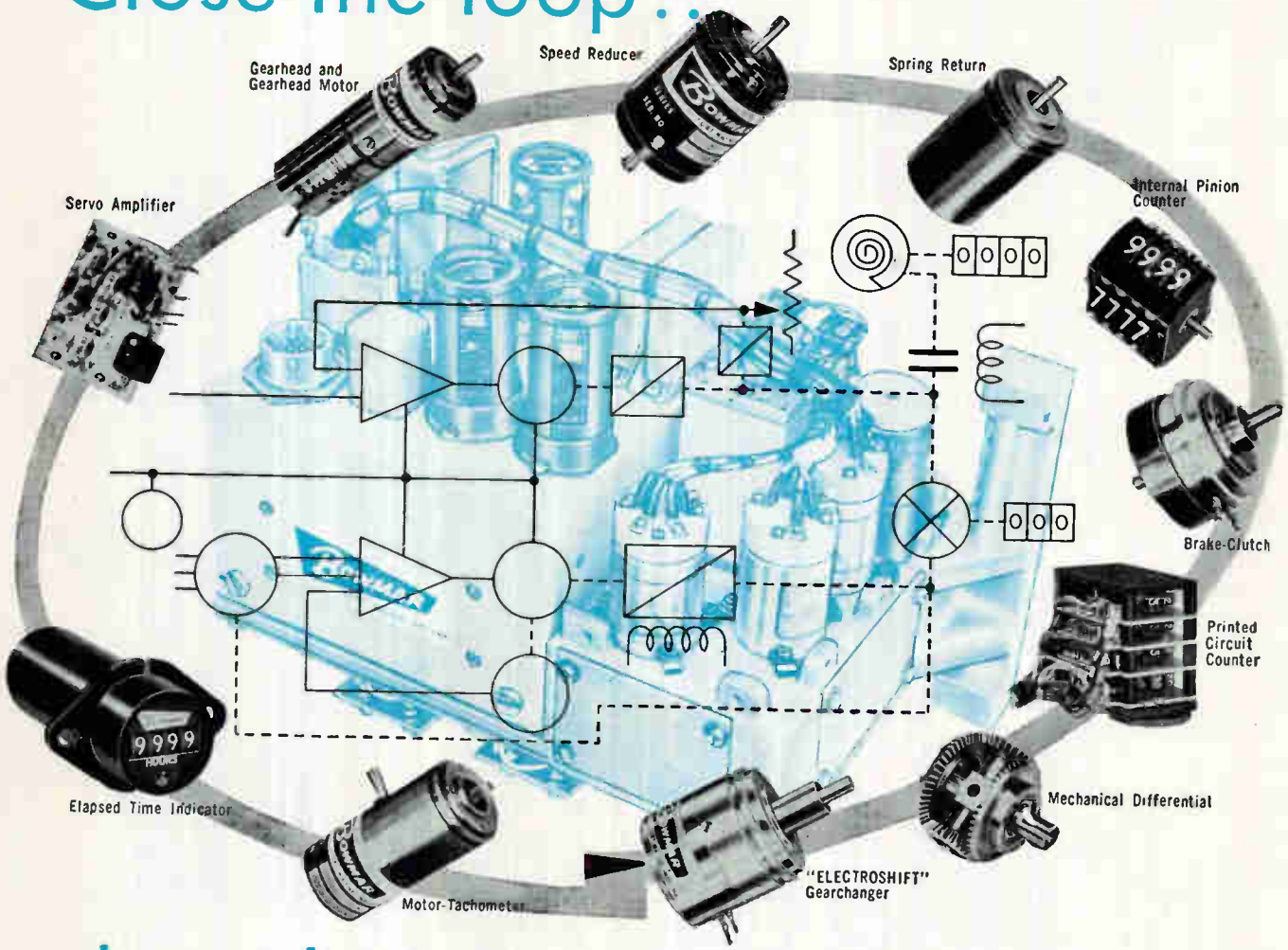
Random-Access Memory Uses Magnetic Tape on Cards

MAGNETIC FILING SYSTEM for computers has been developed by National Cash Register for its NCR-315 data-processing system. Called card random-access memory (CRAM), the device is made of magnetic tape on cards 14 in. by 3¼ in. Cards are notched, suspended on rods; 256 cards form a cartridge supported by 8 rods. Electromechanical selection system drops a card at a time onto a rotating drum, where it is held as long as needed by vacuum.

Single card holds 21,700 alphanumeric characters or 32,550 digits; a cartridge can hold 803 million alphanumeric characters or 5.5 million decimal digits. Access time to data in a card already on the drum is 14 milliseconds; acquisition time to a card is of the order of tenths of a second. A 315 system can use up to 16 Cram cartridges.

The device has a higher volumetric efficiency than a magnetic drum. Serial transfer rate from card to computer is 100,000 alphanumeric characters or 150,000 digits a second.

Close the loop . . .



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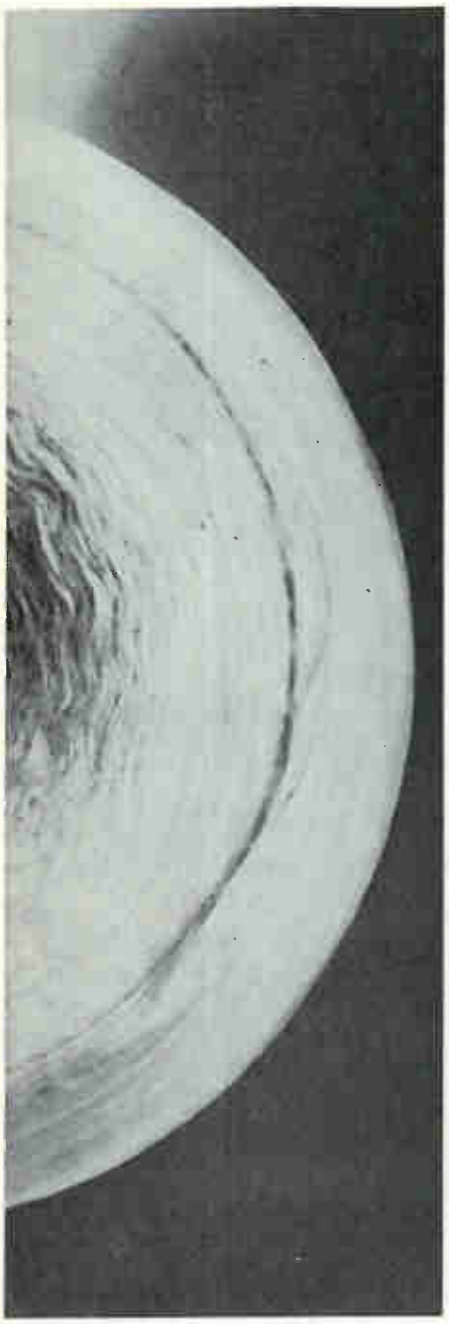

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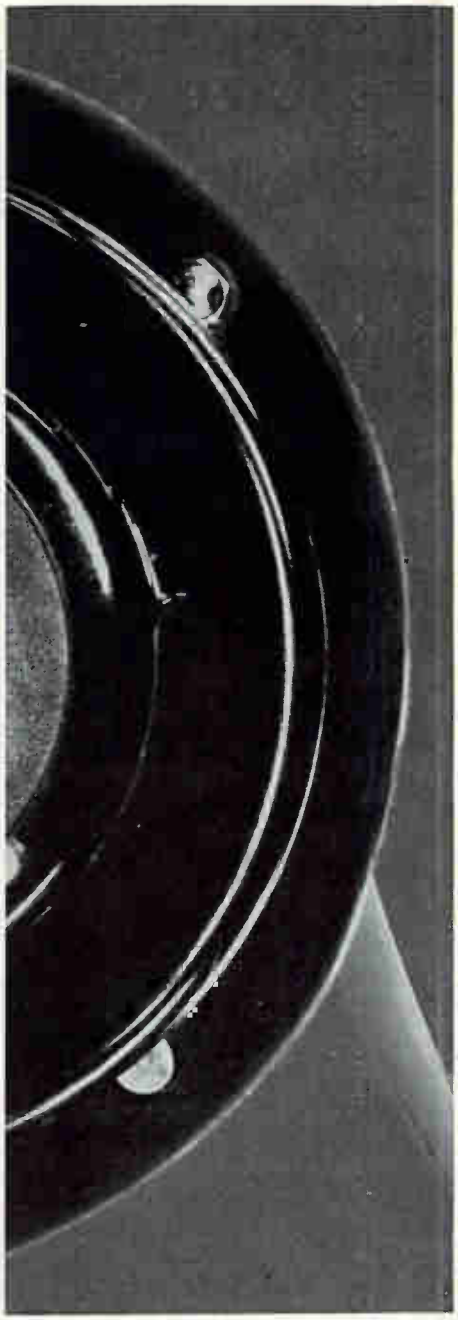

Counting memos, reports, letters, addresses—Veeder-Root counters pay off on a wide variety of office machines, providing businessmen with that extra measure of control.

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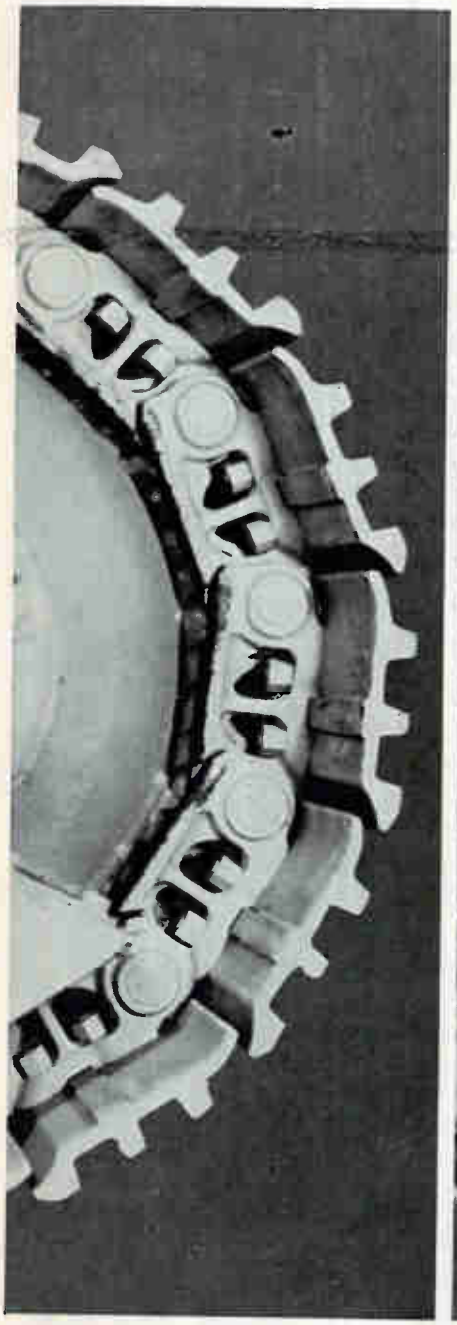
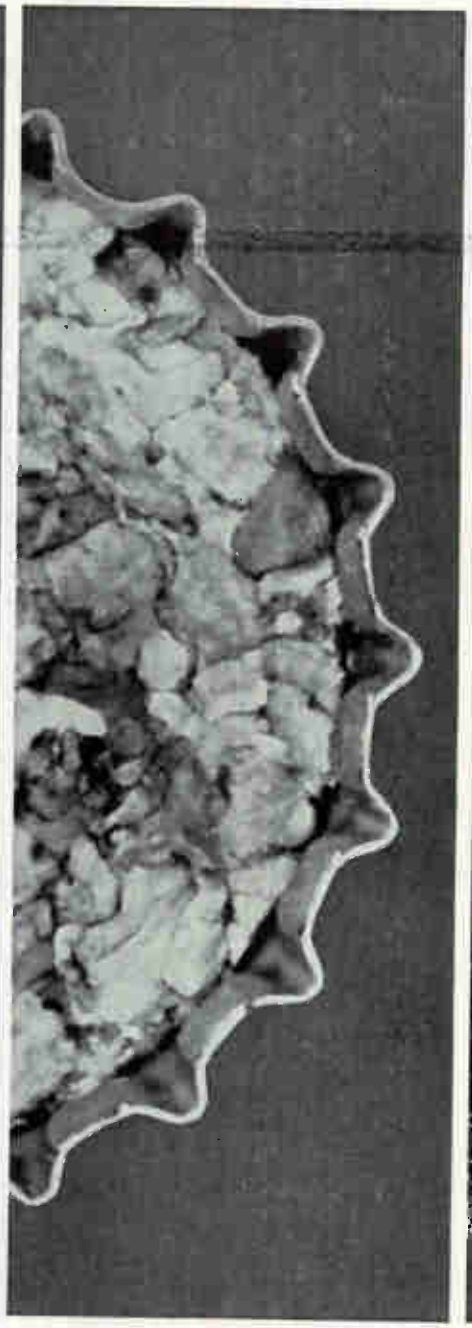
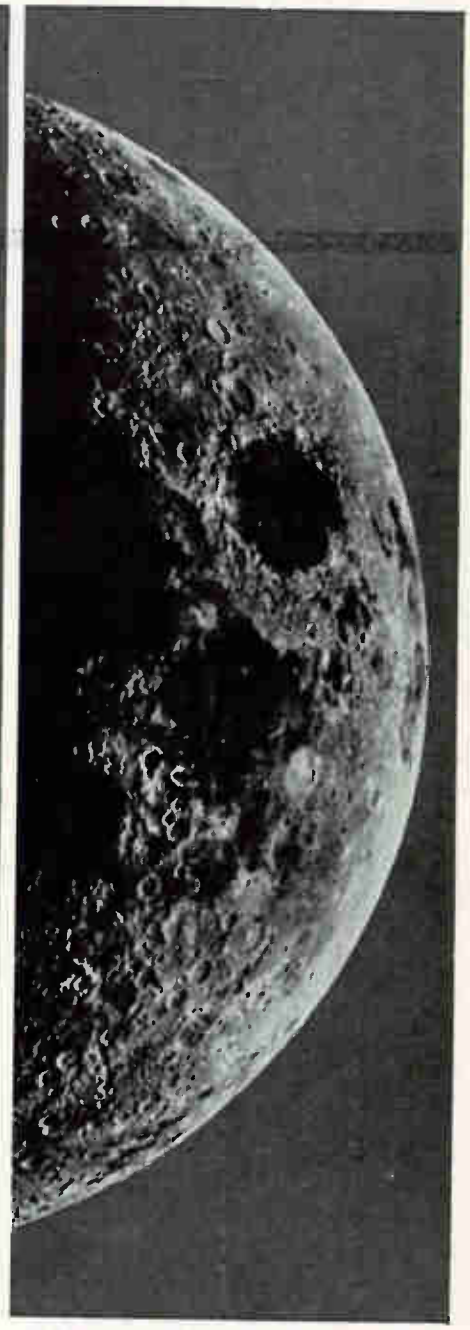
counting controls for industry, defense and space exploration



In farm mechanization and heavy construction, equipment designers use Veeder-Root counters to report productive work accomplished by harvesting machines and giant earth movers.



Whether it's counting bottle caps, pills or tiles, Veeder-Root electronic counters with photo-electric input record production up to a surprising 300,000 units per minute.



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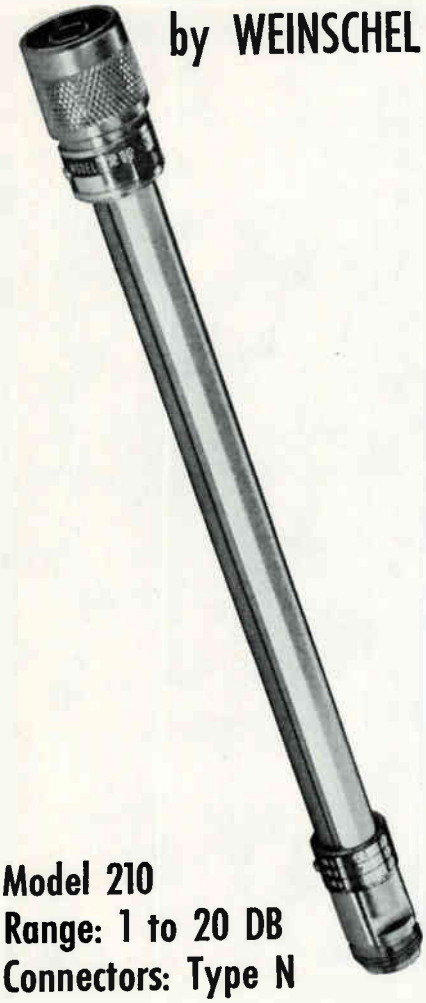

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WASHINGTON OUTLOOK

THE PENTAGON has bucked the question of Nike-Zeus production to the White House for decision. The Army wants at least $200 million extra in the fiscal 1962 budget to start producing equipment for two Zeus antimissile defense centers. The Eisenhower budget for fiscal 1962 earmarks $250 million just to continue research and development.

The Army plans to use production facilities originally built to manufacture test quantities of Zeus components. The Army's original proposal was to tool up for full production and at a cost of many billion dollars equip 70 Zeus batteries. Eisenhower twice rejected this proposal.

Herbert F. York, Director of Defense Research and Engineering under Eisenhower, who was still on the job at press time, once again advised against Zeus production. He believes the Zeus system, as now designed, would be virtually helpless against an ICBM salvo attack including decoys. York tells Kennedy more R&D effort is needed before justifying a move to production. York's successor will be physicist Harold Brown.

ALSO BUCKED to the White House for decision is the future of the Air Force's B-70 bomber development. A sharp cutback is under consideration. One idea is to go back to the Eisenhower policy of limiting the project to a stripped-down, prototype Mach 3 aircraft and to cancel or stretch out work on electronic subsystems.

The Nike-Zeus and B-70 decisions will be made by the White House before the Kennedy amendments to Eisenhower's fiscal 1962 defense budget are sent to Congress within the next week or so.

LEGISLATION requiring all new tv sets to include uhf reception will be sought by FCC. The Commission feels this is the only way uhf can ever be made commercially feasible. If the sets are there to receive a uhf signal, both commercial and educational uhf stations will spring up.

Commission lawyers feel that such a requirement is constitutional. EIA disagrees. Hearings in the past have always floundered on the constitutional question, and proposals have died in congressional committee.

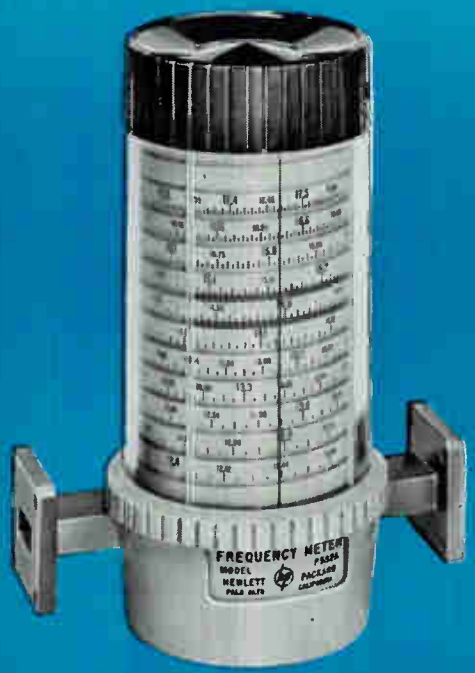
Word of the proposed legislation was presented by outgoing Chairman Frederick W. Ford in testimony before a Senate committee on a bill granting $1 million to states to establish educational tv. Newton Minow, the new chairman, a strong educational tv booster, will support the Ford proposal.

SCRAMBLE among electronic producers to get in on the ground floor in space communications has stirred up a rumpus over NASA's handling of the active satellite program. The immediate cause is the recent addition of new frequencies that can be used in communicating with the satellite.

There will be only one active space communication system because of the high cost and large volume of traffic that such a system can accommodate. The firm or combination of companies that wins NASA's development contract will have the inside track toward emerging as the dominant factor in any commercial system developed.

NASA says the new frequency bands were added because of foreign participation in the program. But several companies are asking what basic changes occurred in the 30-day interval between NASA's original bidders and conference in January and the addition of frequencies on Feb. 24. Some of them also question the closeness of the new frequencies to those approved for AT&T's experimental use.

With the strong show of interest that's coming from industry, a basic question emerges: Why is the government developing a commercial satellite system when industry is scrambling to do it on its own? Government space communications needs are being handled by the Army with its Courier and Advent systems.



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SPECIFICATIONS

Model No.	Overall Accuracy (%)	Frequency Range KMC	Dial Calib. Accuracy (%)	Calibration Increment (MC)	Max. Temp. Coefficient % per ° C	Price
G532A	0.065	3.95 - 5.85	0.033	1	0.0012	$325.00
J532A	0.065	5.30 - 8.20*	0.033	2	0.0012	300.00
H532A	0.075	7.00 - 10.0	0.040	2	0.0015	250.00
X532B	0.080	8.20 - 12.4	0.050	5	0.0010	175.00
M532A	0.085	10.0 - 15.0	0.053	5	0.0012	275.00
P532A	0.100	12.4 - 18.0	0.068	5	0.0012	210.00
K532A	0.110	18.0 - 26.5	0.077	10	0.0013	280.00
R532A	0.120	26.5 - 40.0	0.083	10	0.0017	300.00

K and R band models available with circular flange adapters; specify K532AC and R532AC respectively.

*When used between 5.3 to 7.5 KMC, or 5.7 to 8.2 KMC, single mode resonance is achieved.

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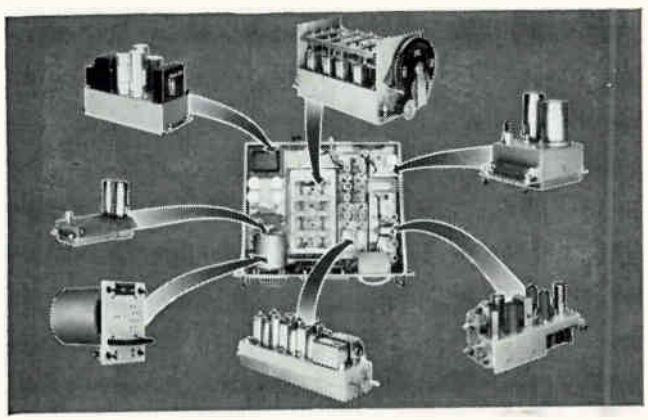
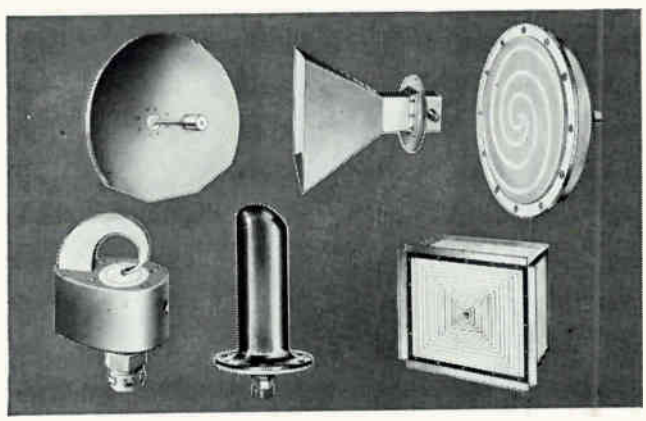


Hallicrafters communications leadership is exemplified by new high frequency Single Sideband receiver, (model no. SX-116). 100% modular design permits simple modification for compatability with existing and future communications systems. Stability, with proper available plug-ins, is better than one part in 10,000,000 per month. Hallicrafters also offers an existing capability in receiving and transmitting techniques up to frequencies of 50,000 megacycles.

Hallicrafters participation in the Atlas missile project helped to develop capability for many areas of the complex missile field, including code translator data systems; ground support equipment; ECM testing and antenna systems. Current explorations involve latest Infra Red techniques.



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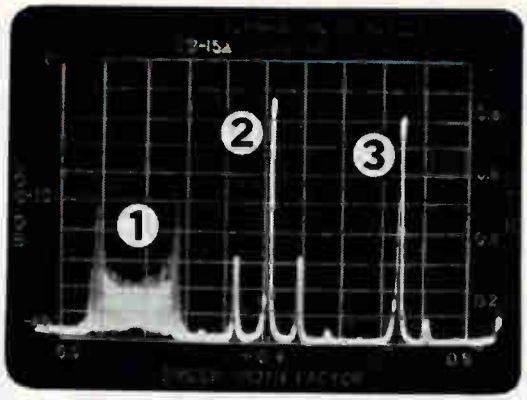

Lab setup shows SB-15a versatility. (1) FM display measures dynamic deviation. (2) & (3) are AM and SSB signals, respectively, with sine wave modulation.

PANORAMIC's SB-15a SPECTRUM ANALYZER 0.1 KC TO 600 KC

Panoramic's advanced Model SB-15a automatically and repetitively scans spectrum segments from 1 kc to 200 kc wide through the entire range (0.1 kc to 600 kc) . . . plots frequency and amplitude along the calibrated X and Y axes of a long persistence CRT, or on a 12 x 4½" chart (optional RC-3a/15). Sweep rates are adjustable from 1 to 60 cps.

Adjustable resolution enables selection and detailed examination of signals as close as 100 cps. Self-checking internal frequency markers every 10 kc. Also internal amplitude reference • Only 8¾" high, the SB-15a is completely self-contained, needs no external power supply or regulator.

PANORAMIC PRESENTATION MEANS

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SUMMARY OF SPECIFICATIONS

Frequency Range: 0.1 kc to 600 kc.

Sweepwidth: Variable, calibrated from 1 kc to 200 kc.

Center Frequency: Variable, calibrated from 0 to 500 kc.

Markers: Crystal controlled, 10 kc and 100 kc plus harmonics.

IF Bandwidth: Variable, 100 cps to 4 kc.

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Amplitude scales: Linear, 40 db log (extendable to 60 db) and 2.5 db expanded.

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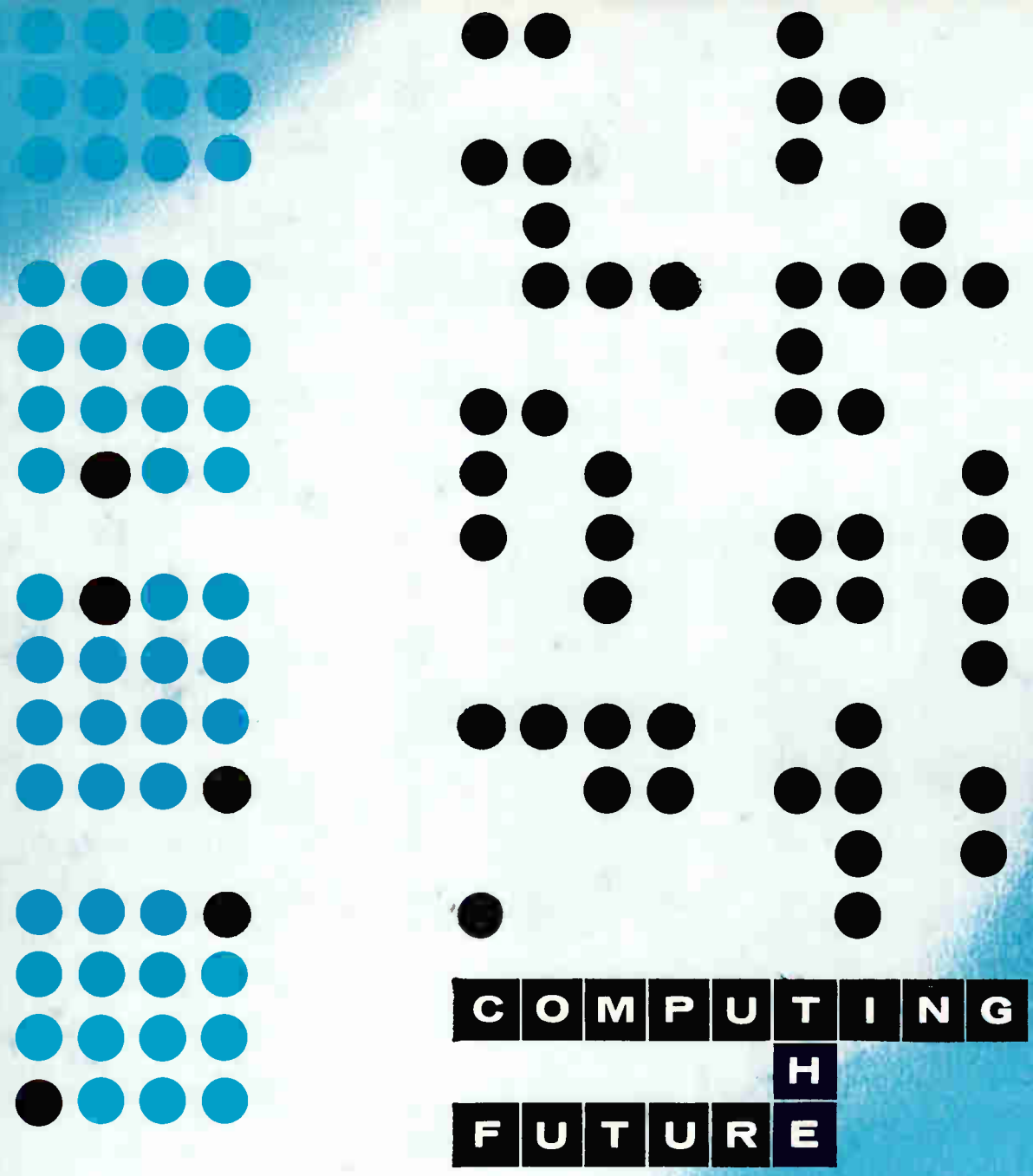

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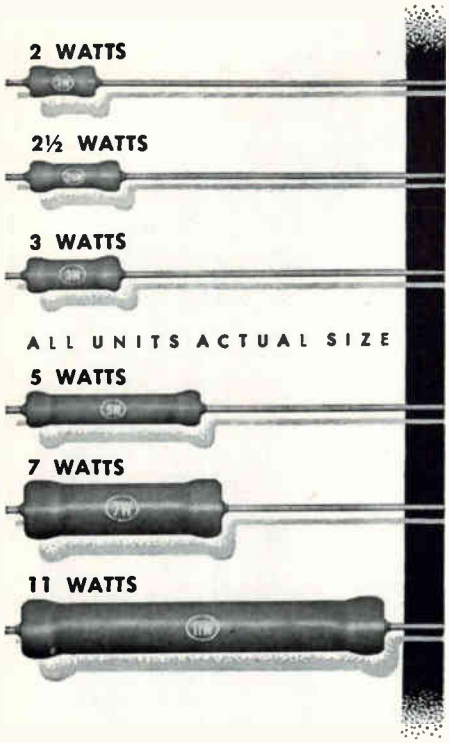

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Survey Points to Rise in Antenna Market

MILITARY ANTENNA market is expected to rise significantly within the next five years, going from a present level of between $130 and $240 million to between $400 and $600 million.

This growth is indicated in a survey taken by Robert C. Sellers & Associates, Garden City, L. I. The survey is based on inquiries sent to all firms listed under "Antenna Manufacturers" in the ELECTRONICS Buyers' Guide. There was a reply of 48.5 percent, representing 103 manufacturers.

Of the reporting companies, 57 have under 500 employees, 17 have under 2,000 and 29 have over 2,000. Most replies were originated by company sales managers or other officials concerned with market planning.

Most firms said they believe space projects and large-scale systems will be a major factor in increasing the size of the antenna market. More than 50 percent of the firms said there is a distinct trend by systems contractors to pull the antenna business back into their own companies rather than issue subcontracts to specialty antenna manufacturers.

Despite this feeling, specialty antenna manufacturers feel that long-range antenna business volume will be distributed among their own ranks. One manufacturer feels that although a prime contractor might decide to make his own antenna if he were planning a one-shot prototype, he would still call on a specialized company to fill a contract requirement for quantities of such an item.

JAPANESE consumer electronics production figures for the first nine months of 1960 exceeded those of the same period of 1959 according to a survey by the Department of Commerce.

In the first nine months of 1959 1,969,400 sets were made. In the same period a year later, the figure rose to 2,583,100. Respective dollar values were $233,711,000 and $287,949,000 for each nine-month period.

Production of radios with three or more transistors also rose sharply, in the first nine months of 1959, 6,765,400 units were produced. In the same interval of 1960, 9,407,000 were made. These figures include home, portable and car radios.

THIRD-QUARTER shipments of electronic components declined about 5 percent last year, reports the Business and Defense Service Administration of the Department of Commerce. Most of the drop was in components shipped for military end use, and came at a time when component output usually reaches annual peaks.

Nonmilitary component output also failed to show the normal upward movement during the latter half of the year. This is attributed to contra-seasonal levelling off of consumer electronic equipment volumes. Only the output of tv picture tubes, quartz crystals and transformers exceeded second-quarter levels. Shipments of other components either decreased or remained at second-quarter levels.

Also noted was a decline in the lumped category of semiconductor devices. The drop is due to lower unit prices since the number of units shipped continue to rise.

FORECAST of continuing high volumes for components, however, is made by a General Electric spokesman, L. B. Davis, vice president and general manager of the company's components division. For the industry at large in 1961, Davis predicts factory sales of $827 million for electronic tubes of all kinds, and semiconductors sales amounting to $626 million.

These sales include, says Davis, 385 million receiving tubes, 180 million transistors and 11 million tv picture tubes. For the first half of the year, semiconductor rectifiers will continue to follow sales patterns established during the last half of 1960 when upward

growth patterns slackened somewhat. Sales volume is expected to increase by 16 percent, from an estimated $116 million to a new high of $136 million in 1961.

DEPARTMENT OF COMMERCE analysis of selected electronics items imported during 1960 shows a general upturn in dollar value as compared with 1959 figures.

Television cameras and parts, for example, rose to a 1960 total of $1,092,000 as compared with about $227,000 in 1959.

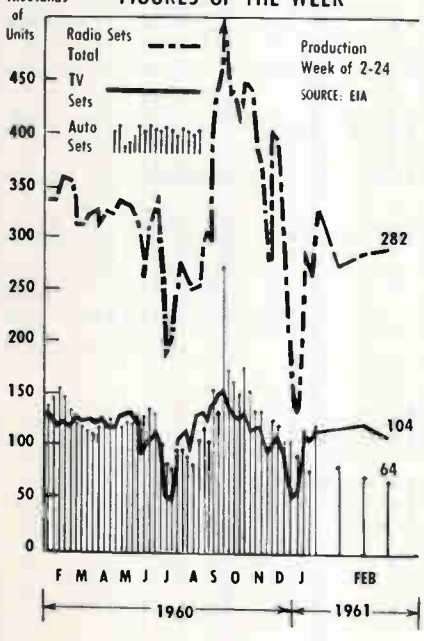
Television tubes and parts also reflected an increase by going from $387,000 in 1959 to $464,000 in 1960. In the category of miscellaneous tv apparatus and parts, the 1960 total was $1,946,000 as against $688,000 a year earlier. Radio parts also climbing steadily as an import item over the past several years, stood at about $92,652,000 at the close of 1960. At year-end 1959, the figure was $72,724,000.

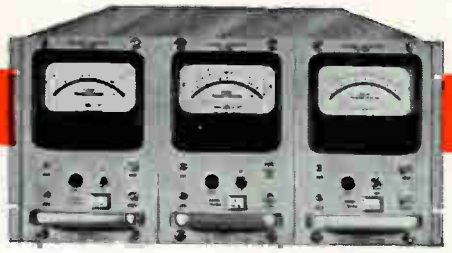
Photocells, electron tubes and parts almost doubled as a category by jumping to $2,394,000 in 1960 as against $1,358,000 in 1959.

Phonographs showed a slight dip last year. Dollar value of imported phonographs was $1,329,000. In 1959 the comparable figure for imported units stood at $1,813,000.

Imports of electronic test and recording gear, instruments, radar equipment, loudspeakers and some other audio devices showed a steady rise all through 1960.

FIGURES OF THE WEEK





AIRPAX
TELEMETRY
DISCRIMINATORS

AIRPAX discriminators for FM/FM telemetry applications use a MAGMETER® frequency detector, a saturating magnetic core device. Discriminator accuracy and long term stability permit convenient calibration of VCO's and other subcarrier frequency generators over all IRIG bands.

The illustration shows 3 UNIVERSAL discriminators mounted in a 19" relay rack panel. Each can be converted to any IRIG band by plug-in frequency detectors and filters.

FEATURES

Rectangular 4½" Mirrored Scale Panel Meter for accurate calibration

•

Standard IRIG center frequencies, deviation percentages and intelligence bandwidths

•

Input sensitivity 10 millivolts RMS minimum

•

60 db dynamic range

•

Linearity, 0.25% of bandwidth or better

Request Bulletin F-69

AIRPAX ELECTRONICS INCORPORATED

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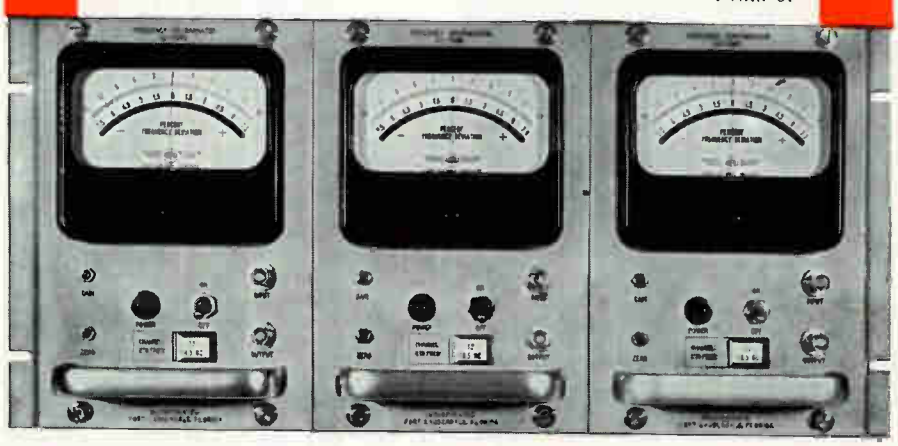

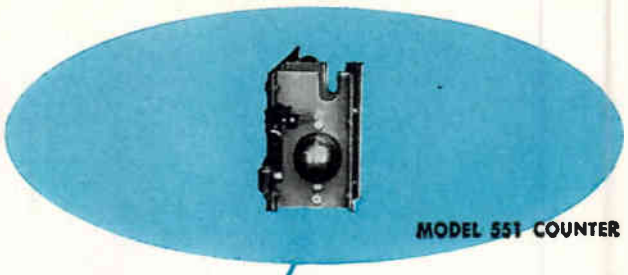

MODEL 551 COUNTER

meet the new counter that made the new

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Model 550 Digital Voltmeter possible

*MODEL 550, ALL-ELECTRONIC DIGITAL VOLTMETER, $1370

One third the number of parts of previous counters. . . that's just one of the reasons why the new Franklin Model 550 Digital Voltmeter guarantees a reliability never before possible. Add to this Franklin's use of the new *Beam-X tube and long-life *Nixie indicator . . . and you know its reliable. And speaking of the New Franklin Model 550 all-electronic Digital Voltmeter, there are other benefits besides the new counters . . . effectively infinite input impedance on all ranges through 120 V dc . . . reads from 100 microvolts to 1200 V dc . . . 0.1% absolute accuracy . . . all electronic . . . self-contained calibration cell . . . handsome, rugged construction for rack or bench use . . . 7" high panel . . . and more . . . *For all the new facts, ask for Bulletin 311.*

*See it at IRE Booth 3838

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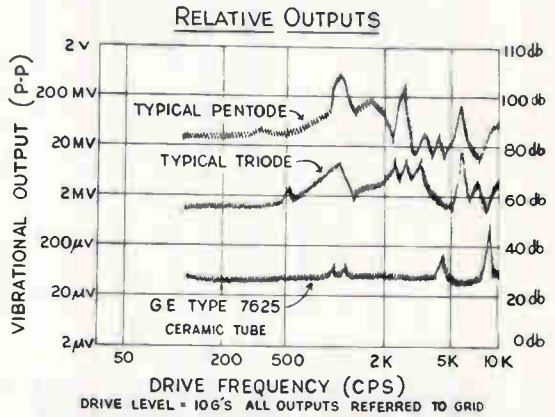
GE ELECTRONICS

Modernize Circuit Design...Use G-E Ceramic Tubes

CUT NOISE UP TO 1000 TIMES

Comparison between G-E type 7625 ceramic tubes and military-type glass tubes, in low-noise audio circuits, shows up to 1000 times lower vibrational output for the 7625. These graphically illustrated results show that the 7625, with its high input impedance, is ideally suited for such applications as threshold infrared, audio, and sub-audio detectors, even under conditions of severe shock and vibration.



Low noise is only one of many benefits ceramic tubes provide over glass tubes and solid-state devices. Depending on the tube type, such specific advantages as high gain, wide VHF-UHF frequency response, outstanding nuclear radiation tolerance, and high temperature resistance are available.

Numerous industrial and military projects currently under development would benefit greatly from the flexibility of ceramic tubes in a wide variety of applications. Many of these applications are discussed in detail, and the entire line of G-E ceramic tubes shown, in the Ceramic Tube Information Folder available by writing to:

General Electric Company, Receiving Tube Department, Room 7091A, Owensboro, Kentucky

Visit IRE booth 2908 to see the complete line of G-E ceramic tubes.

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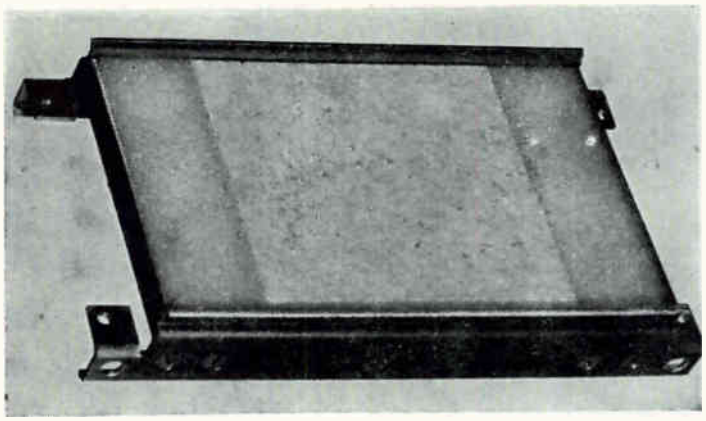
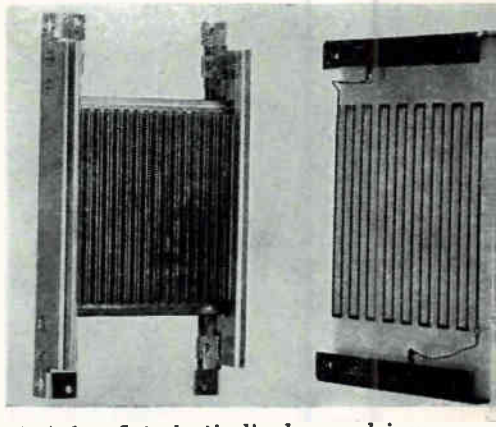
431-110





Orthophase dynamic speaker (left) is about size of pocketbook (8 by 4 in.), has flat plastic diaphragm driven by 17 light-alloy tapes distributed equally over 4 by 5 in. active surface of diaphragm, which moves ter) has quency range. Maximum displacement is about ¼ in. Cross-section (right) is taken through diaphragm and

FRENCH COMPONENTS GETTING

PARIS—MORE PERFORMANCE in smaller packages. That was the keynote as some 400 manufacturers from France and eight other countries put their latest wares on display here recently at the Fourth International Electronics Components Show.

A swing around the booths left visitors with the impression that Tom Thumb had taken over. French component makers, spurred by the continuing trend to transistors and printed circuits, now have on the market pinhead ceramic capacitors, carbon potentiometers that wouldn't cover a thumbnail, transformers small enough to play dice with.

At the same time, performance and frequency ranges are climbing. Compagnie Generale de Telegraphie sans Fil (CSF) of Paris, for example, displayed a backward-wave tube with 10—30 milliwatt output at 150,000 Mc, or 2 mm wavelength. COSEM, Puteaux, Seine, plans to start production runs this year of a diffused-base germanium transistor with cutoff frequency in the order of 700 Mc. Compagnie Francaise Thomson-Houston of Paris had at its booth S band klystrons with 30 Mw peak power output.

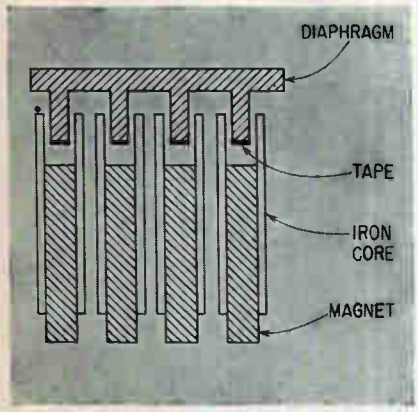
Booths at the Fourth International Electronics Components Show

Sales of the industry are climbing, too. Results for 1960 announced by the Federation Nationale des Industries Electroniques at show time put the industry at the $650-million level, 22 percent higher than 1959. Component and tube manufacturers accounted for $206 million of the total.

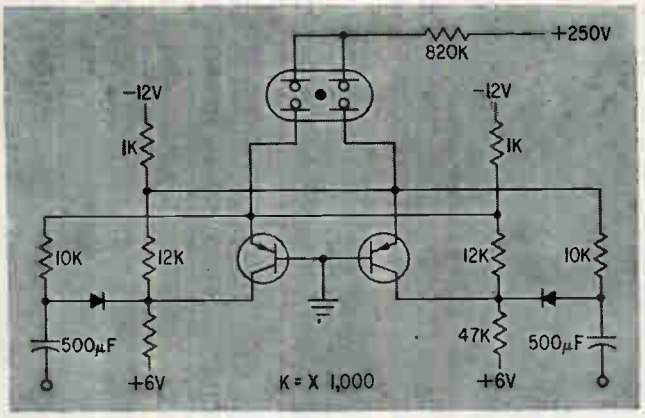
A whopping increase in semiconductor production marked the year; the number of diodes and transistors produced shot up from 18 million units in 1959 to 34 million in 1960. Industry insiders predict semiconductor output will nearly double again this year.

Although the Show generally reflected a steady march ahead in technology, French loudspeaker manufacturer Gogny of Paris took a giant step. The company unveiled its Orthophase electrodynamic speaker, about the size of a pocket book, with a flat plastic diaphragm driven by light-alloy tapes.

Specifications for the unit show



by metal tapes. Moving element (centre like a piston over the audio frequency magnetic circuit (Gogny)



Circuit for typical use of four-electrode miniature neon indicator that operates on 6-volt differential (L.I.R.E.)

SMALLER

By ARTHUR ERIKSON
McGraw-Hill World News

±2 db frequency response from 1,000—25,000 cps with intermodulation distortion less than 2 percent. The frequency range can be extended downward to 40 cps, the manufacturer says, with a suitable baffle. The unit can handle power inputs from 3—10 watts; impedance is 0.35 ohm.

Another component that attracted considerable attention was a four-electrode miniature neon indicator that operates on a voltage differential of six volts. The unit, about ¼ in. in diameter by 1 in. long, was designed for transistor applications. An obvious one is an on-off indicator for a transistorized flip-flop, the manufacturer L.I.R.E., Clamart, Seine, points out.

A relay that wieghs only 3 grams was introduced by Le Prototype Mecanique of L'Etang-la-Ville, Seine et Oise. Sensitivity threshold is 30 mw and with properly designed circuits response time as fast as 100 microseconds can be had, the manufacturer claims. The unit withstands shock and vibration in excess of 30 g. Maximum rating for the spst contacts is 0.5 amp. The unit measures 25/64 in. diameter by ½ in., is hermetically sealed, has life expectancy greater than 500 million operations in low-current applications.

Among the instruments on display, Katji's (La Courneuve, Seine) low-frequency transistor tester provoked interest. The shoebox-size instrument provides direct readout of the four parameters in a hybrid quadripole. In the common emitter connection, for example, input resistance, back emf, current amplification and output resistance under operating conditions can be read from a dial. Ranges for the parameters are: amplification coefficient 0—480; back emf ratio 0.4×10^{-4} to 2.10^{-2}; input resistance 50—25,000 ohms; output resistance 500—250,000 ohms. There is also a connection that permits display of the output signal on an oscilloscope.

Pay television turned up at the Show. French manufacturer Coupatan of Rouen introduced a coin-operated timer for tv sets sold on installment. For every 100-franc piece (about 20 cents) dropped in the slot, the set owner-to-be gets 30, 40 or 60 minutes of viewing time, depending on how lenient the dealer's credit plan is. The timer can hold up to six coins ahead for uninterrupted viewing.

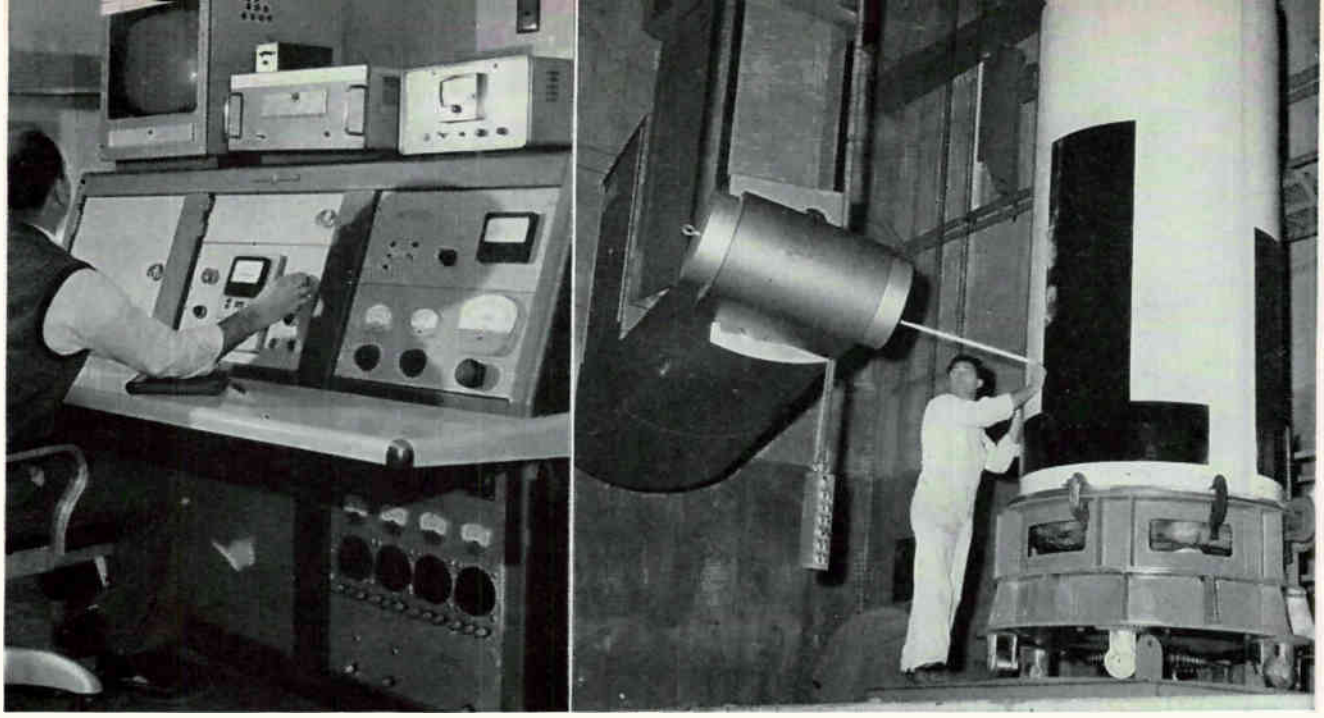
Echo's Skin Suggests Ribbon Transducer

ALUMINUM-COATED plastic used as a skin material for Echo I suggested itself recently to Air Force Scientist L. Shodin at the Cambridge Research Labs as a ribbon transducer.

In tests, the transducer showed uniform response over a frequency range from 250 cps to the ultrasonic range. It permits sound reproduction at greater intensities than conventional ribbon transducers.

Shodin's loudspeaker consists of a thin sheet of plastic stretched across a frame. Bordering the strip are split magnets. Thin strips of a conducting material are impregnated into the plastic diaphragm, between the split magnets. Several narrow ribbons are used instead of a broad conductor; they are affixed on both faces of the plastic.

Smooth response is due to use of low-mass materials in the diaphragm. Resonance of the moving elements is damped by air alone. Device can be used to pressure-modulate dissimilar media, since it is impervious to gases or liquids.



Engineer at console (left) uses closed-circuit tv during actual exposure after technician (right) has set up 10-million-volt radiographic linear accelerator to examine 5-ft-thick rocket engine

X-Rays Penetrate Solid-Fuel Rocket Engines

LOS ANGELES—A ten-million volt X-ray machine powered by a 630-Mev electron linear accelerator, now makes it possible to inspect large rocket engines for Navy missiles. Designed and built by Varian Associates in Palo Alto and installed at the Naval Ammunition Depot's Quality Evaluation Laboratory in Concord, California, the machine supplements similar equipment employed extensively in the development of the Polaris missile system, and in testing engines used in Minuteman and Skybolt missiles.

The solid-propellant motor of missiles must be flawless, with no cracks or voids to upset the controlled and predictable burning rate. Any flaw in solid-propellant fuel or insulation system could cause rocket failure.

With specifications for flexibility, small X-ray source size, optimum energy range, high radiation output and adequate radiation protection, the X-ray unit is especially designed for industrial radiographic application.

With the accelerator, radiographs may be made of the entire thickness of a five-foot diameter solid-fuel engine in two to three minutes. Before installation of this unit, two-million volt X-ray units were capable of penetrating only one-half of this thickness and the X-ray film had to be placed inside the solid-propellant to make an X-ray examination. According to Navy spokesmen, the new machine can examine a complete engine in 15 exposures.

The two-million volt machines presently used to examine large rockets sections or engines will be used for other tasks better suited to this equipment.

Heart of the linear accelerator (linac) is a powerful electron gun that aims a pulsed barrage of electrons at a gold target, causing it to emit X-rays powerful enough to radiograph a five-foot engine section in minutes. Flaws as small as a few hundredths inch in diameter can be detected.

Radiation output is equivalent to 70,000 curies of radium (approximately 70,000 grams). Radiation is much more penetrating than that from either radium or the artificial radioisotope cobalt 60.

A recently installed Eastman Kodak automatic processing machine now permits developing, fixing and drying of X-ray film in 13 minutes instead of two hours previously required in hand processing. Dubbed X-Omat, the new unit has an output of 140 completely processed radiographs an hour.

Unusual features of the linac include water-cooled rotating gold target, 90-deg X-ray emission to accelerator waveguide and a rotating X-ray head.

Weight of linac is 8,000 lb exclusive of mechanical suspension and the unit is approximately 13 ft long, 3.6 ft wide and 7 ft high. The accelerator waveguide is 3 inches in diameter and 98 inches long. Maximum average current is 30 microamp at 10-Mev. The S-band microwave frequency, is 3,000 Mc with a pulse repetition rate of 50 pulses per second variable to 500 pps.

With pulse duration of 2.2 microseconds, the energy per pulse is 0.6 joule at 10 Mev. Electron beam focusing is accomplished by a triple electromagnetic lens. The X-ray source size is one millimeter maximum, and X-ray energy is ap-

proximately 6-Mev to 12-Mev. Radiation production is as high as 1,000 roentgens per minute measured at one meter, and electron range is 1.8 in. of Lucite at 10-Mev. Maximum X-ray penetration is 78 in. of solid propellant. Cost of the system is $89,000.

Liquid-Cooled Amplifier Boosts Radar Ecm Power

A TRAVELING-WAVE TUBE that multiplies by 60 the strength of airborne radar jamming countermeasures systems, has been announced by Sperry Gyroscope.

This increase in power and effectiveness was achieved by dissipating the power-limiting heat generated by the normal operation of conventional helix traveling wave tubes.

An extremely small diameter hollow tubular helix conductor was introduced in the tube through which a coolant was pumped at high pressure. This substitution for the conventional solid wire helix conductor boosted the power capability of a broadband X-band tube from its normal 50 watts to 3,000 watts.

Helix tubes have the capability to amplify signal strength without electrical or mechanical tuning over a frequency range at least double that of other types of microwave amplifiers. They can also amplify simultaneously a great number of signals at different frequencies. But until this development, Sperry said, power output had been less than adequate over the wide frequency range.

The inside diameter of the copper-plated, stainless steel helix tube Sperry used is 19 thousandths of an inch. The wall of the helix is six thousandths of an inch thick.

Experimental coolants included both water and fluorocarbon especially developed for use over a range of temperatures from −76 F to 842 F. Sperry ran thermal tests of helices in which 3,000 watts were dissipated in a piece of helix ½-in. long with the fluorocarbon flow rate only three hundredths of a gallon per minute.

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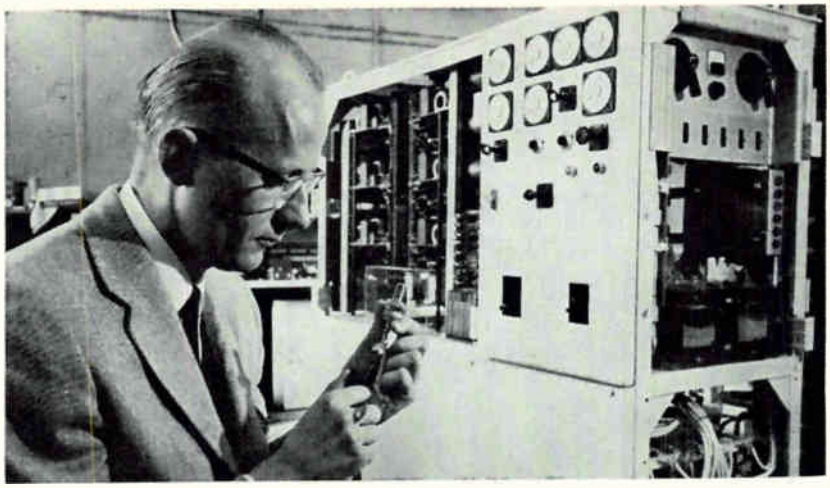


Engineer R. A. Koehler examines scr element used in inverter housed in cabinet on wheels

Inverter Does Work of Motor-Generator Set

By ROY J. BRUUN
Assistant Editor

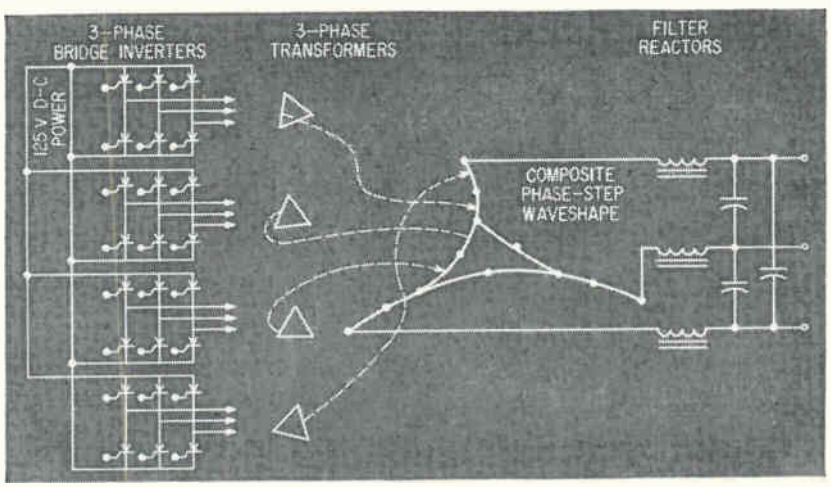
SCHENECTADY, N. Y.—Development of a high-capacity solid state inverter for converting 125 volt d-c power to a variable-frequency 120 to 240 volt 3-phase a-c output was recently announced by GE's General Engineering Laboratory. Company says the device has 10 times the power-handling capacity of other solid-state inverters . . .being rated at 50 Kva.

Current plans are for the lab to use it as portable plant equipment that will displace a 60-hp motor-generator set which is almost three times as heavy and is not portable. The 50 Kva inverter is expected to help solve what has been the most difficult problem in development work on new power sources: low-cost conversion of d-c power to a-c, says R. A. Koehler, engineer at the laboratory.

Many uses of electricity, he says, are found in situations where motor generator sets, normally used for d-c to a-c conversion, are unsuitable because of weight or maintenance factors.

Military applications, as on submarines where noiselessness is important, are also possible.

Basically, the unit consists of a set of 3-phase bridge inverters composed of silicon control rectifiers. Output voltages from the bridge inverters differ in phase. Inverter output frequency is determined by a unijunction oscillator, and is adjustable from 50 to 500 cps. The gating signals from the oscillator are applied to the free terminals of the silicon control rectifiers.



Simplified schematic diagram of 50 Kva-scr inverter

The variously phased bridge inverter voltages are connected through 3-phase transformers to an output filter network. Here they are vectorially added to produce a composite phase-step waveshape. By adjusting the phase-relationship of the bridge inverter outputs, the 3-phase output from the filter network can be varied from 120 to 240 volts.

Overall efficiency of the device is claimed to be greater than 80 percent. Efficiency of the scr elements, which are rated at 50 amps, is said to exceed 95 percent. Output frequency accuracy is given as plus or minus 1 percent. There are supposed to be less than 5 percent total harmonics in the sinusoidal output waveform.

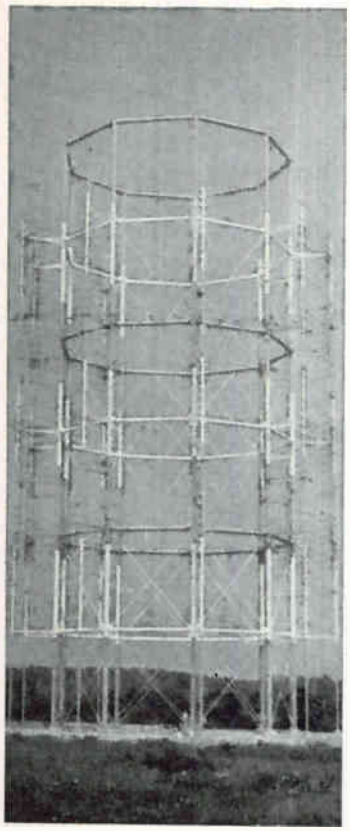
Because of its low-maintenance requirements it is expected that the solid state inverter should be especially useful in isolated installations, such as weather outpost stations, where apparatus must operate unattended. Low maintenance is attributed to absence of moving parts and bearings.

Brazil Plans to Buy Swedish Telephone Gear

STOCKHOLM—L. M. Ericsson Co. reports a fourth contract has been received here to supply telephone equipment to Brasilia, the new capital of Brazil.

Equipment delivered and on order for the inland city's telephone system now totals some $5,800,000.

The latest contract calls for extending Brasilia's first automatic telephone exchange from 5,000 to 10,000 lines, and setting up a new 10,000-line automatic exchange.



Dresser-Ideco built the antenna, above, and others, for Collins Radio Company to be used in Air Force single sideband global communications.

More than 100,000 components have been built by HST for Atlas, left, and other missile systems. Worker, above, directs antenna installation at top of world's tallest TV tower built by Dresser-Ideco at Cape Girardeau, Missouri. SIE portable seismic equipment, right, is used around the world in the search for oil.

ELECTRONICS

– *Another Growing Field Served By Dresser*

Dresser products and technical abilities play an important role in the expanding electronics market. Experience gained by Dresser in manufacturing electronic equipment for oil exploration has been adapted to the development of instrumentation for many other vital applications, including airborne telemetry, process and automation controls, blast detection and other defense and industrial projects. In Missouri, a Dresser television tower – the tallest structure ever made by man – reaches skyward for 1,676 feet. Giant missiles probing outer space use Dresser transformers; and other Dresser-built electronic components play exacting roles in operation of supersonic jet aircraft.

Dresser has long been a leader in supplying equipment and services to the world-wide oil, gas, chemical industries. While retaining this leadership, the twelve Dresser companies have served other growth industries for many years with specialized yet diversified capabilities.

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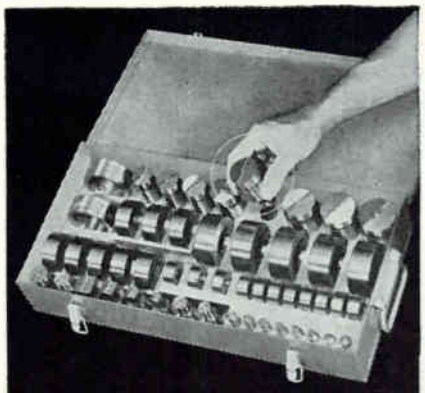

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PUNCH-PAK NO. 2 contains round punches and dies from 1/16 to ½" in 1/16" increments, round sizes from ½" to 2" in ⅛" increments, squares in ½", ⅝", ¾" and 1" sizes, one die holder and two die adapters.

Die Adapter A-2 ¾" diameter—1¼" bore, Die Adapter B-2 ¾" diameter—2⅛" bore.

DIMENSION DATA

All Di-Acro Punches to ½" have ½" diameter shanks, 2 13/32" length.
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All Di-Acro Dies from ¾" to 1⅜" are 2⅛" diameter, ⅞" high.
All Di-Acro Dies from 1½" to 2" are 2¾" diameter, 15/32" high.

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Science Bureau Active In Capital

METROPOLITAN Washington (D. C.) Science Bureau, sponsored by the city's Board of Trade, began operations this week to carry out plans that have been in formulation for some two years.

The Bureau is made up of scientific and science-oriented organizations in the Greater Washington area, extending well into Maryland. Members include representatives from private research and manufacturing companies (of which there are more than 150), and government and university groups.

Electronics companies include GE, CEIR, ACF Electronics, Datatrol, Frederick Research, Litton, Materials Testing Co., Melpar, Matrix Corp., Rabinow Engineering, Pixon, Vitro Labs., Washington Tech Assoc., Weinschell and Welex.

National professional and engineering groups have also expressed an interest in the organization.

The Bureau's aim is to make the Washington area more attractive to scientists and to scientific organizations. A central registry and information service is being set up to give information about scientists, engineers, organizations and events in the D.C. area. Local firms will also be able to call on the Bureau for recruiting brochures.

Bureau officials say they are giving attention to the problem of providing more opportunity for graduate and post-graduate studies. Technical training programs also are being studied.

British Computers To Direct Air Traffic

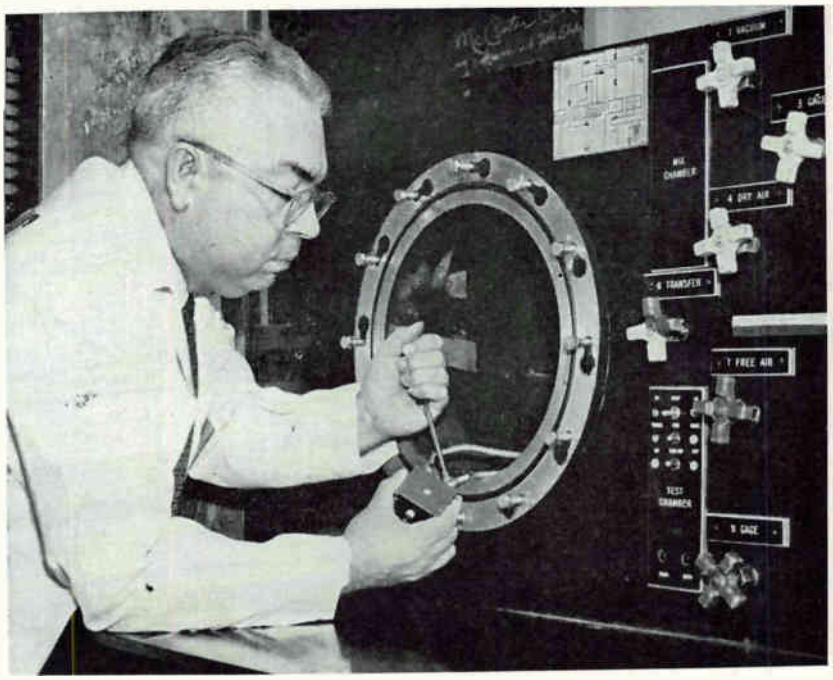
LONDON—Ministry of Aviation is getting set for detailed studies on application of automatic techniques for air traffic control.

Two programs are underway and two computers have been ordered, one Ferranti Appollo and one Elliott 502. Goal of the study is to step up efficiency, reduce work load on controllers and boost capacity of present control systems.

Ministry spokesmen say there is no connection between this study and the drive by some interests to integrate British civil and military air traffic control.

Step one of the study project

Explosion Chamber Tests Components



Vacuum chamber, 12 in. in diameter and 15 in. deep, tests explosion-proof components for the Boeing B-52H missile launcher

concerns compilation and processing of in-flight and re-flight data over the North Atlantic. The Appollo computer will be installed at the Scottish Air Traffic Control Center at Prestwick this summer and will be at work for at least three years.

Its object will be to derive information on automatic equipment for routine manual data processing, to standardize and regulate traffic flow into the center and to minimize manual processing. It will also be used to test control instrumentation systems and data display devices.

A second phase of the Ministry study concerns design of future ATC centers and will be carried out at London Airport, using the Elliot 502 unit.

Predicts School Tv Will Spread Rapidly

EDUCATION TELEVISION head at UCLA, Rudy Bretz, says that television instruction will soon become a regular part of classroom instruction. Several hundred school districts in more than 30 states are already using television. Fifty school districts in southern California alone use tv as a teaching tool. One district has a closed-circuit system feeding 400 classrooms in twenty schools from four studios.

New Technique Treats Tremor Diseases

DESTRUCTION of a small brain segment known as the substantia nigra by electrolysis is the basis of a new technique developed at UCLA for treating tremor-producing diseases. Parkinson's disease consistently affects this part of the brain. Through a small entrance in the cranium, bipolar needle electrodes may be guided by established brain landmarks to the proper depth as determined by a metric scale on the drive shaft of the electrode holder. With passage of current, a rectangular area of the substantia nigra is destroyed to stop abnormal tremor-producing impulses.

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Now, you can afford the data recording facilities you need . . . as few as 2 channels, as many as 4, 6, 7 or 14.

Mnemotron pioneers this **price-plus-precision** breakthrough with a unique pulsed FM principle and fully transistorized, self-contained, interchangeable modules.

Precise, economical and portable, Mnemotron is ideal for these applications in industry, research and medicine: • Data acquisition, storage, analysis and reduction • Time scale contraction and expansion • Dynamic Simulation • Programming • Computer Read In and Read Out

With Mnemotron, you can do more with paper recorders, too . . . expanding frequency response and channel capacity, saving you from being "snowed" with data, letting you look at the same data at different time scales.

When the data you want is analog, record and reproduce it with greater accuracy and much lower cost with Mnemotron. Write, wire, phone today for complete details on this new concept in instrumentation tape recording.

Model 204 features:
Any 2 of these speeds:
1⅞, 3¾, 7½, 15 ips
Frequency Response:
DC-800 cps @ 15 ips
DC-400 cps @ 7½ ips
Linearity: 0.2% full scale
Noise: Less than −50 db full scale
Crosstalk: below 70 db

SEE MNEMOTRON—IN ACTION—AT THE IRE SHOW
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Precision Analog Data Tape Recorders and Biological Computers

CIRCLE 31 ON READER SERVICE CARD

new...
Malco
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TERMINALS
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For Quick
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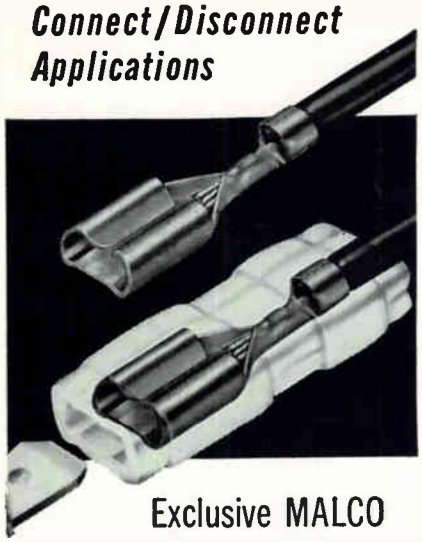
Applications

Exclusive MALCO
Design eliminates faulty
connections...assures
uniform crimping.
Specially contoured insulating sleeve accurately guides terminal into position on male tab. Entry of male tab (outside of terminal) within the insulating sleeve is positively prevented.
Malco Terminals are available in chain form for rapid machine crimping to wire. Insulating sleeves are also machine applied

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Engineering Math—In Whose Hands?

MATHEMATICS for engineers should be taken out of the hands of mathematicians. This was the sentiment advanced at a recent seminar held in Paris by the Office of European Economic Cooperation's Office for Scientific and Technical Personnel.

Behind the sentiment lies the dual nature of mathematics—a powerful working tool for engineers but also an abstract world for mathematicians. Delegates agreed that math for engineers should be kept concrete. They felt that in undergraduate courses math topics should be introduced by showing their use as tools in science and engineering with exercises drawn from practical applications. One seminar speaker said the best way for engineers to learn differential equations is as part of a laboratory course.

Another speaker pointed out many engineers have run into design trouble because their math instructors, obsessed with elegant solutions, never taught them that an integral or differential equation can always be solved by numerical methods. Unable to solve the equation analytically, the engineer may falsely simplify his problem and run into trouble, the speaker said.

REFLECTION of radar waves by water and ice particles in the atmosphere has been theoretically calculated by Benjamin M. Herman and Louis J. Battan at the University of Arizona. Their present work is based on their initial 1959 calculations which, they say, first determined that hailstones may reflect much more energy than equal-size raindrops. Herman hopes that the results of the study will provide a substantial improvement in the utilization of radar for observing thunder storms and hailstorms.

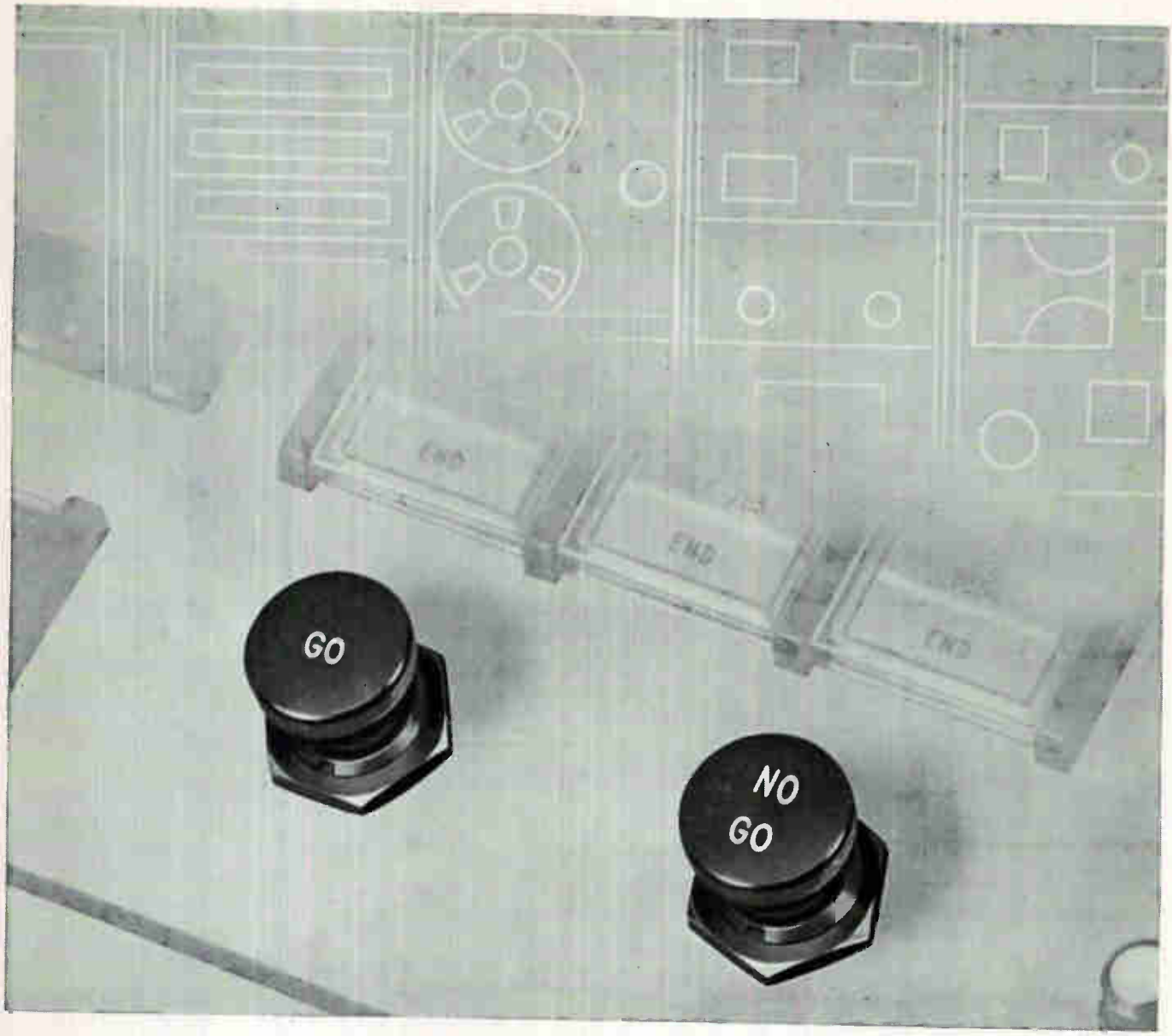
Savings Banks Going Electronic

INSTANTANEOUS ACCESS to magnetically-stored savings bank records through a data processor which also performs off-line functions such as mortgage accounting is provided by a specially designed teller machine.

The machine is part of the new savings bank account system built by Teleregister Corp.

In a recent demonstration at the Boston meeting of the National Association of Mutual Savings Banks, a pass book was inserted (photo) and instantly updated by a processor at Howard Savings Institution, Newark, N. J., 250 miles away.

The system is now being installed in three mutual savings institutions in the East: the Howard Institution; Union Dime Savings Bank of New York City; and the Society for Savings, Hartford, Conn.



THEY RELY ON RADIATION'S AUTOMATIC TEST EQUIPMENT TO PIN-POINT "LITTLE" TROUBLES IN BIG SYSTEMS

Locating the single faulty component or circuit in an advanced electronic system can be expensive—in time, money, and mission success. Putting its finger promptly and *automatically* on these "little" sources of trouble is one of the unique capabilities of Radiation's Automatic Test Equipment—Model 301.

Whatever electronic systems it supports—missile guidance, flight, computers, or industrial process control—Model 301 takes the trouble out of *trouble-shooting, check-out* and *calibration* procedures. Model 301 utilizes thoroughly proved, readily adaptable standard building blocks. Systems can be tailored reliably and economically to each customer's specific ATE requirements.

Typical features available in Radiation's Automatic Test Equipment include: maximum testing speed in direct keeping with speed capabilities of the system under test; ability to maintain a constant check on its own functional accuracy while testing is in progress; test routine and test tolerances variable by operator as required; completely flexible data storage, programming and resolution; comprehensive published reliability data on all standard building blocks.

Radiation's exceptional capabilities are serving both industry and the Armed Forces in a broad range of advanced electronic applications. If you would like to know Radiation's capabilities in an area of specific interest to you, or would like complete information on Model 301, write to Radiation Inc., Dept. EL-3, Melbourne, Florida. Radiation's plants are at Melbourne and Orlando, Florida; Palo Alto, California; and Philadelphia, Pennsylvania.

RADIATION
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CIRCLE 33 ON READER SERVICE CARD 33

Highly Reliable

HITACHI "SEMI-CONDUCTORS"

For Industrial Use
Switching Transistors and Diodes

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Hitachi semi-conductors provide the basis for the excellent capacity of the Hitachi Electronic Computer HITAC 103.

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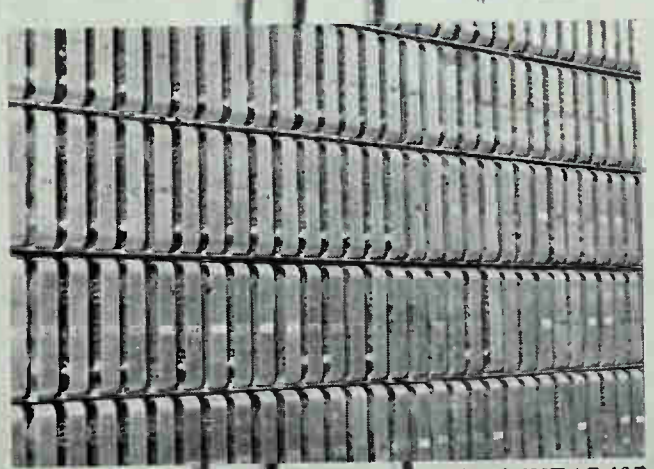

Back of HITAC 103.

Hitachi, Ltd.
Tokyo Japan

Cable Address "HITACHY" TOKYO

NATIONAL Chokes

R-45 series, a new family of ferrite bead chokes for use as filament chokes, parasitic suppressors, and series elements of low-pass filters for frequencies from 5 to 200 mc. Insulated with an impregnated fiberglass sleeving, these chokes will handle 2 amperes of filament current with voltage drop of less than 0.02 volts, temperatures to the Curie point of 125°C.

R-40 series ferrite-core chokes...extremely high Q for small size. They are primarily for use in networks and filters at frequencies from 50 kc to 1500 kc, and as resonant elements in IF and RF circuits. Fungus-proof varnish impregnation per MIL-V-137A.

R-25

series MIL-inductance chokes for high frequency circuits, as filament chokes and peaking coils, inductance per MIL-C15305A, coil forms per MIL-P-14, and impregnation per MIL-V-173A.

R-33, R-50 and R-60

series RF coils are wound on molded phenolic forms per MIL-P-14 and coated with a tough, fungus-resistant varnish. R-50-10 choke is wound on a powdered-iron coil form instead of phenolic.

National features a full line of stock choke items, and will wind chokes to your specification on any standard form. Send us your requirements. Write for components catalog.

National RADIO CO., INC.
MELROSE 76, MASS.

CIRCLE 200 ON READER SERVICE CARD

MEETINGS AHEAD

Mar. 20-23: Institute of Radio Engineers, International Convention, All PG's; Coliseum & Waldorf-Astoria Hotel, New York City.

Mar. 21-22: Institute of Printed Circuits, Annual; Barbizon-Plaza, New York City.

Mar. 27-31: Temperature, Its Measurement and Control, ISA, AIP, NBS; Veterans Memorial Auditorium, Columbus, O.

Mar. 28: Rochester Soc. for Quality Control, ASQC; Univ. of Rochester, Rochester, N. Y.

Mar. 28-29: Nuclear Aspects of Atmospheric and Space Systems, ANS; Statler-Hilton Hotel, Dallas.

Apr. 4-6: Electromagnetics and Fluid Dynamics of Gaseous Plasma, IRE, IAS, U. S. Defense Research Agencies; Engineering Societies Bldg., New York City.

Apr. 4-7: Audio Engineering Society; Ambassador Hotel, Los Angeles.

Apr. 5-7: Global and Space Environments, Institute of Envir. Sciences; Sheraton Park Hotel, Wash., D. C.

Apr. 5-7: Materials and Electron Device Processing, ASTM Committee F-1; Benjamin Franklin Hotel, Philadelphia.

Apr. 10-14: International Air Symposium, FAA; Atlantic City, N. J.

Apr. 11-12: Instrument Automation-Electronics Exposition, Ohio Valley; Cincinnati Gardens, Cincinnati, O.

Apr. 11-13: Ultrapurification of Semiconductor Materials, Air Force Cambridge Research Laboratories; New England Mutual Hall, Boston.

Apr. 12-13: Information and Decision Processes; Engineering Dept., Purdue Univ., Lafayette, Ind.

Apr. 18-19: Inter-Industry Conference on Organic Semiconductors, Armour Research Foundation of Illinois Institute of Technology and ELECTRONICS, McGraw-Hill; Terrace Casino, Morrison Hotel, Chicago.

looking for these silicon transistor types?

available in quantity from **Transitron**

PNP

- 2N1131
- 2N1132

(multi-purpose medium power)
Write for Bulletin TE-1354-1131

NPN

- 2N696
- 2N697

(multi-purpose medium power)
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- 2N698
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(high voltage medium power)
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- 2N1252
- 2N1253

(low storage time, medium power)
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- 2N706

(high speed logic transistor, small signal)
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NOW! Order these popular types of silicon transistors from Transitron, pioneering developer of silicon transistors and producer of the industry's broadest line of high-quality semiconductors!

- **Higher Frequency Requirements**
- **More Mechanical Ruggedness**
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- **Produced by Gaseous Diffusion Techniques**

For full data . . . including the latest refinements achieved by Transitron's advanced production techniques . . . write for Bulletins above.

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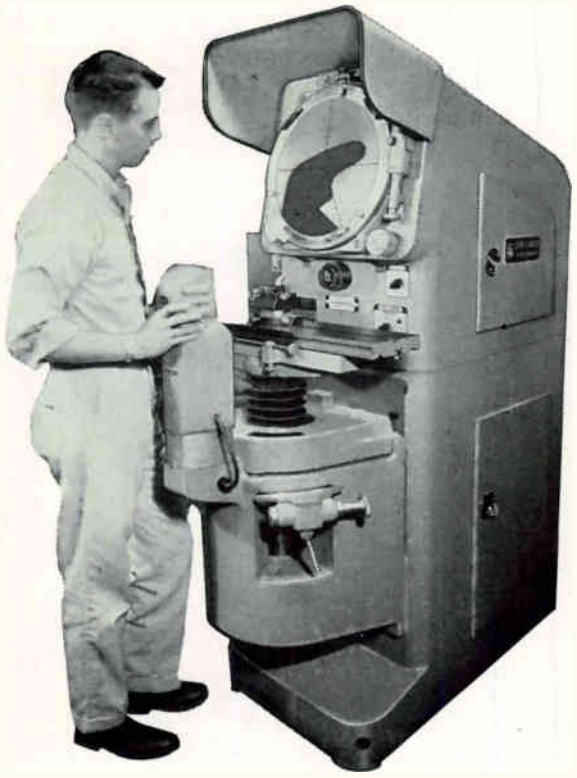
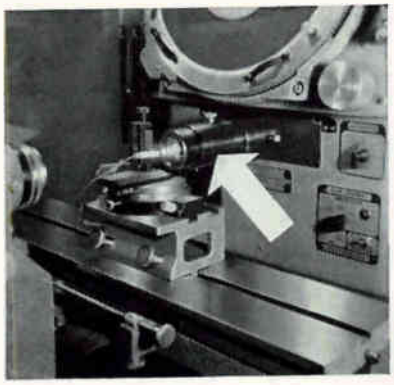
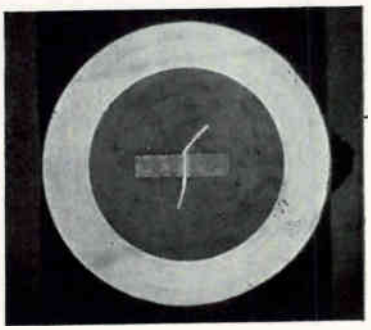


Model FC-14 J & L Optical Comparator



CENTRALITE adapter (arrow) slips easily into place on J & L Optical Comparator — used here to inspect tiny read/record head.

CENTRALITE image of read/record head clearly shows two magnetic poles separated by aluminum foil insulator at 31.25 magnifications.



NOW...closer inspection of micro-assemblies

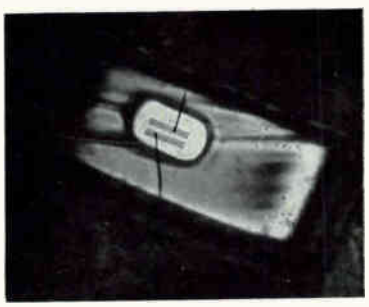
...with CENTRALITE and PARABOLITE

Simply slip on a CENTRALITE or PARABOLITE adapter, and your J & L TC-14 or FC-14 Optical Comparator becomes even *more* versatile. You'll use it for critical inspection jobs that may have previously seemed impossible.

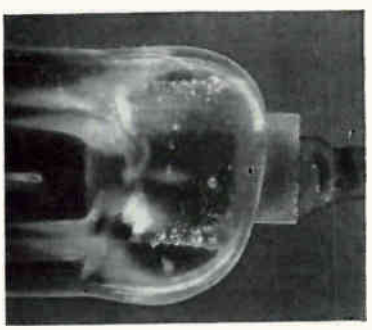
For example, CENTRALITE provides a highly concentrated light which now permits the projection of a precise image of a tiny read/record head used in a computer component. Light is concentrated intensely on the part and reflected back through the J & L projection system onto the Comparator screen. CENTRALITE is also used for micro-inspection of a mesa diode assembly.

PARABOLITE permits detailed examination of a tiny tunnel diode assembly by surrounding it with concentrated light. Simply by rotating the diode, you can take a close look at seal, bubble configuration at fusion points, gold contact to wafer, and other critical details.

Solve *your* inspection problems with J & L Optical Inspection Equipment. Send for Catalog LO-6013 now.



Micro inspection of this mesa diode assembly at 100 magnifications is clearly detailed with CENTRALITE.

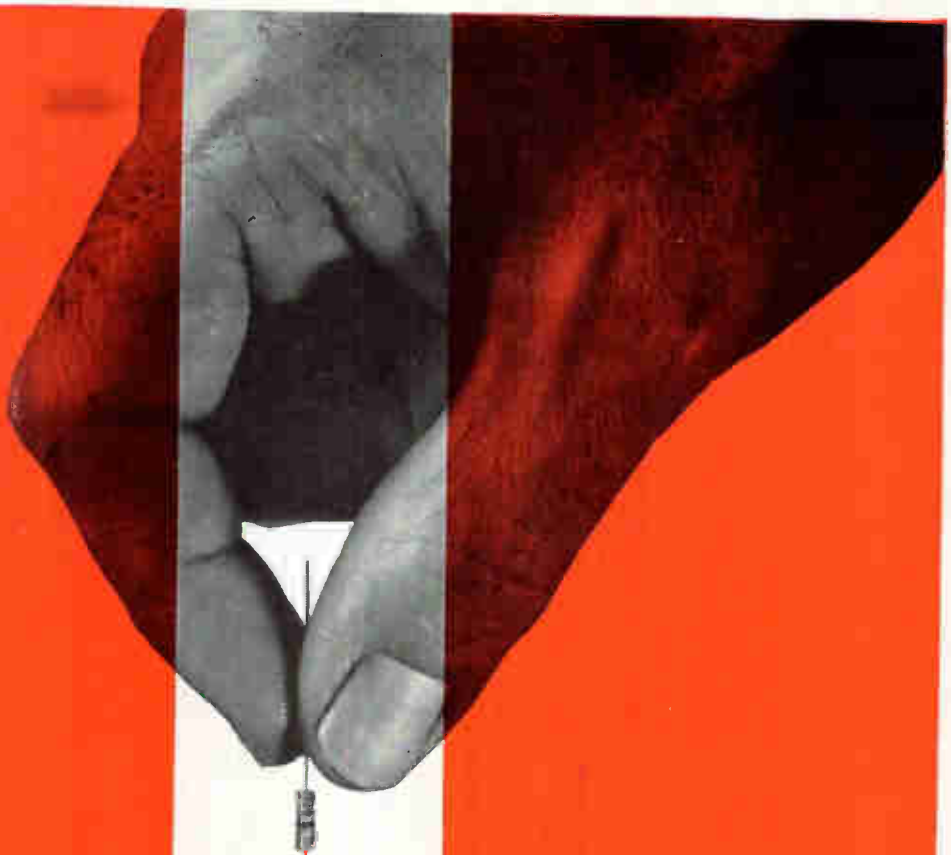


PARABOLITE makes possible a sharp close-up of bubble configuration at the fusion point of this tunnel diode (50 magnifications).

JONES & LAMSON MACHINE COMPANY

539 Clinton Street, Springfield, Vermont

Turret Lathes • Automatic Lathes • Tape Controlled Machines • Thread & Form Grinders • Optical Comparators • Thread Tools



ALL-GLASS SUB MINIATURE RF DIODES

FM discriminator circuits
VHF/UHF general purpose
Low-noise balanced mixers through X-band
RF Harmonic Generation
AM clipping in IF amplifiers
RF Power Monitoring (pulsed & CW)
RF Sweep Circuits
RF Cavity Tuning (preselectors)
RF Leveling, Limiting & Switching
VHF/UHF Parametric Circuits
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A series of tiny, more adaptable, military-rugged diodes with axial wire leads designed for maximum convenience in all miniature strip-transmission-line or coaxial circuits.

All-glass sealing assures reliable hermetic seal, particularly when diodes are soldered into a circuit. All-glass packaging reduces shunt-capacitance for improved RF bandwidth at microwave frequencies.

A complete line of microwave diodes

Fixed-Base Cartridges | Reversible Polarity Cartridges | Special Purpose Diodes | Coaxial Diodes | "Pill" Varactors

Engineering Standards Data Sheets on all new Microwave Associates subminiature VARACTORS, MIXER DIODES, VIDEO DETECTORS, RF DISCRIMINATOR DIODES, and AM CLIPPER DIODES sent on request.

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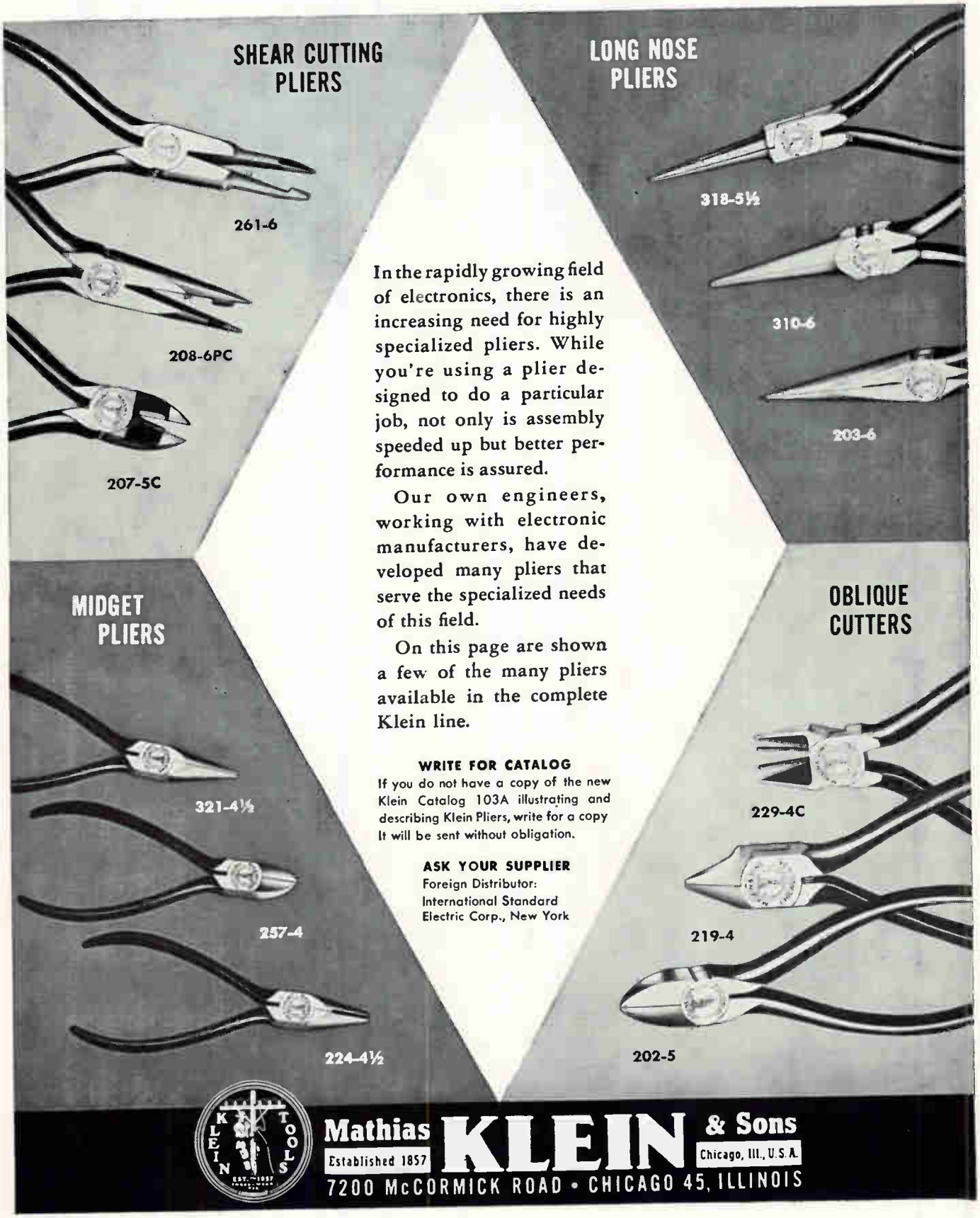
SPEEDING UP ASSEMBLY LINE WITH KLEIN ELECTRONIC PLIERS



In the rapidly growing field of electronics, there is an increasing need for highly specialized pliers. While you're using a plier designed to do a particular job, not only is assembly speeded up but better performance is assured.

Our own engineers, working with electronic manufacturers, have developed many pliers that serve the specialized needs of this field.

On this page are shown a few of the many pliers available in the complete Klein line.

WRITE FOR CATALOG

If you do not have a copy of the new Klein Catalog 103A illustrating and describing Klein Pliers, write for a copy It will be sent without obligation.

ASK YOUR SUPPLIER

Foreign Distributor:
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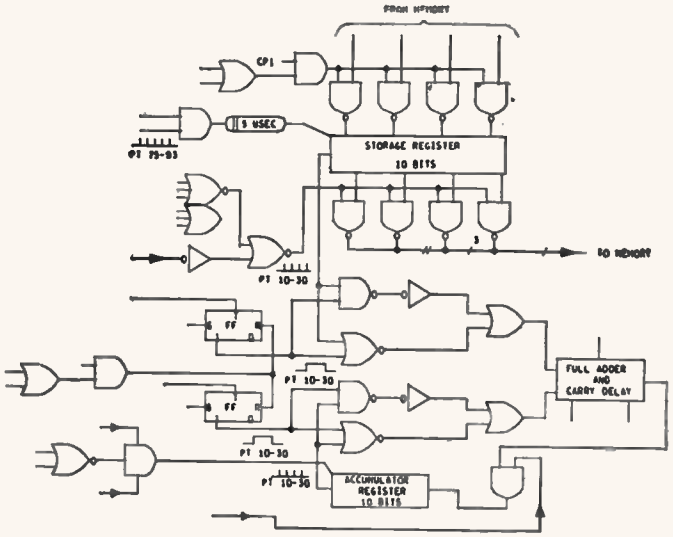
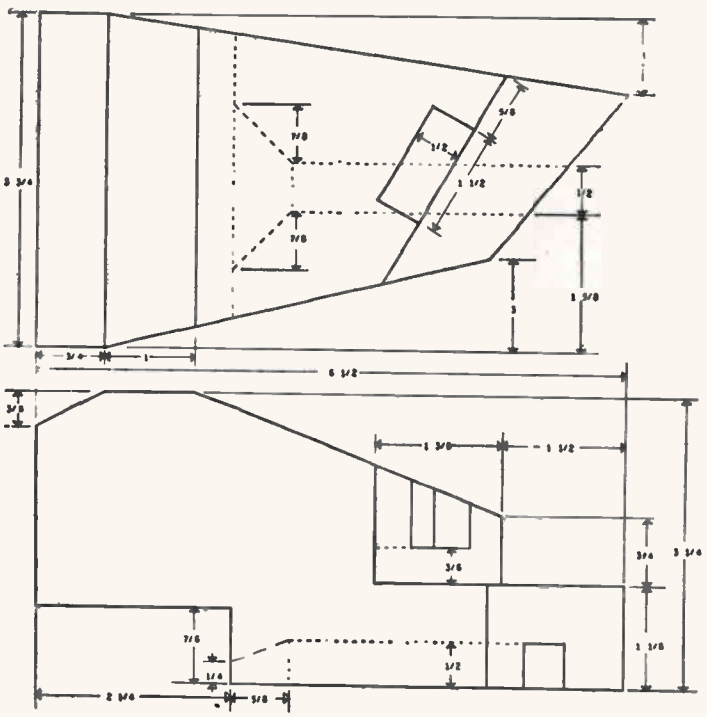
7200 McCORMICK ROAD • CHICAGO 45, ILLINOIS

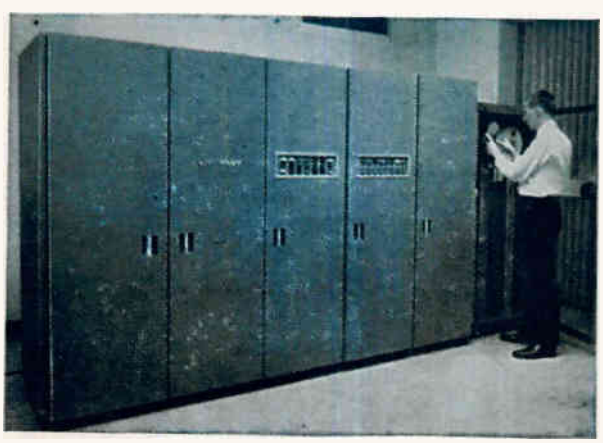
NOW!

Automatic drafting like this from your computer in less than 1 second!



Actual drawings produced by the S-C 4020 High-Speed Microfilm Recorder





The S-C 4020

Instantaneous mechanical drawing is now a reality, with the Stromberg-Carlson S-C 4020 High-Speed Microfilm Recorder. Automatic drafting can cut weeks from design time, saving invaluable engineering man-hours. Here's how it works:

A computer is programmed with the contours and specifications of the part to be designed, using APT (Automatically Programmed Tool) language. The computer operates the S-C 4020 Recorder which makes multi-view mechanical drawings of the part in a fraction of a second. After the drawings have been checked, output of the computer can be used to operate a numerical control tool and produce the part. Capabilities of the S-C 4020 include recording data on microfilm at 17,500 points per second, plotting graphs on microfilm at 12,500 points per second, recording complex logic circuit drawings, tabular printing and forms projection. Write for more details to Stromberg-Carlson-San Diego, Dept. B-21, P. O. Box 2449, San Diego 12, California.

STROMBERG-CARLSON-SAN DIEGO
A DIVISION OF **GENERAL DYNAMICS CORPORATION**

Entirely New Diode Concept...Combinations

LAMIN

SILICON DI

Pacific Semiconductors, Inc. announces a new approach to the production of silicon diodes to provide performance characteristics never before possible.

The PSI Laminar process makes possible large scale production of diodes having these outstanding features:

Great Mechanical Stability
Ultra-Fast Recovery
Extremely Low Capacitance
Extremely Low Leakage
Extremely Low Stored Charge
High Rectification Efficiency
Double Hermetic Seal
200°C. Storage Temperature

HOW IS SUCH PERFORMANCE AND GREAT MECHANICAL STABILITY POSSIBLE?

Briefly, the PSI Laminar Diode with its many layers, permits extremely low series resistance coupled with a very small junction area to provide a structure yielding a combination of speed, conductance and capacitance never before obtainable.

The laminated silicon element is provided with a glass-like surface layer which passivates the silicon and gives the element complete moisture integrity. This thoroughly sealed element is then welded within the standard PSI package . . . *double hermetic sealing.*

The front contact of the PSI Laminar Diode is decisively imbedded in a gold lamination on the crystal giving the device complete and absolute protection against failure due to shock and vibration. *Front contact failure is positively eliminated!*

WHAT DIODE TYPES WILL BE AVAILABLE?

All diode types now being made from conventional mesa and planar processes. These include types ranging from high conductance core driver to ultra fast computer logic diodes.

PSI®

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TRW 12955 CHADRON AVENUE, HAWTHORNE, CALIFORNIA • A SUBSI

specs never before possible!

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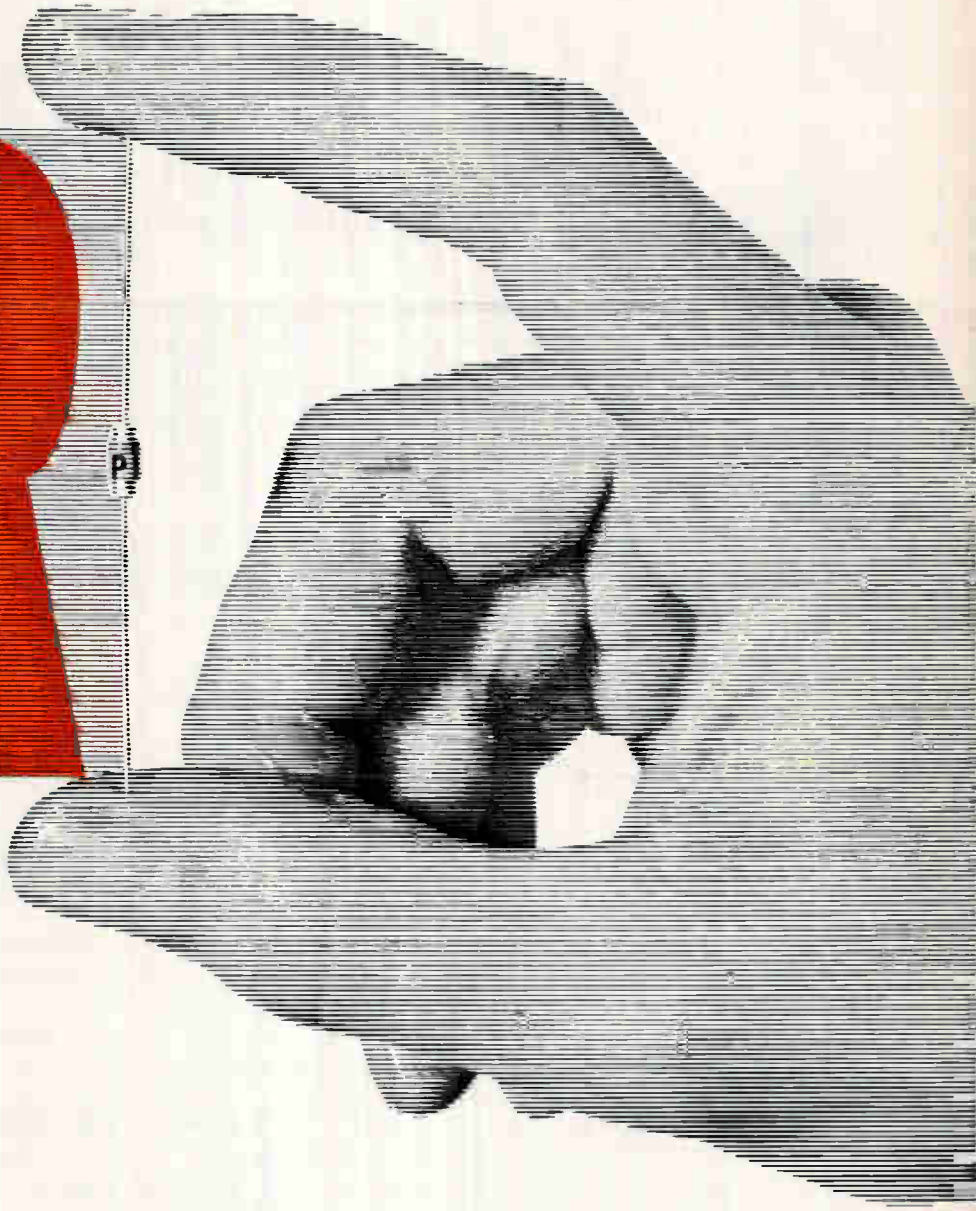

) D E S

LAMINAR type IN3257

Forward current @ 1 volt > 30mA
Saturation voltage > 100V @ 25°C
I-20V < .025μA @ 25°C; I-50V < 25μA @ 150°C
Reverse recovery < 3 nanosec
Capacitance @ zero volts < 2mmfd
Rectification efficiency 45% @ 100mc

AMINAR type IN3258

Forward current @ 1 volt > 100mA
Saturation voltage > 100V @ 25°C
I-20V < .025μA @ 25°C; I-50V < 25μA @ 150°C
Reverse recovery < 4 nanosec
Capacitance @ zero volts < 4mmfd
Rectification efficiency 40% @ 100mc
(Recovery test conditions switching from 10 mA forward to −6V, Recovery to 1 mA, Lumatron recovery tester.)

LAMINAR high conductance core driver types also available.

The new PSI Laminar diodes will make possible many new approaches to high performance, high reliability circuit design. For full details phone, wire or write a PSI field office near you.

uctors, Inc.

OF THOMPSON RAMO WOOLDRIDGE INC.

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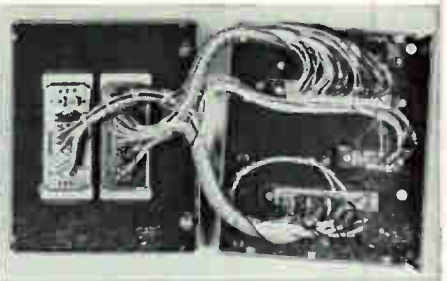

BEFORE — A Costly, Time-Consuming Assembly Problem Using Conventional Wiring

AFTER — Wiring Errors Eliminated; Weight, Cost and Time Saved Using Flexprint Wiring

50% reduction in wiring costs of this electrical assembly

Originally, 82 color-coded wires were involved in the manufacture of airborne junction boxes by John Oster Company, Chicago.

A switch to Sanders Flexprint wiring — flat, flexible printed circuitry — replaced the 82 wires with 5 Flexprint cables and reduced total installed costs of the finished component by 50%. Here's how this money-saving switch was accomplished:

BEFORE FLEXPRINT WIRING, assembly of junction boxes for an airborne electrical system required a costly sequence of assembly line operations: each box called for the selection of 82 color-coded wires . . . cutting them to various lengths . . . lacing and cabling . . . identification and positioning . . . then soldering into tight corners. Opportunities for human error and mounting costs were inherent in the job, as in most electrical assembly work. With conventional wiring one more trouble source occasionally cropped up — closing the junction box created strains on the folded harnesses, and was apt to cause broken connections.

WITH SANDERS FLEXPRINT WIRING, five flat, flexible cables and 4 shields replaced the bulky harnesses (shown). Complete flexibility lessens — virtually eliminates — the likelihood of broken connections when the junction box is once assembled and closed.

WHAT CAN FLEXPRINT WIRING DO FOR YOU? It costs nothing to find out. Just send dimensional drawings, sketches or artwork of your current wired assembles with the following information:

1. Electrical specifications
2. Termination requirements
3. Environmental conditions
4. Approximate quantity

We'll send you a proposal specifying estimated costs and delivery date. Or, if you'd prefer, we'll send you a new brochure describing Flexprint wiring in detail.

FLEXPRINT®

PRODUCTS DIVISION
SANDERS ASSOCIATES, INC.
NASHUA, NEW HAMPSHIRE
Inglewood, California **Washington, D. C.**

® Trademark Sanders Associates, Inc.; Patents pending in U.S. and abroad.

"Visit us at Booth #1723 IRE Show"

Five Flexprint cables and 4 copper shields cut 50% of material-labor costs. Each cable is an accurate printed circuit, clearly numbered for easy, progressive assembly. Conductors of Flexprint wiring are totally encapsulated within the insulation except at termination. Terminations are exposed copper pads, pierced to fit pin connectors. The four unitized shields fold between the cables and maintain constant coupling effects.

Assembly gets off to a fast start! One-piece Flexprint cables are self-positioning. They locate conductors and terminations with flawless accuracy. Each pierced termination pad automatically fits itself over its own connector pin. Wiring errors are almost impossible! And soldering becomes a high-speed operation because each connection is *completely* visible, not hidden in the connector or lost in a tangle of wires. Assemblers can see at a glance that each connection is tight and right.

TAKEN FROM TOMORROW

BIPCO™ Modules — Built-In-Place Components In Modular Form . . .

The Burroughs Corporation announces the commercial availability of tomorrow's techniques . . . today. BIPCO modules combine the reality of performance, low cost and immediate availability, to signal a major transition in the state of the art.

Thin Film Memory Planes and Solid State Multi-element Modules are the first of the BIPCO module family. The Thin Film Memory is capable of storing 20 words of 8 bits each for a total of 160 bits of information, and has a cycle time of 0.2 microsecond. The Solid State Module is a binary coded decimal to decimal diode converter which utilizes 40 diodes in matrix logic.

Burroughs Corporation's breakthrough in Built-in-Place Components is made possible by the unique combination of two major new techniques. First, multi-element components are simultaneously fabricated within a single device. Second, these elements are placed in a predetermined pattern in such a manner as to facilitate complex internal connections.

This combination of techniques has resulted in BIPCO Modular Devices with simple inputs and outputs which perform functions normally requiring myriads of elements and connectors.

Write for BIPCO Module Technical Brochure.

See Them at Booths 1211-1213-1215, *IRE Show*

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ANOTHER ELECTRONIC CONTRIBUTION BY

Burroughs Corporation

ELECTRONIC TUBE DIVISION

Plainfield, New Jersey

FROM PHILCO

NEW HIGH-SPEED SWITCHING TRANSISTOR IN TO-18 CASE...

MASS PRODUCED with ABSOLUTE UNIFORMITY to the TIGHTEST SPECS IN THE INDUSTRY

Actual Size

This new Philco Germanium MADT is specifically designed for high-speed switching applications and is the ideal NOR logic transistor. The MADT Precision-Etch* process makes it possible to manufacture the 2N779 with the tightest control of parameters of any transistor in the entire industry. This extreme uniformity greatly simplifies the design of high performance, low cost switching circuits. For complete data and information, write Dept. E31761.

*Trademark Philco Corp.

MADT® 2N779

ABSOLUTE MAXIMUM RATINGS

Storage Temperature	−65°C to +100°C
Collector Voltage, V_{CES}	−15 volts
Total Device Dissipation at 25°C	60 mw

ELECTRICAL CHARACTERISTICS (T=25°C)

	Min.	Typ.	Max.	
Static Characteristics				
Collector Cutoff Current, I_{CBO} (V_{CB} = −5v)		1.0	3	μa
DC Current Amplification Factor, h_{FE} (V_{CE} = −0.5v, I_C = −10 ma)	50	90	200	
Base Voltage, V_{BE} (I_C = −10 ma, I_B = −0.5 ma)	0.29	0.33	0.36	volt
Collector Saturation Voltage, V_{CE} (SAT) (I_C = −10 ma, I_B = −0.5 ma)	.09	0.12	0.16	volt
High Frequency Characteristics				
Output Capacitance, C_{ob} (V_{CB} = −3v, I_E = 0, f = 4 mc)		1.9	2.5	μμf
Input Capacitance, C_{ib} (V_{EB} = −1v, I_C = 0, f = 4 mc)		6.0	10	μμf
Gain Bandwidth Product, f_T (V_{CE} = −5v, I_E = 7 ma)	320	450		mc
Switching Characteristics				
Rise Time, t_r (β_C = 10)		13	18	mμsec
Hole Storage Factor, K'_s		39	50	mμsec
Fall Time, t_f (β_{CO} = 10)		10	18	mμsec

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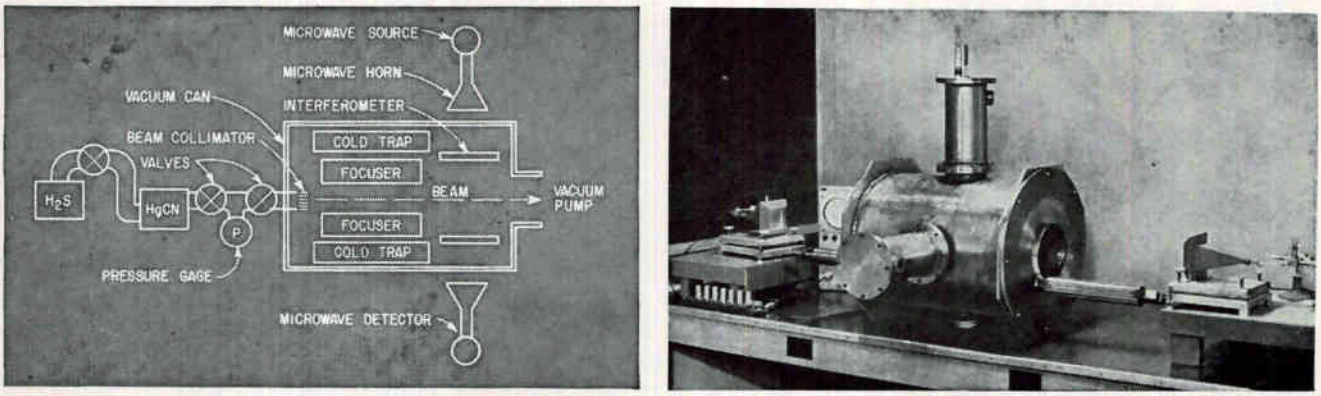

FIG. 1—Diagram and photo of HCN maser and attendant microwave equipment

Beam Maser for 3 Millimeters Uses Hydrogen Cyanide

HCN maser at 88 Gc has possible applications as power source, amplifier, and frequency standard

By FRANK S. BARNES, DALE MALEY, Electrical Engineering Dept., University of Colorado, Boulder, Colorado

THE BEAM MASER shows promise for a number of specialized applications, such as a source of small amounts of power at very high frequency, a narrow-band low-noise amplifier at specific fixed frequencies, and a precise frequency standard.

At present, its most important use is as a frequency standard. A Swiss group[1] has developed a maser frequency standard, using ammonia at 23 Gc, that is accurate to about 3 parts in 10^{11}. Another maser was recently developed, using a beam of hydrogen atoms, that shows promise of becoming an even more precise frequency standard at 1,400 Mc.[2]

Interest in a hydrogen cyanide maser at 3 millimeters or 88 Gc is several-fold, but two points of interest predominate. First, it is desired to check theoretical calculations on the usefulness of a microwave Fabry-Perot interferometer and on the focusing efficiency of linear molecules. If these calculations are verified experimentally, then it will be possible to evaluate with confidence the usefulness of a number of other molecular transitions for use in the frequency region around a tenth of a millimeter, where at present there are neither amplifiers nor signal sources.

Secondly, there is some possibility that the HCN maser may prove to be an interesting frequency standard.

The beam maser is a simple device for converting the internal thermal energy of a molecule into electromagnetic energy. The word maser is an acronym coined by Townes and his associates[3] for "molecular amplification by the stimulated emission of radiation." Thus, it is a quantum mechanical amplifier in which neutral molecules are used to generate microwave energy.

Figure 1 shows the four major parts of a beam maser in schematic form together with a photograph of the partially assembled maser. The source includes a reservoir for the HCN, a fine needle valve to control the gas flow, and a collimator grid to form the beam.

The collimator grid is made up of a large number of thin-walled tubes. The diameter of these tubes is small compared to the mean free path of the gas molecules so that the molecules tend to enter the vacuum chamber in a well-collimated beam.

In addition to kinetic energy, each HCN molecule may contain energy in the form of rotation about an axis perpendicular to its atomic axis (Figs. 2A and 2B). This energy is expressible in terms of an angular momentum vector J which, according to quantum theory, can only take on values that are integral multiples of $h/2\pi$, where h is Planck's constant. The number of molecules in each of these energy states is proportional to $\exp(-W/KT)$, where W is the molecular energy, K is Boltzmann's constant, and T is the absolute temperature. Thus, the number of molecules in a given energy state goes down as the energy level increases. For the maser at 3 mm, the interest is in the lowest rotational energies for which $J = 0$ and $J = 1$.

The focuser consists of a series

of alternately biased plates arranged radially about the beam axis (Fig. 2C).

These plates create a large inhomogeneous electric field whose magnitude is approximately given by $|E| = kr^{(n/2-1)}$, where n is the number of poles and k is a constant. In the classical approximation, each HCN molecule may be thought of as having an induced electric dipole moment. The potential energy of the molecule is a function of its average orientation in the electric field. For simplicity, consideration will be given to only the two energy states, which are represented by dipoles oriented parallel and anti-parallel to the electric field. In this inhomogeneous electric field, the force on the high-energy molecules with their average dipole moments oriented against the electric field is toward the beam axis, and the force on the low-energy moleclues is away from the beam axis.

Consider how these induced dipole moments affect molecules in the $J = 0$ and the $J = 1$ rotational energy levels. The average dipole moment for the $J = 0$ energy level is always aligned with the electric field and this is specified by setting the orientation quantum number M equal to zero. In the radial field of the focuser, the force on these molecules pushes them out between the focusing rods where they are captured on the liquid nitrogen cold trap. The molecules in the $J = 1$ energy level may have their average dipole moment oriented either with or against the electric field with equal probability.[4] Thus, approximately half the molecules in the $J = 1$ energy level with an orientation quantum number $M = 0$ are focused toward the beam axis and appear at the output of the focusing structure.

The third important component of a maser system is the resonant structure. At frequencies below 30 Gc this is usually a long cylindrical cavity that is resonant in the TM_{010} mode. However, in going to higher frequencies, the radius of such a cavity becomes so small that it is difficult to put a beam through it. Also, the Q of the cavity varies inversely as the square root of the frequency. Thus, search is required for a structure with dimensions that are large compared to a wave length. Although a large cavity that is resonant in a high-order mode might work, a much more promising structure is a microwave Fabry-Perot interferometer of the type developed by W. Culshaw at the National Bureau of Standards.[5] To a first approximation this device has properties of a cavity with dimensions large compared to a wavelength. However, only TEM modes will propagate, and it is relatively easy to excite only a single resonant mode. A more complete description of the interferometer system is given later in this article.

If an HCN molecule makes a transition from one rotational energy to another, it may either radiate or absorb energy, depending on whether it is going from a state of higher to lower potential energy or the reverse. Thus, a molecule going from the $J = 1$ to the $J = 0$ rotational energy level radiates a quantum of energy ΔE at a frequency given by $f = \Delta E/h$ or 88 Gc. A radiative transition may be either spontaneous or induced by an external electromagnetic field.

The spontaneous emission occurs with random phase and orientation, and it is the limiting source of noise in a maser amplifier. At 88 Gc, this noise source corresponds to a thermal noise source with an effective temperature of 28 K. For oscillators, the spontaneous transition probability can be made sufficiently small compared to the induced emission probability to be neglected.

Probabilities for absorption and induced emission are equal and proportional to the power density in the vicinity of the molecule. Thus, the net interaction with an applied electromagnetic field is determined by the difference between the numbers of molecules in the upper and lower energy states. In the classical approximation, the electromagnetic field may be thought of as applying a force that tends to change the speed of the molecular rotation. If the frequency of the electromagnetic waves corresponds to the exact energy difference between two allowed molecular energy levels through the equation $\Delta E = hf$, then the applied force does not average to zero and it is possible to induce transitions. If the transition is from a high to a low energy level, it is accompanied by the addition of a quantum of energy, hf, to the exciting electromagnetic field.

A molecular beam with an excess of molecules in the high-energy-state can be treated as a high-Q parallel-tuned circuit in which the resistor has a negative sign (Fig. 2D).

The condition for maser oscilla-

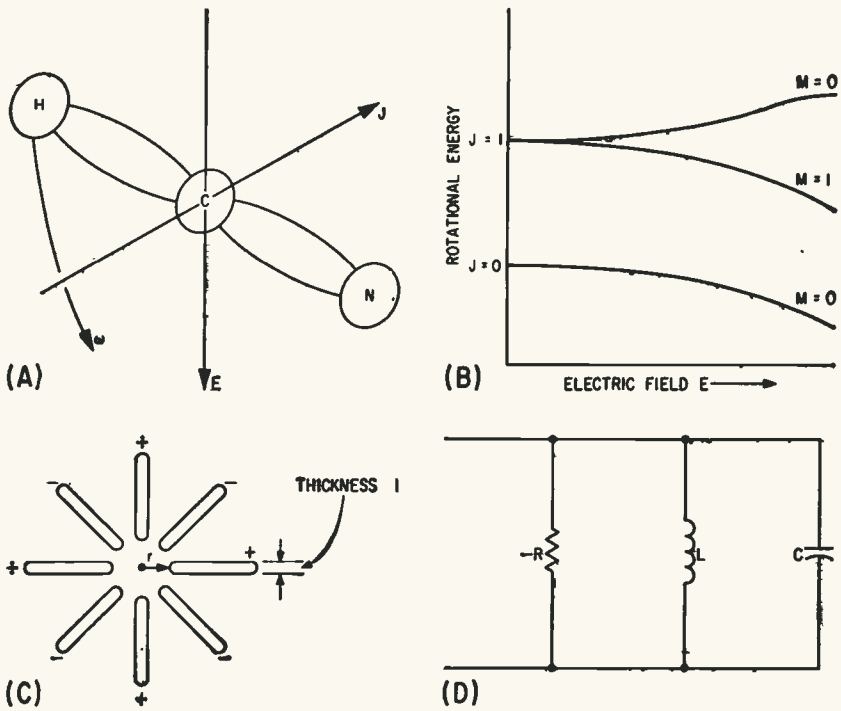

FIG. 2—Classical model of HCN molecule (A); variation of rotational energy as a function of electrical field (B); schematic of focuser (C); and equivalent circuit for maser beam (D)

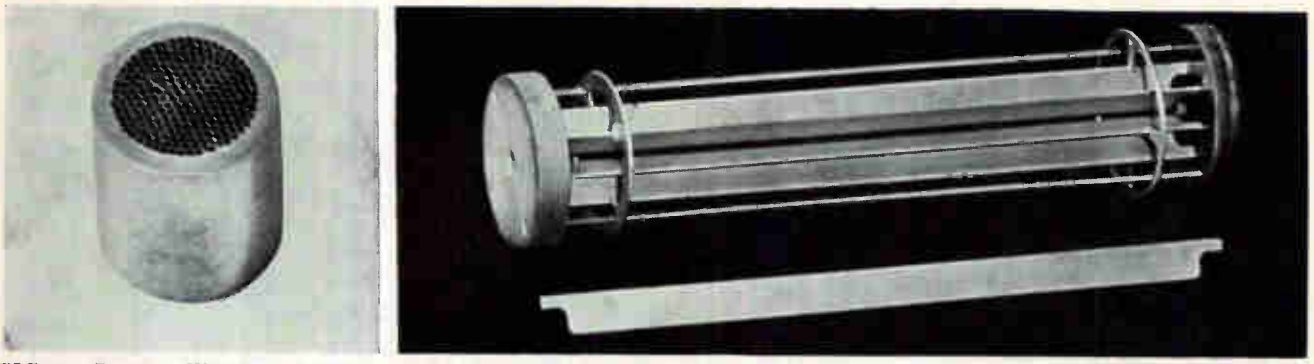

FIG. 3—Beam collimator structure (left) and beam focuser (right)

tion is that the power emitted by the beam must be equal to the power absorbed by the resonant cavity for coupling to the output system. This condition is expressed by the equation: $PNhf = \epsilon_o E^2 V\pi f/Q$, where N equals the difference between the number of molecules in the upper and lower energy states flowing through the cavity per second, h is Planck's constant, f is the transition frequency, P is the transition probability, ϵ_o is the dielectric constant for free space, V is the volume enclosed by the resonant structure, E is the average electric field strength, and Q is the loaded Q of the cavity. A first approximation for the transition probability is given from perturbation theory by

$$P = \pi \frac{|\mu_{ij}|^2 E^2 T^2}{2h}$$

where $|\mu_{ij}|$ is the matrix element for the transition and T is the flight time of a molecule through the resonant structure.

Combining these equations gives the following expression for the minimum number of high-energy molecules that must flow through the resonant structure to obtain oscillation: $N = \epsilon_o h V/(\pi |\mu_{ij}|^2 Q T^2)$ The high Q and the large T lead to the choice of the Fabry-Perot interferometer as a resonant structure.

The fourth important component of a maser system is the vacuum pump system. To maintain a well-collimated beam, the mean free path of the molecules must be large compared to the dimensions of the vacuum chamber. For HCN, this requires a background gas pressure of 5×10^{-6} mm of Hg or less. Under typical operating conditions the maser beam supplies 10^{17} molecules per sec to the vacuum chamber. To pump this flow of gas requires a pumping system whose capacity approaches 10^4 liters per sec. The most economical way of obtaining this high pumping speed for intermittent operation is with liquid nitrogen cold traps. If cold traps are used as the principal vacuum pump, then only a small diffusion or ion pump is required to remove the noncondensable gases.

Hydrogen cyanide is unfortunately a deadly gas, and concentrations in excess of a hundred parts per million are fatal in a few minutes. To minimize the hazard to the project personnel, a number of precautions were taken. First, the gas-handling portion of the apparatus will be operated under a hood in a well-ventilated room. The exhausts from the hood and the vacuum pumps are into a closed water trap that should dissolve the gas and dilute its concentration to negligible proportions.

A second precaution is the use of a hydrogen sulfide and mercuric cyanide generating system that enables the quantity of HCN existing at any given time to be kept to an absolute minimum. The flow of the gas from the generator is controlled by a fine needle valve and monitored with a mercury Dubrovin vacuum gage, that reads pressures in the region 0.5 to 25 mm of Hg beam formation. If the gas is allowed to flow into the vacuum system through a fine pinhole, its angular distribution is described by a cosine law and the intensity of the beam varies inversely as the square of the distance from the pinhole. As the electric field of the focuser can exert only a small force on the molecules, it is desirable to obtain a beam with better collimation. One way of doing this is by letting the molecules flow through a long tube with all its dimensions small compared to a mean free path. Here it can be shown that most of the molecules are confined to an angle with the beam axis less than $\theta_c = \tan^{-1} d/l$ where d is the diameter of the tube and l is the length. Varian Associates have devised a method for obtaining a large number of such channels in a small cross section. They take aluminum wire about 10 mils in diameter and plate it with about one mil of copper. These strands of wire are laid parallel to each other and compressed until the copper flows together to form a honeycomb structure. After additional copper plating for structural strength, sections may be cut in the desired length and the aluminum etched out. This process yields a fine grid structure that is about 80 percent transparent. The grid in Fig. 3 (left) is expected to yield a beam with an angular width of less than 15 deg.

The focuser shown in Fig. 3 (right) represents an attempt to optimize the focusing efficiency and the ease of construction. An optimum focuser for the $J = 1 \rightarrow 0$ transition in HCN would have the following properties: (1) a variation in the magnitude of a radially symmetric electric field from zero to a maximum value in excess of 150 Kv per cm; (2) the lowest possible applied voltage for the above maximum field strength; and (3) the maximum transparency for defocused low energy molecules. One solution to this problem is an n-pole focuser. The magnitude of the electric field for a focuser of this type varies as $r^{(n/2-1)}$ if the pole pieces are portions of a hyperbolic surface. This field, which is easily

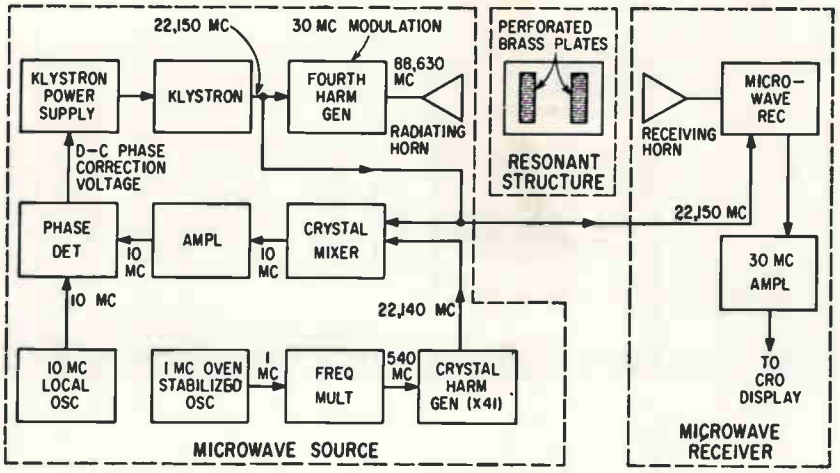

FIG. 4—Block diagram of Fabry-Perot interferometer and associated microwave equipment

described analytically, is used to approximate the field generated by parallel plate pole pieces that have cylindrically shaped edges. The principal design problem is the choice of the ratio of the plate thickness to the radius r from the beam axis to the inside edge of the plate. If this ratio is small, the magnitude of the field midway between the pole pieces is small compared to that at the surface of the pole pieces. If the ratio is large, the transparency is poor and the field between the pole pieces is larger than at the inside surface. A reasonable design compromise for an eight-pole focuser is a ratio of $\frac{1}{4}$, which gives a transparency of approximately 60 percent, and a reduction of the maximum field strength midway between the pole pieces to about seven-tenths.

A diagram of the three-millimeter wave interferometer and supporting equipment is shown in Fig. 4. The equipment consists of three subsystems: (1) a phase-locked microwave source and a radiating horn; (2) receiving horn and microwave superheterodyne receiver; and (3) resonant structure, consisting of two parallel perforated flat brass plates.

During test and alignment, energy is transmitted from the source to the horn and radiated in a narrow beam. The perforated parallel plates are placed normal to the beam. Some of the incident energy is coupled through the perforations or irises into the region between the plates, where it may be reflected many times before being absorbed or coupled out to the receiving horn. An appreciable amount of energy is transmitted through the structure only when the structure is tuned to resonance; that is, when the tangential component of the electric field is zero at each plate surface. This occurs only when the plates are an integral number of half-wavelengths apart. To allow for tuning of the structure through the vacuum wall, each plate may be moved independently in the direction of the beam with a push rod. The alignment of the plates parallel to each other is accomplished by adjusting three micrometer screws holding each plate. Alignment and flatness of the plates must be such that any deviation in distance between them is a small fraction of a wavelength.

After alignment and tuning of the resonant structure, the microwave source is turned off and the HCN beam is allowed to enter the region between the plates. If the resonant structure is tuned to the transition frequency of the HCN, an appreciable fraction of the radiated energy is coupled to the receiving horn.

The microwave source, shown in Fig. 4, provides an energy source with which to tune the resonant structure to the natural frequency of the HCN transition. The source consists of a phase-locked 2K33 K-band klystron oscillator capable of delivering 40 to 60 milliwatts at 22,150 Mc, a cross-guide fourth-harmonic generator producing about 10 microwatts at 88,600 Mc, an a pyramidal radiating horn that produces a beam of less than 3 deg. A 30-Mc modulation voltage on the harmonic generator crystal produces, among others, a frequency 30 Mc in excess of the fourth harmonic of the klystron. This frequency, 88,630 Mc, is the maser frequency, and when the interferometer is tuned to the HCN transition, it will be the only frequency to reach the receiver.

The microwave source must satisfy three requirements: (1) adequate frequency stability; (2) adequate power output; and (3) collimation of the energy into a narrow beam.

The Q of the resonant structure is expected to be about 50,000 to 100,000, and thus to see the interferometer resonance a source is needed that is stable to better than one part in 10^5. To make measurements on maser amplification, the work will be over a region of only a few kilocycles, and thus there should be a short-time stability of better than one part in 10^8. One method of achieving this is by phase-locking the klystron oscillator to a 1-Mc quartz crystal oscillator. Using r-f techniques, the 1-Mc signal is frequency multiplied in a multiplier chain to 540 Mc, where about 1 watt is fed to a crystal mounted in a K-band waveguide. The 41st harmonic, or 22,140 Mc, is generated and propagated in the guide. This 22,140 Mc is mixed with a small portion of the klystron output at about 22,150 Mc, and a difference frequency of approximately 10 Mc is generated. After amplification, the difference frequency is compared in a phase detector with a 10-Mc signal from a local oscillator. Any variation from 10 Mc in the difference frequency is represented by a d-c voltage from the phase detector; this d-c voltage is impressed on the repeller of the klystron to adjust the frequency more nearly to 22,150 Mc.

The fourth harmonic generator will deliver somewhere around 10 microwatts of fourth harmonic, which is 88,600 Mc. The 30-Mc modulation on the harmonic generator should then yield in excess of one microwatt of power at the maser frequency of 88,630 Mc. Assuming about 20 db loss through the resonant structure, about 10^{-8} watts of power will be available for detection at the receiver.

The transmission of energy through the plates of the resonant structure is highly dependent upon the angle of incidence of the energy. Normal incidence yields maximum transmission. Then, as angle of incidence varies from 90 deg, a series of minima and maxima occur in transmission percentage, none of the maxima being as large as at normal incidence. Thus, if a large portion of the microwave energy from the source is to be used for tuning the structure, this energy must be presented in a narrow beam. Consequently, a pyramidal horn was built with dimensions flaring from the RG-99/U waveguide to an aperture 3.25 inches square. A solid dielectric (polystyrene) lens was also built to form a plane phase front at the aperture of the horn.[6] Diffraction theory for an aperture of this size (about 25 wavelengths in transverse dimension) with a plane phase front and a TE_{10} mode gives a beam-width in the vertical plane of about 2 deg, and about 2.8 deg in the horizontal plane. Beam-width here is defined as the angle between half-power points in the beam, and the vertical and horizontal planes are those two planes containing the axis of the beam.

The receiver consists of a lens-corrected horn that is identical to the radiating horn, plus a harmonic mixer and an i-f amplifier as shown in Fig. 4. This receiver must detect power levels of 10^{-8} watts during alignment and tuning, and 10^{-11} watts during maser operation.

Local oscillator power for the receiver is obtained from the klystron in the source, at 22,150 Mc. The incoming signal from the resonance structure is at the maser frequency, 88,630 Mc. In the harmonic mixer, the fourth harmonic of the local oscillator, or 88,600 Mc, and the incoming signal mix to produce a signal at the difference frequency of 30 Mc. This 30-Mc signal is then amplified and displayed to assist in tuning the structure or to measure the power generated by the maser.

The resonant structure consists of the perforated parallel plates, each mounted on a cart that slides on a track in the direction of the microwave beam (Fig. 5).

The requirements of the resonant structure are a high Q and large transverse dimensions. The following characteristics of the plates affect the Q: surface reflectivity, flatness, adequate transverse dimensions and plate alignment.[5, 7]

Reflectivity of the plates, defined as the ratio of reflected power to incident power, has been investigated by Culshaw.[7] He has developed criteria for determining, at a given frequency, optimum values of plate thickness, iris diameter, and iris spacing for optimizing reflectivity. These criteria, coupled with practical considerations concerning machinability, indicate a satisfactory set of dimensions at 88 Gc to be a plate thickness of $\frac{1}{32}$ inch, an iris diameter of 0.0465 inch, and a center-to-center spacing of 0.1 inch.

To ensure flatness, the $\frac{1}{32}$-inch brass stock was first carefully chosen for uniform thickness. In drilling the perforations, the brass was placed between two flat one-inch aluminum pieces to minimize burrs. After the perforations were drilled, each plate was carefully finished with emery paper. Finally, the plates were annealed and then stretched, in a specially-made die set, much in the same manner as the stretching of a drumhead. The punch and die were forced together in a hydraulic press, then bolted together while still under compression to become a permanent frame for each plate. After the frame was bolted together, the holding ring was removed and the excess brass outside the frame cut off.

The diameter of the perforated plates is six inches, which is about 45 free-space wavelengths at 88 Gc. Judging from Culshaw's theoretical results with square plates[4], such a size seems to be large enough that diffraction problems will not be as limiting as other problems such as flatness and alignment.

In conclusion, the authors acknowledge the helpfulness of W. Culshaw and R. Mockler of the National Bureau of Standards, and the University Office of Research Services in facilitating this undertaking. This work has been jointly supported by the University of Colorado Council on Research and Creative Activity and the National Science Foundation.

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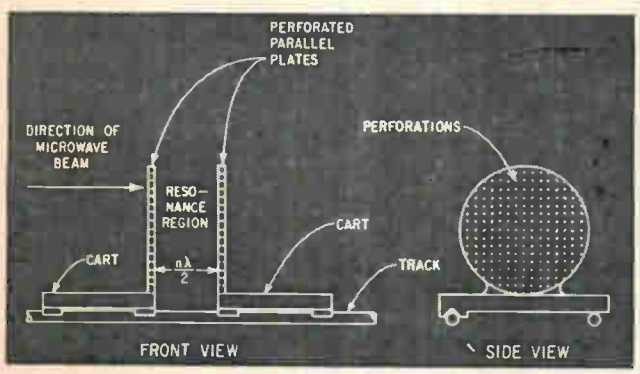

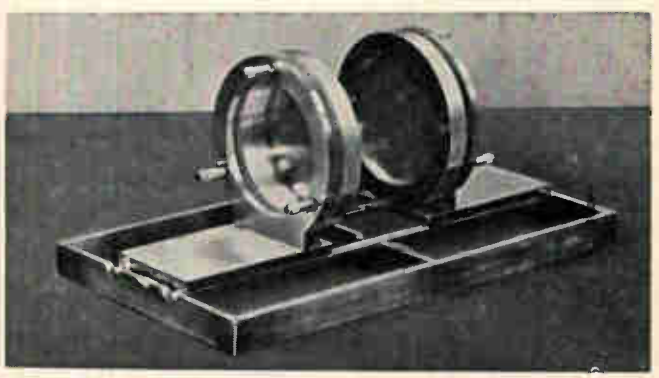

FIG. 5—Diagrams and photo show tunable resonant structure consisting of perforated plates mounted on tracks

Storing Complete Decimal Digits

Time of magnetization of ferrite cores is the basis of this computer storage technique

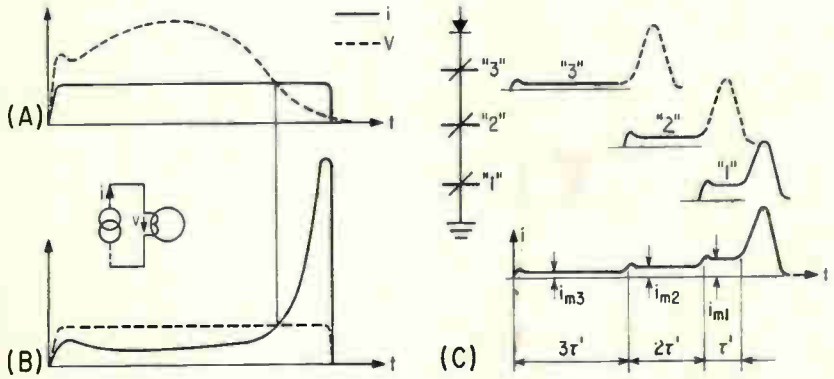

FIG. 1—Constant current pulse (A); constant voltage pulse (B); and magnetization of a stored 6 where τ' is the magnetization time per unit (C)

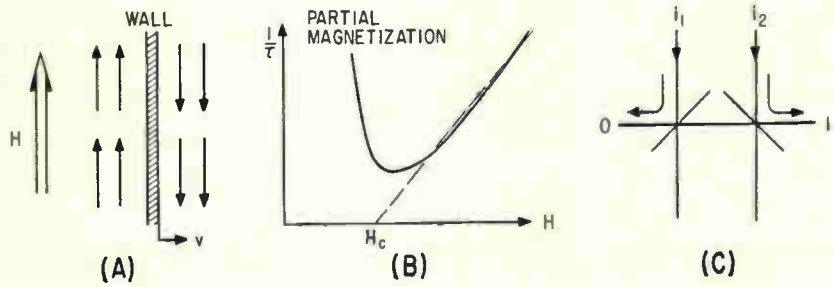

FIG. 2—Illustration of domain-wall displacement where H is magnetizing force and v is velocity of wall displacement (A); plot of magnetization speed (B) where H_c is coercive force, τ is magnetization time; and mirror symbols (C): i_1 is set to zero, i_2 stores a unit

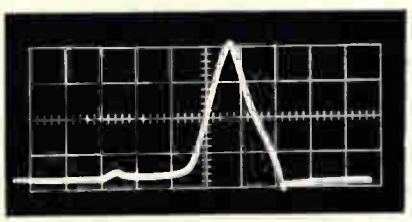

FIG. 3—Oscillogram of magnetization current—1 square is 200 ma, 1 μsecond

FERRITES with a rectangular hysteresis loop are now widely used to store digital information. Usually, they indicate whether they contain a storage unit (bit) or not. In this application, the magnetization time is the basis for a computer storage technique and corresponds directly to the stored digit. A combination of four cores can store any decimal digit. In the complete circuit, consisting of strings of such cores, whole decimal digits can be handled with one clock pulse only.

A ferrite with a square hysteresis loop has two possible states: completely positive (one) or completely negative (zero) saturation. Changes of state are referred to as magnetic switch-over. Saturation and remanence induction are about equal. A small coercive force is desirable as this means little magnetization losses.

If a constant current pulse is applied to a coil on a ferrite core (Fig. 1), a constant magnetic field *H* results, inducing a voltage pulse as shown in Fig. 1A (dotted line). Theoretically, the curve can be deduced from the hysteresis-loop.[2] Since there are two peaks, it is assumed that two different physical processes take place.

First peak: Initially, all elementary magnets occupy preferred

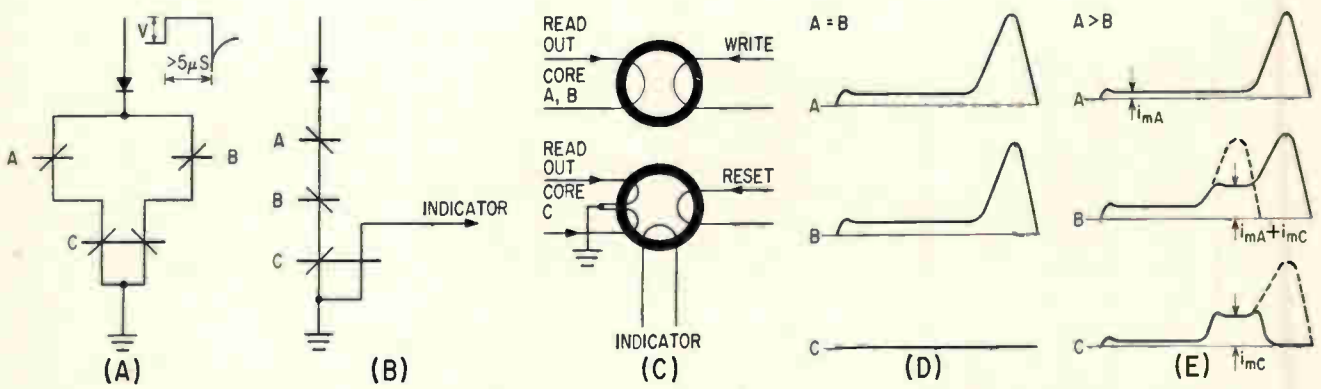

FIG. 4—Principle of counting: read out (A), and write (B), where core A is the unknown digit, B is the reference digit and C is the comparing ferrite; core wiring is shown in (C); (D) and (E) are flow graphs of read out

With One Clock Pulse

By ANDRE A. JAECKLIN, Swiss Federal Institute of Technology, Telecommunications Institute, Zurich, Switzerland

directions determined by crystal anisotropy.[2] Such elementary magnets can be represented by spring-models: the applied magnetizing force will cause rotation about the axis of each elementary magnet until equilibrium is established. The deviation is small, but it appears in the whole ferrite simultaneously and without delay. These rotations induce the initial voltage peak.

Second (main) peak: A material with a square hysteresis-loop consists mainly of crystals with antiparallel elementary magnets.[2] The magnetic domains are separated by 180-degree walls (Fig. 2A). Intermediate stages are possible but only in the wall itself.

This antiparallel magnetization is stable. As soon as a first domain changes its direction of magnetization, it influences the adjacent domain. This takes place at the boundaries of the first domain. The wall will be displaced and the reaction continues sequentially. Wall displacement can be considered as the process of magnetization. This theory of the magnetization process has been given support by studies of single-crystal ferrites.[3] Velocity of wall displacement varies from 30 to 700 meters per sec.

Magnetizing force is proportional to the magnitude of the current pulse. To assure complete magnetization, the coercive force H_c should be exceeded for a sufficiently long interval (magnetization time). Partial magnetization must be avoided. Magnetic storage in this method deals only with saturated cores.

Magnetization time decreases when the magnetic field is increased. Figure 2B shows a linear dependency, which can be explained by a viscous damping of wall movement.[1]

To distinguish the two different directions of magnetization, a mirror-symbol is introduced (Fig. 2C). A horizontal line characterizes the ferrite with its two states: ZERO to the left, ONE to the right. The transverse stroke symbolizes a mirror reflecting the incoming current pulse in the direction of its corresponding state.

The discussion thus far has dealt only with constant-current pulses—magnetization time is directly proportional to the magnitude of the current. What happens when a constant voltage pulse is applied to the ferrite core? Assuming an ideally square hysteresis loop, the coercive force H_c will be constantly maintained during the whole magnetization process. Equation (1) shows that during magnetization i_m remains constant as well.

$$H_c \sim i_m \cdot N \tag{1}$$

$$\phi \sim \int_{\text{neg saturation}}^{\text{pos saturation}} i_m \, dt = i_m \cdot \tau \tag{2}$$

$$\phi \sim H_c \cdot \frac{\tau}{N} \tag{3}$$

where H_c = coercive force, i_m = magnetizing current, ϕ = saturation flux of a core, τ = magnetizing time, and N = number of turns on the coil. From Eq. 1 follows that the magnetization current i_m is inversely proportional to the number of turns N on the coil.

For any given core, the saturation flux ϕ remains constant. It is given by the material and its dimensions. Eliminating i_m in Eq. 1 and 2 gives Eq. 3. Since ϕ and H_c are given constants, τ and N have a fixed ratio. This means that the magnetization time τ can be changed proportionately to the number of turns N on the coil. This fact is the basis for the storage method under discussion.

An ideally square hysteresis loop was assumed above; but what if the hysteresis loop is not ideal? The current diagram to be expected can be constructed approximately from the voltage curve induced by a constant current pulse (Fig. 1A). Supposing the momentary impedance of the ferrite coil to be the same for a current pulse as for a voltage pulse, Fig. 1B is deduced by inversion of Fig. 1A. Comparison with the oscillogram of Fig. 3 shows good agreement. The end of magnetization cannot accurately be fixed as the current peak has a finite slope (Fig. 1B).

A blocking oscillator (BO) is a good source for voltage pulses with a low internal resistance. Pulse duration must be greater than the total magnetization time of the maximum number of switched cores (which is less than 5 μs in this example). No other specifications for the pulse are needed.

During the pulse a magnetic field is built up in the transformer of the BO. At the end of the pulse the field induces a negative peak, the so-called backswing. A diode cuts off this unwanted peak (Fig. 4).

The BO of Fig. 5A works as an ideal voltage source up to a load of several 100 ma. It is only somewhat sensitive to load during the rise time. If too much current is drawn in the first moment, the regenerative process will be disturbed and the pulse decays again. This effect determines the minimal admissible impedance of the ferrite coil. It determines the minimal number of turns (5 in this example). As soon as a ferrite is completely magnetized, the current rises towards a high value. Automatically, the BO starts to cut off the current and protects itself against excessive load.

Delayed by the inductance of the load, the current rises after the voltage pulse has started. As soon as it induces the coercive force, the core begins to magnetize. During the whole magnetization time, the current i_m remains approximately constant (Fig. 3). This limiting value is called the threshold cur-

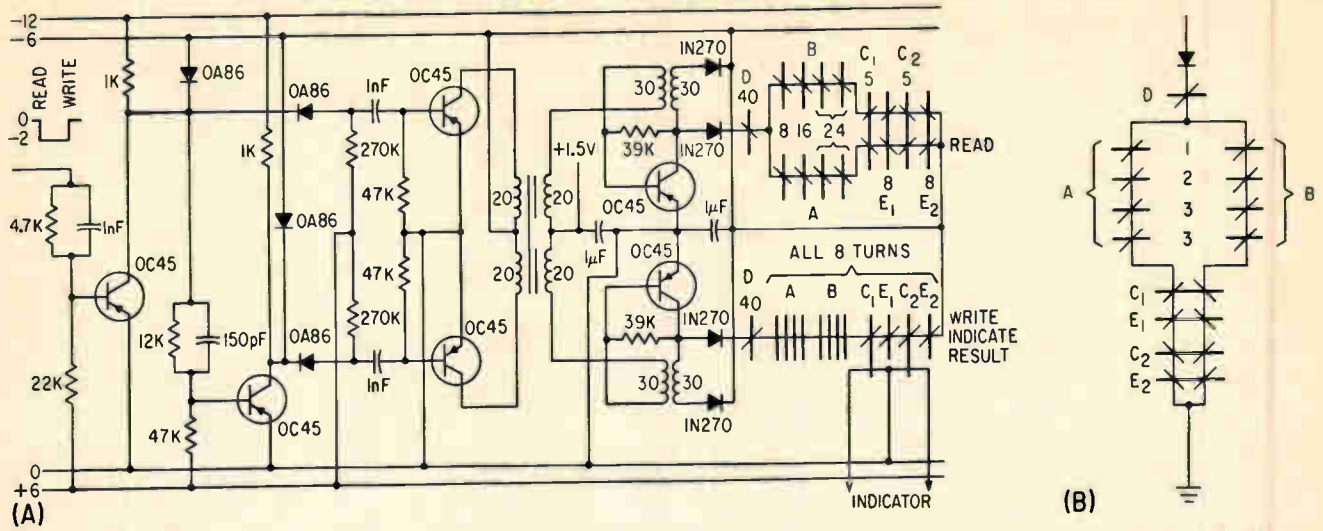

FIG. 5—Trigger circuit and magnetic register (A). Read out of a digit (B): where A is the unknown digit, B the reference digit, C_1 and C_2 the comparing ferrites, D the delaying core, and E_1 and E_2 the compensating cores (cores A, B and C are 1/6 inch diam., D and E are 1/12 inch diam.)

rent. A low threshold current i_m results from a high number of turns on the core.

Consider a number of cores with different windings connected in series (Fig. 4B). As soon as the current reaches its threshold value in one core, the whole voltage drop is across this core until magnetization has finished. Only then can the current increase until it has reached the threshold current of the next core. This process is illustrated in Fig. 1C for three different cores.

The core with the lowest threshold current i_m (which means the longest magnetization time) always magnetizes first. For any series connection of cores with different coils, the sequence of magnetization is fixed. Automatically, the core storing the highest number is selected first (automatic selection, Fig. 1C).

Note that a small initial peak is induced in all the cores together. This comes from the magnetic rotation as mentioned above. Similarly the increasing current at the end of the pulse gives a small additional magnetization for all cores (Fig. 1B). In the circuit of Fig. 5A, these disturbing effects do not influence the main process.

Magnetization time depends largely on the voltage of the pulse, but because the magnetization time is compared with that of another ferrite, the voltage dependence is eliminated. As indicated above, comparison of magnetization times is equivalent to the comparison of the stored digits.

Figure 4A shows such a method of comparison. Suppose both cores *A* and *B* are able to store any decimal digit. Core *A* contains the unknown while *B* represents a reference digit. Core *C* is initially in an indifferent magnetic state (no remanence). It has two equal windings which tend to magnetize *C* in opposite directions. Consequently only the difference of the currents through *A* and *B* is effective in *C*.

If the digits *A* and *B* are equal, there is no effect in *C* as the currents cancel at every moment (Fig. 4D). But if *A* is greater than *B* (Fig. 4E), magnetization of *B* is completed first. As soon as this point is reached, current in branch *B* increases until it is sufficient to magnetize *C*. Core *C* switches from the indifferent state to ONE. In a properly designed circuit, *C* is fully magnetized before *A* has reached complete magnetization. To ensure automatic selection, *C* requires the highest threshold current.

If *A* is smaller than *B*, the inverse process takes place. Core *C* will be switched to ZERO.

Every read out of a magnetic core is destructive. To restore the old or to store new information, a second step (write pulse) is needed. During the write pulse, the individual magnetization time is of little importance. Only the read out coil determines the numerical value of a given core. Consequently one standard coil can be used to reset the core or to write in information.

After comparing the cores *A* and *B* (Fig. 4A), one of the three possible results ($A > B$, $A = B$, $A < B$) is stored in *C*. The write pulse of Fig. 4B now resets *C* to its initial indifferent state. In the same time, a special winding (Fig. 4C) passes the result on to an indicator or to a logic circuit that decides about further operations.

In dealing with decimal digits and complete magnetic switch-over of the individual ferrites, *A* and *B* (Fig. 4) must be symbols for a group of magnetic cores. In a decimal code, strings of four cores are needed (Fig. 5B). The numerical value of a single ferrite should be kept as low as possible. Therefore choose the code 1-2-3-3. Figure 5B shows the read-out arrangement of these cores. Magnetization time per unit is $\tau' = 0.4$ μsec.

By a write pulse similar to that of Fig. 4B, string *A* and string *B* can be set to any decimal digit (see Fig. 6A).

Note that the comparing ferrite *C* of Fig. 4 measures the relative magnetization time of the strings *A* and *B*; *C* has initially an indifferent magnetic state. This supposition is impossible for a single

core (square hysteresis), but it can be accomplished by taking the average induction of two cores C_1 (initially = ZERO) and C_2 (initially = ONE) as in Fig. 5B.

For $A > B$, C_1 and with it the average induction will turn to ONE. If $A < B$, C_2 will turn to ZERO, which means average induction ZERO. The most important case is represented by $A = B$. None of the cores C_1, C_2 will change its magnetic sense. The average induction remains indifferent. Thus, the three possible results are well defined.

During its rise-time the blocking oscillator (BO) is sensitive to load. As automatic selection always causes the highest impedance to magnetize first, the initial load will usually not be critical for the BO. In case A or B should store a ZERO (Fig. 5B), counting core C must be dimensioned not to overload the BO. If both A and B represent ZERO's the blocking pulse will be completely disturbed although this will not affect the result in C.

A delaying core D helps to get rid of this initial effect. This core is connected in series with all the other cores and will be magnetized by every pulse. Its threshold currect is lower than that of ferrite 3. This means a long magnetization time, which is undesirable. By choosing a miniature core with a small cross section this delay can be reduced. Then the blocking oscillator cannot be overloaded. All the windings on the cores A, B, C can be reduced, as a large load is now permissible from the start. The effective rise time of the pulse is given by the delaying core independent of the stored digit.

Unfortunately, all ferrites show differences in the hysteresis loop, which leads to differences in the magnetization times. The higher the digital value of a ferrite, the greater the temporal deviation. That is why the code 1-2-3-3 gives the most reliable layout. Assume that A and B (Fig. 5B) store the same digit. The corresponding hysteresis loops differ somewhat. During read out a small current pulse on one of the counting cores C will result. A compensating core E can then absorb this pulse (Fig. 5A). Compensating core and counting core must have the same threshold current. The former is again a miniature ferrite which magnetizes much faster than the counting core. Most of the undesired pulse in C is absorbed by the compensating core. If A and B are not equal, one of the cores C (Fig. 5A) will be magnetized. A certain part of this magnetization pulse is absorbed by the corresponding compensating core E. Since E is a miniature ferrite and coil C is dimensioned correctly, this loss of magnetization pulse is insignificant. With a deviation of magnetization time up to 45 percent a unit (that is 15 percent for the value 3), an accurate recognition of a decimal digit could still be obtained.

Normally, the circuit needs neither delaying nor compensating cores, but they increase reliability.

In magnetization time storage, designed for application in computers, every decimal digit needs a string of four cores to be stored. String A is an arbitrary digit in the memory; A is compared with an appropriate string, B, of the accumulator.

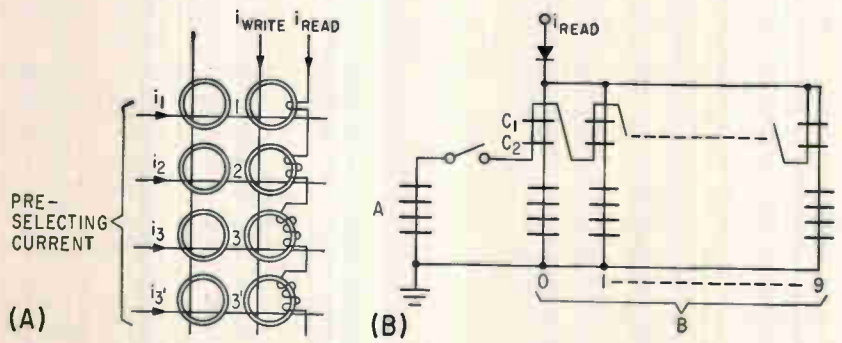

FIG. 6—String of four cores in a memory array (A); and illustration of network for read operation (B)

In writing, a logical network decides about the preselecting current (Fig. 6A) corresponding to the decimal digit to be stored. Each preselecting current amounts to half as much as the core needs to be switched. When a write pulse is applied to the whole string, the individual place of the decimal digit is chosen.

The accumulator of the computer contains ten strings B, where the numbers 0 to 9 are permanently stored (Fig. 6B). Assume that each string contains four cores to store the corresponding digit and two comparing cores C_1, C_2. (In practice the hardware can be appreciably reduced.) If a number A is to be read out, it is switched to the accumulator. A read pulse is applied to A and all the ten strings B simultaneously (Fig. 6B). In every string B, one of the cores C will be switched over. Only the C cores of the string that equals A give no output. Thus a decimal digit can be transferred from memory to accumulator in one clock pulse only.

A laboratory model using the method of magnetization time storage has been built with the following results: switching time per unit, 0.4 μsec; switching time per digit, 5 μsec; max deviation of hysteresis loop, 45 percent, core 1; 22 percent, core 2; and 15 percent, core 3.

The main feature of this method is the capability of handling a whole decimal digit with one clock pulse only. With modern ferrite material speeds of 2 μsec per pulse may be possible.

Some interesting points result from further development. If we admit a variable length of the voltage pulse, partial saturation of some cores may occur. This allows a completely new system of magnetic logic to be set up by the same technique. An adding circuit based on this method requires a minimal number of clock pulses. Computing speed more and more approaches the limits given by the material.

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How to

Phase detector for 15 Mc to 400 Mc. Upper cabinet contains balanced tuned amplifier, phase detector, and null indicator; lower cabinet contains coaxial variable delay line and four plug-in step delay lines for extending range of total delay

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PHASE MEASUREMENT is becoming increasingly important in many fields, especially in the development of automatic control devices, guidance and tracking systems and broadband communication circuits. A number of instruments for phase measurement has been developed.[1-11] They may be summarized in two groups according to their operating principles: squaring and averaging; and nulling and comparing with a precision phase shifter.

The block diagram of Fig. 1A explains the basic principle of the first group. Signals E_1 and E_2 are applied to limiter amplifiers LA_1 and LA_2 respectively. The outputs of both LA_1 and LA_2 are square waves whose zero-axis-intersecting points remain identical to those of the input sine-wave signal and whose amplitude always remains constant regardless of the variation of input signal level. Cathode-coupled limiters with negative feedback have been found suitable for LA_1 and LA_2.[1] The coincident generator produces a square pulse with duration equal to the time interval between the leading edge of the output square wave from LA_2 and the trailing edge of the output square wave from LA_1. The amplitude is also constant and not affected by the fluctuation of signal frequency or signal amplitude. Coincident slicers and multivibrators have been successfully used.[1, 2] The average value of the square pulse from the coincident generator is equal to the phase angle between the input sinewaves. Figure 1B shows the relationship of waveforms for this group of phase-measuring instruments. Sinewaves E_1 and E_2 are input signals, E_1' and E_2' are square waves at the output of LA_1 and LA_2 respectively. Current I_{bp} is the signal current of the coincident generator. Current I_{ba} is the average value of I_{bp}. Time T is the period of the signal frequency and t_1 is the time interval between zero-crossing points of E_1' and E_2'. From these waveforms, the phase angle can be given as: $\theta = 180° - (KI_{bp} \times t/T) = 180° - KI_{ba}$.

A direct-current meter can read phase angle directly in degrees between E_1 and E_2 when either E_1 or E_2 is shifted 180 deg. If 180-deg phase shift is not added, the meter will read phase angle from 180 deg to 360 deg between E_1 and E_2. If a multivibrator is used for the coincident generator, the output meter, which reads the average current of one tube of the multivibrator, can read the phase angle directly in degrees from 0 to 360 deg.

For signals up to 500 Kc, instruments based on this principle offer the advantages of direct reading in degree, no amplitude adjustment, and no frequency adjustment. However, at higher frequencies, this method fails to achieve an accurate reading because the rise time of the output square pulses from LA_1, LA_2, and the coincident generator cannot be made negligibly short in comparison with a period of input sinewave using conventional tubes or transistors.

The block diagram in Fig. 1C is shown for explanation of the operation of the second group. Input signals enter the phase shifters then proceed to the phase detector and null indicator. The procedures for measuring phase angle is as follows: (A) equalize the phase delay of both channels to eliminate errors due to the difference of lead inductances and stray capacitances between the two channels. This may be done by applying an identical signal to both inputs, then adjusting the phase shifters until the output indicator becomes minimum or null; (B) apply both signals simultaneously with the same input connecting cables as used in (A), then adjust the phase shifters again for minimum or null on the output indicator. The phase difference between E_1 and E_2 equals the difference of phase readings between (A) and (B).

For frequencies between 100 Kc to 15 Mc, spirally wound delay lines can be used as phase shifters.[7] Figures 1D and 1E show a continuously variable delay line with spirally wound inductor and distributed capacitance to ground. The characteristic impedance is equal to $\sqrt{L/C}$ ohms and the time delay per unit length is equal to $\sqrt{LC}$ seconds, where L is in henrys and C in farads per unit length.

The electrical connection is shown in Fig. 1F. By feeding the input signal to the variable contact, the plate of V_1 is connected in parallel with $R_o/2$, and the grid of V_2 is in parallel with R_o. The standing wave caused by stray capacitance from both tubes can be minimized to less than 1 percent from 100 Kc to 15 Mc, when a line with value of R_o less than 200 ohms is used. The amplification is about equal to $g_m R_o/2$.

When the input signal contains a large amount of harmonics and noise, the accuracy of phase nulling is greatly impaired. Thus a differential tuned amplifier should be inserted between the phase shifters and phase detector. A single tuning circuit is used for both channels E_1 and E_2 so that no phase difference between channels E_1 and E_2

Measure Phase at High Frequencies

Phase delay is compared with a continuously variable delay standard, using instruments that operate up to 2,000 Mc with an accuracy of 0.1 deg or 1 percent

will be created by drift of signal frequency or improper adjustment of the tank circuit tuning capacitor. The sensitivity of the instruments can also be increased many times (approximately equal to $g_m \omega LQ$) by adding a balanced tuned amplifier. In addition, it is possible to achieve continuously variable attenuation without phase shift by changing the bias voltage of each channel separately.

The photo shows a phase detector for operation between 15 Mc and 400 Mc. Figure 2A shows the circuit of the instrument. For an operating frequency between 15 Mc and 400 Mc, three plug-in tuning circuits are used. Input signals E_1 and E_2 are fed through two separate coaxial attenuators, 10 db each, into the continuously variable delay line and fixed delay line. Two more coaxial attenuators are connected between the delay lines and the grids of the two input tubes. These four coaxial attenuators terminate the coaxial delay line and isolate the input capacitance and the grid losses of the pentodes from the delay system at high frequency.

The grid bias of both input tubes can be adjusted separately to compensate for the difference in amplitudes of input signals. The phase detector consists of a vector-difference rectifier. This rectifier uses a high-frequency germanium diode for producing an output d-c potential proportional to the vector difference of the two input voltages. The dual triode serves as a bridge amplifier for exciting the panel microammeter. The vector sum of $E_1 + E_2$ is developed across R_L, and may be fed to an external receiver. When the receiver is tuned to the signal frequency, both the sensitivity and selectivity of nulling will be increased with the gain of the receiver. This instrument can measure phase within 1 percent or 0.1 deg for frequency ranges up to 400 Mc. When the input signal amplitude is from 1 to 10 volts, the panel meter can be used as null indicator. When the input signal is below 1 volt, a receiver or millivoltmeter is needed for null detection. Signal amplitude as small as one millivolt has been found satisfactory for phase measurement when a receiver is used as null detector. For frequency above 400 Mc, the differential tuned amplifier becomes useless because resonance occurs within the structure of the tubes. Therefore, a variable-step coaxial attenuator is recommended in place of the differential tuned amplifier for amplitude balancing.

If the signal frequency is known, the phase detector shown in Fig. 2B has been found satisfactory for phase measurement up to 2,000 Mc. Reference signal E_1 is applied to a

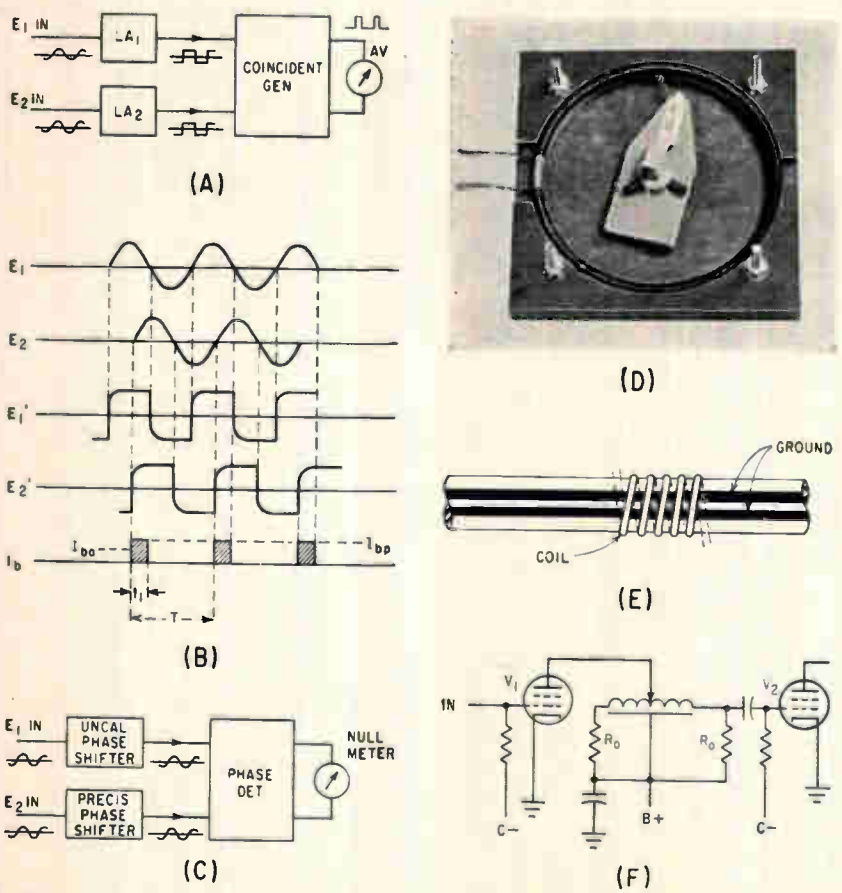

FIG. 1—Block diagram of direct-reading phase meter (A) and waveforms (B) at various points in this instrument; block diagram of comparison phase meter (C); continuously variable delay line (D) using spirally wound coil (E) and distributed capacitance; and electrical connection of variable delay line (F)

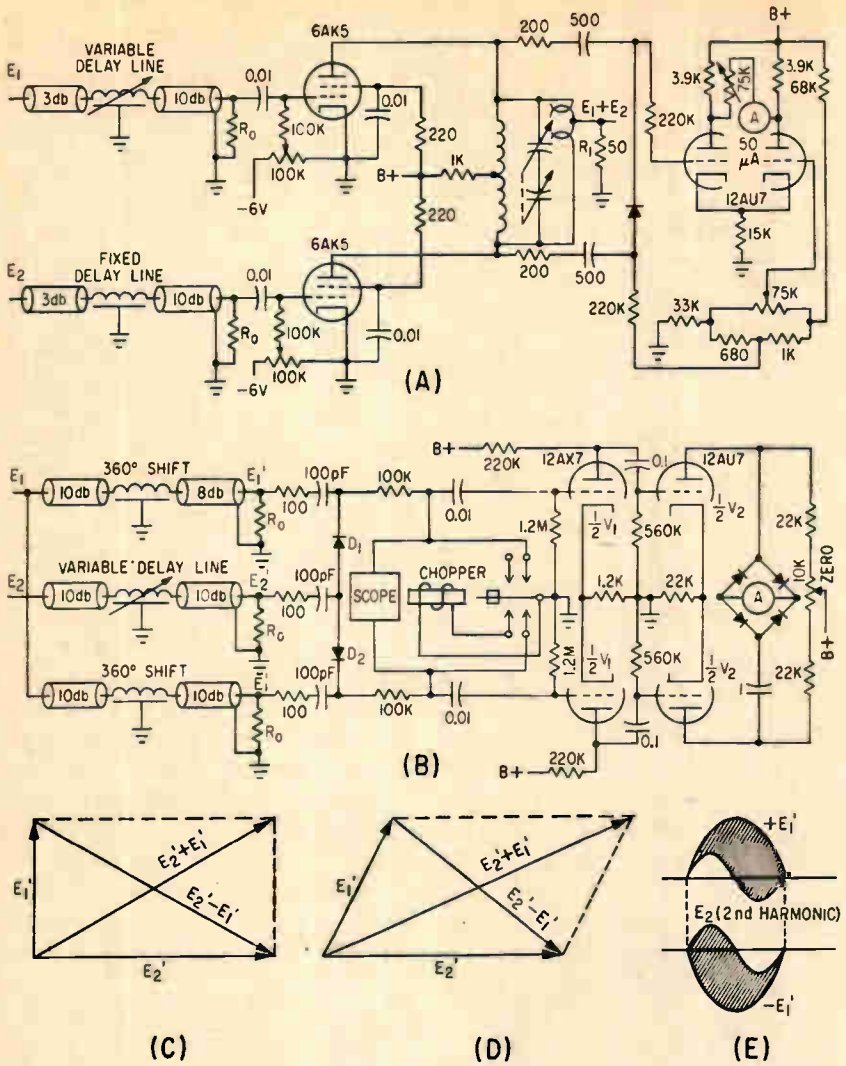

FIG. 2—Schematic (A) of phase detector shown in photo, for use up to 400 Mc; schematic of phase detector (B) for operation up to 2,000 Mc; operation of the phase detector, showing vector relation (C) for 90 deg between E_1' and E_2', vector relation (D) for phase angle other than 90 deg between E_1' and E_2', and diagram (E) of E_2' as an even harmonic of E_1'

10-db coaxial attenuator, then to the 180 deg phase-shift coaxial delay line. Signal E_1 is also applied to a second 10-db attenuator, then to the 360-deg phase shift coaxial delay line. The unknown signal E_2 is applied to a third 10-db attenuator, then to the coaxial continuously-variable delay line. The outputs of these three delay lines are isolated by three separate attenuators before entering the phase detector. The values of attenuation are 10 db each for both the variable delay line and the 180-deg delay line and 8 db for the 360-deg delay line. The decrease of attenuation for the 360-deg delay line is made so that the output amplitudes of both the 360-deg delay line and 180-deg delay line are equal. The vector diagrams of Figs. 2C and 2D show the operation of the detector.

The potential developed across diode D_1 is $|E_2' - E_1'|$ and the potential across diode D_2 is $|E_2' + E_1'|$. If E_1' is made 90 deg with respect to E_2' by variation of the coaxial continuously-variable delay line, the absolute amplitude of $|E_2' + E_1'|$ equals $|E_2' - E_1'|$. Therefore, the output of the phase detector is zero, regardless the variation of both signal amplitudes E_1 and E_2. The phase detector produces no output if the frequency of the unknown signal, E_2, is not equal to the frequency or the odd harmonic of the reference signal, E_1, because their average product is zero. The even harmonic of E_2 also will produce no output from this phase detector. In Fig. 2E, the upper shaded area represents the electric charge introduced by D_1 to the capacitors at its anode and cathode. Likewise, the lower shaded area represents the same introduced by D_2. These two areas are equal; and their difference, which is the output of the detector, is always zero. However, the odd harmonic of E_2 would produce output and introduce error to the condition of phase null.

The output of this phase detector can be fed into a balanced oscilloscope. The requirement of bandwidth of the oscilloscope depends on the frequency of the modulated envelope; normally 100-Kc bandwidth is sufficient. A straight line shows on the screen of an oscilloscope when E_1' is 90 deg with respect to E_2. The signal is not amplitude or pulse modulated, a chopper amplifier can detect the null. This amplifier consists of two dual triodes, V_1 and V_2, as shown in Fig. 2B. The output is applied to a bridge rectifier then to a d-c milliammeter used as a null indicator. When the milliammeter reads zero, it represents the conditions when E_1' is 90 deg with respect to E_2'. The operating procedures of the entire instrument are: (1) equalize the time delay of both channels by applying an identical signal to both inputs; (2) apply both the reference and unknown signal to the input terminals with the same input connecting cable used in (1), then adjust the variable delay line again for null on the indicator. The phase delay between E_1 and E_2 signals can be as much as 10 to 1.

The author acknowledges the aid of R. St. Louis and R. DeMetro.

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Author checks signals from the preamplifier in a character-reading machine

WIDEBAND TRANSISTOR PREAMPLIFIER

Handles Low-Resistance Transducers

Readout from magnetic heads and other low-level signal sources is accepted by preamplifier, whose gain is constant within ±3 db over the range 10 cycles to 1 megacycle. Details of circuit design are presented

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COMBINATION OF FEEDBACK and judicious choice of circuit type has been used in an a-c coupled solid-state preamplifier for magnetic read heads and other transducers having low d-c resistance. The gain is flat within ±3 db from 10 cycles to 1 Mc, and noise level is below 0.1 millivolt referred to the input. Nominal gain is 49, while changes in a-c source impedance from 0 to 5,000 ohms, variations of ±3 percent in supply voltage, and temperatures ranging from 25 to 55 C cause a maximum gain variation of ±2 percent. At 10 Kc, the input impedance is greater than 150,000 ohms and the output impedance is less than 10 ohms. The circuit can deliver ±4 v peak signals at 10 Kc and ±0.5 v at 1 Mc.

The input stage is a common-emitter amplifier with a-c and d-c degeneration. The d-c equivalent circuit is shown in Fig. 1A.

A 2N168A is used with d-c emitter current fixed at approximately 300 microamperes, and collector reverse bias nominally 2 volts for low-noise operation. With a typical head resistance of approximately 300 ohms, the effect of I_{c_o} in the first stage is kept to a minimum. The stability factor, $S = dI_c/dI_{c_o}$, for this stage is nearly unity. The cumulative effect of I_{c_o} for both Q_1 and Q_2 (Fig. 2B) can cause the base-to-collector bias on Q_1 to vary from 2.5 to 1.25 volts for a temperature range of 25 C to 55 C. The stage can handle any input signal within the output dynamic range of the amplifier, and for all conditions of beta and I_{c_o}.

The a-c equivalent circuit for the first stage is shown in Fig. 1B.

Source impedance, $Z_s(\omega)$, may be constant, or it may vary, as does a magnetic readout head's. The equivalent generator, $e_s(\omega)$, covers the frequency spectrum of the signal. The transistor is represented by its T-equivalent circuit, where junction capacitance has been included. Capacitor C_1 (see Fig. 2B) bypasses the constant current supply in the emitter circuit, leaving only the feedback divider, R_3 and R_4, in the a-c circuit. Because of low d-c emitter current in Q_1, the leakage current in C_1 must be small so that the high temperature operating point will not be affected.

Output impedance of the transistor can be found using[1]

$$Z \cong \frac{Z_c\,[(Z_s+r_b)\,(1-\alpha)+r_e+R_e]}{Z_s+r_b+r_e+R_e} \qquad (1)$$

where $Z_c = r_c/(1 + j\omega\, r_c\, C_c)$. This

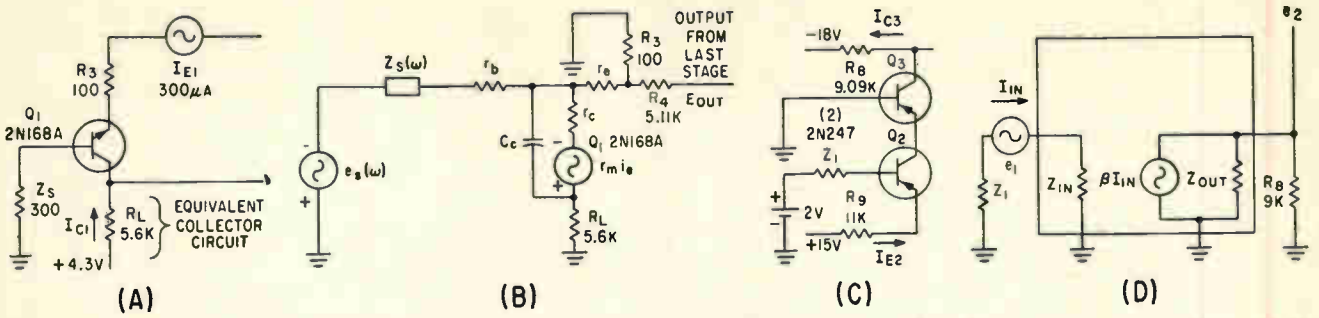


FIG. 1—Equivalent circuit of input stage for d-c signals (A) and a-c signals (B); direct current equivalent of the loop gain (F) and same circuit as a voltage source (G); equivalent circuit of complete preamplifier (H)

impedance is large at low frequencies but at high frequencies must be taken in parallel with $R_L = 5{,}600$ ohms, to determine Z_1 the equivalent source impedance of the first stage.

Using the equivalent source representation of the first stage, the d-c equivalent circuit of the second stage of the preamplifier is shown in Fig. 1C.

Emitter current of Q_2 is fixed at about one milliampere and since the current gain from the emitter of Q_2 to the collector of Q_3 is approximately 1, the d-c output level is about −9 volts. The collector of Q_3 is biased near the center of its operating range while the collector of Q_2 has only about two volts bias; Q_2 remains linear, however, since its collector voltage is held constant by the emitter junction of Q_3 which is approximately at ground. The leakage current I_{co} of Q_2 cannot affect the collector voltage of Q_2, but it adds to the leakage current of Q_3. The equation is

$$I_{c3} = \alpha_3 \alpha_2 I_{E2} + \alpha_3 I_{co2} + I_{co3} \quad (2)$$

The 2N247 was chosen for this stage because of its high alpha cutoff frequency and moderate beta and power dissipation rating. The stage provides a high voltage gain and at the same time corrects the open loop gain and phase response curves. This requires a circuit with the gain characteristics of a common-emitter amplifier and the high output impedance of a common-base amplifier. The high transistor output impedance enables the overall output impedance, including R_8, to be relatively independent of frequency.

Voltage gain of this stage is essentially the same as that of a single common emitter amplifier since Q_3 is a current amplifier with gain of nearly 1. The approximate equivalent circuit for low frequencies is shown in Fig. 1D.

If $Z_{out} >> 9{,}000$ ohms, then

$$e_2/e_1 \cong (-\beta R_8) I_{in}/(Z_1 + Z_{in}) I_{in} \cong 9{,}000 \times 35/6{,}000 \cong -50 \quad (3)$$

Factor Z_{in} is the input impedance of Q_2 and is usually about 1,000 to 5,000 ohms, β is the common-emitter current gain of Q_2. The gain calculated in Eq. 3 will not vary directly with β in practice, because Z_{in} will also change in the same direction as β, tending to keep gain constant.

Gain and phase compensation is accomplished by adding R_{10} and C_3 in the collector circuit of Q_3. The equivalent output circuit including the lag network is shown in Fig. 1E.

If Z_{out} is much larger than 9,000 ohms at the −3 db frequency of this lag network, the response will be as predicted by theory, and proper shaping of the open loop will be obtained. If Z_{out} approaches 9,000 ohms and is variable near the 3 db frequency of the lag network, the response will not be as predicted and will vary from one transistor to another. Thus, the grounded-base circuit, having an inherently higher output impedance than a grounded emitter, is used in the output of the second stage. The output impedance is increased by a factor of $\beta \cong 50$ over a stage having a single common-emitter transistor.

The output stage is an emitter follower using two transistors in parallel (see Fig. 2B). Emitter resistors, R_{11} and R_{12} divide the load equally between dissimilar units, and the 2N247 has been chosen for its high alpha cutoff rating. This simplifies design for closed-loop stability. The d-c emitter current in each transistor is about 1.5 milliamperes. A 5,110-ohm load resistor is chosen so that a large load capacitance can be driven without causing the emitter junction to be cut off by fast falling signals while still providing a reasonable dynamic range.

Output impedance, Z_8, of this stage, at low frequencies, is given approximately by

$$Z_3 \simeq (R_9/\beta) + (R_{11} \times R_{12})/(R_{11} + R_{12}) \cong (9{,}000/50) + 25 \cong 200 \quad (4)$$

The a-c gain of this stage is approximately 1.

The feedback loop is closed around these three stages and is driven from the output emitter followers. The 5,110 ohm feedback resistor causes negligible loading on the output.

Operation of the closed loop amplifier can be observed most easily at low frequency where phase shifts are negligible and all gains are at midband values. This approach will be expanded to include variations in the equivalent source impedance, and variation of transistor parameters with frequency. The gain of stage 2 and stage 3 will be assumed constant for low-frequency calculations and all phase shifts will be measured, rather than calculated, for high frequency, closed-loop stability.

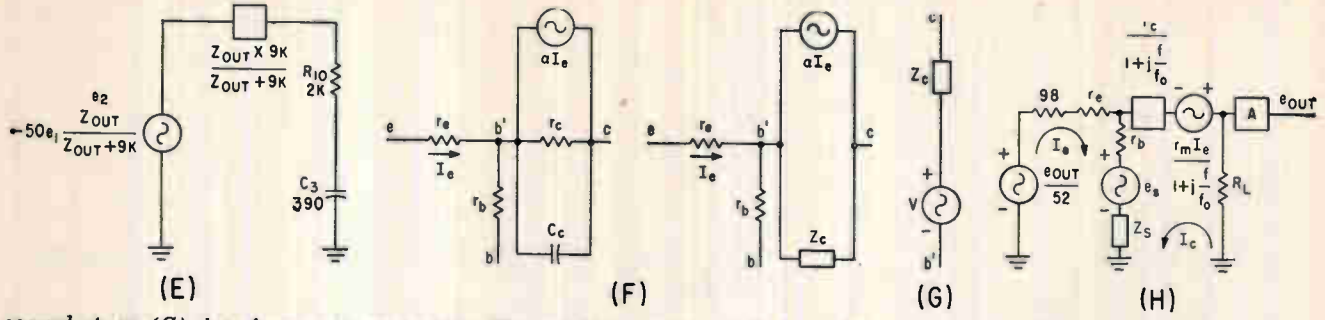
The transistor equivalent circuit of Fig. 1F is used in the first stage where

$$Z_e = \frac{r_e}{1 + j\omega r_e C_e} = \frac{r_e}{1 + jf/f_o}$$

and for a 2N168A

$$f_o = 1/2\pi r_e C_e \cong 4Kc$$

The collector equivalent circuit may be converted to a voltage



second stage (C), low-frequency equivalent (D), and its output equivalent (E); equivalent first stage for analysis of

source as shown by Fig. 1 G where

$$V = \alpha I_e Z_c = \alpha I_e r_c/(1 + j f/f_o)$$

Since $r_m = \alpha r_c$, the generator may be written as

$$V = I_e r_m/(1 + j f/f_o)$$

Further definitions may be made for convenience

$$Z_m = \alpha Z_c$$
$$Z_d = Z_c - Z_m = (r_c - r_m)/(1 + j f/f_o)$$

The equivalent circuit of the complete feedback amplifier is shown in Fig. 1H. The cascaded gain of the second and third stages will be treated as a constant A ($= -50$ at low frequency). With the feedback network (e_{out}, R_3 and R_4) represented in its Thevenin equivalent form, and

$$e_{out} = -I_e R_L A \qquad (5)$$

the loop equations for this circuit are

$$-e_s = I_s (98 + r_e + r_b + Z_S) + I_e (r_b + Z_S + A R_L/52)$$

and

$$-e_s = I_s [r_b + Z_S + r_m/(1 + j f/f_o)] + I_e [R_L + r_b + Z_S + r_c/(1 + j f/f_o)]$$

Solving for I_e and eliminating insignificant terms gives

$$I_e \cong 52\, e_s/-R_L A \qquad (6)$$

providing A is large and Z_s is small. Substituting Eq. 6 into equation 5 gives

$$e_{out}/e_s = 52$$

Using worst case transistor parameters for Q_1 and assuming the lowest value of A ($= -50$), the midband gain, e_{out}/e_s, will be 49 ± 2% for all worst case parameters, provided $Z_s < 5{,}000$ ohms.

The assumptions of constant gain for second and third stages must be modified for stability analysis, and all phase shifts through the circuit must be taken into account. A frequency shaping network, shown in Fig. 1E, is included between the second and third stages to guarantee stability margins for highest beta transistors. Measured values of phase margin, and gain margin were 47 degrees and 3.5 db respectively. The closed-loop response curves of this amplifier, driven from a low impedance source, are shown in Fig 2A. The −3 db point is above 1Mc, and the phase shift is less than 4 degrees below 100 Kc.

The author acknowledges the contributions of D. A. Starr for the original circuit configuration and design and of R. Averill for performing amplifier tests.

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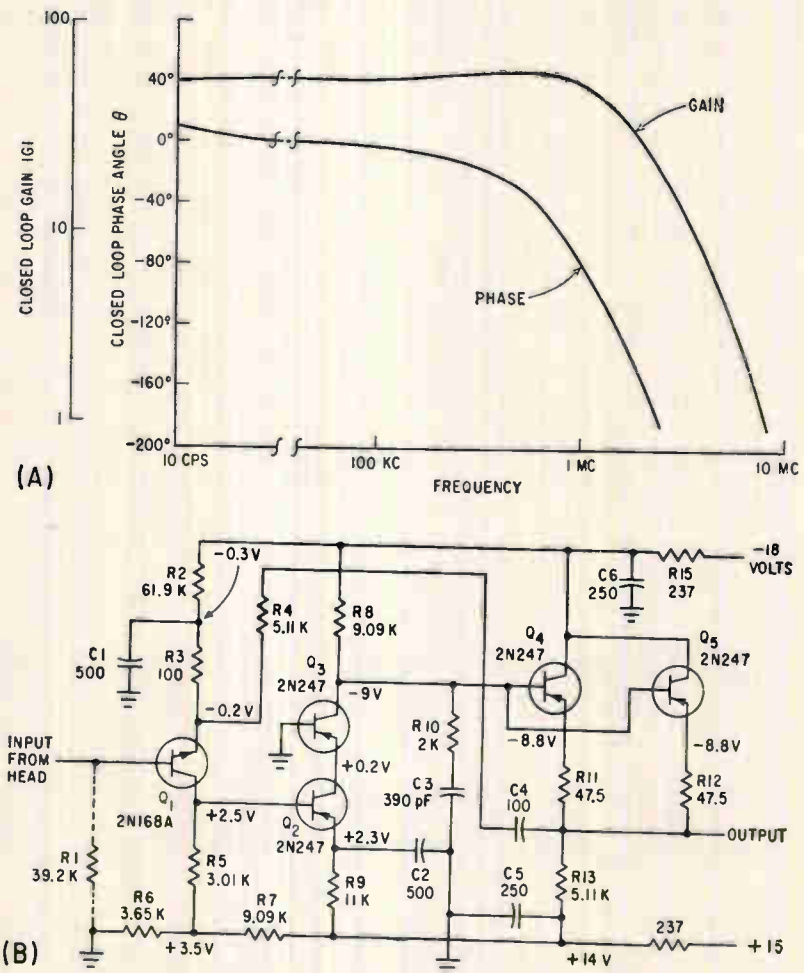
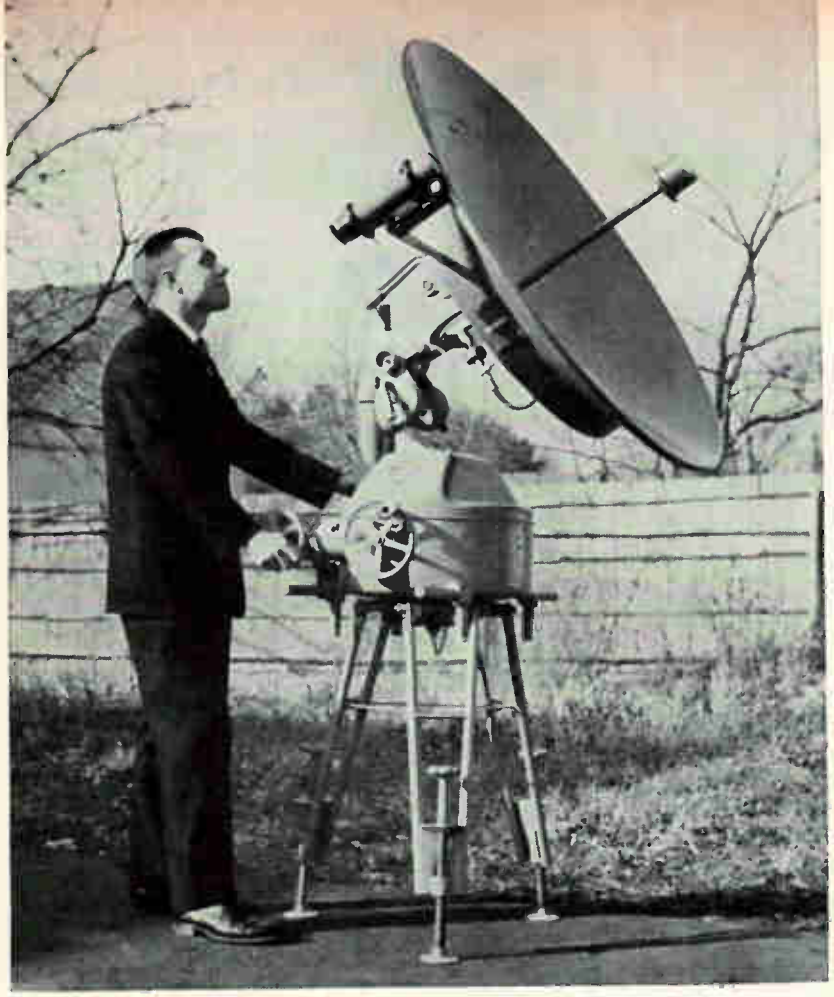


FIG. 2—Curves of loop gain and phase shift (A); complete preamplifier circuit with parallel transistors in the outout stage (B)



Portable tracking antenna for 1,680 Mc

Conventional meteorological radiosonde system is altered to permit subcarrier telemetering. Neutron counter tube output activates subcarrier oscillators, which in turn frequency-modulate the r-f carrier

Modifying a Telemetry System

By LEON HILLMAN,
Automation Dynamics Corp.,
ROBERT C. HAYMES,
New York University, New York

SYSTEMATIC investigation of cosmic-ray neutrons has been underway at New York University for some years. As a part of this program, it has become desirable to make neutron intensity measurements at high altitudes using polyethylene balloons as the lifting vehicle and telemetering equipment to make the measurements.

The particular problem described is measurement of diurnal variation

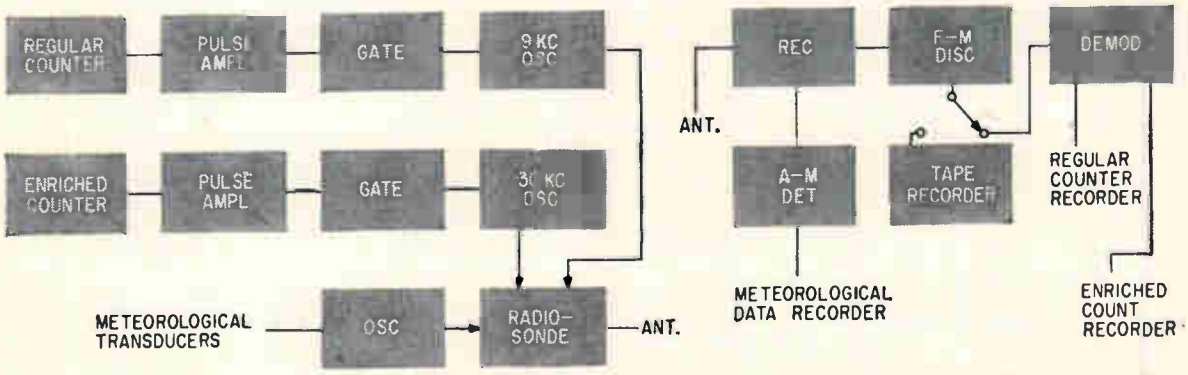


FIG. 1—Conventional radiosonde transmitter has two additional subcarriers for telemetering counter tube pulses. Ground receiver can make either direct-count or magnetic tape recordings

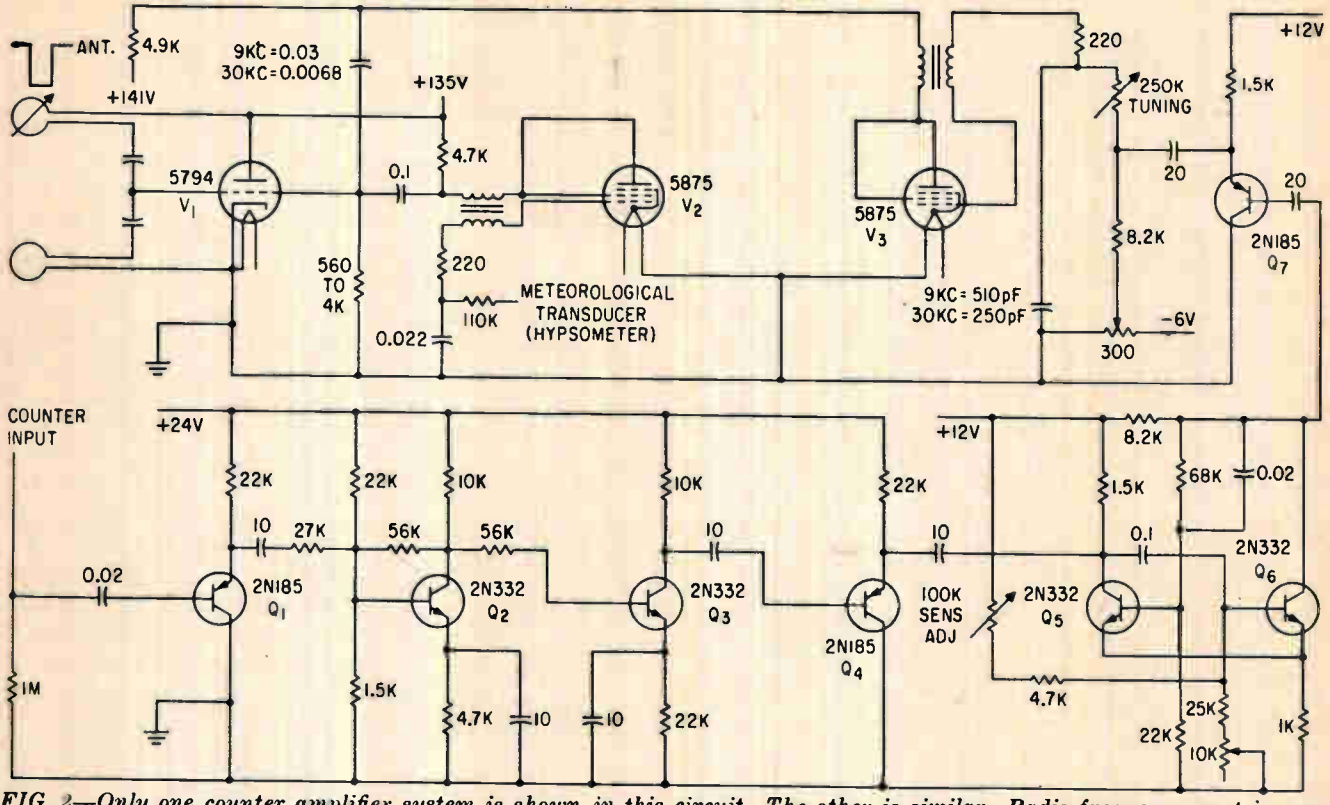


FIG. 2—Only one counter amplifier system is shown in this circuit. The other is similar. Radio-frequency part is conventional radiosonde transmitter

for Balloon-Borne Neutron Detection

of the neutron intensity at altitudes above 80,000 ft. From such measurements, it can be determined if any neutrons exist in the primary cosmic-ray beam.

Since the free neutron is unstable, any primary neutrons must originate fairly close to the earth (within our solar system). The most likely source for such neutrons would be the sun. Evidence for the existence of such a radiation could be inferred from a day-night effect at high altitudes.

The experimental method uses two neutron counters carried aloft by the balloon. The balloon then floats at its ceiling altitude through the sunset period while the radiation intensities are telemetered back to a receiving station. Data, after being corrected for altitude fluctuations, are then examined for any statistically significant difference between the day and night intensity.

Because neutrons are uncharged, the usual techniques of charged-particle detection, such as Geiger and scintillation counters, cannot be directly applied. Instead, an indirect measurement is performed based on the disintegration of the boron nucleus.

When a slow neutron interacts with a nucleus of the B^{10} isotope, the following reaction occurs

$$n + B^{10} \rightarrow Li^{7} + H_e^{4} + Q \qquad (1)$$

where Q, the energy released in the reaction, is approximately 2.5 Mev. It is shared by the two charged fragments, the lithium nucleus and the alpha particle.

It is the ionization produced by these two charged particles that is detected. The counter is a proportional counter filled with BF_3 enriched in the B^{10} isotope. Only pulses equal to or greater than 2.5 Mev in amplitude operate the equipment.

The second neutron counter differs from the first counter only in that it uses boron depleted in the B^{10} isotope. Thus, any background events (such as nuclear stars formed in the walls of the counter) that have been detected by the first counter, can be corrected for. Both counters must have the same background counting rate.

The two telemetered counting rates provide information for two simultaneous equations. The solution enables the evaluation of the slow-neutron density in the presence of a large amount of background radiation.

For example, if the first counter

is enriched so that 96 percent of the boron nuclei are of the B^{10} isotope, then the counting rate of this counter E is

$$E = 0.96\,n + b \qquad (2)$$

where n is the number of neutrons that would be detected by a counter filled with 100 percent B^{10}, and b is the background. Similarly, if the other counter uses BF_3 that is depleted to only 10 percent B^{10}, then its counting rate D is

$$D = 0.10\,n + b \qquad (3)$$

where b may be assumed equal for both counters because they are located at the same point in space at the same time, and have identical geometries. The solution of these two simultaneous equations yields

$$n = 1.14\,(E - D) \qquad (4)$$

The pulse from such a counter is usually in the range of from 2 to 25 mv, and from a high internal impedance. The pulse is of the order of 50 μsec duration.

Neutron intensity depends strongly on the altitude, thus, a correction must be made for changes in altitude of the balloon.

Functions of a radiosonde system were extended to measure and transmit all variables. A meteorological radiosonde system using the AN/GMD-1A ground system and AN/AMT-4 radiosonde transmitter at a carrier frequency of 1,680 Mc was the basic equipment. This apparatus is normally used for measuring and transmitting humidity, temperature, pressure and reference signals from an ascending balloon. The intelligence is telemetered by sequencing between humidity and temperature, the time of switching being a function of discrete pressure steps. The carrier is switched off for a period of about 75 μsec at a rate between 10 and 200 cps, as a function of a resistance in the sensing circuit. The amplitude-modulated oscillator also undergoes a large degree of frequency modulation.

For the cosmic-ray flights the usual radiosonde equipment was retained except for the addition of the hypsometer for high-altitude, low-pressure measurements. To simultaneously telemeter neutron counts from two separate channels, two f-m subcarrier oscillators were provided. The block diagram of Fig. 1 shows the overall system. The two proportional counter tubes are activated from a common high-voltage power supply. Counter pulse signals are amplified and signals above a preset amplitude triggers a subcarrier gate that activates the subcarrier oscillator, which in turn frequency modulates the r-f carrier. The schematic shown in Fig. 2 shows the transmitter circuit and one of the two subcarrier oscillators and gate circuit.

At the receiver the functions of position tracking and demodulation of the radiosonde audio modulation are accomplished. Addition of the high-frequency f-m subcarrier pulse does not influence this channel. The subcarrier pulses are passed through a discriminator. Output of the f-m detector contains the two subcarrier frequencies as well as a large pulse resulting from the undesirable f-m component of the low, audio-frequency modulation. A subcarrier demodulator isolates each subcarrier output and produce one output pulse for each subcarrier pulse. The output pulses can be fed into a dual-channel magnetic-tape recorder or an electromechanical count recorder. A built-in scaler permits the output pulses to be scaled by a factor of ten when high neutron activity provides pulse rates that exceed the time constant of the electromechanical recorder.

An alternate demodulating technique consists of recording the subcarrier signals directly on the tape recorder. Tapes are played back through tuned filters to permit detection of the subcarrier pulses.

Signal output of the boron trifluoride proportional counter consists of negative exponential pulses, ranging in amplitude from several millivolts to several tenths of a volt. Counter response to gamma radiation accounts for most of the pulse output below two millivolts. For a constant thermal neutron flux, the depleted counter is one-fifth as sensitive as the second, isotopically enriched counter tube. However, both counters are equally sensitive to gamma radiation and provide for elimination of the counts due to the background gamma field. The anticipated maximum neutron pulse rates were approximately 75 ppm and 300 ppm for the depleted and enriched detectors. The counter tube plateaus are approximately 200 v in length, running upwards from a nominal voltage of 2,300 v. To eliminate the need for a 3,000-v battery pack, a d-c to d-c transistorized power converter was developed to supply counter voltage. Due to the low signal level output provided by the counters, it was required that the noise output of the power converter be held below a peak value of one mv. Decoupling of the supply voltage to each proportional counter was provided by an r-c filter in each of the high-voltage output leads. The supply is provided with a high-voltage adjustment that permits the initial voltage to be set in accordance with the plateau characteristics.

Pulse amplifier and subcarrier gating circuits are shown in Fig. 2. Transistors Q_1 through Q_4 are pulse amplifiers. A negative pulse at the output of the proportional counter is coupled to the base of Q_1. Common-collector configuration was used for the input stage to improve impedance coupling between the relatively high output impedance of the proportional counter and the succeeding low impedance transistor stages. Direct coupling between Q_2 and Q_3 provides transistor operating point stabilization tending to reduce the effects of parameter drift. The common-collector buffer stage Q_4 reduces the loading effect of the monostable gate circuit on voltage amplifier Q_3. To provide a subcarrier gating pulse independent of the input trigger level, transistors Q_5 and Q_6 were used in a monostable multivibrator. This circuit provides a uniform pulse height and width positive output pulse for each of the random trigger pulses appearing at the collector of Q_4. Duration of the positive pulse at the gate output is a function of the intercoupling time constant of the circuit and is adjusted to deliver an output pulse width of one-tenth msec. Transistor Q_7 couples the gate pulse to subcarrier oscillator V_3. By using common collector configuration in this stage (Q_7), isolation is obtained for the monostable gate collector circuit and matching to the low-impedance subcarrier oscillator is achieved.

Signals received from the balloon transmitter are simultaneously tracked at several locations. At the launching site the AN/GMD-1A radio direction finder automatically tracks the balloon signals and pro-

vides positional data in azimuth and elevation. Portable tracking stations supplement the receiver at the launching site and consist of a receiving antenna, 1,680-Mc f-m receiver and high-speed tape recorder. These portable stations are located at the estimated down-wind position so that telemetered signals can be picked up from the balloon at about the point when they are getting out of range.

The tape recorder provided for direct recording of the subcarriers from the receiver was of the commercial audio type, modified to permit recording of sinusoidal signals to 50 Kc. Data reduction is accomplished by playing the tapes back through tuned filters feeding a detector circuit. Pulses from each channel were counted by an electronic counter.

An alternate technique for counting telemetered pulses consists of an electronic demodulator providing instantaneous readings. This technique produces immediate results, but in the event of poor signal-to-noise ratio or drift in the subcarrier frequencies, requires careful operator tuning during the flight. The tape recorder technique resulted in less dependence upon operator skill and has yielded more consistent results.

The output of the f-m discriminator (as shown in Fig. 3) contains the two subcarrier oscillator frequencies. In addition, there is present the unwanted pulses that result from the frequency modulation of the carrier at the audio blocking rate between 10 and 200 cps. These steep pulses are about ten times as large as the subcarrier signals and would be counted as neutron pulses if they were not eliminated from the counting process. There is also a 30 cps signal at the f-m detector output whose magnitude is a function of the tracking position of the parabolic antenna but of no significance to the subcarrier channel because of the low frequency.

The output of the f-m discriminator is fed to three-stage amplifier V_{1A}, V_{1B} and V_{2A} as shown in Fig. 4. The amplified signals are fed to one-shot multivibrator V_{3A} and V_{3B}, V_5 and V_6 whose trigger level is established to be fired at the higher level of the audio modulation pulses. The time constant of the multivibrator has been established to clamp the gate tube V_4 for the duration of the radiosonde blocking oscillator pulse or 75 μsec. Thus, the unwanted pulses never reach the subcarrier filter stage.

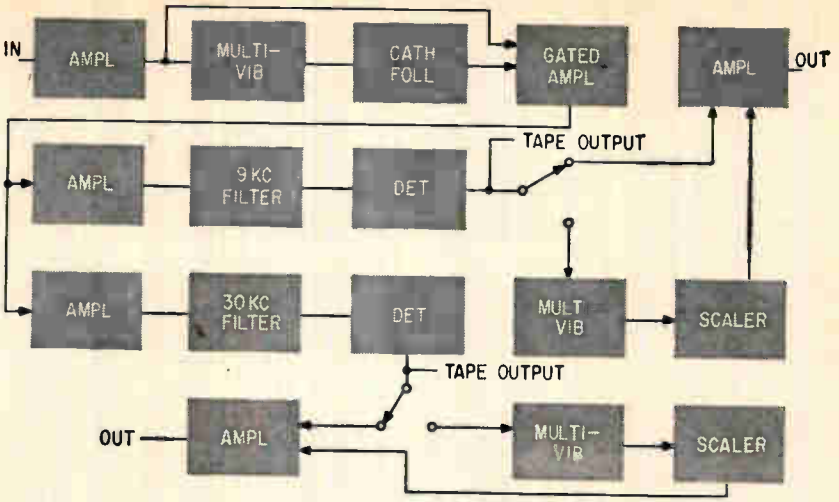


FIG. 3—Ground station subcarrier demodulator accepts signals from the f-m detector. The gated amplifier rejects the a-m portions

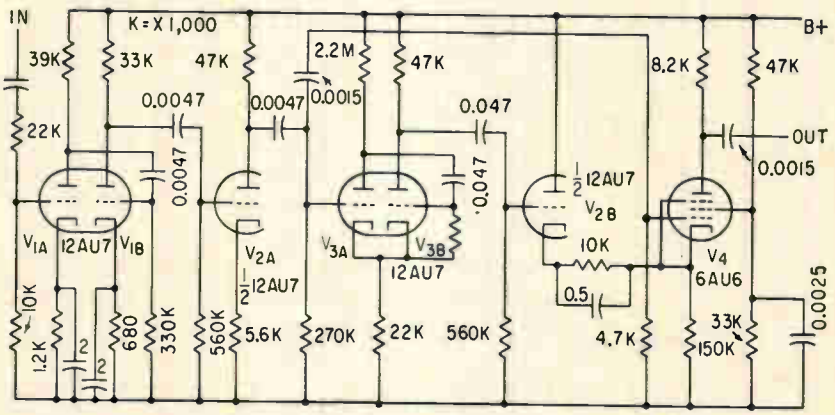


FIG. 4—Ground station gated amplifier removes unwanted pulses resulting from frequency modulation of the carrier by the meteorological oscillator

Output of gated amplifier V_4 consists only of bursts of the two subcarrier frequencies and is fed to two similar demodulator channels. With a spread of 21 Kc between the subcarrier frequencies, isolation of each channel is readily achieved. Since five-percent drift of the subcarrier oscillators is possible, sufficient bandwidth was desired in the filter circuit to eliminate the necessity of tuning. A T-network filter was designed with the desired bandpass.

Subcarrier pulses are demodulated in their channels and the output fed either directly to the relay amplifier stage or through a ten-to-one scaler. The detector output pulse is controlled largely by R-C and adjusted for the time constant of the counting device.

It is possible that the belts of intense radiation observed by the satellites may be due to the decay of secondary, or albedo neutrons, in space into protons and electrons. These neutrons presumably result from the interactions of protons in the primary cosmic radiation with the earth's atmosphere. Some fraction of these neutrons then are scattered back into space by the atmosphere.

Authors acknowledge contributions of S. A. Korff, project members at New York University and Automation Dynamics Corp., Tenafly, New Jersey.

Work was supported in part by the Joint Program of the Office of Naval Research and U. S. Atomic Energy Commission, and in part by the U. S. National Committee for the International Geophysical Year.

Two-Stage Sine-Wave Clipper

Square waves can be generated from sine waves by symmetrical clipping. Flatness of wave tops is increased by adding a second stage at output

By W. E. NEMETH,
Elgin Micronics Div.,
Elgin National Watch Co., Elgin, Ill.

WHEN DRIVEN with sine waves, the circuit of Fig. 1 will deliver high-quality square waves over a wide frequency range. Output voltage is about 1.5 volts peak-to-peak and is essentially constant, provided the input voltage is high enough to saturate the diodes. Typical oscillograms of waveforms are shown in Fig. 2 for two input frequencies. Typically, the output is flat topped within 2 percent and the ratio of rise time to half-period is 0.5 percent or less.

Six silicon diodes are used. Diodes D_1 through D_4 must be able to handle the moderate currents generated by the usual input of 115 volts rms. No reverse ratings are required since clipping occurs for both positive and negative voltage. Resistor R_1 is determined by V_{ap}/I_p, where V_{ap} is peak input voltage and I_p is maximum safe current for D_1 through D_4. Power rating of R_1 is then V_a^2/R_1, where V_a is input volts rms. For fast rise times, V_a should be as high as practicable, as should I_p. However, good results are obtained with power dissipations much lower than that required in the circuit of Fig. 1. Resistor R_2 is not a critical component.

If fractional-microsecond rise times are desired, circuit capacitances and inductances must be held to a minimum. Noninductive resistors and high-speed diodes should then be used.

Diodes D_1 through D_4 act as a preregulator for the output diodes. The waveform V_b is round topped because the relatively large current peaks through the diodes introduce some voltage regulation. Voltage V_b is about 3 v p-p.

Rise time of V_b depends upon the magnitude of V_a, and increases as I_p is increased by decreasing R_1.

The limiting rise time $= t_r + (\sin^{-1} K)/\pi f$, where f = applied frequency in cps, $K = V_b/V_{a(p-p)}$ with V_b being about 3v p-p and $V_{a(p-p)}$ about $3V_a$, and t_r = the sum of the forward and reverse recovery times of diodes D_1 though D_4. In practice, the limiting value can be approached without appreciable power dissipation.

Voltage V_c essentially follows the rise time of V_b (assuming no slow up due to diodes D_5 and D_6), but the wave tops are flat because the moderate rounding of V_b is almost completely regulated by D_5 and D_6.

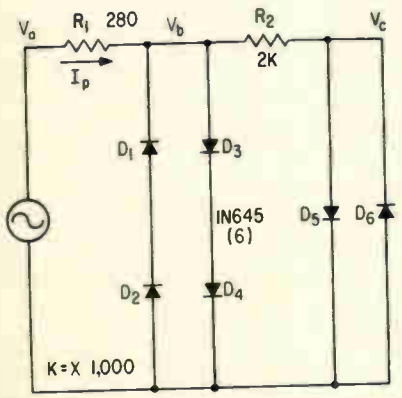


FIG. 1—Simple two-stage clipping circuit produces square waves with tops flat to two percent

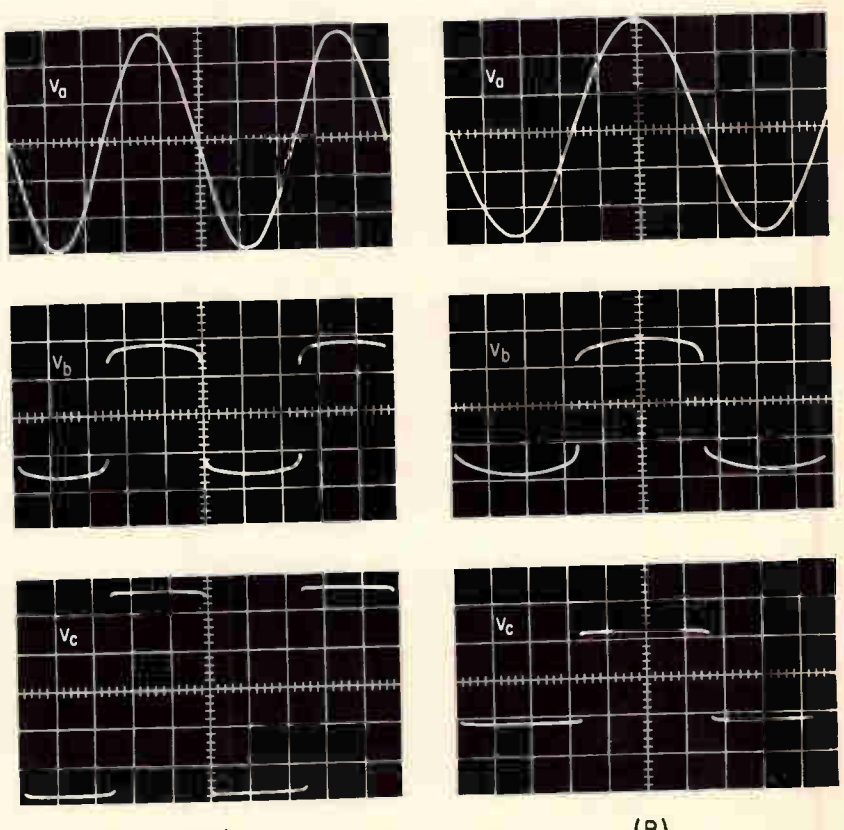
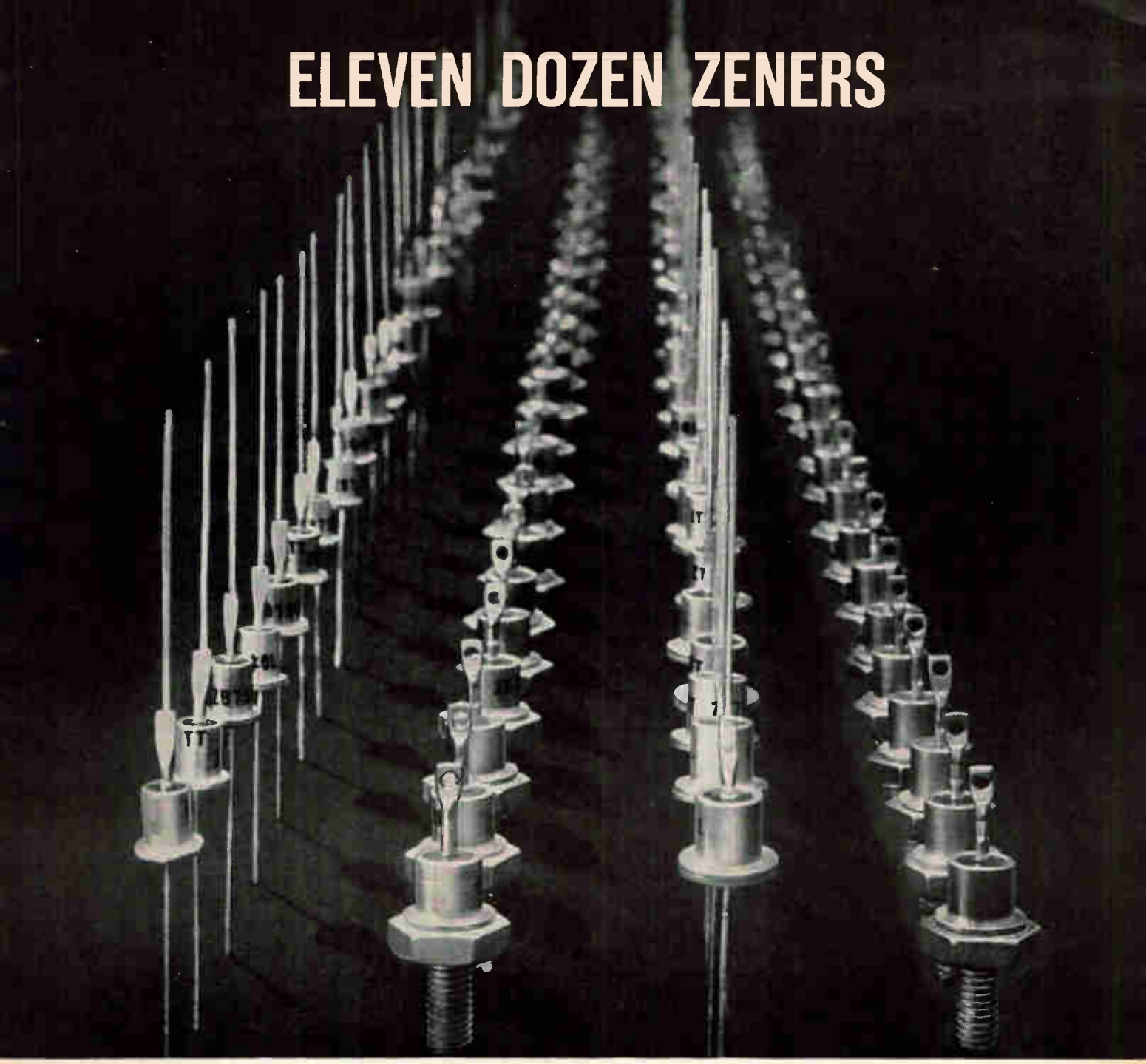


FIG. 2—Photos show quality of square waves from sine wave input for 60 cps (A) and 1,600 cps (B). Input V_a is about 200 v peak-to-peak, V_b 3 v peak-to-peak and V_c 1.5 v peak-to-peak

ELEVEN DOZEN ZENERS



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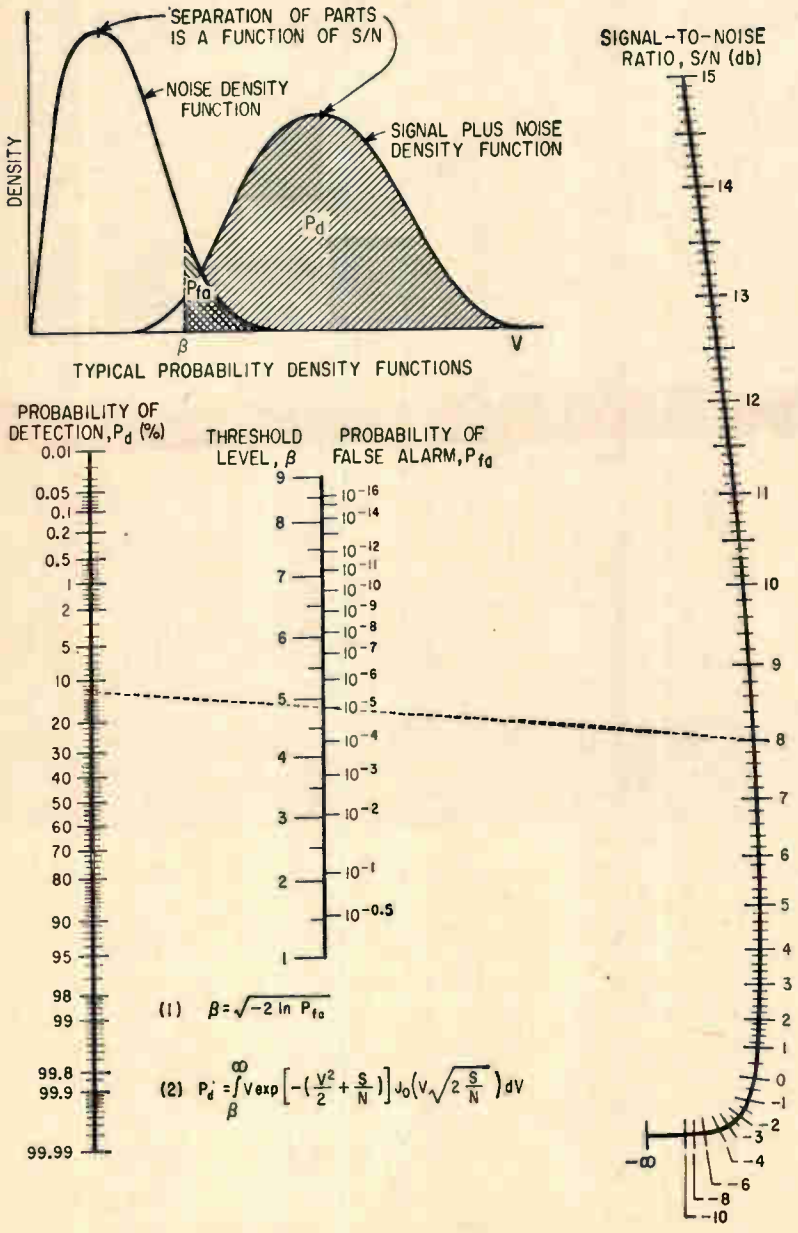
CIRCLE 65 ON READER SERVICE CARD

NOMOGRAM DETERMINES PROBABILITY OF

Detecting Signals in Noise

By DONALD E. BAILEY
NEIL C. RANDALL
Research Division, Philco Corporation, Philadelphia, Pa.



Straight line through points of two known variables will give the third variable, with accuracy ± one division of the S/N scale. If a S/N ratio of 8 db is available and a P_{fa} of 10^{-5} is wanted, a straight line between these points gives the probability of detection as 12.3 percent. Threshold level is about 4.8

IN RECEIVING SYSTEMS it is often desirable to determine detection probability for signals in noise. This nomogram gives a method of doing it without solving integral equations[1, 2], or using tables[3, 4], when dealing with envelope detection of signals with nonfluctuating amplitude accompanied by additive Gaussian noise.

Signal-to-noise ratio S/N is the rms power signal-to-noise ratio, threshold level β is the input voltage above which the detector gives an output, and false-alarm probability P_{fa} is the probability that noise voltage will exceed the threshold. Equation 1 relates threshold level and false-alarm probability, assuming Gaussian noise and normalizing with respect to rms noise current.

Probability P_d that the sum of instantaneous voltages of signal and noise will exceed the threshold, is the integral, from threshold level to infinity, of the probability density function of signal plus noise[1, 2], as in Eq. 2, where J_0 is the Bessel function with imaginary argument, and V the envelope of the signal-plus-noise current normalized by rms noise current. Density functions in the figure show typical relationships among P_d, P_{fa}, β and S/N. The nomogram is a semiempirical solution of Eq. 2 for a power S/N ratio measured in the receiver i-f.

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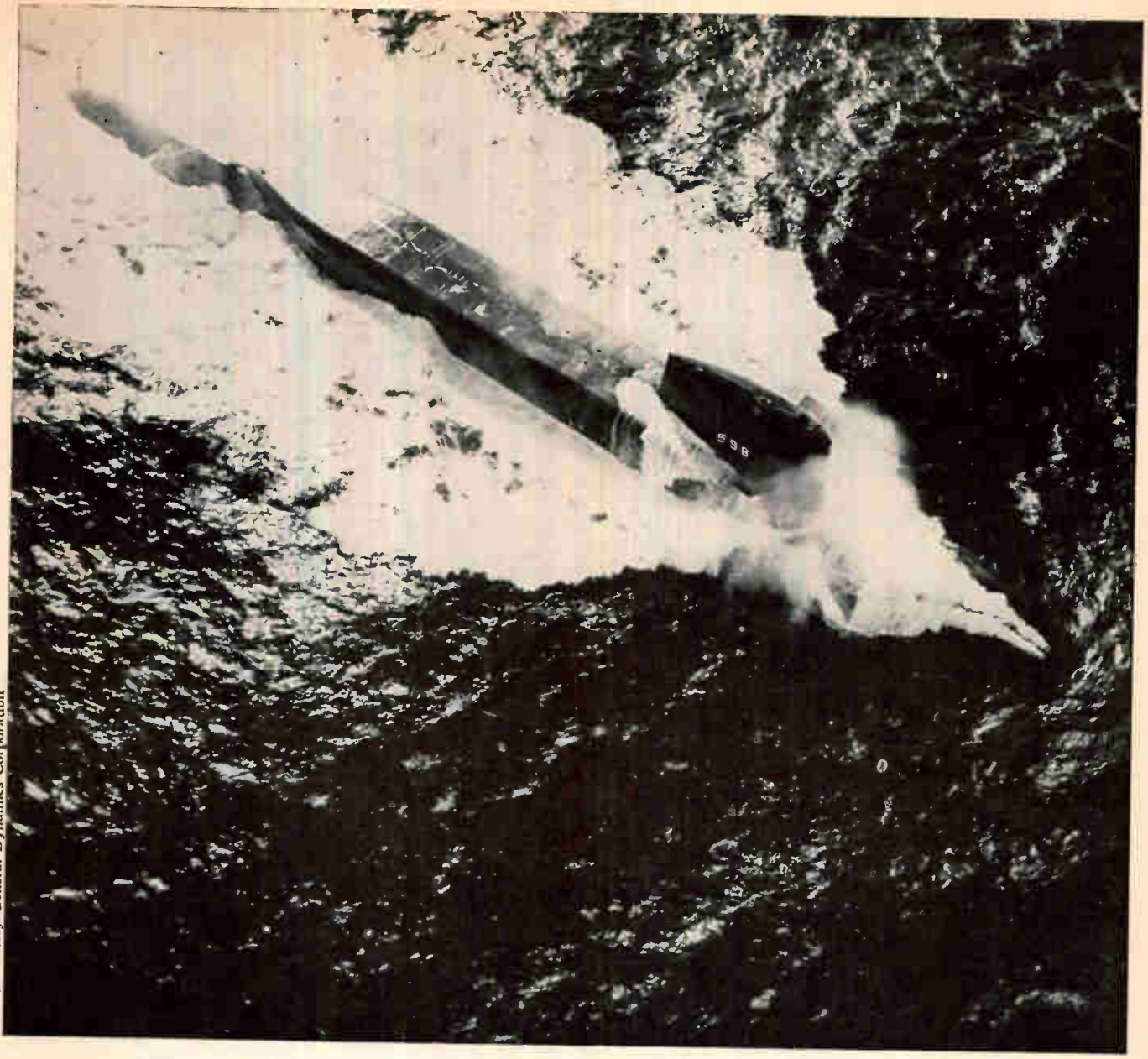

Photo, courtesy General Dynamics Corporation

MIGHT on the MAIN

EDO CONGRATULATES THE U.S. NAVY on its mighty deterrent fleet, symbolized by the *U.S.S. George Washington* on operational patrol – fast, far-ranging, Polaris-armed. Edo is proud to share as prime contractor in the Navy's Polaris program by designing and building systems that are being tested and proved daily as the *George Washington* and her FBM sister ships prowl their protective missions . . . "a fleet that will never attack first, but possess sufficient powers of retaliation, concealed beneath the sea, to discourage any aggressor from launching an attack upon our security."*

President John F. Kennedy's State of the Union message, January 30, 1961

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Cornwall, Ontario

March 17, 1961

Tunneling Superconductors Are Studied

By IVAR GIAEVER,
General Electric Research Laboratory, Schenectady, N. Y.

QUANTUM MECHANICAL tunnel effect has been combined with the phenomenon of superconductivity. The controllable nonlinear voltage-current characteristics of the experimental devices had a negative-resistance region similar to a semiconductor.

Only laboratory models have been constructed but they provide additional insight into these phenomena. The work was described at the Solid State Circuits Conference in Philadelphia.

When the vacuum space between the parallel metal plates of the ideal capacitor in Fig. 1 is about 10^{-4} cm wide, no steady-state d-c is observable. If the vacuum space is reduced to about 10^{-7} cm, appreciable d-c results although classically such current flow is energetically impossible. The current is the result of the tunnel effect.[1]

For small fields, tunnel current is proportional to voltage. At higher voltages, current gradually changes to a Fowler-Norheim[2] (cold-emission) relation. Tunnel current is closely related to separation of the metal plates, decreasing exponentially with increased separation. Thermionic emission does not account for the current because it is nearly independent of temperature.

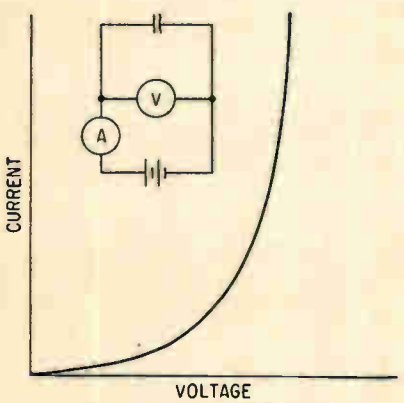

FIG. 1—When vacuum space between plates is less than about 100 A, tunnel current flows

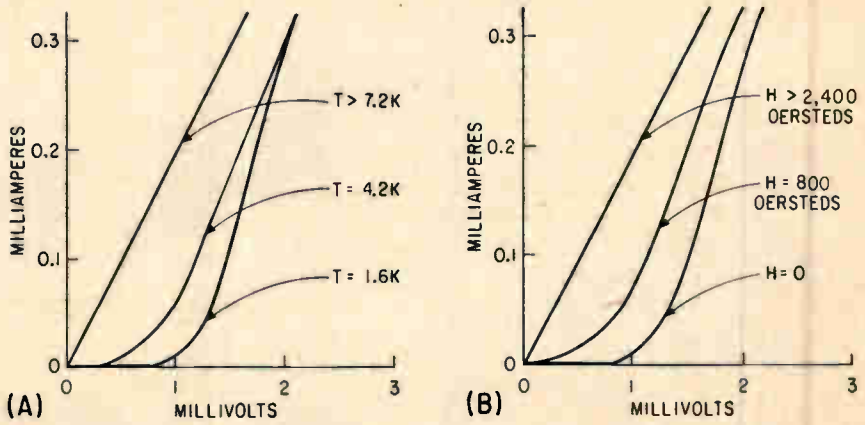

FIG. 2—Characteristics of Al-Al_2O_3-Pb sandwich is shown as a function of temperature (A) and magnetic field (B)

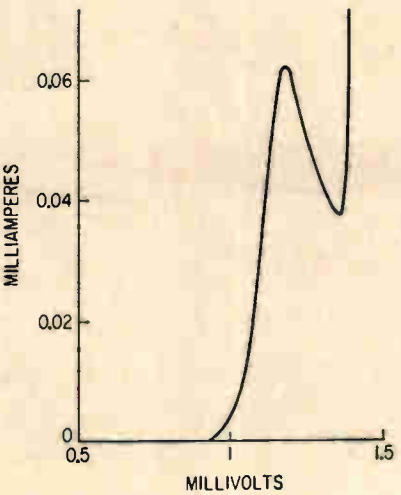

FIG. 3—Negative resistance of Al-Al_2O_3-Pb sandwich is shown at temperature of 1 K

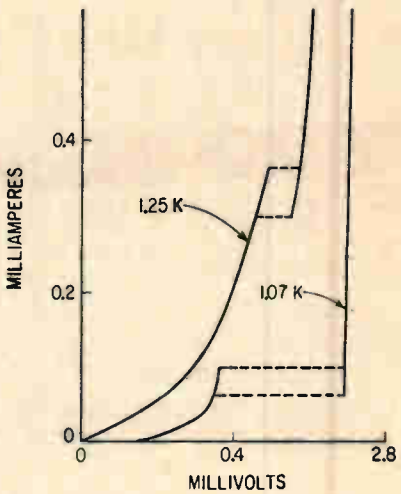

FIG. 4—Temperature effects are shown for sandwich comprising layers of Al-Al_2O_3-In

Practically, separating two metal plates with such a narrow region of vacuum is difficult. However, they can be separated by a thin aluminum oxide film. A strip of aluminum film is evaporated on a clean glass plate and the aluminum surface is oxidized. A metal is then vapor-deposited across the first strip. Current through the aluminum oxide film is primarily the result of tunneling.[3]

If superconducting material is used for one of the metals in the sandwich, the current-voltage characteristic becomes nonlinear,[4] as shown in Fig. 2A. The change occurs because a forbidden energy range centered at the Fermi energy appears in the electron density of states of a superconductor when it goes from its normal to its superconducting state.

The nonlinear current-voltage relationship can be changed by subjecting the sandwich to a magnetic field, as shown in Fig. 2B. The characteristic is independent of polarity.

A coil is wound around the capacitor-like device in Fig. 6. Tunnel current can be modulated by a control current through the coil. The device then possesses the features of a switch or similar triode-like device.

If both metals are made superconducting, a negative-resistance

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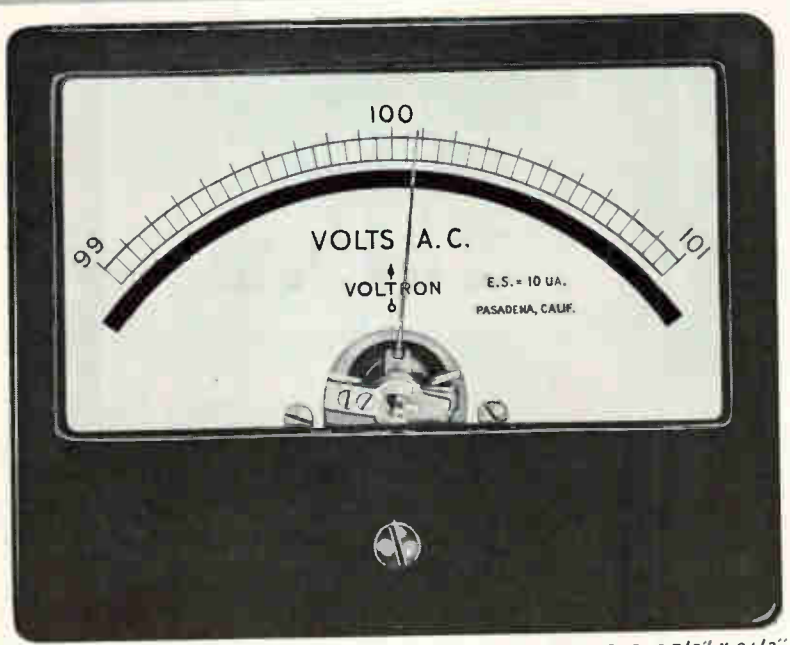

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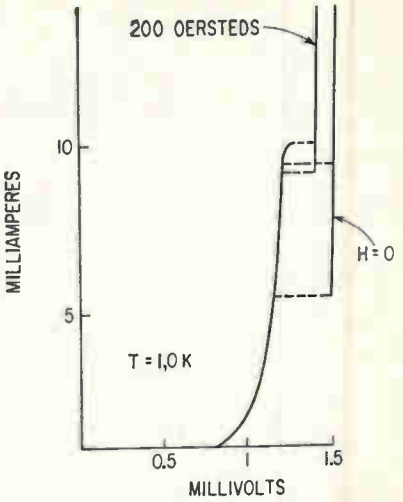
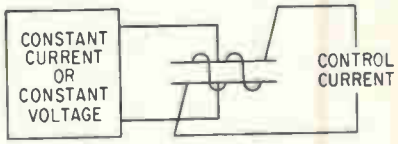


FIG. 5—Magnetic field effects are shown for sandwich comprising layers of Al-Al_2O_3-Pb

region appears in the voltage-current characteristic,[5, 6] as shown in Fig. 3. Again, the characteristic is independent of polarity. The negative resistance is closely related to the energy gaps and to the rapidly changing density of the states of the two superconductors. The value of the negative resistance is a function of operating temperature as well as of the applied magnetic field, as shown in Fig. 4 and 5.

Current can also be varied over wide limits by changing thickness of



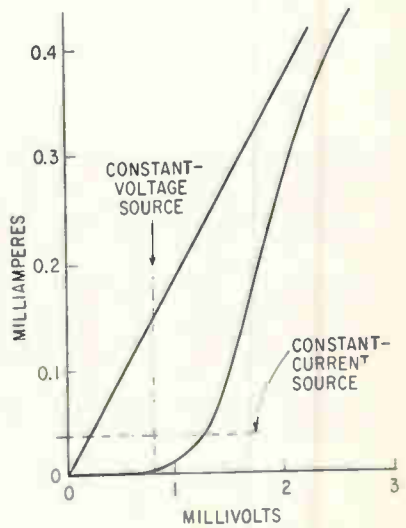


FIG. 6—Adding coil permits control of device

the oxide layer. Resistances measured with both metals in their normal states ranged from 10^{-4} ohms/cm^2 to 10^6 ohms/cm^2. Both voltage at which negative resistance occurs and the negative-resistance region itself depend on the combination of superconductors used. This voltage is usually in the millivolt region and the figures shown are typical.

The author acknowledges the assistance of J. C. Fisher, C. P. Bean, K. Megerle and P. E. Lawrence.

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(2) L. Nordheim, *Physik Z*, 30, 1929.
(3) J. C. Fisher and I. Giaever, submitted to *J Appl Phys*.
(4) I. Giaever, *Phys Rev Ltrs*, 5, 1960.
(5) I. Giaever, *Phys Rev Ltrs*, 5, 1960.
(6) F. Nicol, S. Shapiro and P. H. Smith, *Phys Rev Ltrs*, 5, 1960.

Programmer Will Drive Tracking Antenna

ANTENNA position programmer is planned for tracking the NASA Nimbus series meteorological satellites. The first 700-lb Nimbus is expected to be put in orbit this year by a Thor-Agena rocket. These research vehicles are successors to the Tiros series.

The antenna programmer is being designed by Datex for Collins Radio. It will provide tracking signals to the antenna servo system.

The computed satellite orbit will be recorded on teletypewriter tape. Actual antenna position will be derived from the servo system when the satellite is being tracked. The analog tracking information will be encoded by equipment also being designed by Datex. Real time data will be provided by a digital clock.

In the remote control mode, the programmer will provide analog voltages to the antenna drive system derived from the tape recorded orbital information. In the automatic tracking mode, the programmer will sample actual tracking angles.

If the signal from the satellite is lost, the antenna will be directed by the programmer based on computed orbit. However, this information will have been corrected in accordance with the information obtained from the tracking samples.

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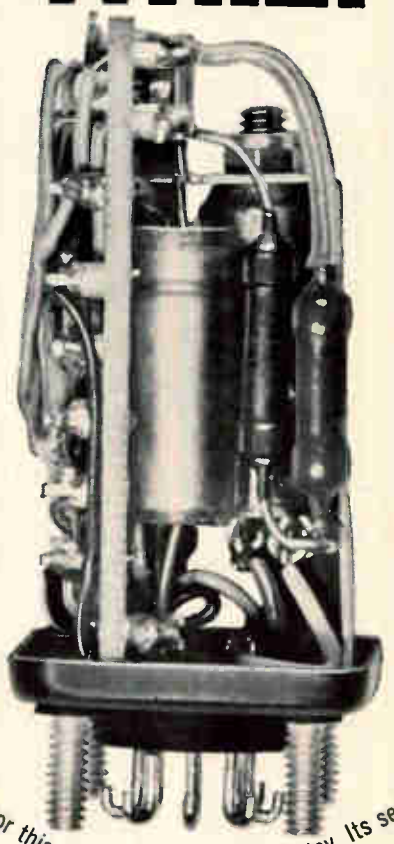

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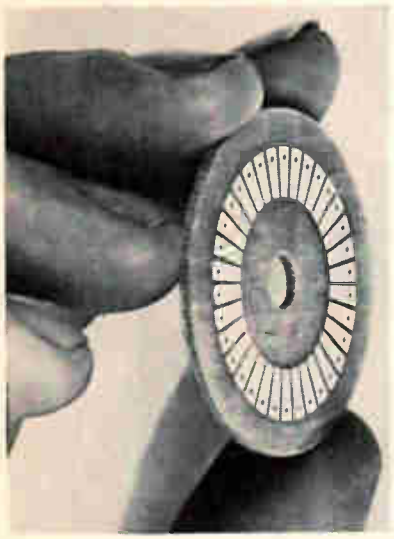

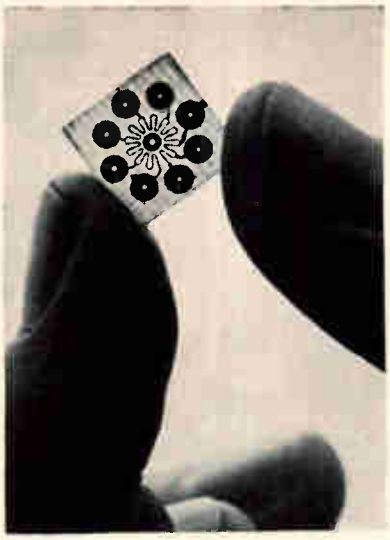

Creative engineering, applied to printed circuits, is exemplified by flush-circuit switching device (left), and a versatile resistor element (center). Steve Gulyas operates metallurgical microscope equipped with electric furnace (right), a significant tool in selecting proper materials for these circuits

New Design Concepts in Printed Circuits

By STEPHAN GULYAS,
Vice President of Research & Engineering, Precision Circuits, Inc., New Rochelle, N. Y.

NEW BASE MATERIALS and conducting metals have carried electronic circuits a long way since printed-wiring concepts had their start about 13 years ago. Printed wiring is now an important part of electronic design. And in today's circuits, printed boards are necessary for modern systems.

Designers have solved old problems of warp, wear, and outgassing of the dielectrics. Components for printed-circuit boards are now well packaged, well isolated and well cushioned. These techniques have reduced manufacturing and assembly costs to a fraction of the price of point-to-point wiring, and with greater reliability. Manufacturing processes involving printed wiring are more adaptable to quality control and inspection, are more consistent, and performance data on the materials and metals has been assessed for over a decade.

A line is drawn between boards destined for military and industrial applications, and those used for commercial purposes. For the military, the boards must withstand tremendous shocks, vibration, and other hostile environments. Establishments engaged in design must maintain research and engineering personnel to continuously extend the performance for these applications.

Developmental activities at Precision Circuits, Inc., show how creative engineering can multiply potential applications.

For example, a flush-circuit (photo at top of page, left) has been produced for switching applications. This switch consists of pie-section conductor segments plated into a base insulating material. A rotating brush contacts each segment, producing pulses or sequencing signals. Previously these devices were limited because of limitations of the dielectric or base material.

Proprietary materials and manufacturing techniques have now been developed which eliminate these shortcomings.

A developmental switch has completed a 2-million life cycle test with no sign of wear, either on the brush, conductor or insulator. The new flush circuit, called Permadisc, has a base hardness of Shore D 95. It exhibits a maximum outgassing of only 0.08 percent. Tests run on a specimen ¼-in. thick and 2-in. diam show only 0.001 TIR (total indicator reading) change in flatness, and no measurable change in flushness or surface smoothness after being subjected to 125 C for 60 hours. Widespread application of this device is expected in critical data-handling systems.

Precision Circuits also has pioneered an interesting concept in packaging called Unicell (see p 74). These units solve the paradox of achieving both high reliability and economic maintenance for the military. Components are isolated and cushioned in a dielectric material, with printed wiring connections for easy assembly. The components are protected from shock and vibration, and a component that fails can be removed and replaced easily.

Up to now, the usual encapsulation techniques preclude reuse of the assembly even if one component fails, or they are too cumbersome to repair.

The Unicell concept packages each component in epoxy and plastic foam. The dielectric material does not add substantially to the weight of the assembly, an impor-

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Frequency:	1Kc, 10 Kc. 100 cps to 20Kc with ext. osc.
Readout:	Direct—no multiplying factors

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Accuracy:	.01% at 1Mc points
Output:	.1μV to 1V into 52Ω
FM:	0-300Kc
Δf:	Frequency calibrated, 0-100Kc
Mod. Freq.	100cps—100Kc

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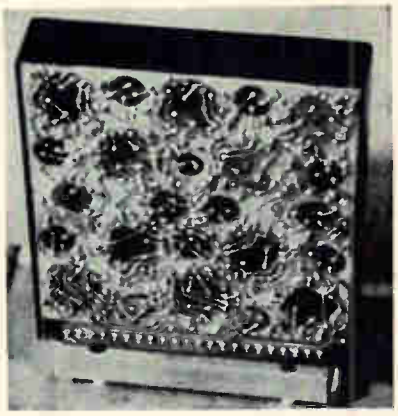
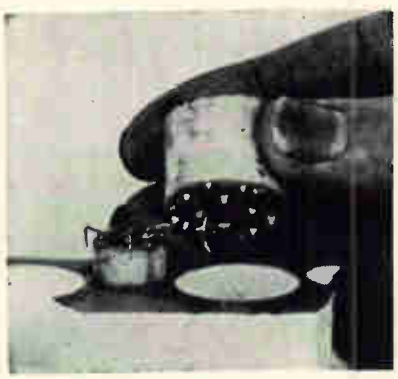
tant factor in space applications.

Components are inserted in separate cells with a plug of dielectric material (see photo). Each element is stored separately and the possibility of short circuiting is eliminated. Also, each component is held firmly on all sides, reducing substantially the possibility of leads being broken from shock or vibration. Leads from each component are brought to printed-wiring boards attached to both sides of the cell.

Each module, or subcircuit is then inserted into a base housing consisting of identical dielectric



Connected cells are easily removed



Unicell is housed in foam and epoxy

material. Both sides of the assembly are faced with printed wiring boards, which provide connections between cells and connector pins. The base assembly is protected on three sides by a metal frame, so no special adapters are needed to unplug the unit. All leads are brought to one end of the assembly and terminate with pin-type connectors. Electrical interconnections between components are accessible on the face of the assembly, greatly simplifying trouble shooting.

Developmental units, produced to date, have passed all required military specifications for shock,

vibration, and other tests.

Another proposed system consists of wafer-thin resistor elements which can be stacked and connected to obtain any value of resistance. Each element measures 0.3-in. diam and ten-thousandths of an inch thick. Elements are composed of a dielectric base material to which a resistive circuit is attached. The circuit can be tapped at eight points to create different resistance values. Present plans are to space the taps to give a linear change in resistance.

The system allows a large range of resistance values to be covered by a few standard elements.

PRINTED-CIRCUIT PROGRAMS

The Institute of Printed Circuits, Inc., 27 East Monroe St., Chicago, is a National Trade Association of the printed-circuit industry. This group, founded in 1957, has helped standardize printed-circuit techniques and dimensional tolerances. The fourth annual meeting of the IPC will be held in New York City, Mar. 21-22, at the Barbizon-Plaza Hotel. All sessions will be open only to representatives from member companies.

The military establishments have conducted a number of programs on standards and test procedures for printed circuits, integration and packaging of transistorized printed-circuit assemblies, ultraminiature printed - circuit connectors, and printed-circuit research in general.

Current areas of interest to the military are protective-packaging techniques, hermetic-sealing techniques, printed-circuits for nuclear environments, layered printed wiring, high-temperature printed circuits, and printed-wiring soldered connections.

Several government contracts are now active in these areas, conducted by International Resistance Co., Inland Testing Laboratories, Sylvania, Cinch Manufacturing Co., Mellon Institute, Haloid Xerox, Molded Insulation Co., General Electric, and others.

Two technical reports, now released by agencies of the U. S. Government for public dissemination are:

(1) High-Temperature Printed Circuits, PB 129 597, Ordered from Library of Congress, Photoduplication Service, Publication Board Project, Washington 25, D. C. Covers period from 10/59 to 12/59, $12.30.

(2) Performing Research on New Approaches to Printed Circuits, PB 137 520, Ordered from same agency as above. Covers period from 3/56 to 11/57, $13.80.

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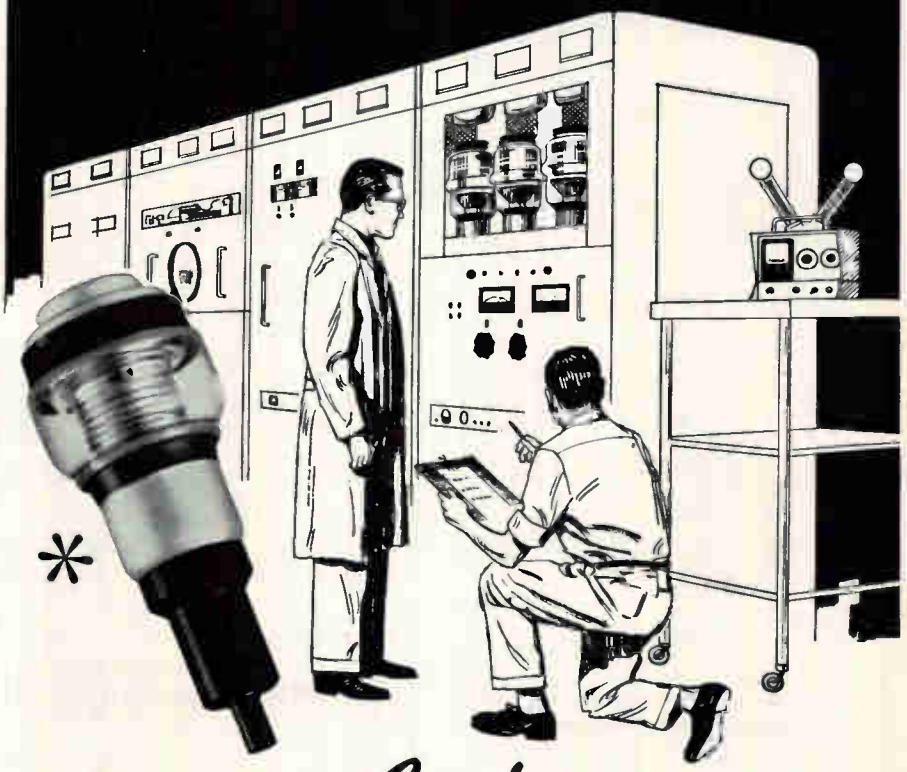

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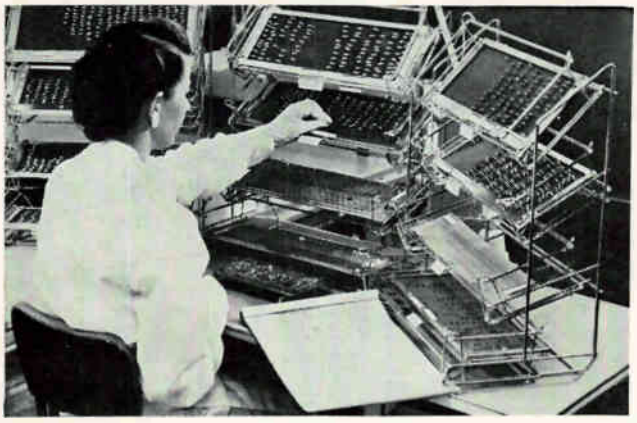


Wire racks place all parts within easy reach of the assembler

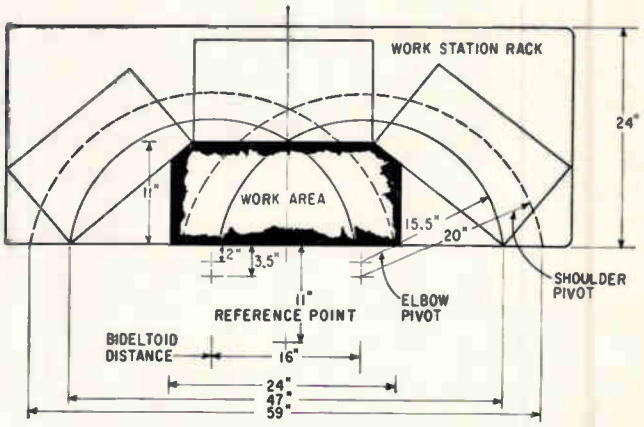


FIG. 1—Work station plan is based on furniture and body dimensions

Human Engineered Assembly Stations

By GEORGE PETERS,
Autonetics Division of North American Aviation, Inc., Downey, Calif.

WORK STATION DESIGN was tackled early in development of a packaging and handling system for high-reliability missile components. Major objectives were preservation of component reliability and "humaneering" to ensure maximum productivity. The work stations present assemblers with all the components needed to assemble a circuit board at a single station, avoiding degrading multiple handling.

Component carriers and grid boards for loose components are displayed on wire racks in a semicircle around the assembler. Placing components and tools in the most advantageous position required careful consideration of the physical measurements of assemblers. When parts are easy to see and reach, work rates and accuracy are improved and fatigue lessened.

A thorough review and analysis of anthropometric data (human body measurements and relationships) was made. Although other manufacturers' needs may require consideration of different parameters, the description of a typical

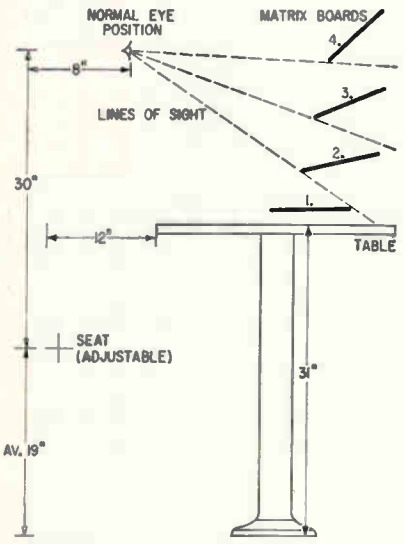


FIG. 2—End view of work station

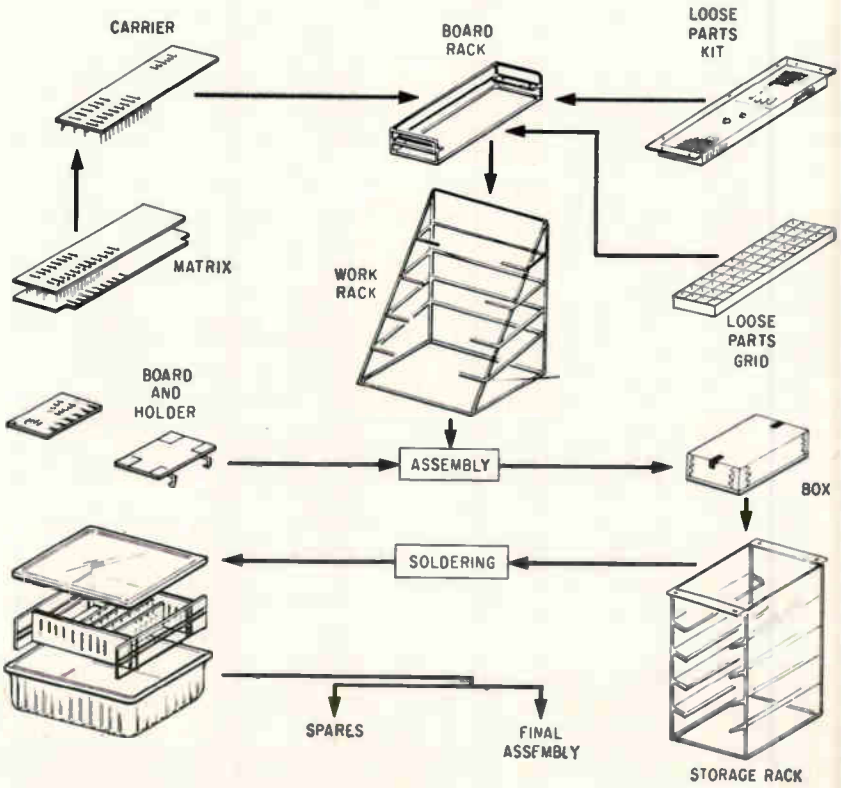
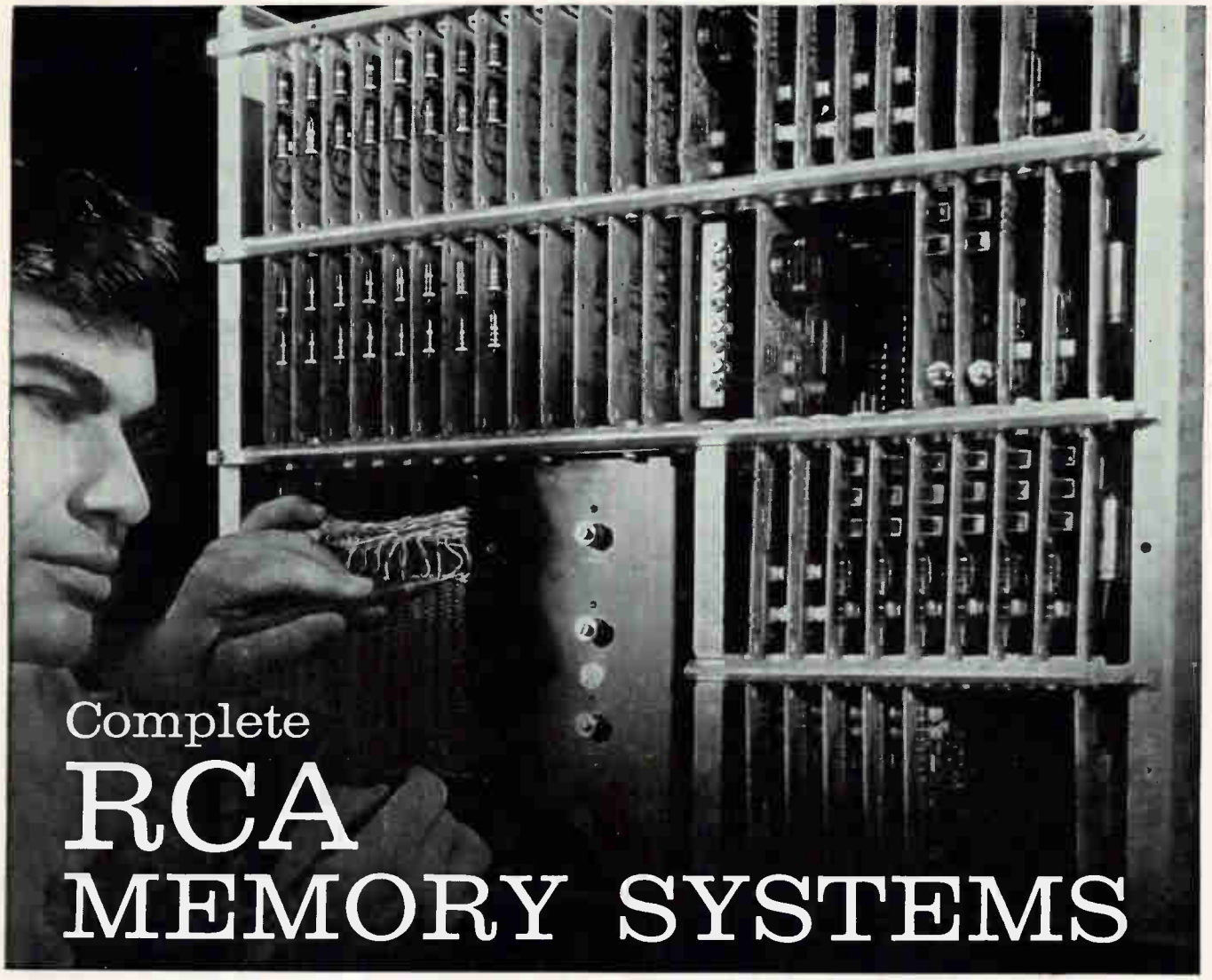


FIG. 3—Simplified diagram of handling and assembly procedures



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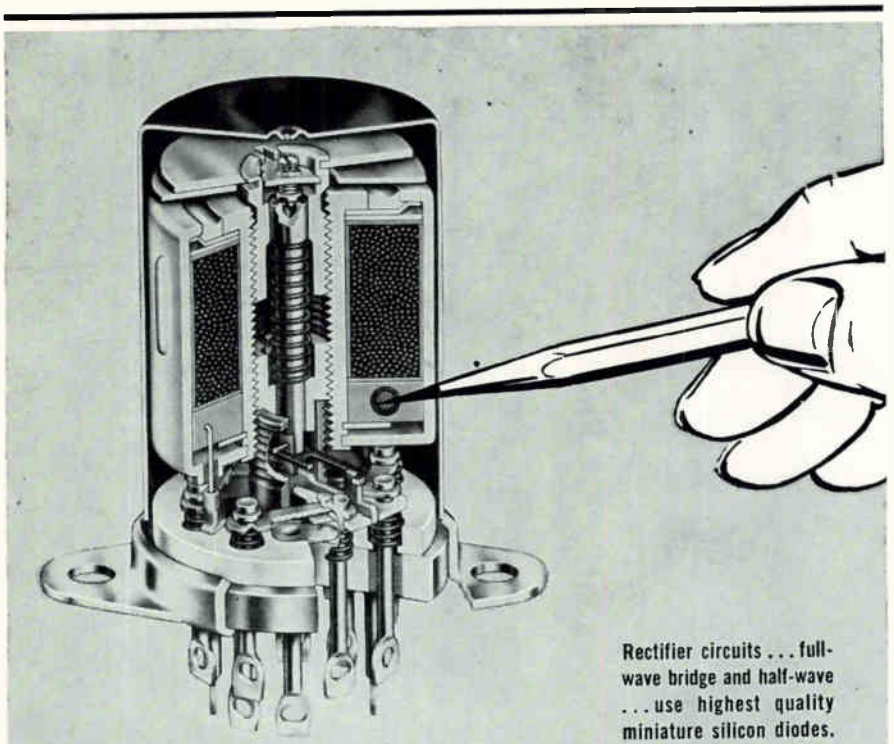

Relay shown 1½ times actual size

Rectifier circuits . . . full-wave bridge and half-wave . . . use highest quality miniature silicon diodes. Note potted construction.

For reliable switching try "Diamond H" Series RA and SA relays with a-c coils

These relays are identical in size and weight to Hart's widely specified Series R and S d-c relays and meet the same specifications*. And, thanks to their unique design, they provide the same shock resistance (to 50G), the same vibration resistance (to 20G-2000 cps), and the same performance under temperatures ranging from −65°C to +125°C. Contact ratings from dry circuit to 10 amps, 115 volts a-c resistive and 30 volts d-c resistive.

The complete line of "Diamond H" miniature hermetically-sealed relays includes hundreds of models. Contact ratings, pull-in and drop-out times, temperature, vibration and shock ratings, mounting arrangements and other specifications can be varied to meet your particular performance requirements. Ask for descriptive literature and specification list.

*Like the R and S series, they meet the requirements of MIL-R-5757C. Models are also available to fill the requirements of MIL-I-6181.

Visit us at I.R.E. Booth 1637

THE HART MANUFACTURING COMPANY
202 Bartholomew Avenue
Hartford 1, Conn.
Phone JAckson 5-3491

setup (Figs. 1 and 2) may be helpful.

Location of components on a work bench depends not only on body structure and normal ranges of vision. It also depends on such relatively inflexible factors as production furniture dimensions (usually adjustable to average body size ranges), lighting and material flow lines. Ideally, tables, benches, chairs and stools would be specially designed, but it is more practical to design around existing equipment.

Interactions of body parts are reckoned against furniture limitations. Working ranges, for example, depend on arm length, shoulder breadth, shoulder joint play, reaching direction, back angle, sitting height, wrist position and normal eye position. Fig. 1, a top view of a scale layout, was made to analyze reach ranges and insure that all parts are accessible. Fig. 2 determined angles of boards and carriers in the racks, to keep each completely visible with the eyes in their normal position.

A bibliography of useful anthropometric studies is given. Those on Air Force servicemen and women were found most useful. Relatively little data exist for electronics industry workers, especially women, and data on extra-large, extra-small or handicapped personnel is insufficient.

Carriers and boards are handled during delivery and in-process storage in individual wire-form racks which fit into the work stations. Circuit boards are delivered in modular tote boxes like those shown in Fig. 3. This integrates the work station with the handling system.

Component carriers appear early in the system as part of a matrix

Board is fitted into wire and plastic insert of tote box

Autonetics packaging and handling system won a first place award for the author in the Materials Handling Division at the Society of Packaging and Handling Engineers annual national competition, held at the 1960 Western Packaging and Materials Handling Show

assembly. Components, with leads precut and formed, are loaded into the assemblies by suppliers. The assemblies go directly into automatic test equipment and power load storage racks. After testing, the matrix is disassembled by passing the lower board through molten solder, freeing component leads. The upper board, or carrier, goes to storage areas and then to assemblers. The system is partly shown in Fig. 3.

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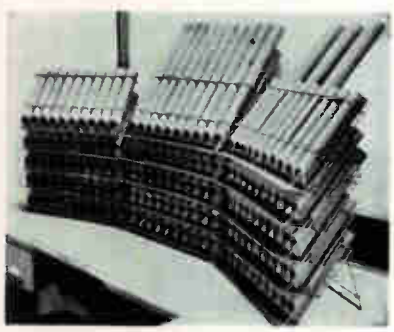
Wire Fed from Tubes In Stackable Racks

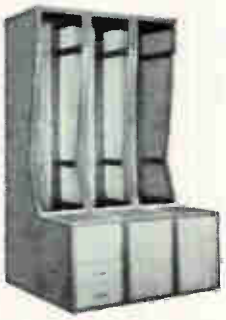


Rack used singly

WIRE DISPENSER recently announced by Products for Industry, Inc., Stamford, Conn., consists of 10 plastic tubes held in a rack. Wires of any length can be clipped in the tube for one-at-a-time withdrawal. Containers can be stored after being loaded with cut wire. Racks can be hung, used on an easel stand or stacked.

3-IN-ONE AMCO ENCLOSURE SYSTEM

Provides Cooling, Mounting and Lighting in Modular Enclosures for Electronic Instruments in Any Installation



Aluminum

Semi-Custom

Custom

No one type of enclosure meets all environmental and physical demands. AMCO has developed 3 complete systems integrated into 1 system with interchangeable accessories, applicable for both commercial and military use.

ALUMINUM...Unique! Meets any size... Flush or recessed mounting of panels. Almost any shape from 13 basic parts . . . 3 castings & 10 extrusions. Units from 6" to 20 ft.; slopes from 0° to 90° standard. MilSpecs 6062-T6 extrusions and 356-T6 castings.

SEMI-CUSTOM...Heavy-duty, more internal clearance... 14 ga. box-channel steel frames, 12 ga. gusseting provides exceptional rigidity both front-to-back and side-to-side. Frames based on 22 1/16" increments provides clearance for recessing 19" wide panels. Meets EIA Standards.

CUSTOM...When space and appearance are critical... 16 ga. double-channel steel frames, based on increments of 19 1/16" widths, supports in excess of 3000 lbs. Multi-width panels and cowlings give single-unit appearance with series mounted racks. Meets EIA Standards.

Amco manufactures all necessary blowers, chassis slides, doors and drawers, writing surfaces, cowling lights and other accessories. **Check the extra savings you get thru Amco's combined-discount system of racks and accessories.** *PLUS FREE ASSEMBLY.*

Amco is your one complete source of Modular Instrument Enclosure Systems and Accessories. Write today for catalog of complete specifications.

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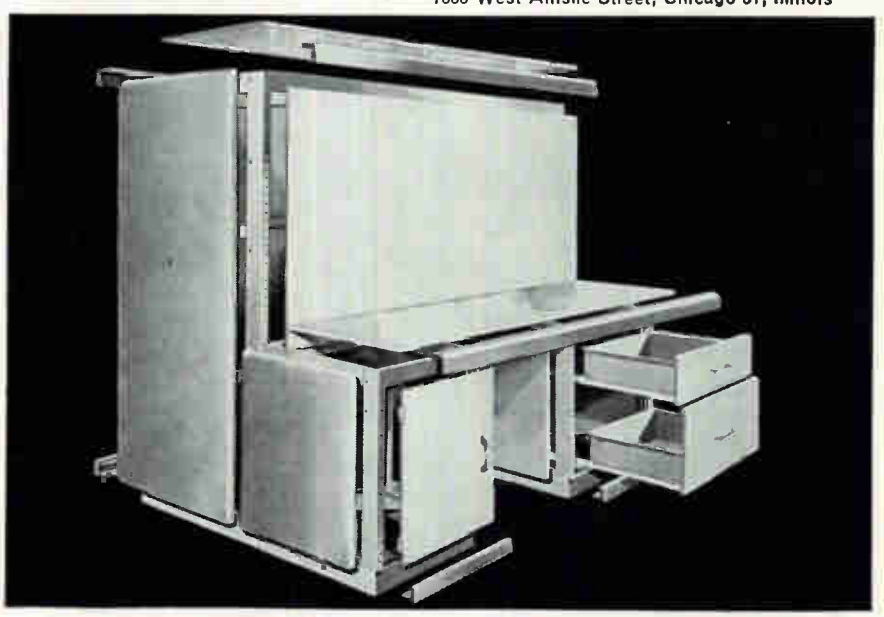
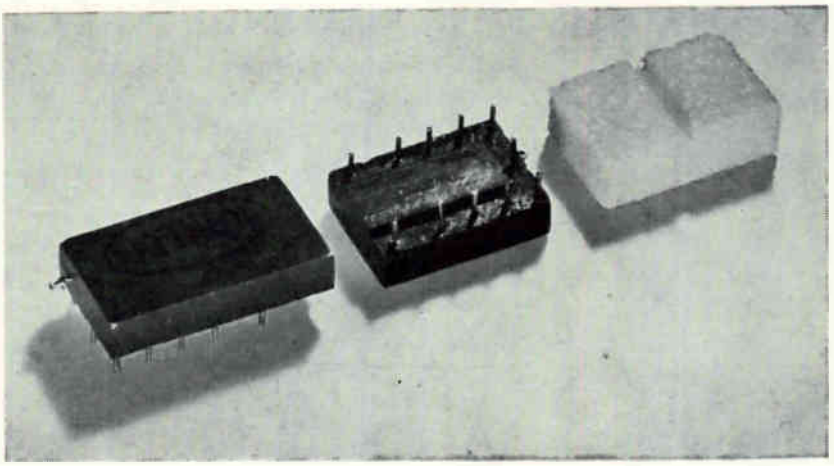
Factory trained representatives in principal cities of U.S. and in Canada.

AMCO ENGINEERING CO.
7333 West Ainslie Street, Chicago 31, Illinois



See us at the I.R.E. Show, Booth Nos. 4501-4503

New On The Market



Nine Logic Circuits

WELDED CIRCUIT TECHNIQUE

NINE Weld-Pak logic circuits for direct substitution in transistorized computer circuits have been introduced by Industrial Components div., Raytheon Co., 55 Chapel St., Newton 58, Mass.

A typical plug-in unit uses 17 diodes, capacitors and resistors and two transistors in modules 1 × ¾ by less than ⅜ inch. Operating temperature is from −55 to 55 C.

The nine circuits, numbered WM-101 through WM-109, are: NOR gate, NOR gate and emitter follower, flip-flop, emitter follower, diode AND, diode OR, counter-shift register flip-flop, clock variable, and an inverter. All units require +10 v and −10 v supplies, with clamp supply when necessary.

Operating speed is to 100 Kc, except the clock variable, which operates to 300 Kc.

Prices range from $25 to $50, with 30 to 60 days delivery.

CIRCLE 301 ON READER SERVICE CARD

Tunnel Diode Amplifier

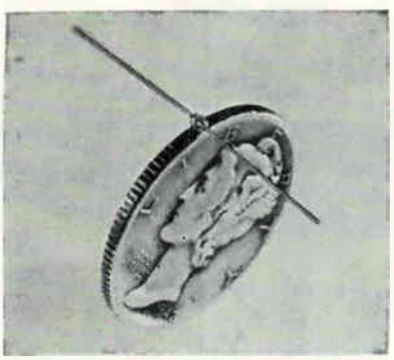
LOW-NOISE, BROADBAND

LOW-NOISE, broadband tunnel diode amplifiers, designed and manufactured by Micro State Electronics Corp., 152 Floral Ave., Murray Hill, N. J., can cover octave bandwidths at uhf.

Noise level of the hybrid-coupled amplifier is 3.5 db. The OTA 250, operating from 250 to 500 Mc, can be used with traveling wave tube and vacuum-tube amplifiers in the uhf region.

Uses include countermeasure, high sensitivity spectrum analyzers, broadband telemetry, antenna multicouplers, broadband surveillance, high definition broadband radar, broadband communications, and ultrahigh frequency direction finding systems.

CIRCLE 302 ON READER SERVICE CARD



Two Glass-Sealed Diodes

FOR LOGIC CIRCUITS

TWO microminiature glass diodes are announced by Texas Instruments Inc., P. O. Box 5012, Dallas 22, Texas.

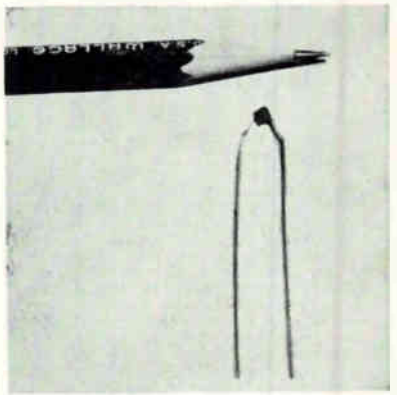
The MICRO/G diodes have a diameter of 0.040 and are 0.060 inch long.

The TI-2 and TI-6 are for computer diode and transistor-diode logic circuits, and for high-speed switching. Electrical characteristics are said to be equal or superior to those of normal size computer devices, with reverse recovery of 10 and 100 nsec respectively.

The diodes use diffused silicon mesa wafers with oxide-passivated surfaces, giving stability and reliability.

Prices are competitive with larger counterparts and the diodes are available off-the-shelf from TI distributors.

CIRCLE 303 ON READER SERVICE CARD

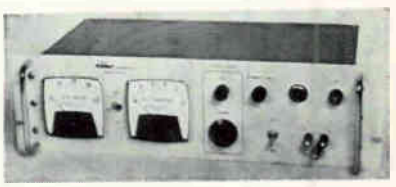


Ceramic Capacitors

TO 2,500 PF

SUBMINIATURE ceramic capacitor line named Wee-Con is announced by Erie Resistor Corp., 644 W. 12th St., Erie, Pa. This series of dipped phenolic coated, plate ceramic capacitors are available in six sizes varying from 0.15 × 0.15 × 0.1 to 0.6 × 0.5 × 0.15. The capacitor shown is available to 2,500 pf, with a Z5U temperature characteristic. Other properties include: wide range of both TC and Hi-K dielectrics; 10 pf to 0.036 μf; 200 volts d-c working voltage; 85 C operating temperature.

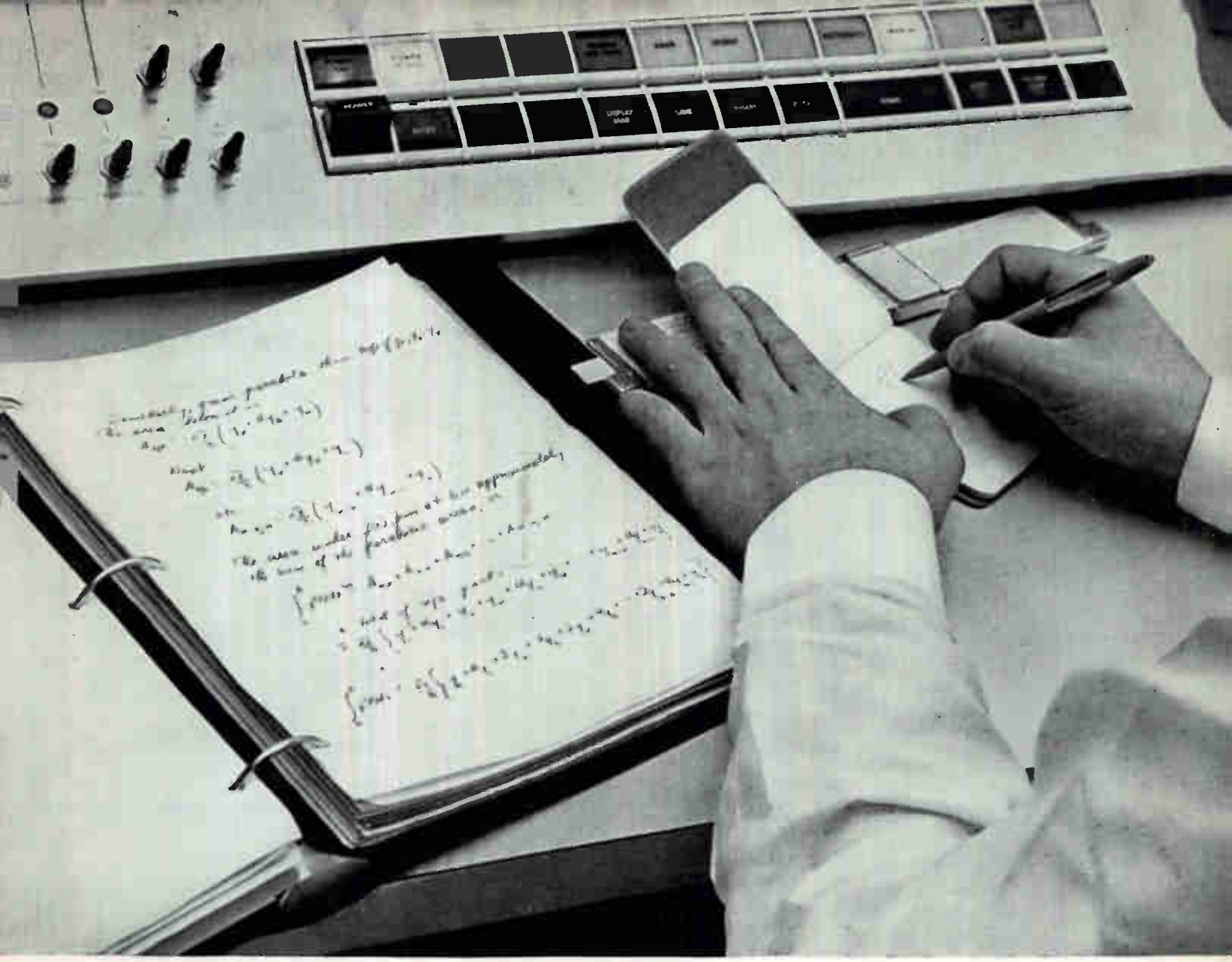
CIRCLE 304 ON READER SERVICE CARD



Efficient Power Supply

SWITCHING REGULATOR

NO ADDITIONAL internal heat is generated in transistorized power sup-



Free engineers for creative assignments with the new low-cost IBM 1620

The IBM 1620 Data Processing System is a low-cost solution to the problem of freeing engineers for their most creative and profitable assignments. Here's why:

EASY TO USE—Just a two-day training class is all you need to put your 1620 into operation. This means no delays in learning to use the 1620 computer.

In addition, you get a wide range of free programming services including FORTRAN and GOTRAN. FORTRAN is the powerful scientific language that lets you solve problems without writing detailed computer instructions. GOTRAN is a simplified language (a sub-set of FORTRAN) that lets you enter simplified problem statements and data into the computer with the solution immediately available, in one simple operation.

FAST—The 1620 solves a set of ten simultaneous equations in only 20 seconds. It inverts a 10 x 10 matrix in just 42 seconds.

POWERFUL—The 1620 inverts a 40 x 40 matrix. With optional additional core storage the 1620 can handle matrix inversion problems of a much higher magnitude.

GET FULL DETAILS—The 1620 is the most outstanding engineering and scientific computer in its price range. A basic installation rents for just $1,600 a month.

To learn how the 1620 can free you for more creative engineering work, call your local IBM representative.

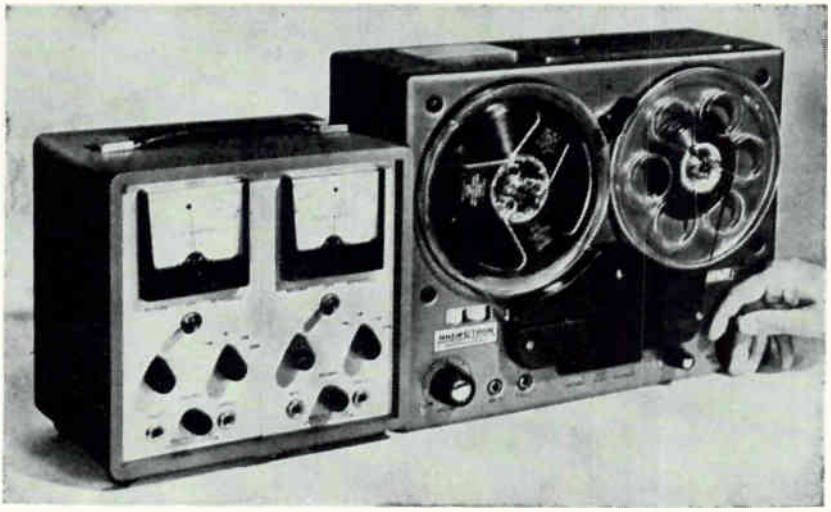
IBM's 1620 is a compact desk-size computer.

IBM®
DATA PROCESSING

ply from continuous overloads or continuous shorts. A continuously variable limiting circuit confines the maximum current to between 1.0 and 10.5 amperes.

Power supply efficiency of 80 percent is attained by using a switching preregulator. Specifications of Model RB-40V10SS include: 105 to 125 volts, 60 to 400 cps input; output of 0 to 40 volts at 10 amp; load regulation of 0.01 percent. Transient recovery is 50 mv max within 50 μsec. Parallel and series operation. Size is 5¼ x 19 x 14 inches; wt, 35 pounds. The unit is available from Valor Instruments, Inc., 13214 Crenshaw Blvd., Gardena, Calif.

CIRCLE 305 ON READER SERVICE CARD



Analog Recorder

PORTABLE 2-CHANNEL

MODEL 102A record/reproduce system, manufactured by Mnemotron Corp., 3 N. Main St., Spring Valley, N. Y., is a portable 2-channel system, complete with tape transport.

Recording and reproduction of analog data from 0 to 400 cps is by pulsed f-m, giving 0.2 percent accuracy. The recorder can be used for time scale contraction and expansion, dynamic simulation, programming, and computer read-in and read-out.

The device has 3 tape speeds, wide dynamic range, independent record and reproduce channels, and low noise and low crosstalk. Price is $1,390.

CIRCLE 306 ON READER SERVICE CARD

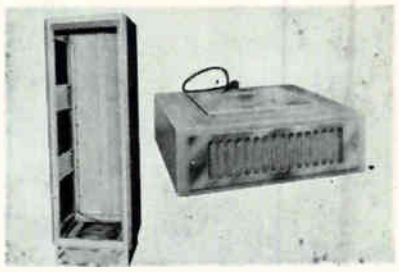
Semiconductor Lappers

GIVE HIGH PARALLELISM

TWO precision planetary lappers for semiconductor crystal processing, producing parallelism within five millionths of an inch and high flatness, are available from Dallons Laboratories, Inc., 5066 Santa Monica Blvd., Los Angeles, Calif.

Each model will lap both faces of a slice simultaneously. Model PL-2875-B has a 2⅞ inch track and ten carriers or work holders, and will lap 10 slices 1¾ inch diameter, or 60 smaller slices, to a thickness of 0.008 inch. Model PL-1875-B will lap 51 small slices to a thickness of 0.003 inch.

CIRCLE 307 ON READER SERVICE CARD



Rack Cooler

SUPPORTS 2,000 POUNDS

PONTOON BASE BLOWER is designed for installation under electronic cabinet, will support a 2,000 pound load. Two models are available, one with a 500 cfm output, one with 250 cfm output.

The units use centrifugal blowers to supply filtered air; they can be equipped with heavy duty casters. Motors meet MIL-SPEC-CC-M-636A. Shipment can be made from stock; McLean Engineering Labs., P. O. Box 228, Princeton, N. J.

CIRCLE 308 ON READER SERVICE CARD

Preamplifier

PARAMETRIC TYPES

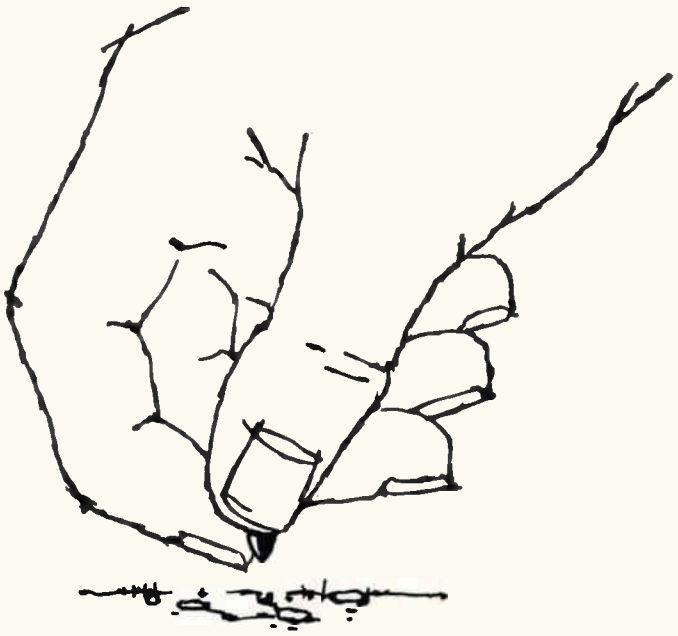
LEL, INC., 75 Akron St., Copiague, N. Y. The RA-1 series of reactance amplifiers, built as a weatherproofed sealed unit for antenna mount use, is suited for distant range tracking, troposcatter links, or radio astronomy uses. Passband is 225-260 Mc; gain, 25 db; noise figure, less than 2 db; input and output, 50 ohms.

CIRCLE 309 ON READER SERVICE CARD

Flutter Meter

HIGHLY SENSITIVE

AMPLIFIER CORP. OF AMERICA, 398 Broadway, New York 13, N. Y. Model 590-A-1 provides a sensitive,



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This is *planned* advertising. You might call it "planting for tomorrow".

The sales seed in an advertising message bears abundant fruit if sown in fertile ground . . . readers of this publication, for example, who, in *buying* this issue, have demonstrated their interest in what we have to say.

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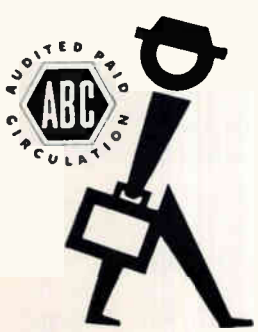

electronics

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More than 107 types standard solder terminals

WEBSTER KNOWS

In fact, his definition certainly applies to CAMBION® Standard Solder Terminals. As parts which terminate plenty of trouble in electronic circuitry construction, they've gained universal approval from manufacturers, professional technicians and hams.

Starting with top quality brass, each CAMBION solder terminal is precision machined, quality inspected, electroplated with silver, electro-tin or gold — or to your own plating specifications. Close quality control is maintained, and inspections made at each successive manufacturing step to assure that each terminal meets or exceeds applicable MIL specifications, such as MIL-Q-5923C.

That's why, as with all components in the broad CAMBION line, top quality is guaranteed for the more than 30,000,000 CAMBION Solder Terminals in stock . . . in more than 107 different types: single, double and triple turret; feed-through, double-ended, hollow and split.

The broad CAMBION line includes plugs and jacks, solder terminals, insulated terminals, terminal boards, capacitors, shielded coils, coil forms, panel hardware, digital computer components. For a catalog, for design assistance or for both, write to Cambridge Thermionic Corporation, 437 Concord Ave., Cambridge 38, Mass.

CAMBRIDGE THERMIONIC CORPORATION
CAMBION®
The guaranteed electronic components

rapid and accurate method of visual indication of wow and flutter content of all types of tape recorders and playback equipment. A built-in preamplifier and input attenuator will accept voltages from 1 mv to 300 v. Connection may be made directly across magnetic tape playback heads, or across high-level circuits delivering up to 300 v. Flutter and wow readings can be made down to 0.01 percent. Unit is designed for use by schools, labs, broadcast stations, and recording equipment manufacturers.

CIRCLE 310 ON READER SERVICE CARD

Variable Transformer
WITH SELECTION SWITCH

OHMITE MFG. CO., 3627 Howard St., Skokie, Ill. Featured in the VT8G portable, variable transformer is the overvoltage-no overvoltage selection switch. With it, the user can limit the maximum output of the transformer to the line voltage (120 v) or to the overvoltage rating (140 v). Price, 1 through 5, $28.50.

CIRCLE 311 ON READER SERVICE CARD

Resin Encapsulant
TRANSPARENT, FLEXIBLE

DOW CORNING CORP., Midland, Mich., introduces Sylgard 182, a silicone resin encapsulant that permits visual inspection of circuits and components within potted, em-

bedded or encapsulated assemblies. Applied as an almost colorless liquid—after blending with its curing agent—it cures in place even in totally confined enclosures, to form a transparent mass having outstanding dielectric properties, good moisture resistance, flexibility and toughness.

CIRCLE 312 ON READER SERVICE CARD

Complex Ratio Bridge
SOLID STATE

GERTSCH PRODUCTS, INC., 3211 S. La-Cienega Blvd., Los Angeles 16, Calif. Model CRB-4 a-c bridge is capable of generating and indicating the complex ratio needed to duplicate a ratio under test. A self-contained phase- sensitive null indicator is used to show when the two ratios are exactly equal. Measuring only 5¼ in. high, this rack mounted unit operates from a-c line or internal battery source. Models can be supplied for any fixed frequency in the range of 50 to 1,000 cps.

CIRCLE 313 ON READER SERVICE CARD

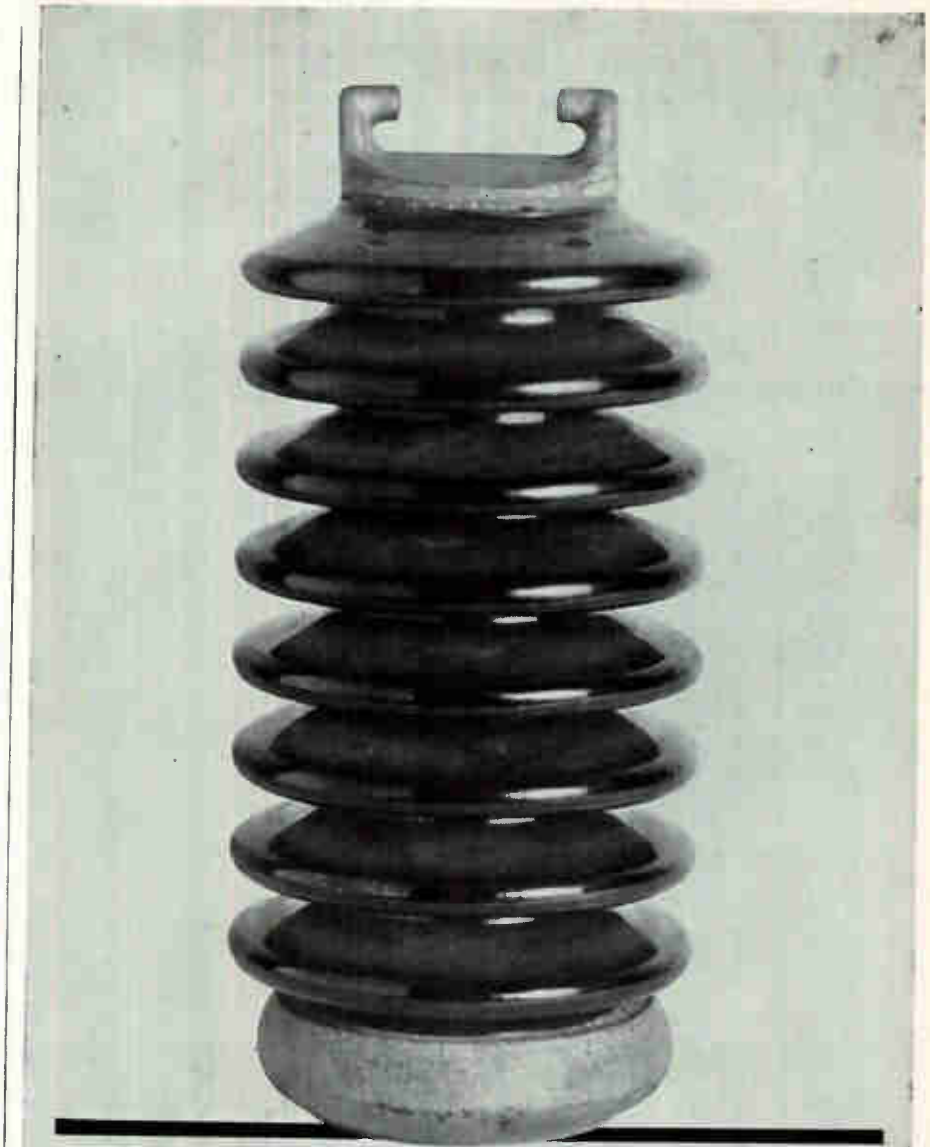
P-C Connectors
TANDEM DESIGN

CONTINENTAL CONNECTOR CORP., 34-63 56th St., Woodside 77, N.Y. Series 600-7 p-c connectors are used in missile and rocket ground guidance equipment, and offer a unique tandem design that combines four groups of p-c receptacles in a single 8.63 in. long molding. A total of 140 contacts are divided into two sets of 38 and 32 contacts separated by an integral center barrier in the molding. Either two or four, ⅛ in. p-c boards can be inserted in the receptacle.

CIRCLE 314 ON READER SERVICE CARD

Oscilloscope
HIGH SENSITIVITY

EDGERTON, GERMESHAUSEN & GRIER, INC., 160 Brookline Ave., Boston 15, Mass. Model 707 Milli-Mike oscil-



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Transistors, tubes and electronic equipment get there fast, safe and sound on Air France! Swift, frequent service throughout the week to The Common Market, The Outer Seven, Mexico, almost anywhere in the world. Service from New York, Los Angeles, Chicago, Montreal, Anchorage, and every flight carries 10,000 pounds! Cargo compartments are pressurized and temperature-controlled. Save on crating, shipping weight. New low insurance costs, too! Air France speeds cargo to more cities in more countries than any other airline. Specify Air France to your Cargo Agent!

AIR FRANCE CARGO

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first choice **FOR** *critical applications*

POLYCON SEC MYCON

ADJUSTABLE PRECISION POLYSTYRENE CAPACITORS

.01% accuracy hermetically sealed

SOUTHERN ELECTRONICS hermetically sealed precision adjustable capacitors are finding many applications in analog computers, network tuning circuits, differential analyzers and similar electronic circuitry that requires the utmost in accuracy and reliability.

SEC has pioneered in the design and manufacture of **hermetically sealed** adjustable capacitors, and this experience has resulted in a **.01% accuracy standard**, and a degree of in-circuit-reliability not previously available at any price. **SEC** adjustable capacitors incorporate features proven to be years ahead of any comparable product now available.

GENERAL SPECIFICATIONS

Available from .01 mfd. to 10 mfd.
Accuracy: .01%
Long Term Stability: 0.03%
Temperature Coefficient: —100 PPM per °C
Temperature Range: —40°F to +140°F

Write today for complete specifications and general catalog.

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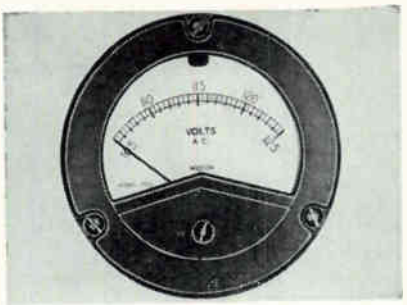
SOUTHERN ELECTRONICS *Corporation*

150 WEST CYPRESS AVENUE
BURBANK, CALIFORNIA

loscope has both single-transient and repetitive signal capabilities. Features a d-c to 2,000 Mc bandwidth, 0.2 nsec rise time, an illuminated parallax-free reticle, high sensitivity, and ease of operation. Repetition rate is 100 Kc.

CIRCLE 315 ON READER SERVICE CARD



Ruggedized Meters
TWO SIZES

WESTON INSTRUMENTS DIVISION of Daystrom, Inc., 614 Frelinghuysen Ave., Newark, N. J., has available a line of low-cost ruggedized instruments in a-c, d-c, and a-c rectifier types, designed to meet government specification MIL-M-10304B. The instruments, employing newly designed movements, magnetic systems, and cases have undergone intensive high shock, tumbling and vibration tests. They are being offered in 2½ and 3½ in. sizes.

CIRCLE 316 ON READER SERVICE CARD

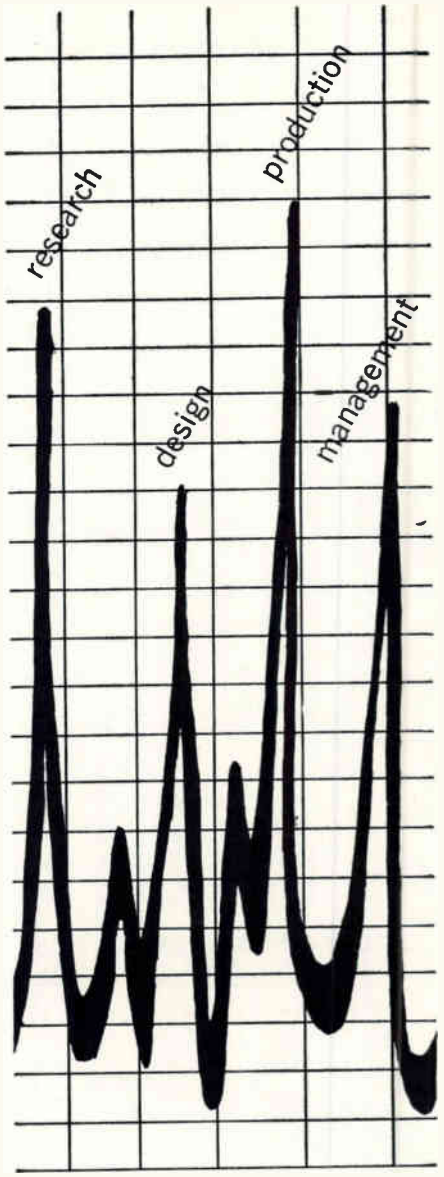
Fuse Posts

LITTELFUSE, INC., Des Plaines, Ill. Four miniature posts with two different knob and connecting terminal combinations fit all 3AG applications.

CIRCLE 317 ON READER SERVICE CARD

Industrial CRT
BONDED SHIELD

SYLVANIA ELECTRIC PRODUCTS INC., 730 Third Ave., New York 17, N. Y. Type SC-3076 is a 5-in. industrial Bonded Shield cathode ray tube that



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features a permanent built-in reference scale on an integral reflection-free safety panel. It offers maximum image visibility, wide angle viewing, simplified mounting and styling, decreased reflection, protection against breakage, simplified tube face cleaning, and a self-contained writing surface.

CIRCLE 318 ON READER SERVICE CARD

Ceramic Capacitor

ELECTRAMICS CORP., P. O. Box 275, Solana Beach, Calif. Ultraminiature Ceramin capacitors provide low dissipation factors and desirable temperature coefficient curves.

CIRCLE 319 ON READER SERVICE CARD

Controlled Rectifier
FIVE AMPERE RATED

INTERNATIONAL RECTIFIER CORP., 1521 E. Grand Ave., El Segundo, Calif. Types X5RC2 through X5-RC40 silicon controlled rectifiers will switch up to 5 amperes of current over a peak reverse voltage range from 20 to 400 v. They are designed for low power switching and control applications, and enable rapid firing (1 to 5 μsec) with a minimum of current (2 to 5 ma typical) on such applications as static inverters, d-c motor control, frequency changing, etc.

CIRCLE 320 ON READER SERVICE CARD

Signal Generator
VERSATILE UNIT

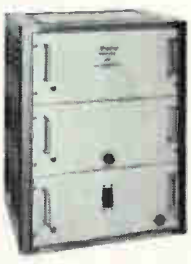
JERROLD ELECTRONICS CORP., 15th and Lehigh Ave., Philadelphia 32, Pa. Model 900-B offers a versatile combination of measurement functions and eliminates the need for

NOW! A WHOLE FAMILY OF...

Powertron
ELECTRONIC GENERATORS

Single Phase With Output Powers From 3VA-750VA

Two-Phase With Output Powers From 6VA-1500VA



Three-Phase With Output Powers From 9VA-2250VA

TYPICAL SPECIFICATIONS
(Model 250 Illustrated Above)

Fixed Frequency	400 C.P.S.
Accuracy	.25%
Distortion	Less than 1%
Regulation	Less than 1%
Output Power	250VA
Variable Frequency	350-450 CPS
External Freq. Range	50-4000 CPS
Output Voltage	0-125V RMS
Mounting	Desk Top or 8¾" x 19" Rack Panel.

- HIGHER POWER UNITS TO ORDER
- FREQUENCY ACCURACIES AVAILABLE TO .001%

OFF THE SHELF DELIVERY ON MANY OF THE MODELS LISTED BELOW:

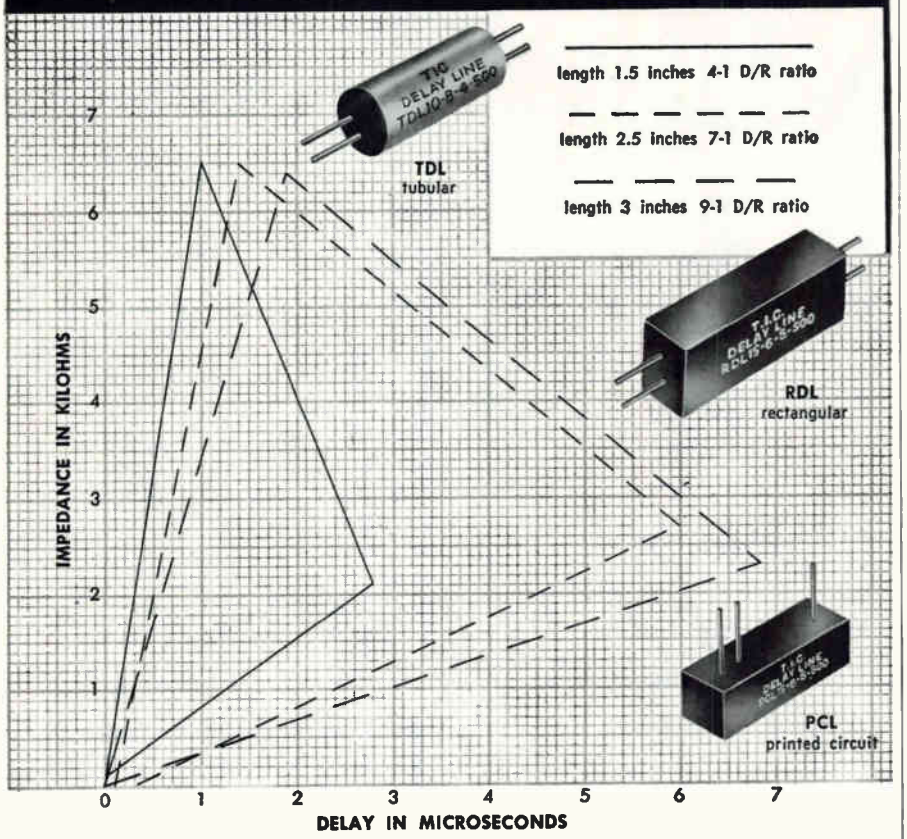
Model 1040 (1Ø, 3VA)	Model 1040-2 (2Ø, 6VA)	Model 1040-3 (3Ø, 9VA)
Model 1040A (1Ø, 8VA)	Model 1040A-2 (2Ø, 8VA)	Model 1040A-3 (3Ø, 24VA)
Model 1500 (1Ø, 20VA)	Model 1500-2 (2Ø, 40VA)	Model 1500-3 (3Ø, 60VA)
Model 150 (1Ø, 160VA)	Model 150-2 (2Ø, 320VA)	Model 150-3 (3Ø, 480VA)
Model 250 (1Ø, 250VA)	Model 250-2 (2Ø, 500VA)	Model 250-3 (3Ø, 750VA)
Model 750 (1Ø, 750VA)	Model 750-2 (2Ø, 1500VA)	Model 750-3 (3Ø, 2250VA)

WRITE FOR DESCRIPTIVE BROCHURES AND PRICES

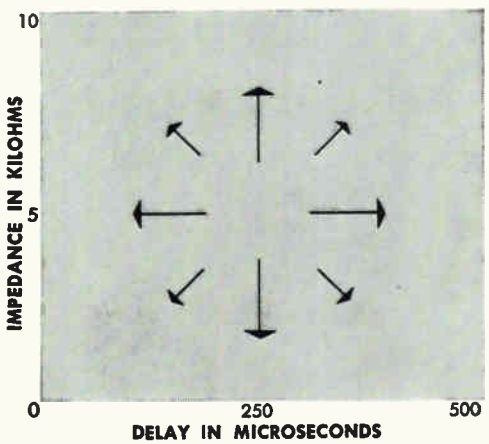
ITECO
INDUSTRIAL TEST EQUIPMENT CO.
55 E. 11th ST. • NEW YORK 3 • GR. 3-4684

Visit Booth No. 3613—Radio Engineering Show
New York Coliseum, March 20-23, 1961

Plot your lumped constant delay line needs on these charts! *



* If your requirements fall within any one of the triangles then the TIC standard type in any configuration is your answer. For other specifications PDL type provides Delay time to 500 microseconds, Impedance 25 to 10,000 ohms, Delay to Rise ratios to 150-1.



TIC OF CALIFORNIA

DELAY LINES

FEATURE:

- **HIGHER RELIABILITY**
- **LOWER ATTENUATION**

TIC's lumped constant delay lines are available in three standard configurations, TDL (tubular), RDL (rectangular), PCL (printed circuit), PDL series (are made to customer specifications). They feature a higher delay to rise time ratio per cubic inch than is available with conventional techniques. Every TIC Delay Line is hermetically sealed and complies with applicable MIL specs. TIC Delay Lines are M derived, phase and frequency compensated with excellent pulse response characteristics and exceptionally low attenuation. Standard lead lengths of RDL and TDL units is 2". The PCL lead length is ¾".

Prompt delivery. Write, wire or call.

TIC OF CALIFORNIA ©1960

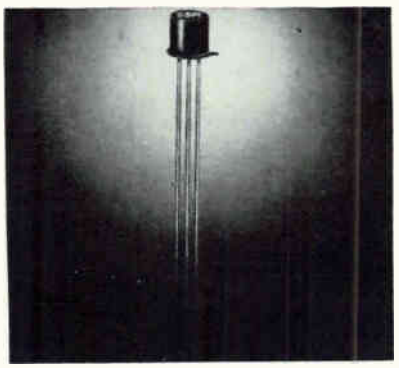
TECHNOLOGY INSTRUMENT CORP. OF CALIFORNIA

850 LAWRENCE DRIVE, NEWBURY PARK, CALIFORNIA • HUdson 5-2165

Western Sales Offices • BEVERLY HILLS, CALIFORNIA • OLEANDER 5-7661

much of the test equipment now required for r-f sweep frequency measurements between 500 Kc and 1,200 Mc. Sweep widths as narrow as 10 Kc and as broad as 400 Mc; high stability; built-in attenuator, marker generator, and scope preamplifier are among the features.

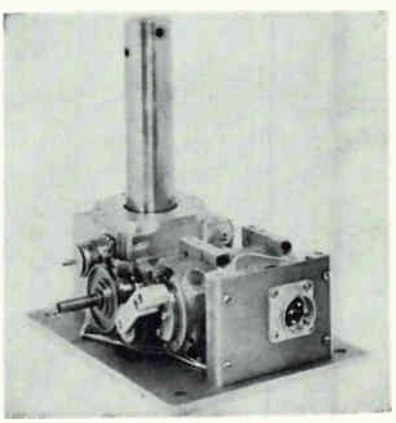
CIRCLE 321 ON READER SERVICE CARD



Triggered Semiconductor
SIMPLIFIES LOGIC

SOLID STATE PRODUCTS, INC., One Pingree St., Salem, Mass., has available a Trigistor series, which offers a new concept in logic circuitry. With complete on-off control at a single base input, binary functions can be accomplished with only one active element per stage, and the number of auxiliary components is similarly reduced. Practical logic levels down to 1 ma are possible.

CIRCLE 322 ON READER SERVICE CARD



Servo Actuator
8-MILLISEC RESPONSE

AMERICAN ELECTRONICS, INC., 1725 W. Sixth St., Los Angeles 17, Calif., has developed an 8-millisec response electric servo actuator for the control of flight surfaces of missiles. Utilizing a constant speed minia-

When you need **POWER...**

choose NICAD

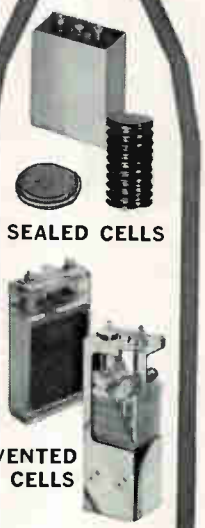
NEW Nickel Cadmium Rechargeable Batteries

SEALED CELLS

Hermetically sealed and rechargeable, Nicad batteries are small in size, require no maintenance, operate in any position. They make practical the battery operation of many types of equipment not previously suited to dry, mercury, or lead acid types.

VENTED CELLS

High surge power cells, in sintered or pocket plate types, are capable of sustained voltage at high discharge rates over a wide temperature range. They have extremely long life . . . little or no maintenance. For more of the POWER story, write Dept. E-61.



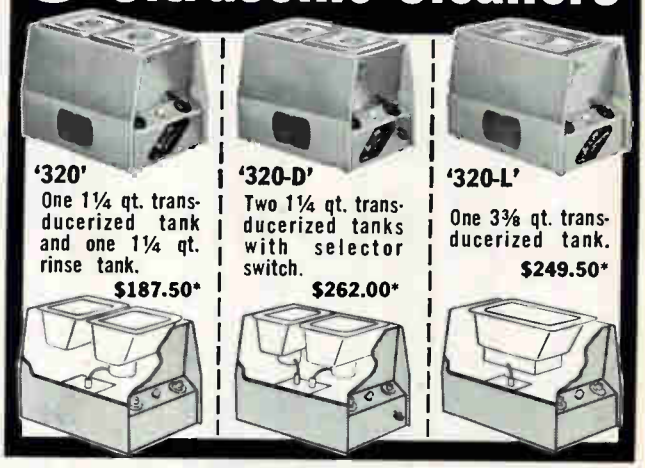
GOULD-NATIONAL GN BATTERIES, INC.

NICAD DIVISION
Gould-National Batteries, Inc.
St. Paul 1, Minnesota

CIRCLE 214 ON READER SERVICE CARD

The ULTRA CLEEN '320' Series now has

3 'PEAK POWER' Ultrasonic Cleaners



'320'
One 1¼ qt. transducerized tank and one 1¼ qt. rinse tank.
$187.50*

'320-D'
Two 1¼ qt. transducerized tanks with selector switch.
$262.00*

'320-L'
One 3⅜ qt. transducerized tank.
$249.50*

*With 1 pint of Hydro-Sonic Cleaning Solution Concentrate

All 3 Ultra-Cleen '320' ultrasonic cleaners are compact—yet their 'peak power' cleans a larger volume of larger pieces faster, more quickly, more efficiently. New electronic circuitry transmits ultrasonic sound waves directly from built-in generator to transducerized tank. Write today for details!

WATCHWORD OF THE WATCHMAKER

"The finest in precision parts cleaning for over 30 years"

L & R MANUFACTURING COMPANY

588 Elm Street, Kearny, N. J. · Chicago 2, Ill. · Los Angeles 13, Calif.

CIRCLE 202 ON READER SERVICE CARD

Are you selling the whole buying team

Tough competition *demands* that the electronics man be reached and *sold* wherever you find him: *Research, Design, Production, and Management.* Only advertising in electronics reaches all four... the same men your salesmen call on. Put your advertising where it works *hardest* . . . . .

in **electronics**

STABILITY:

ONE PART IN

ONE HUNDRED MILLION

NEW SERIES . . . PACKAGED CRYSTAL OSCILLATORS

Shown: Bliley CCO-7M 1000 kc Packaged Oscillator

FEATURES

- Transistorized circuitry with high precision glass-sealed crystal
- Standard frequencies . . . 1000 kc (Type CCO-7M) and 5000 kc (Type CCO-7L)
- **STABILITY:**
  . . . at room temperature: 1 x 10^{-8}
  . . . over range 0°C. to +60°C.: 3 x 10^{-8}
- *BULLETIN 522 AVAILABLE*

Bliley

BLILEY ELECTRIC COMPANY
UNION STATION BLDG., ERIE, PENNSYLVANIA

CIRCLE 89 ON READER SERVICE CARD

Thermal Time Delay Relays

Instant Reset

Voltage Compensated

Vibration Resistant

Precision-built Curtiss-Wright thermal time delay relays reset instantly when de-energized — provide the same delay period for each succeeding cycle. Compensated for wide voltage variations. Available in either 28V DC or 115V AC, 60 or 400 cps. Chatter-free operation, under severe shock and vibration conditions. Small sized, hermetically sealed, temperature compensated for precise, reliable operation and long life. Preset time delays from 10 to 180 seconds with SPST, SPDT or DPDT snap action contacts.

Write for latest complete components catalog #505

See Curtiss-Wright at IRE — Booth 1521-23

AD NO. 4505

Electronics Division
CURTISS-WRIGHT CORPORATION
East Paterson, New Jersey

Try this simple test. Tie a piece of Gudelace around a pencil in a half hitch and pull one end. Gudelace's flat, nonskid surface grips the pencil—no need for an extra finger to hold Gudelace in place while the knot is tied!

Gudelace makes lacing easier and faster, with no cut insulation, or fingers—no slips or rejects—and that's *real* economy. Gudelace is the original flat lacing tape. It's engineered to *stay* flat, distributing stress evenly over a wide area. The unique nonskid surface eliminates the too-tight pull that causes strangulation and cold flow. Gudelace is made of sturdy nylon mesh, combined with special microcrystalline wax, for outstanding strength, toughness, and stability.

Write for a free sample and test it yourself. See how Gudelace takes the slips—and the problems—out of lacing.

GUDEBROD BROS. SILK CO., INC.

Electronic Division
225 West 34th Street
New York 1, N.Y.

Executive Offices
12 South 12th Street
Philadelphia 7, Pa.

CIRCLE 203 ON READER SERVICE CARD

FOR PRINTING
of
ELECTRONIC COMPONENTS
of almost any shape:

REJAFIX MARKING MACHINES

Hand-operated, semi-automatic and fully automatic models.
Why not send us samples of your products. They will be test-printed and returned to you for your examination!

Est. 1922

POPPER & SONS, INC.
300 Park Ave. South New York 10, N. Y.

CIRCLE 204 ON READER SERVICE CARD

Coils for Contact Capsules

SINGLE • DOUBLE • TRIPLE

For Class B
Class F
Class H
operation
(Please specify)

Coto-Coils

COTO-COIL CO., INC., 65 Pavilion Avenue, Providence 5, R. I.

CIRCLE 205 ON READER SERVICE CARD

AO TRACEMASTER PAPER TAKE-UP STORES ENTIRE 1000 Ft. RECORD!

The AO Tracemaster offers a superior paper take-up mechanism that stores *complete 1000 ft. record* on one roll. Automatic braking device assures constant correct tension (even at full 500 mm/sec. chart speed) to maintain wrinkle-free chart surface for writing notes, interpreting or measuring record.

Convenient, built-in paper cutter permits you to cut the record cleanly and quickly at any point . . . free end can be replaced on take-up spool in just a few seconds.

This outstanding convenience and performance of the paper take-up mechanism is typical of every detail of the AO Tracemaster . . . just one more example of the high standards of precision manufacturing that make it the world's finest 8-channel direct writing recorder. Send for complete information . . . *now!*

American Optical Company

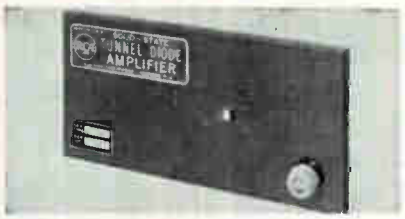
Instrument Division • Buffalo 15, New York

CIRCLE 206 ON READER SERVICE CARD

March 17, 1961

turized motor as its source of motion, and a new clutch to give left or right action, each flight control surface is directly connected to its own actuator.

CIRCLE 323 ON READER SERVICE CARD



Microwave Amplifier
TUNNEL-DIODE TYPE

RADIO CORP. OF AMERICA, Harrison, N. J. The SS-500 miniature tunnel-diode amplifier has a gain of 15 db and a maximum noise factor of 6 db over the 1275-1325 Mc range. It has excellent stability and does not require use of a pump. A circulator is required to isolate the output terminal from the input.

CIRCLE 324 ON READER SERVICE CARD

Multiplier-Divider

AIRPAX ELECTRONICS INC., Seminole Division, Fort Lauderdale, Fla. Solid state device applies to any type process control. Accepts three d-c analog input voltages, X, Y, and Z, and forms an output proportional to XZ/Y.

CIRCLE 325 ON READER SERVICE CARD

Sonic Delays
STANDARD OR CUSTOM

COMPUTER CONTROL CO., INC., 983 Concord St., Framingham, Mass., announces a line of sonic wire de-

Stepping Motors

BI-DIRECTIONAL HIGH RELIABILITY POSITIVE LOCK

Compact and lightweight Curtiss-Wright bi-directional digital motors index precisely and lock positively between each angular rotation when converting electrical pulses to mechanical motion in missile, aircraft, automation and actuation applications. Ruggedly constructed and dynamically balanced for long life and reliable service under severe environmental conditions, shock and vibration. Low power required for high speed operation.

Temperature: —65°F to +165° F
Vibration: 20 G's to 500 CPS
Shock: 30 G's for 11 milliseconds along each axis

AD ND 4502

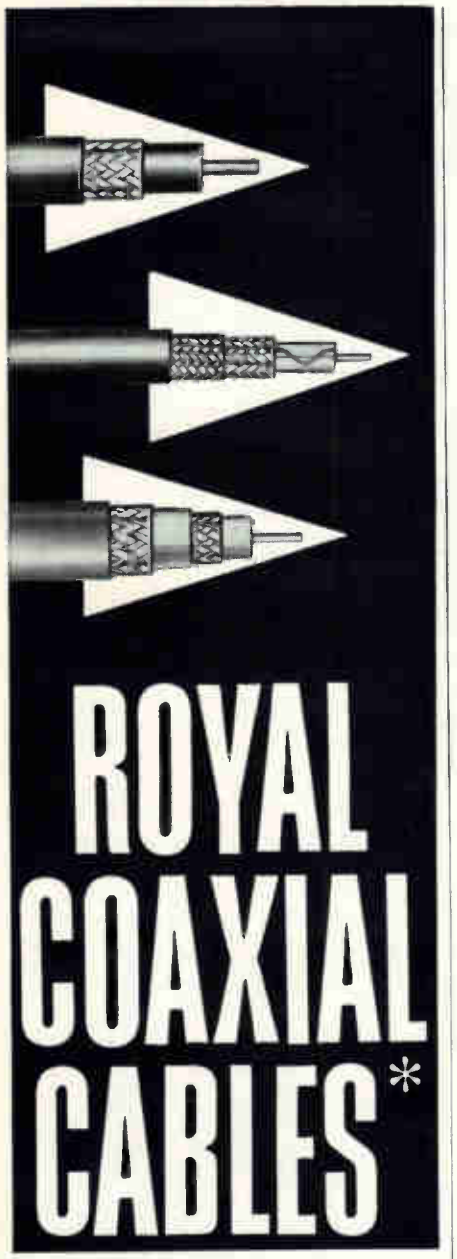
Write for latest complete components catalog #502

TIME DELAY RELAYS • DELAY LINES • ROTARY SOLENOIDS • DIGITAL MOTORS • TIMING DEVICES • DUAL RELAYS • SOLID STATE COMPONENTS

See Curtiss-Wright at IRE—Booth 1521-23

Electronics Division
CURTISS-WRIGHT CORPORATION
East Paterson, New Jersey

CIRCLE 91 ON READER SERVICE CARD



ROYAL COAXIAL CABLES*

Dependable performance is the greatest asset of Royal coaxial and multi-conductor cables. They are made to exacting standards for exacting applications. Whatever your requirements . . . for electronic equipment, the military, or community TV applications, Royal can supply stock or special constructions with built-in satisfaction.

Ask for Bulletin 4C-3-L (stock constructions) or let us quote on your needs . . . representatives coast to coast.

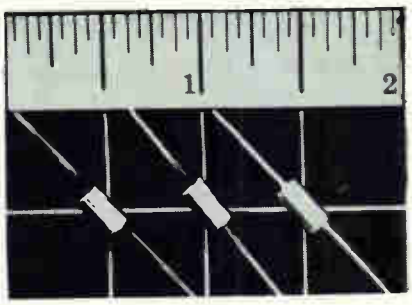
ROYAL ELECTRIC CORPORATION
301 Saratoga Avenue
PAWTUCKET • RHODE ISLAND

In Canada: Royal Electric Company (Quebec) Ltd., Pointe-Claire, Quebec

ROYAL ELECTRIC ... an associate of

lay lines (high density storage up to 1,500 bits). First types to be offered are magnetostrictive lines with delays of 5 to 1,000 μsec and center frequencies from 500 Kc to 2 Mc. Currently in production are 1 Mc fixed length digital storage lines.

CIRCLE 326 ON READER SERVICE CARD



Silicon Rectifiers
MINIATURIZED

BRADLEY SEMICONDUCTOR CORP., 275 Welton St., New Haven, Conn. Series BC 100, 200 and 300 silicon rectifiers are 0.105 in. in diameter by 0.250 in. long and 1 amp, 0.75 amp, 50 amp respectively at 50 C ambient with all peak reverse voltages from 50 to 2,500 v; operating temperature up to 175 C; double diffused junction; designed to meet MIL-S-19500 and MIL-E-1; adaptable to printed circuits.

CIRCLE 327 ON READER SERVICE CARD

Weight Gages

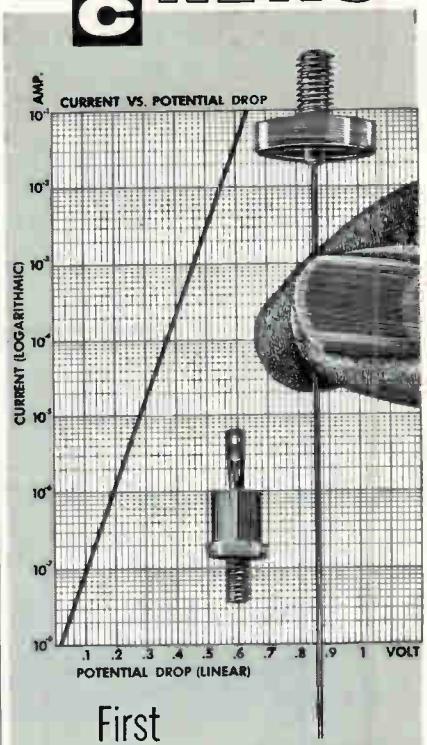
ELECTRONIC CONNECTORS INC., 84-45 Abingdon Rd., Kew Gardens 15, N. Y. Gages check the retention and extraction forces of socket contacts to assure conformance with military specifications.

CIRCLE 328 ON READER SERVICE CARD

Servo Amplifiers
HIGH-TEMPERATURE

BULOVA WATCH CO., INC., Electronics Division, 40-01 61st St., Woodside

CC NEWS



First commercially-produced

Logarithmic Diodes

The forward conductance of this silicon diode shows a linear voltage drop to a logarithmic increase in current over a range of up to eight decades — making this new device a versatile new component for electronic circuitry where current levels have to be controlled, registered, measured, and voltage sensed.

Write for catalog sheets and quotations.

CONTROLS COMPANY OF AMERICA

CC *ELECTRON DIVISION*

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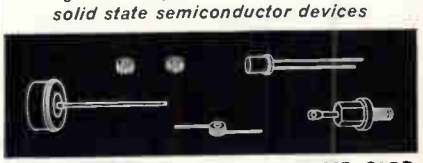
P.O. Box 957 Tempe, Arizona

Designers and producers of customized solid state semiconductor devices



CIRCLE 217 ON READER SERVICE CARD

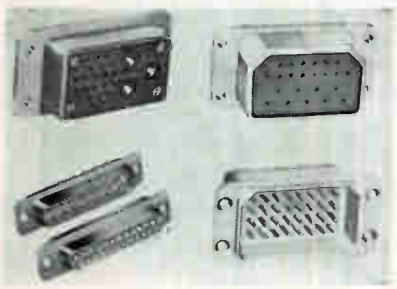
77, N. Y. High-temperature transistorized servo amplifiers meet or exceed the new ABMA soldering spec PDS-C1 and MIL-E-5400A and MIL-E-5272A. Available in 3.5 and 6 and 12 w sizes at $90 to $279 depending on quantity. Power outputs and input impedances: 3.5 w (size 11 motor) constant 10,000 ohms resistive; 6 w (size 15 motor) 25,000 ohms; and, 12 w (size 18 motor) 50,000 ohms.

CIRCLE 329 ON READER SERVICE CARD

Power Pentode

AMPEREX ELECTRONIC CORP., 230 Duffy Ave., Hicksville, L. I., N. Y. Tube incorporates two frame grids, both control and screen. Premium quality (PQ) tube, output pentode, designed for 10,000 hours.

CIRCLE 330 ON READER SERVICE CARD



Rack/Panel Plugs

CRIMP SNAP-IN CONTACTS

CANNON ELECTRIC CO., 3208 Humboldt St., Los Angeles 31, Calif., offers rack/panel plugs with crimp type snap-in contacts. DPX, DPA, DPD, and D subminiature plugs together with the environmental types, such as DAD and DED plugs, include the crimp snap-in contacts which are 5-amp, gold plated copper. Coaxial inserts are also available. The Monobloc insulation is made of dially phthalate.

CIRCLE 331 ON READER SERVICE CARD

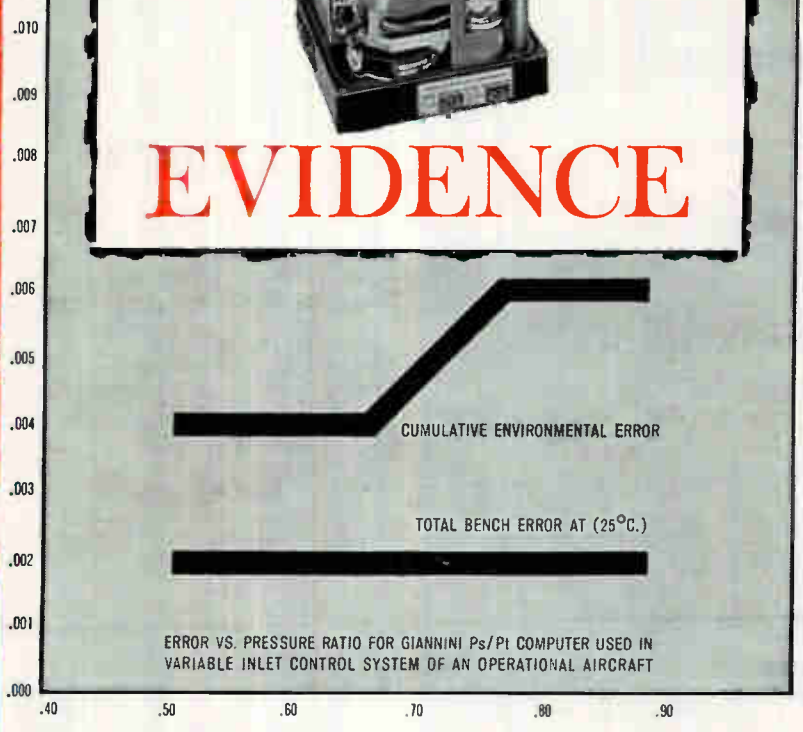
X-Y Recorder

TRANSISTORIZED

F. L. MOSELEY CO., 409 N. Fair Oaks Ave., Pasadena, Calif. Model 135 is an 8½ by 11 in. X-Y recorder weighing 20 lb. It provides built-in calibrated X-axis time sweeps, plus 16 calibrated ranges on each axis, with an infinitely variable vernier. It features high input resistance, a

HOW RUGGED, SENSITIVE, AND RELIABLE IS A GIANNINI FORCE BALANCE PRESSURE TRANSDUCER? HERE'S

GRAPHIC EVIDENCE



ERROR VS. PRESSURE RATIO FOR GIANNINI Ps/Pt COMPUTER USED IN VARIABLE INLET CONTROL SYSTEM OF AN OPERATIONAL AIRCRAFT

Extremely low bench error. Only slightly greater error under maximum environmental conditions. That's the story told on the graph. And by the operational success of this Giannini product in flight. It's the best way we know of to measure a pressure ratio, whether the application is a true air speed indicator, static source compensator, engine pressure ratio sensor, mach transducer, or you name it. Instrument systems with this kind of performance available to your specifications on short lead time. One more reason why you hear it said: **When it's from Giannini you get it on time, it works when you get it, and it keeps on working.** Send for technical bulletin GTN 360.

Giannini Controls Corporation
A NAME TO PLAN WITH
1600 South Mountain Avenue, Duarte, California
SERVO COMPONENTS & SYSTEMS · AIR DATA INSTRUMENTS & SYSTEMS
INERTIAL INSTRUMENTS & SYSTEMS
Sales engineering offices: Pasadena • Palo Alto • Seattle • New York • Chicago • Dayton • Washington
GCC 1-15

We deal in

ULTRA-LOW FREQUENCY LEVEL AMPLITUDE

- VIBRATION MEASUREMENT
- DATA INSTRUMENTATION
- DATA TRANSMISSION, RECORDING AND PROCESSING

every day

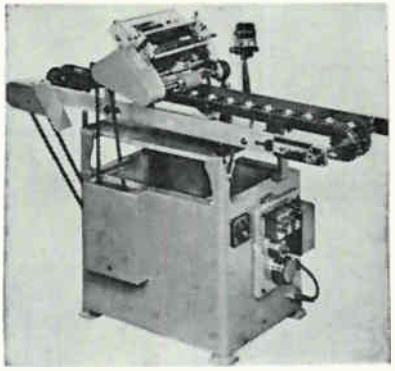
Many space age customers now benefit from our unique capabilities in R&D and manufacturing. These capabilities stem from years of experience in dealing with the demanding, classical problems in the earth sciences. Our competent staff of 250, and our complete electromechanical manufacturing facilities in our new 60,000 sq ft. plant are ready to serve you. We invite inquiries concerning your specific problems.

GEOTECH

The Geotechnical Corporation
3401 Shiloh Road, Garland, Texas
Phone BR 8-8102

self-contained vacuum paper hold-down, full range calibrated zero set and zero suppression on each axis, plus high recording speed.

CIRCLE 332 ON READER SERVICE CARD



Marking Machines
FOR COMPONENTS

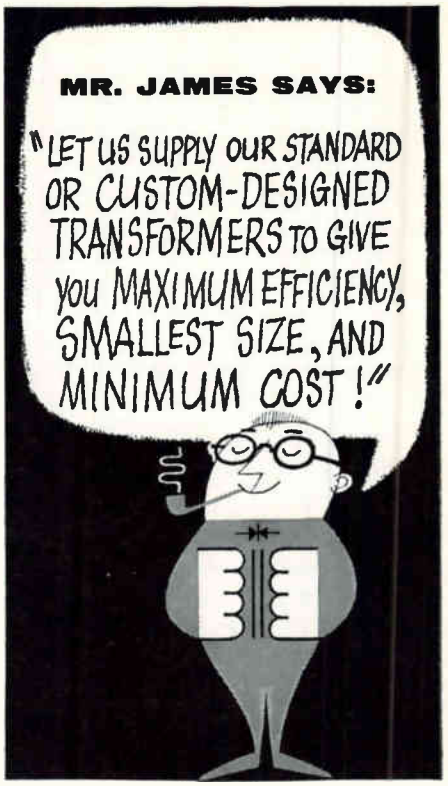
INTERNATIONAL EASTERN CO., 801 Sixth Ave., New York 1, N. Y. Model RG (illustrated) is a conveyor type machine for printing cylindrical pieces such as capacitors, tubes, etc. Printing rate is 3,600 pieces per hour or if a double conveyor is used, twice that output is possible. Model B3-2F is a hand operated machine, which will be set up with a special lever action numbering head for printing serial numbers in a minimum of space.

CIRCLE 333 ON READER SERVICE CARD

Vacuum Oven
HIGH TEMPERATURE

TRI METAL WORKS, INC., Riverton, N. J., has developed a commercial oven that can operate at temperatures as high as 800 C and pressures as low as 0.000001 mm. It can attain temperature uniformity of ±3 deg at 0 to 800 C. It functions consistently and effectively at temperatures above 250 C and at pressures lower than 0.025 mm, without custom modifications.

CIRCLE 334 ON READER SERVICE CARD



INSTRUMENT TRANSFORMERS

A complete line of unique input and low power transformers designed for instrumentation circuits where accuracy, balance, precision with both electromagnetic and electrostatic shielding are required.

MINIATURE TRANSFORMER

.750 in.

Miniature transformers based on the universally used C-2450 kit for circuit application in input. interstage and output. Efficient transistor coupling with JAMES transformers reduces costs, increases efficiency and improves reliability.

SUB-MINIATURE TRANSFORMER

.5 in.

Micro-miniature designs based on the C-2650 kit provide ½-inch diameter encapsulated designs with unique plug and solder in finish . . . the correct way to design transistor circuits.

Contact "Mr. James" for technical consultation on the correct transformers for your application. Write for further information and technical manuals on JAMES transformer kits and standard transformer designs. Custom designed samples in 76 hours at moderate cost.

TRANSFORMERS • CHOPPERS • RELAYS

JAMES
ELECTRONICS INC.
4050 N. Rockwell, Chicago 18, Illinois
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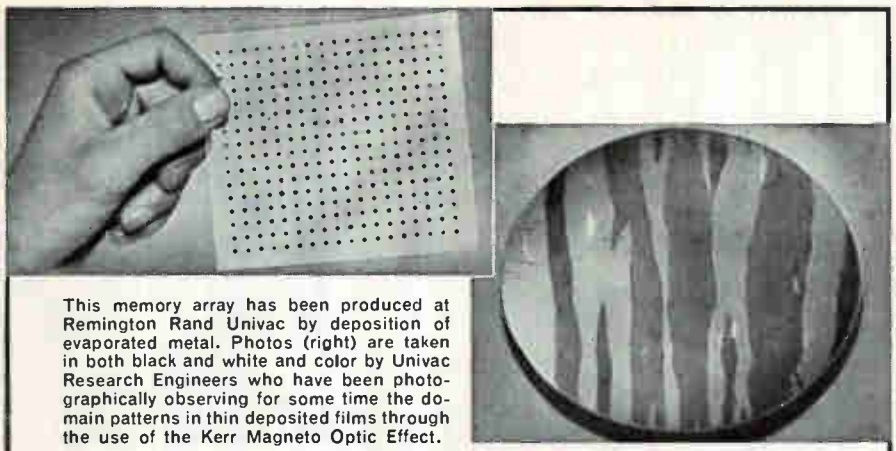
CIRCLE 208 ON READER SERVICE CARD



This memory array has been produced at Remington Rand Univac by deposition of evaporated metal. Photos (right) are taken in both black and white and color by Univac Research Engineers who have been photographically observing for some time the domain patterns in thin deposited films through the use of the Kerr Magneto Optic Effect.

Univac now has a number of opportunities for participation in exceptionally interesting projects which offer both professional and personal reward. These positions are significant in their potential for advancement.

The following are among those openings immediately available to experienced, capable people:

- RESEARCH ENGINEERS
- PRODUCTION RESEARCH ENGINEERS
- COMMUNICATIONS ENGINEERS
- MECHANICAL ENGINEERS
- ENGINEER WRITERS & EDITORS
- RELIABILITY ENGINEERS
- QUALITY CONTROL ENGINEERS
- PRODUCTION ENGINEERS
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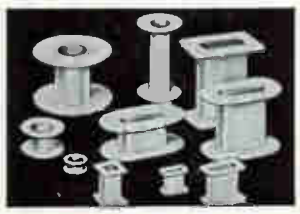

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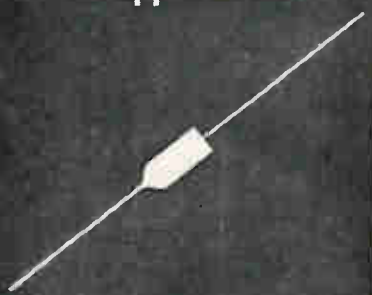

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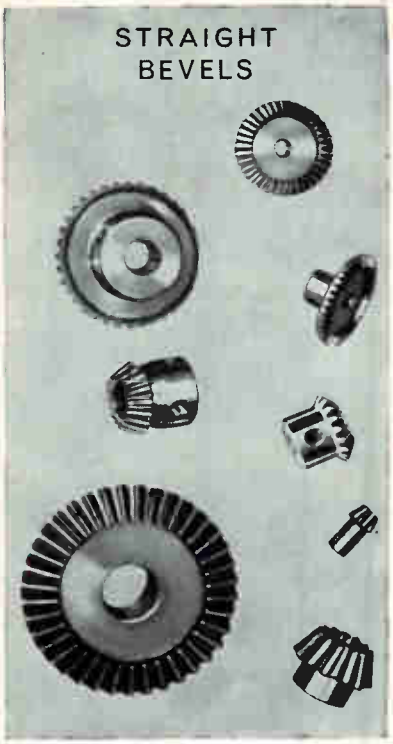

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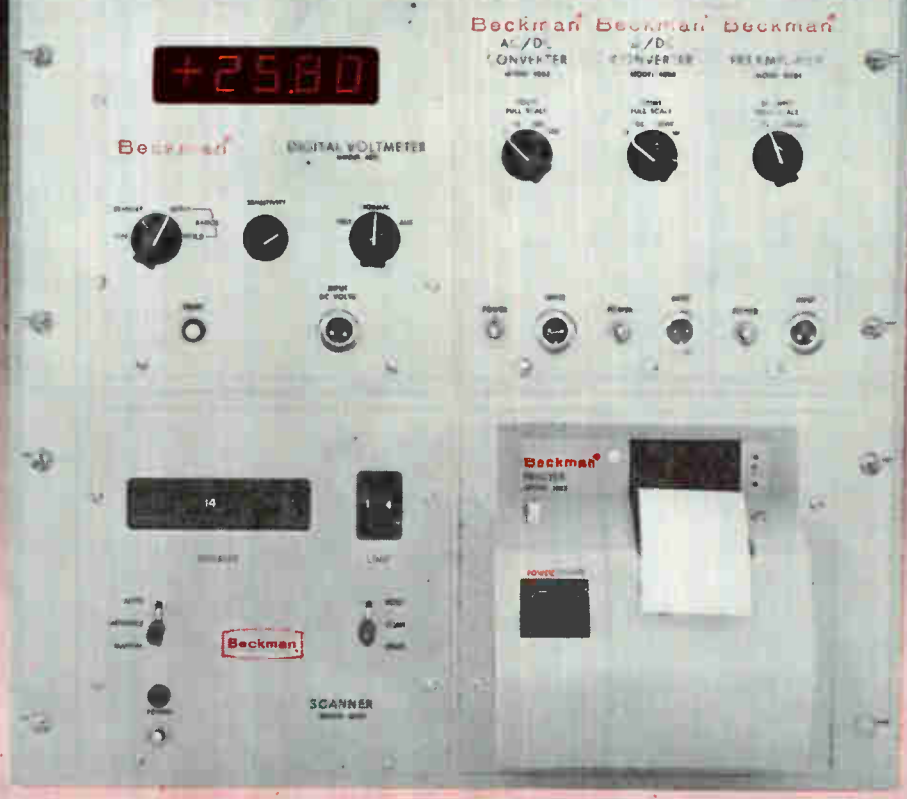

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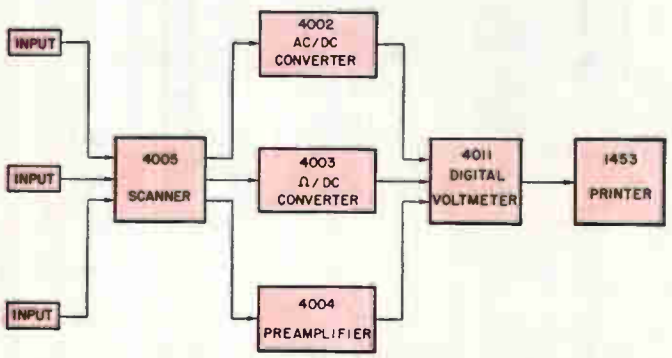
Price for the complete system about $4800

For detailed specifications on all these instruments and their use together, write for Brochure A4011.



Beckman 4011 a complete portable dvm is available, as are the other modules shown above, as a portable package.

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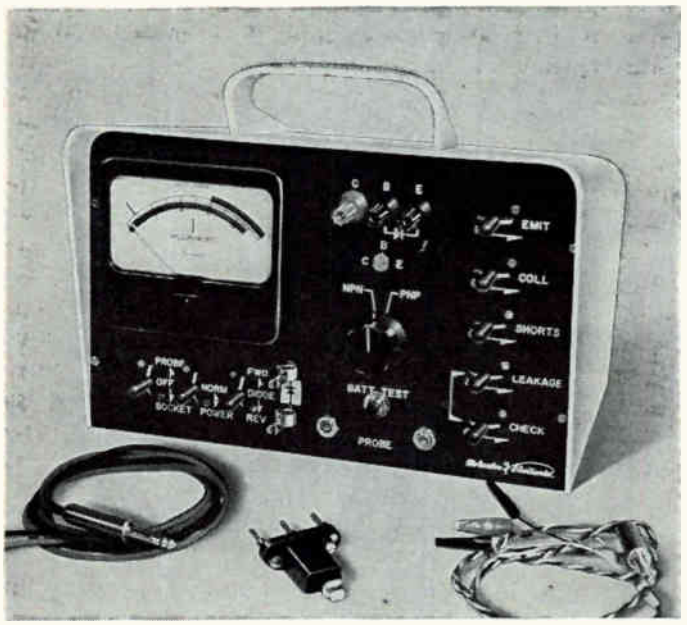

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Literature of the Week

WAVE ANALYSIS Minneapolis-Honeywell Regulator Co., 10721 Hanna St., Beltsville, Maryland. Two automatic wave analysis systems, a cross spectral analyzer, and a two-channel analyzer for transfer function plotting are described in a 16-page brochure.

CIRCLE 335 ON READER SERVICE CARD

RELAYS Potter & Brumfield, a division of American Machine and Foundry Co., Princeton, Ind., has published a 16-page catalog displaying the company's line of electromagnetic relays. The four types covered are telephone, military, power and general purpose.

CIRCLE 336 ON READER SERVICE CARD

SOLENOIDS Ledex Inc., 123 Webster Street, Dayton 2, Ohio. A leaflet illustrates the basic application principles of the company's rotary solenoids.

CIRCLE 337 ON READER SERVICE CARD

OSCILLOSCOPES Tektronix, Inc., P.O. Box 500, Beaverton, Oregon. A 15-page, short-form catalog presents all currently manufactured Tektronix oscilloscopes and associated equipment, including 24 conventional oscilloscopes, 6 portables, and 12 rack-mount versions.

CIRCLE 338 ON READER SERVICE CARD

WELDING LINE Hughes Aircraft Co., Vacuum Tube Products Div., 2020 Short St., Oceanside, Calif. A short-form catalog provides data on thin metal welding equipment, including nine different power supplies and eight weld heads and handpieces.

CIRCLE 339 ON READER SERVICE CARD

COMPONENTS Temec, Inc., 7833 Haskell Ave., Van Nuys, Calif., has published a 4-page brochure displaying the firm's antenna pedestals, tracking and servo systems, subassembly components, etc.

CIRCLE 340 ON READER SERVICE CARD

RECTIFIERS General Electric Co., W. Genesee St., Auburn, N. Y. Two wall charts, "Rectifier Selection Chart" and "Characteristics of

for printed wiring applications

PRECISION
wire-wound resistors

Improved design in Cinema's CE400 resistors offer superior performance characteristics and greater ease of installation in printed-wiring boards. Microminiature in size these precision units are ideal for use in critical applications where space is at an absolute premium.

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CE444E	.25	¼"	5/16"	600K
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CE446E	.5	¼"	¾"	1.7 Meg.
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Also available in axial lead types as CE200 Series. Write for complete technical details to...

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CIRCLE 207 ON READER SERVICE CARD

Common Rectifier Circuits Chart," assist in the selection of optimum silicon and germanium rectifier components for basic circuits.

CIRCLE 341 ON READER SERVICE CARD

INTERVAL TIMERS Electronic Products Corp., 44642 Belair Rd., Baltimore 6, Md. Ten-page engineering bulletin gives specifications and application notes on interval timers, solid-state and relay actuated, for use in missile systems, sequencing circuits, counter control, event signal, etc.

CIRCLE 342 ON READER SERVICE CARD

AUTOMATIC PROGRAMMING Bendix Computer Division, 5630 Arbor Vitae, Los Angeles 45, Calif. An eight-page brochure describes the major automatic programming systems for the Bendix G-15 digital computer.

CIRCLE 343 ON READER SERVICE CARD

FACILITIES BROCHURE Magnasync Corp., 5546 Satsuma Ave., N. Hollywood, Calif. A 12-page brochure portrays the company's history, research, engineering and production facilities in the realm of magnetic recording and ground support systems and associated fields.

CIRCLE 344 ON READER SERVICE CARD

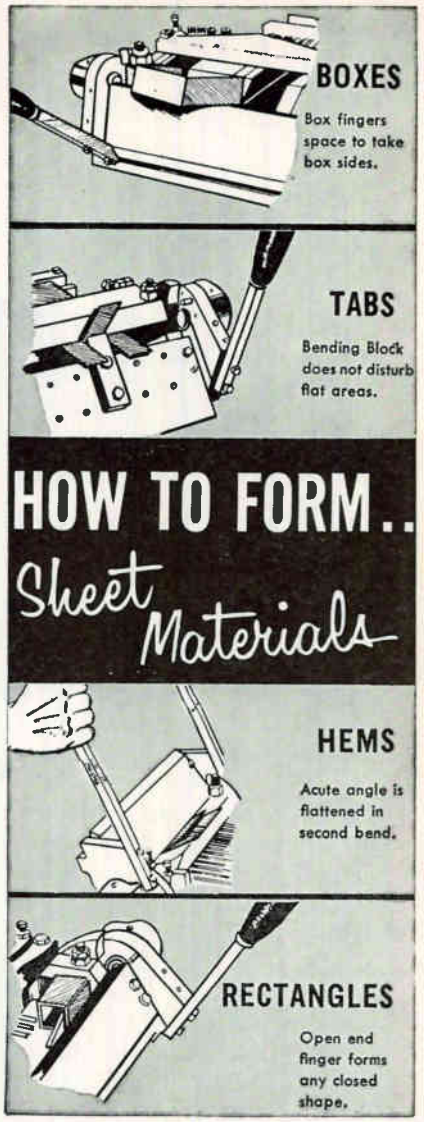
DATA PROCESSING Philco Corp., Tioga and "C" Streets, Philadelphia 34, Pa. An illustrated brochure explains the model 2000 electronic data processing system. Featured are the data link system, the high speed printer and magnetic drum storage.

CIRCLE 345 ON READER SERVICE CARD

HIGH-SPEED RELAYS The Bristol Co., Waterbury 20, Conn. Six-page bulletin, No. AV2022 covers the company's Syncroverter high-speed relays. Terminology is tabulated and test circuits are described.

CIRCLE 346 ON READER SERVICE CARD

PRECISION CIRCUITS Precision Circuits, Inc., 85 Weyman Ave., New Rochelle, N. Y. An illustrated brochure describes the company, its products and facilities, especially the production of printed wiring boards and assemblies. Send requests on company letterheads.



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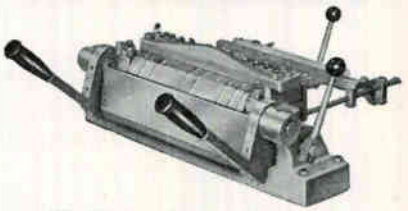

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CIRCLE 101 ON READER SERVICE CARD

Norden Opens East, West Plants

UNITED AIRCRAFT CORPORATION'S Norden division recently completed a large-scale consolidation program which brought together a major portion of its activities within two new, engineer-research and manufacturing facilities.

One move involved the transfer of approximately 1,400 employees and tons of laboratory, office and factory equipment from four locations to Norden's new 350,000 sq-ft facility (picture) at Norwalk, Conn. The move consolidated operations formerly carried on in leased plants at Stamford, Bridgeport, and Milford, Conn.; and White Plains, N. Y.

In the other phase of the consolidation, Norden's Data Systems department moved into a new 50,000-sq-ft facility at Costa Mesa, Calif. The department's 220 employees and engineering and manufacturing equipment were transferred from leased quarters at both Santa Ana and Gardena, California.

The Costa Mesa facility is a modern, one-story structure situated on a 35-acre tract about 40 miles south of Los Angeles.

The Norden division is now operating in three basic areas: the design and manufacture of military systems and components at Norwalk; the design and manufacture of commercial and industrial control systems and data processing equipment at Costa Mesa, and the design and production of precision rotating components at Norden's Ketay department, at Commack, L. I.

The new Norwalk plant is situated on an 80-acre tract. The multi-million dollar facility, rectangular in shape, is built around an inner court.

Among the laboratories' equipment items is a 24-ton "walk in" environmental chamber. A super-clean room for assembly of precision components has been built into the manufacturing area, running the entire width of the area.

Norden is a pioneer in the research, development and manufacture of systems and products which have been contributing to the electronic and electromechanical technologies.

Among the division's new programs is a study contract for the Maritime Administration, to investigate and suggest solutions for problems involved in the instrumentation and mechanization of merchant ships to operate them automatically.

The work at Norwalk also includes development and production of air data transducers and associated electronics, airborne and missileborne pressure transducing systems, digital encoding systems and digital converters, ground checkout equipment for aircraft and missiles, and closed-circuit television, cameras and systems.

One of the most significant developments at Norden during the past two years is the company's work in miniaturization. Motor tachometers, for example, now range from size 08 to 18, resolvers from 08 to 23. A new line of size 5 and 11 synchros has been added, and also a line of size 8 synchros, resolvers, servo amplifiers and servo motors.

Easton Named to NBS Advisory Committee

IVAN G. EASTON, vice president for engineering, General Radio Company, West Concord, Mass., has been appointed to an advisory committee on calibration and measurement services, recently established by the National Bureau of Standards.

As a liaison between NBS and industry, the committee will serve to coordinate precision measurement, calibration and standardization practices.

Airpax Cambridge Names Coughlin

THOMAS W. COUGHLIN has been appointed chief engineer of the Cambridge, Md., Division of Airpax Electronics Inc.

Employed by Airpax in 1952, he was made production supervisor, production manager and factory manager in succession before his recent appointment as chief engineer.

Ryan Transdata Fills Three Top Posts

APPOINTMENTS to three top posts at Ryan Transdata, Inc., have been announced by the Ryan Aeronautical Company's San Diego subsidiary.

Franklyn E. Dailey, Jr., formerly with Stromberg-Carlson in managerial capacities is named manager of engineering and research.

Josh W. Gershuny, former president of Moletronics Corp., South El

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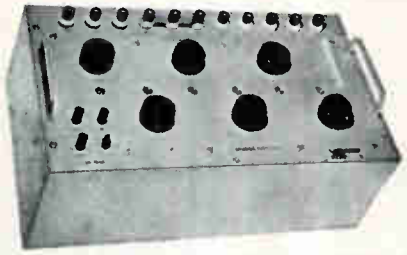

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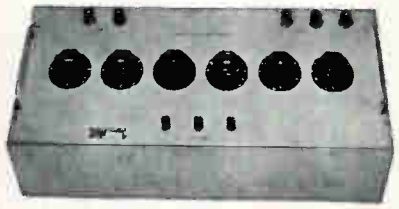

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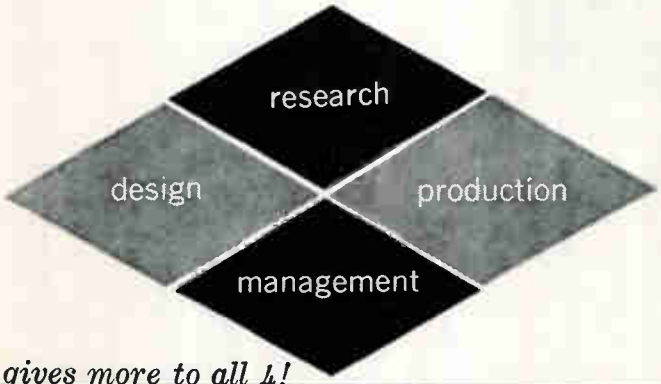

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TYPES: Standard Radio Octal, and 9-Pin Miniature . . . **List Price, $4.00.**

Also — **Amperite Differential Relays:** Used for automatic overload, under-voltage or under-current protection.

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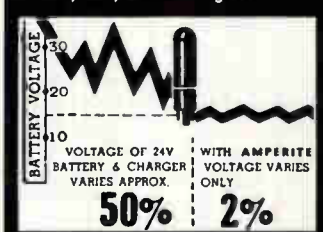

Hermetically sealed, they are not affected by changes in altitude, ambient temperature (—50° to +70° C.), or humidity . . . Rugged, light, compact, most inexpensive . . . . . **List Price, $3.00.**

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Monte, Calif., becomes manager of marketing.

Gordon L. Johnson, previously associated with Stromberg-Carlson as assistant to the vice president, is appointed manager of planning.

Bassett Moves Up At General Electric

L. A. BASSETT has been promoted to the position of manager of transistor sales for the General Electric Company's semiconductor products department, Syracuse, N. Y. His office will be located in the department's marketing headquarters in Liverpool, N. Y.

Bassett joined the company as a design engineer in the television receiver department in 1951. Prior to his present appointment he was district sales manager in the New England area for the semiconductor products department.

Anderson Establishes New Company

WILLIAM H. ANDERSON has formed Anderson Electronics, Inc., Altoona, Pa., for the manufacture of quartz crystals and filter crystals. Engineering facilities are located at University Park, Pa., for filter crystal work.

Anderson was formerly associated with General Electric Co., communication products department.

Ortronix Moves To New Plant

ORTRONIX, INC., designer and manufacturer of precision electronic and electromechanical systems, has moved to its new 25,000-sq ft facility in Orlando, Fla.

Only two years old, Ortronix currently holds contracts in excess of $1,500,000 according to A. R. Kilbey, president. The firm is presently building high speed automatic scale ranging digital multimeters for the Martin Co., Orlando.

PEOPLE IN BRIEF

Edward F. Miller, Technical Materiel Corp., advances to chief project engineer. **Reinhold Ludwig Noor,** previously with Philco Corp., joins the Waller Corp. as application engineering manager. **Thomas R. Bristol** promoted to assistant manager, linear beam dept., of Litton Industries' electron tube division. **Orval L. Buckner** leaves the Magnavox Co. to become manager of quality control for the commercial products division, General Dynamics/Electronics. **Bert F. Prentiss** moves up to chief inspector at the Bendix Corp. **C. J. Harrison,** senior vice president of Rixon Electronics, named chairman of EIA's small business committee. **J. Murray Hall** transfers from the Canadian Westinghouse Co. to Lenkurt Electric Co. as an electrical engineer in the firm's microwave products projects group. **Daniel P. Ross** of Thompson Ramo Wooldridge, Inc., advances to senior engineering specialist in the Tapco group research dept. **Hamish T. Law,** formerly with Ferranti, Ltd., of Edinburgh, Scotland, appointed microwave engineering manager for the Westinghouse electronic tube division. **Leonard Rosendahl** leaves Anaconda Wire and Cable Co. to join the Industrial Timer Corp. as head of the applications engineering group on programming equipment.

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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)

3171

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

CATEGORY OF SPECIALIZATION

Please indicate number of months experience in proper block(s)

	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
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50

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electronics

WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

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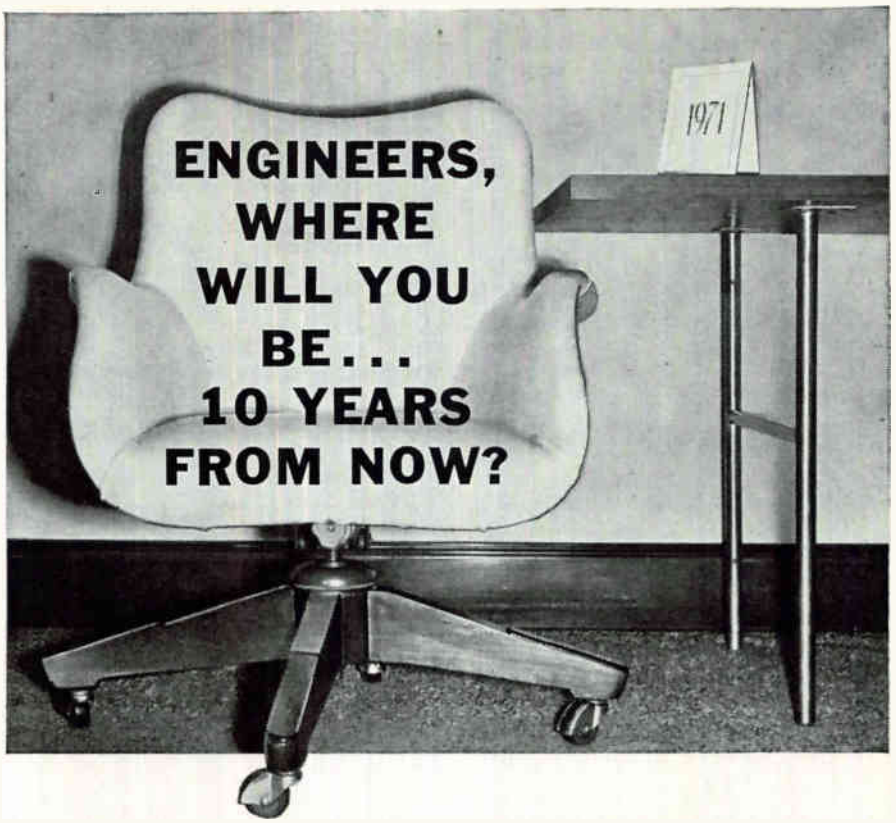

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- Sales engineering
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- Auto radio design
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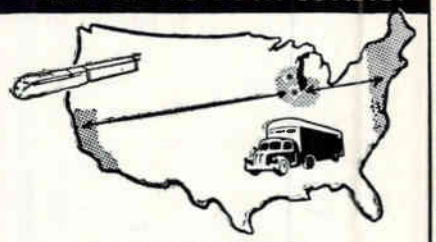

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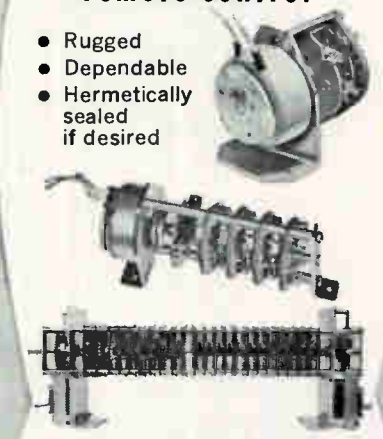

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75 kW CW to 10 kW

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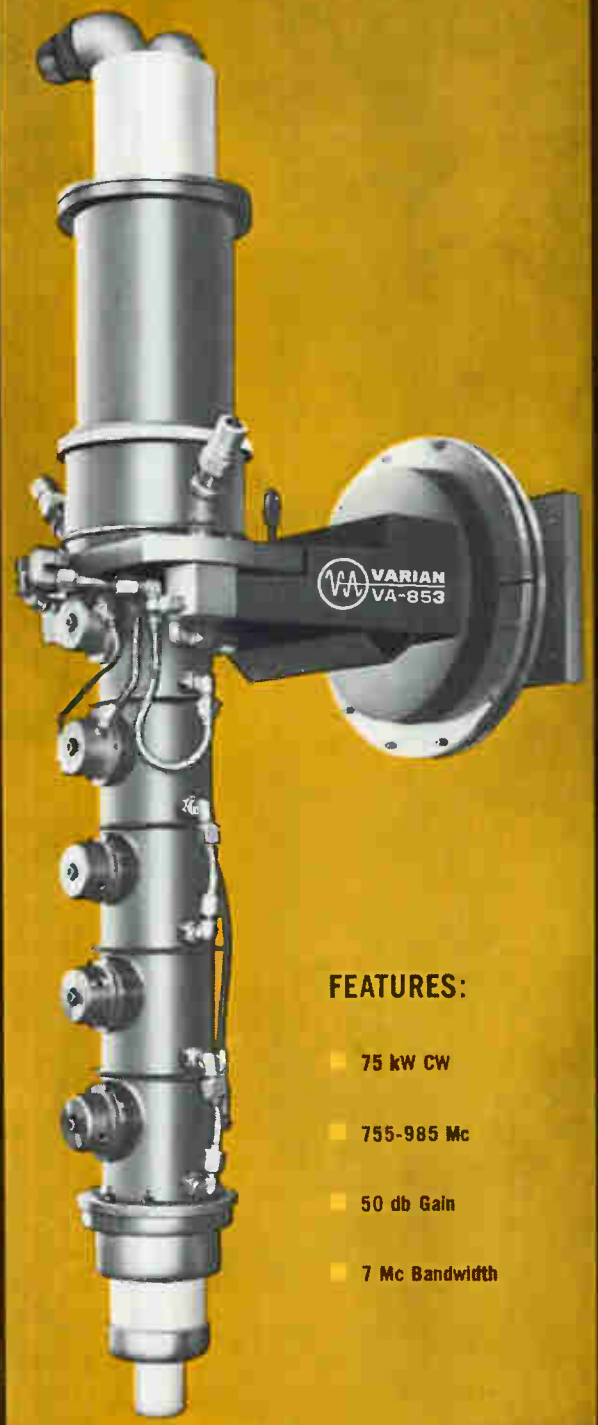

FEATURES:

- 75 kW CW
- 755-985 Mc
- 50 db Gain
- 7 Mc Bandwidth

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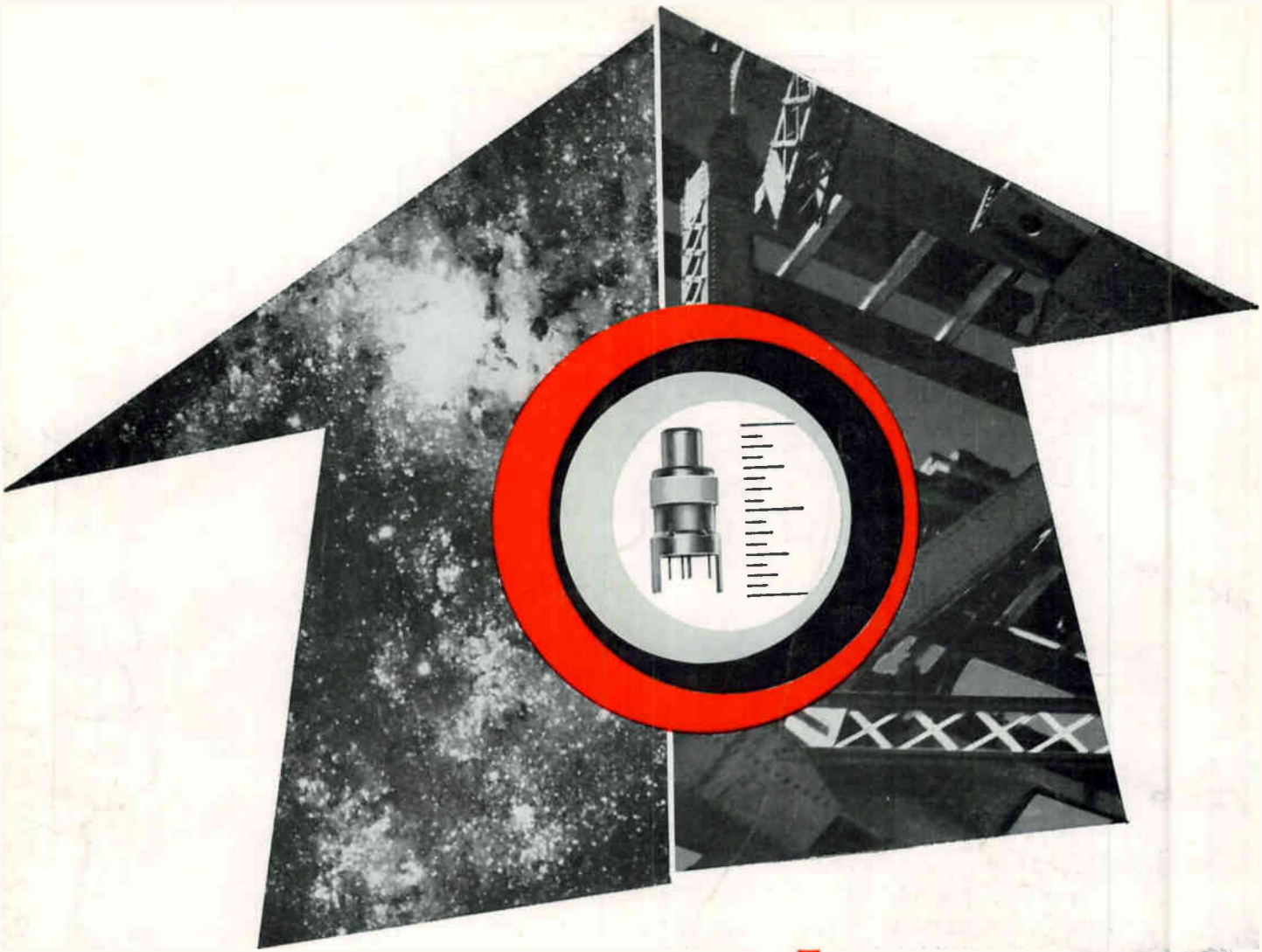

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FOR HIGH-GAIN, RF, IF, VIDEO AMPLIFIER, & MIXER SERVICE. This new member of the nuvistor family in combination with its companion medium-mu and high-mu industrial triodes (7586-7895) gives you vastly expanded flexibility in design of equipment for critical industrial and military applications where extreme compactness or very high packaging densities are essential requirements.

One third the size of conventional miniature pentodes, and consuming approximately one-half the heater power, this new sharp-cutoff tetrode embodies all the advantages of the nuvistor design: · low power drain · low-voltage operation · high transconductance at low plate voltage · extremely low interelectrode leakage · exceptional uniformity of characteristics from tube to tube · all-ceramic-and-metal construction for extreme resistance to shock and vibration · operation at full ratings at any altitude.

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NUVISTOR TETRODE GENERAL DATA

ELECTRICAL:		
Heater, for Unipotential Cathode:		
Voltage (ac or dc)	6.3±10%	volts
Current at 6.3 volts	0.15	ampere
DIRECT INTERELECTRODE CAPACITANCES:		
Grid—No. 1 to plate	0.01	μμf
Grid—No. 1 to cathode, grid—No. 2, heater & shell	6.5	μμf
Plate to cathode, grid—No. 2, heater & shell	1.4	μμf
Heater to cathode	1.4	μμf
CHARACTERISTICS, CLASS A_1 AMPLIFIER:		
Plate Supply Voltage	125	volts
Grid—No. 2 Supply Voltage	50	volts
Cathode Resistor	68	ohms
Plate Resistance (Approx.)	0.2	megohm
Transconductance	10,600	μmhos
Plate Current	10	ma
Grid—No. 2 Current	2.7	ma
Grid—No. 1 Voltage (Approx.) for plate current of 10 μa	−4.5	volts

INDUSTRIAL SERVICE

MAXIMUM RATINGS, ABSOLUTE-MAXIMUM VALUES:
For Operation at Any Altitude

PLATE SUPPLY VOLTAGE	330 max.	volts
PLATE VOLTAGE	250 max.	volts
GRID—No. 2 (SCREEN-GRID) SUPPLY VOLTAGE	330 max.	volts
GRID—No. 2 VOLTAGE	110 max.	volts
GRID—No. 1 (Control-Grid) VOLTAGE:		
Negative bias value	55 max.	volts
Peak positive value	2 max.	volts
CATHODE CURRENT	20 max.	ma
GRID—No. 1 CURRENT	2 max.	ma
PLATE DISSIPATION	2.2 max.	watts
GRID—No. 2 INPUT	0.2 max.	watt
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	180 max.	volts
Heater positive with respect to cathode	100 max.	volts
MAXIMUM CIRCUIT VALUES:		
Grid—No. 1 Circuit Resistance:*		
For fixed-bias operation	0.5 max.	megohm
For cathode-bias operation	1 max.	megohm

*For Operation at Metal-Shell Temperatures up to 150°C.