March 16, 1962

electronics

A McGraw-Hill Publication 75 Cents

TUNNEL DIODES

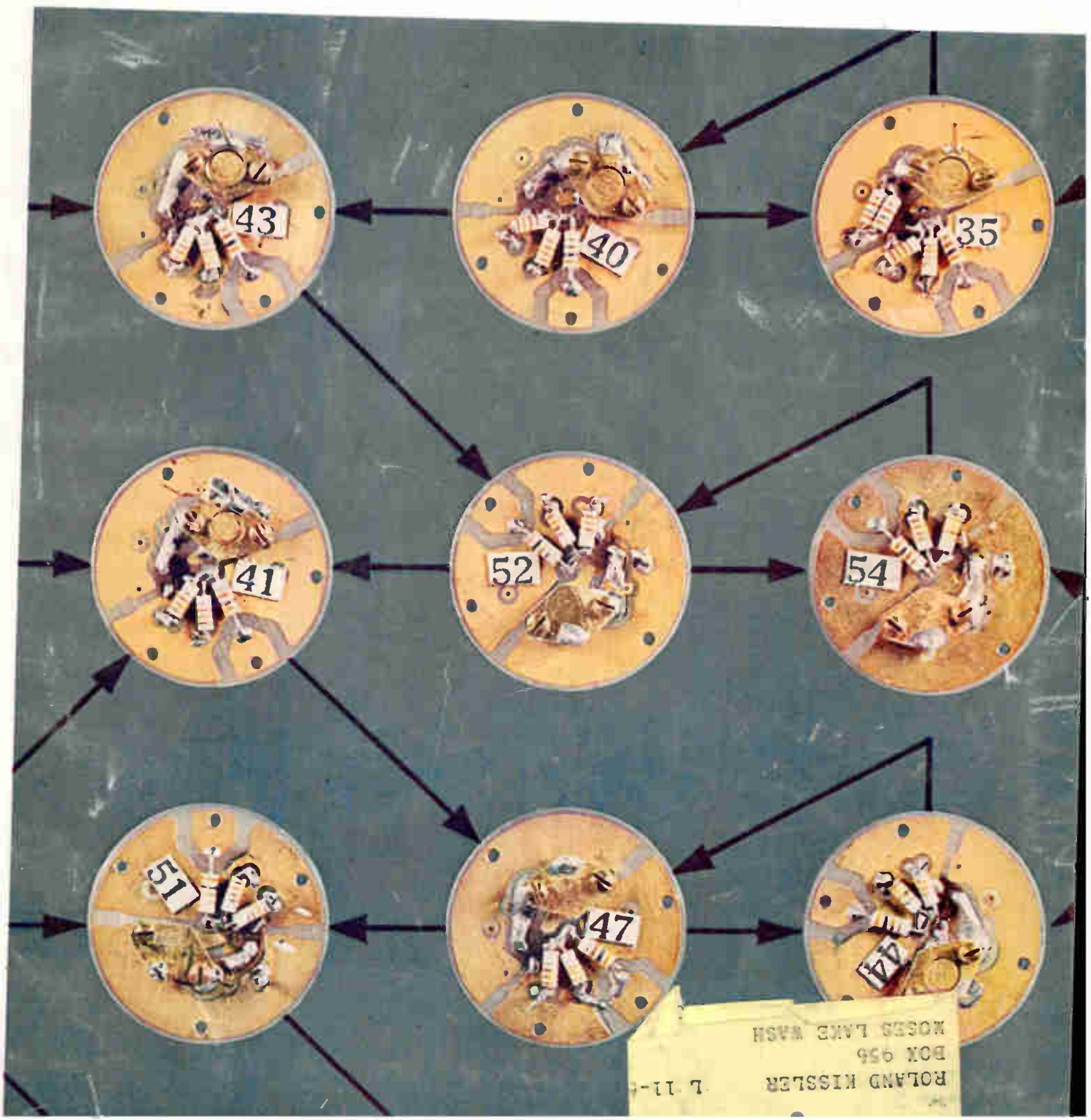
For nanosecond logic, p 72
(photo below)

NUCLEAR RADIATION

Designing for high dosage, p 51

ISOLATED PARAMP

Circulators not required, p 58



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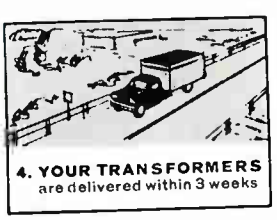

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MAGNETICS OPERATION

CIRCLE 251 ON READER SERVICE CARD

March 16, 1962

electronics

A McGraw-Hill Publication 75 Cents

W. W. MacDONALD, *Editor*

Contents continued

electronics

March 16, 1962 Volume 35 No. 11

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CONTENTS continued

DEPARTMENTS

We've Just Not Been Trying

"DURING THE LAST FIVE YEARS . . . many new electronics firms have been started . . . almost none of which has failed. I believe something is wrong with a situation that perpetuates nearly every one."

The words are those of Finn J. Larsen, Army Assistant Secretary for Research and Development. They could be taken literally. Or they might have been chosen for their dramatic effect. At any rate, the electronics industry, by its very nature, requires a large number of companies. The sum total of their contributions, large and small, makes up the vast technological complex that is so vital to our scientific program, our national defense, our commercial expansion and our present way of life.

Where such a large number of companies is involved, obviously not all contribute at the same rate. But the intricate demands of today's technology often permits the smallest sub-subcontractor to play as vital a role as a major industry leader. Years ago a keen observer of the current scene gave us the words "For want of a nail, the shoe was lost . . ." and it is much like this in our field today.

Mr. Larsen's comments on the few failures in the field of electronics, however he meant them, put us in mind of the tv comedian who read to his audience a fictitious report to the effect that national traffic accidents during the week had been 28 percent below predictions. He followed this statistic with the statement "Some of you out there are just not trying!"

OLIVES AND COMPUTERS—How would you build a machine that could be taught by reward and punishment to do things better? Or even a machine that could modify its own actions in the light of what it had learned?

A computer could be rewarded by adding appropriate logic for a correct answer, so it gave a similar answer more speedily next time. For punishment, circuits that yielded wrong answers or didn't contribute to right ones could be pared away. Fit the computer with a robot armed with tools for adding or removing circuits—or with some electronic system that achieves the same result—and the reward-punishment process is automated.

But what if the nature of the problem changes? Suppose the computer is trained to recognize the letter *E*. What does it do when presented with an *F*? It's likely the parts removed in the *E* recognition process are vital to *F* recognition. So they would have to be replaced and others removed as *F* is learned. This is hardly the best example of an automatic process.

In his concluding article on bionics this week, Assistant Editor Lindgren discusses some more reasonable approaches to apparatus that learns by reward and punishment. Their basic simplicity helps these devices adapt themselves to a change of problem without drastic alterations.

One approach looks like a jar of olives. Except the olives are small metal spheres and the vinegar is acid that attacks the spheres and develops a nonconducting layer between their points of contact.

Electric pulses break down the insulating layers between spheres. Since the jar is fitted with electrodes through its wall, these pulses can be applied to any of the outer layer of balls and detected at other chosen locations. The apparatus is rewarded by bonus pulses that maintain a useful conducting path when the desired response is detected. If it delivers the wrong output, it is punished by allowing the insulation layers to reform.

Coming In Our March 23 Issue

SYMBOGRAPHY. As promised a few months ago, we publish next week 500 graphical symbols and letter symbols for electronics diagrams. They will be arranged on one side of a 30 by 11½-inch foldout special section.

Another article tells how a tunnel diode working as an oscillator with a saturable reactor provides an excellent frequency-control device, by R. E. Morgan, of GE.

J. W. Martin and J. R. Cox, of Texas R&D Corp., in still another feature, describe uses of a solion tetrode in a chromatograph. An integrator using solion cells can drive a transistor, to operate control circuits.

COMMENT

The Cocktail Party Effect

I'm glad to see all this high-level dissertation on the cocktail party effect (*Crosstalk*, p 3, Feb. 16). I had observed this phenomenon for years—particularly in Washington and New York press parties—but had made no scientific analysis of it.

I had attempted to discuss my observation with other party attendees on various occasions, but at this point in the party the ambient noise level was too high for intelligent conversation. (It's hard to be profound while shouting.)

I finally concluded that my auricular system S/N somehow diminished directly in proportion to either party duration or alcoholic saturation. Thanks for helping clear up this disturbing conclusion. I'm leaving now to pick up some earplugs and go to a cocktail party.

HAL GETTINGS
Dynatronics, Inc.
Orlando, Florida

The Crosstalk discussed several cocktail party effects. One is the ability of a party attendee to screen out unwanted conversation and concentrate on the interesting talk, another is to decide from what direction a given sound comes. Combining these two effects, the party-goer can listen to a remote conversation when the nearer one becomes dull.

A third cocktail party effect is the gradually increasing noise level as speakers from several groups try to talk above the general din. The louder one person talks, the higher the others tend to raise their voices to combat him. The result is a cumulative increase in noise level until everybody is shouting to make himself heard.

Transmission-Line Charts

In reading the December 1, 1961, issue, I noticed the article Logarithmic Transmission-Line charts (p 48), by H. F. Mathis: In this article, the author introduces the same logarithmic charts that I have published, as early as 1955, in the French periodical *L'Onde Electrique*.

R. GUILLIEN
Director
l'Ecole Nationale Superieure
d'Electricite et de Mecanique
University of Nancy, France

Professor Mathis sent us a letter he received:

A few days ago my attention was drawn to an article entitled Logarithmic Transmission-Line Charts. I wish to refer to Fig. 2 (p 50), the Logarithmic Z — θ chart, which is basically similar to a chart published by the writer twenty-five years ago in the Marconi Review. It was still customary in those days to use hyps or nepers as units of attenuation, and the chart was plotted in those units. Between the chart published by you and the one by the writer there is a difference in origin of abscissae of 90 degrees or one-quarter wavelength.

I enclose copy of a paper written by three notable Marconi engineers: C. S. Franklin, N. M. Rust and B. J. Witt, on the design and setting up of the feeders and aerials of the world's first television station, at Alexandria Palace, London. It was my job to devise the chart in question to facilitate the feeder and aerial calculations in 1936 for the Alexandria Palace project, and the paper provides examples of its use in that project.

H. CAFFERATA
Marconi's Wireless
Telegraph Company, Ltd.
Chelmsford, Essex, England

Professor Mathis writes that he did not prepare a research paper but one intended to be a working tool, similar to others that had gone before, yet different in some details. He encloses a letter he wrote to Mr. Cafferata, which reads in part:

You may be interested in knowing that E. A. Kennelly published almost the same charts in 1914, in his very large book "Chart Atlas of Complex Hyperbolic Functions," which was published by the Harvard University Press. I did not know this until it was called to my attention by a friend.

H. F. MATHIS
The Ohio State University
Columbus, Ohio

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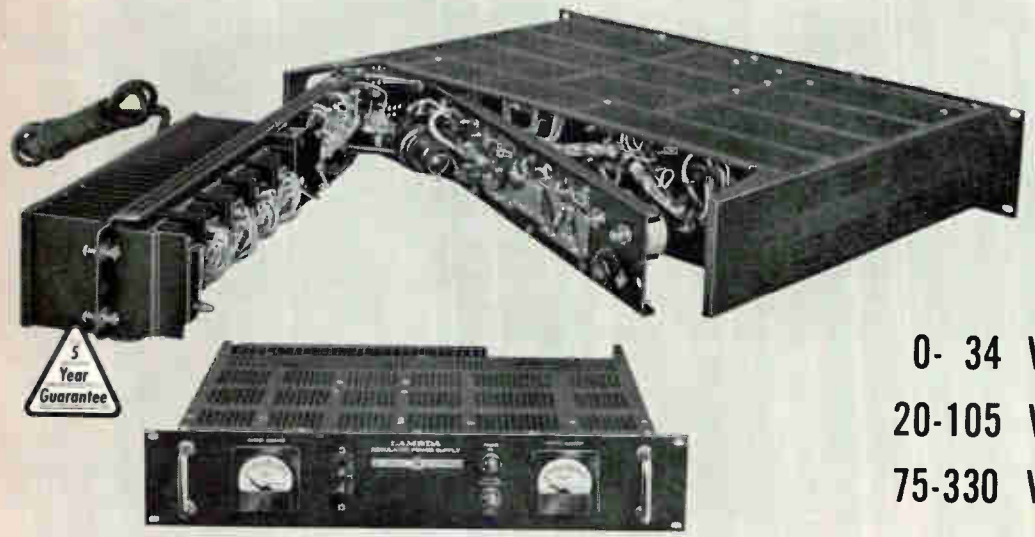

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LA100-03B	0- 34 VDC	4 V	0-10 AMP	510
LA200-03B	0- 34 VDC	4 V	0-20 AMP	795
LA 20-05B	20-105 VDC	10 V	0- 2 AMP	350
LA 40-05B	20-105 VDC	10 V	0- 4 AMP	495
LA 80-05B	20-105 VDC	10 V	0- 8 AMP	780
LA 8-08B	75-330 VDC	30 V	0- 0.8 AMP	395
LA 15-08B	75-330 VDC	30 V	0- 1.5 AMP	560
LA 30-08B	75-330 VDC	30 V	0- 3 AMP	860

Regulation (line) . . . . . Less than 0.05 per cent or 8 millivolts (whichever is greater). For input variations from 105-140 VAC.

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LA100-03B, LA40-05B, LA15-08B	7" H x 19" W x 14⅜" D
LA200-03B, LA80-05B, LA30-08B	10½" H x 19" W x 16½" D

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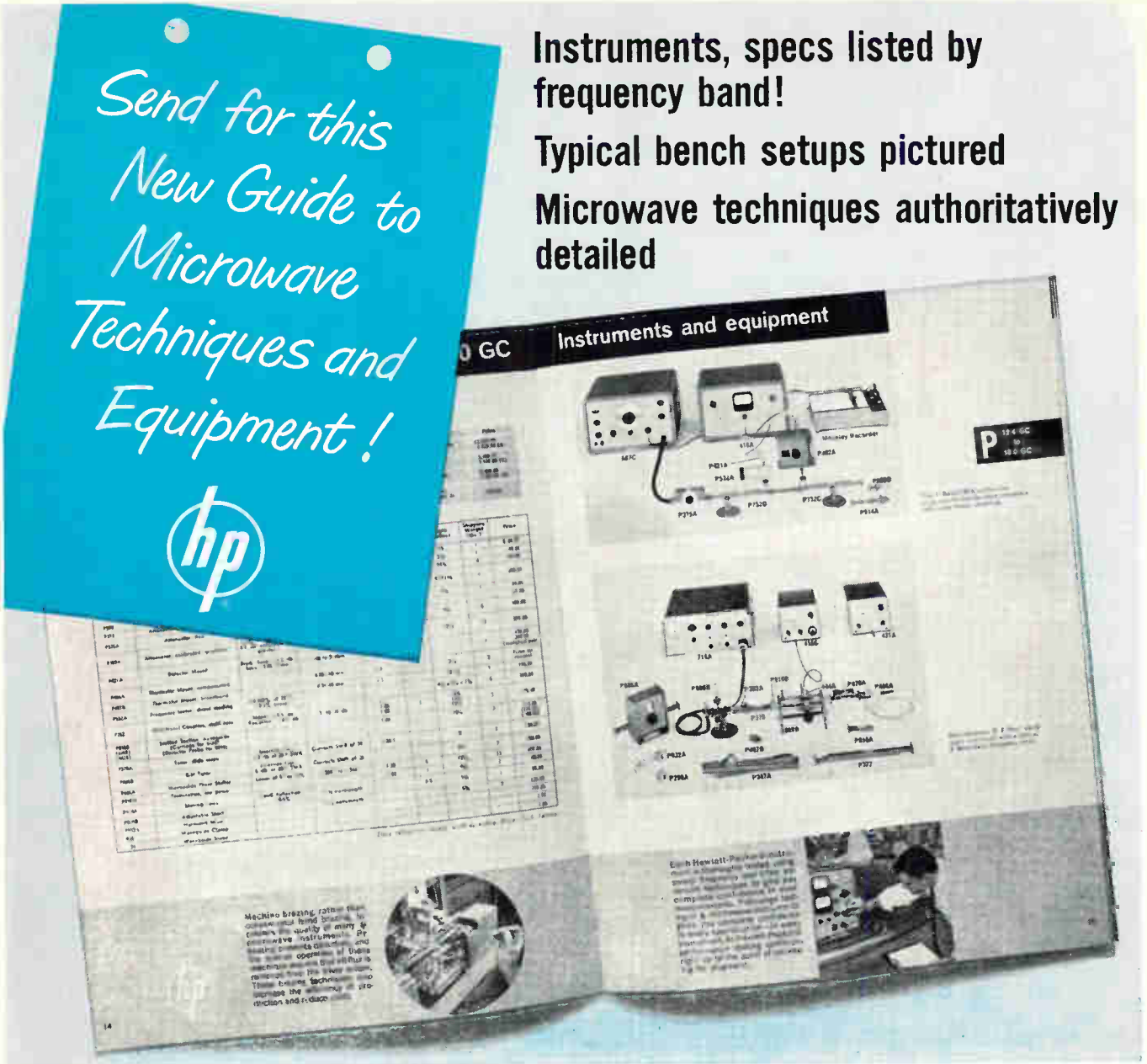

Instruments, specs listed by frequency band!

Typical bench setups pictured

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This new hp Microwave Catalog gives you a complete listing of Hewlett-Packard's full-range tested microwave instrumentation, together with helpful descriptions of various microwave measurement techniques. The information and the instrumentation are fully indexed, with instruments and equipment listed by frequency bands. Just find the frequency ranges in which you are interested . . . and you have basic specs on all available equipment and instrumentation, together with a photograph of a setup incorporating the instruments.

Typical of the information in the catalog are discussions of swept frequency measuring techniques, methods for measuring SWR, and measurement of frequency, impedance, attenuation, power and noise figure.

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ELECTRONICS NEWSLETTER

NASA Selects AT&T as Engineering Consultant

WASHINGTON—NASA is negotiating with AT&T on a contract to provide system engineering support for manned space flight programs, including Mercury, Gemini and Apollo. The Bell System is to provide analysis and fact-finding support, but not hardware.

The arrangement is reminiscent of Air Force contracts for missile and space programs (p 22, Aug. 25, 1961). Air Force first used Space Technology Labs, a profit-seeking organization, and then Aerospace Corp., a nonprofit firm. STL's parent, Thompson Ramo-Wooldridge, was banned from selling hardware on STL project. Whether a similar ban will be placed on AT&T's Western Electric will be determined at the negotiation meeting, it was reported.

Dollar amount and duration are also to be negotiated. Duration will probably be one year, subject to renewal. NASA hopes to build up sufficient in-house capability to eventually dispense with this type of contract altogether. An estimated 200 AT&T personnel will be responsible to Joseph Shea, NASA deputy director for manned space flight systems.

Fast-Searching Cryogenic Memory Associates Data

CRYOGENIC associative memory circuit has been developed by General Electric's Heavy Military Electronics department and Research Laboratory. The device simultaneously compares all stored computer information, associating input data with any portion of related data in the memory. GE says it is the first operative circuit of its kind.

The memory circuit is composed of numerous lead and tin cryotrons, evaporated on a glass substrate. The circuit is kept in liquid helium, at a temperature of −452 F. Leads pass through the flask to room-temperature computing equipment.

GE says the memory's small size, high capacity and high speed should result in applications in military and commercial computers, including air traffic control, missile detection and satellite monitoring and control.

The engineering model measures 3 by 6 by ½ in., contains 81 cryotrons and stores three 3-bit words. Density can be raised to 16 21-bit words. GE estimates that a comparison time of 50 μsec would be needed to locate the first association in a 300,000-bit memory.

West Ford Project Gets Go-Ahead for New Launch

BOSTON—Space Science Board is giving MIT Lincoln Laboratory approval for a second try at West Ford. A 40,000-mi-long orbiting belt of dipoles, 2,000-mi high, is to be used as reflector for intercontinental communications at 8 Gc.

The new payload has been extensively modified. The package launched Oct. 21, 1961, did not disperse its dipoles because the ejected package failed to spin, leaving the fibers clustered. Five or six clumps have been tracked for several months by Lincoln Lab's Millstone Hill uhf radar equipment.

Besides mechanical redesign, a vhf beacon and telemetry have been added to indicate package position, spin and tumble rate, and dipole dispensing. To make room, the number of dipole fibers has been reduced from 350 million to 250 million, cutting weight to 50 lb.

Dipoles will be ejected on ground command only if the package goes into suitable orbit, to make sure dipoles have limited lifetime. During the wait for the second launch, high-capacity digital data transmission equipment has been tested with the moon as a substitute for the dipoles.

Commerce Department Sees Electronics Rise in 1962

WASHINGTON — Business and Defense Services Administration of the Department of Commerce sees 1962 as another growth year for electronics. More competition, however, will keep profits from rising at the same rate as factory value.

Here are the estimated increases: systems and equipment, $7.2 billion, up seven percent; components, $3.7 billion, up from $3.54 billion; consumer electronics, $1.9 billion, a gain of seven percent, with a rise of 50 to 100 percent anticipated for color tv.

Figures do not include R&D, business expenses and operating revenues. R&D may reach $2.8 billion in 1962. Among the few declining segments are receiving

Court Upholds Pay Tv Broadcasts in Hartford

WASHINGTON—U. S. Court of Appeals last week upheld the FCC's authority to permit trial operation of pay tv systems. In dispute was the three-year license for RKO's Phonevision Co. in Hartford, Conn.

Connecticut Committee Against Pay Tv and a group of theatre chains said the FCC could not authorize a broadcasting system which requires payment of fees by the public. The court said Congress gave FCC power to experiment and develop communications facilities.

Phonevision plans to present 40 hours a week of programs over station WHCT, charge from 25¢ to $3.50 a program. The system was developed by Zenith Radio Corp.

tubes, which are expected to drop $10 million, to $350 million. While semiconductor sales will rise $30 million, to $610 million, the profit increase will not be as large, BDSA says.

Ocean-Bottom Seismograph Detects Nuclear Blasts

DALLAS—Texas Instruments is reported to have developed a seismograph which will detect natural earth tremors and distant nuclear detonations when it is placed on the ocean floor at depths to 1,600 fathoms. The station is said to sense, gather and store seismic information automatically. Data is digitally recorded on magnetic tape for later recovery and interpretation. The system was developed as part of Project Vela Uniform.

Another Line of Large Computers on the Market

ANOTHER SERIES of computer systems, the 1800, was announced last week by Minneapolis-Honeywell's EDP division. One system is a central processor which performs more than 120,000 three-address operations a second and has a memory cycle of 2 μsec. A floating-point arithmetic unit operates at nanosecond speeds when used with the processor.

Developed for "very large business and scientific" uses, the two units combined sell for over $1 million. The arithmetic unit makes extensive use of tunnel-diode circuits. Equipment utilizes features of the Honeywell 800 systems and will work with peripheral equipment in the 800 line.

Plan Computers That Read and Make Parts

ROCHESTER, MINN. — Development programs in numerical machine control and also in character reading systems are underway at IBM's General Products division here.

A new laboratory is working on ways to integrate numerically controlled machines into moderately sized manufacturing operations. Aim is a data-processing system that will tie together parts design and manufacturing. Investigations will be made of mechanism synthesis by computer, parts selection and fitting and production techniques for selection and control of machines.

Object of the character recognition program is to develop equipment that is faster and more versatile than optical and magnetic readers now made by IBM. One aim is high-speed alphanumeric readers. Contextual reading, recognizing groups of letters and words, is one technique to be probed.

High-Accuracy Ranging System Contract Given

MOTOROLA'S Military Electronics division in Arizona has won the $3 million contract for R&D on the Goddard Range and Range Rate Tracking System. Using carrier and side-tone modulation measurements, the system is to track near-space and cislunar probes with position accuracy of a few feet and velocity within fractions of a foot per second. Stations are to be transportable, to accommodate different satellite orbits. Development of ground and airborne equipment for NASA will take about a year.

Apollo Will Use Fuel Cells as Power Source

NORTH AMERICAN AVIATION is awarding two competitive contracts for development of fuel cells for Apollo spacecraft. One contract will go to Pratt & Whitney and the other to Tapco division of Thompson-Ramo-Wooldridge.

The cells, operating on oxygen and hydrogen are expected to provide a lightweight electrical power source, with potable water for the crew as a byproduct.

Ionics, Inc., of Cambridge, Mass., has teamed up with Tapco. Ionics has developed a unit reported to deliver 250 w at 28 v. It uses a stack of 40 internally-manifolded dual membrane cells.

In Brief . . .

ARMED SERVICES Electro-Standards Agency (ASESA) will move this summer from Fort Monmouth to the new Defense Electronics Supply Center, Dayton, Ohio.

JAPAN'S electronics exports to the U. S. in the first nine months of 1961 were $78.4 million, up 24 percent over the 1960 period.

NASA launched its Orbiting Solar Observatory last week (p 8, March 2). The agency also announced it was establishing its Atlantic and Pacific Missile Ranges as independent field installations.

FORD MOTOR will include all-transistor ignition system as optional equipment on 1963 trucks.

BECKMAN INSTRUMENTS and Toshiba have formed a jointly-owned company, Beckman-Toshiba, in Tokyo. It will produce Beckman products in Japan.

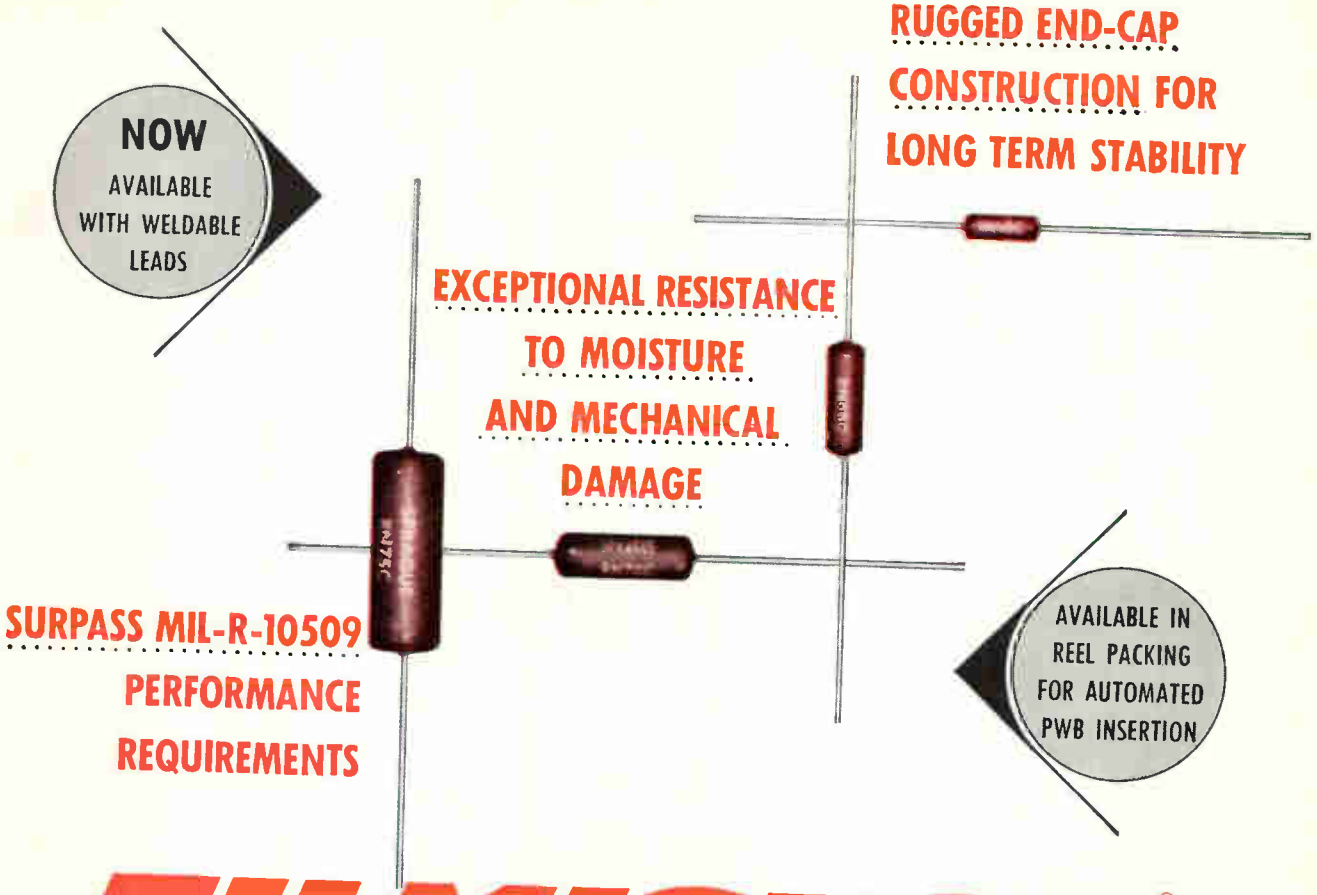
DEFENSE DEPARTMENT patent policies were rapped by the Joint Congressional Economic Committee. It wants the Pentagon to follow AEC policies for greater public use of inventions.

BENDIX announces its computer division will specialize in engineering and scientific computers for military and other uses.

R&D CONTRACTS include $200,000 to Electro Nuclear Systems in field of undersea warfare. Tasker Instruments will study analog-digital hybrid computer organization for Air Force.

ANTENNA contracts include $700,000 to Rohr for two more missile range tracking antennas, and $79,000 to Scientific-Atlanta for a tracking system for the Saturn booster.

MILITARY CONTRACTS include $2.4 million to Fairchild Camera & Instrument, tv systems for Talos missiles; $1 million to Kinetics Corp., switching devices for Titan; $800,000 to Manson Labs, for uhf tactical communications for Navy.



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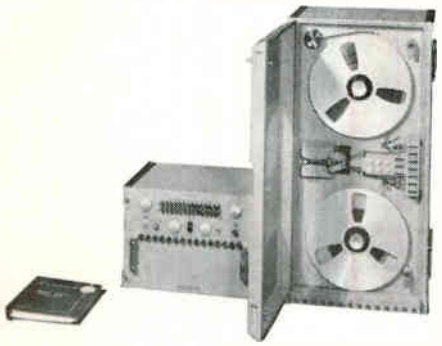

MINCOM'S NEW CMP-100 is the first mobile field recorder/reproducer with wideband and predetection performance. Like Mincom's standard-rack CM-100, the new **Series CMP** records up to 1.2 mc on seven tracks at 120 ips — with the positive accuracy possible only with longitudinal recording on fixed heads. Its two major components can be placed in an over/under configuration, side by side, or separated; it is easily fitted into many airborne, shipboard or van installations. The only transportable field system with six speeds, **CMP** is wired for full remote control and has two monitor playback channels.

Mincom Series G-100 – Now 600 kc at 120 ips

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2. Mincom's method of longitudinal recording with stationary heads assures **reliable** response up to 1.2 megacycles. The mechanical precision of Mincom's fixed-head assemblies is an important factor in recording continuous, uninterrupted data, as well as in ease of operation and reduction of maintenance down time.

Mincom Division 3M COMPANY

Los Angeles 25, California • Washington 4, D.C.

WASHINGTON OUTLOOK

CONGRESS SUPPORTS AIR FORCE ON B-70

A NEW POLITICAL RUMPUS is shaping up over the B-70 program. The House Armed Services Committee, in approving an aircraft, missiles and ships authorization bill for next year, added $320 million to the administration's $171 million B-70 budget. In unprecedented language, the committee "directed, ordered, mandated, and required" the use of the extra funds.

The present B-70 schedule calls for three stripped-down prototype models of the Mach 3 plane for flight testing. The House committee put in the extra funds to resume development of the bomb-nav, communications, and other electronic subsystems and to expand the program to six prototypes (including one fully-equipped weapon system model).

The committee, in effect, is supporting the Air Force in its fight against Defense Secretary McNamara on the B-70. McNamara showed no sign of changing his adamant stand against a B-70 stepup. He has already refused to spend the extra $180 million voted by Congress for the B-70, is holding this year's level of spending to $220 million. Odds are the Senate Armed Services Committee and the two appropriations committees will continue the pressure on McNamara.

Air Force has been unsuccessfully pushing for funds to reorient the program toward weapon system status, with eventual production of at least 35 operational-model aircraft. The plane has been redesignated the RS-70 (reconnaissance strike), would be crammed with missiles and reconnaissance apparatus and would no longer function as a conventional bomber with predetermined targets. Its mission would be to roam over enemy territory after an initial ICBM exchange, performing surveillance and selecting strategic targets.

NIKE ZEUS PRODUCTION HELD UP

ON ANOTHER CONTROVERSIAL defense project with considerable electronic implications—the Army's Nike Zeus anti-ICBM—the House Armed Services Committee supported McNamara's decision to withhold production.

Said the Committee: "These (terminal defense) systems would still not necessarily solve the problem of nuclear fallout from surface explosion outside the defended areas. There is a limit to the range of effectiveness of any terminal defense system." (The Army reported that a Nike Zeus launched at Kwajalein Island last week intercepted a simulated target missile.)

FAST ACTION ON SATELLITE SYSTEM?

COMMUNICATIONS SATELLITE CONTROVERSY continues, but Congress is now agreed on one point: it wants to settle the ownership issue this year. Senator Robert S. Kerr privately says he can send a bill to the Senate that will meet with administration approval. He wants to get a bill through the Senate in the next few weeks. The House must still hold hearings, so congressional agreement is likely to be a month or more away.

Predictions are that final legislation will bear the administration label, for political reasons, but with considerable alterations. The three bills now before Congress are the administration plan for public stock offerings, backed by the Department of Justice, but not FCC Chairman Newton N. Minow; Senator Estes Kefauver's proposal for government ownership, and Kerr's bill for ownership by domestic and international common carriers.

Big carriers like ITT and AT&T are backing Kerr, industry support is divided between the Kerr and administration plans. Opposition in Congress to the administration plan centers around the unwieldliness of the corporate structure it proposes. Participating communication companies, for example, would have limited control over decisions.

Meanwhile, the administration will meet Premier Khrushchev's recent bid for cooperation in space by offering the Soviets a share in a world-wide communications satellite system. This would not affect any U. S. ownership plan.

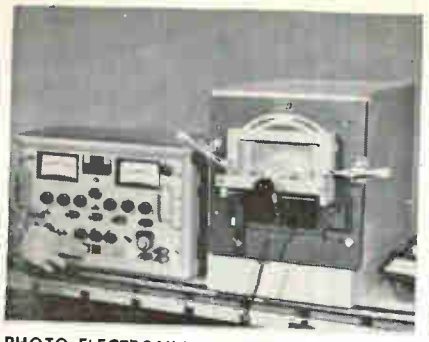
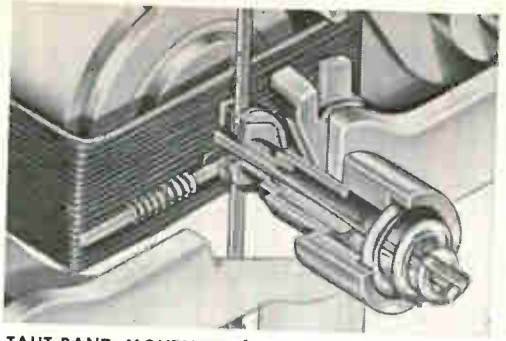


PHOTO-ELECTRONIC CALIBRATOR makes an individual scale to fit the exact response of each meter movement. There is no tracking error whatsoever.

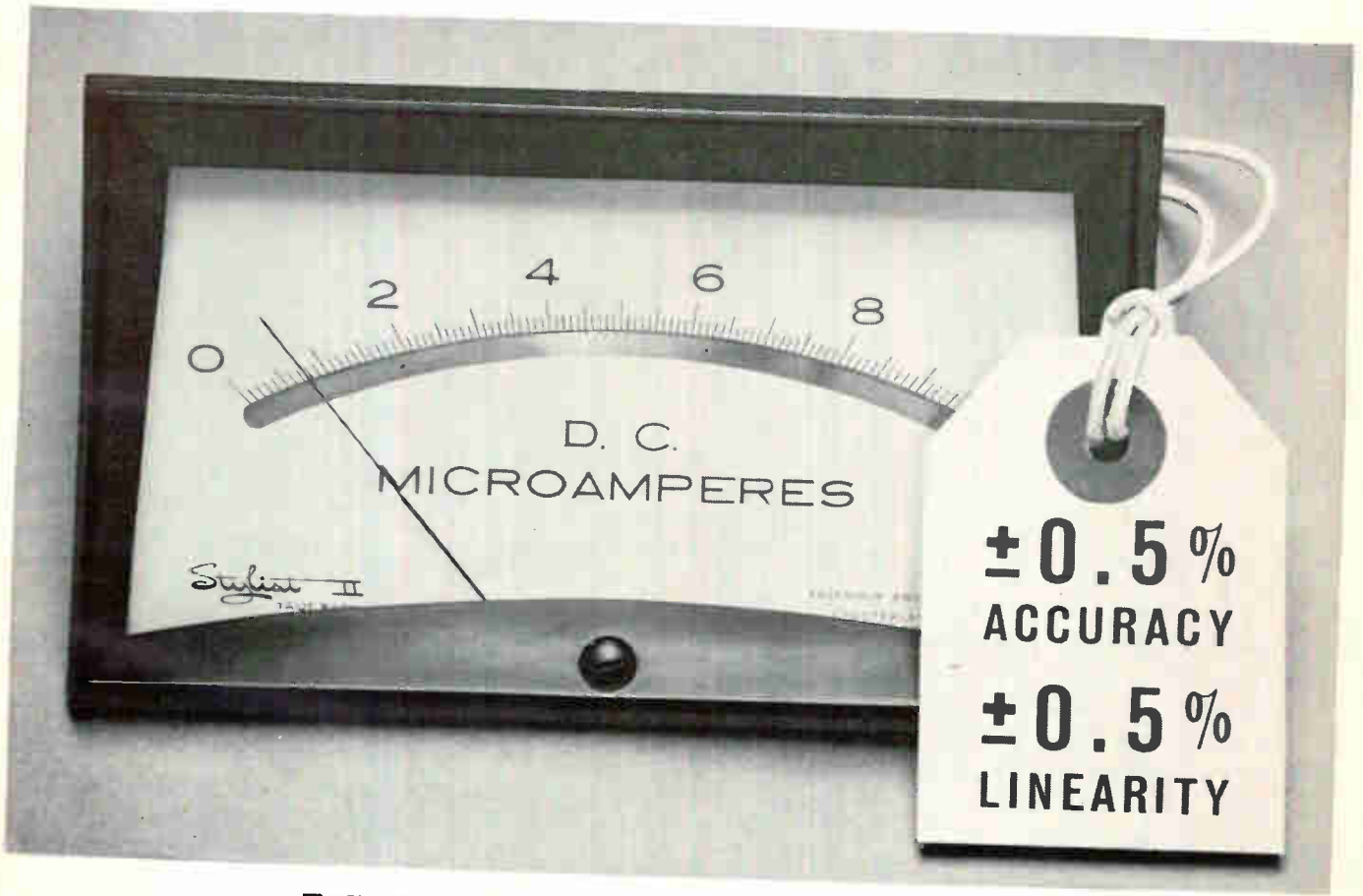


TAUT-BAND MOVEMENT has no friction, no hysteresis . . . gives perfect repeatability. High-tensile band, low-mass suspension is non-destructible in normal use.

NEW BULLETIN 30 describes the various models of Super-Calibrated meters available and gives full specifications and prices. Request your copy.

FIRST SUPER-CALIBRATED TAUT-BAND METER

SEE IT IN IRE BOOTH 3916-18



Full Scale Sensitivities to 2ua or 2mv

Someday, maybe, all meters will be super-calibrated. Until then you can get them only from API.

Super-Calibration permits you to upgrade present meter performance, but it also permits you to reduce costs if you are using more complicated instruments now for this level of performance.

Super-Calibrated meters have the inherent D'Arsonval stability plus the extreme ruggedness of taut-band design. They are interchangeable—between magnetic and non-magnetic panels—without calibration shift.

Write for Bulletin 30.

ASSEMBLY PRODUCTS, INC.
CHESTERLAND 4, OHIO

SA 2582

March 16, 1962

CIRCLE 13 ON READER SERVICE CARD

MEASURE VOLTAGE IN THE PRESENCE OF HIGH NOISE WITH NEW FLOATED AND GUARDED INTEGRATING DIGITAL VOLTMETER

You can easily and accurately measure voltage down to millivolt level, despite large common mode and spurious noise superimposed on the measured signal—with the DY-2401A Integrating Digital Voltmeter. You can use the DY-2401A on a lab bench—or take advantage of complete programmability, BCD outputs, and compatability with other instruments for systems use.

This totally new instrument provides 140 db effective common mode rejection at all frequencies, including dc, enabling 10 volts of common mode pickup to appear on the signal with less than 1 microvolt error in the DY-2401A reading.

Fully floated and guarded input circuitry blocks induced ac ground currents, or common mode signals, existing between voltmeter and signal source. Additionally, an active integration technique presents the average reading of the input voltage applied during a selected sample period, minimizing error due to noise unavoidably superimposed on the measured signal.

The DY-2401A is the most useful and versatile digital voltmeter available today. Here are some of the additional advantages you receive:

±300% OVERRANGING on the four most sensitive ranges provides additional accuracy and resolution on the commonly used 1-to-3 area.

ALL-ELECTRONIC CIRCUITRY assures maximum reliability, speed and noiseless operation.

BCD OUTPUT referenced to ground retains floating and guarded features when DY-2401A is used with output recorder.

±0.01% OR ±1 DIGIT STABILITY on the four highest ranges.

INTERNAL CALIBRATION SOURCE with ±0.01% per month stability.

10 CPS TO 300 KC frequency and frequency ratio measuring capability enables use as a solid state electronic counter with crystal-controlled time base.

FULL PROGRAMMABILITY with remote control lines referenced to chassis ground to allow system incorporation with complete retention of floating and guarding.

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A Division of Hewlett-Packard Company

dy®

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SPECIFICATIONS

2401A Digital Voltmeter

RANGE AND MEASUREMENT SPEED:

1-second sample period
99.999 mv, 999.99 mv, 9.9999 v, 99.999 v, 999.99 v

0.1-second sample period
100.00 mv, 1.0000 v, 10.000 v, 100.00 v, 1000.0 v

0.01-second sample period
0100.0 mv, 01.000 v, 010.00 v, 0100.0 v, 01000. v

±300% overranging on four most sensitive ranges; overload circuit, at approx. 310% of range, automatically switches to 1000 v range.

DISPLAY:
5-digit Nixie readout. Polarity, decimal point, measurement units and overload condition indicated automatically.

COMMON MODE NOISE REJECTION:
Overall rejection, better than 140 db at all frequencies, 160 db at dc, provided by floated and guarded input circuitry with 1000 Ω in low side of measurement pair.

LINEARITY: ±0.005% of full scale or ±1 digit.

STABILITY: ±0.01% or ±1 digit on 4 highest ranges.

INTERNAL CALIBRATION:
Provides stability of ±0.01% per month.

INPUT IMPEDANCE:
Precision 1 megohm, 1 volt range and above; 100 K ohms, 0.1 volt range only.

RECORDER OUTPUT: BCD output referenced to ground.

SIZE: 6⅝" x 19" x 18⅜", 48 lbs.

PRICE: $3,950.00.

See these New Instruments at New York I.R.E., Booths 3015-3017

FOR THE FIRST TIME—an AC/OHMS Converter which provides Floated and Guarded Broadband AC Voltage and Rapid Resistance Measurements.

DY-2410A AC/Ohms Converter

Full programmability with remote control lines referenced to chassis ground to allow system incorporation with complete retention of floating and guarding.

For AC Measurements

50 CPS TO 100 KC MEASUREMENT RANGE with 110 db common mode rejection at 60 cycles when used with DY-2401A.

5 RANGES including high resolution 0.1 volt rms range.

300% OVERRANGING on the four most sensitive ranges provides additional accuracy and resolution in the commonly used 1-to-3 area.

For Resistance Measurements

6 RANGES from 100 ohms to 10 megohms with 300% overranging feature on all ranges.

UNIQUE DC GUARD makes possible fast resistance measurements by minimizing cable capacitance charging time.

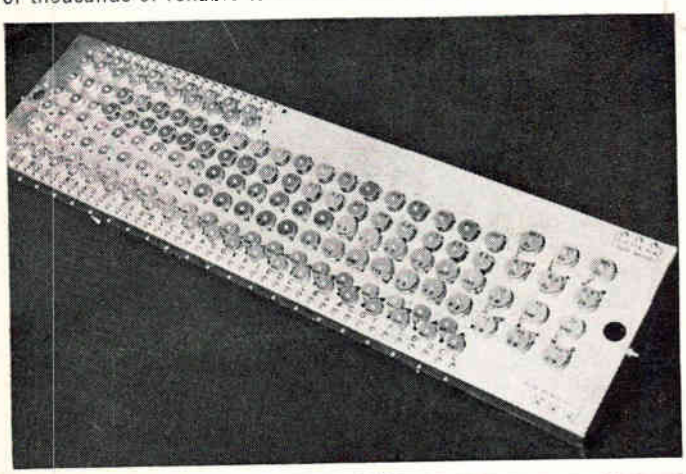
PRICE: AC/Ohms (DY-2410A), $2,250.00; AC only (DY-2410A-M1), $1,850.00; ohms only (DY 2410A-M2), $1,650.00.

Write today for data sheets on the DY-2401A and 2410A, which discuss instrument principles of operation, specifications and applications. Or better still, for a demonstration at your own bench, just call your Dymec/Hewlett-Packard representative.

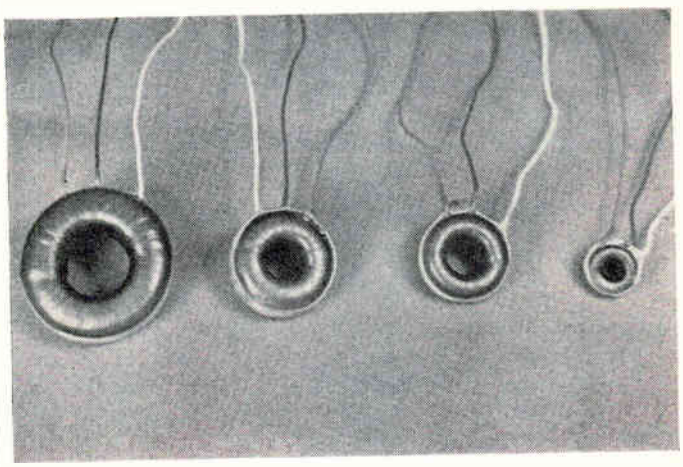
We manufacture

Allen ELECTRONIC ORGANS.

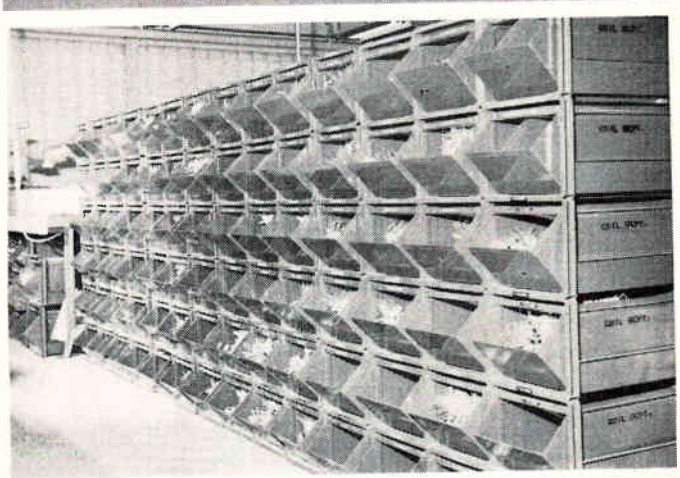
Each year we produce, at an ever expanding rate, hundreds of thousands of reliable toroids for these instruments.



These inductors use Permalloy, Ferrite or Powdered Iron cores.



Our facility for producing these inductors represents one of the most modern and efficient toroidal production plants in the country.



For our own production we constantly maintain a stock of approximately 150 different sizes of toroidal inductors, covering an inductance range of 10 Mh. through 30 henries.

Other component portions of Allen Organ manufacture have already been utilized by a multitude of electronic companies.

We believe that we are eminently qualified to supply these toroids at very competitive prices and, in many cases, for immediate shipment "out of stock".

For quotations, please contact Dept. 2303

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COMPONENTS DIVISION
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COMPLETE ELECTRON BEAM SYSTEMS

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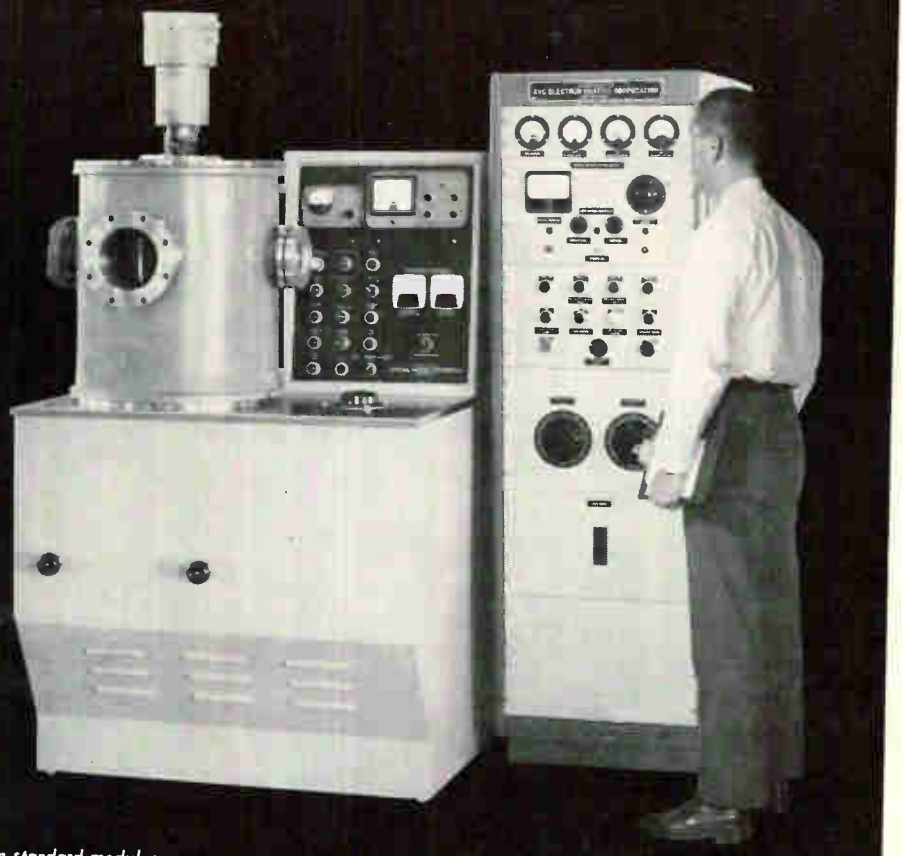

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Equipment features **— temperatures in excess of 7000°F • compact, modular construction • instantaneous automatic regulation of emission current • magnetic focus and deflection of beam • pulsed emission and focus • adjustable over-load current protection • no exposed high potential • system efficiency in excess of 90% • safe and easy operation • programmed operation**

Headline news in electron beam systems and techniques is being made by Electron Heating Corporation. EHC has a unique application-engineering "task force" to work with you in problem-solving. Included in the "task force" are *process and application engineers* with an intimate knowledge of the field; *electronic design engineers* who have pioneered in the development of high power electron beam systems and controls; and *vacuum engineers* with an extremely broad background in all phases of vacuum technology. Important, also, is the feature that EHC Systems designs use STANDARD PROVEN MODULES (a variety of completely tested gun designs, power supplies, controls and vacuum systems with known characteristics). *Send for literature . . . or tell us about your requirements.*

EHC *modular design*

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proven electron beam systems for research, development and production

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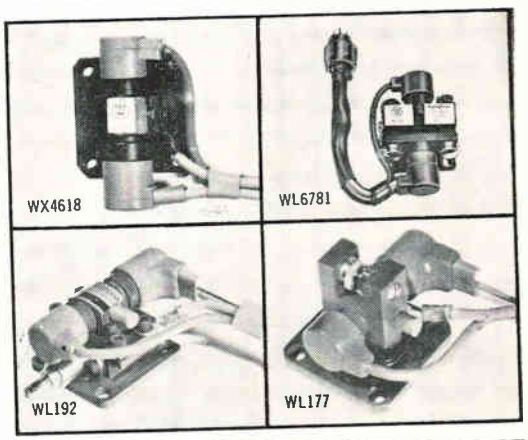
NOW... WESTINGHOUSE REFLEX KLYSTRONS

Now Westinghouse—with more than 30 years' experience in the microwave field—offers complete facilities for volume production of reflex klystrons. To assure you prompt service, more than 100,000 square feet of plant space is set aside for the manufacture of these and other microwave tubes.

Shown here are both cavity and waveguide tuned x-band tubes. Fixed-tuned, tuneable and trimmable types are also available. For application engineering assistance and quick-selector catalog, write to Westinghouse Electric Corp., Elmira, New York. **You can be sure . . . if it's Westinghouse.**



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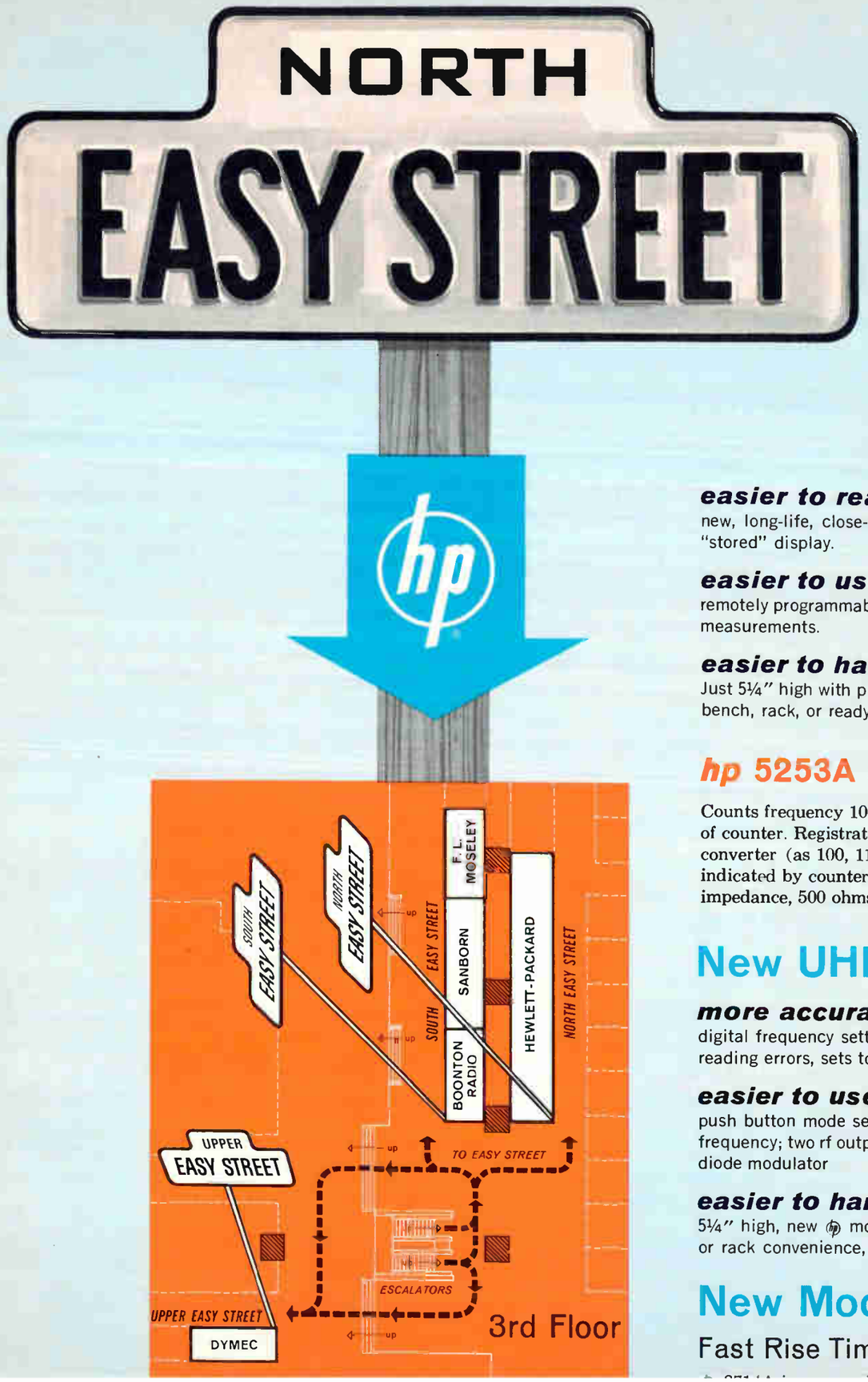
electronics



Solid State All-Purpose Counter ...Plug-ins to 500 MC!

Measures:

frequency
time interval
period
multiple period average
ratio

hp 5243L 20 MC Counter

easier to read
new, long-life, close-spaced Nixies. Non-blinking "stored" display.

easier to use
remotely programmable—plug-in units for making more measurements.

easier to handle
Just 5¼" high with plug-ins. hp modular construction for bench, rack, or ready portability.

Measures frequency directly (0 to 20 MC); period (average of up to 10^5 periods); ratio between two frequencies. With addition of plug-in units counts frequencies of 100 MC to 500 MC and can measure time interval of 1 μsec to 10^8 seconds. Time base stability $5/10^8$/week. Operates from —20° to +65°C.

In addition, hp 5243L is an excellent secondary frequency standard with outputs from 0.1 cps to 100 KC, 1 MC and 10 MC/sec selectable by rotary switch. All functions can be remotely controlled except for display time and sensitivity. Sensitivity, 100 mv rms; coupling, dc or ac. Input impedance, 100 K ohms/volt (10 K ohms at 100 mv). $2,750.00.

hp 5253A 500 MC Converter

Counts frequency 100 MC to 500 MC, retains accuracy of counter. Registration, 9 places, first two indicated on converter (as 100, 110, 120 . . . 210), next seven places indicated by counter. Input voltage, 0.1 volt rms; input impedance, 500 ohms. $475.00.

hp 5262A Time Interval Plug-in Unit

Model 5262A, shown installed in Counter above, measures time interval, 1 μsec to 10^8 seconds with time base accuracy, ± 1 count. Input voltage, 0.5 volt peak minimum, dc coupled input; input impedance, 100 K ohms/volt. Independent or common start-stop with positive or negative trigger slope. $285.00.

New UHF Signal Generator, 800 to 2,400 MC

more accurate
digital frequency setting and readout; no ambiguity or reading errors, sets to within 2 MC

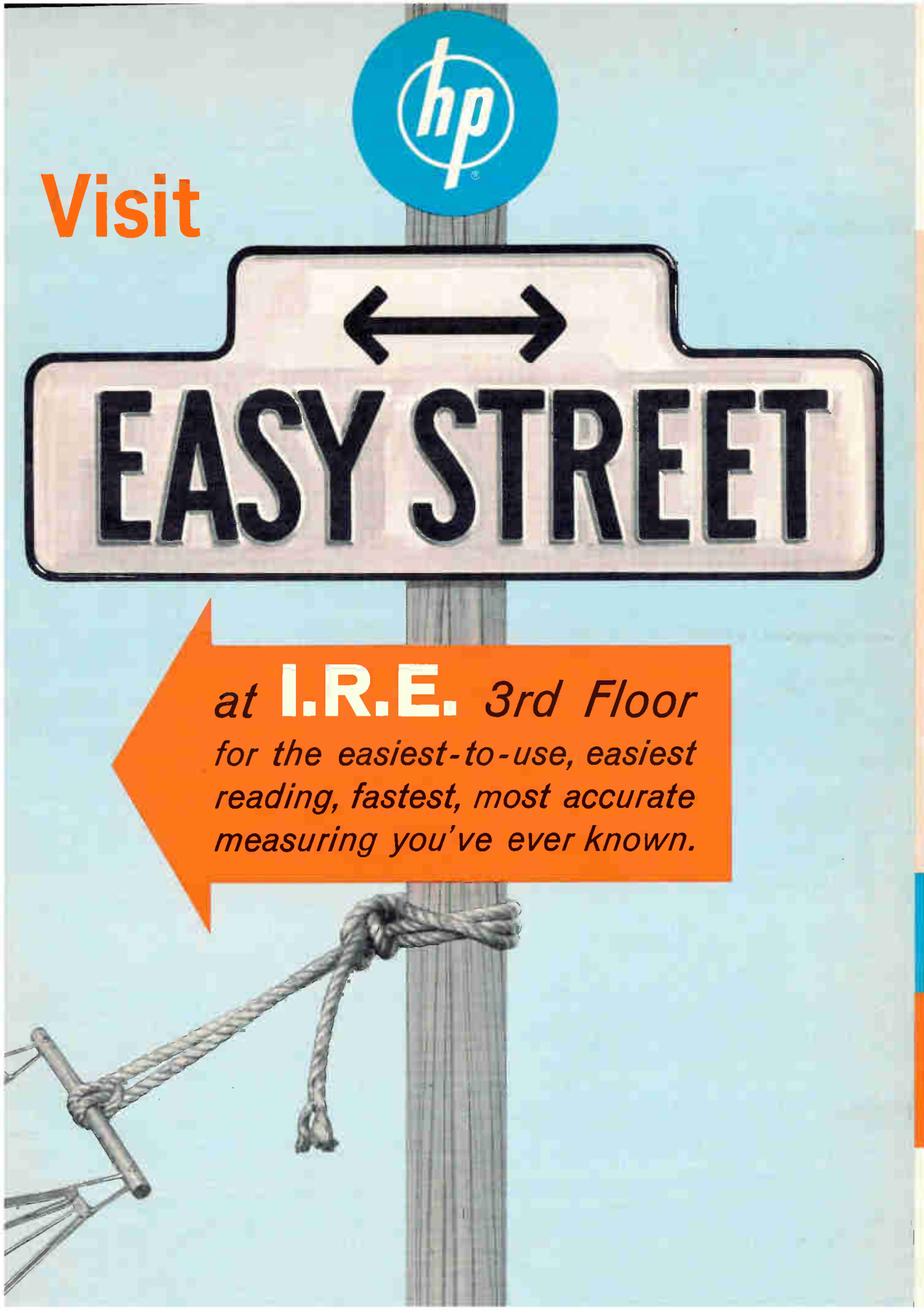
easier to use
push button mode selection, precisely constant output and frequency; two rf outputs — calibrated and gross; new PIN diode modulator

easier to handle
5¼" high, new hp modular construction for all units — bench or rack convenience, self-stacking

New hp 8614A Signal Generator provides automatically leveled output within ± 0.5 db from 0 dbm to —125 dbm, or unleveled 10 mw or more across the band. hp 8614A is extremely easy to use with push button mode and function selection and digital frequency readout accurate to ±1%. Its small size makes it ideal for bench top use where it may be stacked with its companion modulator unit (below). Frequency stability is approximately 0.05%/°C change in ambient temperature; less than 1,000 cps peak incidental fm; less than 0.001% change for line voltage variation of ±10%. $1,650.00.

New Modulator

Fast Rise Time, Push Button Controls



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greater measuring ease new accuracy and convenience, in advanced equipment from

BOONTON RADIO

Boonton 202-J

New 202-H and 202-J AM-FM Signal Generators, offering improved linearity, solid state power supplies, reduced microphonics, improved electronic tuning, automatic level set, increased fm modulation bandwidth, improved fm deviation metering. Type 202-H covers broadcast, VHF-TV and communications bands, Type 202-J covers 215-260 MC military telemetering band. Also see new Type 219-A FM Stereo Modulator which accurately simulates the recent FCC-approved stereo broadcast signal. Prices on request.

F. L. MOSELEY

Moseley 680

New 680 Series Strip-Chart Recorders providing 1 mv/in to 20 v/in range in 10 steps, 1 mv full scale optional, zener reference supply, instant change of 8 chart speeds, high pen speed of 0.5 sec full scale, high accuracy 0.2% full scale operation to 500 v off ground, solid state circuitry, output pot, event marker, Hi-Lo limit switches (optional), rack or table mounting, chart tear-off or paper take-up roll. Model 680, $750.00. Model 681 (one speed, one range), $625.00.

SANBORN

See Model 860-4000 FIFO Amplifier, 0 to 10 KC, fully transistorized, ideal for amplifying data from wide bandwidth transducers. Model 2000 Magnetic Data Recorder, 7-channel FM tape system. Model 360 Event Recorder, records up to 120 parallel ON-OFF events on a 16" wide electrically sensitive chart, Model 350-2500 True RMS Pre-amplifier (25 to 300 v, 0.05 to 5 amps) and Model 7 DCDT Differential Transformer Displacement Transducer providing unlimited resolution, high accuracy and sensitivity, no phase and balancing problems. Prices on request.

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New DY-6100 Industrial Multimeter System for scanning and measuring up to 25 data input channels. Includes DY-2900 Input Scanner, Digital Voltmeter and Printer. Also see DY-2401A Digital Voltmeter to measure millivolt signals accurately; DY-2410 AC/ohms-to-DC Converter- true multimeter versatility. Prices on request.

HARRISON LABS

on lower EASY STREET (1st floor) Booths 1429-31

New Model 575A SCR Regulated 75 Amp DC Power Supply, probably offering highest current rating of commercial supplies using SCR's, yet compact, lightweight, more immune to line transients. Output 0 to 36 v, 0 to 75 amps, $1,450.00. Also Model 806B, 36 v, 3 amp power supply with 0.01% regulation, $350.00. Model 822A Dual Range Power Supply offering 32 v, 2 amp and 60 v, 1 amp outputs; 0.01% regulation, $275.00.

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Booths 1429-31

signal source between 800 and 2,400 MC to provide rf pulses and square waves having less than 20 nsec rise time, less than 10 nsec decay time and an on-off ratio up to 80 db.

In addition to having an internal pulse and square-wave generator with a rep rate variable from 50 cps to 50 KC for modulating the rf, hp 8714A can be driven by external pulses at rates to 1 MC. For pulse burst durations of less than 1 sec, repetition rate may be as high as 2 MC.

Sync pulses in advance of the rf pulse and simultaneous with the rf pulse are also provided. $850.00.

hp 8614A UHF Signal Generator (top)
hp 8714A Modulator (bottom)

hp 241A Push Button Oscillator

New Push Button 1 MC Oscillator

more accurate no ambiguity, punch-in exact frequency desired, 1% basic accuracy, 0.02% resettability

easier to use instantaneous frequency selection, ideal for repetitive and production testing

easier to handle very compact, new hp modular construction for bench, rack, or ready portability

hp 241A, with push button frequency control, gives three digit resolution in selection of frequencies, yet provides utmost simplicity of operation. Ideal for situations where several preset frequencies are required quickly and accurately. Frequency coverage is 10 cps to 1 MC; frequency stability is better than ±0.03%/°C from 0° to 55°C. $425.00.

New Probes for *hp* 428A/B DC Current Meters

hp 3529A Magnetometer Probe. Measure magnetic fields as low as 1 milligauss, ac fields, Earth's field; place circuit components for minimum magnetic interaction. Connects to hp 428A/B DC Current Meters, reads milligauss/milliamperes on hp 428A/B. hp 3529A, $75.00.

hp 3528A Clip-On Current Probe. Has 2⅝" aperture for making measurements on large cables or waveguides. Provides readings 3 ma to 1 amp or 1 ma to 10 amps depending on whether used with hp 428A or 428B DC Current Meters. hp 3528A, $300.00.

hp 716A Klystron Power Supply

hp 716A will not only power 250 different types of klystrons, but its unusually low ripple and its high regulation mean almost total absence of fm and am from high-performance klystrons. Reflector voltage may be set to within ±½% ±1 v on the direct-reading 3-foot voltage scale; beam voltage may be set to within ±2%. Features include beam current to 100 ma, an fm sawtooth supply, square-wave supply for on-off operation, and a 6.3 v regulated dc klystron filament supply for maximum tube stability. $675.00.

New Operational Amplifier

The new hp 463A Operational Amplifier can be used for analog computing functions, as a high impedance integrator, or as a dc polarity inverter. Features solid state circuitry, low noise photoconductor chopper. May also be used as a normal dc amplifier.

Two plug-in units are available to switch gain from 1 to 1,000 or to insert your own input and feedback networks for analog work. Open-loop dc gain is 10^7. The amplifier features low noise (3 μv rms) and low drift (5 μv/day referenced to input). $425.00.

Amplifier Levels Broadband Power

New hp H01-8401A Leveler Amplifier, when used with a directional coupler and an hp 431A Microwave Power Meter, modulates microwave signal generators and sweep oscillators so that they provide level output across their operating bands. System output is level ±0.1 db to 1.0 db across the band, with no fine grain discontinuities. Output power is constant regardless of load and may be instantly changed in 5 db steps by use of the power meter switch. A microwave amplifier may be inserted in the system ahead of the sampling point to provide 1 watt of level microwave power. $200.00.

New Versatility for *hp* 185 Scopes

New Switching Time Tester

hp 186A Switching Time Tester plugs in to hp 185 oscilloscopes, makes rapid measurements of transistor, diode and tunnel diode switching characteristics with nanosecond resolution. Also provides convenient means of testing pulse response of high speed circuits. hp 186A comprises a fast rise pulse generator, single channel vertical amplifier and two power supplies for biasing components under test. Four plug-in jigs are supplied for testing transistors, diodes, tunnel diodes and external networks. hp 186A, $1,500.00.

New Delay Line

hp 1100A Delay Line (not pictured) permits you to view the leading edge of a signal used to trigger hp 185 oscilloscopes. A special load incorporated into the hp 1100A compensates for frequency losses in the delay line. The delayed signal is virtually identical to the input signal. $300.00.

New Attenuators

New **hp 350C and 350D** are 500, 600 ohm attenuators, adjustable in 1, 10 db steps to 110 db. Accuracy better than ±1 db, 0 to 110 db, dc to 1 MC. 5 watts continuous duty. hp 350C or 350D, $110.00.

New **hp 355C and 355D** are coaxial attenuators designed for operation from dc to 1 GC. hp 355C provides 12 db attenuation in 1 db steps; hp 355D provides 120 db attenuation in 10 db steps. hp 355C or 355D, $125.00.

See back page for new easy-to-use equipment from Boonton Radio, Dymec, Harrison Labs, F. L. Moseley, Sanborn at **I.R.E.**

on

NORTH

EASY STREET

See and operate these new, easy-to-use hp instruments

New hp 175A 50 MC Oscilloscope

easier to read full 6 x 10 cm display on hp internal graticule CRT. No parallax, no astigmatism

easier to use wide plug-in versatility, controls in logical array, improved triggering, beamfinder

easier to handle new hp modular construction for bench or rack. Completely accessible for easy servicing

easy to service Main vertical amplifier easy to set up and adjust since no "distributed amplifier" techniques are used. Only six vacuum tube and five transistor types are used

Internal sweep: 24 calibrated ranges, 0.1 μsec/cm to 5 sec/cm, ±3%. Vernier provides continuous adjustment between calibrated ranges and extends slowest sweep to 15 sec/cm. Times-10 magnifier. Horizontal amplifier passband, dc to 300 KC. hp 175A, $1,325.00.

Vertical and horizontal plug-ins tailor hp 175A to a wide variety of applications

hp 1750A
40 MC Dual Trace
Vertical Plug-In,
$285.00

hp 1753A
40 MC Single Channel
Vertical Plug-In,
$155.00

hp 1752A
5 mv Vertical Amplifier
Plug-In, $225.00

(Pictured in hp 175A above)

hp 1783A
Time Mark Generator,
$130.00

hp 1781A
Sweep Delay Generator,
$375.00

hp 1780A
Auxiliary Plug-In,
$25.00

hp 120B 450 KC Oscilloscope

The new hp 120B Oscilloscope combines more desirable features to give you more actual measuring help than any 450 KC scope ever produced. Not only are reading errors from parallax and distracting reflections eliminated, but you have a genuinely unique array of electrical and convenience features for measurements from dc to 450 KC.

Model 120B combines minimum controls with hp automatic triggering for utmost speed and convenience. Horizontal amplifier dc to 300 KC, phase-shift between amplifiers less than 2°. Balanced input on most sensitive range for noise rejection at low levels. Times-5 sweep expander, all ranges. New modular design for rack or bench use. hp 120B, $475.00.

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CRIMPING TOOLS

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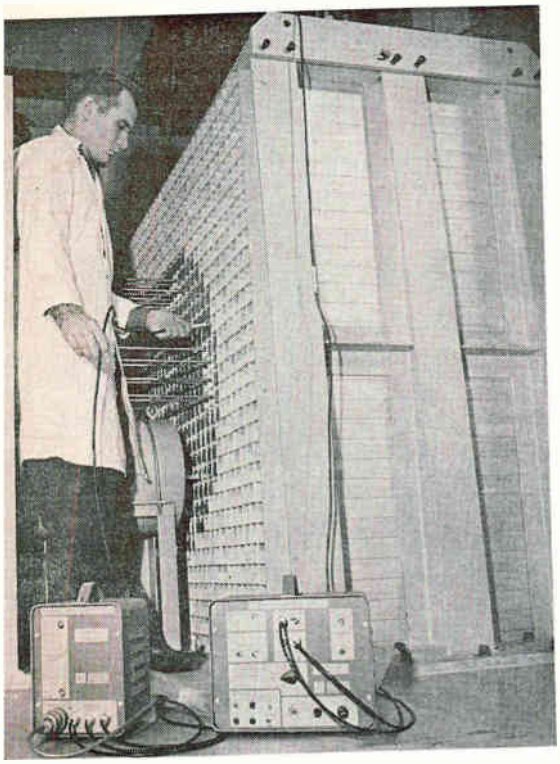
More than 20 years ago Cannon originated the crimp-type plug to fulfill the growing needs of the aviation industry. Since then, our research and development has kept pace with expanding technology, until today we provide plugs with crimp snap-in contacts for every application, every environment. A full range of crimp tools—hand, semi-automatic, automatic—gives you the utmost in flexibility. Whatever your requirements...whether standard solder pot versions or crimp snap-in contacts—consult your nearest Cannon sales office or distributor. For further information, write to:

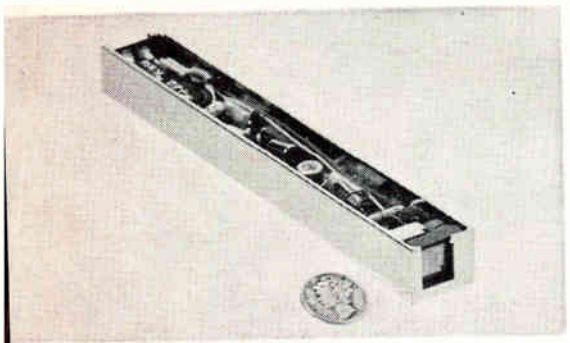
CANNON PLUGS

CANNON ELECTRIC COMPANY, 3208 Humboldt Street, Los Angeles 31, California

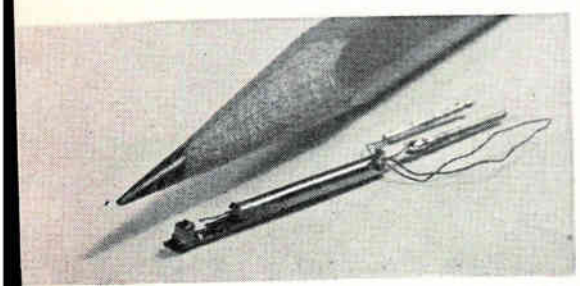
Semiconductor Radiation Detectors



Atomics International uses neutron spectrometer in epithermal thorium reactor experiment



Semiconductor detector with miniature amplifier. These units may be stacked to form array



Detector can be inserted in body cavities as radioistope tracer

By HAROLD C. HOOD
Pacific Coast Editor

LOS ANGELES—The nuclear semiconductor radiation detector is changing from a laboratory curiosity to a developmental manufactured device. One estimate of the potential market for semiconductor detectors next year is $\$\frac{3}{4}$ million.

So far, the usefulness of the detectors has been demonstrated in space measurements, probing oil well survey holes, determining neutron spectrums as a function of position in nuclear reactors, and in many industrial process control instruments.

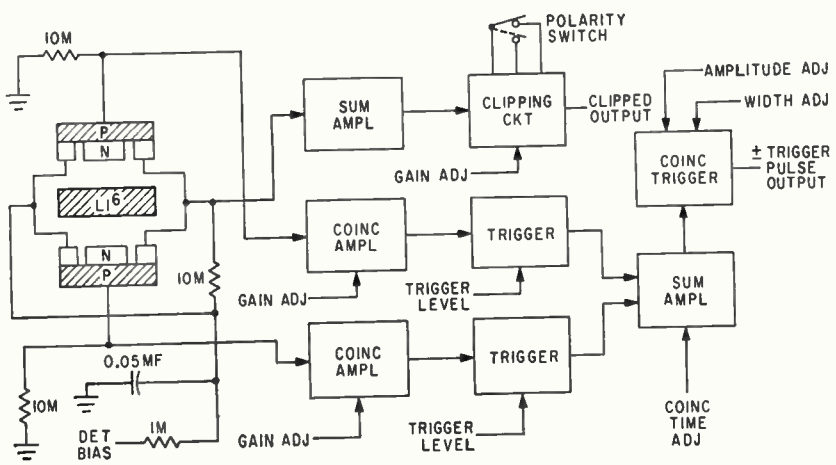
Basic principle upon which the solid-state detector operates is illustrated. In a device developed by Solid State Radiation, Inc., phosphorus is diffused into high-resistivity *p*-type silicon. An *np* junction results somewhat less than one micron below the surface and a *p*-type depletion area extends for several hundreds of microns below. As ionizing radiation crosses this depletion region it gives up energy in the formation of electron-hole pairs. The internal electric field separates the electron-hole pairs and an external circuit pulse, the rise time of which is typically in the nanosecond range, results.

Stephen S. Friedland, SSR president, says the quantity of charge generated within a semiconductor detector from a given nuclear source is 10 times that generated within a gas detector. Formation of an electron-ion pair in gas requires 32.5 electron volts while an electron-hole pair in a semiconductor detector results from 3.5 ev.

One-dimensional detector arrays have replaced photographic plates in space-borne beta-ray spectrometers. The instruments need not be recoverable, since data may be telemetered back to earth, and the spectrum is reported as a continuously changing function of vehicle height. Arrays of 10 elements each were flown aboard Discoverers 29 and 31. Spectrum range was 70 Kev to 1 Mev.

A proton spectrometer under development, using 16 side-by-side detectors for Van Allen belt measurements, will have a range from 10 Mev to approximately 200 Mev. Another, measuring up to 15 Mev, is orbiting in two Navy Transit satellites and reported to be sending back reliable data.

An epithermal neutron spectrometer, sandwiching a thin layer of Li^6 metal between two semiconductor detectors, shows considerable promise in the field of neutron and reactor physics, according to Friedland. One is being used in the Advanced Epithermal Thorium Reactor Program being sponsored by Southwest Atomic Energy Associates at Atomics International. The spectrometer measures the neutron energy spectrum directly with a linear output in the range of 0.5 to 15 Mev. Alpha and triton particles from the lithium-hydrogen reaction deposit energy in the two



Simplified block diagram of epithermal neutron spectrometer

Demonstrate Their Practicality

detectors, the total shared energy is summed electronically and its amplitude is linearly related to incident neutron energy (see block diagram).

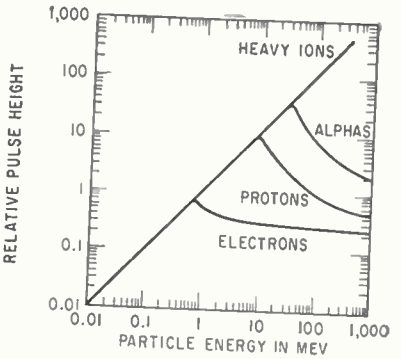
Other neutron detection devices use semiconductor detectors coated with suitable neutron-to-charge particle converter materials such as B^{10}, U^{235}, H, and Np^{230}.

Another two-dimensional array device developed at SSR is a beam profilometer of pulsed beams from large particle accelerators. Presentation of the beam during each burst of particles reportedly slashes many weeks from evaluation time. Another two-dimensional unit, using B^{10}-coated detectors is used to investigate flux density near a nuclear reactor and for nuclear reactor explosive diagnostics.

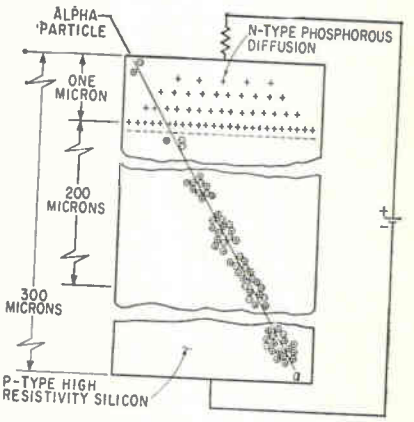
Three-dimensional arrays, the company says, may be feasible for cube-shaped cloud chambers. By feeding coordinates and pulse heights of triggered detectors into a computer, it may be possible to compute instantaneously the total energy and identify the particle. Under investigation is the possibility of substituting a continuous slab of semiconductor material in this application, to reduce the number of amplifiers and power supplies needed.

A spokesman for Jet Propulsion Laboratory is optimistic about space applications for both diffused junction and gold-silicon surface barrier types of semiconductor detectors. They are inherently small, rugged, fast and have low power requirements. Reliability expectations will be studied since anticipated uses call for lifetimes of three months to several years.

Size depends only on requirements for attaching leads to the two sides of detectors and for mounting. JPL expects several of the interplanetary Mariner and Voyager probes to fly SSR units and points out that semiconductor detectors have little competition in measuring many parameters important in space work, such as charged particles. However, crystals like sodium iodide and cesium iodide, used with multiplier photo tubes, will remain the only practical devices for measuring gamma rays in near future, JPL says.



Range of linearity of pulse height vs energy for nuclear particles



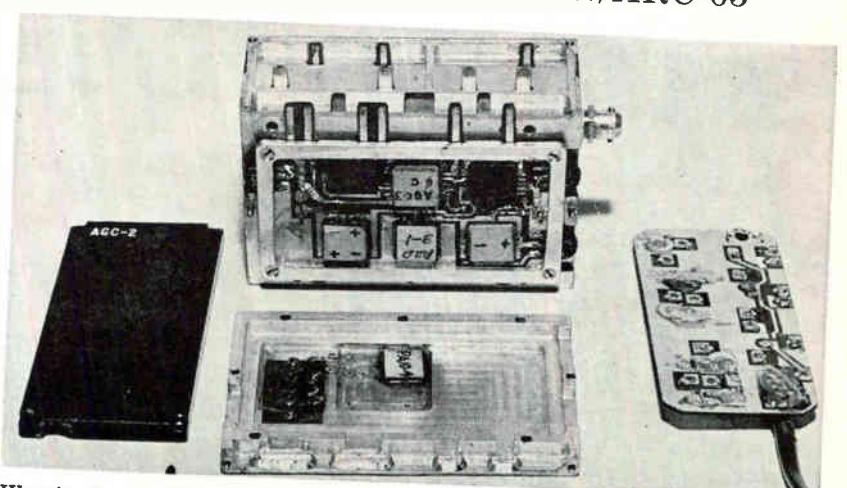
What ionizing radiation does when it enters solid-state detector

SSR adds that the future of the new detectors must be evaluated with cautious optimism. As yet, life characteristics of the device are unknown and some shelf deterioration has been reported. Some devices may exhibit excellent properties one day, be of questionable use the next and return to excellence the third day. A correlation of transistor production techniques with those of semiconductor detectors is expected shortly to give detectors the reliability shown by transistors. Also under investigation is the effect of nuclear radiation damage on the detectors. After large doses, some fast neutron damage has been noticed.

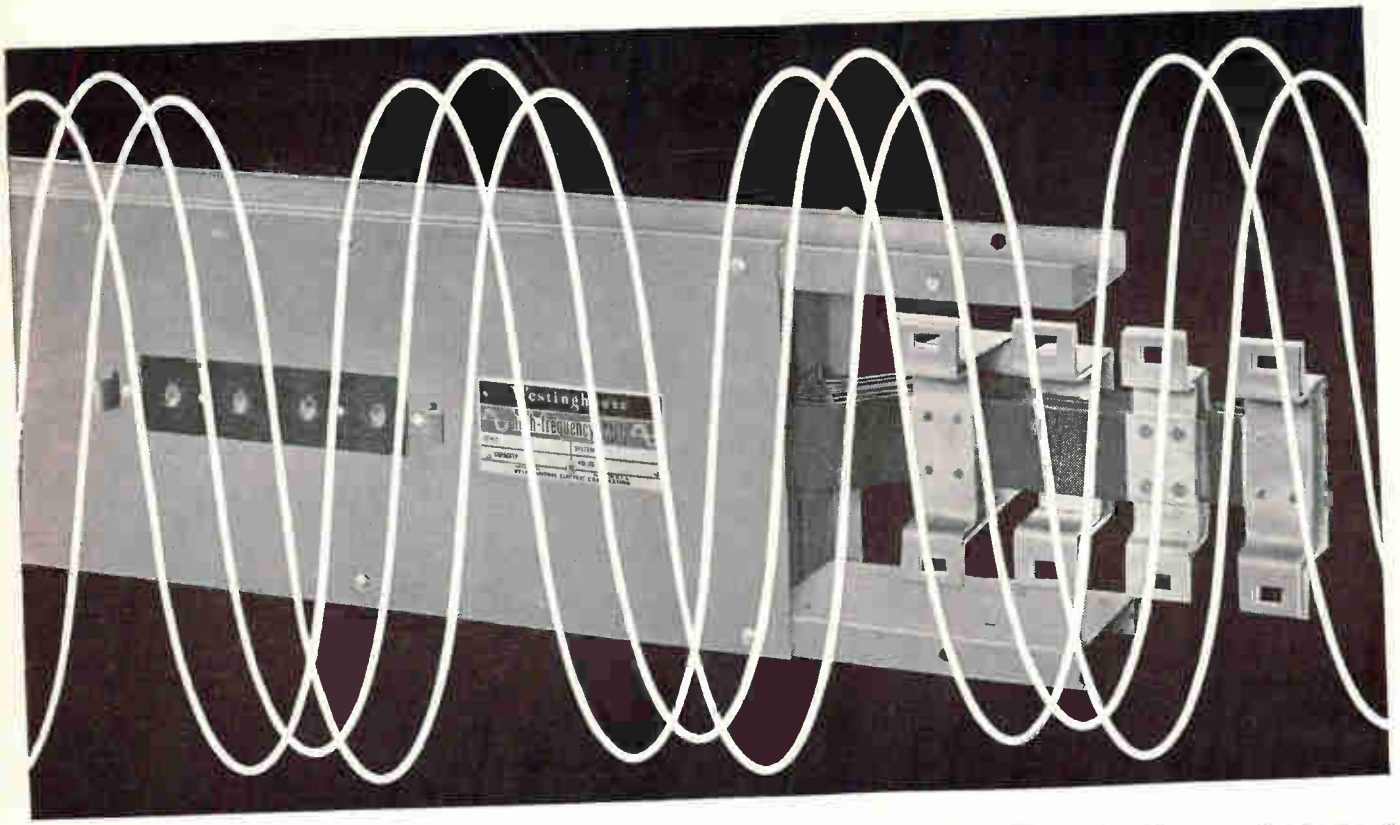
Exposure to comparable gamma ray fields produces similar deterioration.

Other companies actively engaged in nuclear semiconductor detector development include Ortec, RCA of Canada, and Hughes.

Molecular Circuit Version of AN/ARC-63



Westinghouse Electric and the Air Force this month showed a molecular circuit version of the AN/ARC-63 emergency communications receiver. It weighs ½-lb, compared to 5 lb for the conventional set. The number of parts was reduced from 219 to 82, including nine functional blocks (mixer-oscillator, three i-f and two a-f amplifiers, audio detector, differential and two-stage agc d-c amplifiers)



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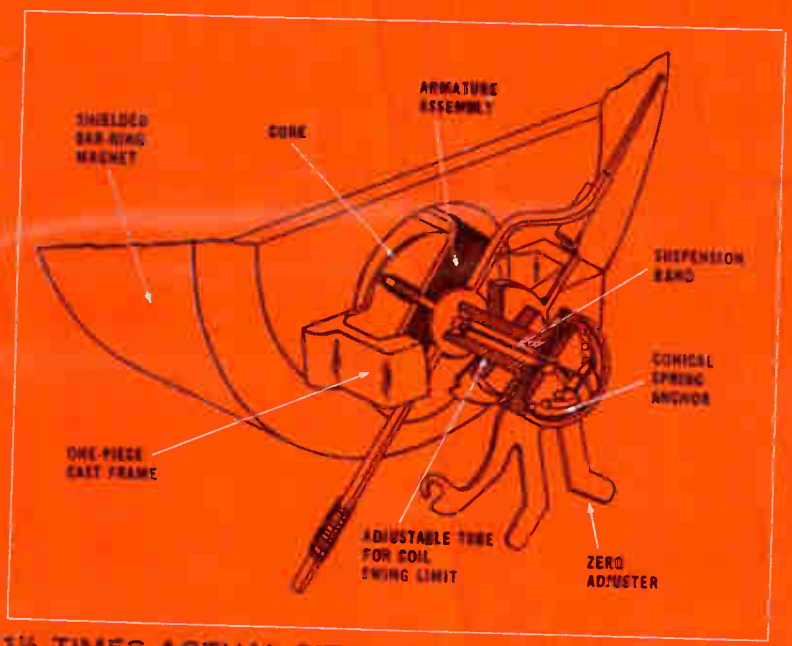

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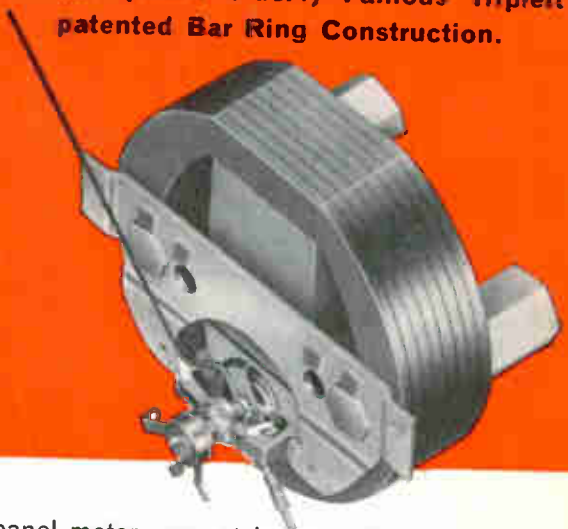

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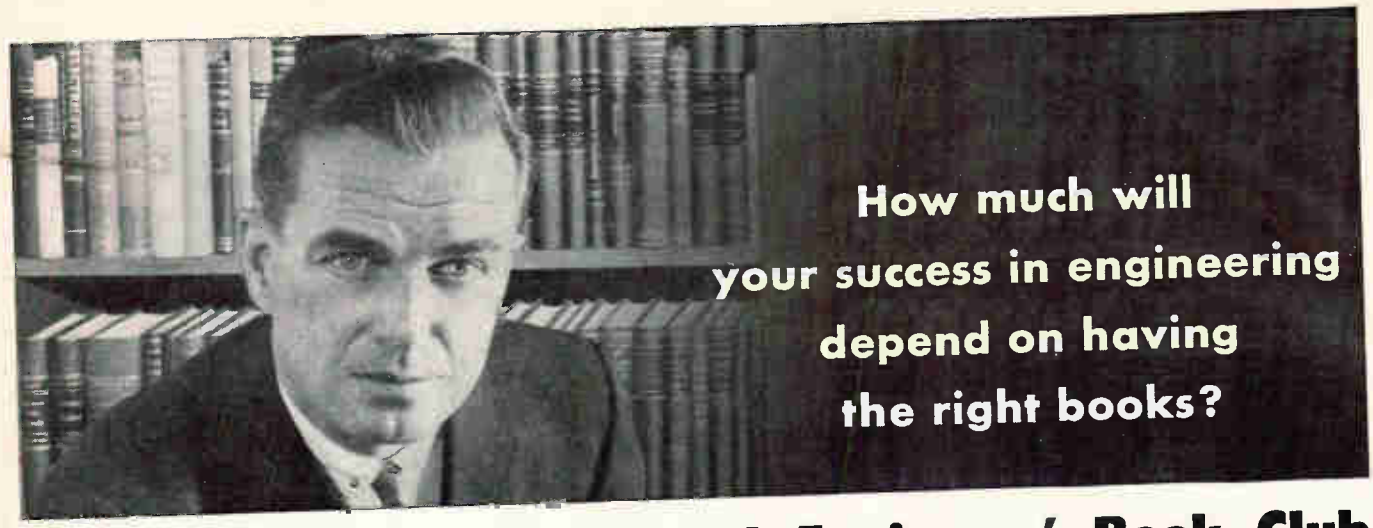

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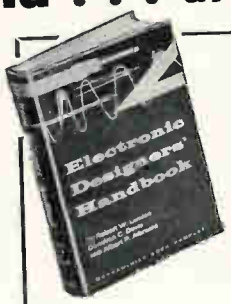

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PROBLEMS AND PROPOSALS:

Manned Spacecraft Landing Systems

By ROY J. BRUUN
Assistant Editor

ONE OF THE KNOTTIEST problems now facing manned space system designers is how to bring the vehicle in safely through reentry to a controlled touchdown on land.

Several electronics companies are now designing landing systems. Approaches range from an instrument landing system incorporating available subsystems, proposed by GE, to an on-board adaptive control recommended by General Precision Labs. Raytheon leans toward an airborne guidance system with ground support equipment. Sperry takes a pilot-oriented approach.

The system under development at General Electric's Systems division would regulate the descent path from 500 miles out. The vehicle path would be controlled to dissipate the kinetic energy without overheating or overstressing the vehicle. Landings can be made under automatic control, or the pilot can use a display and perform designated control responses.

GE says over 100 landings have been simulated with the system, on an analog computer, and that it is ready for application to specific vehicles.

Subsystems include the AN/TPQ-10 radar being produced for use by the Marine Corps in close-support bombing operations, a GE 225 computer and airborne beacon and decoder (Mod III G). The latter is similar to units developed as part of a radio command guidance system for launching ICBMs and boosters. Airborne weight is 28 lb.

System operation is outlined in the block diagram. Radar data enables the computer to compute position and velocity and generate satisfactory flight paths. Flight commands go to the vehicle over the radar link until the vehicle comes in for a landing at its particular stalling speed. Accuracy is expected to be 1 to 2 fps.

GPL's report on its study program says that the complexity of landing a spacecraft may require an on-board adaptive control system. Adaptive systems respond instantly to operational conditions, not pilot or ground control. The adaptive system would back up ground-based regulator and servo-type systems.

An adaptive system, GPL feels, could cope with unpredictable operating variables. It could, for example, interrelate flight parameters to stall the vehicle the required few feet above the runway. Reasoning is that since vehicle, position and environmental parameters cannot be accurately foreseen, closed loop control is needed.

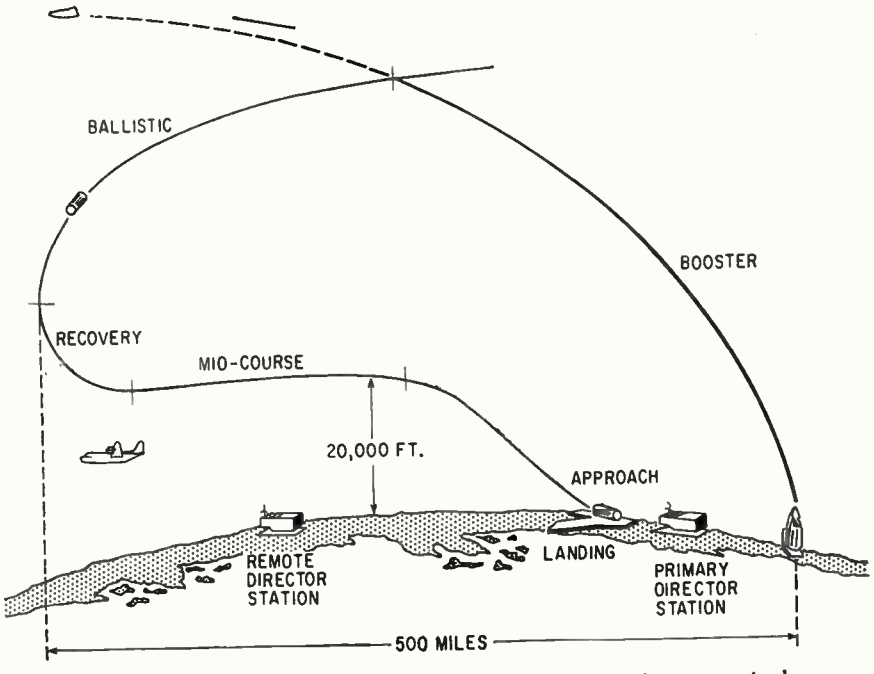
The regulator control system requires establishment of a reference trajectory and would act on deviations from that reference. The servo control system would control from existing position and conditions along a path estimated according to predicted future conditions. The adaptive backup system would make a "best estimate" of the effects of sudden changes in variables and controls.

Another argument in favor of including adaptive controls, GPL says, is the difficulty of maintaining air-ground communications through the ionized air that would sheath the reentering vehicle.

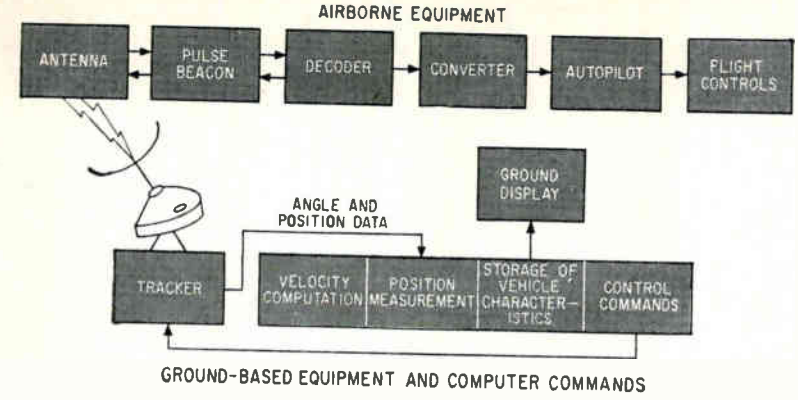
GPL stresses that the first consideration in manned vehicles is personnel safety. Provision should be made to monitor life-support equipment and operate emergency equipment. If retrorockets misfire, for example, the pilot should be able to transfer into an orbit transecting the fringes of the atmosphere.

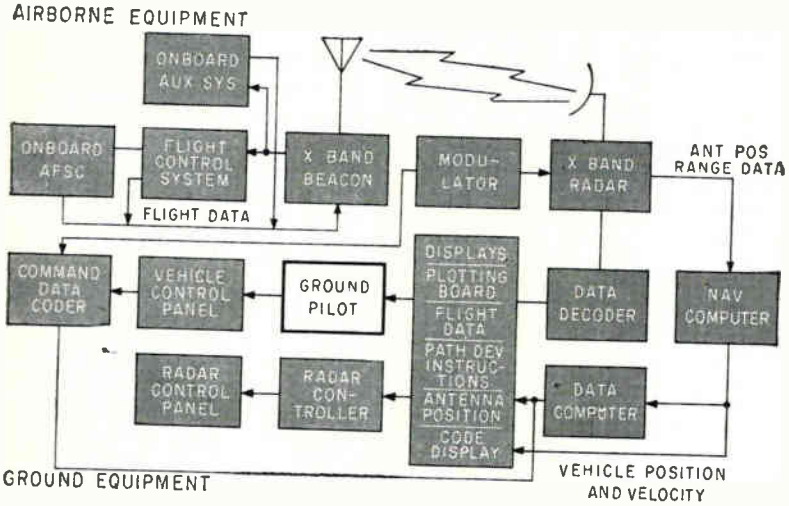
Raytheon has been studying and planning instrumentation for a recovery control to be established at the Air Force Flight Test Center, Edwards AFB, Calif.

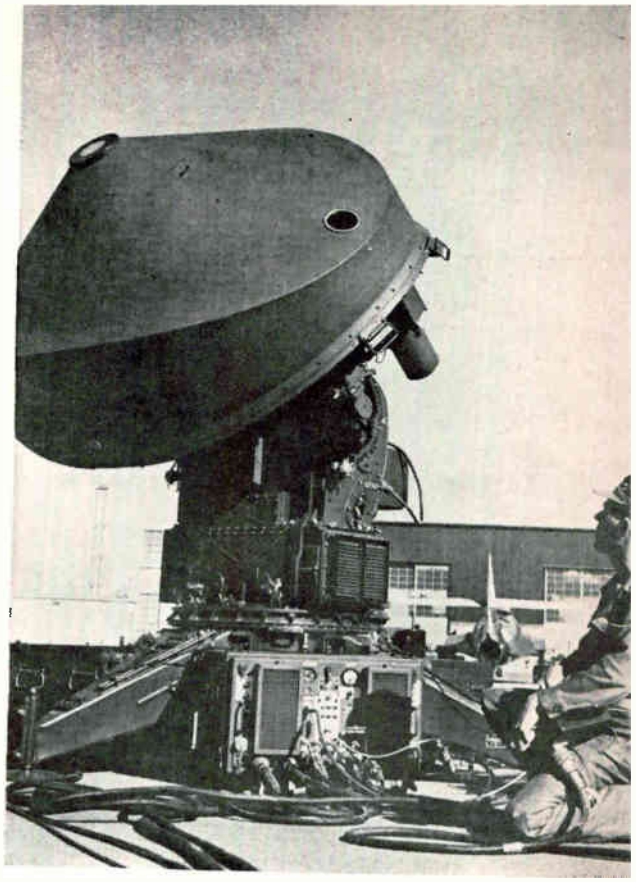
A company spokesman says that



Sperry system may require two ground stations for optimum control







System proposed by GE (top left) would use available equipment like AN/TPQ-10 radar (above) originally designed for close-support air bombing. In Sperry system (left), pilots in air and on ground are given prime control roles

the weight penalty of maneuvering engines makes it likely that spacecraft will be gliders, creating severe terminal guidance problems. The trajectory of the approaching vehicle "may be viewed as a string whose slack may be oriented in many different ways" relative to the direct line between reentry and landing points.

The guidance system, he says, must enable the vehicle to fly a large number of "nominal trajectories which together encompass all the vehicle's maneuver potential."

Raytheon says the system could compute trajectories or select them from storage. However, real-time computation is difficult to achieve. Large, rapid-access storage would be required since it is uncertain whether taped data could be searched in time. Even if a trajectory is found quickly enough, the problem of controlling the vehicle remains. A glider's position and velocity cannot be forced to correspond to a trajectory.

Raytheon points out other guidance problems. Radar, the traditional ground-based instrument, gives only position and range rate information. Errors are introduced when vector velocity is computed. While inertial guidance systems measure velocity accurately, their position information is not reliable during the terminal portions of a flight. Inhibition of communications by the reentry plasma sheath would depend on vehicle characteristics and communications frequencies.

Raytheon feels that reliability problems favor basing the system's principal components on the ground. But economics and versatility favor an entirely airborne system. With an airborne system, the vehicle could land at locations not equipped with ground-based equipment. The ultimate solution will probably be a combination of ground and airborne equipment, Raytheon says.

Further analysis of the problems and equipment requirements—particularly line-of-sight instrumentation, computers and terminal equipment—is needed, the company says.

Sperry Phoenix is developing a space vehicle landing system that consists of a control radar unit housed in a highway van and transponder equipment located in the spacecraft to receive and transmit coded radar signals. Called Man (Microwave - Aerospace - Navigation), it has been in development 1½ years. A company spokesman recently said that "it is possible that radar line-of-sight limitations will necessitate the use of an airborne-relay-mode of operation or the addition of an auxiliary ground station."

Sperry engineers see earth-based recovery systems for manned vehicles as primarily a pilot aid. To determine this, Sperry conducted extensive investigations of re-entry recovery and landing of unmanned glider vehicles. This study is reflected in the illustrated system in which a "ground pilot" assumes pilot functions. Ground pilot controls the "transition (re-entry) maneuver and navigation to a high key point." As the vehicle approaches flare-out and touchdown, phases during which time and computational factors become more critical, the automatic (computer-controlled) mode is used with the ground pilot monitoring the operation and overriding the control in the event of emergency (failure) conditions.

French Ready Implosion-Proof Tv Tubes

By ARTHUR ERIKSON
McGraw-Hill World News

PARIS—What wasn't displayed had industry insiders buzzing at the Fifth International Electronics Components Show held here recently.

Implosion-proof tv picture tubes were whisked off the stands of two manufacturers as the show opened. The official explanation: French safety regulations require a protective glass in front of picture tubes, so the new versions won't be released until this requirement is changed. But some informed showgoers felt the real reason was set makers' worries that news of an important tube development for next year's sets would keep hesitant prospective buyers out of the market for a while longer.

It's an open secret that SOVIREL, a company that supplies the glass for French-made picture tubes, is producing tubes with a fused steel coating that extends about four inches back from the face. The fused steel checks the spread of fissures should the glass crack. La Radiotechnique by midyear will have on the market an implosion-proof tube, developed jointly with SOVIREL, with a tight polyester-glass sheath applied under pressure. The sheath extends about halfway back and there is a metal band around the edge behind the face.

Displays underlined a steady technological advance. CSF, for example, has an experimental O-type Carcinotron with 10-mw output at 0.7-mm wavelength. Thomson-Houston showed a high-power klystron with 25-Mw peak and 30-Kw average output over a frequency range of 2,700-3,100 Mc (with two tubes), up from 5-Mw peak and 10-Kw average last year.

French instrument makers are also climbing toward higher frequencies. Ribet-Desjardins, for one, displayed a sampling oscillograph with two identical channels having a passband of 0.5 nsec. Chauvin-Arnoux has a microvolt-ammeter, accurate to 3 percent, that can measure a-c currents to 1 amp at frequencies to 1 Mc. D-c component has no effect on the reading, made with a microclip transformer so the circuit doesn't have to be disconnected.

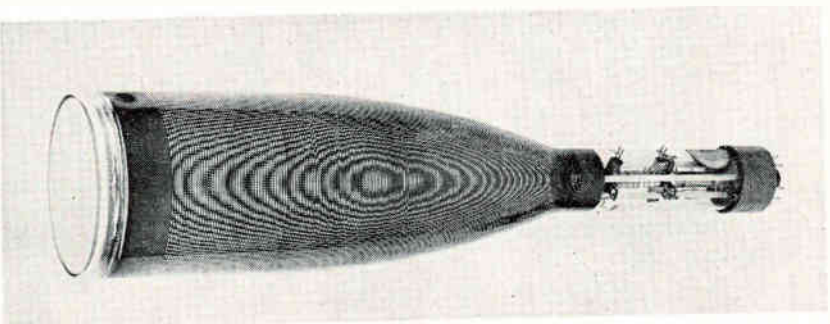
A brushless variable transformer provoked considerable interest. In S.E.I.M.'s Variavolt, the lamination stack for the primary magnetic circuit is split along the line of zero flux and spring-loaded against a rotor carrying the secondary winding. This arrangement eliminates air gap between the primary and secondary, so losses are no more than in a fixed transformer. A nickel-stainless steel tube screens the secondary, which is completely isolated from the primary. Ratings run to 2 Kva. Output voltage varies steplessly from zero to 200, 300 or 500 volts, depending on the angle of the secondary winding.

S.T.A.R.E.C. showed a coaxial relay that switches within 10 ms either of two coaxial inputs to a single output. The unit handles up to 3 kw at 100 percent, modulation, has vswr less than 1.05 over a frequency range from zero to 400 Mc.

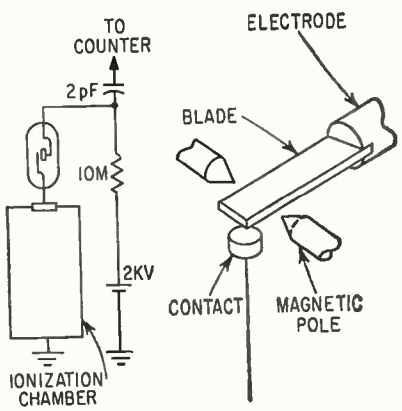
CSF's electrostatic relay integrates low-level outputs from de-

TEMPTING MARKET

PARIS—*Sales curves for the French electronics industry are moving up. The Federation Nationale des Industries Electroniques said 1961 sales topped $800 million, 21 percent over 1960. Components accounted for more than a third of the total. A market like that tempts manufacturers from other countries and the show reflected the temptation. A full third of the 600-odd exhibitors were non-French, West Germany led the outsiders with 67 exhibitors followed by the U. S. with 57*



La Radiotechnique 1-Gc crt prototype. Helical post-acceleration gives sensitivity of 30 v/cm horizontal and 10 v/cm vertical



Charge buildup triggers movement of blade in CSF relay, integrating low-level outputs

S.E.I.M. brushless transformer varies output by changing angle of secondary winding

vices like ionization chambers or photoelectric cells. The outputs are stored on a collecting electrode fitted with a ferromagnetic blade restrained by two magnetic poles. When the charge built up on the blade equals the relay's sensitivity setting (10^{-10} coulomb or better), the electrostatic force between the blade and a contact just below its free end overcomes the magnetic force. The blade snaps against the contact and discharges, developing a pulse. Frequency of the pulses from the electrostatic relay represents the output of the device connected to the collecting electrode.

Digital Computer Will Run Red Lights in LA

LOS ANGELES is making a pilot installation this spring of a traffic control system run by a digital computer. In the initial installation, it will operate 26 lights along four miles of Sunset Boulevard and 10 lights on approach streets. Traffic flow data will be telephoned from automatic detectors to a Thompson Ramo Wooldridge RW-300 computer at City Hall.

West Germany May Join Private Satellite Net

BOSTON—It is likely that West Germany will build a ground station for Telstar, Bell Telephone Lab's communications satellite experiment (p 26, Feb. 16). The station would be in addition to one at Andover, Me., and those planned in England and France, John R. Pierce said at an MIT lecture.

Among other comments, Pierce expressed skepticism that the state-of-the-art is ready for the Army Advent Project to place a satellite in synchronous orbit. For communication satellite networks, he remarked, high-power, long-life equipment should be developed now, even before reliable boosters are ready. Among needs are masers not dependent on gas liquefaction and five-year attitude controls.

Pierce said that of satellites launched to date, only Vanguard I had anything like the lifetime needed. Telstar, he said, approaches the limits of today's art.

Kerr Cell Camera Films in 5 Nsec

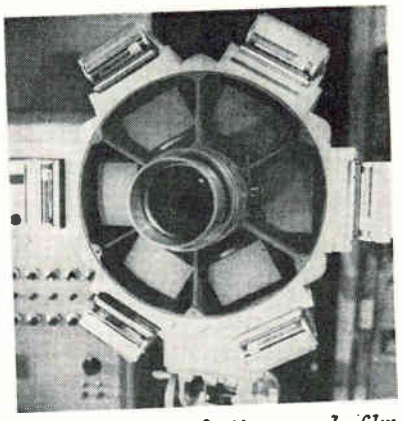
LOS ANGELES — Complete photographic records of high-speed physical phenomena have been made possible by development of a framing camera with Kerr cell shutters, reports Electro-Optical Instruments, of Pasadena. The camera takes six frames at a rate of 100 million frames a second with exposure times as brief as 5 nsec.

Collected by an f/3.5 objective lens with a focal length of 10 in., light is split into six beams by a six-faced, silvered prism, allowing separate images of the same event, from the same aspect, to be seen through the same set of optics.

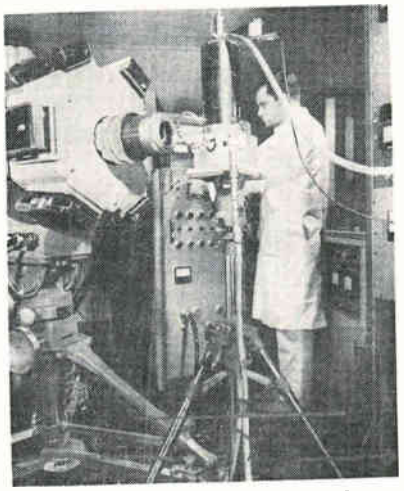
The control system includes six channels of regenerative and passive trigger delays, modular pulse generators and pulse-forming networks, and series or parallel synchronous selectors.

Interframe time is continuously variable from 5 to 700 nsec. Framing rate is independent of exposure time and optical resolution. The latter two can be selected arbitrarily to accommodate the available light and the rate of the event.

The camera is intended for studies of explosive hydrodynamic phenomena, classical explosive propagation, exploding wires, and hypervelocity impact. The high energy densities of these phenomena allow self-luminous photography at very brief exposure times. For rapid evaluation, photos can be made on Polaroid film.



Six Kerr cell shutters and film holders surround central lens



Camera set up to photograph exploding wire at 100 million frames a second

Minnesota Sets Week Aside for Electronics

MINNESOTA last week celebrated its growth in electronics with exhibits in St. Paul and Minneapolis and the dedication of new graduate facilities at the University of Minnesota.

State officials now consider the industry a prime element in the state's economy. A spokesman for Gov. Elmer L. Anderson said new electronics plants reversed a downward trend in employment during 1959 and 1960.

In 1955, 26,135 Minnesotans were employed in electronics plants. By the end of 1961 there were 44,438 and another 1,500 jobs are anticipated in 1962. The number of companies increased from 89 in 1955 to 157 by 1962.

Growth of the industry has been aided by a gubernatorial committee set up by Orville Freeman, now U. S. Secretary of Agriculture (ELECTRONICS, p 30, June 17, 1960).

Development of suburban industrial parks is being pushed. Last year in the New Hope region, for example, the Twin Cities Science Industry Center saw new plants for National Connector, Miniature Instruments, Electro Nuclear Systems and Nedmac.

A regional research institute is in the final planning stages, under direction of W. G. Sheperd, chairman of the gubernatorial committee and head of the university's department of electrical engineering.

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Crimp, snap-in type contacts are plated with .000030" gold over .000030" nickel (min.). There is no metal "creep". No debilitating oxide insulation buildup. Contact pressures are engineered to avoid excessive or quick plating wear. Consequently, AMPin-cert connectors last longer, give maximum performance and assured reliability.

Research findings on plating and facts on the AMP gold over nickel standard are available in reprints of papers published by AMP Research. Write for your copy today.

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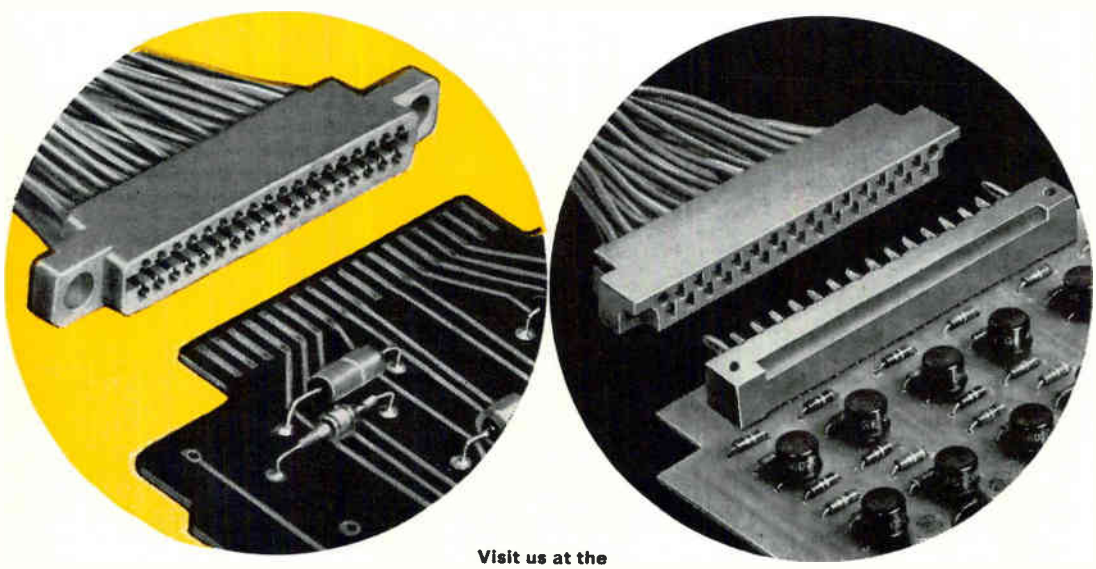

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MEETINGS AHEAD

AUDIO ENGINEERING SPRING CONVENTION, AES; Ambassador Hotel, Los Angeles, Mar. 19-26.

IRE INTERNATIONAL CONVENTION, Coliseum & Waldorf Astoria Hotel, New York City, Mar. 26-29.

QUALITY CONTROL CLINIC, Rochester Society for Quality Control; University of Rochester, N.Y., Mar. 27.

ENGINEERING ASPECTS OF MAGNETO-HYDRODYNAMICS, AIEE, IAS, IRE, University of Rochester; University of Rochester, N.Y., Mar. 28-29.

QUALITY CONTROL ADMINISTRATIVE APPLICATIONS CONFERENCE, American Society for Quality Control; University of Montreal, Canada, Mar. 29-30

READ-ONLY DIGITAL COMPUTER MEMORIES DESIGN & APPLICATION DISCUSSION, Institution of Electrical Engineers (British); Savoy Pl., London, April 3.

ELECTRONIC & ELECTRICAL INDUSTRIAL-COMMERCIAL EQUIPMENT SHOW, Electrical Manufacturers Representatives Assoc. of Michigan; Artillery Armory, Detroit, April 4-6.

CHEMICAL & PETROLEUM INSTRUMENTATION SYMPOSIUM, Instrument Society of America; DuPont Country Club, Wilmington, Delaware, April 9-10.

NONDESTRUCTIVE TESTING CONVENTION, SNT; Pick-Carter Hotel, Cleveland, Ohio, April 9-13.

BUSINESS EQUIPMENT EXPOSITION, Business Equipment Manufacturers Association; McCormick Place, Chicago, April 9-13.

PLASMA SHEATH SYMPOSIUM, AF Cambridge Research Labs; New England Mutual Hall, Boston, April 10-12.

SOUTHWEST IRE CONFERENCE AND SHOW; Rich Hotel, Houston, Texas, April 11-13.

JOINT COMPUTER CONFERENCE, IRE-PGEC, AIEE, ACM; Fairmont Hotel, San Francisco, Calif., May 1-3.

HUMAN FACTORS IN ELECTRONICS, IRE-PGHFE; Lafayette Hotel, Long Beach, Calif., May 3-4.

ELECTRONIC COMPONENTS CONFERENCE, IRE-PGCP, AIEE, EIA; Marriott Twin Bridges Hotel, Washington, May 8-10.

AERO-SPACE INSTRUMENTATION SYMPOSIUM, Instrument Soc. of America; Marriott Motor Hotel, Washington, D. C., May 21-23.

ELECTRONICS PARTS DISTRIBUTORS SHOW, Electronic Industry Show Corp.; Conrad Hilton Hotel, Chicago, May 21-24.

NATIONAL AEROSPACE ELECTRONICS CONFERENCE, IRE-PGANE; Biltmore Hotel, Dayton, Ohio, May 22-24.

SELF-ORGANIZING INFORMATION SYSTEMS CONFERENCE, Office of Naval Research, Armour Research Foundation; Museum of Science, and Industry, Chicago, May 22-24.

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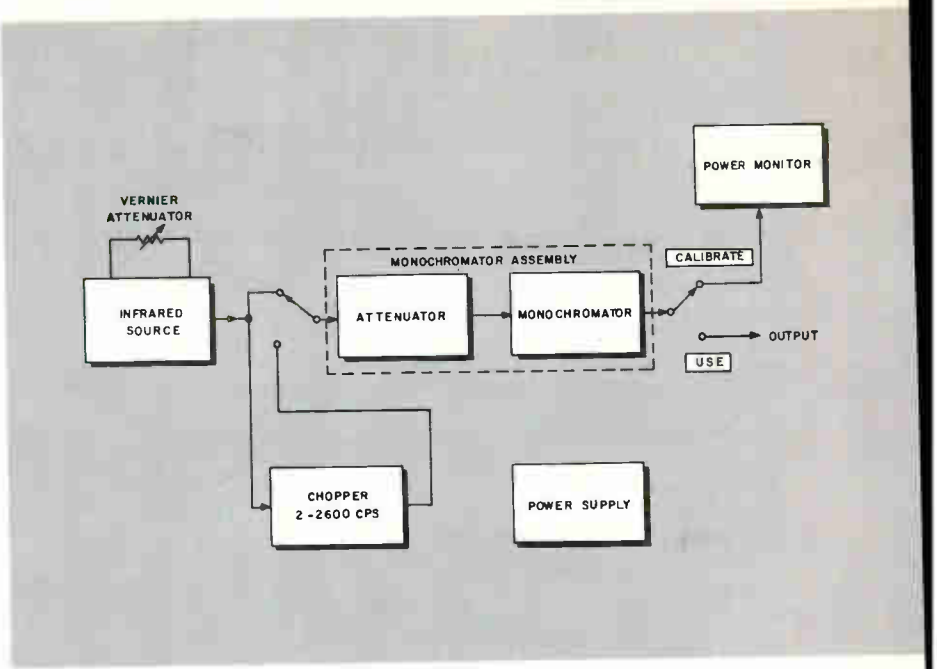

The instrument consists of a source, chopper, attenuator, monochromator and a power monitor.

The source produces a broadband radiated noise spectrum in the band of wavelengths from 1 to 14 microns, which is then filtered to produce the desired output signal.

Selection of desired wave length is accomplished by a monochromator (optical bandpass filter). The spectral profile of the output is governed by the entrance and exit apertures of the monochromator, which are cam-programmed to provide the bandwidth specified.

A choice of two specific output signals is provided: (a) a point source that radiates into a 5° cone; (b) a collimated beam one inch in diameter.

To distinguish output radiation from background radiation, the signal can be modulated by means of a chopper – a rotating shutter device located between the light source and the lens system focusing into monochromator.

Power is monitored by means of a factory-adjusted thermistor bolometer and preamplifier, and a synchronous voltmeter.

Stepwise attenuation of the output signal is obtained by means of neutral attenuator grids placed within the monochromator.

SPECIFICATIONS

- Wave Length Range – 1-14 microns
- Dial Calibration – 0.2 microns
- Output Format – Switch selection of (a) Point Source 5.4° Cone of Radiation or (b) Collimated Beam 1-inch Diameter.
- Bandwidth – .35 micron Typical at 3 db points (at 5 microns)
- Power Output – 1 microwatt Typical (at 5 microns)
- Power Output Accuracy – ± 15%
- Step Attenuator – 10⁷:1 in seven 10:1 steps
- Step Attenuator Accuracy – ± 10% per step
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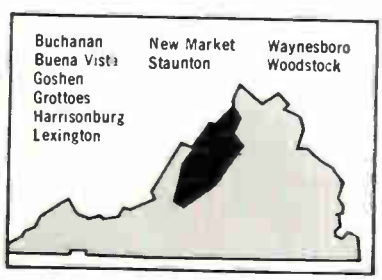

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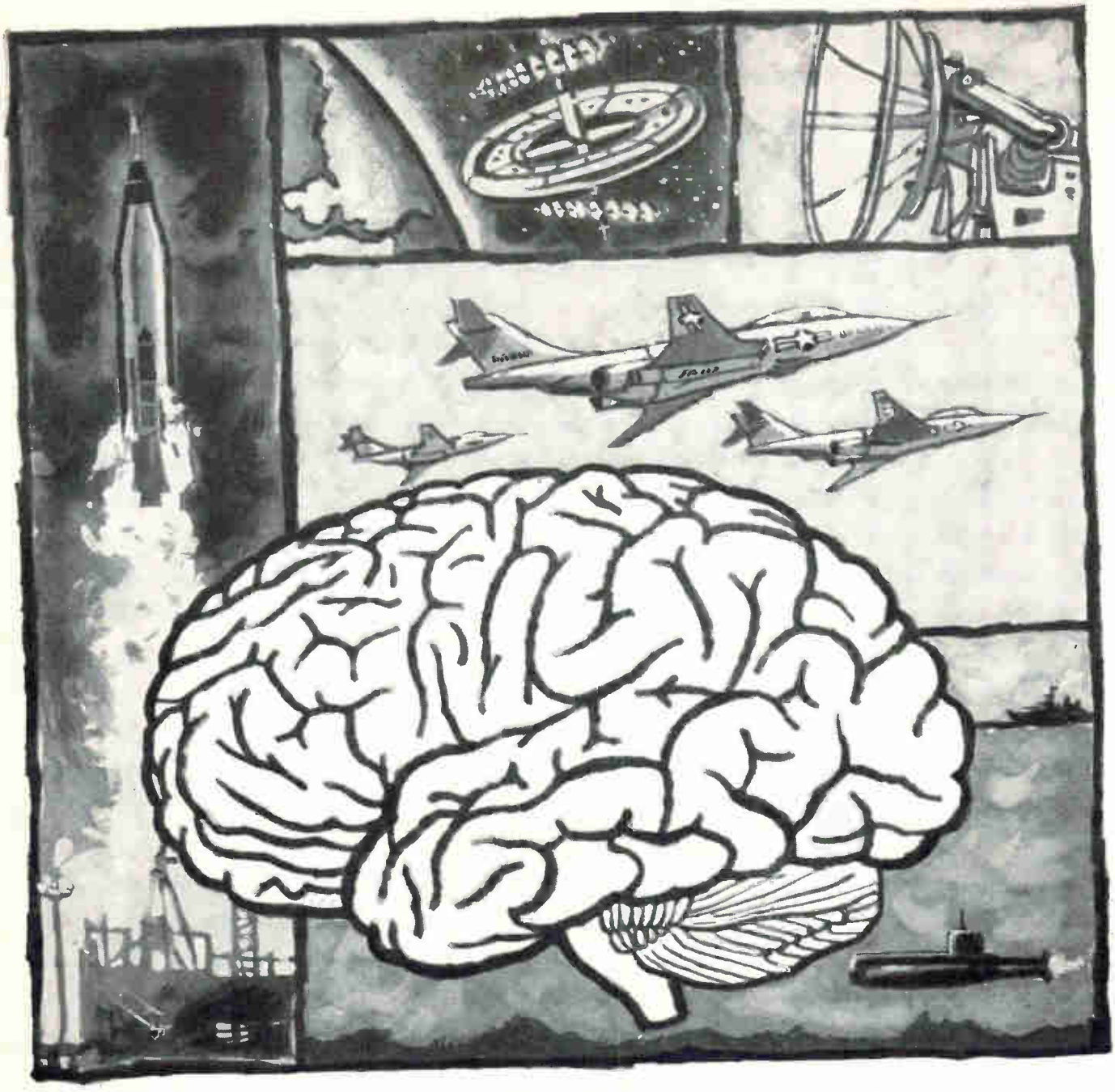

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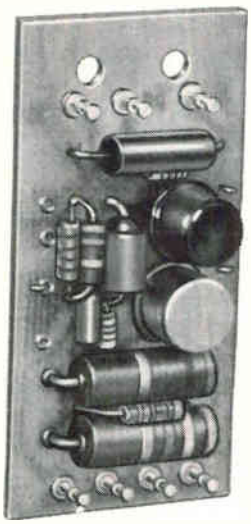

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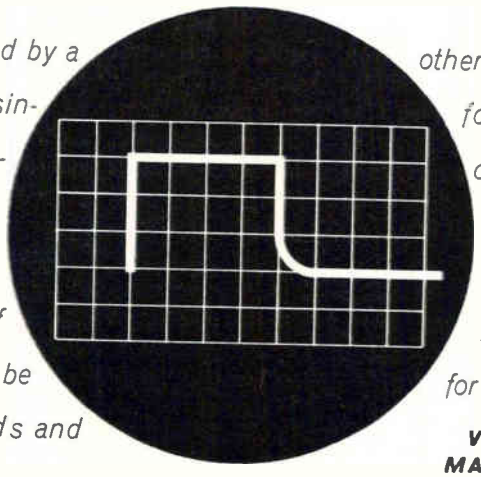

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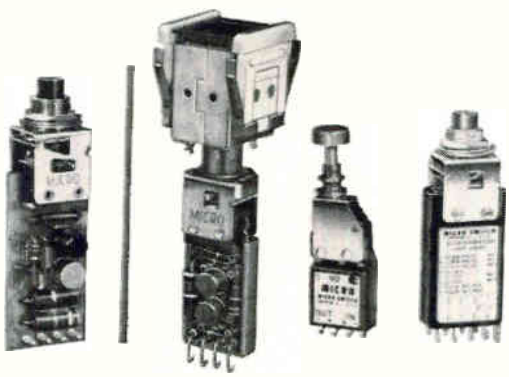

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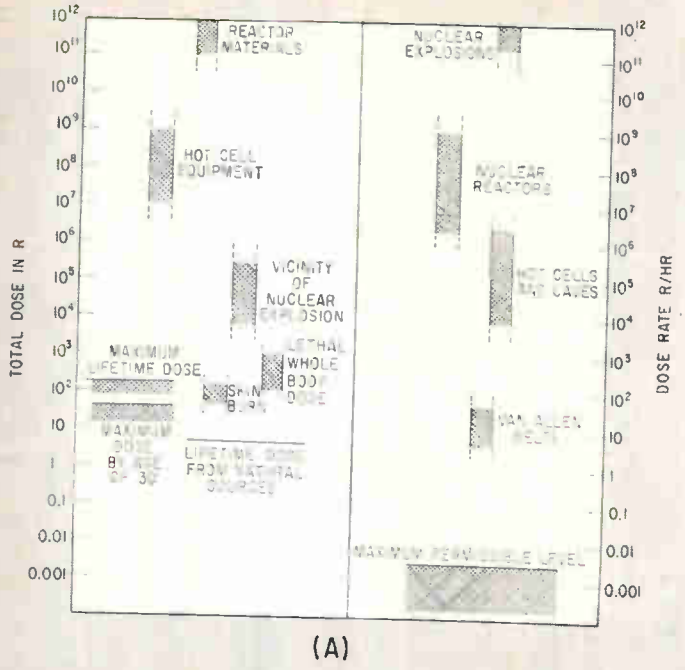

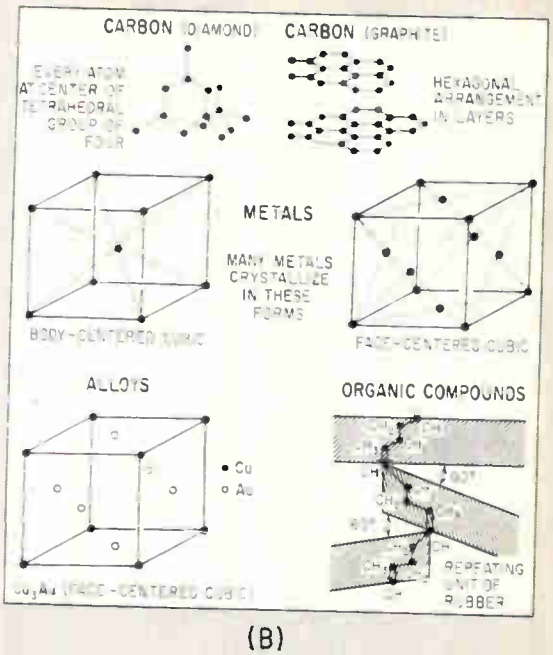

FIG. 1—Comparison of total doses and dose rates (A). Typical structures (B)

Designing Equipment for Nuclear Environments

How equipment and components are affected by radiation of high dosage, low dose rate and low rate of change of flux level radiation. Damage is illustrated with simple models of the structure of matter

By P. BARRATT,*
Pye Ltd.
Cambridge, England

A PREVIOUS ARTICLE in ELECTRONICS discussed the effects of transient radiation on electronic circuits.[1] Here, a different radiation environment, characterized by high doses but comparatively low dose rates and rates of change of flux levels is considered. Table I illustrates the differences between weapon explosion and reactor environments.

Electronic component behavior is only one aspect of the design problem; to it must be added: equipment activation; radiation heating; mode of equipment use and compatibility of the equipment with its environment, involving chemical and radiation properties.

Experimental data are still limited and theoretical predictions must frequently be qualitative rather than quantitative. For these reasons an approach is outlined which has proved valuable in this type of work. The aim is practical, that of building up background knowledge to help resolve design problems when there are no guides.

The starting point is the expression of the structure of matter in terms of simple models, followed by the study of radiation damage in relation to the models. These aspects are sufficient for the determination of significant radiation types and the assessment of the relative suitabilities of available components of a given type. Published data, with their uncertain-

*Deceased, Feb. 11, 1962

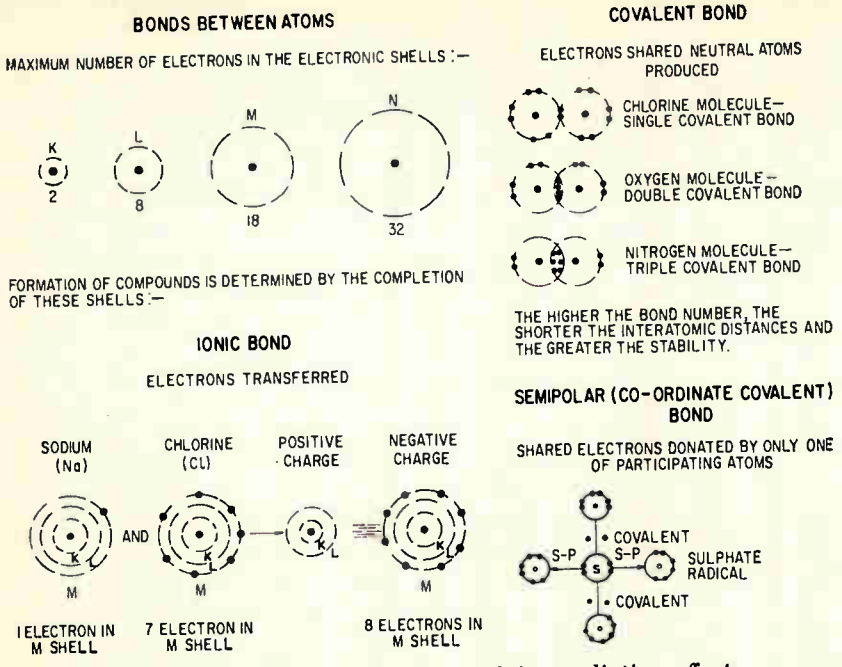

FIG. 2—Type of bond is important in studying radiation effects

ties as to the precise flux spectrum and irradiation temperature, need be used only to indicate the order of magnitude of significant doses or dose rates. In this work, too great reliance upon figures is inadvisable since the equipment is probably intended to work in an ill-defined environment. But, in some cases, radiation must be counted at least as important as such items as temperature and pressure.

Figure 1A shows the doses and dose rates encountered. Note that equipment within caves used for handling active material receives doses several decades greater than in the vicinity of a nuclear explosion. Television equipment used in shut-down reactors is regularly subjected to 10^6 R hr^{-1} of gamma radiation and receives total doses well in excess of 10^9 R during its life. Gamma doses of 10^{10} R hr^{-1} can occur in a working reactor.

There are a number of other situations in which moderate doses can be received, like near accelerators or active sources. These have been discussed already in more detail.[2]

The conditions requiring electronic parts and equipment to be exposed to radiation can be readily summarized. Humans can be exposed only to radiation levels which are low relative to those commonly used in nuclear technology, hence they cannot be used directly as a control or observing agent. This results in a demand for remote observation, control and transmission.

Knowledge of the basic structures of materials is essential in interpreting and predicting radiation effects. The important features may lie in nuclear or electronic properties, lattice arrangements, chemical bonding and molecular orientation. Often, the detail in which a material must be considered depends on the property.

Mechanical and some physical properties can often be explained in qualitative terms without considering finer scale detail than the molecular. Physical properties such as electrical resistivity are related more to the electronic configurations.

Consistent with these simplifications, only four classes of materials (metals, inorganics, organics and semiconductors) need be distinguished. Figures 1B, and 2 illustrate the following discussion.

TABLE I — COMPARISON OF ENVIRONMENTS

Radiation source	100-kiloton nuclear explosion	100-Mw power reactor
Equipment location	¼–½ mile from center	Max flux position in core
Gamma dose rate (R hr^{-1})	10^{12}	10^8
Neutron dose rate (cm^{-2} sec^{-1})	10^{18}	10^{13}
Duration of irradiation (sec)	10^{-6}	10^8
Total neutron dose (cm^{-2})	10^{12}	10^{19}
Total gamma dose (R)	10^6	10^{13}

Metals are represented as an assembly of ions with a large number of free electrons. Ionization effects, such as occur with gammas, are not expected to produce appreciable damage since the changes in electron concentration are relatively small. However, particles can dislodge atoms from lattice positions, giving changes in mechanical properties and small changes in electrical properties as electrons are obstructed by the disruption of the orderly lattice. There is a similarity with a simple picture of heat conduction, but radiation can give far higher local energy concentrations than occurs with thermal effects. When nuclear reactions occur their products are impurity atoms.

Inorganic materials are characterized by more marked chemical bonds than occur with metals. The electrovalent bond implies the presence of ions, and again there is comparative insensitivity to ionization. However, ionization sensitivity is greater than for metals.

Organic compounds are often complex assemblies of groups of atoms and are taken to include silicon-based as well as carbon-based materials. All types of radiation can cause considerable damage since ionization breaks the chemical bonds that determine the material properties. This sensitivity to radiation is in accord with the greater sensitivity to temperature increase that is found with the two previous groups. High melting point is frequently allied with resistance to radiation. Polymers—long chains of groups of atoms forming one, two or three-dimensional networks—are particularly important. Orientations and lengths of the chains are important in determining properties.

Semiconductors are only the borderland between metals and nonmetals but their importance in electronics warrants specific treatment. The complexities of the semiconducting state are well known and radiation effects considered in detail are equally complex. Nevertheless, many effects can be explained using conventional ideas of charge carriers. The crucial point is the sensitivity of properties to small changes in charge carrier concentrations.

These four classes correspond to the classification of radiation damage effects and are convenient for grouping components of a given type. For example, capacitors may rely on organic or inorganic dielectrics.

Mention should be made of dislocations, a useful concept in considering solid-state behavior.[3,4] They are imperfections in the structure and can give the material different properties to those it would have with a perfect lattice. They may represent weak points in the structure or sinks for other defects. This discussion cannot pretend to be even a survey of the useful models but, with the following section, it shows the value of a superficial approach to solid-state physics in the practical application of radiation damage concepts. Further information is available.[5,6,7,8]

Table II includes all types of radiation that may be encountered. The list can be reduced considerably; except in special cases, equipment containers or distance itself will remove all but neutrons and gammas. A possible exception lies in beta particles; viewing equipment may require the exposure of optical components to appreciable beta levels. Neutrons and gammas are most significant since the other particles show damage behavior similar to that of neutrons.

Before summarizing the most important mechanisms it is useful to define the threshold energies which radiation must possess to produce significant changes in material. There is considerable dependence on atomic weight but Table III, indicates the general situation.[1] The values given assume that a lattice displacement requires an atom to be given 25 ev.

As the discussion of material structure indicates, the properties of matter depend either on how its constituent atoms are located spatially (the lattice) or how they are held together (bonding), or both. Radiation effects can be considered as displacement effects in which atoms are moved, with resulting disturbance of electrons, and ionization effects in which the atom remains in its lattice position but the local electron configuration is changed. Particulate radiation therefore produces both displacements and ionization while gammas show predominantly ionizing action. Displacement effects can be further broken down into vacancies and replacement collisions. Vacancies are created when an atom leaves its lattice site and comes to rest in interstitial positions of unstable equilibrium. Neutron reactions produce new nuclides which are then impurity atoms. Replacement collisions occur when one displaced atom ejects another from its lattice site, which it then occupies since it has insufficient energy to leave. Figure 3 illustrates a number of the damage mechanisms.

These concepts agree with the observed types of damage. Effects range from permanent damage, which can only be partially annealed out, to temporary effects which disappear as soon as radiation is removed. Many materials show such limits of behavior, while others show both effects with widely varying relaxation times for partial recovery from the damage. Figure 4A shows the characteristics symbolically, but the association of total dose effects with displacements and of rate effects with ionization is not generally valid.

Materials classification and radiation effects can now be brought together.

Metals are virtually insensitive to gamma radiation (apart from heating effects) and fast neutron doses of at least 10^{20} n/cm^2 are necessary before displacement effects produce significant changes in properties, such as resistivity and density, that are important from the electronic viewpoint. Magnetic properties may be affected by doses that are a decade lower.

Inorganic materials show more sensitivity; optical properties are affected by both neutrons and gammas in, for instance, glasses. Displacement effects lead to significant density changes for doses of 10^{18}. As a working rule for insulators, a dose of 10^{20} n/cm^2 leads to expan-

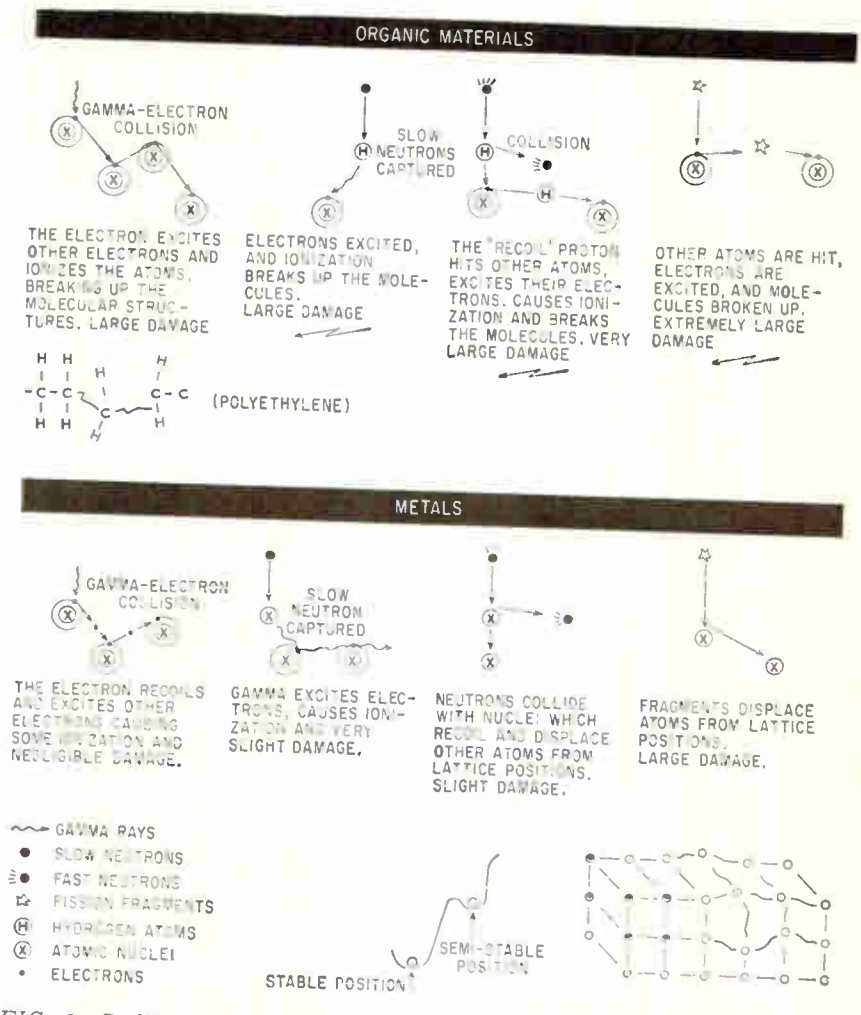

FIG. 3—Radiation damage mechanisms in organics and metals

sions of the order of 1 percent in insulating materials, and below this, expansion is linearly related to dose. Glasses may shatter for neutron doses in excess of about 10^{17} n/cm^2. Their optical transmission may be affected by gamma doses of only 10^7 R or neutron doses of 10^{14}—10^{15} n/cm^2. Where comparison is appropriate, inorganic compounds are sensitive to doses a decade lower than those which are important with metals in the same application.

Organic materials may become effectively different materials for comparatively low doses. Changes in mechanical rather than electrical properties prevent their usage. The increase in conduction resulting from ionization can be considerable. Polymers are particularly susceptible. Figure 4B shows two of the important effects — cleavage and cross-linking — the breaking of chains and setting-up of bonds between chains. Processes such as this leave free radicals which enter into new chemical reactions. An important example is the evolution of gases within plastics, leading to clouding and swelling. In some cases gases may have a corrosive effect.

Generally, cross-linking produces a more rigid material while cleavage weakens it. Organic materials differ in their susceptibilities and it must be emphasized that the many variations within a particular type prevent generalizing as to the behavior of individual examples. For instance, fillers may modify radiation resistance considerably. Silicones in general show behavior similar to carbon-based materials. A total neutron dose of 10^{18} n/cm^2 represents the limit for virtually all plastics and some are useless by 10^{14}—10^{15} n/cm^2. The corresponding gamma doses are 10^5—10^9 R, as lower and upper limits.

Semiconductors are extremely sensitive. Silicon and germanium show considerable property changes by 10^{13} n/cm^2 or about 10^5—10^6 R of gamma. Again there are considerable variations from material to material and property to property, but the use of semiconductive materials in radiation fields should be avoided as far as possible.

With all four classes of material the degree of radiation damage depends not only upon the radiation but also upon previous history, irradiation temperature and impurities. With neutron fields, since the energy thresholds of gamma reactions are usually too high, components should be selected to minimize activity after irradiation. The possibility of contamination of the equipment by active material affects design of the equipment casing only; it is desirable to contain the electronics fully to avoid compatibility problems.

Assessment of the relative merits of two materials from the neutron activation aspect is complicated by the types of active nuclides which are produced in the parent material, irradiation time and decay time. It is necessary to define the period for which the equipment will be irradiated because this determines the nearness of approach to saturation activity. Decay time is important since the active nuclides will decay at different rates. Figure 4C summarizes the general cases while Table IV lists the active nuclides formed by irradiation of some commonly used materials.

Frequently only one nuclide is important and the problem can then be stated simply. Time T_c is defined as the decay time at which samples of two materials that have received identical irradiations have equal activities. If handling is required before T_c has elapsed, one material is used, if later than T_c, the other.

Two simple expressions apply for short and long irradiation times.

If $t_{a,b}$ = half-lives of active nuclides in elements a and b, $A_{a,b}$ = atomic weights of parent nuclei, T_i = irradiation time and $\delta_{a,b}$ = activation-cross sections of parent

TABLE II — RADIATION

Name	Mass	Charge	Nature	Sources	Typical Shielding Materials	Ranges in Air (energy dependent)	Radiation Damage
Neutron	1	0	Basic particle; radioactive Fast neutrons > 10^4 e v Thermal neutrons < 0.025 ev	Reactors, Nuclear reactions	Water, concrete, boron	Up to 100's of feet	Lack of charge gives high penetration, hence distributed damage. Displacements and ionization
Electron (e) or Beta (β)	$\frac{1}{1837}$	−1	Basic particle; stable	Accelerators, Reactors, Nuclear reactions, Active materials	Plastics	Few feet	Easily stopped, damage is a surface effect
Proton (p)	1	+1	Basic particle; stable	Accelerators, Nuclear reactions	Most materials adequate	Inches or less	Charged, so easily stopped; displacements and ionization
Deuteron (d)	2	+1	Proton + neutron; stable	Accelerators, Nuclear reactions	Most materials adequate	Inches or less	"
Alpha (α)	4	+2	Helium nucleus; 2n + 2p. Stable	Reactors, Accelerators, Nuclear reactions, "Natural" Radioactivity	Most materials adequate	Inches or less	"
Fission Product (F/P)	~95 or ~140	Variable	Remnants of atoms which have undergone fission, Maybe: Xe, Kr, Ba, Sr, Cs	Nuclear fission of, U, Pu, Th	Most materials adequate	Inches or less	"
Gamma (γ) X-rays.	Wave	0	Electromagnetic radiation, wavelengths of 10^{-7}—10^{-11} cm	Nuclear reactions, Reactors, Accelerators, Active materials	Lead	Up to 100's of feet	Penetrating; distributed damage; ionization

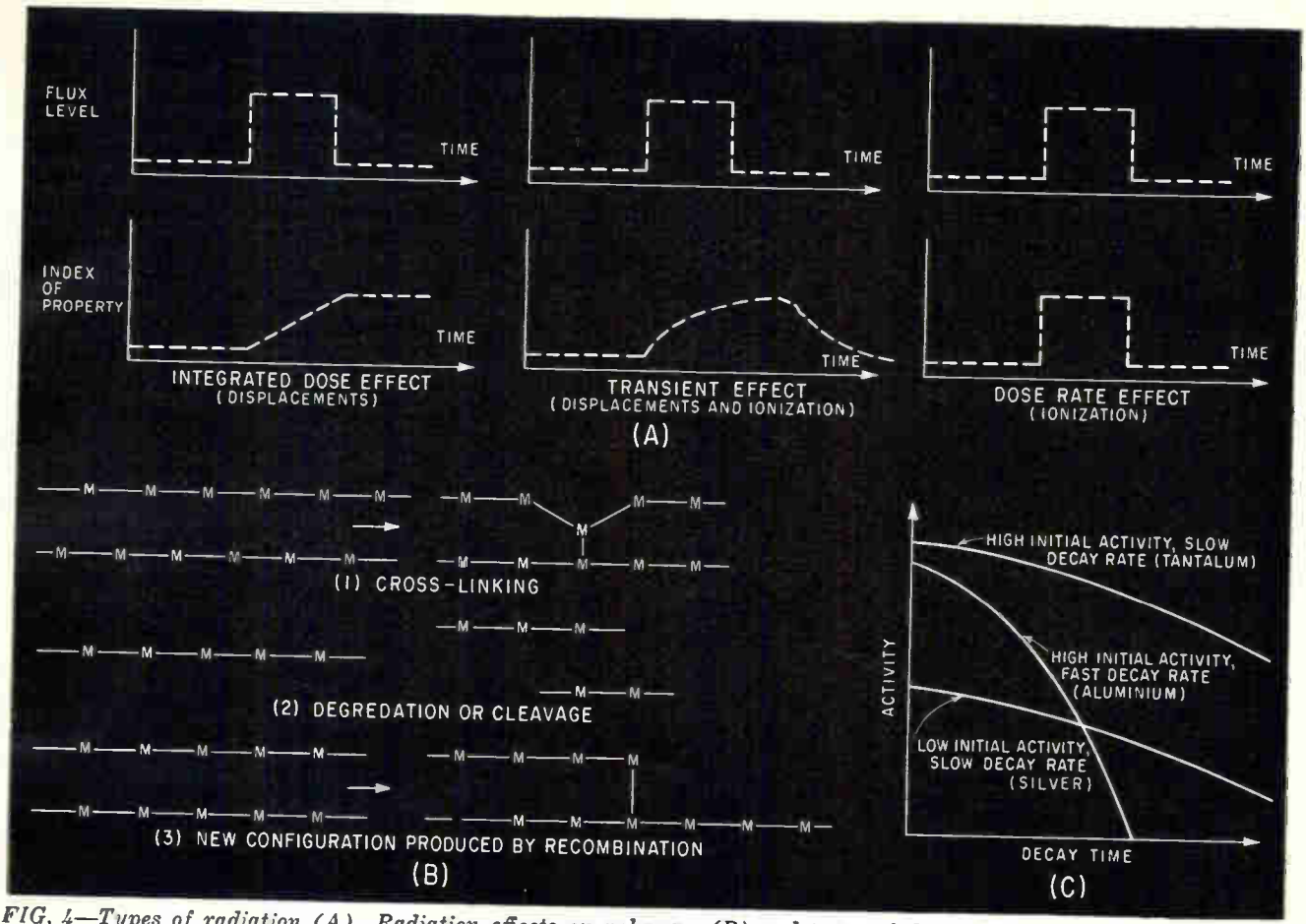

FIG. 4—Types of radiation (A). Radiation effects on polymers (B) and types of decay curves (C)

nuclei; then the decay time is

$$T_c \cong \frac{1.44\, t_a\, t_b}{t_a - t_b} \left[\ln (A_a/\delta_a) - \ln (A_b/\delta_b)\right]$$

for $T_i >> t_{a,b}$ and

$$T_c \cong \frac{1.44\, t_a\, t_b}{t_a - t_b} \left[\ln (A_a/\delta_a) - \ln (A_b/\delta_b) + \ln (t_a/t_b)\right]$$

for $T_i << t_{a,b}$

These expressions apply to equal masses of the two elements; an equal volume basis yields different results.

Use of these limits can still give results of practical interest since they may not differ by a great amount. The general expression for T_c does not show any maxima or minima between the two limits, that is, T_c does not lie outside these limits for any intermediate irradiation time.

Comparison of equal masses of iron and aluminum gives T_c values of 57 m and 13.15 m for short and long irradiations; hence for immediate examination, iron is preferable; if a decay time of an hour or more is permissible then aluminum is the correct choice.

Correct selection can reduce component activities by factors of 10^6 or greater.

Energetic particles or photons are capable of giving considerable heating effects as they give up their energy. Except for a few elements with high thermal neutron absorption cross-sections, thermal neutrons (0.005—0.5 ev) produce negligible heating compared with fast neutrons (0.1—10 Mev) since the fluxes are usually comparable in thermal reactors—the only location in which neutron heating is likely to be important.

Thermal neutrons may, however, lead to activation and the subsequent emission of energetic particles, for example, 2.87 Mev betas from Al^{28}.

Gamma heating and fast neutron heating frequently have similar magnitudes and the effect is uniformly distributed throughout the material since both radiations are penetrating. Beta particles generally produce only surface heating.

In a reactor, gamma heating is usually due primarily to prompt fission and U^{235} capture gammas, hence the heating rate is proportional to the reactor power or flux level.

Published data[9, 10, 11] agree with theoretical estimates in suggesting heating rates of the order of 0.5 watt gm^{-1} for gamma levels of 10^8—10^9 R/hr; taking 1 joule/gm deg C as a typical specific heat, this implies temperature rises of 30 deg C/min assuming no heat losses.

The heating problem can be minimized by: choice of material, provision of conduction paths to a heat sink such as a reactor coolant and designing for the anticipated temperature rises. The high thermal capacity gained by increasing the

TABLE III—THRESHOLD RADIATION IN EV TO PRODUCE DISPLACEMENTS

Radiation	Atomic Weight of Material Atoms 10	100	200
Neutron, Protons	76	638	1263
Alpha Particles	31	169	325
Fission Fragments of Atomic Weight 100	76	25	28
Gamma, Electrons	10^5	6.8×10^5	1.1×10^6

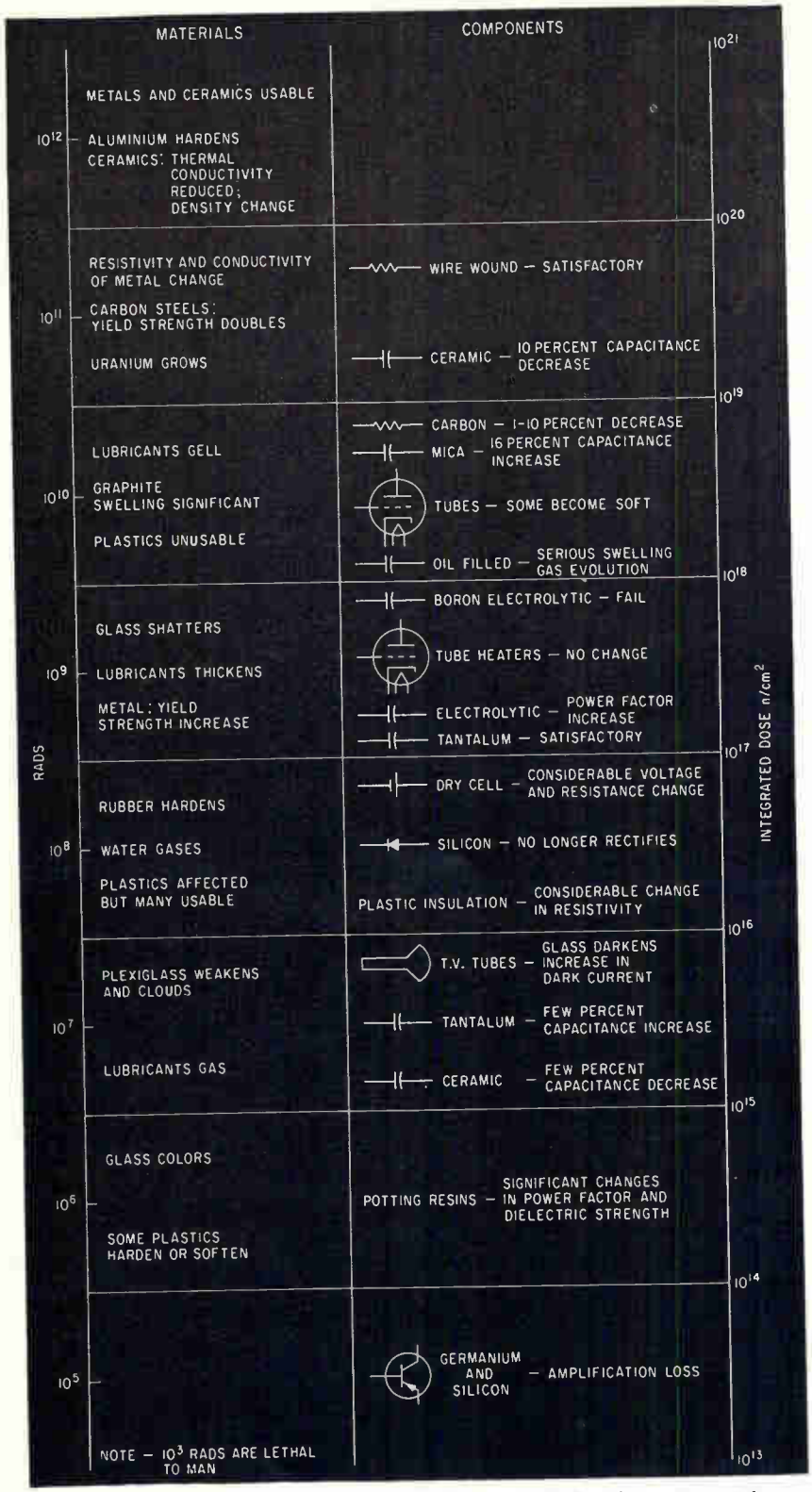

FIG. 5—Radiation damage to materials and electronic components

mass of material is no solution since the total heating rate is, to a first approximation, also proportional to mass. The provision of suitable sensing elements is desirable; thermistors are usable at fluxes of 10^{12} n/cm^2 sec and thermocouples are usually satisfactory.

Absorption mechanisms cannot be described within the scope of this article, for further details references 4 and 12 could be consulted; the constants necessary for calculations are readily available.[13] It is most important to obtain a good representation of the radiation energy spectrum before attempting predictions.

Summaries of experimental results and bibliographies have already been published.[14, 15] These, with experience, form the basis of the summaries. Remember that pre- and postirradiation measurements will not necessarily indicate component performance under irradiation. Figure 5 relates electronic component damage to that of materials.

Some types of tubes may fail with neutron doses of about 10^{17} n/cm^2 but others are still satisfactory after doses in excess of 10^{18} n/cm^2. Envelope failure due to neutron damage is a common cause, particularly with boron-containing glasses. Gamma radiation colors the envelopes but is usually significant only in tubes such as thyratrons, multiplier phototubes, and vidicons which are ionization sensitive. Tubes may be used for neutron doses in excess of 10^{18} n/cm^2 and gamma doses of at least 10^{10}—10^{11}R.

Ceramic, glass, and mica dielectric capacitors are, as would be expected, most satisfactory, typically showing capacitance decreases of a few percent for 10^{18} n/cm^2 or more. For the same dose, plastic dielectrics can show variations of 10-20 percent, and paper capacitors up to approximately 80 percent. Plastic dielectrics will be affected far more drastically by gammas than the inorganic dielectrics. Boron-containing electrolytics may fail with 10^{16} n/cm^2, and oil-filled capacitors are prone to gas evolution.

Tantalum electrolytics have good resistance (a capacitance maximum for 10^{15}—10^{16} n/cm^2 was noted in one type) and are rather better than plastic dielectric capacitors. Effects on power factor are small but appreciable changes in leakage current have been measured. Generally, capacitors can be chosen to match the performance of the tube.

Resistances up to at least 10 megohms are insensitive to radiation damage. Observed resistance decreases may be due to ionization giving external conduction paths. Wire-wound and metal-film types will probably withstand at least 10^{19}n cm^2 and have negligible sensitivity to large gamma doses. Possible weaknesses lie in the former and in the insulation. Typical re-

sistance changes are less than 1 percent for 10^{15}n cm^{-2}. Carbon composition resistors show resistance variations of from 1-10 percent for similar doses. As with all components, some resistors show unfortunate choice of materials or modes of construction and give considerably worse performance than the majority. Composition-type potentiometers appear to be more susceptible, with resistance changes of 10 to 30 percent for 10^{13}n /cm^2.

Neutron doses of 10^{11} n /cm^2 or less can seriously affect the electrical properties of germanium and silicon, while 2×10^6R /hr^{-1} of gamma increases transistor noise levels by 25 db. Selenium withstands higher doses; it is an open question whether silicon or germanium is preferable. Individual diodes and transistors show better performances but tolerable dose levels must be set several orders of magnitude lower than for other components. The great sensitivity to gamma radiation is a considerable disadvantage.

Magnetic properties of materials are not seriously affected by doses of 10^{17}—10^{18}n/cm^2 at least, hence many component types such as motors, relays, chokes and transformers must be judged in terms of their insulation. Leakage currents through plastics may change by a factor of 10^3 and mechanical breakdown can occur at neutron doses from 10^{14}n/cm^2 upwards, or about 10^7—10^8R of gamma depending on the material. Quartz crystals irradiated to about 16^{18}n/cm^2 show frequency changes of less than 0.01 percent. Limit switches will generally be only as good as their housings. Dry cells show erratic behavior for neutron doses in the region of 10^{16}n/cm^2. Encapsulating materials may give almost order-of-magnitude changes in power factor, loss factor and dielectric strength, with smaller changes in dielectric constant at doses of 10^{14}n/cm^2.

There have been few attempts to irradiate and monitor working assemblies. Completely satisfactory performance has been found with units working at 1.2×10^{12} thermal n/cm^2 sec with 10^6—10^7R/hr gamma, and to doses of 10^{16} thermal n/cm^2, 10^{15}f n/cm^2, + 10^9R gamma.

In equipment design, the circuit used in the high flux regions should be minimal. It is far better to have elaborate external, accessible equipment if necessary. This may require a compromise with the policy of making the overall functioning of the equipment as insensitive as possible to variations in the performance of individual components.

Where material choices exist, the preference should be for those with low activation and radiation heating characteristics. Replacing organic materials by inorganic can increase life by 100×, and 1,000× if metals can be used. In reactor work, the assembly should have a low overall neutron absorption cross-section. It is possible to design electronics that will serve as reliably as control rods. This is consistent with using as small quantities of material as possible to minimize total activity.

Structural members should be metal or ceramic, distance rather than insulators should be relied upon for insulation, and regard should be paid to the lower breakdown voltages between points at differing potentials.

It is essential to define the incident radiation as closely as possible and consider each component in detail in relation to the radiation. This involves the generally difficult task of establishing the true composition of materials used in the component.

There is a need to develop a general approach similar to that already suggested so that reasonable decisions can be made without too frequent recourse to expensive and time-consuming experiment. When experiments are necessary they should be fully instrumented so that equipment behavior can be understood under irradiation conditions.

There is generally little to be said for shielding unless, for special reasons, weight and dimensions are relatively unrestricted.

It is hoped that this article has helped to put radiation into perspective as an environmental factor. With meticulous attention to detail, there is no reason why electronic equipment should not withstand for higher radiation doses than are usually required or regard as realistic.

The author thanks the directors of Pye Ltd. for permission to publish this paper and to record that this article represents work carried out by a team drawn from Pye TVT Ltd., Cathodeon Ltd., and Pye Ltd.

TABLE IV — ACTIVITIES OF MATERIALS AFTER IRRADIATION.

For 24 days irradiation at 10^{13} n cm^{-2} sec^{-1} of gm of parent material. Total dose of 2×10^{17} nvt

Element	Active Nuclides	Half-life	Activity
Manganese	Mn^{56}	2.6 hr	390 mc gm^{-1} (Saturated)
Tungsten	W^{187}	2.4 hr	85 mc gm^{-1} (Saturated)
Copper	Cu^{64}	12.8 hr	69 mc gm^{-1} (Saturated)
Tantalum	Ta^{182}	111 d	23 mc gm^{-1}
Aluminum	Al^{28}	2.3 m	13 mc gm^{-1} (Saturated)
Cobalt	Co^{60}	5.2 yr	8.5 "
Zinc	Zn^{69}	51 m	4.6 " (Saturated)
	Zn^{69m}	13.8 hr	0.46 " (Saturated)
	Zn^{65}	245 d	0.37 "
Silver	Ag^{110m}	270 d	1.15 "
Silicon	Si^{31}	2.62 hr	195 μc gm^{-1} (Saturated)
Iron	Fe^{59}	45 d	24 μc gm^{-1}
Oxygen	N^{16}	7.45 sec	1.42 " (Saturated)
	N^{17}	4.145 sec	0.35 " (Saturated)
	O^{19}	29.45 sec	4.89 " (Saturated)
	C^{14}	5568 yr	94.4 μμc gm^{-1}
Hydrogen	H^3	12.26 yr	226 "

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Isolated Parametric Amplifier Has Low Noise Figure

Input to this parametric amplifier is isolated from the output by using two time-varying reactances. Circulators are not needed, thereby reducing insertion loss and amplifier noise

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ALTHOUGH PARAMETRIC amplifiers can perform as low-noise amplifiers in the microwave range, their instability limits their practical use. Amplifier circuits that show the greatest promise are regenerative; that is, small changes in source or load impedances or changes in pump power level cause large changes in gain or produce oscillations. Using circulators with the amplifiers reduces instabilities, but circulators are not available at all frequencies. Furthermore, circulators introduce an insertion loss, which adversely affects the amplifier noise figure, and their use often restricts the frequency range.

Some data has been obtained on parametric amplifiers that do not require ferrite circulators.[1] In a more advanced parametric amplifier circuit, the input is nearly isolated from the output. The use of two time-varying reactances pumped with a relative phase difference of 90 degrees, and two idler frequencies provides the nonreciprocal properties. The circuit constants can be adjusted so that the round-trip gain is less than unity, and oscillation is not possible for any combination of source and load impedances.

The isolated parametric amplifier is expected to have these advantages over the circulator amplifier:

(1) Wide tunable bandwidth of the order of one octave.

(2) Lower noise figure.

(3) Stable operation at frequencies where circulators are not available.

Figure 1 shows the isolated parametric amplifier. Two time-varying capacitances, with a relative phase difference of 90 degrees, couple the two signal resonant circuits to common idler resonant circuits. The idler circuits are tuned to the difference frequency, $\omega_I = \omega_P - \omega_S$, and to the sum frequency, $\omega_{II} = \omega_P + \omega_S$. A 3-db directional coupler provides a power split and a 90-degree phase shift at the signal frequency.

Power incident at port 1 of the 3-db coupler leaves ports 2 and 3. The phase at port 3 leads that at port 2 by 90 degrees. In the absence of parametric action, this power is almost totally reflected into ports 2 and 3 where it recombines and leaves port 4. However, because of the time-varying capacitances, idler currents are generated at frequencies ω_I and ω_{II}. The phasing reinforces the difference frequency currents from the two varactors and cancels the sum frequency currents in the idler resonant circuits.

Since power dissipation at the difference frequency causes regeneration at the signal frequency, amplification takes place at ports 2 and 3. The amplified power then recombines to leave port 4. Hence, there is a power gain between ports 1 and 4.

In the reverse direction, power incident at port 4 also splits and leaves ports 2 and 3, but the phase at port 2 leads that at port 3 by 90 degrees. The phasing causes reinforcement at the sum frequency and cancellation at the difference frequency. Since dissipation at the sum frequency requires an absorption of power at the signal frequency, there is a power loss at ports 2 and 3. Thus an attenuation is observed between ports 4 and 1.

A more quantitative analysis yields relationships for forward gain K_f, reverse gain K_r, and the

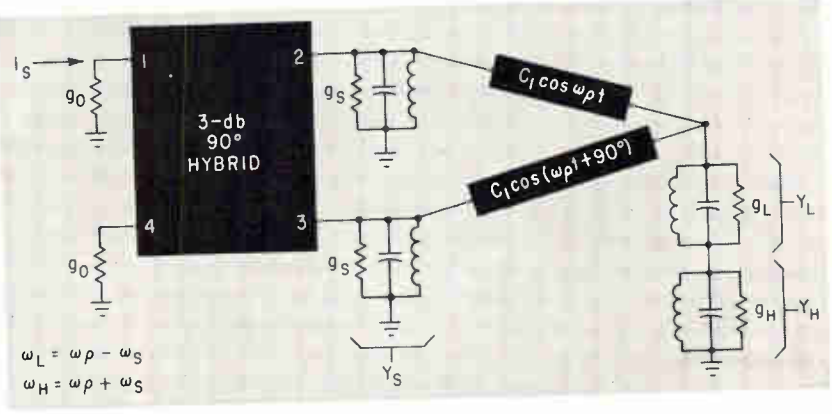

FIG. 1—Power gain in this parametric amplifier circuit is from ports 1 to 4. In the reverse direction, gain is less than unity

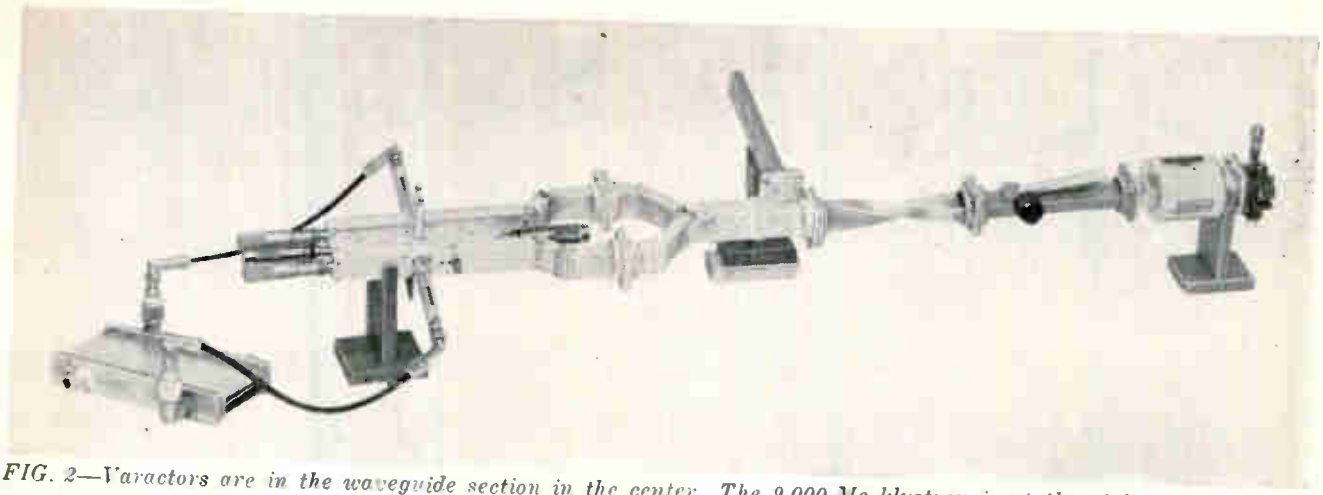

FIG. 2—Varactors are in the waveguide section in the center. The 9,000-Mc klystron is at the right

band-center equivalent noise temperature at high gain, T_{e_0}

$$K_f = \left| \frac{Y_L^* (g_0 - Y_{s1}) + 2F_L}{Y_L^* (g_0 + Y_{s1}) - 2F_L} \right|^2 \quad (1)$$

$$K_r = \left| \frac{Y_H (g_0 - Y_{s1}) - 2F_H}{Y_H (g_0 + Y_{s1}) + 2F_H} \right|^2 \quad (2)$$

$$T_{e_0} = \left[\frac{g_0}{g_s} + \frac{\omega_s}{\omega_L} \frac{(g_s + g_0)}{g_0} \right] \quad (3)$$

where

$$F_L = \frac{\omega_s \omega_L C_t^2}{4}$$

$$F_H = \frac{\omega_s \omega_H C_t^2}{4}$$

(F_L and F_H are symbols only, and are used to simplify Eqs. 1 and 2), g_s is the varactor loss at the signal frequency, g_0 is the characteristic conductance of the 3-db coupler.

$$Y_i \approx g_0 \left(1 + j 2Q_i \frac{\Delta\omega}{\omega_i} \right)$$

is the total admittance of the i-th resonant circuit, and Y_i^* is the complex conjugate of Y_i. The relationships are based on an ideal 3-db 90-degree directional coupler.

When Eq. 1 and 3 are compared with those obtained for an ideal-circulator amplifier, the results are identical. Therefore both amplifiers have the same gain, bandwidth, and equivalent noise temperature. However, since at many frequencies the 3-db coupler has much better bandwidth and insertion loss characteristics than the circulator, the isolated parametric amplifier can be expected to have a lower equivalent noise temperature and greater tunable bandwidth than the circulator circuit.

Equations 1 and 2 show that the reverse gain is nearly the inverse of the forward gain. Under the simplifying assumptions that $\omega_L \approx \omega_H$; $g_L \approx g_H$; and the varactor losses at the signal frequency, g_s, is much less than g_0, the round-trip gain, $K_f K_r$, is equal to unity. The term g_s adds attenuations in both directions.

If the loading at the idler frequencies is due entirely to varactor losses, then

$$g_L = \frac{\omega_L^2 C_v}{\omega_c}$$

$$g_H = \frac{\omega_H^2 C_v}{\omega_c}$$

where C_v is the mean varactor capacitance and ω_c is the angular cut-off frequency of the varactor. Under these conditions, if ω_s is greater than ω_L, the forward gain may exceed the reverse loss. If unconditional stability is required, slight additional loading to the difference frequency resonant circuit can be used to obtain a round-trip gain less than unity.

The experimental model of the isolated parametric amplifier, Fig. 2, can be tuned to operate in the frequency range of 700-900 Mc. A pump frequency of 9,000 Mc is used. The 3-db coupler for the signal circuit, shown at the left in Fig. 2, is connected to the signal circuit matching network by coaxial cables. The center conductors of the signal circuit matching networks pass through the pump circuit waveguides to the varactors located in the center waveguide. These conductors couple both signal and pump power to the varactors.

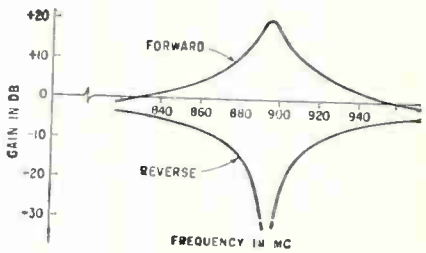

FIG. 3—Gain versus frequency of the amplifier at 895 Mc

The dual-resonant idler cavity is formed in the center waveguide section between two adjustable shorting plungers. The two pairs of varactors used in a balancing arrangement minimize both the pump coupling across the idler cavity and the coupling of the idler power to the pump waveguide.

The output of the pump source, an X-13 klystron, passes through an isolator and a flap attenuator to a waveguide 3-db coupler. The coupler splits the pump power into two parts with the required 90-degree relative phase shift. A tuning screw and an adjustable plunger are used in each of the two pump waveguides to match the pump power to the varactors.

Figure 3 shows gain versus frequency characteristics for the amplifier adjusted for a 20-db forward gain at 895 Mc. The bandwidth is 10 Mc. and the reverse loss exceeds 30 db. The noise figure of the amplifier is 1.5 db.

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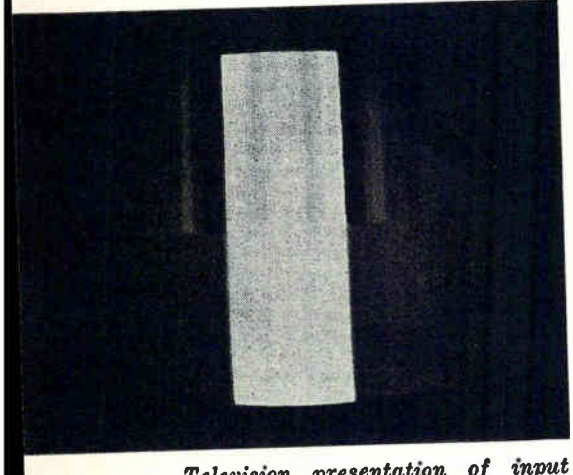
BIONICS PART IV *(Last of a Series)*

Applications and New Directions

Although the range of bionics investigations is wide and the promise great, the payoffs in hardware are not yet numerous. Directions being explored include evolutionary models and learning networks grown in liquid solution

By NILO LINDGREN
Assistant Editor

EVEN a superficial view of bionics projects and the interactions between the many disciplines reveals an impressive range of work. In one sense, there are no specialists in bionics. Investigators from any of the sciences may contribute. An embryologist studies the chronological evolution of electrical activity in the chick embryo, possibly useful in constructing models that function as input-output integrators.[1] A biologist studies the hydraulic and structural aspects of leaf shapes and leaf venation[2] and devises experiments to investigate the automatic control system of the fish.[3] An electrical engineer, veterinarian and biostatistician develop probability models to describe the characteristics of epidemics.[4]



Television presentation of input (bottom) and output (top) of GE contrast device

In studies of the evolution of intelligence, H. J. Bremermann, a mathematician at the University of California, has developed the main evolutionary features in a theoretical model.[5] He has used the model to compute the optimal rate of mutation such that the speed of evolution of a species towards a goal is maximal. The model shows the advantage of sexual reproduction in the development of needed new properties, in contrast to asexual reproduction which must rely on mutation alone to bring new properties into being. This theoretical model is adapted for simulation of evolution on an electronic computer. On a computer an evolution that has taken thousands of years could be simulated in hours. Bremermann suggests many applications for this model. Because man-made tools and techniques, as well as living systems, evolve and develop new properties, Bremermann suggests that the principle of evolution can be applied to the development of man-made artifacts. Work now in progress at U of C deals with the optimization of properties through evolutionary methods with sexual recombinations.[6]

One investigation of adaptive systems, Peripheral Access Lattice Structures, is being sponsored under an Air Force bionics contract. This work is being carried out by R. M. Stewart of the Space-General Corp. in California. His theoretical studies of structurally homogeneous adaptive logic nets has led to the design of two hypothetical machines, PAL-I and Mabiac.[7]

Figure 1 shows a mockup of PAL-I. Each ball and each small disk on the larger disks is a NOR element, formed into an almost completely regular lattice structure, which is tapped at the periphery with three inputs and three outputs. Slight irregularities, having the characteristics of random crystal faults, are introduced into the structure so that it will operate properly.

Although this structure could be extended indefinitely, the model, which has a theoretical minimum of 24 switches, will produce any one of 2^{24}, or more than 16 million, different functions. By stimulus, response and punishment contacts, all on the periphery of the structure, any behavior out of the millions of possibilities can be established in about 50 trials. This conditioning procedure is functionally similar to the Artron developed by Melpar.[8]

The Mabiac may be formed of a tremendous number of small metallic spheres immersed in acid, which will cause coatings to form on the spheres. The system will form a bonded lattice through which waves of polarization may propagate in a manner that may be similar to waves of nerve impulses in a living system.[8] Platinum stimulus and response electrodes attached to a control circuit at the periphery of this lattice would selectively disturb the coated connections throughout this lattice to form the behavior patterns. Since the spheres can be extremely small, the logic potential and microminiaturization aspects are theoretically great.

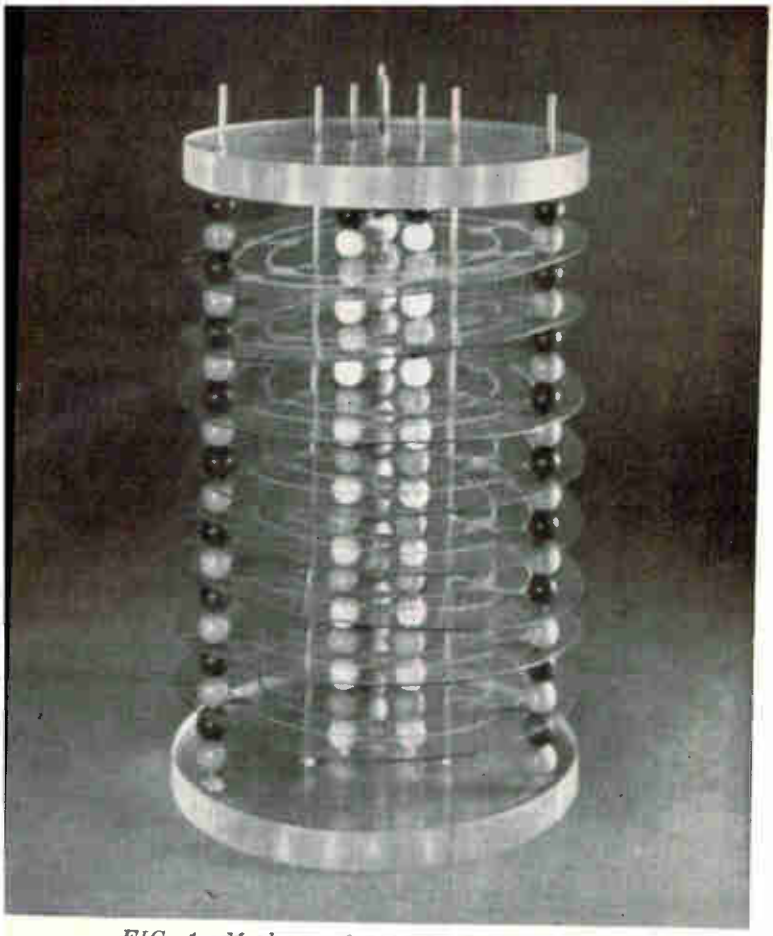


FIG. 1—Mock-up of an adaptive system called PAL-I consisting of 24 switches. By trial-and-error conditioning, this network can be made to converge quickly on any one of 16 million behavior patterns

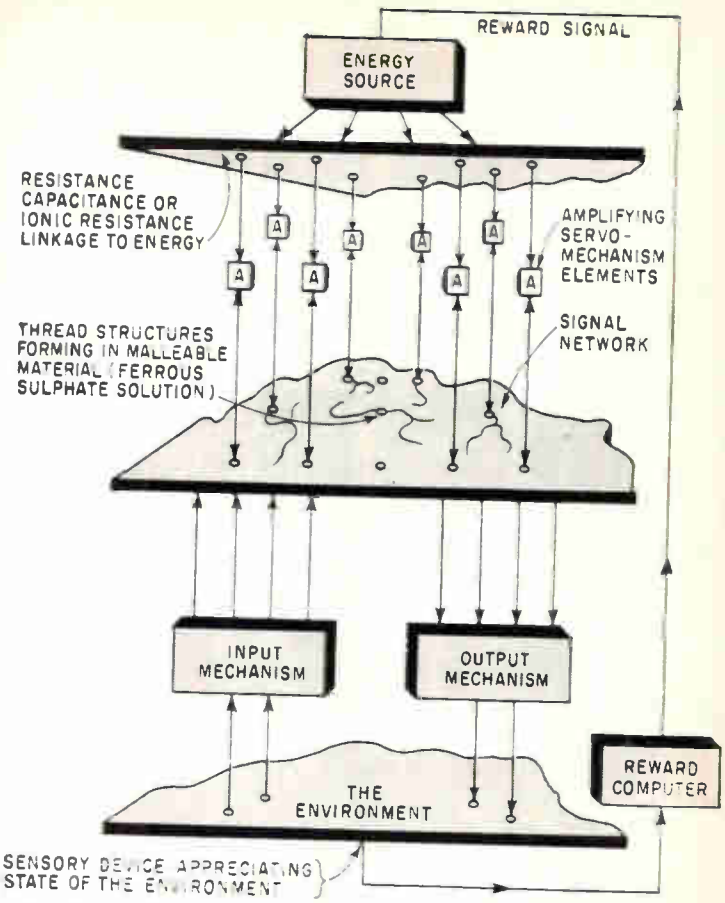


FIG. 2—In this learning network devised by G. Pask of Systems Research Ltd., England, a dynamic signal network of threads is formed in a ferrous sulphate solution. Thread distribution depends on reward signals

Already in the hardware stage is the Artron developed by Melpar. The maze runner delivered to ASD in January is based on 10 component switches or decision elements. Each Artron component is a statistical switch, or binary logical gating device, with 16 possible states. These elements can be wired up completely at random initially; then this original statistical freedom is gradually conditioned or weighted towards performing an intended goal by reinforcing states that tend towards the goal and punishing the states that tend away from the goal. Each statistical switch contains a counter that serves as memory. If part of the Artron circuit is destroyed, or the goals change (that is, the maze is changed) the Artron relearns the new maze, or works towards the new goal.[3] Application of an Artron-type learning network could conceivably be made in an unmanned vehicle which is moving into an unknown environment—for example, a space ship approaching a planet with an unknown atmosphere and gravitational effects. Learning in such cases would need to be rapid, of course, or facilatory, in the sense that the network might make fine corrections to a preprogrammed landing procedure.

Primarily, an Artron-type network could be used with equipment going into dangerous environments. It could be preconditioned on the ground to perform certain functions, to compensate for failures, and learn to deal with changes in environment. Melpar has been awarded another Air Force contract to study the feasibility of using Artron as a means of improving flight control reliability. A limitation with this type of network is its inability to deal adequately with noisy or rapidly changing (shifting) goals. An Air Force contract to study nonlinear problems, "Probability State Variable Devices", has gone to Adaptronics, Annandale, Va.

In England, Gordon Pask has been developing learning networks such as that in Fig. 2. The signal network consists of threads that build up out of a solution of ferrous sulphate as a result of current passed through the solution by the amplifiers. The amplifier electrodes are either sources or sinks of d-c, and the low-resistance metallic threads develop from the sinks along lines of maximum current. These threads tend to dissolve due to local acidity, but remain dynamically stable as long as they pass sufficient current. The distribution of this signal network depends on the goals of the system. Rewards consist of giving more energy or current to the network distribution that performs or interacts with the environment in a desired stable fashion. Using this kind of adaptive network, Pask has made a magnetic receptor and an ear that can discriminate between two frequencies, one 50 cps, the other 100 cps. This ear consists of a gap in thread structure with fibrils that resonate at the excitation frequency.[4]

Another ASD contract deals with Myoelectric Servo Control. It was awarded to Space Labs, Inc., in Van Nuys, California. This concerns the

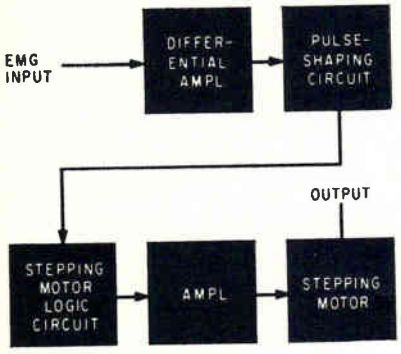


FIG. 3—In a system developed by Litton Systems, Inc., muscle action potentials generated by muscle tension are used in an open-loop control system

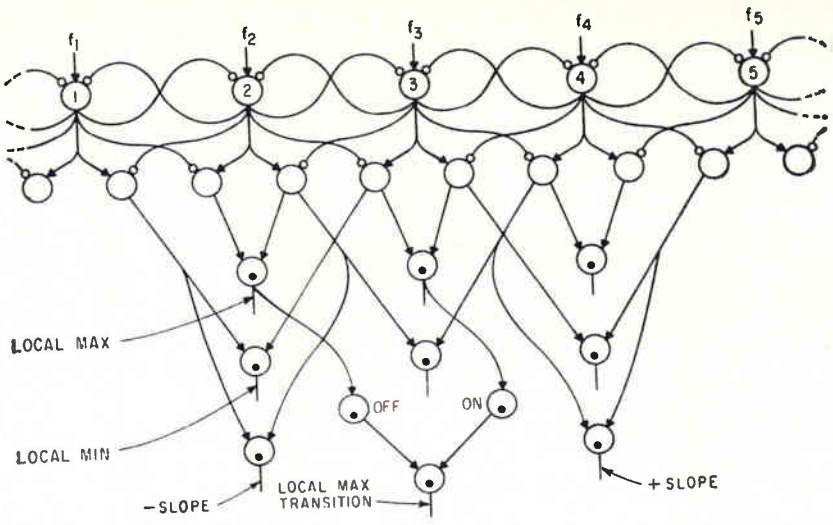


FIG. 4—Speech-processing network under development at RCA uses electronic artificial neurons. Each circle represents a neuron

possibility of using body sensing and nontypical muscle reactions as control elements. This work might tie in with a projected contract called Tactual Perception of Visual Information. If, for example, a spaceman is oriented in a space-vehicle under high g, so that he is unable to use his arms or usual body motions to control his craft, or if he is unable to see his course, he could be fed orientation information to pressure-sensing nerves on the surface of his body. These nerves, though lacking the resolution of the other senses, such as the eyes or ears, nevertheless, might be trained to react characteristically to this input information. Thus, a diffuse sensation on a chest nerve might cause the space pilot to maneuver or tense his shoulder muscles just enough to control and guide his craft. Tensed muscles generate electrical potentials called muscle action potentials or electromyographic potentials, detectable with electrodes placed on the skin and can be converted or interpreted and used in a servo control. This is myoelectric servo control. Related but as yet uncontracted program of interest to the Air Force is a study and development of muscle substitutes.

At Litton Industries in California, considerable work has been done on an electromyographic (emg) open-loop control system.[10] Muscle action potentials, whose spike repetition rate is proportional to muscle tension, activate a stepping motor. Each emg spike applied at the input, Fig. 3, results in a precise incremental shaft rotation at the output. More sophisticated emg control systems are now under development in the Medical Electronics and Bionics dept. of Litton Systems, Inc.

EMG control systems could also be used for power amplification of natural movements, as for example in the U. S. Army's servo-soldier concept.

The development of the optical maser, or laser, makes it probable that as man enters space he will need to transmit information over the astronomical distances at optical frequencies. In one research program at Armour Research Foundation, it has been discovered that chloroplast, extracted from plants, has a narrow frequency acceptance, somewhere near ir. ARF has grown and harvested this chloroplast, deposited it on plates, and formed rudimentary ir detectors.[12] Such detectors might be made more sensitive; conceivably, a systematic search might reveal a spectrum of such narrow-band detectors in the near-optical region. Coupled with lasers, such devices could lead to a profitable exploitation of this frequency spectrum.

In yet another direction, ARF has worked with the olfactory sense, and is developing an artificial electrical nose that should be able to smell or recognize low concentrations of vapor in air.[13]

Other devices near the hardware stage are ear analogs. One of these, under ASD contract Research on Speech Processing through Cochlear Matching, has been designed by the Sensory Systems group at the University of Arizona, headed by J. L. Stewart.[14] Another bionics contract held by this university, in which the AF has a strong interest, is for an electronic simulation of the biological clock, a phenomenon exhibited by both plants and animals, that pace their functions in a cyclic fashion.[15] Being considered, though not yet contracted, is another type of analog of the cochlea based on a nonuniform tapped, solid-state line. Possible recipient for this work is ITT, where much of the theoretical work has already been completed.

Another company involved in the development of a sophisticated speech processor based on neural networks is RCA. The network embodies many of the psychoacoustic phenomena known to operate in the human ear.[16] The motion of the cochlea, the spiral receptor of the ear, is simulated by an RLC transmission line, which is a distributed low-pass structure. The outputs of these filters (f_1, f_2 . . . f_n represent center frequencies) are fed into a neural network, Fig. 4, that preprocesses the frequency information.[17] The first layer of electronic (transistor) neurons[18] enhances small differences in signal amplitude in neighboring channels, the second layer selects the larger output of two neighboring neurons, and from this layer the local maxima, local minima, positive and negative slopes, and their local transitions are abstracted.

At GE's Advanced Electronics Center in Ithaca, N. Y., an elec-

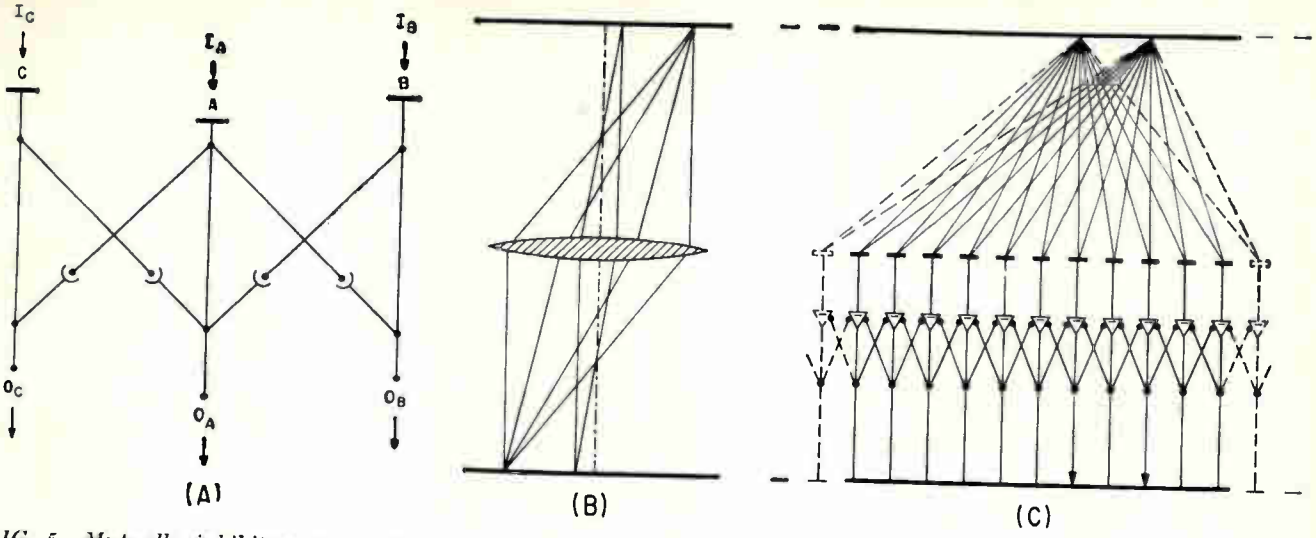


FIG. 5—Mutually inhibitory network is basis for contrast sharpener being developed by GE, Ithaca (A). Diagrams show how two point sources of light are imaged by a lens (B) and by a multifaceted eye in which neural inhibition compensates for diffraction and overlapping field effects (C)

tronic model of the eye of the limulus (horseshoe crab) relies on inhibitory interactions that have been found to exist in multi-faceted eyes. The device, which sharpens contrasts, could be used to accentuate edges in the pattern from an array of ir detectors, or to sharpen and refocus image edges and contours on a tv or radar system by operating on the video signal.[19]

The operation of a simplified mutually inhibitory network, Fig. 5A, is like that of an edge detector (Part III), in which neighboring receptors modify each other's outputs. In the model, receptor units *A, B, C*, which correspond to single facets (ommatidia) of the limulus eye, are connected so that *B* and *C* inhibit *A*, but *B* and *C* cannot inhibit each other. In its model, GE has used 10 summing amplifiers, the outputs of which are changed in magnitude and sign, and fed back as inhibitory inputs to other amplifiers. Various weightings of inhibitory effects can be achieved by changing connections. So far, experiments have been conducted with a linear array of 10 units, but work is going on to develop a two-dimensional planar array of mutually inhibiting units. The photo shows how the edge of a band of light (bottom) has been sharpened (top).

Other studies of these inhibitory networks and of the resolving power of facet eyes have also been conducted by W. Reichardt in Germany. He has shown that lateral or mutual inhibition enables the multifaceted eye to portray perfectly the optical surroundings on the crossection of the optic nerves.[20] This neural inhibition compensates for overlapping of visual fields and for diffraction effects. Figures 5B and 5C illustrate the difference between image formation by a lens and image formation in the multifaceted eye by lateral inhibition. In Fig. 5C, only neighboring operational amplifiers are shown inhibiting one another; in the actual eye, the output of each amplifier is connected to the inputs of all other amplifiers.

Other work in the GE Bionics Engineering section includes the Visilog (visual analog), a device that calculates slant angles to a textured surface, which might be useful in a recognition machine for normalizing figures in the third dimension.[21] Conceivably, the device could be used for landing unmanned vehicles upright on another planet. Another device is an adaptive filter that can learn to recognize repetitive signals buried in noise.[22] The device could be used in recognizing characteristic ir outputs from missiles and in recognizing various kinds of bioelectric signals.[23]

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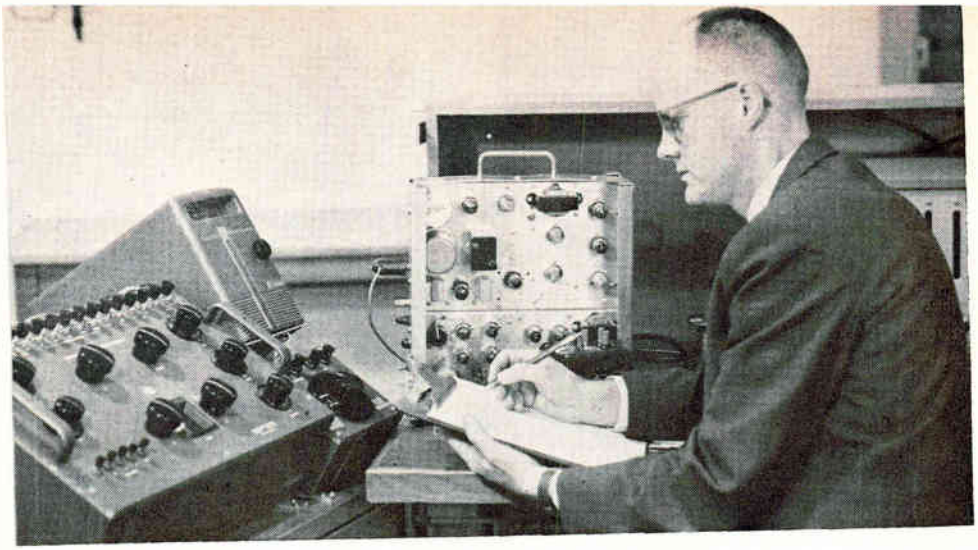


Author Bell measures linearity of voltage-controlled prototype model oscillator

Voltage-Controlled Oscillator Uses Negative Feedback

Specially designed pulse-counting discriminator circuit in feedback loop gives voltage-controlled oscillator adequate linearity for computing applications

By N. W. BELL
V. CHIUNTI
Bell & Howell Research Center, Pasadena, Calif.

VOLTAGE-CONTROLLED oscillator using negative feedback to provide good linearity and stability can be used with a totalizing counter to integrate slowly varying signals. With an events-per-unit-time meter, the oscillator can also be used as an analog-to-digital converter.

Oscillator output frequency varies between zero and 1 Kc as input voltage varies between zero and 10. mv. Linearity and stability are 0.1 percent at maximum frequency.

The voltage-controlled oscillator is conventional except that negative feedback has been added. With high loop gain, operating characteristics depend only on the feedback element, which is a stable pulse-counting discriminator.

The feedback loop is shown in Fig. 1. With zero input feedback tends to make frequency equal to the frequency of the fixed 1.2 Kc oscillator. The difference frequency from the mixer is then zero.

With maximum input of 10 mv, the negative feedback circuit shifts oscillator frequency toward 2.2 Kc so that the sum of the input and feedback voltages to the d-c amplifier again approaches zero. The difference frequency from the mixer is 2.2 Kc − 1.2 Kc = 1 Kc. Zero drifts in the discriminators tend to cancel, and the 1.2-Kc fixed oscillator need not be stable. Linearity depends on linearity of discriminator number 1, and d-c amplifier bandwidth can be much narrower than system bandwidth.

Performance depends primarily on the discriminators, which should be stable, linear and have equal

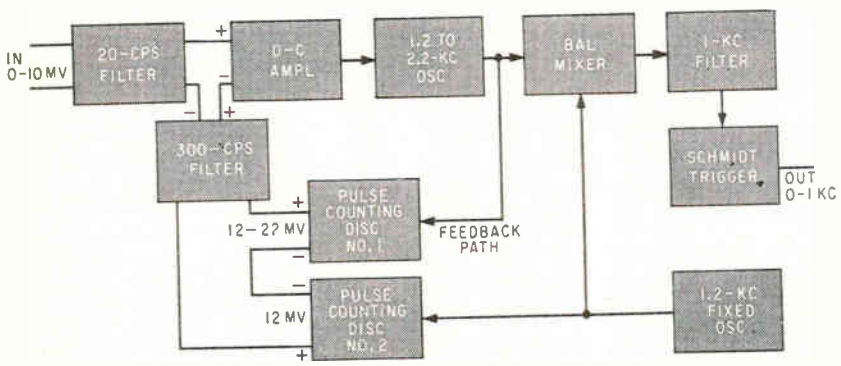


FIG. 1—With high loop gain, oscillator circuit performance depends on feedback discriminator

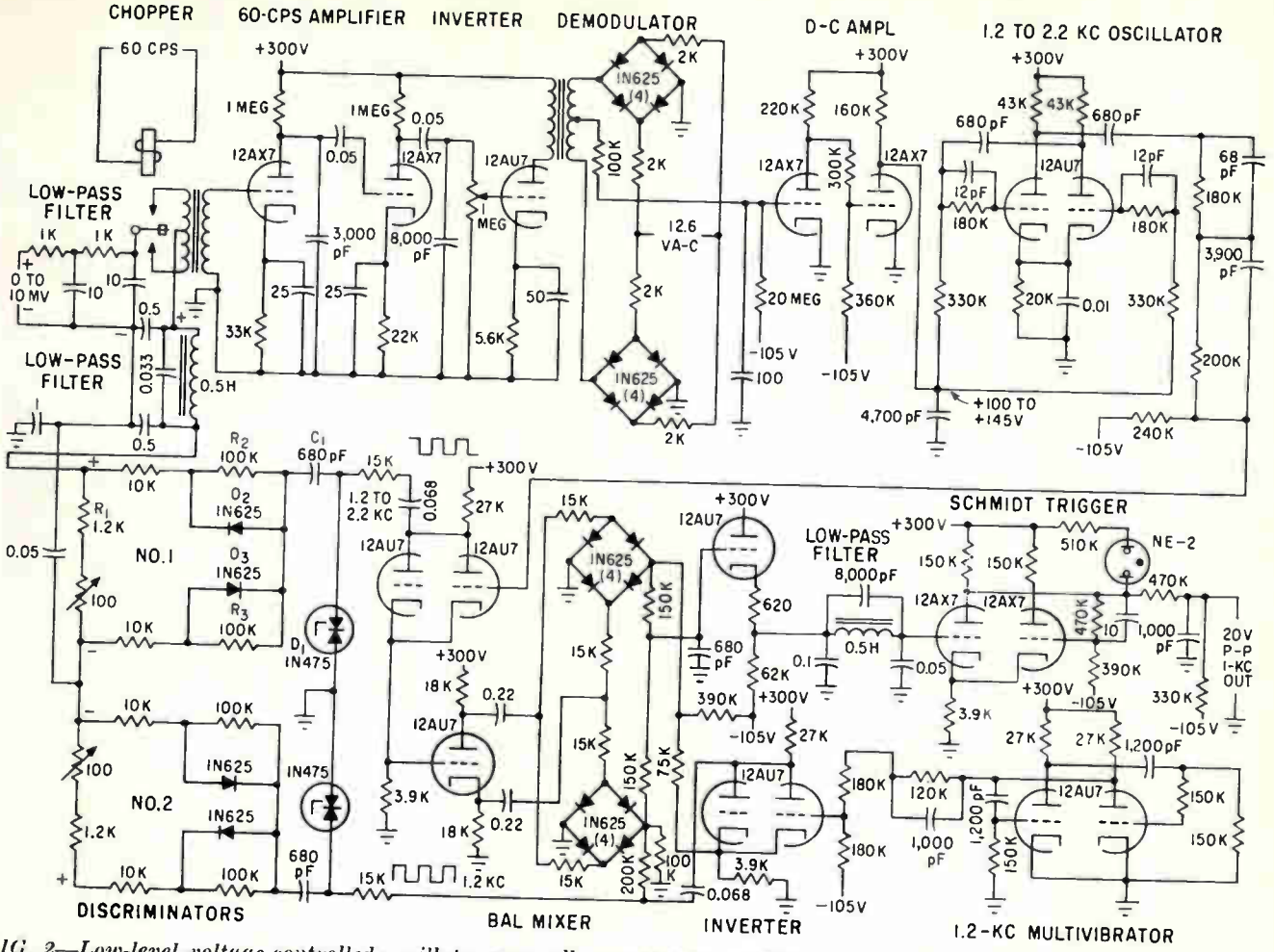


FIG. 2—Low-level voltage-controlled oscillator uses all conventional readily available components with no component selection or matching required

temperature characteristics. The pulse-counting discriminator in Fig. 2 provides linearity of better than 0.1 percent over an octave range. The input square wave is regulated by double-anode zener diode D_1 so that 5-percent variation in input amplitude produces less than 0.1-percent change in output.

Charging current for capacitor C_1 flows alternately through diodes D_2 and D_3. Average charging current produces a voltage across R_1 and the 100-ohm potentiometer that is proportional to input frequency. The d-c output voltage is isolated from ground by capacitors. Charging capacitor C_1 must have low dielectric losses, and silvered mica was found to be satisfactory.

Resistors R_2 and R_3 improve linearity by removing the effects of varying diode resistance near the voltage origin of the diode curve. Temperature coefficient of the circuit depends primarily on regulating diode D_1, and typical values are about 0.025 percent per degree Fahrenheit. The two discriminators are packaged together in a small plug-in unit to cancel the zero shifts caused by temperature changes.

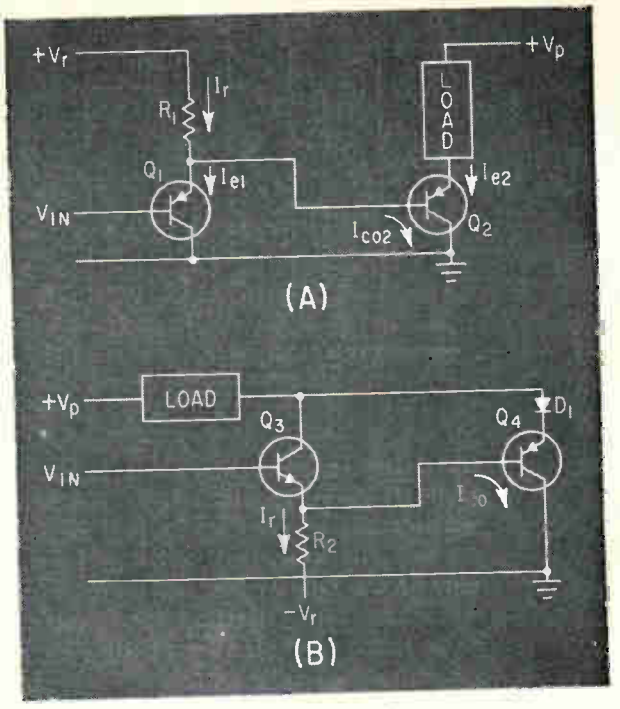
The input filter in Fig. 2 attenuates interference and noise near the 60-cps chopping frequency. The chopped d-c is amplified and then demodulated by a phase-sensitive demodulator. After additional d-c amplification, the signal is used to control frequency of an astable multivibrator, and the square-wave multivibrator output is amplified and fed back to discriminator number 1. Another astable multivibrator operating at 1.2 Kc provides input to the other discriminator. The negative discriminator terminals are connected together and the positive outputs provide the feedback voltage. The negative feedback loop is completed through a filter that removes ripple.

The difference in frequency between the outputs of the variable-frequency and the 1.2-Kc multivibrators is produced in a balanced mixer using two diode rings. The diode rings act as shunt switches across the outputs of the phase inverter. Since one side of each switch is at ground potential and the phase-inverted signals are returned to ground, no isolation transformers are required.

The low-pass filter after the mixer removes high-frequency modulation products. A slicer circuit (Schmitt trigger) following the filter shapes output. Slicer hysteresis is made greater than filter p-p amplitude to avoid spurious outputs. Output is 20 v p-p, sufficient for most counters.

Discriminators 1 and 2 are adjusted for maximum and zero inputs, respectively. Loop gain is set for minimum response time by adjusting gain of the 60-cps amplifier. Response time is about 0.2 seconds. Calibration is maintained within 0.1 percent for several months.

Complementary Compound Emitter Follower



Ordinary compound emitter follower (A); new complementary emitter follower (B)

This circuit uses two complementary transistors to reduce power dissipation and increase power output at the lower frequencies

By T. K. HEMINGWAY and J. WILLIS* English Electric Aviation Ltd., Stevenage, Herts, England

IN APPLICATIONS where the current gain of a single emitter follower is inadequate, it is common practice to connect two transistors in cascade as shown at A in the figure. This is a convenient circuit for a class-A power output stage driving a reactive load where only a small phase shift between input and output voltages is permitted. The base current of power transistor Q_2 is provided from the emitter of Q_1 so the overall current gain is almost the product of the two grounded-emitter current gains. The circuit must be designed so that Q_1 remains conducting under the worst conditions.

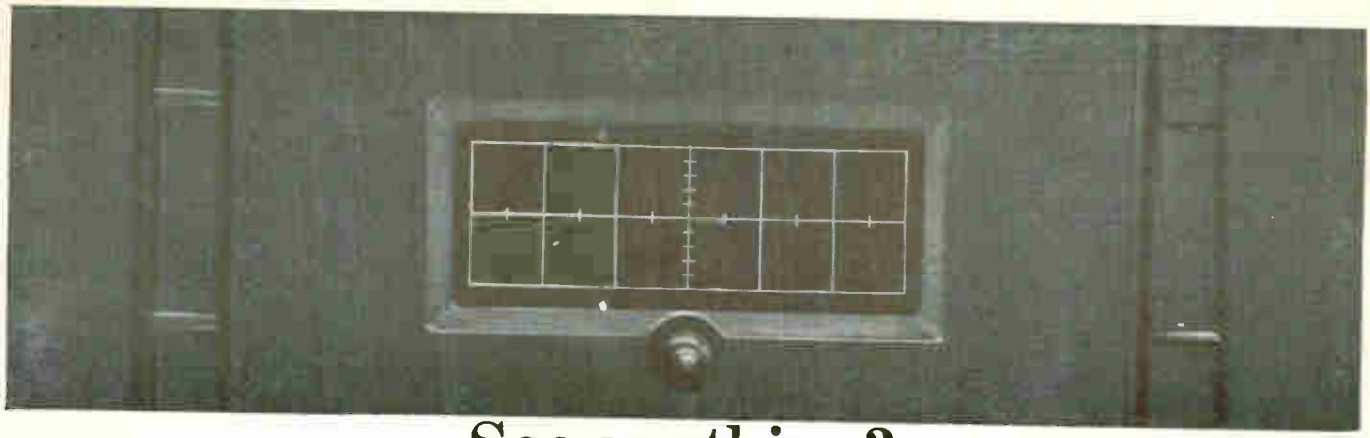
Emitter current of Q_1 is given by $I_{e1} = I_r + I_{co2}/(\beta_2 + 1) - I_{co2}$ where the currents are as labeled in Fig. 1A. From this equation, if I_{co2} exceeds the sum of the other two currents, Q_1 will cutoff and lose control over Q_2. This undesirable state can be avoided by choice of I_r.

The worst condition occurs when the Q_2 junction attains maximum temperature simultaneously with the input voltage reaching its maximum positive value. At this point I_{co} is maximum and I_{e1} is minimum, so I_r must be large enough to make I_{e1} positive in the equation.

Since I_r has its minimum value for maximum positive input voltage, choice of an adequate value under these conditions may result in a high normal standing current through R_1 and Q_1 resulting in large power dissipation in Q_1 unless V_r is large. Then the dissipation in R_1 will be high.

It may be preferable to use the complementary version shown at B. The current drive to Q_1 base is now limited to the standing current I_r through resistor R_2, so the minimum value of I_r must be made large enough to turn Q_1 fully ON under the worst conditions, that is with zero I_{co} and minimum beta in Q_1. However, I_{co} in Q_1 will be drawn directly from the emitter of Q_3, turning Q_3 harder ON so there is no danger of Q_3 cutting OFF at high temperatures. Further, Q_3 collector can now be returned to Q_1 emitter, with possibly the interpolation of diode D_1 or a resistor to establish a minimum V_{ce} of approximately 1 volt for Q_3. The collector voltage of Q_3 thus has a low and nearly constant value, independent of input voltage, and dissipation can be small. This combination may use a silicon low-power device for Q_3 and a germanium power transistor for Q_4.

* Now with Southern Instruments Ltd., London, England.



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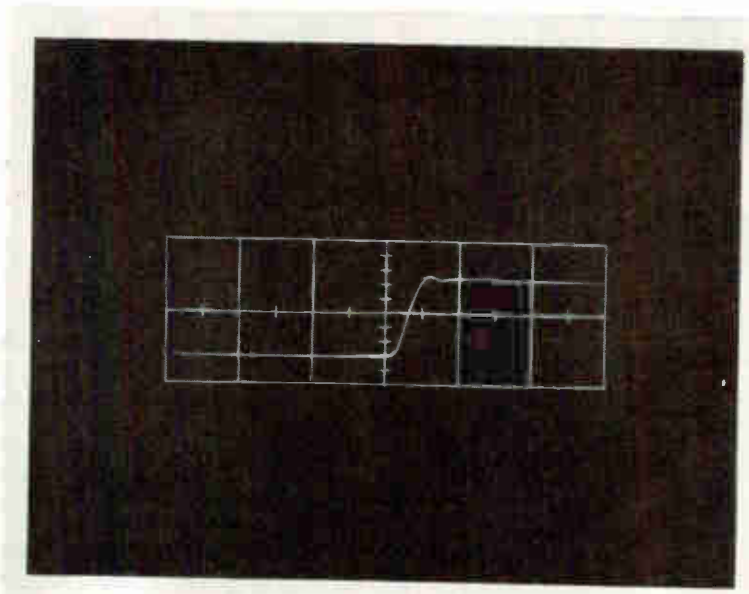

This new film did.

This new film saw something the eye couldn't: the rise time of a single pulse on a Tektronix 519 scope at a sweep rate of 2 nanoseconds/cm. The new film, Polaroid PolaScope Land Film, actually extends the usefulness of existing oscilloscopes by supplying "brightness" that the scope hasn't got!

The reason is that this PolaScope film has an ASA equivalent rating of 10,000, which means it can see things your eye cannot. It has about twice the writing rate of the Polaroid 3000-speed film, currently the standard for high speed oscilloscope photography. (No other commercially available films come anywhere near the speed of PolaScope film.) And because it's made by Polaroid you get a finished usable print – see above – ten seconds after exposure.

PolaScope film will also give you better shots of slower pulses and stationary waveforms. So little light is required, camera aperture and scope intensity can be reduced considerably, and that's how to get really sharp oscilloscope pictures.

And wherever else light is at a premium – such as photomicrography and Kerr Cell photography – PolaScope film will make new applications possible, old applications more useful.

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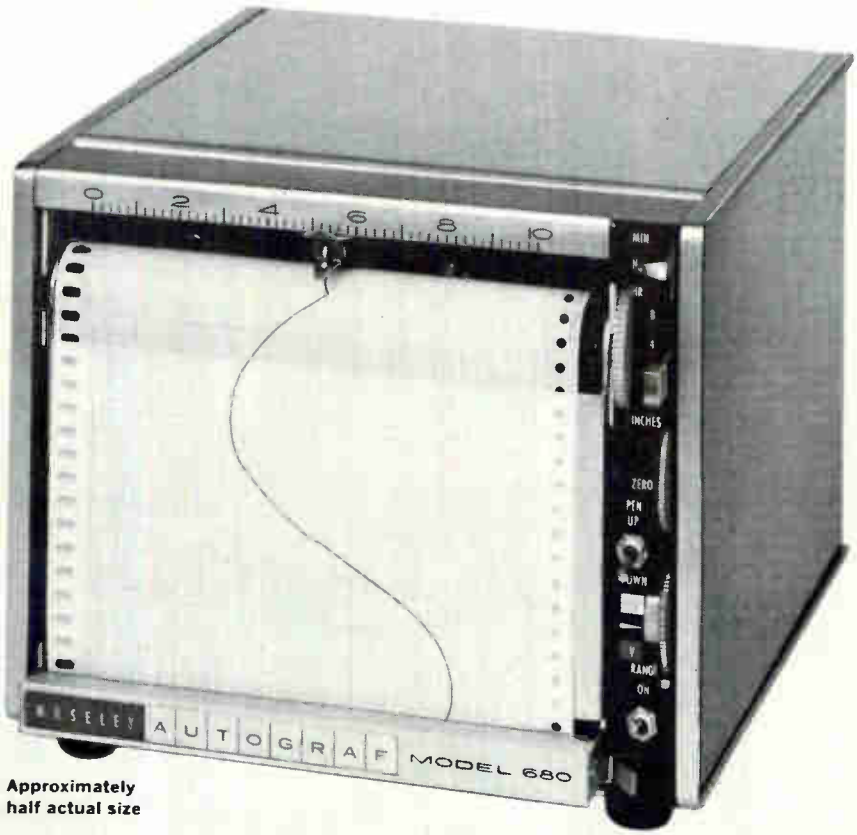

Approximately half actual size

Moseley AUTOGRAF Model 680 Series Recorders have these features: One mv/inch to 20 v/inch in ten calibrated ranges • One millivolt full scale optional • Zener reference supply • Rack or table mounting; heavy industrial case optional • Instant change of 8 chart speeds • Chart tear-off, paper take-up roll • Convenient tilt surface for chart notation during recording • Ultra-compact, with revolutionary reduction in heat losses • High pen speed, ½ sec. full scale • High accuracy, 0.2% full scale • Electric pen lift—remote control of pen • Operates up to 500 v off ground • All solid state circuitry • Output potentiometer, event marker, Hi-Lo limit switches optional • Thermocouple, milliammeter models available • Uses standard 6" paper 100' rolls • 5" recording space • Price, Model 680, $750 • Single speed, single range Model 681, $625 • Data subject to change without notice.

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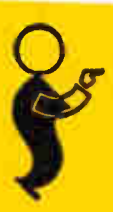

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LOAD LIFE @ 25°C, 1000 hours
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750 volts, dc. . . . . ½ watt, Min. } on value.

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±4%, values to 100k; ±2%, values above 100k.

VOLTAGE COEFFICIENT
Less than ±0.01% per volt. (±0.005% per volt, avg.)

TEMPERATURE CHARACTERISTIC
±3% from 20°C to 105°C

HUMIDITY: 95% RH @ 40°C for 240 hours
±4% to ±5%, values to 250k; ±6% to ±9%, values above 250k.

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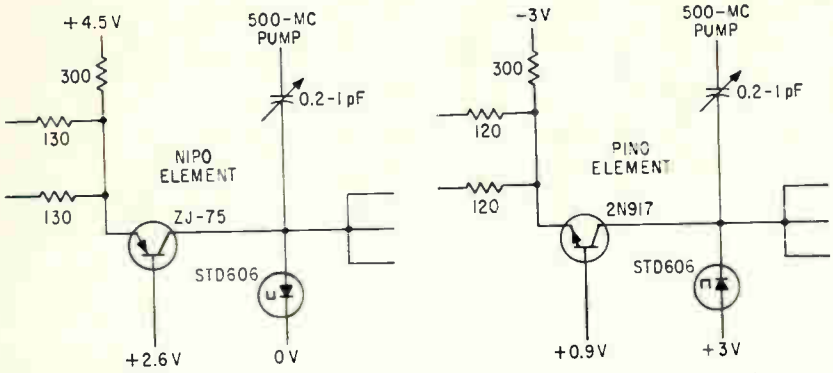
Tunnel Diode-Transistor Provides Fast Logic



THE FRONT COVER. Uhf shift register uses pumped tunnel diode-transistor logic elements, which are made in negative input-positive output and positive input-negative output types

TUNNEL DIODE-TRANSISTOR logic with a 500-Mc bit rate can perform four logical functions in 2 nsec. As faster tunnel diodes and transistors become available, the 2-Gc logic rate can be increased. In addition, the system requires substantially fewer circuit modules.

The logic system, developed by General Electric, is said to take advantage of the high speed of tunnel diodes while providing practical working margins. It was described at the 1962 International Solid State Circuits Conference at the University of Pennsylvania in a paper by W. Peil and R. Marolf (ELECTRONICS, p 7, Feb. 16).

A switching margin of 30 percent is provided by the pumped tunnel diode-transistor logic. Because logical functions are performed sequentially rather than in parallel, only one-tenth the usual number of circuit modules are required. This reduction and the simple six-component module contribute to reliability.

High speed of the logic system can enable real-time radar signal processing to be performed digitally. In high-resolution radar, it could distinguish among multiple targets and calculate velocity in real time. The system is also expected to be useful in high-speed counting and coincidence detection involving real-time control.

Basis of the logic system is a newly developed germanium tunnel diode. Commercially available as type STD606, it has typical switching speed of 50 nsec.

Speed of the system is attributed to the two-input NOR gate shown in the figure, which has a gain of 3 and consumes 50 mw. Because phase inversion occurs through the gate. positive input-negative output (PINO) and negative input-positive output elements are neded. The synchronous information signals are reclocked at each logic gate by pumping the tunned diode with a 500-Mc sine wave. A single phase pump source is common to all circuit modules.

Circuit Operation

With no input signal, the tunnel diode in the NIPO element switches once every positive half cycle of the pump signal from its bias point below the peak voltage into the high-impedance region. A negative input at one or both inputs prevents diode switching, providing a NOR gate. A PINO element is provided simply by using an *npn* transistor and inverting tunnel diode polarity. Since each type element switches on on opposite half cycles of the pump signal, two levels of logic can be performed during a full pump cycle and logic can be performed at a 1-Gc rate. A third element, an inverting transformer, is used where one element feeds another of the same tye. Combinations of the three elements permit any complex logic to be performed.

Operating speed depends primarily on the tunnel diode, which provides gain and switching. The transistor provides isolation between input channels and unidirectional information flow. The isolation permits modules to be interconnected by matched microstrip transmission line. eliminating problems associated with reflections and permitting signal interconnections to be made over long distances. Line length is not critical because of the logic element reclocking. To ensure the same pump signal phase to all modules, a standing wave is generated on the stripline. Because no gain is required of the transistor, it can be operated near its cutoff frequency.

With constant bias and pump voltages, input signal phase error of ±60 degrees can be tolerated. Tolerances of components and of pump and bias voltages compare favorably with all-tunnel diode logic. A-c and d-c power supply tolerances of 20 to 25 percent are attributed to the 30 percent switching margin. Initial component variations are compensated by the variable capacitance in the pump feed.

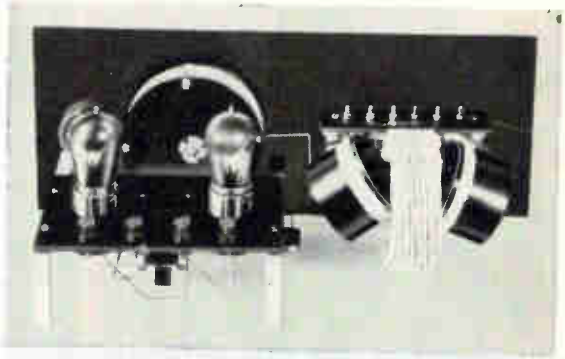
To maintain the information in the system, the frequency band must extend from d-c to 500 Mc and a moderately controlled rolloff should exist to about 1.5 Gc.

A computer using the pumped tunnel diode-transistor logic system could be packaged in almost any form. Computers of 100,000 or more modules could be built without problems of heat dissipation.

Designing Transistor Phase-Shift Oscillators

By F. W. KEAR
The Lytle Corp., Albuquerque, N. M.

SINGLE-TRANSISTOR oscillator provides a sine-wave output using an R-C network to obtain phase shift and determine oscillator frequency. Adding a second transistor enables the oscillator to provide a square-



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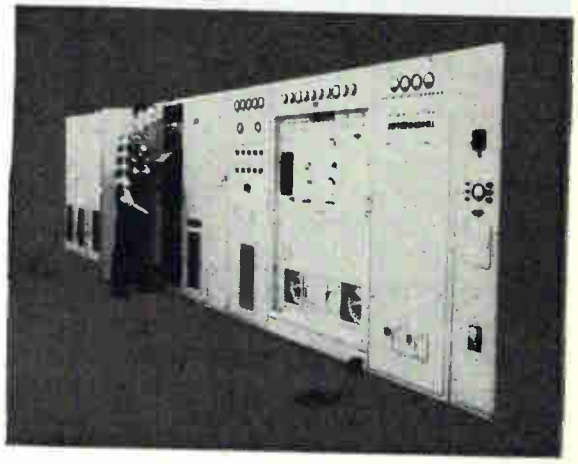

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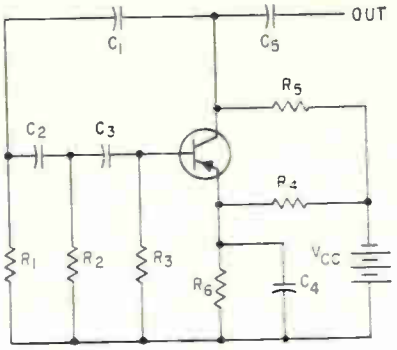

FIG. 1—Three-section R-C network provides required phase shift to obtain positive feedback

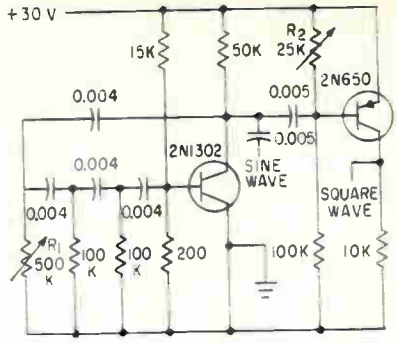

FIG. 2—Phase shift oscillator provides sine-wave and square-wave outputs simultaneously

wave output simultaneously.

The typical phase-shift oscillator in Fig. 1 uses an *npn*-transistor. In the common-emitter configuration, the signal is changed 180 degrees in phase between base and collector. The added 180-degree phase shift required to obtain positive feedback to the base is provided by C_1 through C_3 and R_1 through R_3.

Current flow in the R-C circuit, which consists of resistance and capacitance in series, is determined by the series impedance of the components and the applied voltage, and it can be calculated using Ohm's law. Since reactance in an R-C network is capacitive, voltage lags current at a phase angle determined by the relative values of resistance and capacitance. Voltage drop across the resistance therefore leads applied voltage by this phase angle, and amplitude of the drop is determined by network current.

Obtaining Phase Shift

With a fixed capacitor, phase angle can be changed by varying resistance. As resistance approaches zero, phase angle between applied voltage and current can be varied up to 90 degrees. However, a phase shift network cannot have zero resistance since the only voltage across the capacitor would be applied voltage. With the minimum practical resistance in a phase-shift network, the phase angle will be slightly less than 90 degrees. At least three sections are required to produce the required 180 degrees phase shift to obtain positive feedback in the oscillator. Resistors should generally be chosen so that each section produces about 60 degrees phase shift. Power factor of the capacitor must also be considered because capacitor resistance affects losses and phase shift. Better performance can be obtained by using more than three sections.

Resistors R_1, R_2 and R_3 provide base and collector bias. Capacitor C_1 provides a-c bypass for emitter resistor R_4. Oscillations are initiated by any random noise, such as transistor noise or switch noise as power is applied.

Oscillator output is nearly sinusoidal and frequency is constant except for minor fluctuations caused by voltage and temperature changes. Phase is shifted 180 degrees at only one frequency. As either resistance or capacitance is varied, the frequency at which the correct phase shift occurs also changes. Since most applications of phase-shift oscillators require that frequency be variable, resistance in the phase-shift networks is usually made variable.

If a three-section phase-shift network is used, considerable gain is required from the transistor because of the losses incurred in the network. As the amount of phase shift required of each section is increased, losses in the section also increase because of the increased voltage drop through the resistor and the resistance of the capacitor. It is therefore desirable to use more sections with less phase shift required from each section.

The phase-shift oscillator in Fig. 2 can provide a variable sine-wave signal and a square-wave signal at the same time. Oscillator frequency is changed by R_1 and width of the square wave is varied by R_2. Square-wave width is limited only by oscillator frequency. Four sections are used in the phase-shift circuit.

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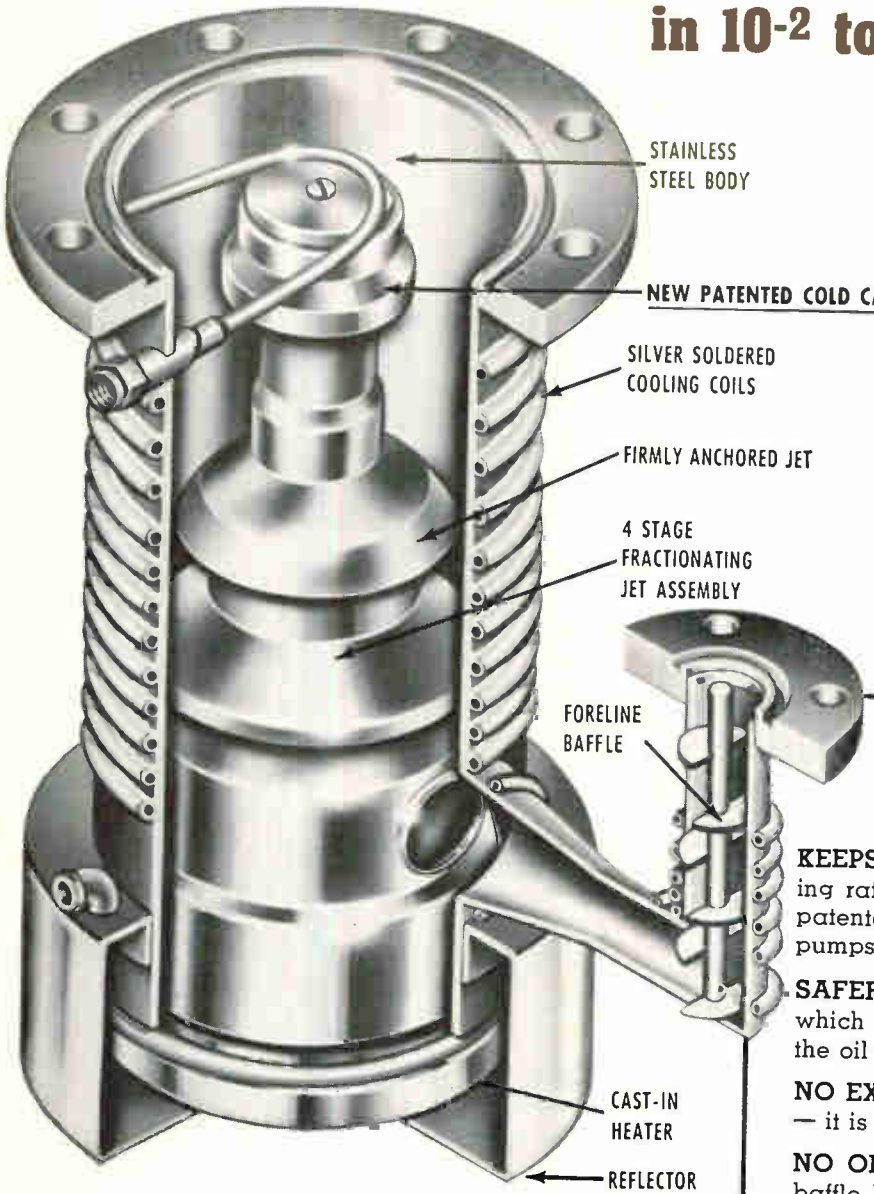

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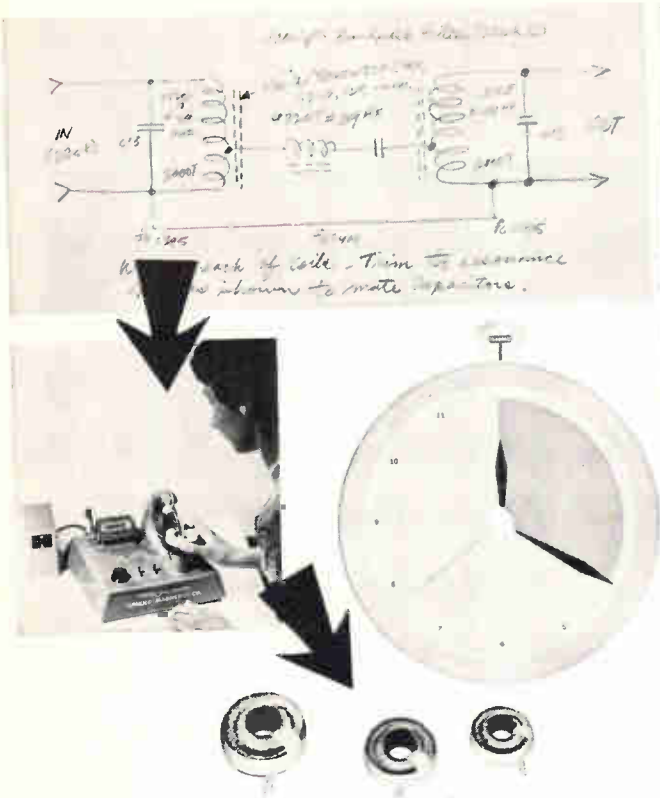

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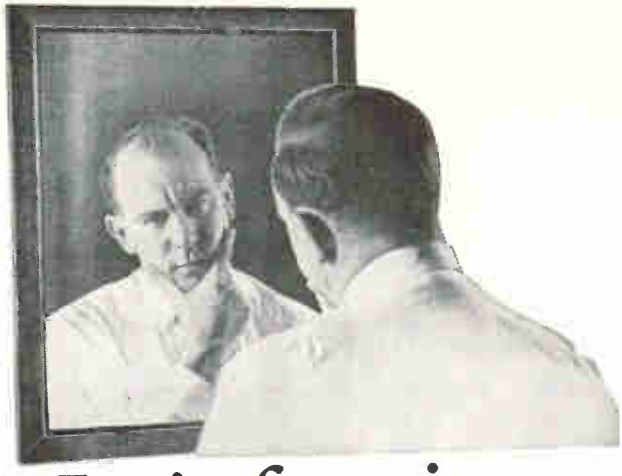

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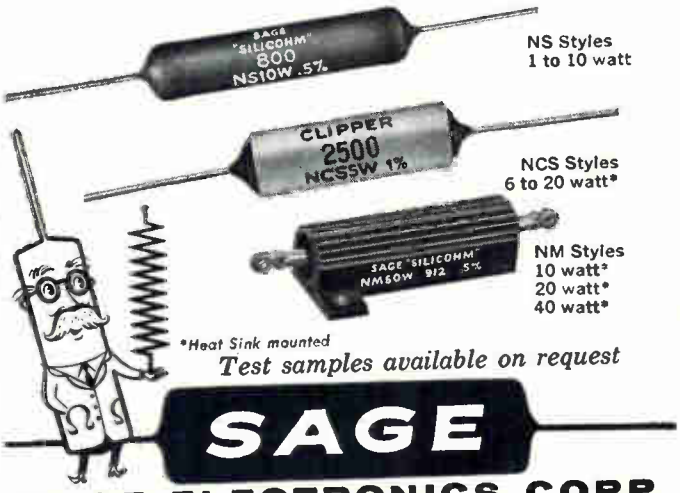

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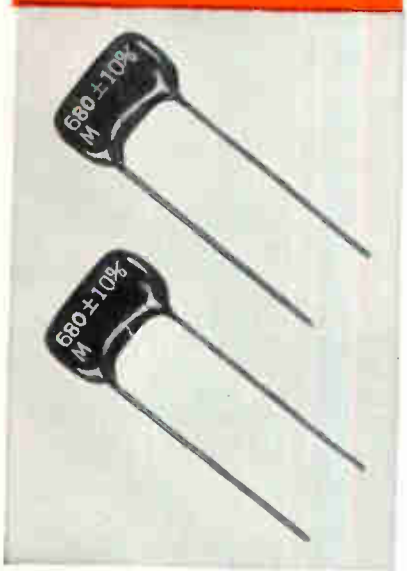

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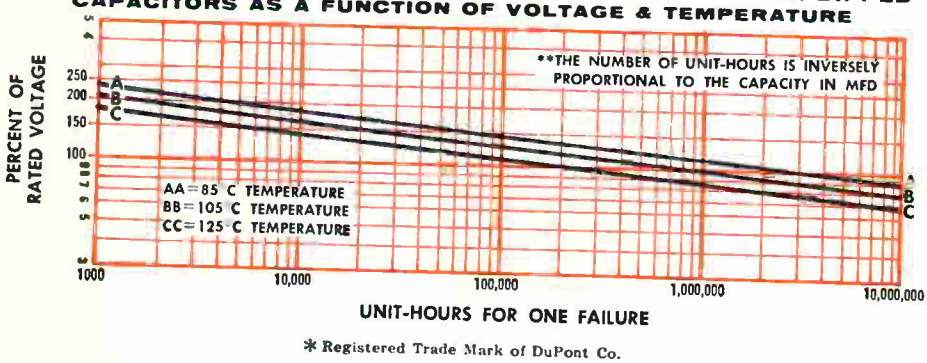

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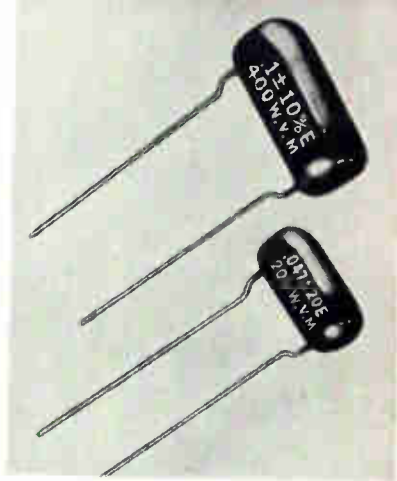

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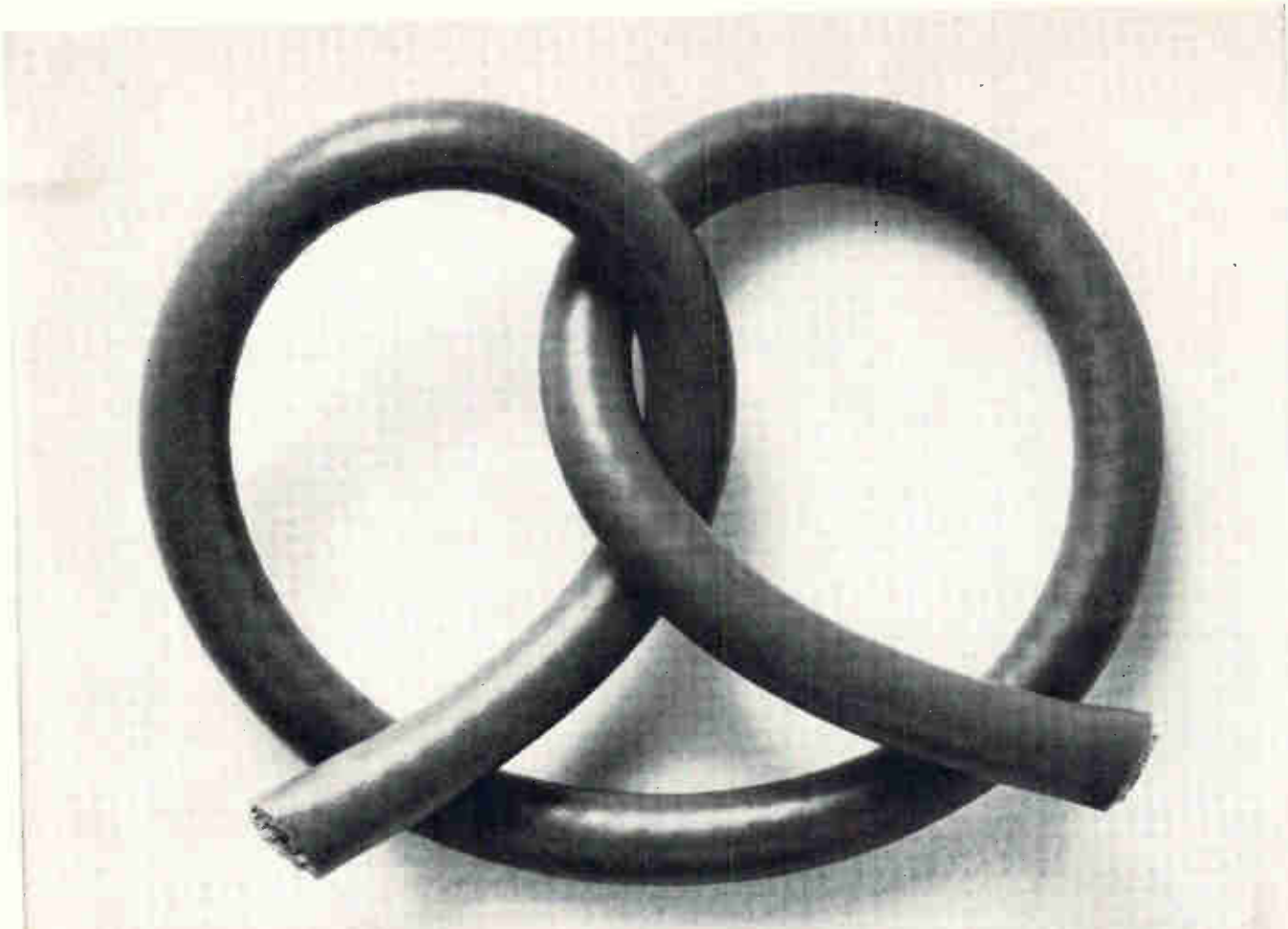

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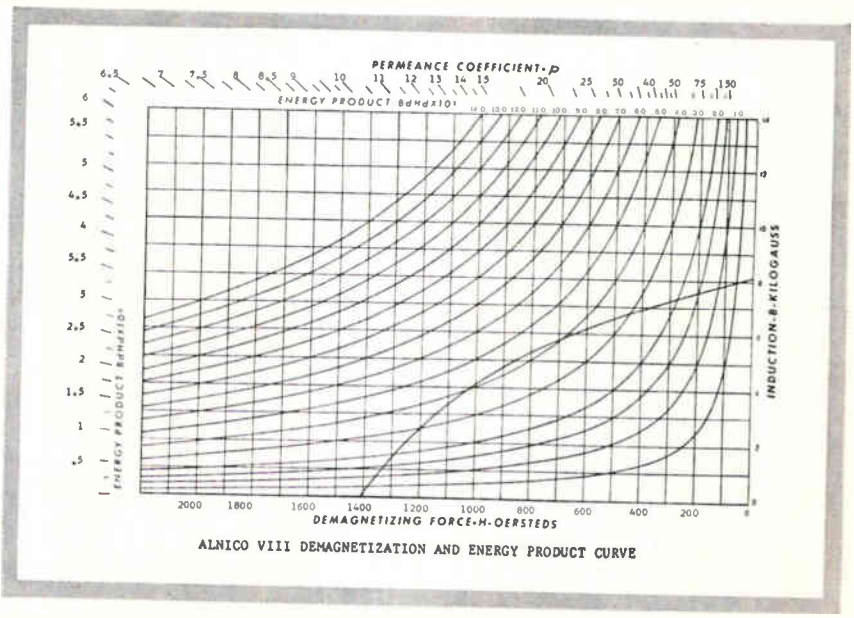

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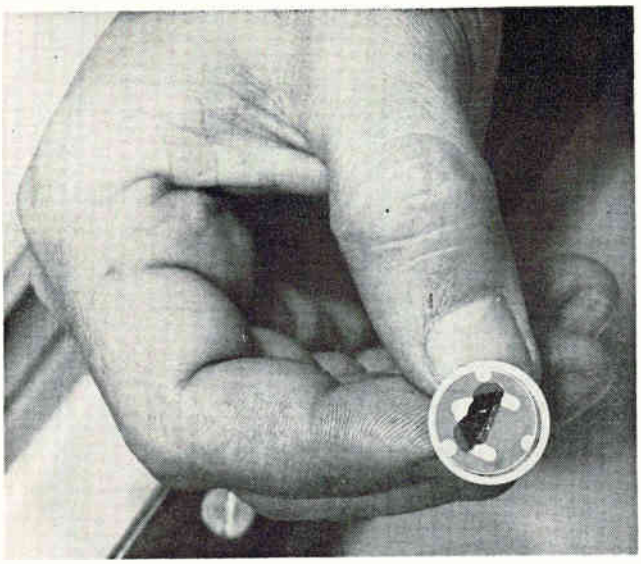
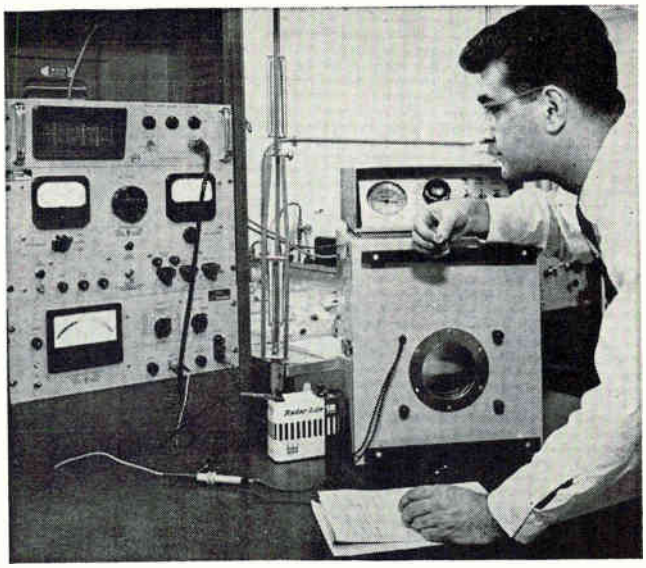




Light-actuated semiconductor analog of the mechanically operated potentiometer (left) is being tested for effects of temperature on voltage deviations by Guido Galli of Giannini Controls

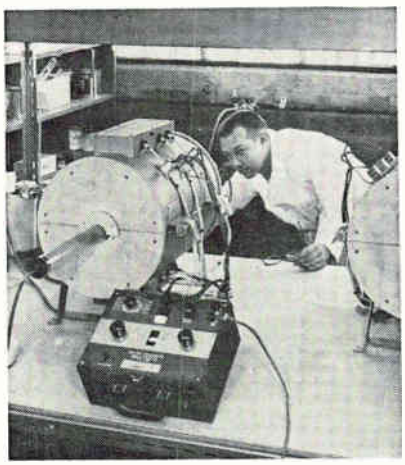
Potentiometer Senses Moving Light Source

By CLAUS HAAKE
GUIDO GALLI
Giannini Controls Corp.,
Duarte, California

AN ELECTRO-OPTICAL potentiometer, now in production, uses a tiny light beam as its wiper arm. Primarily a position-measuring device, the unit functions exactly like an electromechanical potentiometer. However, the Photopot weighs less, is smaller, completely frictionless, has no contact wear, no inertia, and no hysteresis. The device has an infinite life, a very high sweep speed and no resonance frequency.

In the past year, the development of this light-actuated potentiometer has reached a stage of development where it is presently undergoing a severe testing program. Initial results indicate that the properties of the device will be most satisfactory.

The element of this device consists of a resistive film and an adjacent conducting strip which is separated from the resistive strip by a photoconductive crystal. The photoconductive material acts as an insulator when it is in the dark, and as a conductor when illuminated by the light beam. The device is independent of light intensity within wide limits.



Mixed crystals for the photoconductive elements of the light-actuated potentiometer are carefully formed in a modified Frerichs type synthesis, shown above.

One method of using the unit employs a non-movable shield that covers all but a narrow opening to the photoconductive crystal at a small distance from the crystal. When the light source moves, an angle is sensed.

A second method for operating the device involves a light source, fixed with respect to the unit, and a movable shield with its slit. In this way, mechanical movement can be sensed and translated into voltage without friction.

Output of the device is a linear function of the light beam displacement on the crystal. However, functional output can be obtained for special applications.

Although its applications are numerous, the optical pot is best suited for direct light-position measurements. Angular displacements down to only tens of arc-seconds can be clearly resolved.

Sensitivity of the solid-state potentiometer is defined as the ratio of crystal resistance between conditions of light and dark. If CdSe is used as the photoconductor, typical sensitivity ratios of 10^6 at 1,000 microwatts per cm^2 of radiation between 7000 and 7400 Angstroms are observed.

The speed of response, is determind by either the rise or decay of the photoconduction process. The rise time is defined as the time measured from initial dark conditions to 1/e of the final light values. The decay time is defined as

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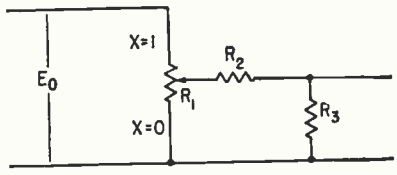
the time measured from initial light conditions to (1 − 1/e) of the initial value. The measured rise and decay times for the average CdSe crystal are 0.001 and 0.005 seconds, respectively. However, the speed of response of the device itself is a complex matter and can best be expressed in terms of operating conditions. The scanning speed is only very loosely connected with crystal speeds. They have been measured to be as high as 7 meters/sec.

The breakdown voltage, measured between any terminal and the case is in excess of 500 volts rms. The insulation resistance, measured between any terminal and the case, is more than 1,000 megohms at 500 v d-c.

Resolution of the device is better than 0.0005-in. over an active length of about 0.5 in. This figure may be improved to yield a resolution of at least 0.00005 in.

Linearity is defined as the maximum deviation from the best-fitting straight line drawn between the 15 and 85 percent voltage points expressed as a percentage of the peak output voltage. Customarily, this is less than ±1 percent. Deviations from linearity of less than 0.2 percent have been observed over a range of 10 to 90 percent of full voltage.



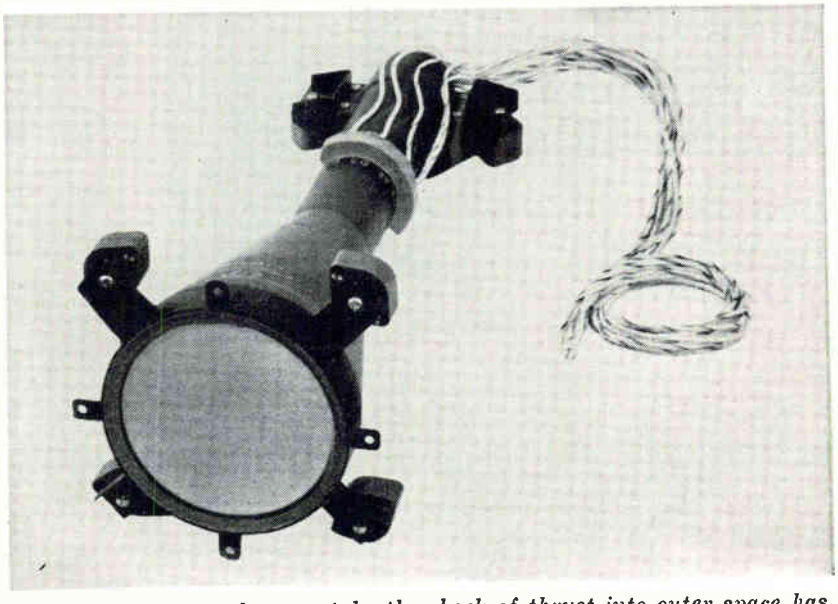
Basic circuit of photopot

Ultimate power dissipation of the device must be necessarily low to preserve the instrument-like qualities built in. Low power consumption would definitely be an asset in most applications.

Temperature dependence rests on the thermal sensitivity of the light-detecting crystal. Thus, temperature influences the output voltage and its linearity. However, if the load resistance in the output circuit is considerably larger than the impedance of the light path, the temperature range of operation is rather wide. Practical temperature limits, assuming not more than 1 percent variation from calibration, will include the range between −54 C and 71 C for a 1 megohm load. Photoconductive materials have been prepared which promise a higher temperature limit.

Evaluations of the deterioration

Rugged Crt For Outer Space



A cathode ray tube that can take the shock of thrust into outer space has been developed by the Electronic Tube and Instrument Division of General Atronics Corporation. The 5-inch single gun, tight tolerance tube can take vibration of 1,000 cycles per second at 0.10 in double amplitude, and impacts as high as 15 G with a time duration of 11 milliseconds, peak value occuring at about 5.5 milliseconds

of materials indicate that single crystals are far superior to sintered layer units. The superiority of single crystals have been further substantiated by applying conventional methods for protecting the crystals.

Among the most intriguing applications for the optically-activated potentiometer is the analog conversion of information. The device can translate a linear motion into a programmed non-linear output and vice versa. The data program to be followed is easily built into the optics.

Other applications suggested are stellar-body position indicator; blast detection system; pickoff for pressure transducer, accelerometer, gyro, torque-angle meter, or mercury manometer; and linear position sensor.

The light intensity from even a 20 KT bomb is adequate to operate the device at a considerable distance. It is not a seismic indicator and could not be fooled by an earthquake. A photometric device coupled with a Photopot could act as a remote station which could give information as to position and yield of a nuclear blast.

Glass Laser Operates In Near Infrared

A LASER using trivalent neodynium doped, barium crown glass, as the active material—rather than a gas or crystal as in previous lasers—has been operated.

Output is in near infrared 1.06 micron region, with a wavelength interval of some 30 angstroms. The glass material is in the form of clad rods, three inches long. Various diameters, including 0.012 inches were tried.

The new laser, developed at American Optical Co., Southbridge, Mass., has been operated with various flashtubes and provides pulsed output. With different levels of pumping power the wavelength interval is variable, from about 5 to 70 angstroms. It is believed that single lines in the output may prove to be as narrow as other lasers.

An advantage of using a glass laser material is the ease in which it can be formed into various shapes. This allows large surface areas for efficient cooling with a minimum of equipment.

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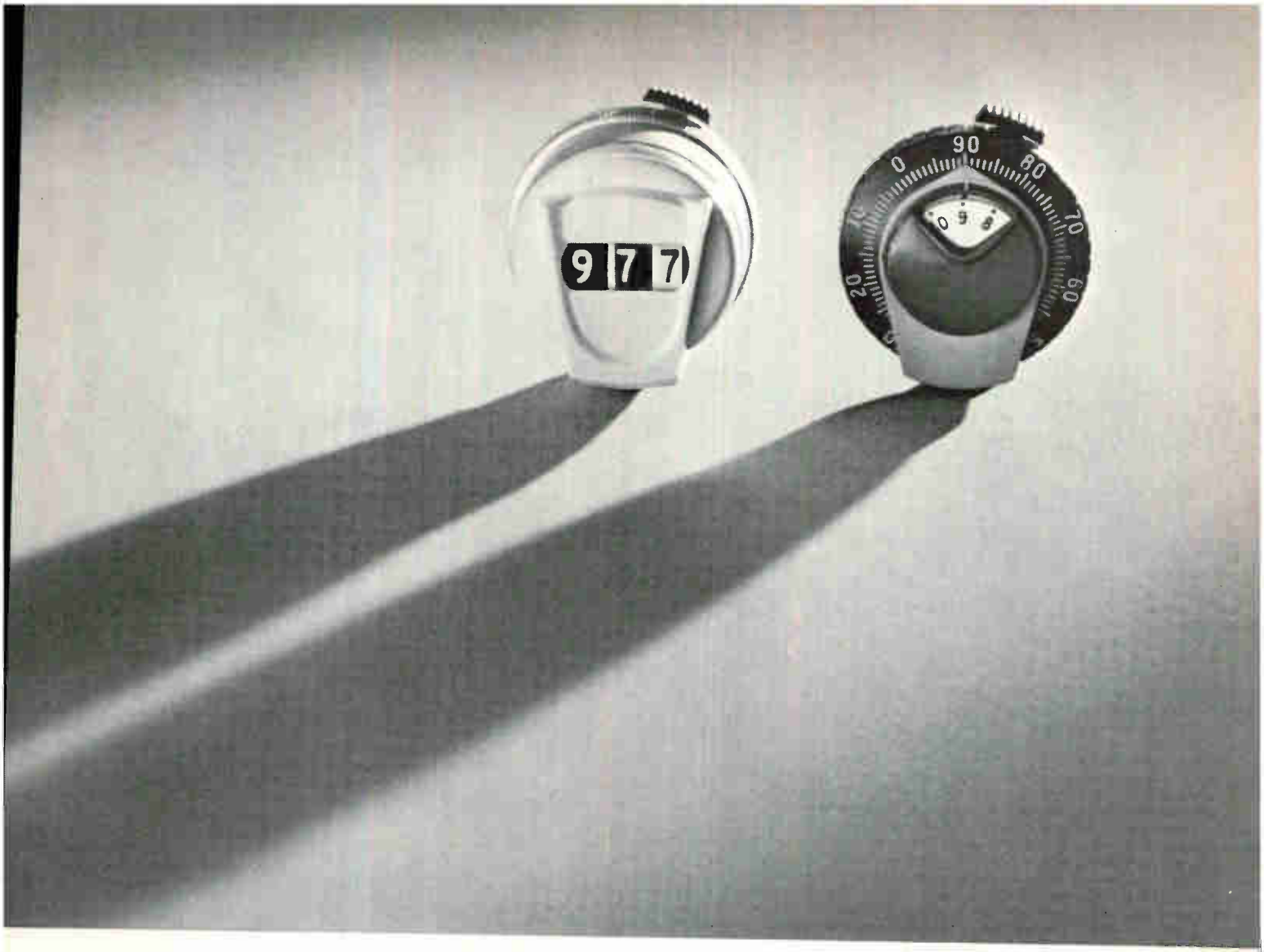

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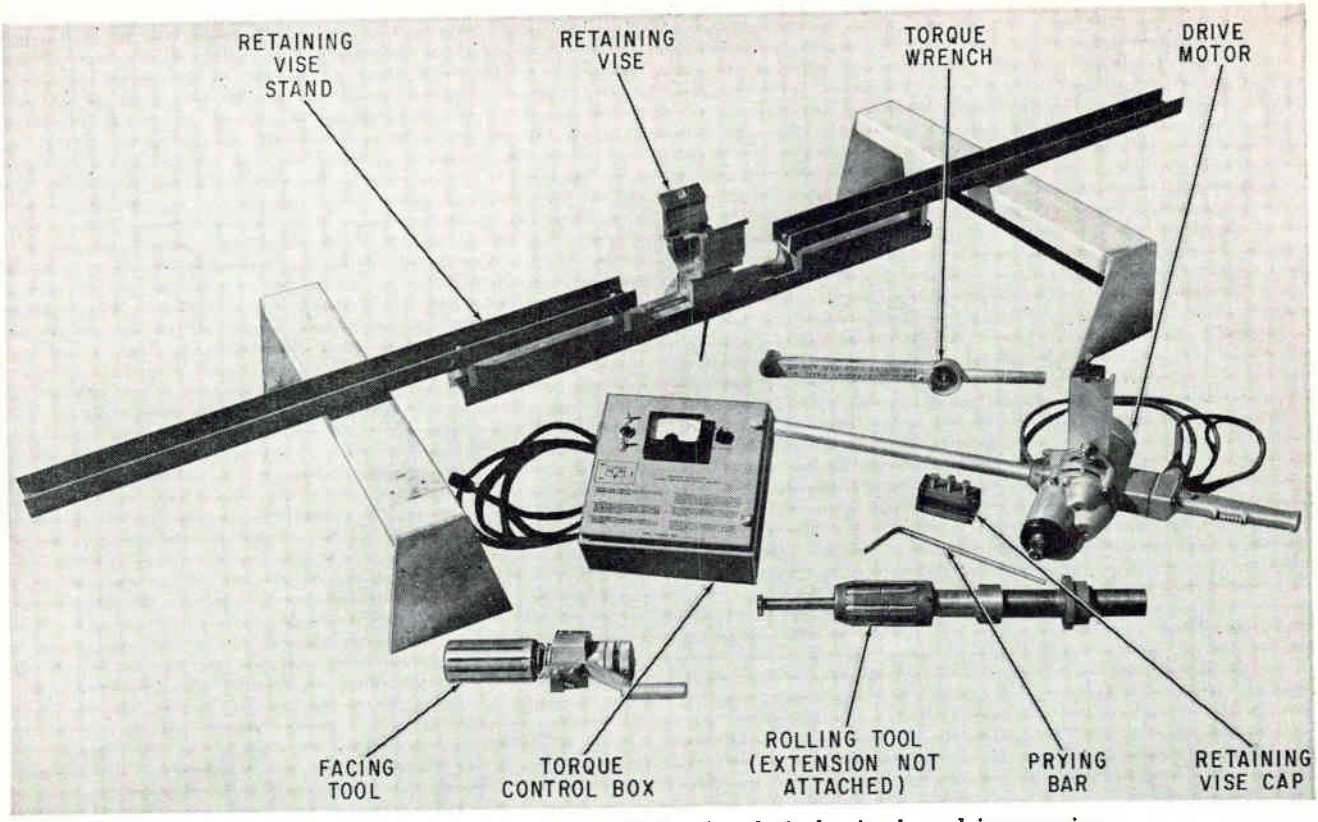


Equipment for making rolled joints in waveguide installation is relatively simple and inexpensive

Rolled Joints Reduce Waveguide Costs

By ROBERT A. ELMIGER*
Venetia, Pa.

WAVEGUIDE RUNS are the veins and arteries of the radio guidance and tracking system used to direct the Atlas ICBM to its target. Many of these waveguide runs are several thousand feet long and must be assembled in the field.

Flanged waveguide, whether rectangular or circular, must be prefabricated at the factory in various lengths. Special provisions must be made for shipment and storage to prevent denting or other damage to the waveguide, often at considerable expense. On the site, the sections are assembled by bolts or clamps with O rings for pressure seals at each joint.

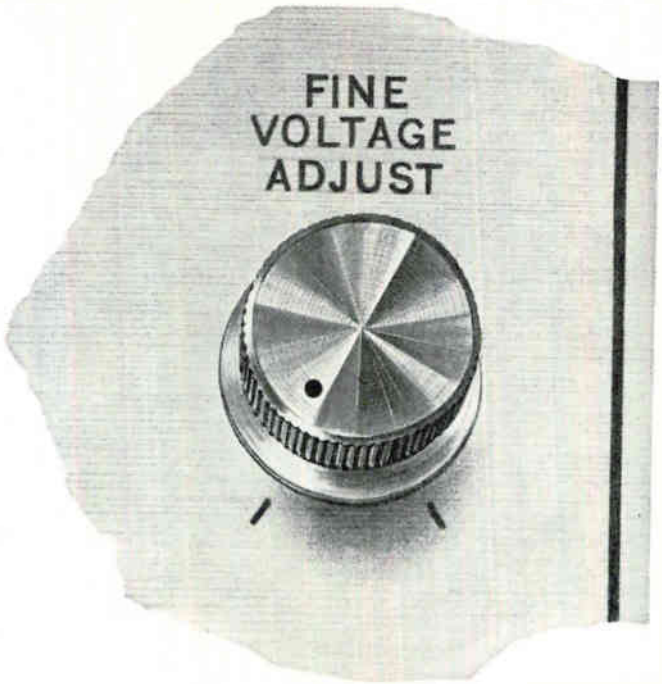
Welded waveguide eliminates pre-fabricating sections. Waveguide material is shipped to the site, where welding is done by specially trained field service personnel. Rectangular waveguide is welded manually; for circular waveguide, an automatic helium-arc welder was developed for field use. The depth of weld penetration, starting dwell time, and speed of torch are automatically controlled and adjustable.

The method being used presently is a mechanical connection, uses circular waveguide and is essentially a rolled joint. Sections of waveguide are butted together inside a stainless steel coupling sleeve. The joint is then rolled and expanded slightly from the inside by a special tool, and a strong, reliable leaktight joint, is formed by cold flow of waveguide metal into small ridges in the coupling. Tooling and procedures are similar to those in rolling tubes into boiler tube sheets. The pressure produced by rolling also helps align the butted sections of waveguide.

Raw waveguide, which is used in all methods, has dimensional tolerances that causes some mis-match. But mis-match is eliminated by the rolling and each joint is essentially a smooth transition between sections. No special experience is required to operate the equipment, and personnel can be trained to use it in 10 to 15 minutes. The rolling tool was developed for General Electric by G. Wiedeke Co.; connections can be made for straight runs only, but this is the bulk of the installation.

First the sections to be joined are faced and deburred with a facing tool similar to that used for preparing waveguide for welding. The pieces are then butted in the center of a machined coupling and the tool, with a 20 foot adjustable extension, is inserted. The tool is then operated either manually or by motor until a pre-set torque is reached, at which time it is automatically stopped. The motor is then reversed and the tool withdrawn. Depending on the torque used, the material, and wall thickness of the coupling, it is sometimes necessary to use a restraining vise around the cou-

*Formerly with General Electric Co., Syracuse, N. Y.



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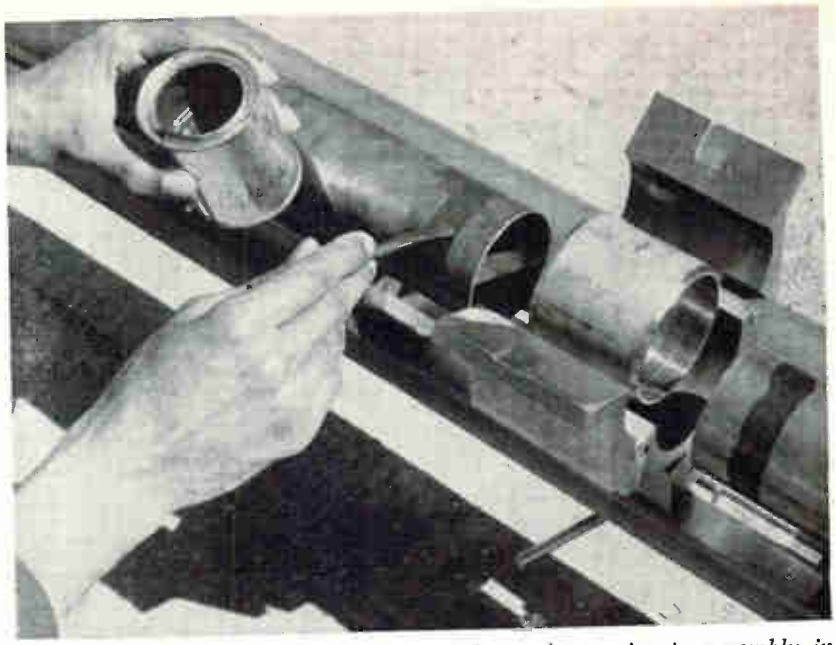

Sealing compound is applied to waveguide sections prior to assembly in grooved stainless steel coupling

pling to prevent excessive increase in diameter. The resulting joint is so smooth that the butting surfaces can hardly be seen. Upon completion of the run, a pressure drop test is made for leak tightness.

Circular waveguide is superior to rectangular in electrical loss characteristics and was used in these installations. The material is commercially hard drawn copper tubing; for welded waveguide, the copper must also be certified oxygen free. To compare physical strength, samples of each type of joint were pull-tested. At about 5,000 pounds pull on both flanged and welded samples, distortion began to occur at the annealed areas of the joints. Actual mechanical failure occurred at from 4,000 to 9,000 pounds for welded samples, and from about 8,000 to 10,000 pounds for flanged joints. Failures of rolled joints occurred between 14,000 and 18,000 pounds pull. These failures were in the waveguide itself where it was gripped in the pull machine. Where the waveguide did not break, failure of the rolled joint was considered to occur when it slipped in the coupling. At this failure point the guide is still intact, with a slight separation between the butted surfaces in the coupling. Electrical tests have shown that several such joints in a run have only a slight effect on attenuation.

In bend tests, in which the free end of a run is lifted several feet, and in jump tests, in which a man jumps on a coupling at the center of a 12 foot section supported at the ends, rolled joints did not fail but welded and flanged joints did. Field tests on welded and rolled joints showed no pressure loss over several weeks when checked at 10 psi. Experience has shown that with flanged joints, considerable leakage occurs, especially when the coupling is exposed to low temperatures that affect the O rings. Electrical checks showed that each method met specifications. Data taken for the rolled waveguide gave an average attenuation that approached theoretical values.

In actual field installation practice some useful comparisons can be made. Flanged joints provide relatively simple assembly but a good pressure seal requires considerable work and checking. Flanged joints also can be easily replaced.

In automatic welding, external

Rolling tool with extension is being inserted into waveguide section

Drive motor with control box

conditions of temperature, wind, dust, and moisture have varying effect on the equipment. Prior to operation, test welds are required. After welding it is difficult to determine weld quality. In addition, only oxygen-free copper tubing, at extra cost, gives satisfactory results. To repair the run, a section is cut out and a new piece welded in. Installation equipment for rolled joints is basically simple and little difficulty is experienced in field assembly. Up to now, no joint has failed pressure test and consequently pressure testing has not been a problem. To repair the run, the affected section must be cut out. Special flanged sections are rolled on if the repair is in the middle of the run, and the remainder of the section is assembled in the normal manner. Test repairs have been made in ½ hour.

Costs of field labor for each method of installation are comparable but overall costs of various installations differ widely. Material costs for welded and rolled installations are almost the same and the major cost difference is in the equipment required.

A complete welder costs approximately $15,000; comparable rolling equipment can be obtained for about $1,500. Figures comparing the rolling method with flanged guide show a saving of about $2.00 per foot of installation for the rolling technique. Waveguide assembled using the rolled method also can be buried underground but flanged and welded joints do not have sufficient strength for the stresses caused by temperature cycles. By burying the waveguide in the ground instead of running it in a trench on rollers as is now done, an estimated $5.00 per foot of run can be saved. Thus, both using rolling and burial, a substantial cost reduction is accomplished.

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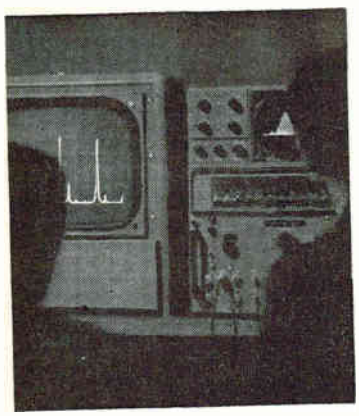

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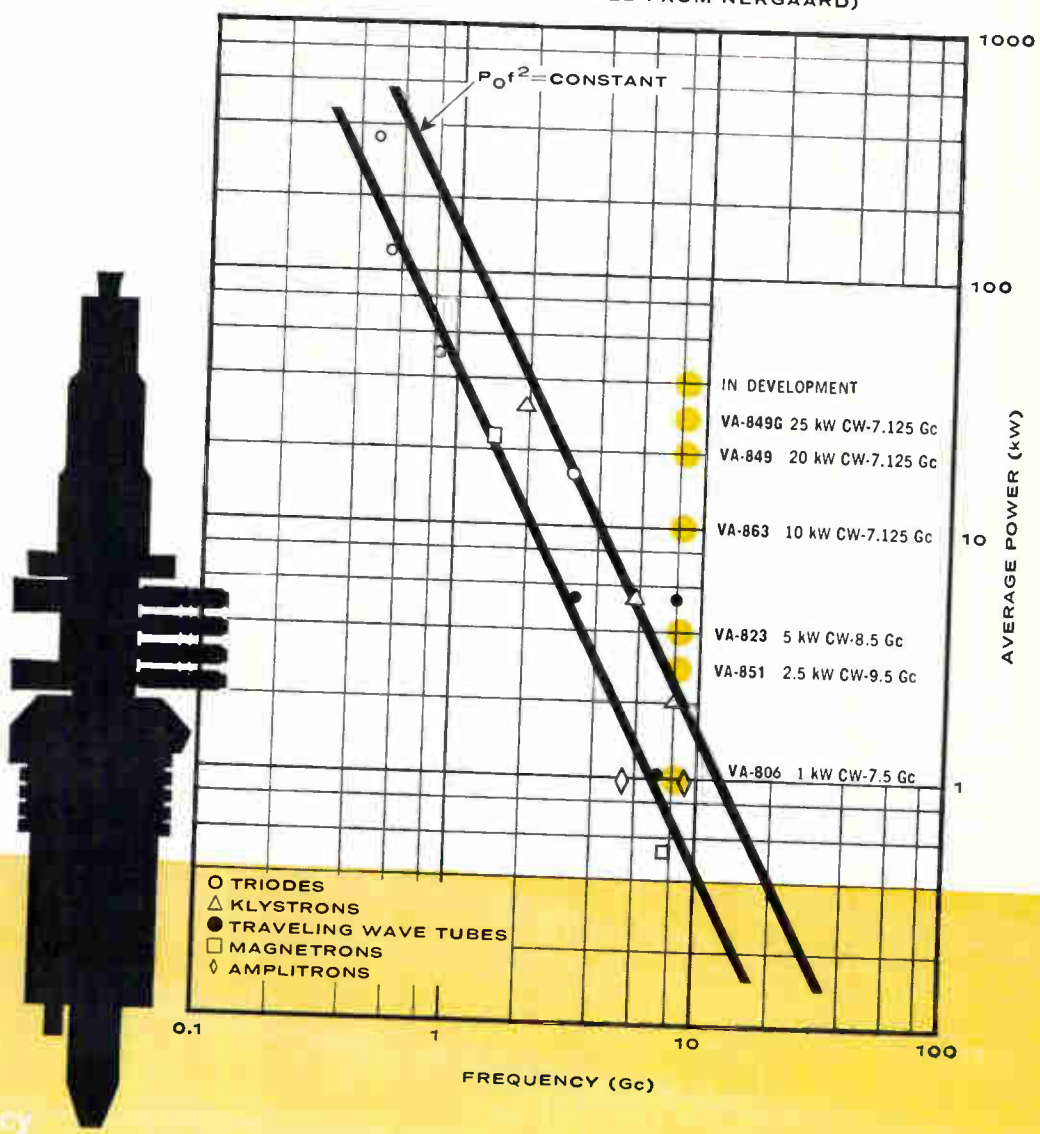
AVERAGE POWER OUTPUT AS A FUNCTION OF FREQUENCY FOR MICROWAVE TUBES. (MODIFIED FROM NERGAARD)



Power surveys by Nergaard,* plotting power output as a function of frequency for tubes of varying powers, predicted that maximum wattage available in X-band would be less than 10 kW CW.

Varian research indicates this figure to be extremely conservative. Varian's recent introduction of the VA-849 amplifier klystron provided the industry with a tube capable of developing 20 kW CW power at 7.125-8.5 Gc. A modified VA-849 developed 51.5 kW power in the laboratory, and is now available as the VA-849G, conservatively rated at 25 kW CW. Varian accomplishments do not stop there. The company is now developing an X-band tube rated at a *minimum* of 50 kW CW.

If *your* microwave project calls for such out-ahead capability in power tube development, write Tube Division. *L. S. Nergaard, RCA Review, Dec., 1960

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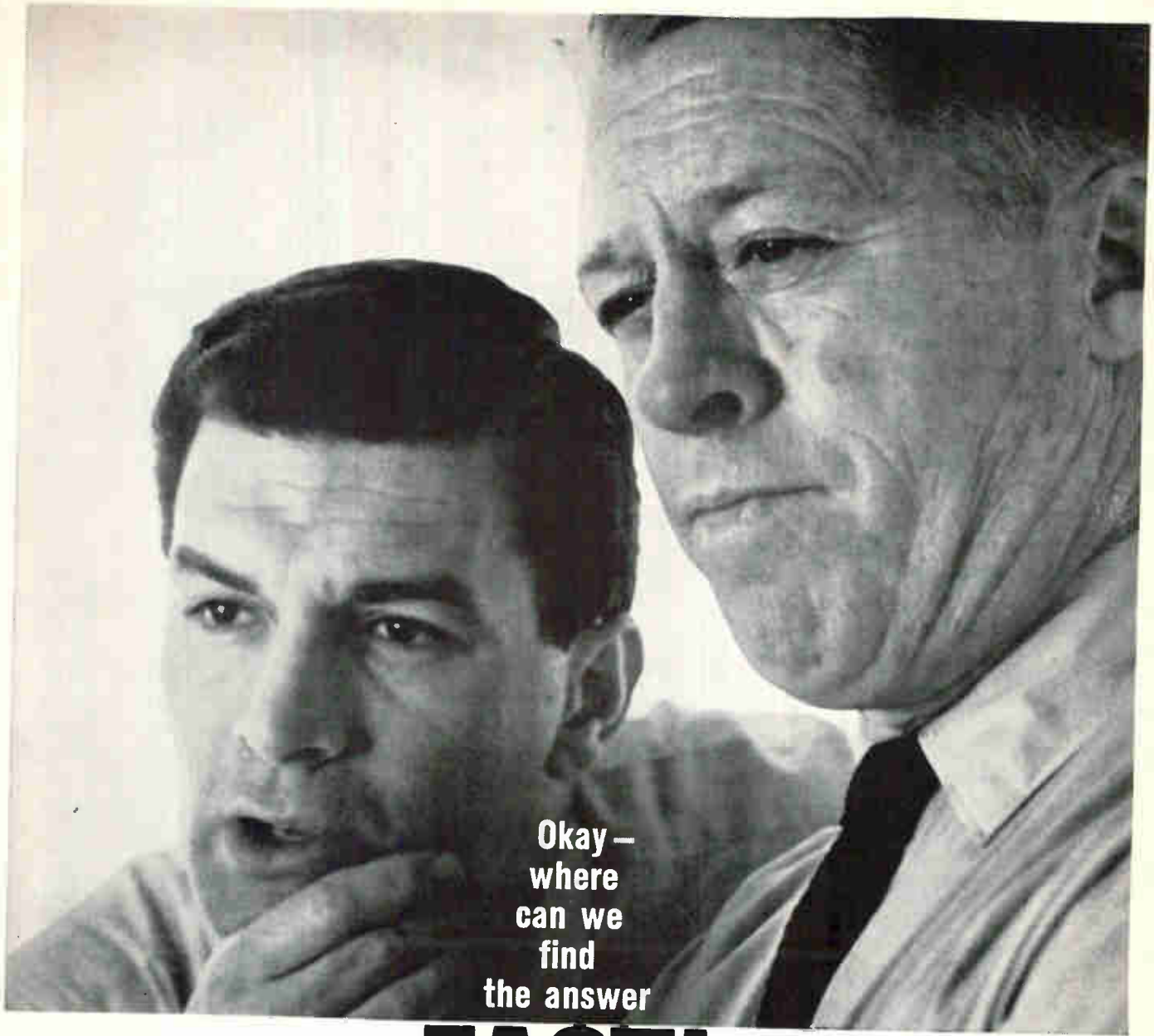
March 16, 1962

CIRCLE 95 ON READER SERVICE CARD 95



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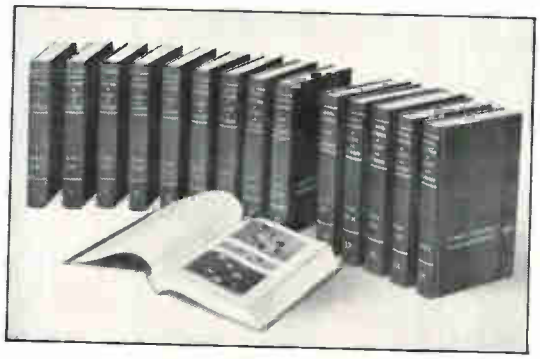
If you find it increasingly difficult to get the up-to-date, expert information you need when you need it—here is important news from McGraw-Hill. A new professional encyclopedia has been developed that gives you latest available information in the scientific and engineering disciplines, and keeps you abreast of the whole spectrum of today's exploding technology.

Short-Cut to Basic Information on Every Aspect of Every Field: For help with everyday problems met in your work—as an instrument to help you bridge the gap between your specialty and other fields into which your work leads you—as a backstop and "refresher" in your own and related areas—there is no substitute for this new ready-reference tool in encyclopedia-form. McGraw-Hill enlisted the support of 2,000 contributors, including Nobel Prize winners and leaders of research and industry, for this unprecedented and widely-acclaimed undertaking.



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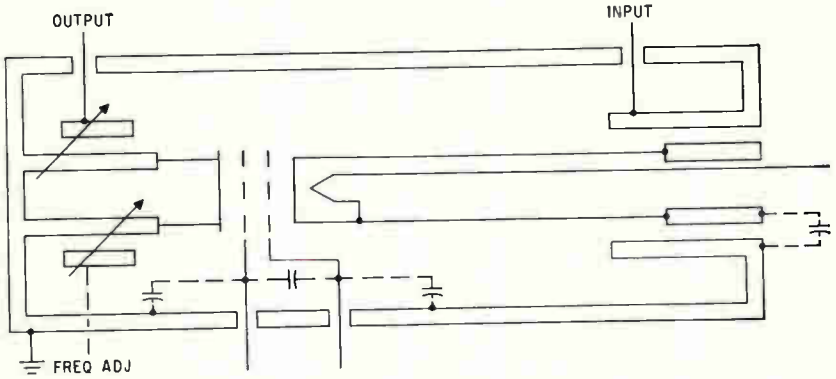
DESIGN AND APPLICATION

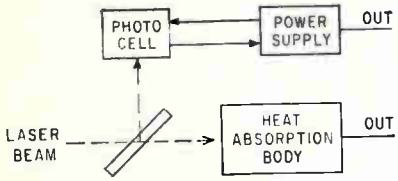


Distributed Constant R-F Module

150 WATTS IN 12 CUBIC INCHES

MICRODOT Inc., 220 Pasadena Avenue, South Pasadena, California, manufactures the Microdot power tetrode module averaging 12 cubic inches with power outputs up to 150 watts. The module features distributed-constant circuit components, weighs less than one pound and covers frequencies from 215 to 1,000 Mc. Special circuit layout effects rapid heat transfer to mounting surface. They can be used as power amplifiers or, frequency multipliers and are available either grounded-grid or grounded cathode.

CIRCLE 301 ON READER SERVICE CARD

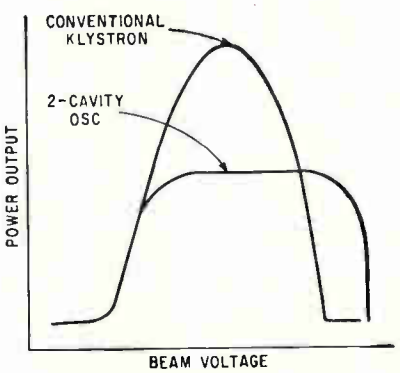


Laser Calorimeter

5-PERCENT ACCACCURACY

ANNOUNCED by Trion Instruments, Inc., 1200 North Main Street, Ann Arbor, Michigan, is the model M1-1 Calorimeter measuring total energy output as a black-body calorimeter and peak power with a photocell. The useful power range is 0.1 to 30 joules with the calorimeter and 0 to 20 Kw with the photocell. Accuracy is better than 5 percent and time resolution of the photocell is approximately 10^{-7} second. The nominal output is 10 μv per joule calorimeter and 100 mv per kilowatt photocell, the input aperture is 0.75 inch and the input range of wavelengths is 0.3 to 3.0 microns. The unit was designed to provide accurate pulsed laser output data and the low-level outputs may be read directly or recorded on strip charts.

CIRCLE 302 ON READER SERVICE CARD

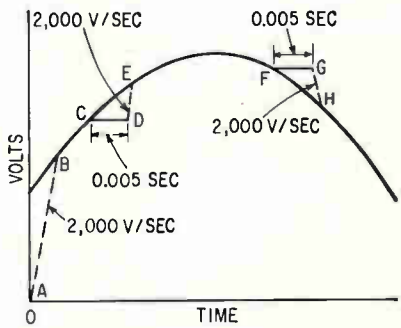


Two-Cavity Oscillator

PUMPS 10 AMPLIFIERS

OPERATING between 18 and 26.5 Gc, the new SOK family two-cavity oscillator made by Sperry Electronic Tube Division, Sperry Rand Corp., Gainsville, Florida, provides from 200 to 600 mw of power with a flat-top output curve. This oscillator will pump 10 or more parametric amplifiers such as used in phased array radar systems. The tubes are metal-ceramic construction and use electrostatic focussing. Cooling is by forced air and the weight is less than 8 oz. The two-cavity oscillator has lower beam voltage, higher output power, higher efficiency and lower a-m and f-m noise than a reflex tube. There is no reflector element and spurious shock modulation and vibration is reduced. Because of the flat-top output, variations in beam voltage produce negligible variation in output power. In many cases, pump levellers and afc circuits can be eliminated. The first member of the SOK family is the SOK-292 operating at 25 Gc, 600 mw output at beam voltage of 1,000 v, current of 35 ma, flat-top bandwidth (minimum) of 20 Mc and a modulation sensitivity (minimum) of 200 Kc per volt.

CIRCLE 303 ON READER SERVICE CARD

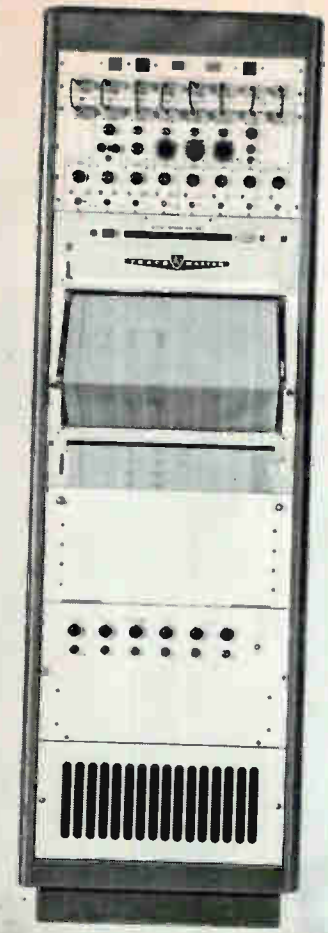


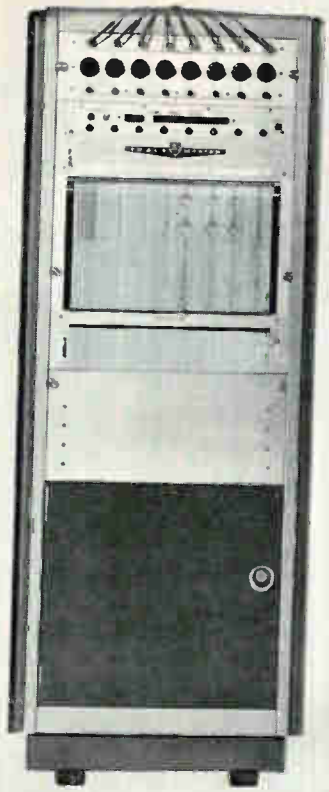
Digital Voltmeter

USES CLAMP AND HOLD

RECENTLY introduced by Non-Linear Systems Inc., P. O. Box 728, Del Mar, California is their NLS CH2 clamp and hold digital voltmeter that makes four digit measurements in ranges of ±9.999/99.99/999.9 v to an accuracy of

CIRCLE 101 ON READER SERVICE CARD→





	SERIES 250 TRACEMASTER 8-channel, Rack Cabinet on casters	SERIES 260 TRACEMASTER 8-channel, Rack Cabinet on casters	SERIES 290 TRACEMASTER Model 291 Single-channel; Portable	SERIES 290 TRACEMASTER Model 293 3-channel; Portable
FREQUENCY RESPONSE	DC to 110 cps. ± 1% at 40 mm. peak to peak. Down 3 db at 140 cps.	DC to 100 cps. ± 1% at 40 mm. peak to peak. Down 3 db. at 125 cps.	DC to 90 cps. ± 5% at 30 mm. peak to peak. Down 3 db at 125 cps.	DC to 90 cps. ± 5% at 30 mm. peak to peak. Down 3 db at 125 cps.
BAND AMPLITUDE PRODUCT	5600 (i.e. 40 mm. x 140 cps.)	5000 (i.e. 40 mm. x 125 cps.)	3750 (i.e. 30 mm. x 125 cps.)	3750 (i.e. 30 mm. x 125 cps.)
SENSITIVITY RANGE	10 Microvolts to 100 v/cm	100 mv/cm to 20 v/cm	50 mv/cm to 50 v/cm	50 mv/cm to 50 v/cm
CHART SPEEDS	0.2 to 500 mm/sec.	1 to 250 mm/sec.	1 to 100 mm/sec.	1 to 100 mm/sec.
CHART CAPACITY	1000 ft. roll	1000 ft. roll	200 ft. roll	200 ft. roll
WEIGHT			18 lbs.	40 lbs.

NOW... a Tracemaster System to meet your recording problem!

AO Tracemaster presents three outstanding direct-writing recorder systems to help you acquire more meaningful low-frequency data.

Series "250" — Ideal for test installations requiring a multi-channel record of diverse signal inputs on a common time base.
Series "260" — Economical recording of simpler, medium sensitivity inputs requiring many identical channels.
Series "290" — Single-, 2- or 3-channel portable Tracemasters; ruggedness and performance reliability in a compact package for those on-the-spot recordings in the lab, field or plant.

. . . And they all feature the advanced Tracemaster Pen Motor and the exclusive direct-carbon-transfer writing method . . . assuring a clean, uniform, high-contrast, fine-line trace that is two to three times finer than any other direct-writing technique.

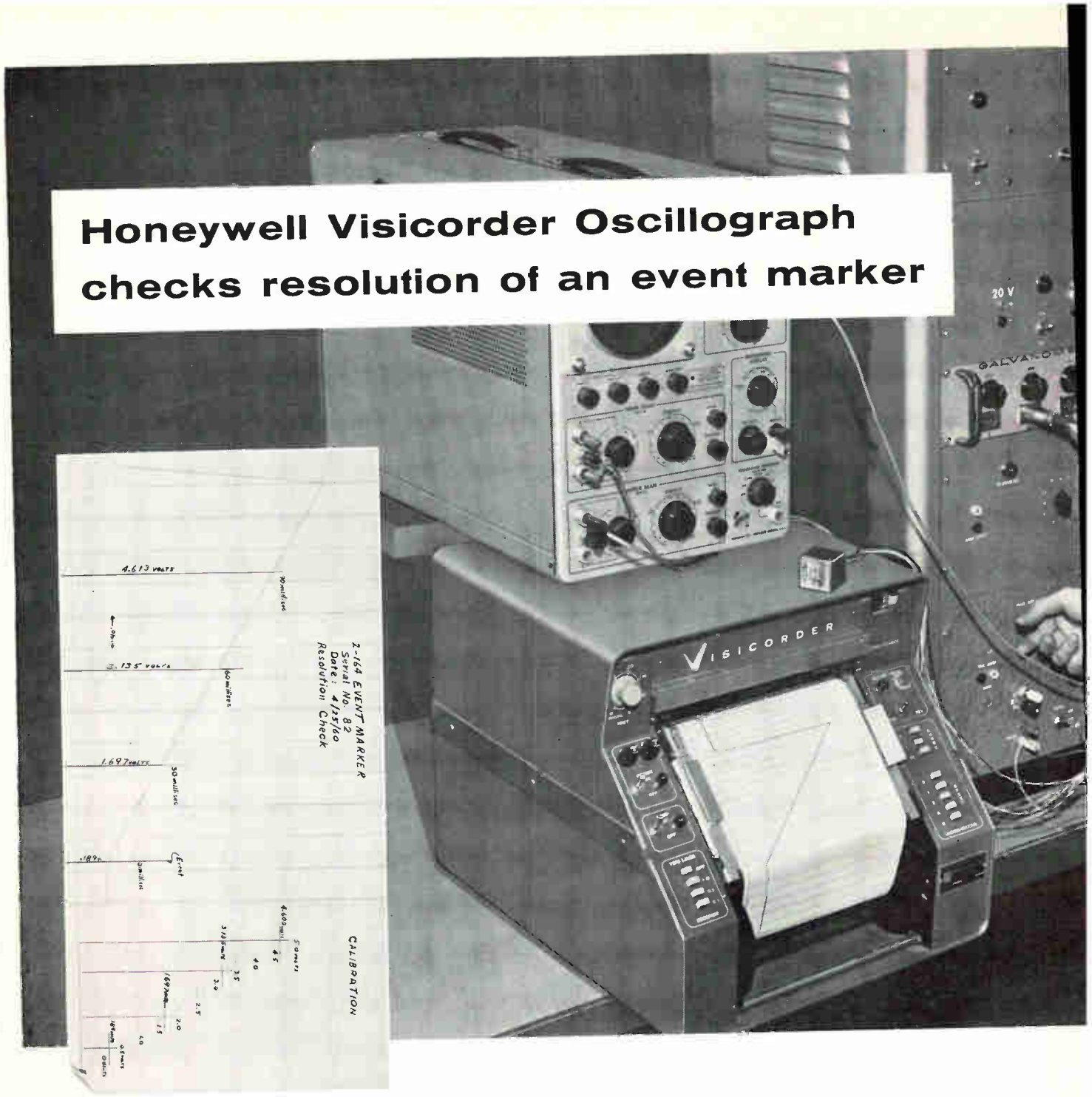
The important specifications above give only some of the many reasons why each system has established new standards of performance for direct-writing recorders in its class and price range. The complete story is yours for the asking . . . just write for the catalog!

American Optical
COMPANY
INSTRUMENT DIVISION, BUFFALO 15, NEW YORK

See a complete demonstration at the IRE . . . AO Booth 3939.

CIRCLE 101 ON READER SERVICE CARD

Honeywell Visicorder Oscillograph checks resolution of an event marker



Electro Development Corporation, Seattle, Wash., uses a Model 1108 Honeywell Visicorder Oscillograph to prove the linearity and resolution of signal conditioner-event markers which they supply to the Boeing Company.

A missile telemetering system samples each channel only once every 30 milliseconds, but missile engineers want to know when some events occur to an accuracy of better than one millisecond.

The event marker (the small cube atop the Visicorder) produces a highly-linear ramp output that starts exactly when the marker is triggered by the event in question. This ramp continues for about 100 milliseconds . . . enough time so that the telemeter system can sample the ramp at least three times. A straight line drawn through these points will accurately determine the occurence of the event.

To check event marker linearity, the ramp is recorded at the very high record speed of 80"/sec. It's this high speed, the .01-second timing lines, the ease of operation, and the wide deflection capabilities of Honeywell galvanometers (approx. 7" in this application) that caused the Electro Development Corporation to select the Model 1108 Honeywell Visicorder.

Honeywell

First in Control

electronics

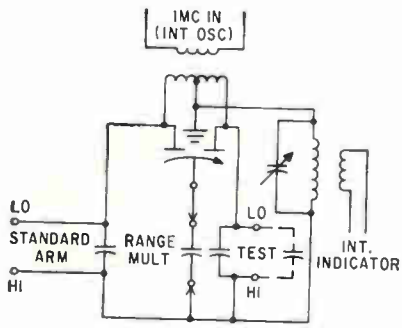
Dick Daniel, EDC Design Engineer, tests linearity of Model 2-164 event marker (small cube atop the Visicorder). Included in the rack at Daniel's right are a voltage calibrator, cathode follower, switching unit, trigger source and power 28V supply designed and built by EDC, and a Honeywell Model T6GA Galvanometer amplifier.

For more details about the Model 1108 (24 channels), the 1012 (36 channels) and other Honeywell Visicorders, write to Minneapolis-Honeywell, Heiland Division, 4800 E. Dry Creek Road, Denver 10, Colorado. Our DDD phone number is 303-794-4311.

CIRCLE 103 ON READER SERVICE CARD

±0.01 percent ±1 digit. When making single readings as an analog-to-digital converter, it has 0.01-percent accuracy, constant 10-megohm impedance, ±0.001 v to ±999.9 v range, 1 μsec maximum read trigger lag and infinitely high measurement speed. The sketch shows the influence of slewing rate when digitizing a voltage waveform. At point *A*, the input is connected to the voltage source and the device slews at 2,000 v/sec. until it reaches *B*. It then tracks the waveform faithfully since the waveform rate is less than 2,000 v/sec. At point *C*, a read trigger is issued and within 1 μsec (disconnect time), the unit disconnects from the waveform and measures the voltage at *C* in 5 ms. At point *D*, the unit again slews at 2,000 v/sec, until point *E*. It again tracks the waveform until point *F* where another read trigger is issued. The read triggers are initiated by the user.

CIRCLE 304 ON READER SERVICE CARD



Capacitance Bridge

0.00002 PF RESOLUTION

RECENTLY announced by Boonton Electronics Corp., 738 Speedwell Avenue, Morris Plains, New Jersey is the 75B capacitance bridge having a capacitance range from 0.00002 to 1,000 pF and a conductance range, calibrated in both conductance and parallel resistance, covering 0.01 to 1,000 μmhos and 1,000 ohms to 100 megohms. The unit also features a built-in d-c bias supply adjustable between 0 and −5 v and 0 to +125 v permitting measurements of component capacitance and conductance in the presence of d-c bias. Applications requiring use of bias include semiconductor junction capacitance and conductance, performance of voltage-variable capacitors and determination of voltage coefficient of capacitors. The circuit (shown in the sketch) is a modified Schering bridge. Coaxial connectors give access to both arms of the bridge allowing for differential measurements. Lowest range has 0.1 pF at full scale spread over 5,000 dial divisions. Bridge output transformer is tuned to 1 Mc to present lowest possible shunt loading of the output signal.

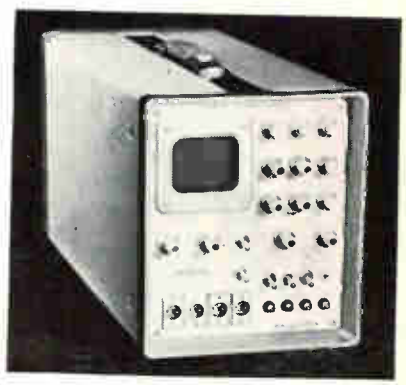
CIRCLE 305 ON READER SERVICE CARD

Coax Attenuators

TWO STANDARD VALUES

RLC ELECTRONICS, INC., 25 Martin Place, Port Chester, N. Y., offers variable coaxial attenuators with minimum insertion loss of zero db. Attenuation is essentially constant as a function of frequency with the required value selected by a linear dial movement. They are made in two standard values with direct reading settings in the AV-25 and linear settings in the AV-35. Units operate from 500 Mc to 11.0 Gc. Low vswr of 1.5 max is maintained by precision coaxial fabrication. Power rating, 2 w average; 2 Kw peak.

CIRCLE 306 ON READER SERVICE CARD



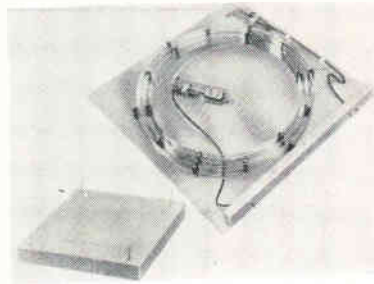
Digital Computer

MULTIPURPOSE

MNEMOTRON CORP., 45 S. Main St., Pearl River, N. Y. CAT400 is a portable, multipurpose digital computer for the study of biological and other variables. In addition to

averaging four different variables simultaneously, it serves a whole range of computing functions, such as: analog to digital conversion, recording fast wave forms, automatic plotting of digital data, statistical distribution of analog and events, and function generation.

CIRCLE 307 ON READER SERVICE CARD

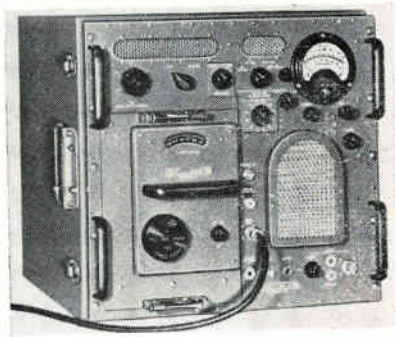


Delay Lines

MAGNETOSTRICTIVE

DELTIME INC., 608 Fayette Ave., Mamaroneck, N. Y. New magnetostrictive delay lines can be used as precise quantitative storage elements in memory systems. Units offer from 20 μsec to 10 millisec delay times, and 5 millisec delay to 1 Mc with return-to-zero. They are housed in steel cases, providing protection against stray magnetic fields and ambient humidity, resulting in long-term stability. Advances in design and materials have reduced delay drift due to temperature changes.

CIRCLE 308 ON READER SERVICE CARD



RFI Meter

EXTENDED RANGE

EMPIRE DEVICES, INC., Amsterdam, N. Y. Frequency range of noise and field intensity meter NF-112 has been extended to 15 Gc with the addition of new plug-in tuner model T-5/NF-112. The entire range from 1.0 to 15.0 Gc is now covered in a single instrument by means of

five plug-in tuning units, thus avoiding costly repetition of circuitry and components common to all frequency ranges. Tuning units can be interchanged in seconds.

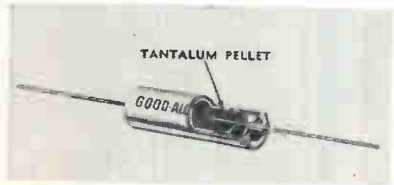
CIRCLE 309 ON READER SERVICE CARD

Slides

FOR MINIATURIZATION

GRANT PULLEY & HARDWARE CORP., High St., West Nyack, N. Y., offers a slide designed in keeping with trends toward miniaturizing and compressing equipment. The Micro-Slide features: ⅛ in. side space, load capacity of 100 lb, continuous ball bearing action, quick-disconnect, full extension of supported unit.

CIRCLE 310 ON READER SERVICE CARD

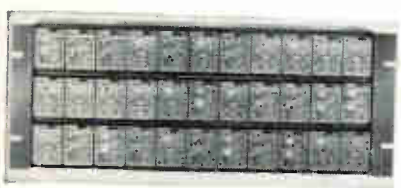


Tantalum Capacitor

SOLID, POLARIZED

GOOD-ALL ELECTRIC MFG. CO., Ogallala, Neb. Type 901 solid, polarized tantalum capacitor features superior leakage characteristic. Range: 0.0047 μf to 0.330 μf in 6, 10, 15, 20 and 35 v d-c. Case: 4 subminiature sizes per MIL-C-26655A.

CIRCLE 311 ON READER SERVICE CARD



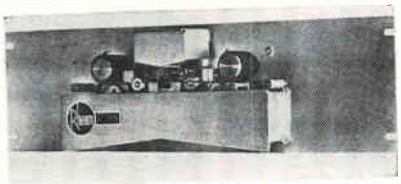
Logic Modules

PLUG-IN UNITS

HARMAN-KARDON, INC., Plainview, N. Y., announces Facilog digital logic modules designed for simple and economical systems interwiring. Each module is separately housed in a plug-in case, approximately 1½ in. by 1¾ in. by 3 in. deep and contains up to 4 separate logical functions, depending upon the complex-

ity of the circuit. Modules plug into a metal frame accommodating 33 modules. Frame may be mounted on a standard relay rack, 10 per 72 in. rack, accommodating up to 330 modules or a max of 1,320 circuits in a single rack.

CIRCLE 312 ON READER SERVICE CARD



Punched Tape Reader

HIGH SPEED

RHEEM MFG. CO., 5200 W. 104th St., Los Angeles, Calif. Model RR-1000 is nominally a 1,000 character per sec unit, and features completely transistorized circuits, photovoltaic sensing cells and rugged two speed motor drives. The unidirectional model is priced at $1,450; bidirectional model, $1,590. Standard model includes 2:1 speed ratio selectable with low level input, and 5, 7, and 8 level tape selection.

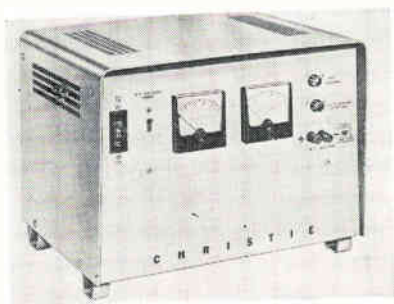
CIRCLE 313 ON READER SERVICE CARD

Sealed Connectors

STAINLESS STEEL

HERMETIC SEAL CORP., Rosemead, Calif. Series SS nonmagnetic hermetically sealed connectors meet all applicable military specifications. They have leak rates in production as low as 1 x 10^{-} cc/sec, with even tighter leak rates possible for special requirements.

CIRCLE 314 ON READER SERVICE CARD



D-C Power Supply

AND BATTERY CHARGER

CHRISTIE ELECTRIC CORP., 3410 W. 67th St., Los Angeles 43, Calif., introduces a line of wide-range d-c

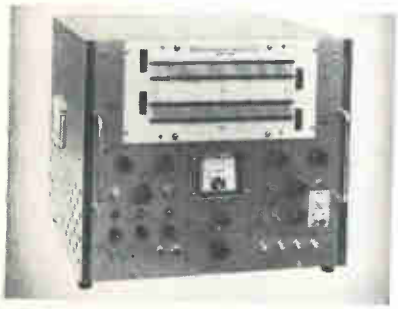
power supplies for laboratory, automatic battery charging or general purpose use. Six models offer a continuous voltage adjustment range of 1 to 145 v d-c and up to 50 amp. Standard a-c supply source required is 115 v, single phase, 60 cycle.

CIRCLE 315 ON READER SERVICE CARD

Packaged Circuits

CORNELL-DUBILIER ELECTRONICS, 50 Paris St., Newark, N. J. Line of low-cost digital computer packaged circuits has operating frequency range of d-c to 1 Mc with 0.2 μsec rise and fall time.

CIRCLE 316 ON READER SERVICE CARD

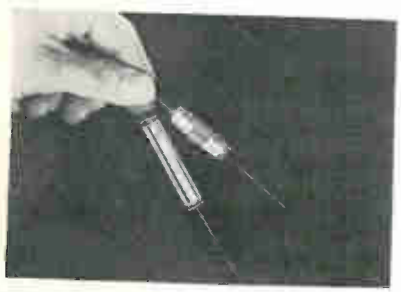


Swept Oscillators

FLAT OUTPUT

ALFRED ELECTRONICS, 3176 Porter Drive, Palo Alto, Calif., offers a series of swept microwave oscillators featuring built-in levelers which hold power output constant to approximately $\pm$0.75 db over the entire frequency range and nominally to $\pm$0.1 over any 100 Mc interval. The 620 B sweepers offer a frequency range from 1 to 26 Gc.

CIRCLE 317 ON READER SERVICE CARD



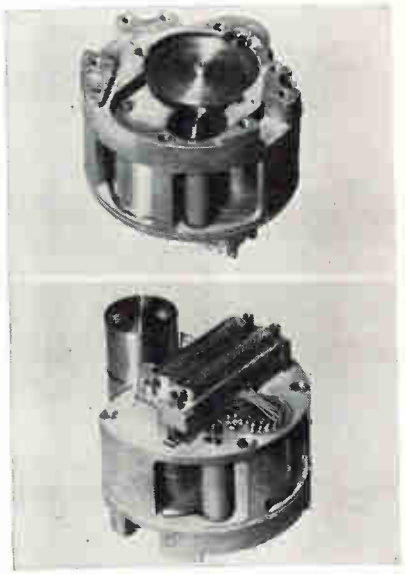
Capacitors

TANTALUM FOIL

INTERNATIONAL ELECTRONIC INDUSTRIES DIV., Standard Pressed Steel Co., Box 9036, Nashville, Tenn. New Super Series etched tantalum

foil capacitors possesses twice the capacity values, case size for case size, of MIL-C-3965/2 units. They are designed to operate over a temperature range of −55 C to 85 C. Voltage range is from 15 through 150 wvdc. Capacitances range from 30 μf to 1160 μf.

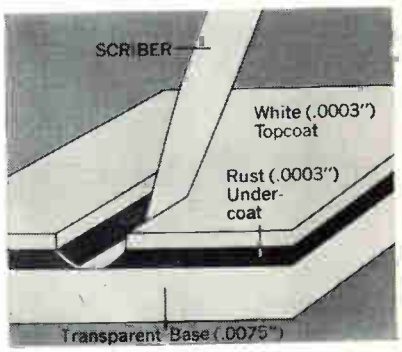
CIRCLE 318 ON READER SERVICE CARD



Tape Recorder
RUGGED UNIT

LEACH CORP., 18435 Susana Rd., Compton, Calif. Tape recorder features precision gear drive (photo above) and silicon rubber capstan (below) as mover for 75 ft of 1 mil Mylar tape. Temperature range (limitation is imposed by tape, not recorder) is −112F (−80 C) and +180 F (+82 C).

CIRCLE 319 ON READER SERVICE CARD

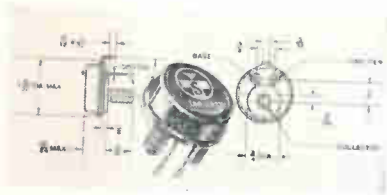


Scribe Coat Film
FOR P-C LAYOUTS

KEUFFEL & ESSER CO., Third and Adams St., Hoboken, N. J. New scribe coat film eliminates the necessity of using light tables in the scribing of printed circuit lay-

outs. It is a double coated film applied to a dimensionally stable base. The first is a rust colored film with high actinic holdback properties; the second is a white top coating for contrast and ease in doing linework.

CIRCLE 320 ON READER SERVICE CARD



Transistors

HIGH POWER

SILICON TRANSISTOR CORP., Carle Place, N. Y., announces four diffused junction silicon transistors—*npn* high power devices suitable for applications in power converters, power supply regulators, relay replacements and controls, and d-c and servo amplifiers. They are 150 w, single-end stud types, featuring low leakage currents, high temperature stability, and low thermal resistance.

CIRCLE 321 ON READER SERVICE CARD

Frequency Standard

MELPAR, INC., Falls Church, Va. Miniature tuning fork frequency standard gives sine waves and square waves with crystal precision.

CIRCLE 322 ON READER SERVICE CARD

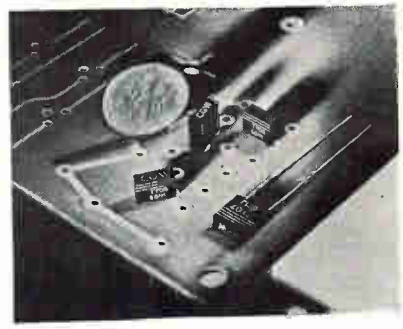
Data Recorder

BATTERY OPERATED

SONY CORP. OF AMERICA, 514 Broadway, New York 12, N. Y. Model PPW-22 spring powered two-chan-

nel analog data recorder/reproducer was designed primarily for acquisition of laboratory-quality data even under conditions of airborne, shipboard and vehicular uses. Complete unit (with battery case) weighs 60 lb and occupies less than 1.5 cu ft of space. It registers d-c to 100 cps data signals by means of pulse-width modulated recording, and reproduces the recorded signals into original form.

CIRCLE 323 ON READER SERVICE CARD



P-C Capacitors

GLASS DIELECTRIC

CORNING ELECTRONIC COMPONENTS, Bradford, Pa., has developed p-c glass dielectric capacitors that eliminate electrical shorts between components. They are equipped with radial leads, are encased in an insulating plastic shell. First units in the line are the TY-06 (1 to 560 pf) and the TY-07 (561 to 1,000 pf). Nominal dimensions of the TY-06 are 0.300 in. long, 0.115 in. wide, and 0.200 in. high. For the TY-07 they are the same except that height is 0.300 in. Operating temperatures are −55 to +125 C, with no derating, and dcvw is 300 v.

CIRCLE 324 ON READER SERVICE CARD

Audio Voltage Standard

PRECISION UNIT

HOLT INSTRUMENT LABORATORIES, Oconto, Wisc. Model 323 provides fully variable voltage from 10 mv to 1,000 v at 5 internal frequencies up to 10 Kc. Using an external oscillator 20 Kc may be obtained at

any voltage setting. Unit will calibrate instruments at any load from 0 to 30 w through its full frequency and voltage range. Short term stability 0.01 percent; long term stability 0.03 percent per month.

CIRCLE 325 ON READER SERVICE CARD

Shielded Console

MEETS MANY MIL SPECS

FALSTROM CO., 185 Falstrom Court, Passaic, N. J. Model C-100 is of heavy duty construction and is adaptable to a wide variety of uses. Panel mounting areas are provided inside both front and rear doors. A slide mounted utility driver is offered in either the front or rear. A slope front instrumentation panel, 17½ by 20 in., is provided in the front of the unit. Standard dimensions are: 58 in. high, 25 in. wide, and 23 in. deep.

CIRCLE 326 ON READER SERVICE CARD

Timing Module

SOLID STATE

HI-G, INC., Bradley Field, Windsor Locks, Conn., offers a solid state timing module, single-pole construction, for d-c operation, with delays on "make" only of 1 millisec to 30 sec or 1 millisec to 20 sec, as required, with a tolerance of ±10 percent over the temperature range. Input voltage 18-31 v d-c; output

250 ma resistive or inductive on normally open. Temperature −65 C to +125 C; vibration 20 g to 2,000 cps; shock 50 g for 11 ± 1 millisec; life 1 million operations minimum.

CIRCLE 327 ON READER SERVICE CARD

X-Y Recorder

BUILT-IN TIME BASE

HOUSTON INSTRUMENT CORP., P.O. Box 22234, Houston 27, Texas. Model HR-95T features high performance servos, interchangeable plug-in control modules, built-in time base on X axis and standard Zener reference supplies. Recorder utilizes conventional vacuum system for holding standard 8½ in. by 11 in. graph paper to platen. New snap-in pen design utilizes standard recorder ink cartridges to eliminate ink filling problems. D-C accuracy is greater than 0.25 percent full scale.

CIRCLE 328 ON READER SERVICE CARD

Low Noise Amplifier

TRANSISTORIZED

MILLIVAC INSTRUMENTS, INC., 1100 Altamont Ave., Schenectady, N. Y. New input configuration provides 50 meg, 50 pf input impedance in this battery-operated amplifier. Noise, with 50 meg input open or shorted, less than 3 μv with a bandpass of 10 Kc. Unit has other input impedances of 10,000 to 100,000

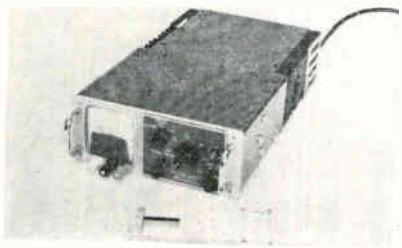
for use with lower source resistances. Upper and lower bandpass filters effectively reduce noise on unused band portions.

CIRCLE 329 ON READER SERVICE CARD

High-Energy Systems

YARDNEY ELECTRIC CORP., 40-50 Leonard St., New York 13, N. Y., announces high-energy electrochemical systems with a wide range of design possibilities—capacity ranging from 0.1 amp hr to 30,000 amp hr.

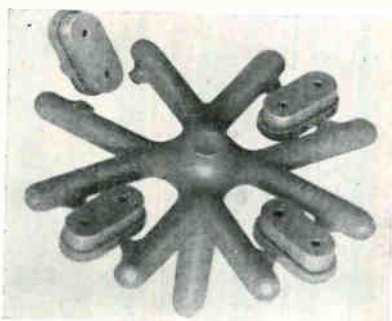
CIRCLE 330 ON READER SERVICE CARD



Power Supply
PROGRAMMABLE

ELECTRONIC RESEARCH ASSOCIATES, INC., 67 Factory Place, Cedar Grove, N. J. Model TR60-2 occupies a panel height of 3½ in. with a ½ rack 8⅝ in. panel length, yet provides highly regulated continuously adjustable output over the range 0-60 v d-c at 0-2 amp. Input is 105-125 v a-c, 60-1,000 cps; line or load regulation less than 0.005 percent, ripple less than 250 μv; temperature coefficient less than 0.01 percent per deg C; transient response better than 50 μsec.

CIRCLE 331 ON READER SERVICE CARD

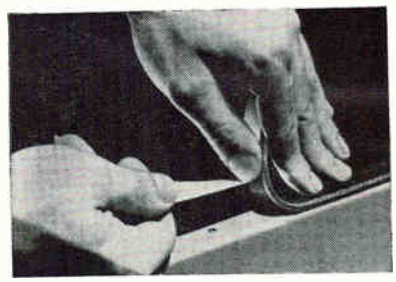


Alumina Ceramics
INJECTION MOLDED

DIAMONITE PRODUCTS MFG. CO., Shreve, Ohio. Injection mold proc-

ess enables the molding of parts from the same basic material usually used for powder pressing. This assures a high standard of quality, yet permits the manufacture of unusual designs that do not lend themselves to the normal powder pressing techniques. Illustrated on p 113 is a typical injection molded part in process as it comes from a multi-cavity die. Actual part being produced is shown disengaged from the sprue.

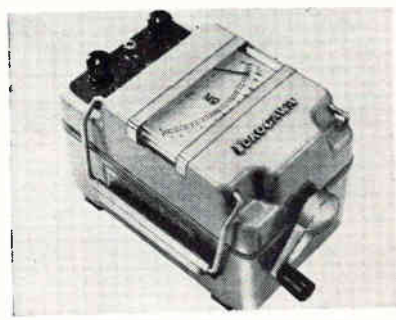
CIRCLE 332 ON READER SERVICE CARD



RFI Gasket
AND FLUID SEAL

TECHNICAL WIRE PRODUCTS, INC., 129 Dermody St., Cranford, N. J. Teckstik is a strip of Monel or aluminum knitted wire mesh integral with a fluid seal of neoprene or silicone, which is backed by pressure-sensitive adhesive material. Resilient and conductive, Teckstik is effective for re-establishing electrical continuity at the joints in all types of rfi shields, while sealing them off from fluids.

CIRCLE 333 ON READER SERVICE CARD



Insulation Tester
GOVERNORLESS

YOKOGAWA ELECTRIC WORKS, INC., 40 Worth St., New York 13, N. Y. Model L-5B is a 2 Kv/5000 megohm tester with no power source or carrying-cart required. In place of the mechanical control of rotation by the governor, the Zener character-

istics of silicon diodes is utilized. This makes reverse rotation possible, eliminates mechanical breakdown of governor and provides constant voltage. Ruggedized pivot-jeweled movement is sandwiched between silicon rubber beds. Entire moving part floats on neoprene shock absorbers. Price is $245.

CIRCLE 334 ON READER SERVICE CARD

Gear Clamps

TECH-OHM ELECTRONICS, INC., 36-11 33rd St., Long Island City 6, N. Y., introduces a line of standard stock miniature precision single and two piece balanced gear clamps.

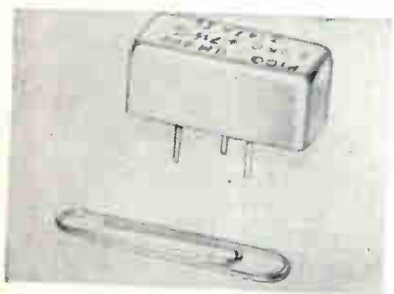
CIRCLE 335 ON READER SERVICE CARD

Potentiometers

PRECISION TRIMMERS

MECHATROL, a division of Servo mechanisms/Inc., 1200 Prospect Ave., Westbury, L. I., N. Y. For use in electrical circuits as a lead screw actuated two or three terminal variable resistance network, the new deposited metal film precision trimmer potentiometers feature a low temperature coefficient of resistance with infinite resolution available at competitive prices.

CIRCLE 336 ON READER SERVICE CARD



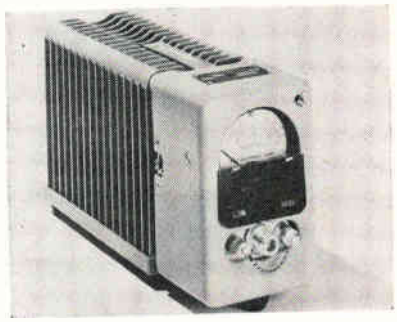
Telemetering Filter

ULTRAMINIATURE

POLYPHASE INSTRUMENT CO., East Fourth St., Bridgeport, Pa. All standard IRIG telemetering channels are covered by a new 1/8 in. by

½ in. by 1/16 in. electrical wave filter. It occupies 0.25 cu in., weighs 9.5 grams, and has p-c mounting. Model 75 B-F is a band pass filter for channels 3.9 Gc and up, and a low pass filter for channels 400 cps through 3 Kc. Impedance 47,000 ohms.

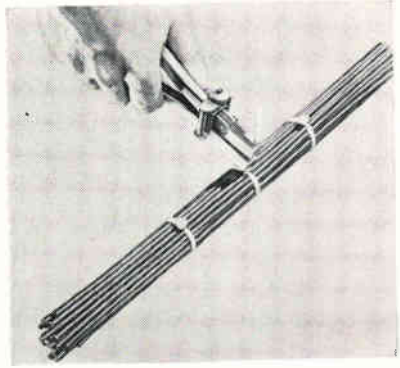
CIRCLE 337 ON READER SERVICE CARD



R-F Wattmeter
PORTABLE UNIT

BIRD ELECTRONIC CORP., 30303 Aurora Rd., Cleveland 39, O. Model 6150 Termaline r-f wattmeter is a termination type absorption instrument having selectable dual power ranges of 0-30/0-150 w. Power values are read directly over the frequency range of 30-500 Mc. VSWR is 1.1 max. Input connector is female type N. Price, $225.

CIRCLE 338 ON READER SERVICE CARD



Cable Ties
SAVE TIME, LABOR

PANDUIT CORP., 17301 Ridgeland Ave., Tinley Park, Ill., introduces a new concept in permanent cable ties—the Sta-Strap. The line combines self-locking Nylon cable ties and clamps with a tensioning tool that automatically cuts off excess strap at a pre-set tension. The result is a big reduction in cabling time and labor with controlled, uniform tie tension.

CIRCLE 339 ON READER SERVICE CARD

March 16, 1962

PRODUCT BRIEFS

ALUMINUM SOLDER corrosion resistant material. Scientific Products, Inc., 521 Marylyn Ave., State College, Pa. (340)

PHOTOCONDUCTOR CELLS cadmium sulphide. Sylvania Electric Products Inc., 730 Third Ave., New York 17, N. Y. (341)

CLUTCH DEVICES ¾ in. diameter. Fae Instrument Corp., 16 Norden Lane, Huntington, L. I., N. Y. (342)

X-BAND MAGNETRON low voltage. Avnet Instrument Corp., 70 State St., Westbury, N. Y. (343)

VOLTAGE REFERENCE 0.025 percent accurate. Electronic Development Corp., 423 W. Broadway, Boston 27, Mass. (344)

FREQUENCY STANDARD 4.999600 Kc. Reeves-Hoffman Division, Cherry and North St., Carlisle, Pa. (345)

DATA TRANSMISSION SYSTEM no multiplexing. Security Devices Laboratory, Rochester 21, N. Y. (346)

SENSITIVE MICROPHONE 0.025-1 cps. The Geotechnical Corp., 3401 Shiloh Road, Garland, Texas. (347)

TRANSISTORS hermetically sealed. Hermetic Seal Corp., Rosemead, Calif. (348)

MICROWAVE SWITCH vswr max 1.08:1. Waveguide, Inc., 851 W. 18th, Costa Mesa, Calif. (349)

RFI FILTER for airborne cameras. Astron Corp., 255 Grant Ave., East Newark, N. J. (350)

P-C PLUGS meet MIL C-21097. Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif. (351)

FOLLOWER INVERTER d-c to sine wave. Arnold Magnetics Corp., 6050 W. Jefferson Blvd., Los Angeles 16, Calif. (352)

INSTRUMENTATION POWER SUPPLY 1½ in. cu. Vector Mfg. Co., Inc., Southampton, Pa. (353)

MINIATURIZED FILM RESISTOR metal oxide. Corning Electronic Components, Bradford, Pa. (354)

DELAY LINES ultrafast rise time. Ad-Yu Electronics Lab., Inc., 249 Terhune Ave., Passaic, N. J. (355)

Literature of

FILTERS Kenyon Transformer Co., 1057 Summit Ave., Jersey City, N.J. Catalog F-621 fully describes the company's standard lines of telemetering, tone channel, and interstage filters. **(356)**

WIREWOUND RESISTORS Kelvin Electric Co., 5907 Noble Ave., Van Nuys, Calif. Catalog P-1 describes encapsulated precision resistors for p-c high density packaging. **(357)**

DIGITAL TRANSDUCERS Diginamics Corp., 2525 E. Franklin Ave., Minneapolis 6, Minn. An 8-page pamphlet of application notes is entitled "What? Why? How? Digital Transducers." **(358)**

TIMERS Logitek, Inc., 54 Rome St., Farmingdale, L. I., N. Y., offers a 4-page brochure on static time delays and time delay relay modules. **(359)**

D-C VOLTAGE REGULATORS Taber Instrument Corp., 107 Goundry St., North Tonawanda, N. Y., has available bulletin on miniature d-c voltage regulators. **(360)**

METALLIZED CERAMIC BASES Advanced Vacuum Products, Inc., 440 Fairfield Ave., Stamford, Conn., has issued a bulletin on high-temperature ceramic-to-metal bases for semiconductors. **(361)**

INSTRUMENTS & COMPONENTS Alford Mfg. Co., 299 Atlantic Ave., Boston 10, Mass. Catalog describes company's r-f instruments and coaxial components. **(362)**

PHYSIOLOGICAL STIMULATOR Theratron Corp., 1821 University Ave., St. Paul 4, Minn. Brochure illustrates and describes the Theratron physiological stimulator for nerve identification in surgery. **(363)**

CRYSTAL CAN RELAYS C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Ill. Type F subminiature crystal can relay is described in a 12-page booklet. **(364)**

ENERGY DATA BOOK Yardney Electric Corp., 40-50 Leonard St., New York 13, N. Y., has available a special energy data book for design engineers. **(365)**

POWER TETRODES Calvert Electronics, Inc., 220 E. 23rd St., New York 10, N. Y., has available a

the Week

catalog containing data on two high frequency power tetrodes. **(366)**

WIREWOUND RESISTORS General Instrument Semiconductor Division, 96 Mill St., Woonsocket, R. I. Bulletin GR-40 describes and illustrates bobbinless precision wirewound resistors. **(367)**

INDICATOR TRIODE Tung-Sol Electric Inc., One Summer Ave., Newark 4, N.J., offers an information guide on the type 6977 indicator triode. **(368)**

ULTRASONIC MACHINING Raytheon Co., 225 Crescent St., Waltham 54, Mass., has published a brochure on ultrasonic machining. **(369)**

CORE MEMORY UNIT Ampex Computer Products Co., 9937 Jefferson Blvd., Culver City, Calif. Eight-page brochure describes the RQL core memory unit. **(370)**

RESISTORS Film Resistors Inc., 242 Ridgedale Ave., Morristown, N. J. Bulletin 12A covers a line of coaxial termination type carbon and metal film resistors. **(371)**

FERRITE BEAD CHOKES National Radio Co., Melrose 76, Mass. Data sheet CO-4 covers newly developed ferrite bead chokes. **(372)**

CLUTCHES AND BRAKES Vibrac Corp., 281 Billerica Rd., Chelmsford, Mass., offers a catalog on a line of magnetic dry particle clutches and brakes. **(373)**

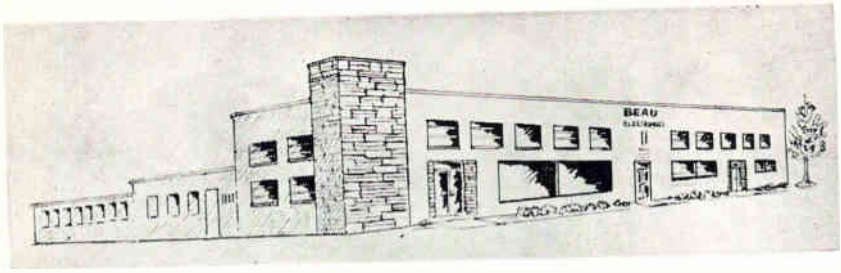
TRANSMISSION LINE SYSTEMS Prodelin, Inc., Hightstown, N. J. Bulletin describes methods for pressurizing coaxial transmission line systems. **(374)**

SEALED CELLS Sonotone Corp., Elmsford, N. Y. Technical data catalog covers a line of miniature sintered-plate, nickel-cadmium sealed cells. **(375)**

HARMONIC GENERATORS PRD Electronics, Inc., 202 Tillary St., Brooklyn 1, N. Y. Technical data sheet discusses varactor harmonic generators. **(376)**

MOLDING COMPOUNDS Dow Corning Corp., Midland, Mich. A 4-page data sheet lists characteristics of 12 different silicone molding components. **(377)**

CIRCLE 121 ON READER SERVICE CARD→



Beau Electronics Opens New Plant

BEAU ELECTRONICS, INC., of Waterbury, Conn., has occupied a new, two-story plant, tripling manufacturing facilities.

Sections of the first floor will be used for winding, grinding and varnishing operations, assembly of mass production items, precision testing and storage of finished and raw stock. Individual locations are designed to streamline production flow.

The second floor will contain air-conditioned offices for management, purchasing, sales, accounting and engineering.

Richard J. Beaulieu, president, said the new plant was needed to meet a rapidly increasing sales backlog. The company, which started in 1958 with two employes, makes hysteresis motors, precision recorders, and instrument and data process controls.

R&D activities will also be expanded. Beau recently developed a tape deck transport designed to use its motors. Flutter at 7.5 ips is 0.07 percent, the company says. The motors have a rotor outside the stator. The motor ring acts as a permanent magnet and the poles shift as frequency varies. The company claims improved torque and stability, due to increased moment of inertia.

Granger Associates Promotes Phelps

JOHN M. PHELPS, Captain USN (Ret.) has been named vice president-operations of Granger Associates, Palo Alto, Calif., with overall responsibility for manufacturing, supply, quality assurance and field services.

Phelps joined the communications equipment firm last November as assistant to the president, John V. N. Granger.

Custom Components Elects Olerud

ROY A. OLERUD has been elected president of Custom Components, Inc., of Caldwell, N. J. Company supplies ferrite and powdered iron magnetic materials to the electronic and electrical industries.

Olerud, who formerly held executive positions with ITT Corp. and Allen B. DuMont Laboratories, replaces Harold I. Danziger, founder of the firm. Danziger will continue as chief executive officer, directing the growth and expansion activities of the corporation.

Kremer Moves Up At Sylvania

MERLE W. KREMER has been elected a senior vice president of Sylvania Electric Products Inc., with responsibility for the company's Electronic Tube and Parts Divisions.

Kremer, who previously was a divisional vice president, is located at headquarters of the Electronic Tube Division in Emporium, Pa.

Potter Instrument Hires Landman

BERNARD S. LANDMAN has joined Potter Instrument Co., Inc., Plainview, L. I., N. Y., as project engineer for the systems department.

He comes to Potter from PRD Electronics, Inc., Brooklyn, N. Y.

Sprague Names Korli Inet Division Head

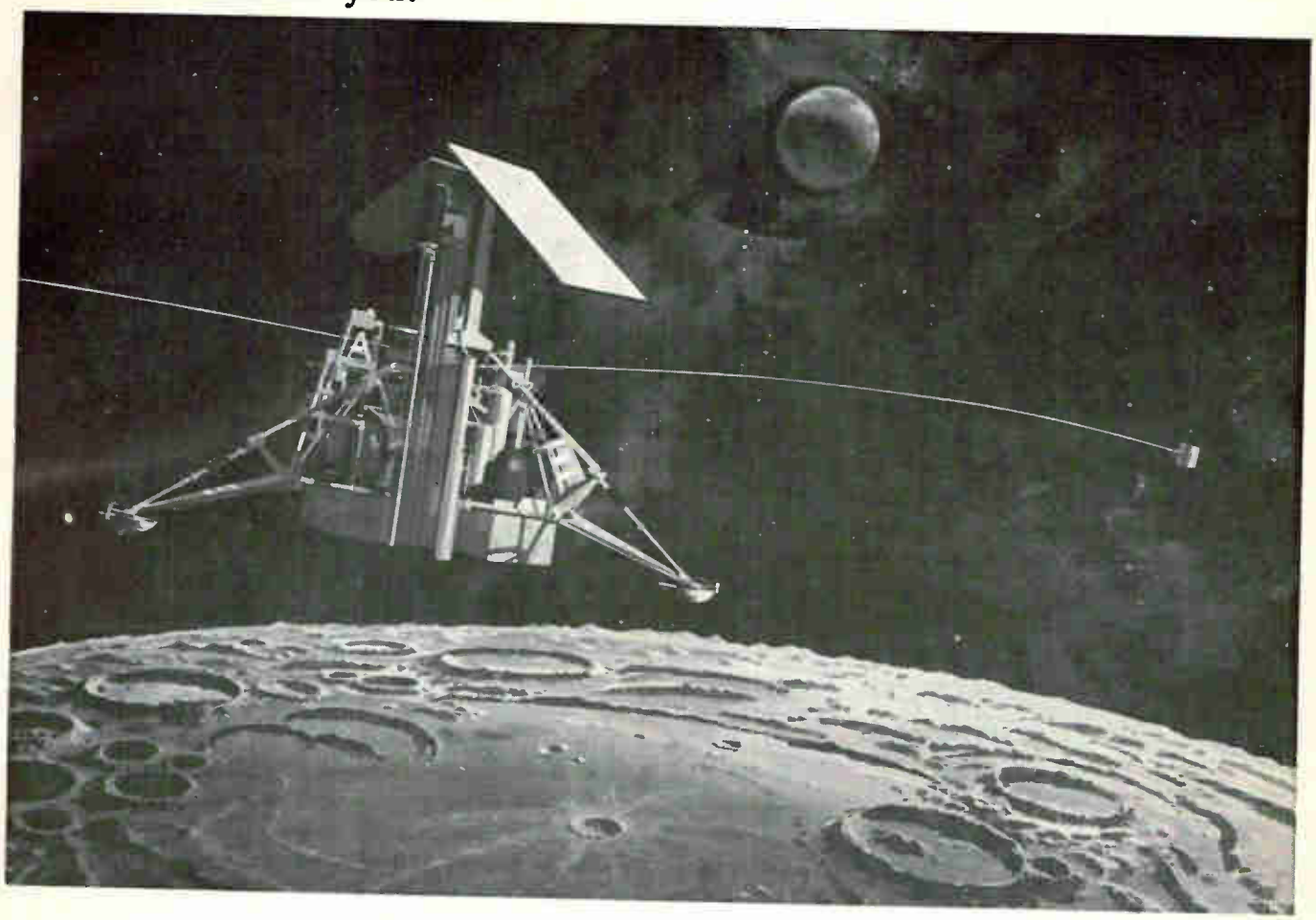
WILLIAM D. KORLI has been appointed vice president and general manager of Sprague Engineering Corp.'s newly acquired Inet Division in Compton, Calif.

Korli was formerly Pacific Division manager of Kurz & Root Co., Inc., Appleton, Wis.

Thompson Joins Microtech

MICROTECH, INC., Cheshire, Conn., announces the appointment of George Thompson as vice president and general manager of the com-

Problem for you:



Soft land this vehicle on the moon

This spacecraft is SURVEYOR, one of the many important projects now under way at Hughes. It will "soft" land on the moon sometime in 1963. Its mission: to pierce and analyze the moon's surface; to transmit back to earth high quality television pictures; and to measure the moon's magnetic and radiation characteristics. To accomplish these demanding objectives, Project Surveyor requires the talents of many imaginative junior and senior engineers and physicists to augment its outstanding staff. A degree from an accredited university and U.S. citizenship are required. Experience in Aerospace Vehicles is preferred but not necessary. A few of the openings include:

CONTROLS ENGINEERS. Concerns airborne computers and other controls related areas for: missiles and space vehicles, satellites, radar tracking, control circuitry, control systems, control techniques, transistorized equalization networks and control servomechanisms.

CIRCUIT DESIGNERS. Involves analysis and synthesis of systems for: telemetering and command circuits for space vehicles, high efficiency power supplies for airborne and space electronic systems, space command, space television, guidance and control systems, and many others.

INFRARED SPECIALISTS. To perform systems analysis and preliminary design in infrared activities for satellite detection and identification, air-to-air missiles, AICBM, infrared range measurement, air-to-air detection search sets, optical systems, detection cryogenics and others.

SYSTEMS ANALYSTS. To consider such basic problems as: requirements of manned space flight; automatic target recognition requirements for unmanned satellites or high speed strike reconnaissance systems; IR systems requirements for ballistic missile defense. Inquire today. Please airmail your resume to:

Mr. Robert A. Martin,
Supervisor of Scientific Employment,
Hughes Aerospace Divisions,
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We promise a reply within one week.

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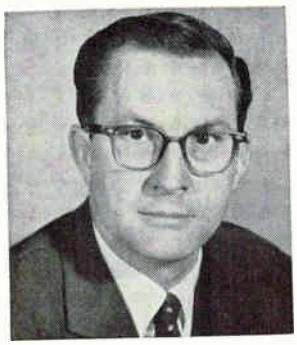
pany. He will assume full charge of all operations of the firm, which is a subsidiary of Talley Industries, Inc., of Mesa, Ariz.

Thompson joins Microtech after more than ten years of service as manager of the Airtron Division of Litton Industries, in Linden, N. J.



Brayshaw Announces New Company

BRAYSHAW ELECTRONICS, INC., recently opened offices and plant at Olivia Street, McKees Rocks, Pa. The new corporation will manufacture selenium rectifiers, silicon rectifiers and other semiconductors and components.

President of the firm is Stanier E. Brayshaw who formerly was manager, semiconductor products R&D at Syntron Corp.

Dickson Electronics Appoints Jones

ROBERT L. JONES has been named production manager for Dickson Electronics Corp., Scottsdale, Ariz.

Dickson Electronics manufactures a line of Zener diodes, reference diodes, and high voltage rectifiers for the electronics industry.

Immediately prior to joining the company, Jones was production manager for silicon alloy and mesa

transistors at Hughes Semiconductor Division.

Wilson Assumes U. S. Sonics Post

U. S. SONICS CORP., Cambridge, Mass., recently named Robert D. Wilson to the new post of director of engineering.

Prior to this appointment, Wilson was manager of research and development administration for the Raytheon Co., and before this, was manager of the advanced development laboratory of the Raytheon Industrial Components division.

PEOPLE IN BRIEF

William T. Thomas leaves Princeton U. faculty to become director of R&D at Induction Heating Corp. **John Heaviside,** formerly with Fairchild Astrionics, appointed product development mgr. by North Atlantic Industries, Inc. **Henry L. Herold,** previously with Hughes Aircraft Co., named computer engineering mgr. for Scientific Data Systems, Inc. **Jan A. Narud,** from IBM Research Center, to Motorola Semiconductor Products as mgr. of circuits research. **Joseph M. Chirnitch,** ex-MB Electronics Co. and Lessells & Associates, takes post of product line mgr.-spectrum analyzers at Spectran Electronics Corp. **Albert Haselman** promoted to executive v-p of Prodelin, Inc. **Eugene C. Frost** moves up to director of quality and reliability assurance at Lockheed-California Co. **Lyle R. Groberg** advances to chief engineer, government products engineering, for Lenkurt Electric Co., Inc. **Ralph M. Wight,** v-p of Litton Industries, elected to board of dlirectors of Magnasync Corp. **John Layport,** formerly with Raytheon, named plant engineer for the Alberox Corp. **Bruno O. Weinschel,** head of Weinschel Engineering, named to the Public Advisory Committee on Air Force Calibration. **R. C. Chase,** v-p and g-m, Spectrol Electronics Corp., elected president of the Precision Potentiometer Manufacturers Association. **Kenneth C. Mathews,** ex-Sylvania Electric Products Co., now president of Mecanair, Inc.

electronics

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ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

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

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

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

COMPANY	SEE PAGE	KEY #
AC SPARK PLUG Electronics Div. of General Motors Corp. Milwaukee, Wisconsin	122*	1
ATOMIC PERSONNEL INC. Philadelphia, Pennsylvania	208*	2
BECKMAN INSTRUMENTS INC. Fullerton, California	212*	3
BRENTON EMPLOYMENT AGENCY Newark, New Jersey	208*	4
BUREAU OF SHIPS U. S. Navy Department Washington, D. C.	114*	5
COWIN ASSOCIATES Garden City, New York	207*	6
EITEL-McCULLOUGH INC. San Carolos, California	116*	7
ELECTRO-MECHANICAL RESEARCH INC. Sarasota, Florida	212*	8
ERIE ELECTRONICS DIV. Erie Resistor Corp. Erie, Pennsylvania	213*	9
ESQUIRE PERSONNEL SERVICE INC. Chicago, Illinois	208*	10
FAIRCHILD STRATOS Aircra't Missiles Div. Hagerstown, Maryland	198, 199*	11
GENERAL COMMUNICATION CO. Boston, Massachusetts	207*	12
GENERAL DYNAMICS/ASTRONAUTICS San Diego, California	79, 80	13
GENERAL DYNAMICS/ELECTRONICS A Div. of General Dynamics Corp. Rochester, New York	210*	14
GENERAL ELECTRIC CO. Communication Products Department Lynchburg, Virginia	128	15
GENERAL ELECTRIC CO. Defense Systems Department Syracuse, New York	127	16

CONTINUED ON PAGE 128

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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)

3/16/62

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

CATEGORY OF SPECIALIZATION

Please indicate number of months experience on proper lines.

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

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41

TO ENGINEERS AND SCIENTISTS
LOOKING FOR GREATEST PERSONAL
INVOLVEMENT IN MAJOR SYSTEMS FOR SPACE:

COMMON SENSE SAYS, "LOOK TO THE HEAVENS"... OR DOES IT?

All of the glamour that surrounds hardware in orbit often obscures one very meaningful fact. As much as 80% of a complete space system is, and remains, on the ground.

Here's another fact. Within General Electric, technical competence for the ground-based portion of space programs concentrates here in Syracuse, New York.

For instance, the highly reliable radio-inertial guidance system our engineers developed for ATLAS (now operational with the USAF) is the same system that has been used for booster guidance on 75% of America's space shots.

Another system, utilizing an entirely different set of engineering concepts, is MISTRAM*. Its current function is to introduce a revolutionary magnitude of precision into ICBM trajectory measurement. Important future ramifications lie in extending the system to global ranges, satellite tracking, space guidance and hypersonic traffic control.

Still other programs such as GEESE (General Electric Electronic System Evaluator), the vast-scale Air Weapons Control System 412-L. Theoretical and Applied Space Physics, Radiation Effects Research, and many more, provide rugged exercises in technical ingenuity.

MISTRAM's basic system concept involves a geometric arrangement of 5 ground radio receiving stations. Missile position, trajectory and velocities are continuously calculated with great accuracy from phase differences in a beacon signal received from the missile. Radar is used only to orient the radio receiving antennas in the general direction of the missile.

AN ADDED THOUGHT

This much diversity in one organization generates a uniquely flexible type of career environment. You can plot and re-plot your best avenue of advancement, without having to leave the company in order to do so.

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A Department of the Defense Electronics Division

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WEEKLY QUALIFICATIONS FORM FOR POSITIONS AVAILABLE

(Continued from Page 126)

COMPANY	SEE PAGE	KEY #
GENERAL ELECTRIC CO. Light Military Electronics Department Utica, New York	130	17
HOLLNBERGER-BURCHELL ASSOCIATES West Islip, New York	208*	18
KOLLSMAN INSTRUMENT CORP. Sub. of Standard Kollsman Industries Inc. Elmhurst, New York	217*	19
LOCKHEED CALIFORNIA CO. A Div. of Lockheed Aircraft Corp. Burbank, California	136*	20
LOCKHEED-GEORGIA CO. A Div. of Lockheed Aircraft Corp. Atlanta, Georgia	120*	21
LOCKHEED MISSILES SPACE CO. A Div. of Lockheed Aircraft Corp. Sunnyvale, California	112*	22
MALLORY ELECTRONICS COMPANY Div. of P. R. Mallory & Co., Inc. Indianapolis, Indiana	208*	23
McDONNELL AIRCRAFT St. Louis, Missouri	211*	24
MICROWAVE SERVICES INTERNATIONAL, INC. Denville, New Jersey	208*	25
MITRE CORPORATION Bedford, Massachusetts	181*	26
MOTOROLA, INC. Military Electronics Div. Western Center Scottsdale, Arizona	212*	27
NATIONAL AERONAUTICS & SPACE ADMINISTRATION Washington, D. C.	129	28
NATIONAL CASH REGISTER CO. Dayton, Ohio	215*	29
PAN AMERICAN WORLD AIRWAYS INC. Guided Missiles Range Div. Patrick AFB, Florida	202*	30
PHILCO WESTERN DEVELOPMENT LABS. Palo Alto, California	209*	31
REEVES INSTRUMENT CORP. Garden City, New York	214*	32
SANGAMO ELECTRIC CO. Springfield, Illinois	207*	33
SCOPE PROFESSIONAL PLACEMENT CENTER Waltham, Massachusetts	208*	34
SPACE TCHNOLOGY LABS., INC. A Sub. of Thompson Ramo Wooldridge Los Angeles, California	15*	35
SPEIDEL CORPORATION Industrial Division Warwick, Rhode Island	214*	36
SPERRY GYROSCOPE COMPANY Div. of Sperry Rand Corp. Great Neck, L. I., New York	212*	37
SPERRY MICRDWAVE ELECTRONICS CD. Div. of Sperry Rand Corp. Clearwater, Florida	217*	38
STANFORD LINEAR ACCELERATDR CENTER Stanford University Stanford, California	102*	39
SYLVANIA MDUNTAIN VIEW OPERATIDNS Mountain View, California	213*	40
UNION SWITCH & SIGNAL Div. of WABCD Pittsburgh, Pennsylvania	128	41

* These advertisements appeared in the 3/9/62 issue.

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The exploration of space, for peaceful purposes and the benefit of all mankind, is the most challenging assignment ever given to the American scientific and engineering community.

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We will provide the professional men who join NASA with the tools they need: a truly intellectual atmosphere, a framework for easy communication with colleagues in universities as well as government and industry laboratories, the most advanced equipment available, and the technical and clerical support to let you concentrate on the important aspects of your work.

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James E. Webb

To scientists and engineers in all disciplines, at all levels:

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...to conduct systems studies regarding integrating hardware, e.g., developing stellar, radio or inertial navigation or guidance systems to perform specific missile function.

STATISTICAL ANALYSIS ENGINEER
...to perform analysis of statistical nature, e.g., correlation, error and probability of success analysis.

For a careful review of your qualifications, and a prompt reply, forward your resume today in strictest confidence. Address: Mr. R. Zukowski, Div. 69-WK., Light Military Electronics Dept., General Electric, French Road, Utica, New York.

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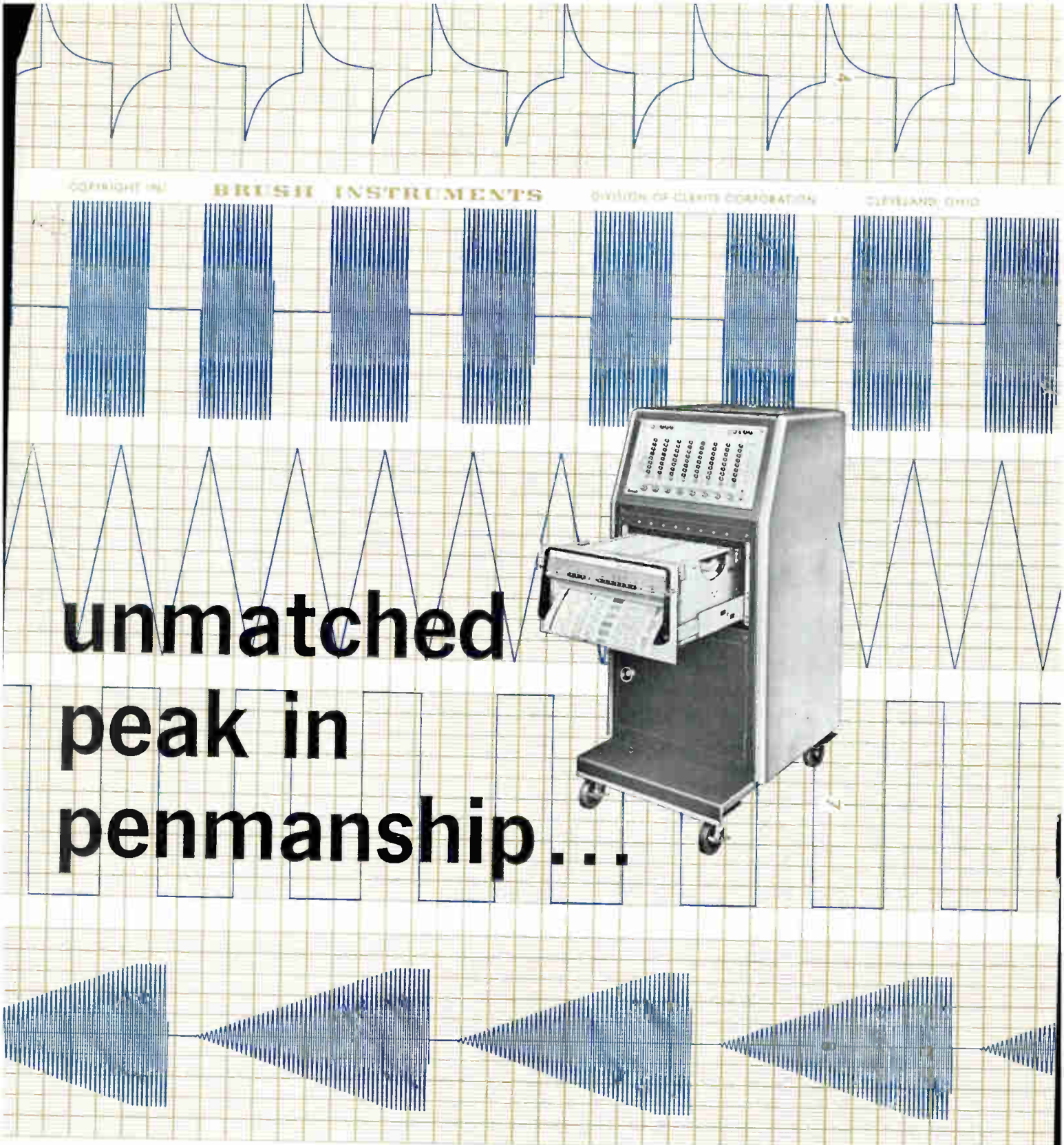

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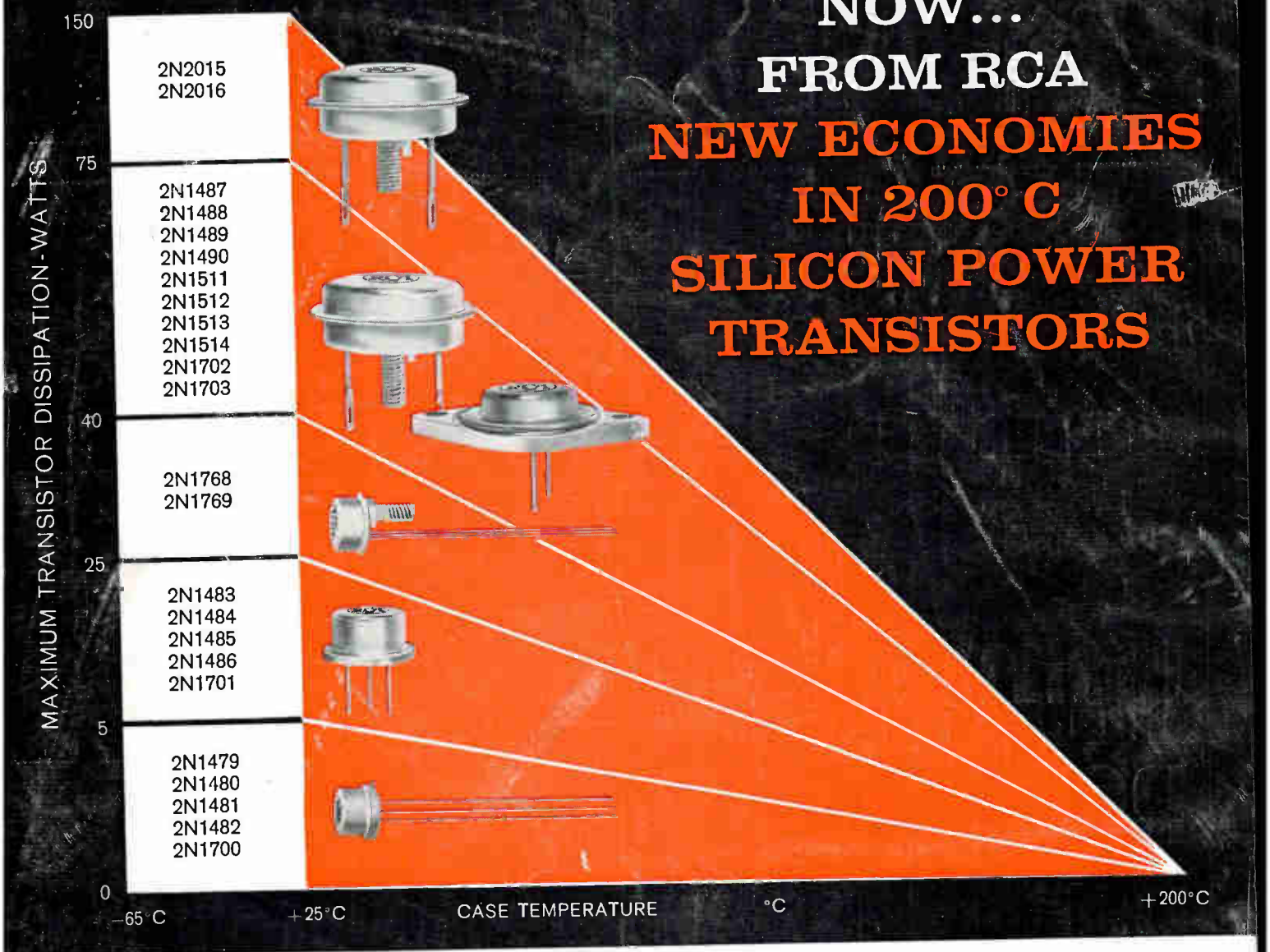

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