February 23, 1962

electronics

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Photo at right

INFRARED GENERATOR

Adjustable in modulation, power and frequency, p 40

TUNNEL-DIODE TRANSDUCERS

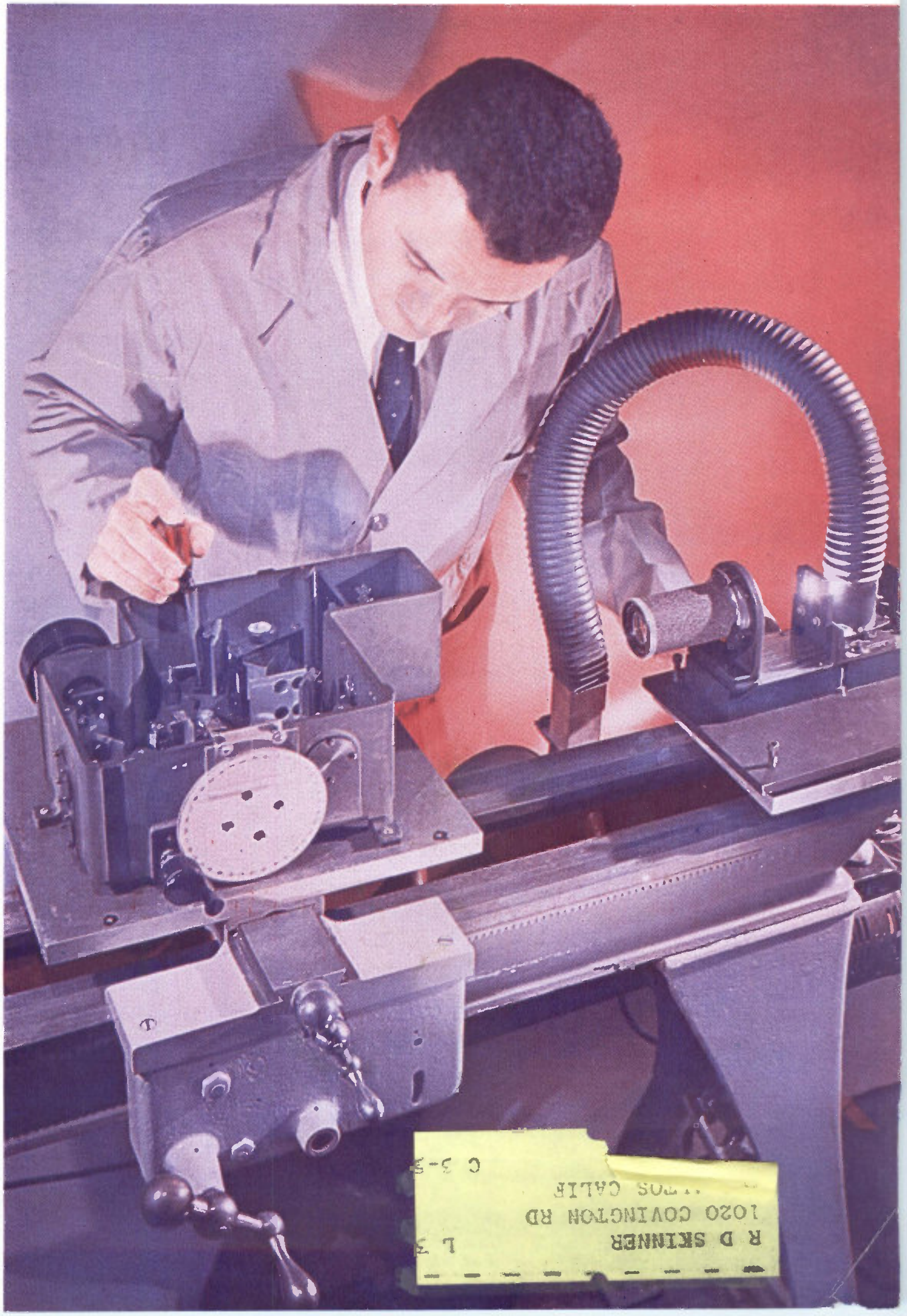
Measure pressure and strain, p 35

BEACON MODULATORS

With solid-state lockout circuit, p 44

POWER SUPPLY

For orbiting satellites, p 47



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electronics

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W. W. MacDONALD, Editor

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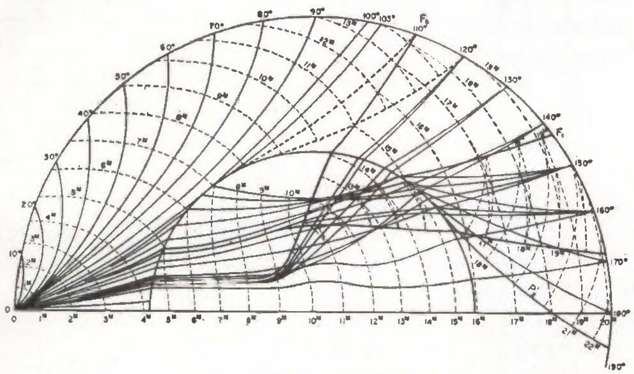
DEPARTMENTS

CROSSTALK



COLD WAR. Mrs. Hyla Napadensky, an Armour Research Foundation project engineer, is back from an Army-sponsored expedition to Greenland. What she found out places a big question mark on the ability of our seismic detection program to identify underground nuclear bomb blasts.

In Greenland, the snow is as deep as two miles. Deep, packed snow like this is a better blast absorber than conventional porous materials and would, in fact, make an excellent atom bomb shelter for men or materials. As a postscript to the report on the explosion experiments, Armour asks: "Could Russian nuclear tests, set off deep down in the Siberian snow, go undetected by Free World detection instruments?"

Chances are, it hasn't come to that yet, because the Atomic Energy Commission thinks it detected an underground nuclear explosion this month in the Semipalatinsk area of Central Asia. But the prospect adds a further complication to the already complicated job of detecting an underground disturbance and then determining whether it is an earthquake or a blast. The shock waves pictured above, for example, could be from either. The diagram (after Gutenberg and Richter) indicates the disturbance originated at the lower left. The inner circle is the earth's core and the outer circle is the mantle. Sorting out such patterns will be the main job of a new center being set up by Consolidated Electro-Dynamics as part of the Vela program (p 28).

CARBON TO CRYSTALS. One of the earliest methods of converting force to a proportional electrical signal was squeezing slabs or grains of carbon together and measuring the change in resistance. The effect is still used in carbon microphones and carbon pile regulators. Later, crystal transducers were developed to convert vibration, tension, acceleration and other physical movements into signals. And, among others, there is the strain gage, sort of a sophisticated carbon pile transducer.

In addition to some special advantages, each transducer has its special problems. Some are noisy, some need extensive calibration and auxiliary circuits, others are relatively insensitive at high frequencies.

The newest generation of transducers, using semiconductors (p 35), offer improvements in several areas at once. They are highly sensitive, have upper frequency limits of not just a few megacycles, but hundreds of megacycles and may even get up to the gigacycle range. They are also efficient electrical-to-physical energy converters. Moreover, semiconductor transducers can lead to computer storages with higher bit densities and to delay lines that can handle more information at higher frequencies.

Coming in Our March 2 Issue

BIOLOGICAL COMPUTERS. Our series on bionics continues with a chapter on living control systems. Assistant Editor Lindgren discusses some of the approaches researchers are adopting in an effort to understand how a brain works and how its principles can be incorporated in computing systems.

W. L. Smoot and H. C. Leahy, of Westinghouse, describe a parametric amplifier for a troposcatter communications system. Other articles tell about a vhf-uhf oscillator that uses self-reactance modulation, by T. M. Conrad, of Flight Electronics; a flying-spot scanner which reviews film records, by A. C. Lewis Brown, of A. C. Neilsen Co., and a simple, reversible, cold-cathode-tube counter, by L. C. Burnett, of Etelco, Limited.

COMMENT

Defining Plasma

The State Section is holding its next semi-annual meeting on April 13-14, 1962, in Tarrytown with a two-day symposium on Plasma Physics. With the printed program we would like to include a short statement defining the area of Plasma Physics for the benefit of the members not too well acquainted with it. This statement is to be concise and accurate.

In talking this over with the Program Chairman, Prof. K. H. Moore, we believe that the statement on p 49 of the issue of July 14, 1961, headed "Defining Plasma" [in the article Plasma Engineering—Part I: Generating and Heating Plasma] is exactly what we are looking for. I would like to ask your permission to quote it verbatim, with its source credited, as about half of the proposed statement. To this Dr. Holt of Rensselaer Polytechnic Institute then wishes to add about an equal number of words on Plasma Physics.

A. FRANCIS TURNER
Secretary-Treasurer
New York State Section
American Physical Society

Permission granted to use the plasma definition, which was written by Senior Associate Editor Michael Wolff for his three-part series on Plasma Engineering (p 47, July 14, 1961; p 33, Aug. 4; p 29, Sept. 1). It reads, in part:

At present the term plasma defines any mixture of particles, some of which are charged, whose spatial dimension exceeds the Debye length and where the percentage of the mixture that is ionized contains an approximately equal number of positive and negative particles so that the overall aggregate is electrically neutral.

Debye length is a measure of the distance at which a given negative particle is shielded by the surrounding positive particles.

Plasma need not be restricted to gases; in fact, there can be two kinds of plasma in solids. The first type is where there are either electrons and positively-charged donors, or holes and negatively-charged acceptors. A second type of plasma occurs in an intrinsic semiconductor where there are only holes and electrons.

Generally, however, plasma describes a gas which in addition to meeting the criteria given above is in such a state of ionization that it becomes conductive enough to be affected by magnetic fields. At temperatures above 20,000 K, ionization is 100 percent for most gases and there are no neutral particles—only positive ions and negative electrons. This completely ionized or "true" plasma is considered a fourth state of matter and is what is most frequently meant by the term plasma.

Magnetic Core Testing

Having read with great interest the article, How Magnetic Materials Behave at Nanosecond Pulse Widths, by Gilbert A. Reeser (p 72, Sept. 8, 1961), I have attempted to obtain details of the third reference, which is V. J. Louden, Proposed Standards For Core Test Methods For Toroidal Magnetic Amplifier Cores, *AIEE Trans Paper* No. 58-71, February, 1958, but apparently this reference is incorrect. I should be pleased if you could check the reference quoted.

D. W. DAVIES
Denis Ferranti Meters Limited
Llangefni, Anglesey
North Wales

Author Reeser replies:

This reference was to a preliminary Transactions paper, and was correct. The paper was later published by The American Institute of Electrical Engineers, and this would perhaps be easier to obtain. Write to AIEE, 33 West 39th Street, New York 18, New York, and ask for AIEE No. 432, January, 1959, Test Procedure For Toroidal Magnetic Amplifier Cores.

This paper is only partly applicable to the pulse testing method described in the ELECTRONICS article. To my knowledge, no standard test procedure exists for this type of testing.

GILBERT A. REESER
Radiation at Stanford
Palo Alto, California

The AIEE informs us that the price of this paper is 50 cents to members, a dollar to nonmembers.

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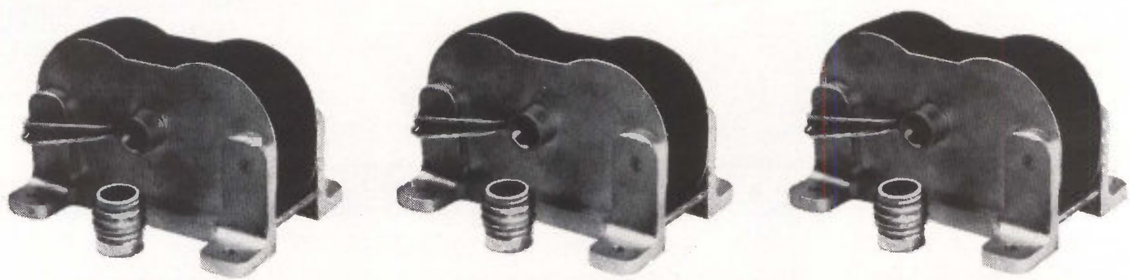

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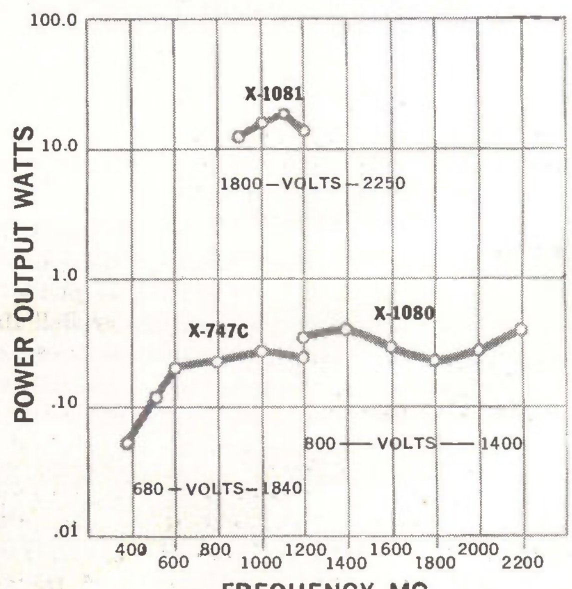
Long life, low noise performance for all three tubes is assured by an injection gun design, which minimizes back-bombardment of the indirectly heated Eimac matrix cathode. Because of the Eimac-developed output circuit design, frequency change with anode voltage is linear, with a precision much better than five parts per thousand. This design also results in reduced output power variation over its range of operation by providing a constant load on the tube, thus minimizing the effects of external load variation across the frequency band.

This is another example of the way Eimac research, development and manufacturing capability are able to meet tomorrow's tube needs today. Another reason to *keep your eye on Eimac*—for advanced high power klystrons, microwave devices and power grid tubes. Eitel-McCullough, Inc., San Carlos, Calif. Subsidiaries: Eitel-McCullough, S.A., Geneva, Switzerland; National Electronics, Geneva, Illinois.



ELECTRONICS NEWSLETTER

Machine Learns to Read Handwriting

MOSCOW—Tass news agency reports that the Institute of Automation and Telemechanics has a machine that recognizes handwritten numbers and is learning to distinguish letters and portraits. The report indicates that work parallel to experiments in the U.S. is being done at the Institute.

The machine was cited, Tass said, by Vadim Trapeznikov at the recent general meeting here of the USSR Academy of Sciences. In an initial experiment with the numbers 0, 1, 2, 3 and 5, it recognized 800 samples —160 of each number—with four mistakes, after being shown samples of the numbers. The program, he said, is based on a "compactness hypothesis," now being applied to studies of animal nervous systems.

Trapeznikov envisioned future devices that could determine system states by the use of signs, which man cannot consciously evaluate. Applications would include the diagnosis, by listening to sounds, of apparatus defects or illnesses.

Single-Gas Masers Considered Feasible

EXPERIMENTS at Bell Telephone Labs have indicated the feasibility of obtaining optical maser action in pure neon. The maximum gain per unit length is considerably less than when helium is included in the system to assist pumping.

The result is important because it indicates that optical maser action will also be possible eventually in the other three rare gases, krypton, argon and xenon. It will make available masers emitting at new wavelengths. The measurements were made by C. K. N. Patel, W. R. Bennett, Jr., W. L. Faust and R. A. MacFarland.

Optoelectronic Relays, Logic Circuits Seen

PHILADELPHIA—Optoelectronic circuits might be used instead of relays in telephone exchanges, J. G. Van Santen, of Philips Research Labs, reported at the Solid-State Circuits Conference last week. Electroluminescent - photoconductive registers would count pulses at speeds of 5 to 20 msec per step.

He also proposed EL-PC matrixes which would multiply two 10-digit numbers in 1 sec. While EL-PC logic circuits are relatively slow, Van Santen said, they avoid crosstalk, need no other type of component, are easily integrated, have small dissipation per element, give high amplification and are low cost.

Converting Carrier to National Command Ship

NAVY is converting the auxiliary aircraft transport carrier *Wright* to a national command ship. The job, assigned to the Puget Sound Naval Shipyard, will cost $25 million, including communications and electronics equipment. Now in the reserve fleet, the ship is 683 ft long, displaces 14,500 tons and has a speed of 30 knots. Defense Department wants at least two such ships for use as alternate headquarters in case of nuclear attack (p 12, Feb. 2).

Telemetry and Autopilot Turn 'Copter into Drone

HELICOPTERS can be controlled from the ground by personnel not trained as pilots, using a system developed by Bell Helicopter Co. It has been installed in two H-13E 'copters under a Navy contract. The drones could be used to deliver antisubmarine weapons, as radar and tv scouting platforms, or as decoys for manned 'copters, Bell says.

The all-transistor system consists of an f-m/pam ground command and transmitter and an airborne autopilot. Ground controls set heading, airspeed and altitude and include a trim stick for takeoff and landing. The craft cannot be commanded to perform any maneuver beyond its limitations.

The present system is effective only when the 'copter is in line-of-sight contact with ground, giving a 15-mi range at low altitude. Bell says range may be extended with microwave beacon and doppler equipment, airborne tv or radar tracking.

Apollo Project Checkout Contract Given by NASA

GENERAL ELECTRIC has been selected by NASA to provide integration analysis for the Apollo space vehicle, assure its reliability and develop and operate a checkout system. The study phase will take about six months and cost $1 million. The implementation phase will last as long as the Apollo project, which is designed to land a man on the moon by 1970. Cost of the second phase will be estimated during the study. GE will work with NASA centers and their major contractors.

Autopilot for Merchant Ships Being Designed

NORDEN is building a course computer and steering system, based on autopilot electronics, for a merchant ship, under contract with the Maritime Administration. It will compute an open-sea course to a specified latitude and longitude, steer the ship there and give a constant estimate of position, distance to go and estimated arrival time. Prototype delivery is planned for late June.

British Electronics Sales Rise 12th Year in a Row

LONDON—British electronic equipment exports rose from $161 million in 1960 to a record $191.8 million last year, the industry's twelfth successive annual rise, the Electronic Engineering Association reported last week.

Domestic and overseas sales totaled about $355.6 million last year, including $112 million for defense programs, compared with $327.6 million total and $166.3 million for defense in 1960.

Exports of radio and tv broadcast transmitters fell by $280,000 to $2.38 million, but overseas sales of radio communication, radar and navigational equipment rose from $47.6 million to $57.7 million.

Industrial electronic control equipment exports increased by $1.4 million to $7 million while radio testing equipment climbed from $4.5 million to $5 million.

Computers have apparently maintained their export position at around $5.6 million. Exports of miscellaneous equipment increased from $7.5 million to $11 million.

Spacecraft Reentry Study Is Launched by NASA

LANGLEY RESEARCH CENTER last week held a bidders' briefing on a new NASA research program called Project Fire. Two spacecraft, each carrying a different instrumentation system, will be launched in the next two years to study reentry problems.

Purpose is to obtain data on materials, heating rates and radio signal attenuation from vehicles reentering the atmosphere at 24,500 mph. Data will be obtained by telemetry, radar and optical tracking.

A 200-lb craft will be used. It will be carried aloft by an Atlas D booster and accelerated back to earth by an Antares solid fuel rocket motor. No attempt will be made to recover the craft.

Navy Tabulates Velocity Of Sound in All Oceans

NAVAL ORDNANCE LAB, White Oak, Md., has prepared a tabulation of the speed of sound in sea water in all oceans, for reference in underwater acoustics studies. The tables take into account the effects of salinity, temperature and pressure on sound velocity at all depths for more than 99.8 percent of the world's oceans.

A total of 747 velocimeter measurements were made with eight seawater samples of varying salinity, at 15 temperatures and eight pressures. Data was interpolated on a computer. The tables replace earlier tables, in error by as much as 10 feet per second, which did not consider effects of temperature and pressure.

Optically Coded Altimeter Reports Aircraft Height

ANALOG-TO-DIGITAL system that enables pressure-type altimeters to report aircraft altitude to ground has been designed and ground-tested at Case Institute of Technology, Cleveland.

Bellows movement rotates an optical code disk divided into opaque and transparent sections in nine rings. There are 501 radial patterns, each representing 50 feet of altitude to 25,000 feet.

On interrogation from ground, a lamp flashes through the disk. The pattern seen through masks is detected photoelectrically and coded. The altitude code, in nine bits, and the aircraft's serial number and type code, in 19 bits, are transmitted to the interrogating ground station.

Another Group Formed to Help Science Communicate

WASHINGTON—The American Association for the Advancement of Science has formed a new subgroup, Section T—Information and Communication. So far, 10 societies dealing with documentation, computers, writing and chemical fields have become affiliates. Goal is to bring together societies and individuals interested in scientific communciation, information storage and retrieval. No specific programs have been planned as yet, but society spokesmen indicate that initial efforts will be to interest scientists and information specialists in each other's problems.

In Brief . . .

U. S. R&D this year will total $12.3 billion, with 75 percent going to aerospace programs, says AIA.

SWEDEN has selected both radar and infrared versions of Hughes' Falcon air-to-air missiles for the new J-35F Draken fighters. The missiles will be made in Sweden.

GENERAL DYNAMICS has a $7.6 million contract for communications systems at three Titan ICBM bases. GD/E is testing a non-scanning, terrain-avoidance radar for low-flying planes.

JOINT VENTURE company has been formed in Japan by Thompson Ramo Wooldridge and Mitsubishi Electric to make and sell process control computers, semiconductor devices and other equipment.

STANDARD REGISTER will market Raytheon's DataRay data communications equipment, for use with Bell System's Data Phone.

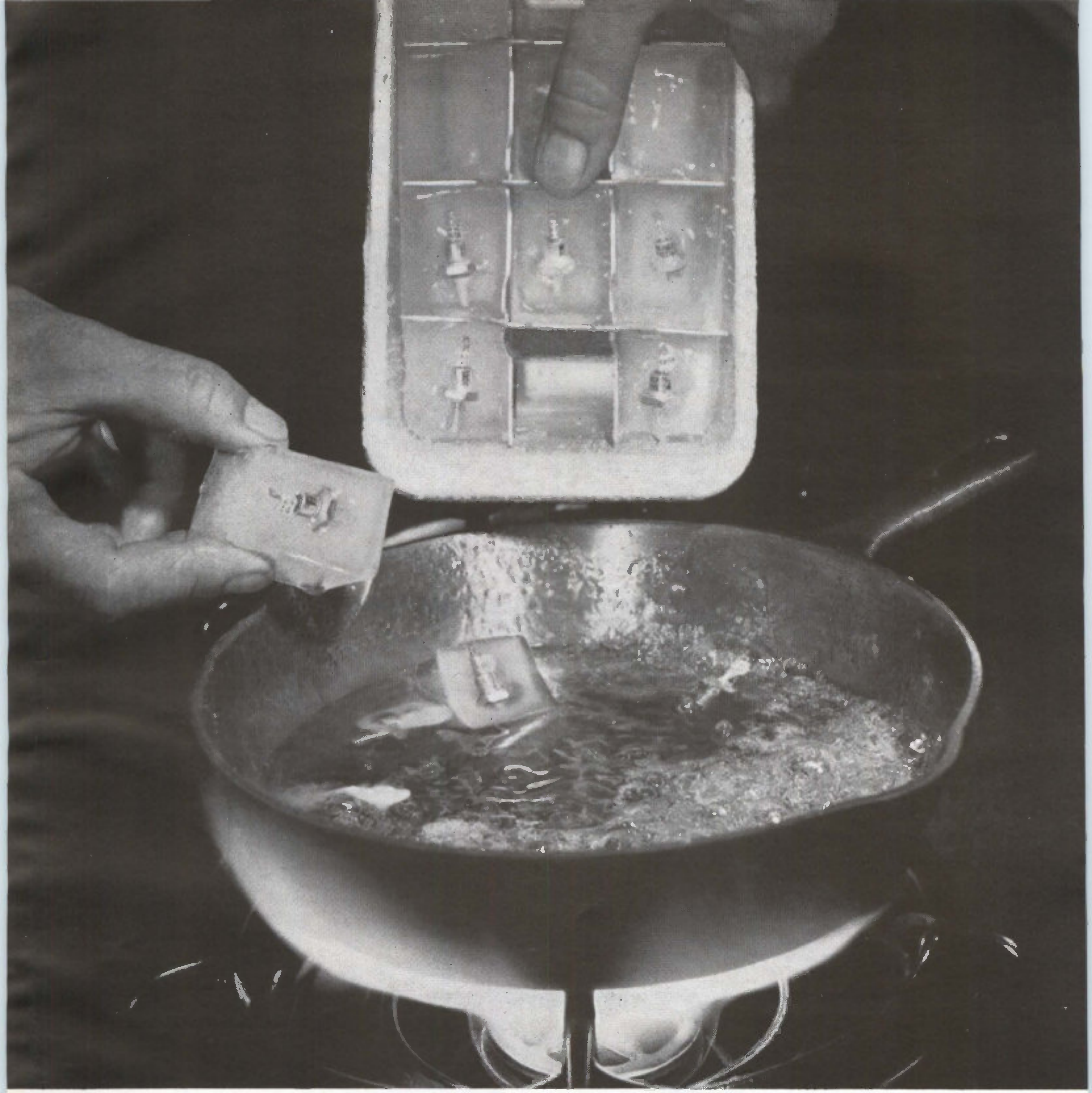
PACKARD BELL is building two large, $750,000 versions of its Trice digital differential analyzers for the Apollo program, also has $300,000 contract for two shipboard data systems for Atlantic Missile Range.

RULES PROPOSED by FAA for magnetic device air shipments include labeling, keeper bars if possible and recalibration of aircraft compasses near shipment.

PHILCO contracts from Air Force include $8.8 million for satellite control systems and $1.5 million for air-ground communications. A $42,000 subcontract goes to Remanco for a voice communications system for Discoverer.

NAVY has awarded Sangamo Electric $8.5 million for sonar equipment. Union Switch & Signal has $275,000 subcontract from Lockheed for airborne sonobouy displays.

PROTOTYPE of Nudets (Nuclear Detonation Detection and Reporting System) will be built by GE for Air Force under $1.8 million contract. It's part of 477L program.



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hp 204B maintains excellent frequency stability even with rapidly changing loads. Frequency stability over the entire 5 cps to 500 KC range is better than ±0.03%/°C from 0° to 55°C. Output is flat within ±3% at all settings of dial and range switch. Distortion less than 1%, hum and noise less than 0.05%. Output 10 mw (2.5 v rms) into 600 ohms; 5 v rms open circuit. hp 204B, with batteries, $275.00. AC operation optional, $25.00 extra.

hp 200AB Audio Oscillator, 20 cps to 40 KC.

Ideal for amplifier testing, modulating signal generators, testing transmitter modulator response. Covers its range in four overlapping bands. Simple operation, just three controls. No zero setting required. High stability, with accurate tuning circuits. Output 1 watt (24.5 v) into a 600 ohm load. hp 200AB (cabinet), $165.00; hp 200ABR (rack mount) $170.00.

hp 200CD Wide Range Oscillator, 5 cps to 600 KC.

Subsonic to radio frequencies covered in five overlapping decade bands. Used for testing servo and vibration systems, medical and geophysical equipment, audio amplifiers, video frequency circuits, etc. 85 dial divisions for reading convenience. Distortion rating less than 0.5% below 500 KC. Output 160 mw (10 v/600 ohms); 20 v open circuit. hp 200CD (cabinet), $195.00; hp 200CDR (rack mount), $200.00.

hp 201C Audio Oscillator, 20 cps to 20 KC.

Especially designed for testing amplifiers, speakers, cross-over networks, this high power oscillator offers an output of 3 watts or 42.5 v into 600 ohms over its full frequency range. Response is 1 db full range. Attenuator adjusts output 0 to 40 db in 10 db steps, provides either low impedance or constant 600 ohm impedance. hp 201C (cabinet), $250.00; hp 201CR (rack mount), $255.00.

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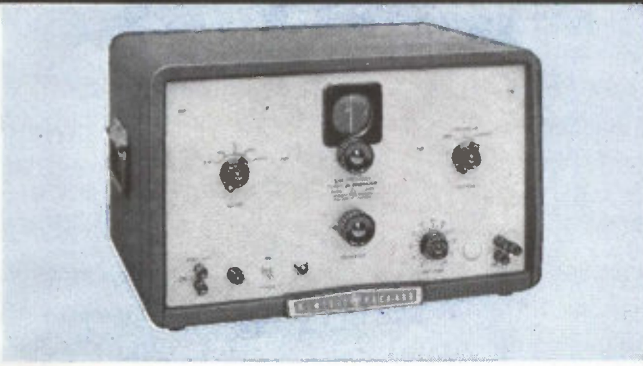
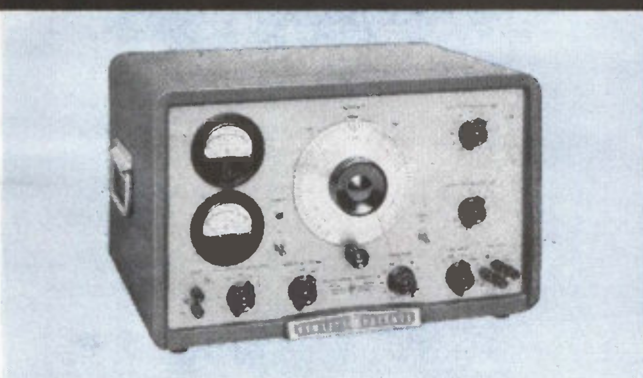


hp 202A Function Generator, 0.008 to 1,200 cps.

Source of transient-free sine, square and triangular waves, frequency continuously variable through 5 bands for electrically simulating mechanical, physical, medical phenomena. Stability within 1%, distortion less than 1% up to 100 cps. Sine, square or triangular waves selectable by front panel switch. Output 28 mw or 30 v p-p/4,000 ohms. hp 202A (cabinet), $550.00; hp 202AR (rack mount), $535.00.

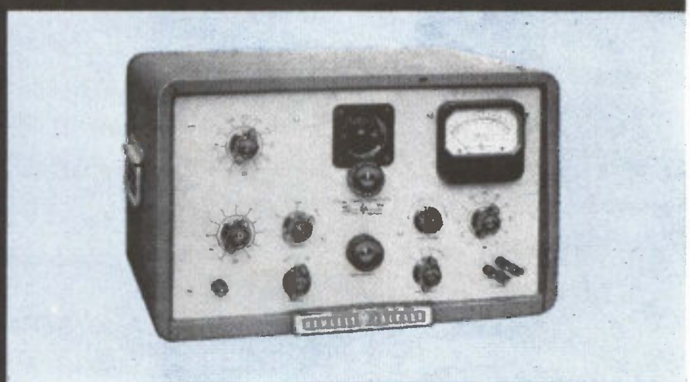
hp 202C Low Frequency Oscillator, 1 cps to 100 KC.

Especially convenient for measurements in the subsonic, audio and ultrasonic regions such as vibration, electro-cardiograph, electro-encephalograph. Distortion less than 0.5%, hum voltage less than 0.1%, short recovery time. Output 10 v/600 ohms. hp 202C (cabinet), $300.00; hp 202CR (rack mount), $305.00.



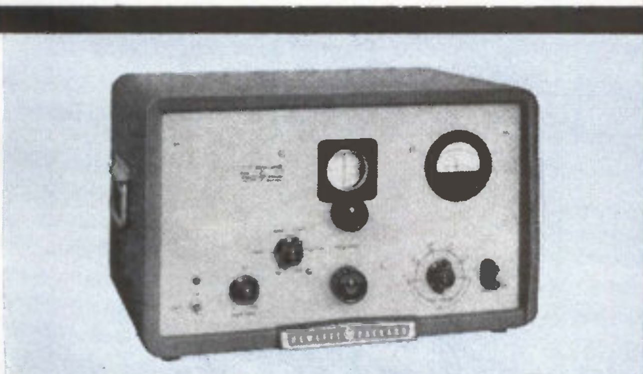
hp 205AG Audio Signal Generator, 20 cps to 20 KC.

Six basic instruments combined in one for high power audio tests, gain measurements. Two voltmeters measure input and output of the device under test. Output 5 watts, adjustable. Output impedance selected by front panel switch. hp 205AG (cabinet), $600.00; hp 205AGR (rack mount), $585.00.



hp 206A Low Distortion Audio Signal Generator, 20 cps to 20 KC.

Distortion less than 0.1% makes the hp 206A ideal for use in testing of FM broadcasting units and high fidelity audio systems. Metered output, variable in 0.1 db steps, +15 dbm into 50, 150, 600 ohms. hp 206A (cabinet) $800.00; hp 206AR (rack mount), $785.00.



hp 650A Test Oscillator, 10 cps to 10 MC.

Metered output flat within 1 db full range. Voltage range is 0.00003 to 3 v. 600 ohm impedance, voltage divider furnished for 6 ohm impedance. Distortion less than 1% to 100 KC. hp 650A (cabinet), $550.00; hp 650AR (rack mount), $535.00.

hp ®

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7564

WASHINGTON OUTLOOK

McNAMARA SHUNS COST-PLUS RESEARCH

DEFENSE SECRETARY McNAMARA has ordered an internal drive within the Pentagon to get more research for the military dollar. He sent a memorandum on this to his deputy director of defense research and engineering, John H. Rubel, some months ago. Specifics are just now coming out.

McNamara admonished the three military services for a tendency to be swayed in placing R&D contracts by "slick paper" and "fancy" proposals that often are more optimistic than the company's capability. The services, too, were criticized for writing elaborate R&D requirements that show little resemblance to the initial field requests for equipment.

McNamara wants the services to use more fixed-fee contracts and trim down as far as possible cost-plus-fixed-fee contracts. Even if a contractor's initial fixed-fee bid is much higher than estimated R&D costs, experience has shown that in the end a fixed fee is usually cheaper than the final cost of a cost-plus-fixed-fee award. If it is impossible to place fixed-fee contracts on an entire R&D program, the Secretary of Defense wants the program broken down. awarding as many elements on a fixed-fee basis is possible. Incentives on cost-plus-fixed-fee awards are encouraged to improve contractor performance.

TEETH IN ETHICS CODE?

THE WHITE HOUSE has issued a new code of conduct for government consultants. Designed to tighten conflict of interest regulations and prevent consultants from using their government positions for private gain, the new code spells out what consultants can and cannot do. Consultants would have to furnish a "full disclosure" of their financial interests.

Administration-proposed legislation to update the conflict-of interest laws is now pending before Congress. It is generally conceded that President Kennedy is acting now to quell congressional moves toward a major round of congressional hearings into conflict-of-interest questions.

By and large, these center on the thousands of scientists and engineers who serve the government as part time consultants. The White House fears that hearings might needlessly cause many of its consultants to shun further government work.

TAX HELP FOR BASIC RESEARCH

TREASURY DEPARTMENT is seeking a formula that will give industry more incentive to do basic research. Less than 10 percent of total U.S. research and development expenditures goes for basic research. The administration feels this is much too small, since basic research is a key factor in the industrial innovations so necessary to economic growth. The treasury is weighing recommendations for the major tax reform program President Kennedy plans to submit to Congress this year. It won't be considered until 1963.

UHF TV HEARINGS SOON

RECENT HORSETRADING between FCC and industry (p 12, Feb. 16) increases prospects for uhf tv. Sen. John O. Pastore, Communications Subcommittee chairman, will quickly move hearings on a bill requiring that receivers be made to pick up the 70 uhf and 12 vhf channels. Hearings will let FCC see if the networks and several key manufacturers are going to back up their endorsement with action.

There is a tacit understanding that if the bill goes through, FCC will soft-pedal network regulation and deintermixture. The industry is not solidly behind the bill. EIA will fight it. Despite an NAB endorsement, many station owners don't want their tv license value diluted by new uhf stations.

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AN ULTIMATE RESEARCH INSTRUMENT

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In addition to this generator, various transducers with proper impedance matching transformers are required to complete an ultrasonics research laboratory. Due to the low output impedance, magnetostrictive transducers may be driven directly by the addition of a DC polarizing source or magnetic bias. Impedance step-up transformers are required for piezo-electric or ceramic transducers at lower frequencies. At the higher frequencies, most electrostrictive transducers exhibit lower impedance characteristics enabling relatively easy transformer matching. International Ultrasonics, Inc. will furnish quotations on matching transformers to specific transducer requirements throughout the frequency range of this instrument.

FEATURES

Hewlett-Packard 650-A Oscillator
Push-Pull Video Amplifier
Push-Pull Cathode Follower Grid Drivers
Push-Pull Output Stage employing 10 matched 6550's
Untuned Broad Band Output Transformer
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Regulated Screen Supply
Sloping Front Control Panel
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Output Power Variable 0 to 250 Watts
Output Impedance 92 ohms

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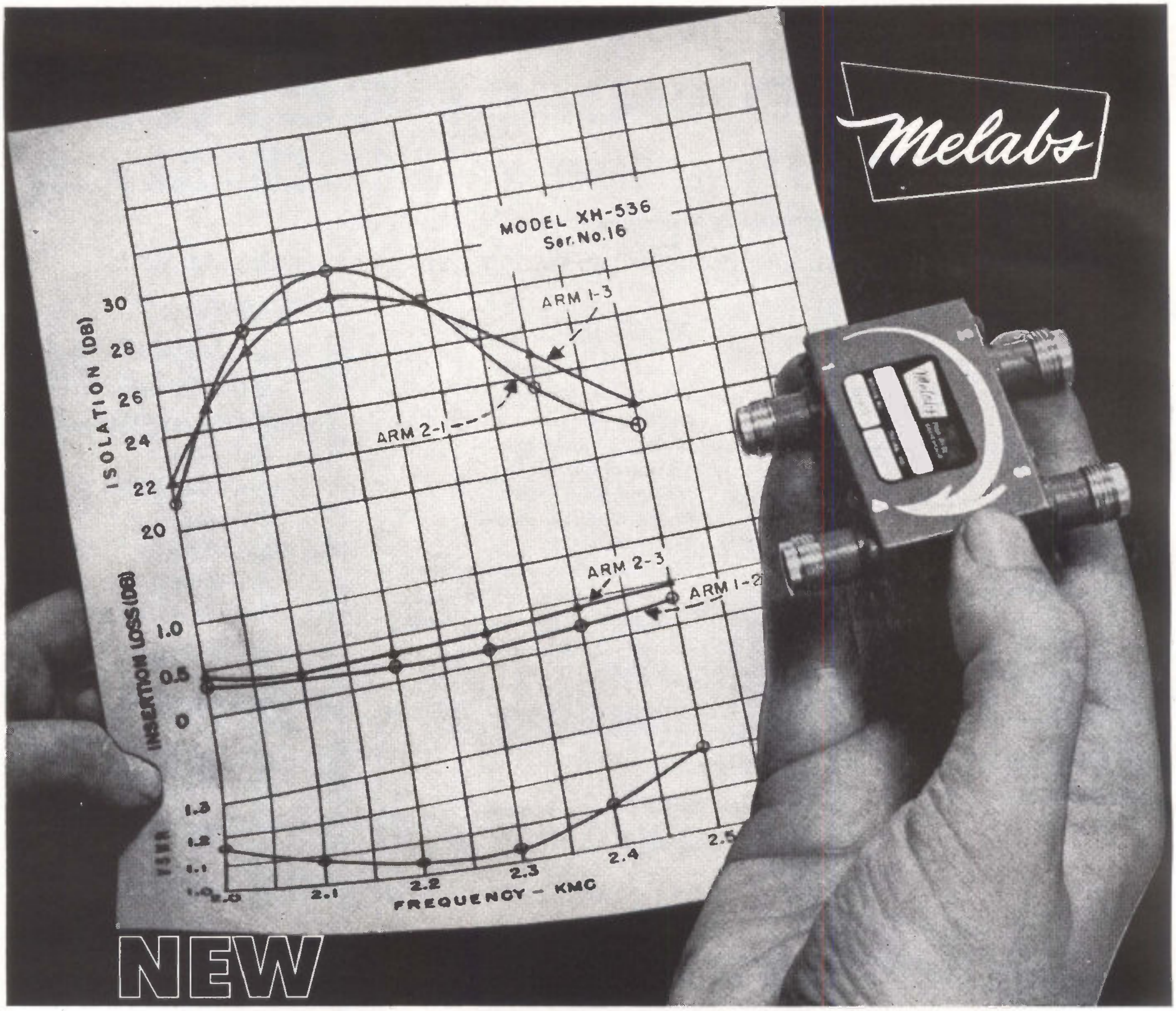

COAXIAL 4-PORT CIRCULATORS

Now available . . . a new series of ferrite 4-port circulators for operation over the frequency range of 400 mc to 8 Gc. All models feature low-loss, high isolation and broadband characteristics. All are small in physical size—ultra-miniature units also available. One of the latter, Model XH-415 (5.4-5.9 Gc) is illustrated. Measured performance for Model XH-536 (2.0-2.5 Gc) is shown on the chart. All of these 4-port models feature *insertion loss* of 0.3 db maximum (0.15 db typical), *isolation* of 20 db minimum (25 db typical), and *VSWR* of 1.2 maximum.

Some of the many standard models:

XH-351 . . . 1.25 - 1.35 Gc **XH-335 . . . 5.4 - 5.9 Gc**
XH-536 . . . . 2.0 - 2.5 Gc **XH-415 . . . 5.4 - 5.9 Gc***
XH-541 . . . . 2.6 - 3.0 Gc ***Ultra-miniature w/TNC connectors.**

Other models can be supplied at any frequency within the 400 mc to 8 Gc spectrum.

A complete line of ultra-miniature Coax Isolators from 1.7 to 8 Gc is presently under development.

OTHER IMPORTANT NEW MELABS CIRCULATORS

Miniature K_u Band, *Broadband Waveguide Circulator Model XH-525.*
Frequency range: 15.5-17 Gc.
Isolation: 20 db minimum.
Insertion loss: 0.5 db max., 0.3 db typical.
VSWR: 1.25 maximum.
Weight: 3 ounces.

Melabs
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Bendix® 25-amp DAP (Diffused Alloy Power) transistors are designed for high-temperature, high-current, microsecond switching. They're 'Dynamically Tested', an exclusive Bendix quality control process that tests each unit to assure uniform reliability. In addition to their high current switching capabilities (typically 25 amperes in 4 μsec) Bendix 25-amp DAP® offers circuit stability over a wide range of temperatures (from −60°C to +110°C). They're rated at high collector-to-emitter breakdown voltages, provide low input resistance, controlled current gain, and low saturation voltage. Write to Holmdel, N. J., for details.

Absolute Maximum Ratings:	V_{CE} Vdc	V_{CB} Vdc	I_C Adc	P_C* W	T_{stg} °C	T_j °C
2N1651	60	60	25	100	−60 to +110	110
2N1652	100	100	25	100	−60 to +110	110
2N1653	120	120	25	100	−60 to +110	110

*P_C is the maximum average power dissipation. It can be exceeded during the switching time.

Bendix Semiconductor Division

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Main Office: South St., Holmdel, N. J.—Ph: SH 7-5400 • **New England Office:** 114 Waltham, Lexington, Mass.—Ph: VO 2-7650 • **Detroit Office:** 12950 W. 8 Mile Rd., Detroit 37, Mich.—Ph: JO 6-1420 • **Midwest Office:** 1915 N. Harlem Ave., Chicago, Ill.—Ph: 637-6929 • **West Coast Office:** 117 E. Providencia Ave., Burbank, Calif.—Ph: VI 9-3961 • **Canadian Affiliate:** Computing Devices of Canada, P.O. Box 508, Ottawa 4, Ont. • **Export Office:** Bendix International, 205 E. 42nd Street, New York 17, N.Y. **Stocking Distributor:** Contact nearest sales office for name of local distributor.

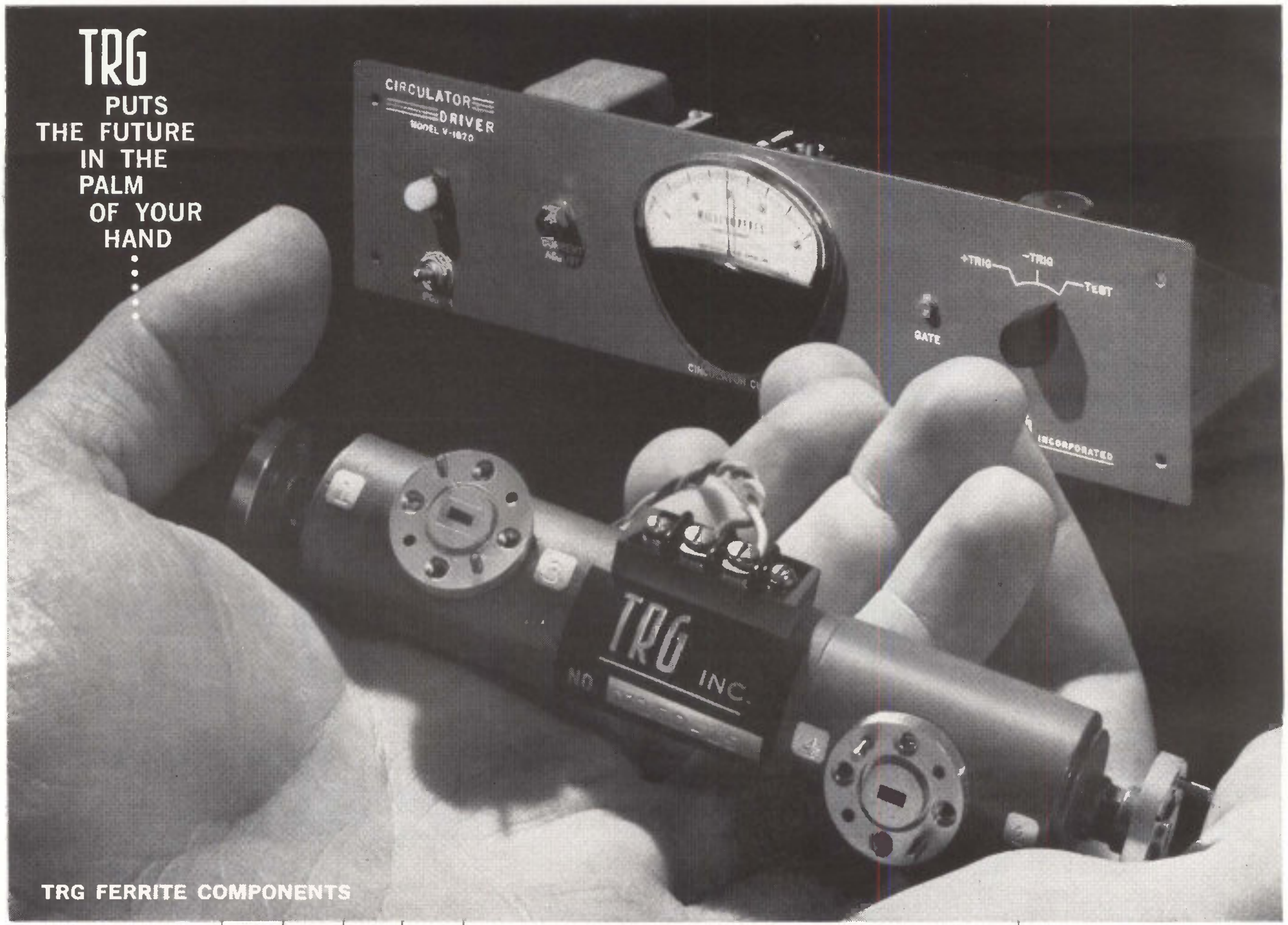
CIRCLE 15 ON READER SERVICE CARD

More new millimeter wave FERRITE COMPONENTS . . . This is the new TRG transistorized switch driver and circulator combination for millimeter wave radiometry. Like most TRG ferrite components, it is available nowhere else — truly a pioneering device in the true sense of that sometimes abused word. Yet, TRG offers this unique combination, as it offers all other TRG advanced components, on short delivery. You'll find the ferrite switch driver and circulator more fully described below. And please remember this: today, there is only one source for a complete line of millimeter wave components of all types, covering the entire 26.5 to 220 KMC region. That source is TRG. Whatever your problem — a component, or complete systems development — TRG has more of everything it takes, including experience, to place the answers right in the palm of your hands. Please write for Catalog 260A today.

TRG

TECHNICAL RESEARCH GROUP, 400 Border St., East Boston 28, Mass.

The new TRG transistorized ferrite switch driver and circulator combinations are available over the entire 26 to 140 KMC region. Applications: millimeter wave radiometry, spectroscopy and radar duplexing. Representative specs: Rise Time, less than two microseconds . . . Repetition Rate, 2 pps—10,000 pps . . . Duty Cycle, 50% Automatic binary reduction of input trigger pulse.



COMPONENT	A-band 26-40 KMC	V-band 50-75 KMC	E-band 60-90 KMC	F-band 90-140 KMC	TYPICAL PERFORMANCE FOR A, V, E and F BANDS		REMARKS
FERIMAT — Tunable Isolator	A100	V100	E100	F100	A, V, E	VSWR 1.25 max. — Loss 1.5db max. — Isolation 20db min.	Tunes over full waveguide range
					F	Under development, present performance quoted on request	
Isolator	A110	V110	E110	F110	A, V, E	VSWR 1.25 — Loss 0.7db — Isolation 17db min., 25db at band center	Bandwidth: 6% A-band, 3% V and E-band, f_o ± 1 KMC F-band
					F	VSWR 1.30 — Loss 1.0db — Isolation 16db min., 22db at band center	
On-off Switch or Variable Attenuator	A120	V120	E120	F120	A, V, E	VSWR 1.25 — Loss 1.5db — Isolation 50db	150 ma switching current, 3μ sec. rise time
					F	Under development, present performance quoted on request	
Modulator	A130	V130	E130	F130	A, V, E	4% Band — VSWR 1.25 — Loss: on 1.5db — off 30db	Normally closed — Approx. 150ma switching current, 3μ sec. rise time
					F	2% Band — VSWR 1.3 — Loss: on 1.5db — off 30 db	
Reciprocal Switch	A140	V140	E140	F140	A, V, E	3% Band — VSWR 1.25 — Loss 1db — Isolation 20db	High power — Approx. 150 ma switching current, 3μ sec. rise time
					F	Under development, present performance quoted on request	
Four Port Circulator	A160	V160	E160	F160	A, V, E	3% Band — VSWR 1.3 — Loss 1db — Isolation 20db	Utilizes two dual mode transducers and a Faraday rotator
					F	Under development, present performance quoted on request	
Switchable Circulator Switch	A162	V162	E162	F162	A, V, E	3% Band — VSWR 1.3 — Loss 1db — Isolation 20db	High power — Approx. 150ma switching current, 3μ sec rise time
					F	Under development, present performance quoted on request	
Transistorized Driver	162D	162D	162D	162D	Rep. Rate: — 2pps to 10,000pps, Rise Time: — Less than 1.5 μsec. with coil of 1mh or less, Duty Cycle: — 50% automatic Binary Reduction of input Trigger, Input Signal: — Plus or minus pulse or square wave, 5 volts peak		Designed for pulsing ferrite waveguide switches and modulators over 26 to 140KMC band

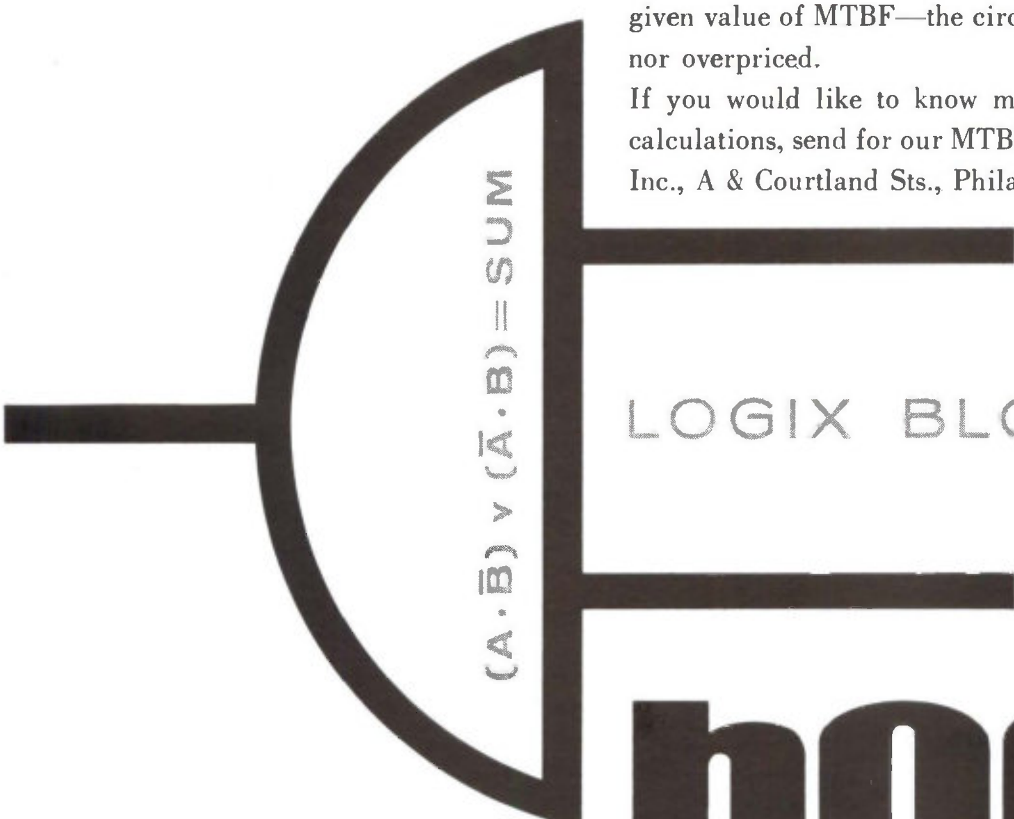
NOTE: TRG ferrite components can be built to operate with existing high power millimeter transmitting tubes. A custom built Model V160 circulator [illegible]ently was successfully tested at 10 kw peak power.

TRG **INC., ANTENNA & MICROWAVE DEPT.,** 400 BORDER ST., EAST BOSTON 28, MASSACHUSETTS • LOgan 9-2110

calculated reliability

Reliability has always been a critical factor in circuit design. One way to achieve it is to calculate the circuit values for a worst case design and then throw in a multiplying factor for the crucial specs on each component. This can run the cost up considerably and generally results in an overdesigned circuit. Another way to achieve it—the way Rese does it for their 1 MC Logix Blocks—is to maximize the reliability by using an end point design. Knowing in advance the desired MTBF (mean time between failures), Rese calculates the stress ratio of every resistor, capacitor, diode and transistor in the circuit. With this information the design can be optimized for a given value of MTBF—the circuit is neither overdesigned nor overpriced.

If you would like to know more about Rese reliability calculations, send for our MTBF folder. Rese Engineering Inc., A & Courtland Sts., Philadelphia 20, Penna.



rese

rese engineering, inc.

CIRCLE 17 ON READER SERVICE CARD

CIRCLE 18 ON READER SERVICE CARD→

Be fussy

Two things determine whether or not a particular printed circuit connector is "right" for your application:

1. How the printed circuit board mates with the connector, and

2. How the connector connects to the rest of the system.

Take mating, for example. Besides having the correct number of contacts, a printed circuit connector must hold the board securely whether the board happens to fall at the high or low end of thickness tolerances.

IT TAKES THREE

These considerations convinced Amphenol engineers that no single contact design could satisfy the requirements of a wide range of applications. So they designed three contacts that will.

One, used in Prin-Cir* connectors, looks a lot like a tuning fork with lips. The circle lip design makes contact overstressing or "setting" impossible—even after repeated insertions. The contact's long spring base also enables it to accommodate boards that range in thickness from .055″ to .073″, while doing an excellent "wiping" job.

EASY DOES IT

But not every application requires the Prin-Cir "bite." For this reason, Amphenol engineers designed connectors with ribbon contacts that mate with a gradual wedge-like force. In blind mating applications, gradual mating makes the feeling of *correct* mating unmistakable. (Just the thing when your equipment may eventually be maintained by less-skilled and less-concerned personnel.) Ribbon contact wedge action also makes it possible for connectors using these contacts to accept the same wide range (.055″ to .073″) of board thicknesses as do Prin-Cir connectors.

Finally, advances in micro-miniaturization (like Amphenol-Borg's Intercon® pre-fabricated circuitry) meant that tinier-than-ever-before connectors were needed. Amphenol's answer was the Micro-Min® receptacle and printed circuit board adapter. Micro-Min contacts are actually tiny springs of beryllium copper wire, formed in a precisely designed arc to assure firm circuit board retention. This unique design makes it possible to space contacts on .050″ centers and crowd 19 connections into a little more than an inch of space.

TERMINATIONS COUNT, TOO

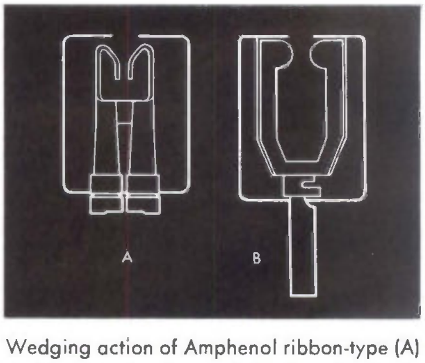
"How to connect connectors to the rest of the system" also merits a good deal of consideration. In some cases, hand soldered terminations will do just fine. In others, higher volume requirements call for high production rate methods like dip soldering and wire-wrapping. Some engineers prefer taper pin terminations.

Our printed circuit connectors are available with contact tails designed for each of these termination methods. In addition, adapters are available for use in connecting printed circuit boards at right angles to each other or in modular arrangements. We make printed circuit connectors with hermetically sealed contacts — still others with coaxial contacts.

Take your choice.

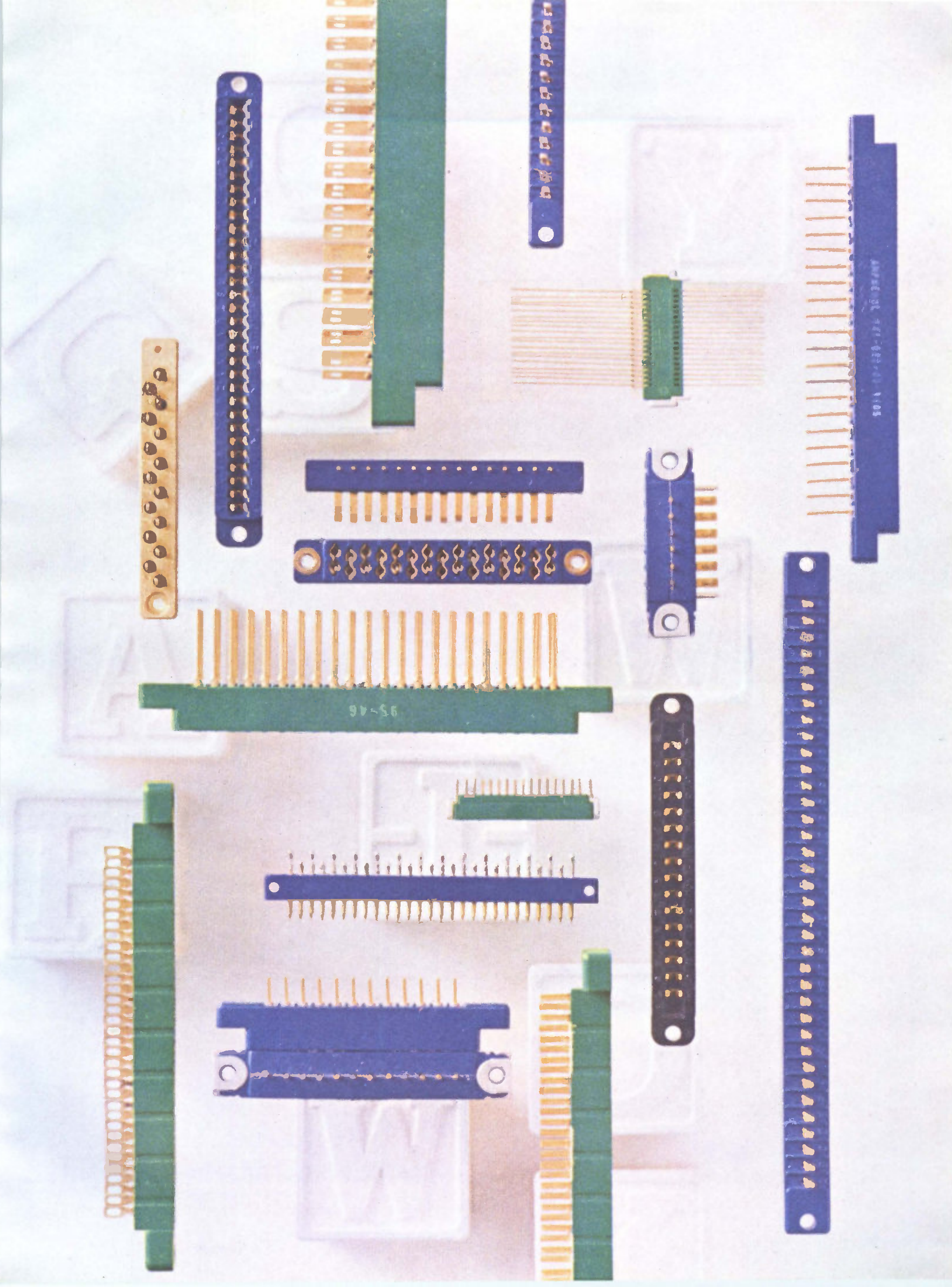
Any Amphenol Sales Engineer or authorized Amphenol Industrial Distributor will be happy to discuss printed circuit connectors (ours) with you. Or, if you prefer, write directly to Dick Hall, Vice President, Marketing, Amphenol Connector Division, 1830 S. 54th Avenue, Chicago 50, Illinois.

*T.M. Amphenol-Borg Electronics Corp.



Wedging action of Amphenol ribbon-type (A) and long spring base of Amphenol Prin-Cir connectors (B) assure firm printed circuit board retention, whether board happens to fall at low (.055″) or high (.073″) end of thickness tolerance.

AMPHENOL **Connector Division** / Amphenol-Borg Electronics Corporation



Gamewell made this special completely from scratch. Every part of this rotary switch was newly designed by Your Engineered Specials service to meet a customer's special requirements. The unit provides bi-directional operation at 160 rpm max. It is rated at 28 VDC, 60 ma...has high vibration and shock resistance...and −55° to +150°C. temperature range. Although this design called for only six poles and 11 switching segments, many more could have been provided. ▪ Gamewell's YES service has developed answers to hundreds of special "pot" and rotary switch problems. Interested? Why not write for the full story? **y**our **e**ngineered **s**pecials service.

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Before shipment, every Con Avionics Power Supply is given a 100-hour simulated operation under "Worst-Case" conditions. The result is a supply guaranteed to give you perfect performance under any and all conditions.

Shown above is the AC-DC "Modular" Power Supply designed for easy incorporation in many electronic assemblies and systems. It features all solid state . . . unique heat sink construction . . . voltages from 2.0 to 305 VDC . . . adjustable output . . . power to 30 watts . . . regulation 0.1%.

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New Low Cost General Purpose Supply available with regulated and unregulated outputs. 0-60 VDC/o-1.5 Amp.

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CIRCLE 21 ON READER SERVICE CARD

Orbiting Ultraviolet System Will Map Stars and the Sky's Radiant Intensity

DIGITAL TV, a recently-developed ultraviolet tv pickup tube and large, precision optics will get practical space tests in late 1963 or early 1964 when National Aeronautics and Space Administration launches the first Orbiting Astronomical Observatory (OAO).

The experiment using these techniques, Project Celoscope, is one of two that OAO will carry. Satellite and ground instrumentation for Celoscope will be designed and built by Electro-Mechanical Research, Inc., for Smithsonian Astrophysical Observatory, experiment supplier.

EMR is building seven subsystems: Uvicon cameras, camera controls and selector, analog and digital data processors, command and program controls, and power supplies (see diagram).

Celoscope is to obtain the uv spectra of some 100,000 stars and map the radiant intensity of the sky in three vacuum uv regions. Vacuum uv is that portion of the uv spectrum existing in vacuum. Atmospheric masking has kept ground-based observers from learning much about it.

In space, four 12-in. Schwarzschild telescopes supplied by Ferson Optics, Inc., will image an area of the sky on four ultraviolet-sensitive Uvicon tv camera tubes. Three are optically filtered to receive uv at 1,100 to 1,600 A, 1,600 to 2,200 A and 2,200 to 3,000 A. The fourth will observe uv at 1,100 to 2,200 A from a slitless spectroscope.

Stars and nebulosities will be scanned. Video information will be transmitted to ground in both analog and digital form, according to commands from the ground to the tv scanning systems.

The command and program control unit accepts a binary-code command and provides 21 on-off and 24 parameter adjustments. Each of the 24 parameters can be adjusted to eight levels. Parameters include sweep speed, beam current, target voltage and exposure time. Exposure time is 1 to 30 sec.

Analog tv will be used primarily for qualitative viewing and scanning nebulosities. A 512-line raster is scanned conventionally and video output is transmitted directly to ground.

Digital Encoding

Under digital tv command, each of the 512 lines is scanned in 512 steps. Upon each step scan, a decision is made whether information is present. If so, the beam is held on until digital encoding is completed. Encoding includes radiant intensity and position coordinates. Collected information is transmitted to ground when the satellite passes over a receiving station.

On the ground, digital data processing equipment will automatically print a star catalogue. Experimenters expect to measure some 100,000 stars during the 12-month life of OAO. Data should tell astronomers more about the composition of interstellar dust, hot star atmospheres, planetary nebulae and, possibly, the hot outer atmospheres of cool stars.

EMR will supply two ground-support display systems to Smithsonian. A portable set will be used for preliminary system checkout and during prelaunch phases. The other will be installed at the Smithsonian observatory for preliminary data evaluation.

Equipment includes digital and analog processors to recreate the telemetered tv scenes. One system will produce a photographic sky map. Another will display a star map image indefinitely on a storage tube, for detailed observation. Data will also be fed to a NASA computer for further processing.

Despite its complexity, the space system is expected to operate for more than a year with 95 percent confidence. High-reliability parts, micropower circuits, redundancy and parallel operation, welded connections, modular construction and encapsulation will be used.

Other OAO Experiments

OAO will also carry a second experiment, furnished by the University of Wisconsin. It will determine stellar energy distribution at 800 to 3,000 A and measure emission-line intensities of diffuse nebulae at those wavelengths. Wisconsin will develop optics, filters, ground support and calibration equipment for seven telescopes and their detectors. Cook Electric is the hardware and electronics subcontractor.

Grumman is building the OAO spacecraft. The second OAO will contain an experiment by Goddard Space Flight Center, using equipment and a guidance system to be built by Standard Kollsman Industries.

A relatively fast, 38-in. Cassegrain telescope with a large-aperture spectrophotometer will gather data on selected stars, nebulae and galaxies. Observations will be made at 912 to 4,000 A.

The third OAO will probably carry a Princeton University experiment to investigate absorptive characteristics of the interstellar medium. Later, Harvard University is to make spectrographic studies of solar activities relevant to sun-earth relationships.

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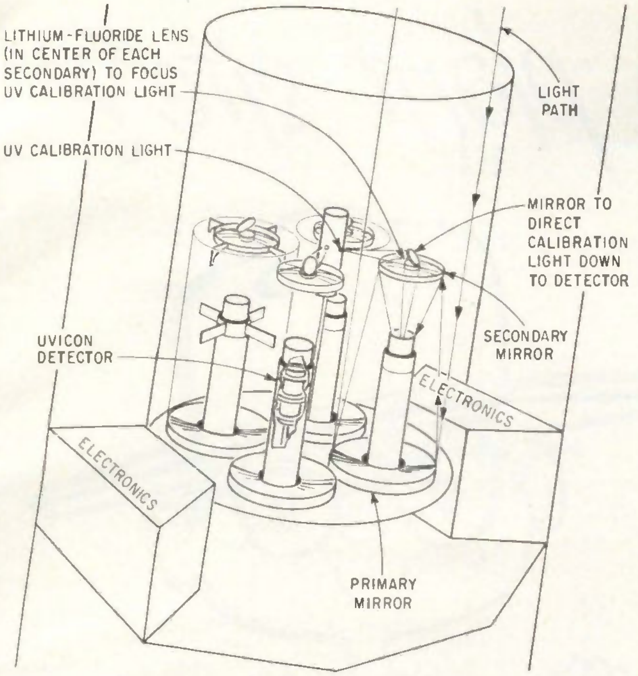
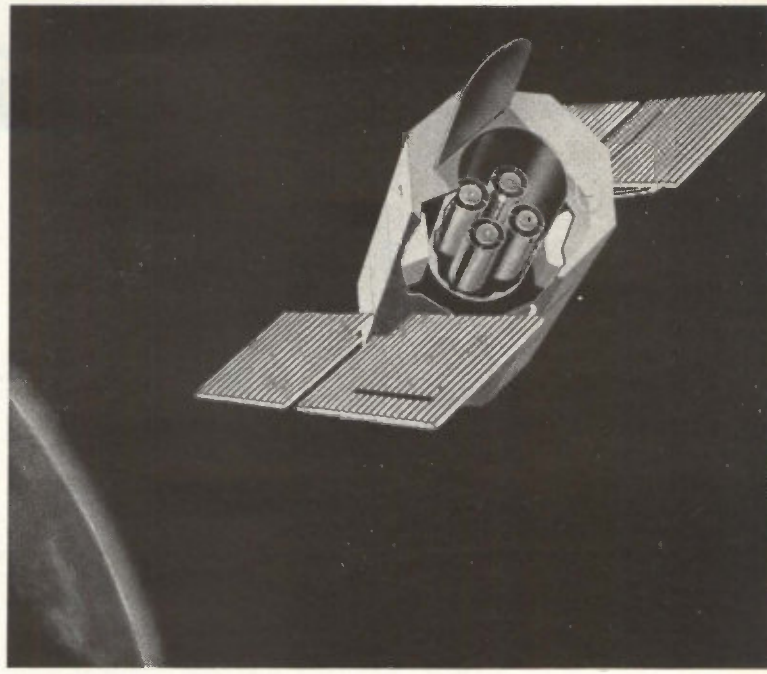
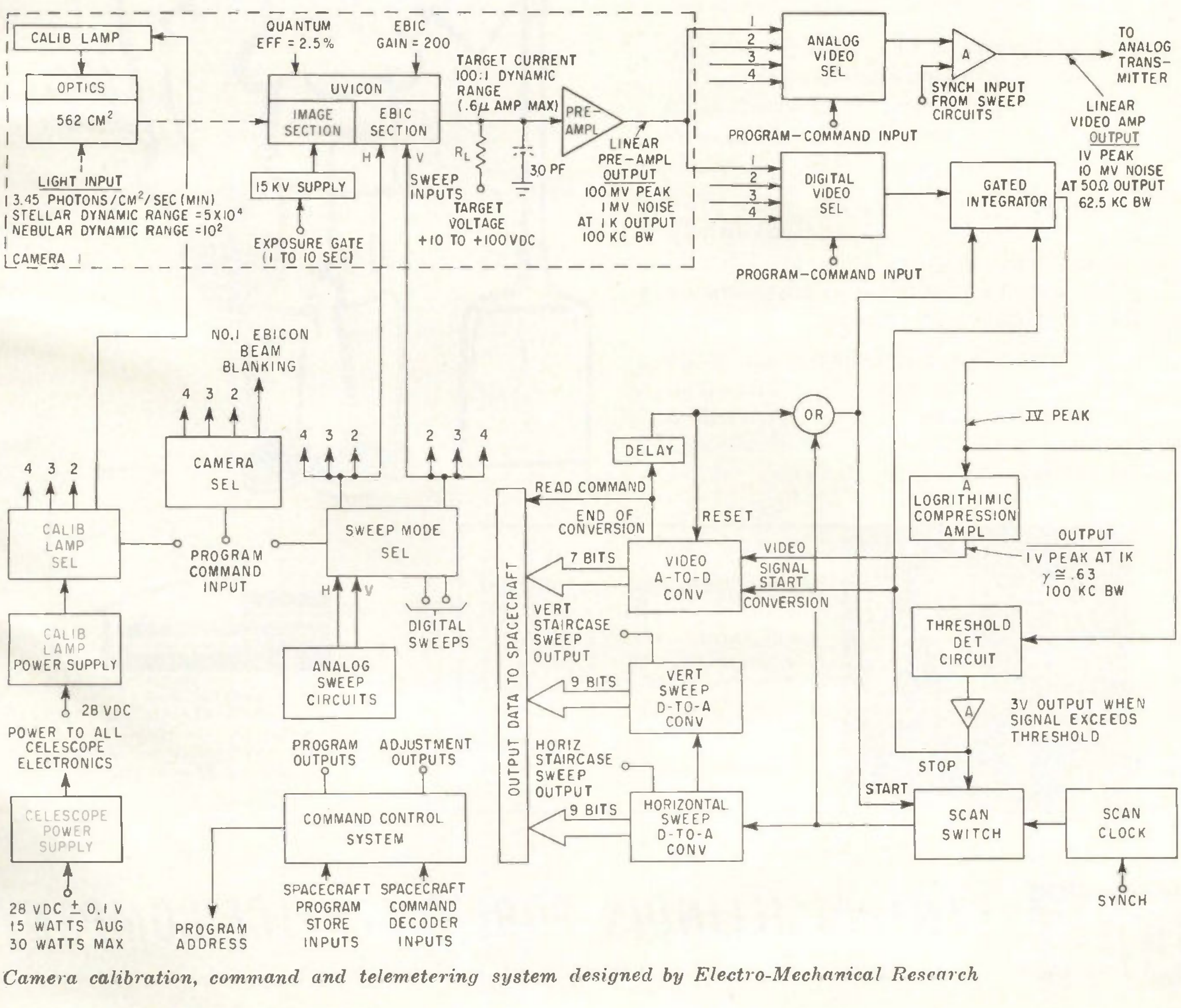


Orbiting Astronomical Observatory will carry telescopes and Uvicon tv cameras to map the sky's radiant intensity



Optical system of Project Celoscope will consist of four telescopes presenting data to tv cameras



Camera calibration, command and telemetering system designed by Electro-Mechanical Research

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C. F. WAYHAM
Industrial Manager

*The central and southern Illinois communities served by CIPS . . . 522 are served with electricity and 27 with gas.

CIPS CENTRAL ILLINOIS PUBLIC SERVICE COMPANY

GENERAL OFFICES: ILLINOIS BUILDING, SPRINGFIELD, ILLINOIS

Engineered for instrumentation applications involving low level signals, the Bendix-Pacific Model TOE-304 millivolt oscillator eliminates the need to amplify the original signal...makes it possible to go directly from transducer to oscillator. The result: increased simplicity, reliability and accuracy, plus more efficient use of many recent transducer developments. Model TOE-304 is compact, lightweight and features semi-conductor circuitry throughout. It is modular and is compatible with all other Series 300 telemetry components. For further information write to Bendix-Pacific Instrumentation Facility, 11600 Sherman Way, North Hollywood, California. Bendix-Pacific area offices are located in New York, Washington and Seattle.

Specifications:

Subcarrier Bands...Standard IRIG
Input Range...±10 mv. 0 to +20 mv. ±20 mv.
Output Voltage...3.0 v. rms open circuit, min.
Linearity...±0.5%
Stability...±1%
Common Mode Rejection...140 db min. at dc.
100 db min. at 400 cycles.

Power Requirements...28 volts dc at 15 ma.
Vibration...25g
Sizes...1.512 x 1.325 x 1.605 inches for bands 4 and above.
1.512 x 1.325 x 1.855 inches for bands 1 through 3.
Weight...4.5 ounces approximately.

THE Bendix CORPORATION

Bendix-Pacific Division

Instrumentation • Airborne Radar • Hydraulics/Pneumatics • USW • Guidance • Electro-Mechanics

CIRCLE 25 ON READER SERVICE CARD

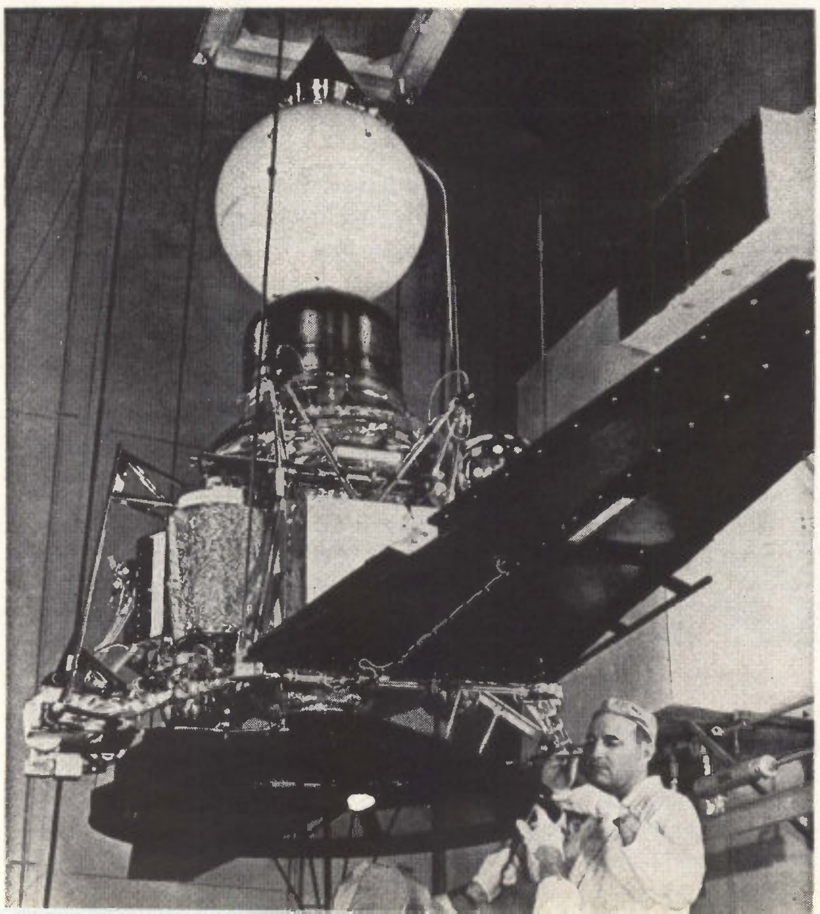
RANGER VIDICON TV CAMERA USES

Since camera worked well in Ranger 3, even if it didn't get to take pictures of the moon, it will go aloft again this year two more times

Six-lb camera and power converter unit are tested at RCA's Astro-Electronics division

Tv system fits into package with 7-inch diameter and 3-inch depth. Box contains power converter

JPL technicians adjusting high-gain directional antenna. Tv camera is at left, with lens pointing up. This was Ranger 3



By JOHN F. MASON
Associate Editor

ALTHOUGH RANGER 3 never got to the moon last month, its tv camera system did operate normally and will be used in two more tries with Rangers 3 and 4 later this year, say scientists at Cal Tech's Jet Propulsion Laboratory. JPL is carrying out the program for National Aeronautics and Space Administration.

Design details on the tv system have only recently become available. Designed by RCA for simplicity and ease of operation, it uses a vidicon sensor for imaging. Unlike conventional vidicons, which use electromagnets to deflect the electron beam, the vidicon in Ranger has all-electrostatic deflection and focus. It also has a special "sticky" target that can be rapidly erased.

To eliminate the bulk and weight of magnets, deflection is handled by charged plates on the tube's interior. The electron gun structure and deflection system is a ruggedized version of an electrostatic unit developed by General Electrodynamics Corp. Focusing is handled by a saddle-field lens arrangement.

The target surface, also developed by RCA, is antimony sulfide oxysulfide, JPL reports. The latent image may be scanned for more than 10 sec with less than 10 percent loss of highlight detail. The image may be erased in 700 msec to clear the tube face for the next exposure.

After a 24-hr soak at 125 C for sterilization, surface sensitivity is maintained at light levels as low as 0.01 ft-candle-sec. The useful dynamic range of some units extends from 0.001 to 0.1 ft-candle-sec with an opening of f-6 and 20-msec exposure.

An image is shuttered on to the faceplate for 20 msec. As the image slowly decays, it is scanned at a rate which yields one complete frame in 10 sec. Each picture consists of 200

ELECTROSTATIC DEFLECTION

scanning lines. Video bandwidth is around 2 Mc.

One-msec switch closures from the command controller sequencer provide commands for shutter and era e. The shutter command terminates erase, triggers the shutter solenoid drives and (after a fractional second delay) initiates the frame sweep. The erase command terminates the frame sweep and initiates the erase mode. This mode consists of illuminating the target with six peripheral lamps, accelerating line and frame scan rates over the target surface and increasing beam current. Although the process normally requires less than 1 sec, circuit simplicity is maintained by continuing to erase for the full 3 sec allotted for readout.

The camera is fitted into the end of a Cassegranian optical telescope, built by JPL to provide the equivalent of a 40-in. focal length instrument in a package 14 in. long. The lunar image picked up by the primary mirror is reflected back to the vidicon photoconductive image surface, which is one-half-in. in front of the mirror. Fused quartz is used for the mirrors and the tubular structure separating the primary and secondary mirrors.

The tv system will begin transmitting when Ranger is about 4.000 Km above the moon. The last full picture telemetered to earth will be at 46 Km altitude, to allow time for transmission before the craft begins to tumble. Coverage of such a picture would be about 517 meters square, resolution about 3 meters a tv line.

One picture will be transmitted every 13 sec, a total of more than 100 pictures. To highlight surface irregularities the shot will be timed so the sun's rays will strike the lunar surface at an angle of 20 to 70 deg.

Tv data will be recorded on magnetic tape. The recorded signal is converted into digital form and rerecorded on computer input tapes. The computer creates a master photograph or cleans up sets of photographs. JPL says photos can be printed out by reconverting from digital to analog. This tape is fed into a film recorder.

Besides lunar photography, Ranger experiments include: gamma ray measurements, to determine approximate concentrations of radioactive materials on the moon's surface; radar reflectivity, to provide information on the character of the moon's surface; lunar seismic activity, to measure possible moon quakes and meteor impacts.

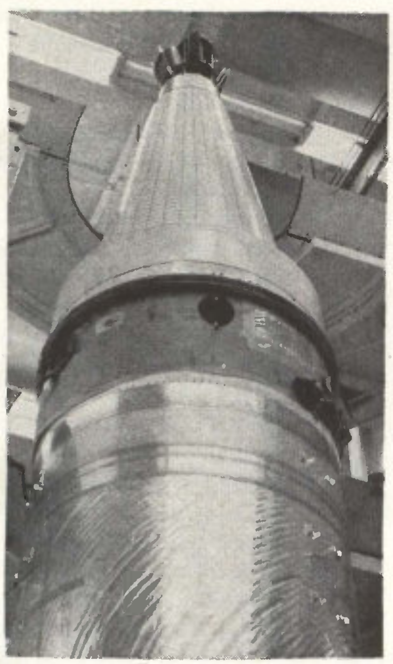
WHY RANGER 3 FAILED

Prolonged burning of the Atlas booster over-accelerated the spacecraft and Ranger 3 crossed the moon's orbital path some 22,862 mi ahead of the moon.

During the midcourse maneuver, an erroneous signal from the ground caused the craft to pitch 116 deg in the wrong direction.

An attempt was made to salvage part of the mission during the terminal maneuver. But a spurious signal generated in on-board logic circuits caused pitching to continue after it should have stopped

Space Power Tester



Air Force has awarded Lockheed the prime contract to test Snap 2 and 10A (System for Nuclear Auxiliary Power) systems in orbiting vehicles. Above, a mockup of Snap 10A atop an Agena satellite produced by the firm

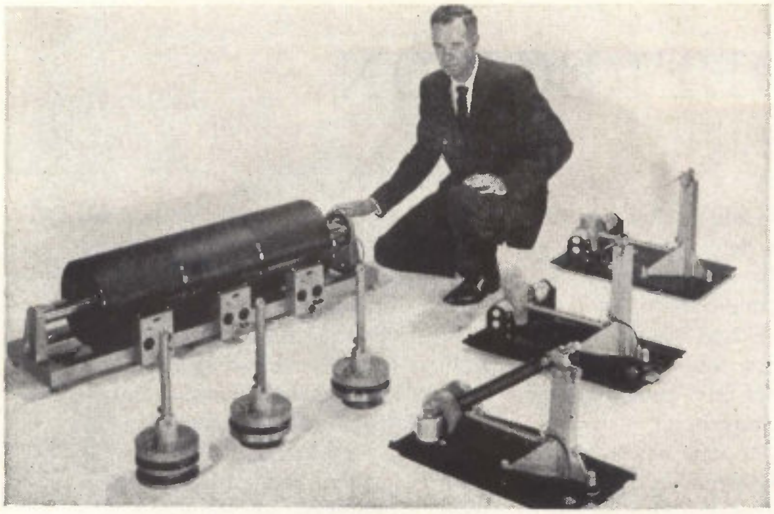
Moving Ball Tracks Radar Target

ELECTROMECHANICAL ball tracker, developed for military applications, allows a radar console operator to track an aerial target with one fingertip, reports Hughes Aircraft Co. Movement of the Bakelite ball positions the tracking pip over the target pip.

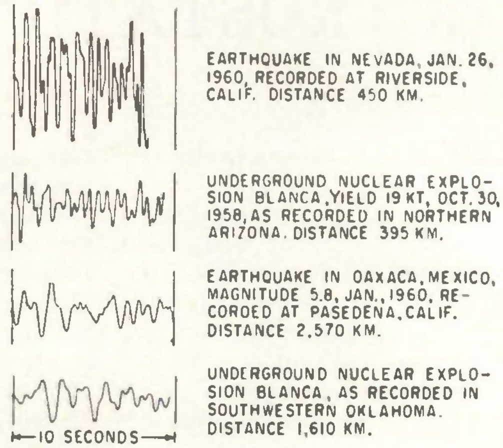
Hughes says the tracker costs up to $2,000 less than other types of electromechanical trackers, which frequently require motion in two directions simultaneously. Movement of the ball in any direction is converted to vertical and horizontal outputs.

The tracker was invented by William F. Alexander, of Hughes' space systems division. It is being used in Army Signal Corps and mobile air defense systems, in the Navy's tactical data systems and, in a miniature version, in airborne systems.

Tracker input is educated thumb



Sensitive seismograph instruments like this Press-Ewing system may solve the nuclear detection puzzle



Examples of similarity of earthquake and nuclear explosion signatures

A-BOMB DETECTION PROGRAM

Spurs Seismology and Instrumentation

By HAROLD HOOD
Pacific Coast Editor

ELECTRONICS IS SPEARHEADING the transformation of seismology from a skilled art to a precise, highly-instrumented science. Paper discs and ink styli in low-funded university laboratories are giving way to digital computers, magnetic tape recorders, and highly sensitive analysis equipment.

Catalyst for this transformation is the belief that seismic techniques may detect and evaluate nuclear blasts in faraway parts of the world. Based on this premise, Advanced Research Projects Agency is establishing a multimillion dollar Data Analysis and Technique Development Center in Washington, D. C., where signals from earth tremors will be collated.

Prime concern of the center will be differentiating between signals emanating from nuclear blasts and more than 20,000 earthquakes detected each year. It will also develop new techniques and hardware for more effective detection and evaluation. Seismic information will be fed from a far-flung network of 40 fixed and mobile recording stations.

As part of Project Vela Uniform, the facility will maintain a master central file of man-made disturbances and earthquake recordings. It will use a large high-speed digital computer, an analog computer, cataloguing, recording and playback equipment. United Electro-Dynamics Inc. has been selected to design, install, and operate the center, which will be staffed initially by 35 scientists, mathematicians, physicists and engineers.

Frank B. Coker, UED vice president, says differentiating a nuclear blast from the myriad earthquakes occurring each day is like finding a needle in a haystack. Man-made underground explosions and earthquake signals appear very similar, if not identical.

Building Seismic Lab

Closely related to the center is a huge seismic laboratory, under construction as the primary development and evaluation laboratory for systems development for Vela.

Located 90 miles northeast of Phoenix in Tonto National Forest, this 23,000-acre installation will glean information from 31 seismometers buried in the ground in steel vaults. Ultimately there may be 100. The site has an unusually low level of microseismic earth vibration.

Detectors will consist of three classes:

- High frequency instruments spread out in a horizontal array four miles in diameter. Configuration is aimed at optimum sampling of bomb and earthquake signals arriving from distant sources while cancelling out local noise. Basic concept is analagous to antenna array theory.
- Detectors for measuring waves at frequencies as low as 0.01 cps. These instruments must be painstakingly shielded from the local environment. "They're excellent detectors of trucks on nearby highways," points out Coker.
- Miscellaneous experimental detectors. These may include ground strain seismometers set in long tunnels buried deep in the earth to measure actual differential movement between points up to 100 ft apart. Sensitive enough to measure surface deflections caused by moon-induced "earth tides," they will pick up ground shifts as slight as one angstrom. One end of a carefully designed rod is bolted to bed rock and the other actuates a capacitive pick-off device.

Also in the experimental category are one or more Kirnos seismometers which ARPA hopes to obtain from Russia. These intermediate frequency instruments measure 0.1 to 1 cps.

The Tonto Forest observatory will contain magnetic and film recorders for cataloguing data from any combination of detectors. Objective is experimentally determining combinations and patterns for maximum signal-to-noise detection.

The new facility will also house Vela Uniform's standards laboratory from which seismometers, galvanometers, and other critical elements will be calibrated. Specially designed vertical and horizontal vibration tables operating at 0.01 to 20 cps will produce amplitudes as low as one micron.

Low-Frequency Analysis

Target date for activation of the Washington, D.C., center is June 1. Interim operations are in a temporary facility near UED's headquarters in Pasadena, Calif. Techniques developed will be incorporated in the Washington operation.

Seismic frequencies vary from d-c to one cps. Since presently available analyzing equipment has a lower limit of approximately one cps, recording tape being scanned is sped up, usually by a factor of 100 or 1,000. This makes it possible to analyze seismic frequencies down to 0.002 cps while using filters of two-cycle width. For initial studies, UED is using one-inch, 14-channel recording tape, and is developing f-m analytic and comparative techniques. A-m is unsatisfactory for low-frequency seismics.

International Center Sought

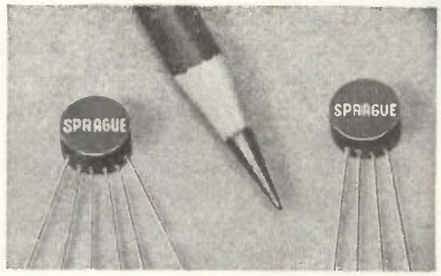
Ultimate aim of Vela Uniform is establishing specifications for an international control center with headquarters in Vienna. A world-wide network of detection stations would be in constant communication with the analysis center, which would decide if signals were from earthquakes or bomb blasts.

One function of the center in Washington will be to seek ways of representing seismic data more simply, to reduce required communication bandwidth. One possibility is representing seismic transient wareforms with special or orthogonal function expansions.

The UED data analysis center contract is initially funded for $12 million. The Tonto Forest observatory will cost several millions; exact funding is not disclosed. Both contracts are under technical supervision of Headquarters, Air Force Technical Applications Center.

(ADVERTISEMENT)

New Nanosecond* Pulse Transformers for Ultra-miniature, Ultra-high Speed Applications



Digital circuit designers will find the new Sprague Type 43Z Nanosecond Pulse Transformers of considerable interest. These tiny transformers have been carefully designed for the all-important parameter of minimum rise time at high repetition rates up to 10 mc.

The new Type 43Z series is comprised of a broad line of 72 pulse transformers in 10 popular turns ratios. They are Sprague's latest addition to the most complete listing of pulse transformers offered by any manufacturer for use in digital computers and other low-level electronic circuitry.

Type 43Z Pulse Transformers are designed so that the product of leakage inductance and distributed capacitance is at a minimum. They are particularly well suited for transformer coupling in transistor circuits since transformers and transistors are very compatible low impedance devices. Nanosecond transformers are equally suitable for transmission line mode of operation, in twisted-pair transmission line coupling, and in regenerative circuits.

The epoxy-encapsulated "pancake" package is excellent for both etched wire board or conventional chassis mounting. To simplify etched-board design, these ultra-miniature pulse transformers are available with leads terminating at the side or the bottom of each unit.

For complete technical information on Type 43Z Nanosecond Pulse Transformers, write for Engineering Data Sheet 40235 to Technical Literature Section, Sprague Electric Co., 35 Marshall St., North Adams, Mass.

*millimicrosecond

CIRCLE 200 ON READER SERVICE CARD

LOW-COST

TYPE 2N979 MADT® TRANSISTORS

Down in size from a TO-9 to a TO-18 case, the new Sprague 2N979 is solving size, cost, and dependability problems for logic circuit designers with the identical performance of the original 2N1499A, with which it is electrically interchangeable.

Designed for use in saturated switching circuits, the 2N979 Transistor is capable of switching at frequencies in excess of 10 megacycles. It consistently shows low storage time, low saturation voltage, and high beta.

Available in production quantities, the 2N979 is a first-run device, not a "fall-out." Produced on FAST (Fast Automatic Semiconductor Transfer) lines with direct in-line process feed-back, high production yields make possible its lower cost.

For application engineering assistance, write Transistor Division, Product Marketing Section, Sprague Electric Company, Concord, N. H.

For complete technical data, write Technical Literature Section, Sprague Electric Company, 35 Marshall Street, North Adams, Mass.

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CIRCLE 29 ON READER SERVICE CARD

Adaptive System Controls Light Planes

MINNEAPOLIS-HONEYWELL this week introduced a push-button autopilot for light, twin-engine aircraft. Called the H-14, it employs a solid-state, self-adaptive computer similar in concept to those Honeywell developed for the X-15 and Dyna Soar.

For example, it will automatically compensate for a loss of power in one engine by banking the aircraft to maintain the intended flight path, without prior instructions.

The basic autopilot consists of a computer, a flight controller, three pneumatic servos, directional, vertical and turn and bank gyro indicators.

Functions include three axis stabilization and control, full-time yaw damping and turn coordination, pitch and roll attitude command, automatically synchronized heading control, all-attitude engage and single-engine recovery.

Options that permit automatic landing include automatic ILS localizer, approach and glide path; altitude control; course director tie-in; and automatic pitch trim. Including options, the autopilot weighs 31.5 pounds.

It can be installed in any light twin engine aircraft with only a minor adjustment in the servos. Honeywell has flown the Cessna 310 and 320, Beechcraft D-18 and Baron with identical model H-14 computers. Beech is offering it as optional equipment in 1962 planes.

The H-14 uses low pressure pneumatic servos. The servos consist of dual on-off magnetic air valves and pneumatic rolling diaphragm actuators similar to a type used in industrial and drone control systems.

Computer's transistor circuits are contained on six plug-in cards

Data Transmitter Links Terminals to Computers

IBM THIS MONTH announced a programmed transmission control unit, the 7750, designed to link a centrally-located computer with a network of communications lines.

Incoming business or scientific information is fed to the computer and routed to the proper terminal after processing. Up to 112 communications lines, each accommodating many terminals, may be used. Terminals may be punched tape or card, magnetic tape, telegraph, or units which link directly with another computer's memory.

The 7750 scans communication lines, strips messages of transmission codes, translate to computer code, puts the messages in priority sequence and feeds them to the computer for processing. After processing, the message is translated into transmission code and routed to the proper terminal.

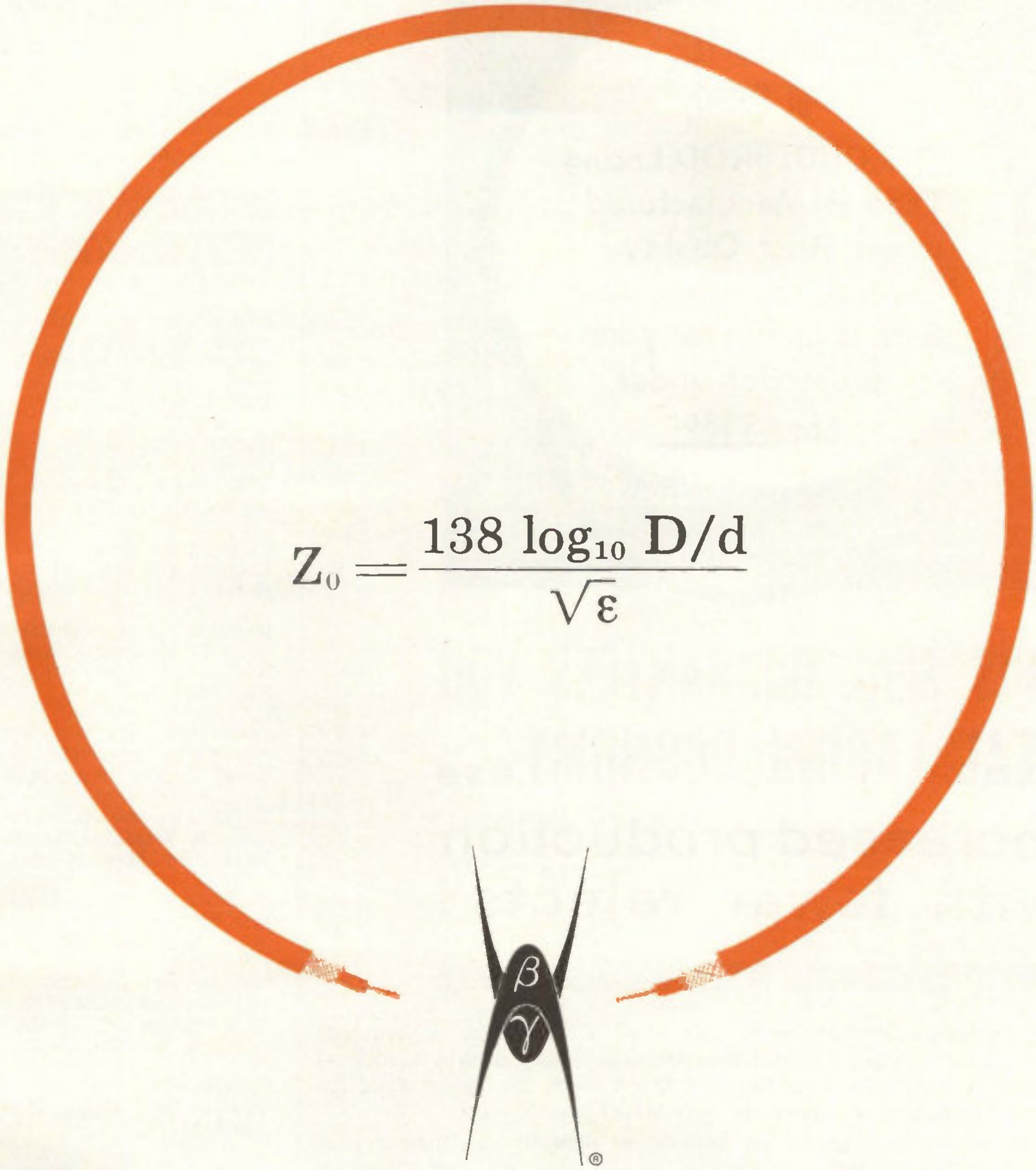
Operation is controlled by a program stored in the unit's memory.

Special Computer Compares Spectrophotometer Curves

HOFFMAN ELECTRONICS is making a solid-state computer designed to eliminate the hand plotting and calculations normally associated with spectrophotometer analysis.

Calibration data, produced by operating the instrument without using a sample, is stored in the memory before the sample is analyzed. This is then compared with readings obtained from the sample. Corrected curves are printed out on a chart recorder and, in digital form, on punched tape. Nixie tube indicators are used for monitoring.

National Bureau of Standards sponsored the development and purchased the first model.



$$Z_0 = \frac{138 \log_{10} D/d}{\sqrt{\varepsilon}}$$

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MEETINGS AHEAD

APPLICATION OF LOW NOISE RECEPTION TECHNIQUES, Institution of Electrical Engineers (British); Savoy Pl., London, **Feb. 28.**

MEDICAL ELECTRONICS DISCUSSION GROUP: Methods of Measuring Man's Environment Temperature, Institution of Electrical Engineers (British); Savoy Pl., London, **Mar. 2.**

APPLICATION OF SWITCHING THEORY TO SPACE TECHNOLOGY Symp., USAF, Lockheed Missiles and Space; at Lockheed, Sunnyvale, Calif., **Feb. 27-Mar. 1.**

SCINTILLATION AND SEMICONDUCTOR COUNTER Symp., PGNS of IRE, AIEE, AEC, NBS; Shoreham Hotel, Washington, D. C., **Mar. 1-3.**

VACUUM COATING Conference, Soc. of Vacuum Coaters; Sheraton-Cleveland Hotel, Cleveland, Ohio, **Mar. 6-7.**

MISSILES & ROCKET TESTING Symp., Armed Forces Communications & Electronics Association Coca Beach, Fla., **Mar. 6-8.**

EXTRA-HIGH VOLTAGE COMMUNICATION, CONTROL & RELAYING, AIEE; Baker Hotel, Dallas, Tex., **Mar. 14-16.**

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

QUALITY CONTROL Clinic, Rochester Soc. for Q.C.; U. of Rochester, Rochester, N. Y., **Mar. 27.**

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

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

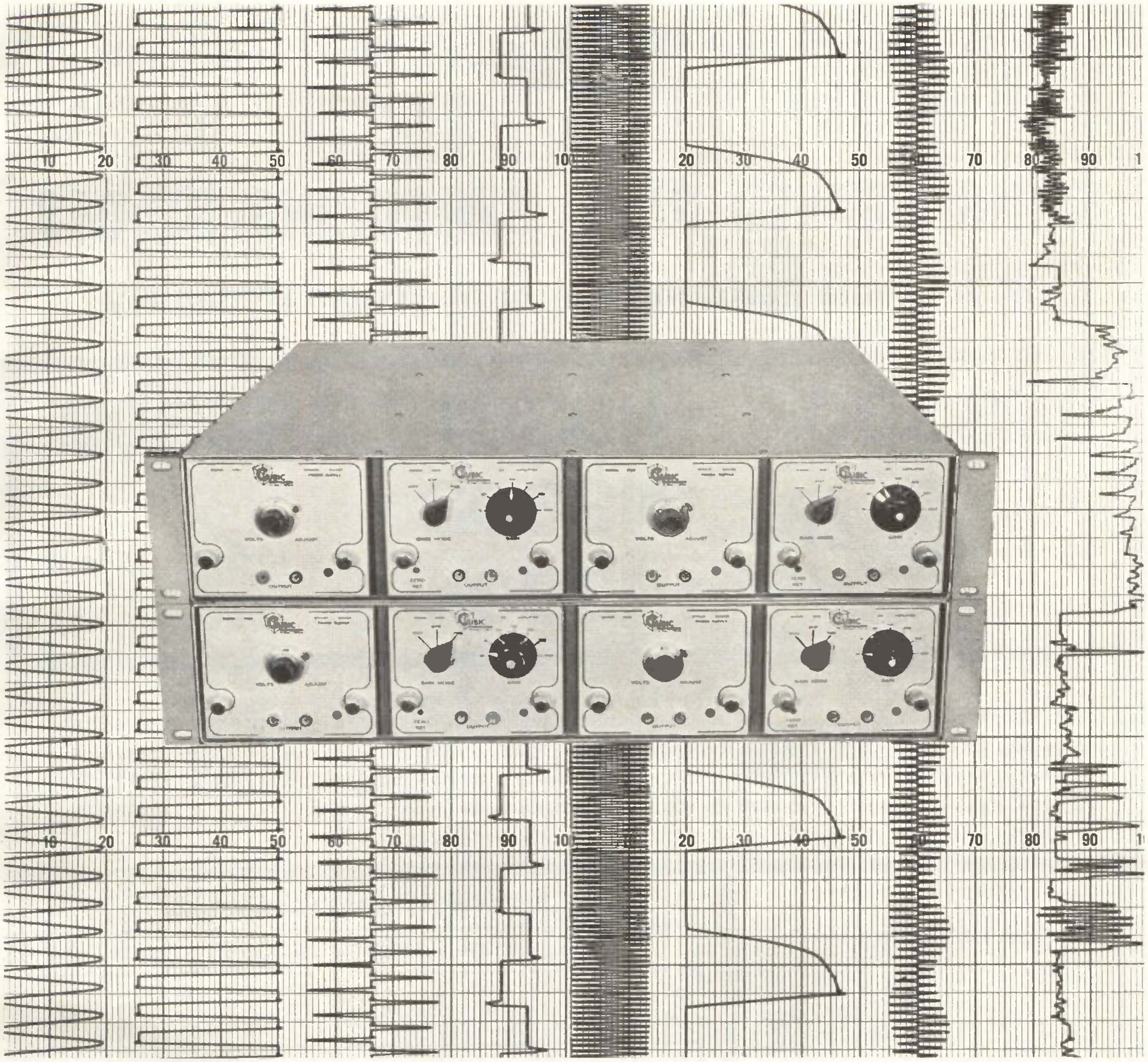
JOINT COMPUTER CONFERENCE, PGEC of IRE, AIEE, ACM; Fairmont Hotel, San Francisco, Calif., **May 1-3.**

HUMAN FACTORS IN ELECTRONICS, PGHFE of IRE; Los Angeles, Calif., **May 3-4.**

ELECTRONIC COMPONENTS Conference, PGCP of IRE, AIEE, EIA; Marriott Twin Bridges Hotel, Washington, D. C., **May 8-10.**

ADVANCE REPORT

SAN DIEGO BIOMEDICAL ENGINEERING *Symposium, AIEE, Inter-Science Inc., Simulation Councils Inc, San Diego Naval Hosp., U. of Calif.: at Stardust Motor Hotel, San Diego, Calif., June 19-21. Papers or comprehensive summaries describing developments or potentials in the following areas (and not reported elsewhere) should be sent by Mar. 1 to The Program Committee, 8484 La Jolla Shores Drive, La Jolla, Calif.: (1) Medical and biology advances made possible by techniques or equipment of the physical sciences and engineering; (2) Physical sciences and engineering aspects applicable or closely related to medicine and biology, e.g. simulation of biological functions, neural models, intelligence machines, bionics.*



Four modules fit a standard rack. Amplifier and power supplies are shown here mixed.

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but have you heard about our power supply that eliminates the need for differential amplifiers and saves you money?

A good, wideband differential amplifier is an expensive piece of equipment. By employing a Cubic Model 1010 Single-Ended DC-Wideband Amplifier priced at only $650, and a Cubic Model 1120 isolated power supply priced at $430, you can obtain superior results at considerable savings. The built-in redundancy of the Cubic system offers much greater protection from data loss in multiple channel test setups. Write for more information to Dept. A-112, Cubic Corporation, San Diego 11, California; or Cubic Europa (S.p.A.) Via Archimede 181, Rome, Italy.

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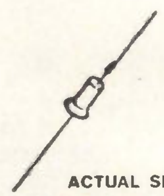
To Contractors and Subcontractors on U. S. Government Projects

5 HIGH-SPEED PNPN SWITCHING DIODES

With Stable Performance for Maximum Reliability

1N3300 1N3301 1N3302
1N3303
1N3304



ACTUAL SIZE

The 1N3300 series is a family of environmentally tested, high-speed, PNPN, two-terminal, silicon switching diodes. Each of the five low-capacity, low-power diodes is sealed in a vacuum-tight case. They are designed for use in high-speed switching circuits at operating temperatures to 175°C. The nominal forward breakover voltage for the series ranges from 18 to 39 volts.

MAXIMUM RATING AT 25° C

I_F 200mAdc

i_f (surge) 50a

P (steady state) 400mW

ELECTRICAL CHARACTERISTICS

	1N3300	1N3301	1N3302	1N3303	1N3304
BV_F (±10%) Vdc	18	22	27	33	39
t_{rr} max. nsec (1)	250	200	200	150	100
t_r max. nsec (2)	80	70	60	60	50

(1) $I_{R1} = 2\ I_F = 200$mAdc
$R_g + R_L$ (@ turnoff) = 100Ω

(2) $R_L = 10Ω$

The 1N3300 series of diodes may be purchased in quantity from Western Electric's Laureldale Plant. For technical information, price and delivery, please address your request to Sales Department, Room 102, Western Electric Company, Laureldale Plant, Laureldale, Pa. Telephone—Area Code 215—WAlker 9-9411.

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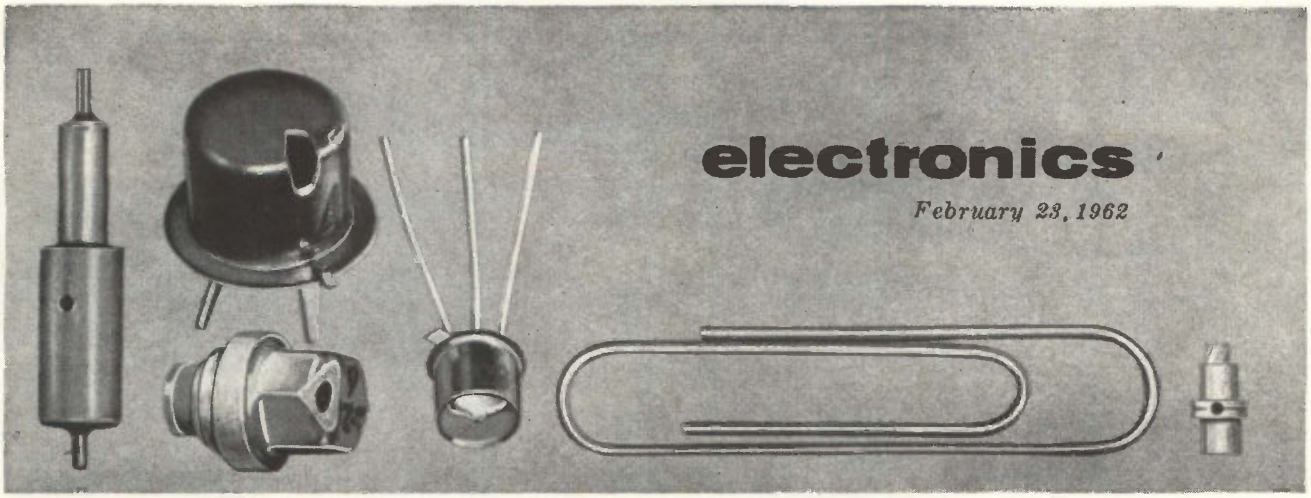


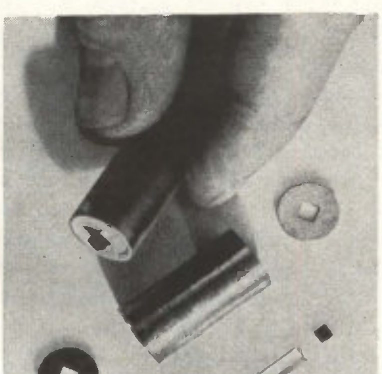
Five experimental semiconductor pressure transducers use the principle of the Esaki diode

SEMICONDUCTOR DEVICES AS

Pressure Transducers

Semiconductor strain gages can give gage factors as high as 30,000. One type of semiconductor transducer which exhibits piezoelectric effects at 10^9 cps and higher may have applications in delay lines and light modulating devices

By WARREN P. MASON Bell Telephone Labs, Inc., Murray Hill, New Jersey



Ultrasonic transducer uses depletion layer to generate signals at 830 Mc; similar units are expected to go to 10 Gc

AN IMPORTANT PROBLEM in mechanics and acoustics is converting mechanical or acoustical pressure into electrical signals, and conversely. Uses are in the pick-up and generation of acoustic signals in air, sea water and solids (including seismic signals), in phonograph pick-ups, roughness indicators, and gages for measuring tension, compression, acceleration, pressure, shear force and torque. At the present time, tranducers for the generation and pick-up of signals are usually of the magnetic, piezoelectric, electrostatic or variable carbon resistor type, while gages for measuring stress components are usually of the wire strain gage type. The wire gages can measure static or slowly varying stresses—which cannot be measured by the other types of transducers—but they have low sensitivity.

Recently a series of semiconductor devices have been constructed that have the advantage of the static property measurement and, in addition, sensitivity comparable to other pick-up and generating devices. Two types of semiconductor pick-up devices and one semiconductor generating device have been developed. One of the pick-up devices is similar to the strain gage but has greater sensitivity. The other pick-up is an active device in which the positive and negative resistance characteristics inherent in a thin *p-n* junc-

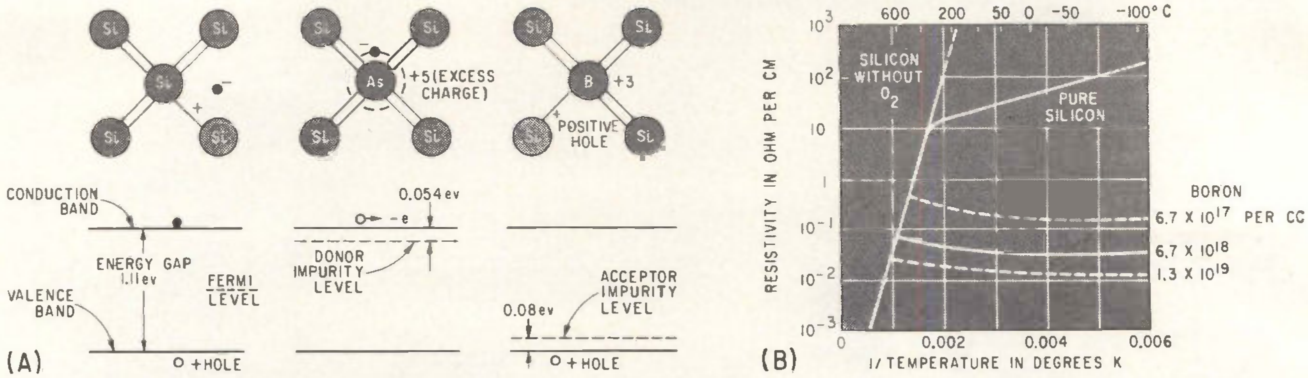


FIG. 1—Silicon, when doped with arsenic becomes n-type material, p-type when doped with boron (A). When silicon is highly doped (B), its temperature sensitivity is greatly decreased

tion (the Esaki diode) are modulated by mechanical stress.

A semiconductor such as silicon has strong bonds to four adjacent silicon atoms through the exchange of valence electrons, as shown by Fig. 1A. Thermal energy, particularly at high temperatures, can break these bonds occasionally. Then an electron is freed or raised to the conduction band and can act as a current carrier. At the same time the broken bond can move, by being completed by electrons from adjacent bonds. It then acts as a positive electron, or hole. Such material without added impurities has an intrinsic resistivity, shown by the slanted line of Fig. 1B; the intrinsic resistivity is a straight line when plotted against the inverse of the absolute temperature. The slope of the line is determined by half the energy gap value; the electrons act as though they moved from a Fermi level that is half way between the valence and conduction bands.

To be of use in semiconductor devices, semiconductors are doped with atoms that provide either an excess of electrons (*n*-type) or an excess number of holes (*p*-type). Arsenic, which has a valence of +5 compared to +4 for silicon, produces *n*-type material. For the *n*-type, four of the five electrons are used to satisfy the bonds. The one electron left is contributed to the conduction band. For low temperatures, energy will be lowered if the electron revolves in a circular orbit about the arsenic nucleus, which has a residual charge of +1. This is indicated by the dashed straight line (Fig. 1A), which is a slight distance under the conduction band edge. For lightly doped specimens, the Fermi level at low temperatures will be along the donor impurity level. As the temperature increases more electrons are freed from their donor levels and the Fermi surface rises. For highly doped samples, such as those used in Esaki diodes, the electrons are free at all temperatures and the Fermi level rises to the top of the conduction band. To produce *p*-type material, atoms of +3 valence, such as boron, are introduced in the semiconductors. Three of the bonds are satisfied but the remaining bond acts as a positive electron and can move around in the semiconductor, producing a resistivity. Figure 1B shows the resistivity in ohm-centimeters as a function of temperature when various concentrations of boron atoms are added to the silicon melt. When the temperature is high enough to reach the intrinsic curve, more conduction results from thermal generation of holes and electrons than from the holes introduced by the impurities. This is an important consideration in such devices. Holes also are more stable if they perform orbits about the negatively charged boron atom, but these holes become free as the temperature rises. In this case the Fermi level for lightly doped samples drops from the impurity line. There are a number of vacant levels above the Fermi surface that can accommodate electrons, which would cancel out the existing holes. This effect is important in thin *p-n* pressure transducers.

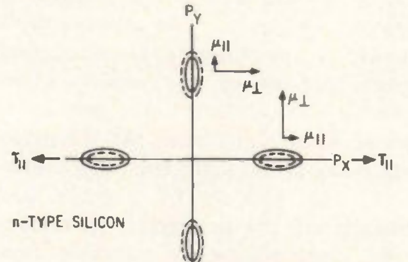


FIG. 2—Energy surfaces are distorted (dashed lines) when a tension is applied along one of the crystal axes

The energy surfaces plotted in Fig. 1A give the impression that they have a spherical symmetry: that is, that it takes the same amount of energy to break the bond irrespective of the directions. Experiments have shown that this is not so. Figure 2 shows the shape of the conduction band for *n*-type silicon: there are six valleys that occur along the crystallographic axes (only four are indicated in the drawing). Since these are values having low energies, electrons tend to congregate around these minimum values. Mobilities of electrons are determined by the second derivatives of the energy surfaces with respect to direction: mobilities of electrons perpendicular to the valleys are five times those parallel to the valleys.

This difference in electron mobility, together with the fact that the energy surfaces can be changed by applying a stress (deformation potential), is the cause of piezoresistance, which has been applied in semiconductor strain gages. A tension $T_{\parallel}$ along one of the crystal-

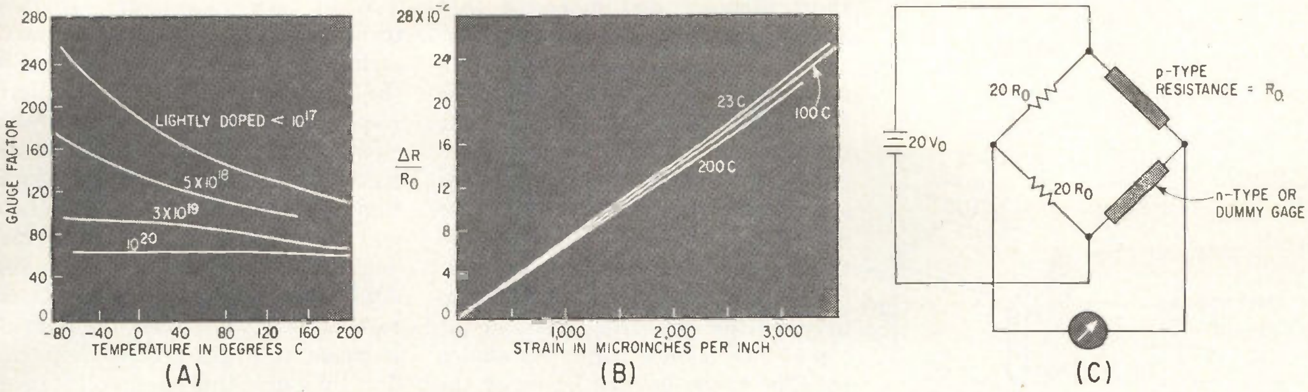


FIG. 3—Gage factor of a highly doped semiconductor is nearly independent of temperature (A) and (B). Special bridge circuit (C) improves linearity of measurement

lographic axes raises the value of the energy surfaces along the direction of stress and lowers the values for the four wells perpendicular to the stress. This is indicated by the dashed lines (Fig. 2), which show energy surfaces for like energies. Since the wells perpendicular to the stress have lower energies, more electrons congregate in these wells than in the wells parallel to the stress. If an electric field is applied in the same direction as the stress, then, since the four perpendicular wells have higher mobilities along the direction of the field and have more electrons, the resistivity decreases as the tension increases. The effect is about 90 times as large as in a metal strain gage. For a field applied perpendicular to the stress, the resistivity increases only half as much as when stress and field are in the same direction. The third type of stress that can be applied in a plane, a shearing strain in the x,y plane, is equivalent to a tension at 45 degrees to the x,y axes and a compression perpendicular to the tension. From symmetry considerations, it can be shown that such a stress affects all the valleys in the same amount and, hence, produces no effect.

For *n*-type germanium the energy surfaces lie along the four cube-diagonals (111 directions), and are most sensitive to a stress in this direction. Tension or compression along a crystallographic axis produces no effect. Both *p*-type silicon and germanium have the same symmetry relations as *n*-type germanium, but the change in resistance is of opposite sign; that is, resistance increases when the material is in tension. Most sensitive of all the materials is *p*-type silicon. Since it has a higher yield stress and will work to higher temperatures, it is the preferred material for semiconductor strain gages.

Although piezoresistance has been known for some time, it is only begining to be applied in practical transducers. This is partly due to the lack of sources of supply and also because the stability of available material was not as good as that of conventional strain gages. By increasing doping levels, it has been shown that the gage factor can be made nearly independent of the temperature. Figure 3A shows the gage factor (change in resistance divided by the initial resistance times the strain) plotted as a function of temperature for *p*-type silicon doped by boron. High doping levels produce a gage factor that changes only slightly with temperature. From Fig. 1B, the initial resistivity increases with temperature, so the change in resistance, ΔR, is more constant than either the resistivity or the gage factor. Further, high doping levels increase the linearity of the change of resistance with strain. Figure 3B shows the percentage change in resistance as a function of strain for the most highly doped sample of Fig. 3A. Linearity is good up to strains of 2,500 microinches per inch and deviates only slightly up to strains of 3,500 microinches per inch. For gages whose thickness is 0.002 or less, strains as high as 5,000 microinches per inch are possible.

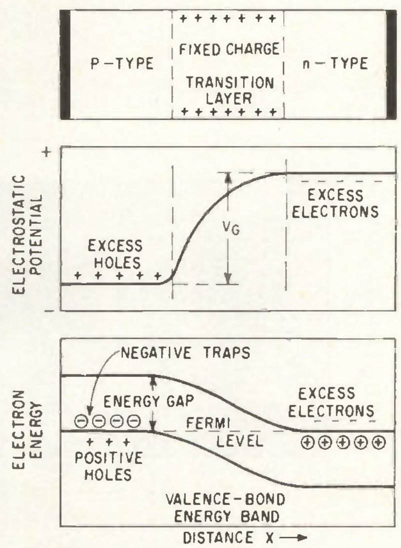


FIG. 4—Depletion layer separates excess electrons on p side from excess holes on n side

One difficulty with semiconductor strain gages is their large change in resistance, which introduces some nonlinearities in wheatstone bridge measurements. Special circuits, such as Fig. 3C, have been devised to make use of these new types of gages.

The newest types of semiconductor transducers use the properties of semiconductor *p-n* junctions. A *p-n* junction, as shown by Fig. 4, contains a *p*-type region, a transition region and an *n*-type region. Junctions can be made by diffusing a layer of *p*-type material into a sample having *n*-type conductivity, and conversely. For thin, highly doped specimens as in Esaki diodes, an aluminum wire loaded with 1 percent boron can be alloyed into a highly doped semiconductor crystal. The boron penetrates for a

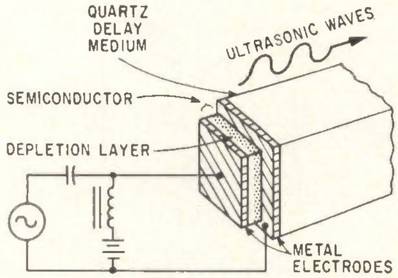


FIG. 5—High-frequency ultrasonic transducer uses depletion layer

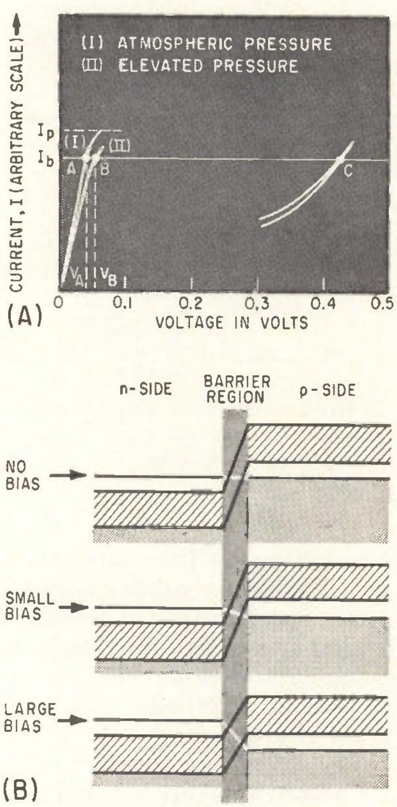


FIG. 6—Effect of pressure (15,000 psi) on Esaki diode (A). Energy relationships (B) for first positive resistance region (no bias) of Esaki diode, negative resistance region (small bias), and second positive resistance region

short distance and makes a thin *p-n* junction.

The energy band structure of a *p-n* junction is determined by the fact that the Fermi surface for the two types of materials must coincide. For lightly doped specimens the Fermi surface of the *n*-type material is between donor level and the bottom of the conduction band; for *p*-type, the Fermi surface is between the impurity level and the top of the valence band. As shown by Fig. 4, the energy levels of the *p* end are raised with respect to the *n* section by nearly the amount of the energy gap. The excess electrons on the *n* side are separated from the excess holes on the *p* side by a depletion layer, from which all electrons and holes are removed. This is the result of the high electric field set up across the layer; the field is oriented to repel both electrons and holes.

The width of the depletion layer is

$$t = \sqrt{\frac{(V - V_G)\,2\epsilon}{en}} \qquad (1)$$

where V is the applied field, V_G the built-in field across the gap (V_G is negative), ϵ the dielectric constant (farads per cm), e the electronic charge (1.6×10^{-19} coulomb), and n the number of impurity levels. For a lightly doped sample having 10^{17} atoms per cc, for example, silicon with a relative dielectric constant of 13 will have a thickness of 1.25×10^{-5} cm. The thickness can be adjusted somewhat with the applied field V.

If the semiconductor is one of the III-V compounds such as gallium antimonide, or a II-VI compound such as cadmium sulphide or zinc oxide, it will have the type of symmetry that makes it piezoelectric. Hence, an alternating voltage applied across the *p-n* junction will produce a piezoelectric wave that will travel down the rest of the sample. Because of the small thickness of the *p-n* junction, such transducers will probably operate from about 5×10^8 to 10^{10} cps. Such frequencies are applicable in delay lines carrying large amounts of information and in light modulating devices in high-frequency communication systems. Figure 5 shows a proposed transducer for such uses.

When forward voltages (positive terminals to *p* side and negative terminals to *n* side) are applied to the junction, the height of the barrier is reduced and considerable current can flow in the positive direction because of thermal agitation of the carriers. A reverse field will cause an increase in the barrier height and will reduce the current flow. Hence, *p-n* junctions act as rectifiers. If, however, the barrier is made thin enough, current can flow by a quantum mechanical process, which allows the electrons or holes to tunnel through the barrier. As can be seen from Eq. 1, the way to make a thin barrier is to use a high doping level, n. For example, for 5×10^{19} impurity atoms per cc, the thickness becomes of the order of 60 Angstroms or 6×10^{-7} cm.

The current through such a junction can be expressed by

$$i = AP$$

where $P = e^{-k\sqrt{M}\,t\,\sqrt{W}}$. In this equation A is a constant containing factors such as the number of carriers available to attempt the tunneling process and their frequency of attempting it; P is the probability of successful tunneling, which depends on M (the ratio of the effective mass of the electron to its mass in free space), t the thickness, and W the energy gap. For t in Angstroms and W in electron volts, k is 0.34. Hence, for germanium with a 60 A thickness the probability becomes $e^{-7.62}$, or one chance in 2,000. This tunneling probability is relatively independent of temperature.

A plot of the current of a thin *p-n* junction (Esaki diode) against voltage gives the typical curve I of Fig. 6A. In the first region current increase is proportional to applied voltage. The current reaches a maximum at I_p, then decreases as the voltage increases (negative resistance region) down to a lower value after which it rises again (second positive resistance region). This behavior is a consequence of factor A in Eq. 2. The value of A depends on the number of available states for tunneling, since for an electron to tunnel through the barrier there must be a vacant state on the other side to receive it.

Figure 6B is a representation of the energy-band structure for an

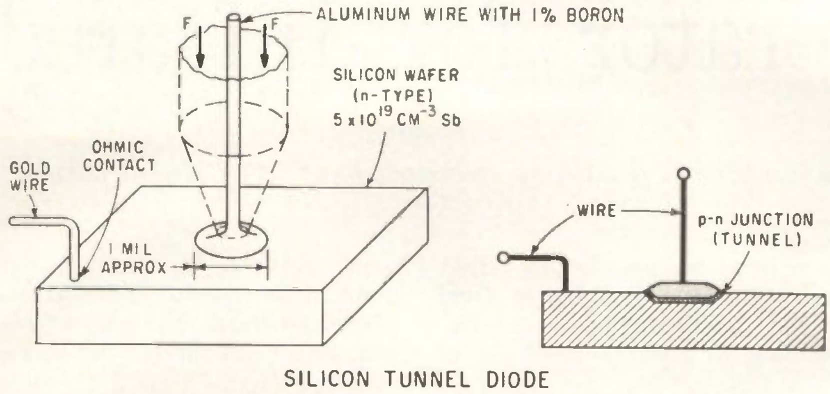


FIG. 7—Technique for making silicon tunnel diode

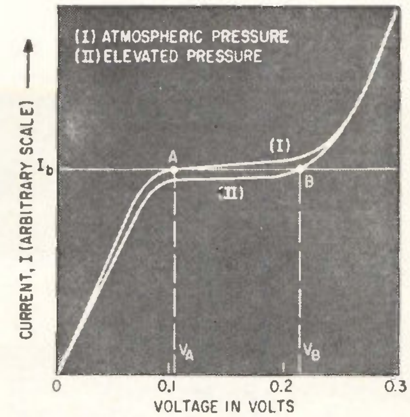


FIG. 8—Resistance in parallel with a tunnel diode allows a gage factor as high as 30,000

Esaki diode as a function of applied voltage. For the top figure, representing no bias, the *n* region has a filled valence band up to the forbidden energy gap (shown by the cross-hatched lines) since there are essentially no holes present at room temperature. The conduction band has a large number of electrons, shown by the shaded area, and the Fermi level is on top of this band. On the other side of the barrier region, which is raised in energy value because of the voltage gradient across the barrier, there are practically no electrons in the conduction band since the conduction is by holes. There is, however, an empty space above the valence band where electrons can exist since, in this region, if present, they would cancel holes and raise the band levels.

For no bias, electrons could flow along the line between the two sides; but since the band levels are determined by a constant Fermi level between sides there are no vacant states opposite the filled states; therefore no current flows. When small voltages are applied, the right-hand side is lowered and empty states are opposite filled states and current can flow. The maximum flow occurs when the empty state region covers the greatest area of filled regions. A still higher bias causes the empty region to be lower than the filled region and the tunneling current decreases as the voltage increases. This is the negative resistance region. Finally when the barrier gets low enough, electrons can jump the barrier under the effect of thermal agitation and the current increases again as in an ordinary *p-n* junction rectifier; this is the second positive region.

To be of use as a stress transducer, one or more of the parameters must change with stress. The only ones appreciably affected are thickness, energy gap and the effective mass; thus the tunneling probability is affected. The largest changes occur in the energy gap and the effective mass. For the following semiconductor materials, a hydrostatic pressure of 20,000 psi changes the peak current I_p by (in percent): Si, + 2.5; Ge, − 15; GaAs, −20; GaSb, −39.

Curve II of Fig. 6A shows the effect of a hydrostatic pressure of 1,000 atmospheres (15,000 psi) on a germanium diode. The slope changes and the peak current is reduced by about 11 percent. One use for such a device, suggested by W. G. Pfann of Bell Laboratories, is as a pressure alarm device. If a constant current I_b flows through the device (Fig. 6A), and pressure lowers the peak of the characteristic curve to the current I_b or below, the device will switch to point *C*, with a much larger voltage drop across it.

The device can also be used to measure pressure. With a constant current I_b going through the device, the voltage will change from V_A to V_B as pressure is applied. Sensitivity is given by

$$\frac{\Delta R}{R \times S} = \frac{(V_B - V_A)}{V_A \times (p/B)} \approx 100 \text{ to } 300$$

where 100 is typical for germanium and 300 for gallium antimonide. Quantity *B* is the bulk modulus for the semiconductor. Hence, these materials have the same order of sensitivity for hydrostatic pressure as silicon for a longitudinal stress. However, there is no necessity for limiting the action to hydrostatic pressure. Figure 7 shows a simple way of making these diodes by alloying an aluminum wire with 1 percent boron to a semiconductor wafer with a high doping. An active area can be made as small as 0.001 inch in diameter. By attaching this active area to a horn or diaphragm, a pressure multiplication factor of 10^6 is easily obtained; such devices are competitive with other methods of pressure measurement or pick-up.

Greater sensitivity can be obtained by using the negative resistance portion of the characteristic. By putting a resistance in parallel with the diode, the sum of the characteristics can be made equal to curve I of Fig. 8. The effect of a pressure is to lower the characteristic to curve II and the voltage change V_B-V_A becomes much larger. By adjusting the input current and the parelleling resistance, gage factors as high as 30,000 can be obtained. This application requires a well-controlled, constant-input current I_b and good temperature stability of the characteristics. Such characteristics can be obtained with zener diode voltage stability coupled with a temperature insensitive tunneling probability.

Signal Generator for Infrared

Electronic and optical techniques combine to produce a monitored infrared signal between

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GENERATION AND DETECTION of energy in the infrared region has become increasingly important in both military and industrial applications. An infrared signal generator recently developed provides an output signal continuously variable from one to fourteen microns, corresponding to about 300,000 Gc to 20,000 Gc.

The infrared signal generator, photo, is used in development, testing and maintenance of infrared detectors, communications systems, target seekers, tracking systems, surveillance systems, and satellites.

The generator has an internal modulator that amplitude modulates the output signal from 2 cps to 2.6 Kc, a step attenuator with a 10^7-to-1 range, a 10-to-1 vernier attenuator, and an output power monitor.

Although the infrared signal

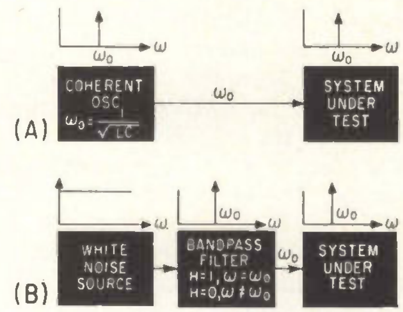
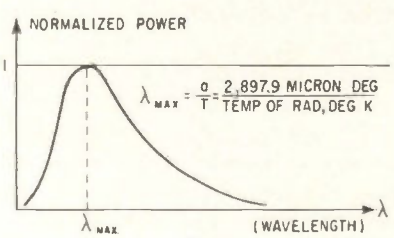
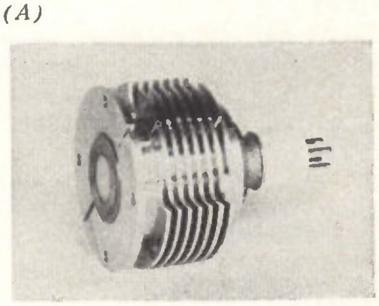


FIG. 1—Generation of a signal by a coherent oscillator, (A); by a noise source and bandpass filter, (B)

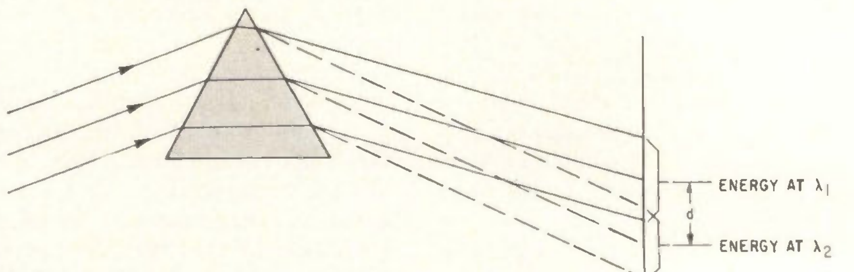


(A)

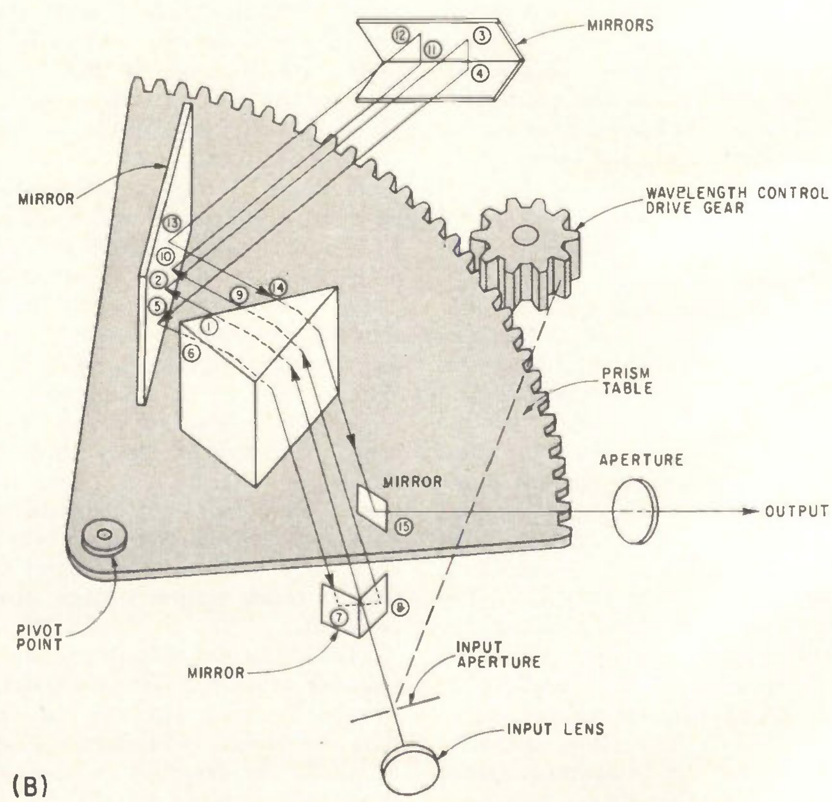


(B)

FIG. 2—(A) Black-body radiation curve, given by Planck's equation; (B), the infrared noise source



(A)



(B)

FIG. 3—(A) Single-pass monochromator. Distance d is to be kept as large as possible. This is done in the compact four-pass monochromator, (B)

Region

1 and 14 microns

Infrared signal generator is operated by Telewave manager, Alan Ross. Wavelength dial is calibrated in 0.2-micron steps, output radiation at 5 microns has power of 1 microwatt, spectral profile 0.35 microns wide

generator is analogous to an r-f signal generator, the method of producing the signal is different. At radio frequencies, a tuned coherent oscillator generates the carrier signal. At infrared frequencies the values of inductance and capacitance, or the dimensions of a resonant cavity, become so small that construction is impossible.

One solution is to filter all but the desired frequency from a noise source. An ideal filter has a transfer function of zero for all frequencies except the one desired; thus the output of a noise source with filter appears to be the same as a coherent oscillator. Practically, the transfer function has a finite slope and the output is a band of frequencies whose bandwidth is controlled by the design of the filter (see Fig. 1).

Conventionally, the source is a glowing ceramic rod or a cavity-type black body. Neither of these are white-noise sources. The ceramic glower has a restricted operating range and mechanical fragility. Although the cavity source overcomes these difficulties, it takes a long time to reach a steady state because of its large thermal mass. Figure 2A illustrates the energy distribution of a black body as given by Planck's equation.

Because no suitable sources were commercially available, a new noise source was developed: a hermetically sealed tungsten filament lamp. Having a small thermal mass, this lamp offers fast response and is as rugged as a conventional photographic projection lamp. Figure 2B shows the lamp in a heat dissipating mounting. This lamp is not a white noise source; its energy is also given by Planck's equation. A true white noise source is impossible because it demands that the source supply infinite energy.

It was next necessary to design a bandpass filter to select the desired infrared wavelength. An electronic filter could not be built for the same reasons that a coherent oscillator is impractical.

The bandpass filter is a monochromator, shown in Fig. 3A. Light incident on the input surface of a prism is refracted because the refractive index of the prism material is different from that of air. The amount of bending depends on the wavelength of the light. At the exit surface, the light is again bent. This bending causes different wavelengths to travel in different directions. The amount of separation between the shortest and longest wavelengths, distance d in Fig. 3A, is related to the dispersion of the prism, which is a property of the material and the prism dimensions. If an exit plate with a small aperture is placed after the prism, then only those wavelengths that coincide with the aperture will appear at the output.

Distance d determines the resolution of the monochromator. Since the angular dispersion is a constant of the prism, the only way in which this distance can be increased is to increase the path length from the prism to the exit aperture, yielding large physical dimensions for the monochromator. Another method is to reduce the aperture size, but this reduces output power. The approach used was to pass the beam through the prism several times, as shown in Fig. 3B, thus increasing the angular dispersion and decreasing the required path length for a given linear dispersion.

A variable aperture at the monochromator input reduces the power variation over the band and compensates for variations in prism resolution. This aperture is ganged to the wavelength control by a cam. Wavelength is adjusted by rotating the table that carries the prism, resulting in a small and mechanically simple monochromator.

Since glass does not transmit infrared, it is necessary to use materials such as rock salt or potassium bromide for all transmitting optics. These materials are water soluble and sensitive to humidity; the monochromator chamber therefore must be kept dry with silica gel.

The monochromator assembly also contains step attenuators, which are insensitive to wavelength variation and have 10-percent transmission. Three attenuators can be inserted into the optical path to attenuate the beam in steps of 10 to 10^7. (The beam can pass up to four times through the same attenuator.) A vernier attenuator provides another factor of ten by varying the intensity of the source. Figure 4 shows the complete signal generator.

The infrared signal is modulated by a rotating chopper that interrupts the monochromator input. The modulation frequency is controlled by a velocity servo driving the chopper. The servo loop has a

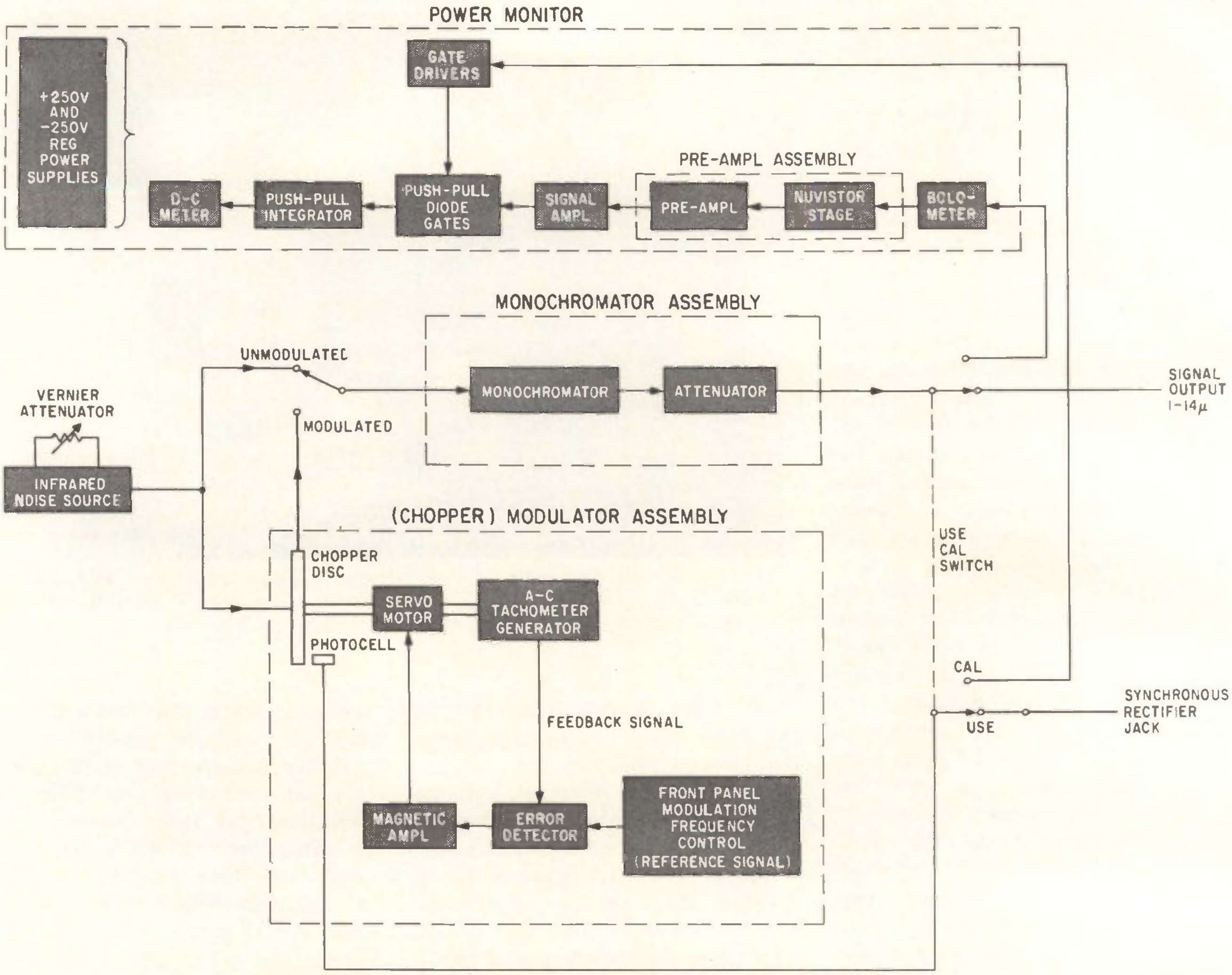


FIG. 4—Infrared signal generator, showing the principal assemblies and their circuits

two-phase servomotor, bridge-type error detector using a tachometer for the error signal, potentiometer for setting the reference voltage and a magnetic amplifier. For low-power-level measurements, a synchronous rectifier, controlled by the chopper assembly, can be connected at the front panel to an external detection system. The rectifier is a photoresistive cell with a dark-to-light resistance ratio of over 10,000 to 1, illuminated by a pilot lamp mounted at the chopper rim. The synchronous rectifier is available only in the 2 to 70-cps modulation range; it is not used at higher modulation frequencies because of bandwidth considerations.

The power monitor circuit, Fig. 5, contains a thermistor bolometer transducer, low-noise nuvistor preamplifier, synchronous detector meter and two highly regulated power supplies. The block diagram for this circuit is presented in Fig. 4.

The bolometer consists of two temperature-sensitive semiconducting resistors (thermistors), one exposed to the signal, and the other kept dark to cancel temperature effects. They are connected in series and biased by positive and negative 250-volt power supplies which are virtually free of hum and noise.

The signal obtained from the junction of the two thermistors is resistance-capacitance coupled to the nuvistor triode preamplifier. Because of the small size of the tube elements and the rigid mounting, the resonant frequency of the tube elements is in the kilocycle range, far above the region of interest. To improve the preamplifier's immunity to line transients that pass through the regulators, the first stage is a difference amplifier. The signal for one grid is derived from the bolometer; the other grid is connected to the output of the power supplies through capacitors. This results in a bridge with the difference amplifier driven by the unbalance signal.

Since the bridge is initially balanced, any transient that causes the voltage of one supply to change relative to ground will cause only a shift in d-c output level, while maintaining balance across the bridge. This shift is applied to both grids of the difference amplifier as a common-mode signal and appears at the output attenuated by the common-mode rejection ratio of the difference amplifier. The desired signal affects only one arm of the bridge, resulting in an unbalance signal which is applied to only one grid and amplified. If the transient changes the total bias across the bridge, the bridge stays balanced while maintaining the same output d-c level, so that there is no signal.

Negative feedback stabilizes the gain against changes caused by component variation with aging

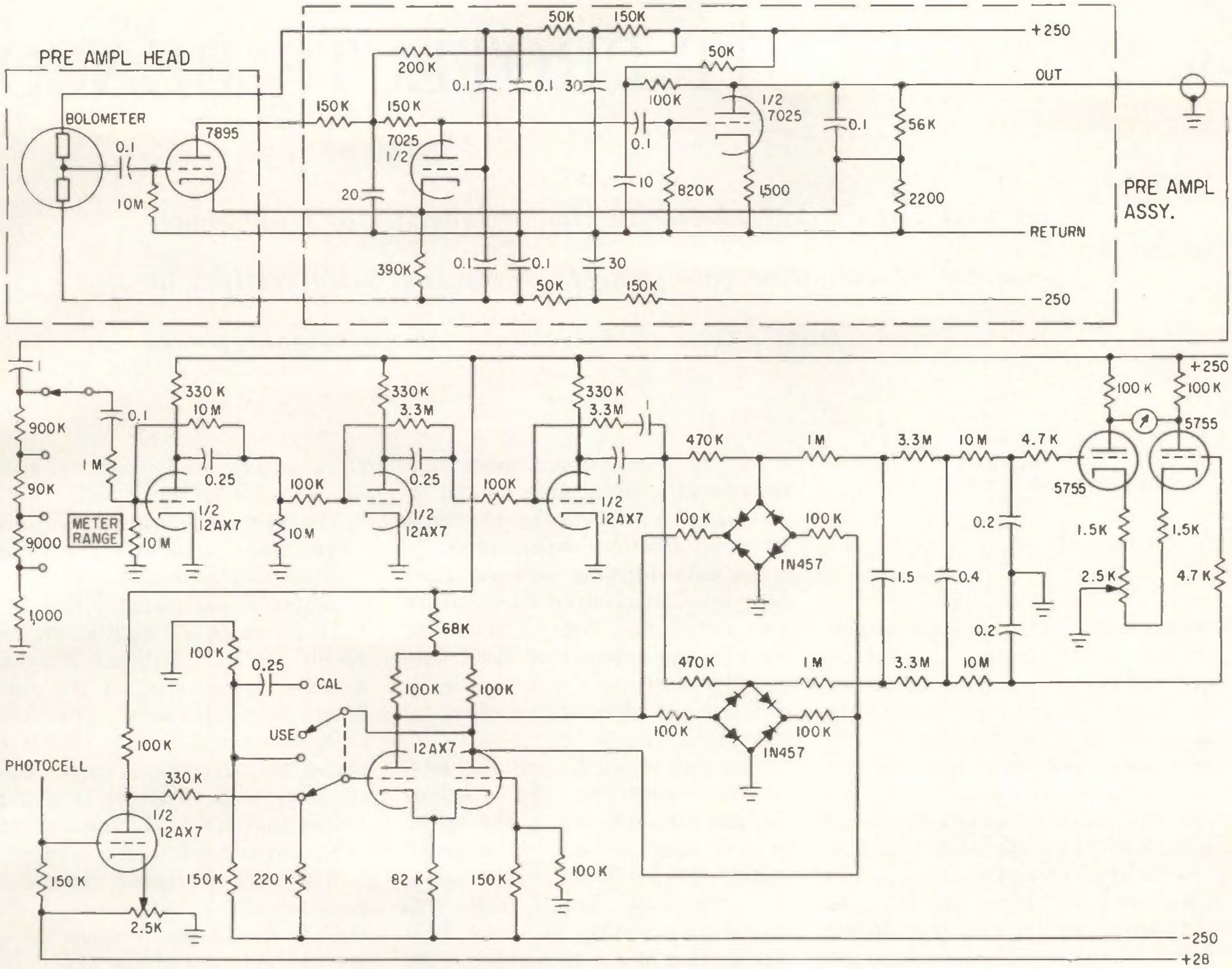


FIG. 5—Power monitor uses a bolometer head (upper left) and nuvistor preamplifier

and temperature change.

The bolometer, grid coupling network and nuvistor are in a small shielded box that is moved in and out of the monochromator output by a linkage actuated by a USE-CALIBRATE control. The USE-CALIBRATE control also transfers the synchronous rectifier to the internal detector.

The rest of the power monitor is on a subchassis mounted in back of the meter. It includes the signal amplifier, two four-diode gates for push-pull rectification and drivers for the gates. Both the positive and negative supplies are used for the gate drivers so that the quiescent plate voltage is zero. Thus the gates need not be capacitively coupled to the driver.

With the internal metering circuit disabled, the driver circuit is a free-running multivibrator. This actuates the gates, keeping the meter needle from quivering.

All bodies radiate energy because of their temperature. At moderate temperatures, part of this radiant energy is in the infrared region. Thus it is necessary to distinguish between this undesired background radiation and the generated signal. If the generated signal is large, the background may not be objectionable because it is a small part of the total. However, with an attenuation range of 10^8 to 1, the signal may be much smaller than the background. Thus synchronous detection is used.

Since noise is completely random, the output of a noise source integrated over a long period of time is zero

$\int_0^T$ (noise $dt = 0$ (T large)

However, the output of the generator is modulated with a square wave. Therefore

$\int_0^T$(modulated output)$dt = \frac{1}{2}$ the peak-to-peak value of the modulated signal (T large)

This is a linear system and the principle of superposition holds

$\int_0^T$(modulated output + noise)dt = $\int_0^T$(modulated output)dt + $\int_0^T$(noise)dt (T large)

which is one-half the amplitude of the square-wave modulated signal.

As long as the system is linear, the noise is cancelled. Thus it is possible to detect signals buried in background noise.

The chopper servo keeps the modulation frequency constant, and the wide range of modulation frequencies available, 2 cps to 2.6 Kc. permits measurement of frequency response. The servo also enables the modulator to return to steady state rapidly after a change in modulation frequency, since the drive from the feedback loop compensates for the rotational inertia of the chopper.

The author acknowledges the assistance of Alan Ross, general manager of Telewave Laboratories.

GATE CIRCUIT PROTECTS BEACON

Lockout circuit prevents inadvertent triggering of transponder modulators. Negative gate protects silicon controlled rectifier or power supply from effects of too closely spaced trigger pulses

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PREMATURE TRIGGERING can be prevented in missile-tracking beacon radars that use a conventional d-c resonance-charging type modulator. A solid-state lockout circuit has been developed that keeps strong echoes and unsynchronized radars from causing malfunctions of transponders on the launching pad.

This type of circuit failure has been eliminated by adding the lockout circuit, Fig. 1A, to the conventional modulator, Fig. 1B. This addition provides an automatic negative gate signal which prevents inadvertent triggering during the recovery time.

In the conventional modulator, the charging inductance L_c and its associated resistance, together with the total effective capacitance, C_N, of the pulse-forming network (pfn) form an underdamped RLC circuit. The inductance and resistance of the pfn and primary of the modulation transformer are negligible compared to that of the charging inductor.

Application of E_{BB} to the RLC circuit results in the familiar damped sinusoid where the initial peak voltage approaches approximately $2E_{BB}$. Diode D_c in series with the RLC circuit holds this initial high voltage at about $2E_{BB}$. Application of E_{BB} thus charges the capacitance of the pfn to V_1 of about $2E_{BB}$. The pfn stores this energy, $1/2CE^2$, so that the discharge waveshape approximates a rectangular pulse—usually of about one microsecond duration.

The pfn may take many forms where the E type or parallel combination or series *LC*, are used. Frequencies associated with L_1, C_1; L_3, C_3; and L_5, C_5 in Fig. 1B represent the 1st, 3rd and 5th harmonics, respectively, of the simulated rectangular pulse. The silicon controlled rectifier scr switch replaces its thermionic counterpart, the thyratron. The scr is a pnpn device that blocks V_1 until a trigger pulse is applied at the gate.

With such a trigger, the scr appears as a low impedance so that the pfn discharges through the scr and the primary of the modulation transformer. The modulation transformer steps up the pulse voltage to a value required for transmitter operation. The scr reverts to its

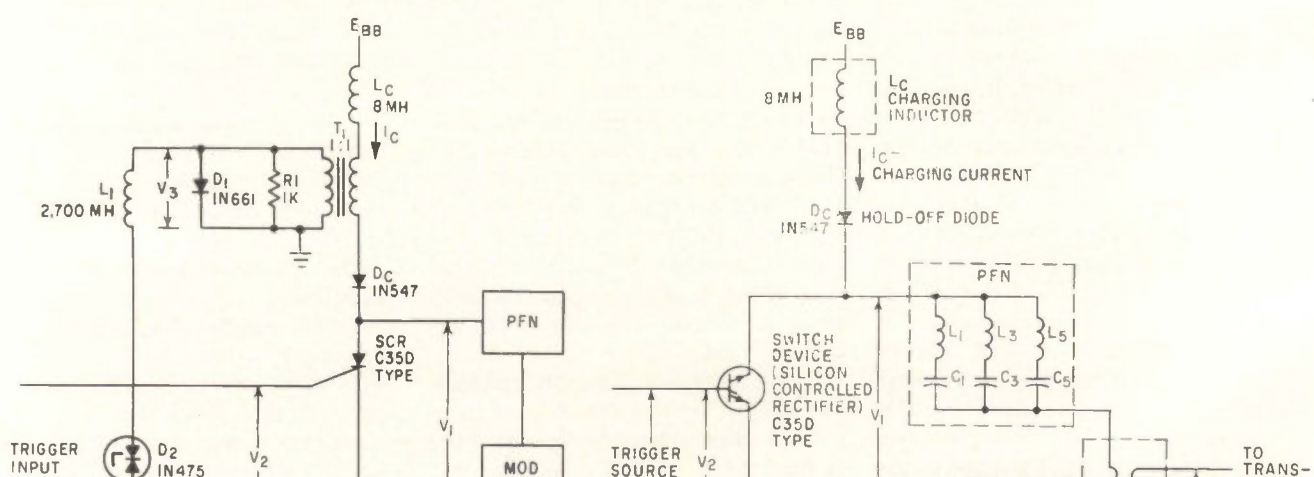
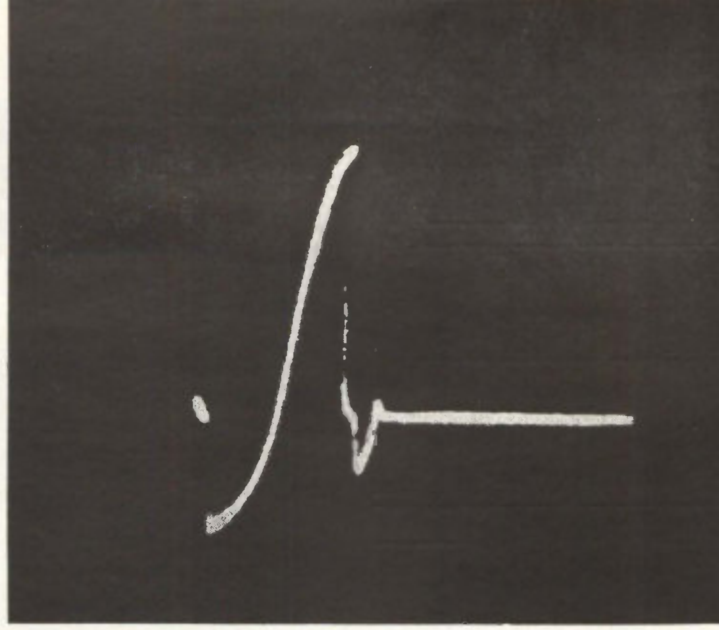


FIG. 1—Lockout circuit additions (A) to conventional d-c resonant charging type modulator circuit (B) consist of T_1, D_1, D_2, L_1 and R_1. Added circuit introduces a negative inhibit gate at the scr gate during critical period when false triggering occur

MODULATORS



Oscilloscope sweep shows failure mode of scr caused by premature recharging

high-impedance state when the current through it drops below the holding current level. At this point, capacitance of the pfn again charges to V_1 at a rate determined by L_c and C_N.

Figure 2A shows typical waveforms associated with the conventional modulator circuit. The approximate value $2E_{BB}$ is reached at T_1, usually in about 50 to 100 microseconds. The negative portion of V_1 is the result of the biased-diode nature of the transmitter, which, together with the shunt inductance of the primary of the modulation transformer, cause the unexpended $1/2LI^2$ to appear across the switch as a negative-going voltage.

The rate at which $2E_{BB}$ is approached must be slow enough to permit complete diffusion of the carriers from the end junctions of the scr. This rate compares roughly with the deionization time required in thyratrons. If insufficient time is allowed for recovery, the scr will not revert to its blocking state and will go into continuous conduction. This will result in destruction of the scr, damage to the power supply or temporary cessation of operation in fail-safe power supplies.

The malfunction caused by triggering during recovery can be explained by considering the charging currents. In Figure 2A the current through the charging choke is shown when the spacing between two pulses, 1 and 2, is sufficient to avoid overlap of the charging currents. In this operation, the charging current is reduced to zero prior to the second firing. In Fig. 2B, however, the spacing has been sufficiently reduced to cause considerable overlap of the charging currents. Therefore, after the completion of the pfn discharge caused by pulse 2, considerable charging current appears at this point.

In Fig. 2B the magnitude of the charging current through the scr is not sufficient to exceed the holding current of the scr since considerable current is shunted in charging the pfn capacitor, C_N, in parallel across the low impedance of the scr, see Figure 3A. However, the presence of an I_{c1} component together with I_{c2} causes V_1 to charge to a higher value and at a faster rate.

The charging current of Fig. 2B indicates that linear charging will occur during the overlap since the

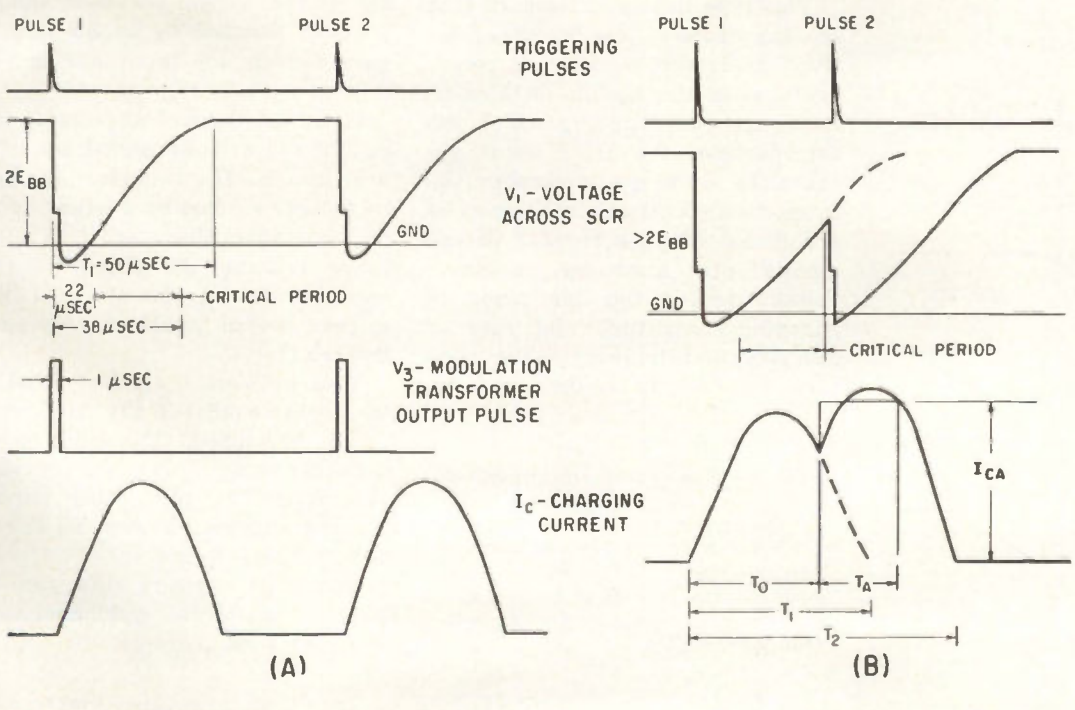
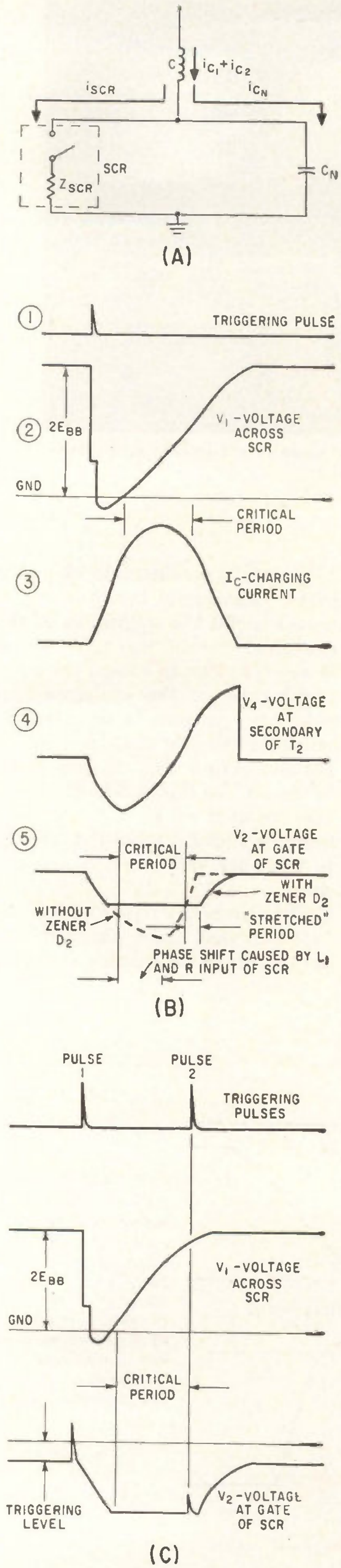


FIG. 2—Waveshapes (A) associated with conventional d-c resonant charging modulator. In (B) the reduced spacing causes considerable overlap of charging current, can destroy scr, or damage the power supply



peak current can be represented as a steady state value, as noted by the dashed lines, with a superimposed ripple.

The charging voltage can, therefore, be approximated as

$$C_c = (1/c) \int_{T_o}^{T_o+T_A} i\,dt \cong \frac{1}{c} I_{CA}$$

during T_A if the ripple is neglected.

If the pulse spacing is further reduced from that shown in Fig. 2B, the charging rate will not permit the scr to revert completely to its original blocking state. Instead at some time during its recharging cycle the carriers in the end junction will not be sufficiently diffused and continuous scr conduction will result.

A photo of this type failure was taken with a memory oscilloscope where the single sweep was initiated by the interjection of pulse 1 before pulse 2. The pulse shows that the charging voltage actually did go above ground by about 40 volts before the failure occurred. The power supply thermal circuit breaker was energized soon after the failure, preventing destruction of the scr or damage to the power supply.

As the spacing to the second pulse is further reduced, the overlap charging current is increased until a component of the residual charging current I_{c1} is sufficient to exceed the holding current of the scr, resulting in continuous conduction immediately upon application of pulse 2.

This type failure extends to that spacing where V_1 just becomes positive. Therefore, during the recovery time of the modulator, a critical range exists during which the introduction of a firing pulse will cause the scr to go into continuous conduction. This critical period is a function of peak current passed during pfn discharge, negative voltage across the scr prior to charging, amplitude and rate of charging, and the junction temperature of the scr. In the described circuit, the critical period takes between 22 to 38 microseconds in a total recovery of about 50 microseconds.

FIG. 3—Equivalent circuit of scr and pfn during recharging with residual charging current from previous charge (A); waveshapes associated with lockout circuit (B); and final waveforms of lockout circuit showing lockout effect at critical period (C)

Normally, the minimum spacing of the triggering pulses is sufficient to avoid difficulty. However, in radar transponders using the d-c resonance-charging modulator, a unique situation exists. While the spacing of the radar pulses is normally sufficient, premature triggering can occur if, at the launching pad, strong echoes appear after the main radar pulse as a result of multipath approaches to the gantry; or if unsynchronized multiple radars are used. While the latter condition is usually manageable, the former condition cannot be controlled readily owing to the proximity of other gantries or structures. The lockout circuit (see Fig. 1A), introduces a negative inhibit gate at the scr gate during the critical period. The circuit uses the voltage induced in the primary of T_1 by the charging current, Fig. 3B-3. The voltage is then transformed to the secondary, Fig. 3B-4. The tendency for ringing is damped by R_1 (Fig. 1). The positive-going portion is removed by D_1.

With zener D_2 removed, the phase shift introduced by L_1 and the equivalent input impedance of the scr optimizes the location of the voltage in reference to the critical period.

The broken-line waveform of Figure 3B-5 shows that the voltage at the critical period is almost properly located to be an inhibit gate for the scr input during the critical period.

However, the second pulse at the end of the critical period can still fire the scr. The negative gate can be further shifted by a larger value of inductance. However, with additional shifting, the location of the second pulse at the start of the critical period would then trigger the scr.

This problem could be solved if the negative pulse in Fig. 3B-5 were merely stretched. The addition of a double anode Zener, D_2, provides this stretching plus other important advantages. Figure 3C shows the final waveforms.

The total recovery time can be reduced considerably, 20 microseconds has been achieved.

Variable pulse-width output of satellite power supply can be seen on the scope

Satellite Power Supply

HAS VARIABLE PULSE WIDTH

Power supply for satellites uses multivibrator for constant frequency and variable pulse-width for regulation. Other features of the short-circuit-proof converter are light weight and high efficiency

By ELLIOT JOSEPHSON
Lockheed Missiles and Space Co., Palo Alto, Calif.

A SATELLITE-BORNE power supply must maintain good regulation over extremes of temperature, operate at high efficiency from widely varying input voltages into changing loads, be short-circuit proof, use a minimum of parts, withstand shock and vibration, and be light in weight.

Specifications for such a supply, shown in the table, are typical and not restrictive. Although d-c input is specified, some space vehicles provide a source of a-c power. However, for efficiency and reliability, it was decided to bypass intermediate equipment and operate directly from the vehicle battery. The circuit is a d-c to d-c converter.

A conventional d-c to d-c converter can be built with the required efficiency, if it is unregulated. Since a series or shunt regulator was out of the question, a modified converter was developed.

In a conventional converter, as the input voltage is increased, the operating frequency also increases. This occurs because a fixed number of volt-seconds is required to saturate the core. For a square hysteresis-loop transformer $Et = k$, where E is the voltage applied to the transformer primary, t is time to switch from one saturated state to the other, and k is determined by core material, configuration, and primary turns.

Hence the frequency changes inversely as the input voltage. If, however, the operating frequency is held constant by introducing a period of offtime after the saturation of each flux reversal,

$$E_{av} = \frac{N_s E t}{N_p T} = \frac{N_s k}{N_p T} = \frac{K}{T}$$

which indicates that the average value of the rectified output E_{av}, is independent of the input voltage.

The required constant-frequency, variable-duration waveform is developed in the circuit of Fig. 1A, where transistors Q_1 and Q_2 are fired alternately by a free-running multivibrator whose period is $2T$. At time 0, the positive-going leading edge of the multivibrator output turns on Q_1 through C_1. A positive voltage is induced in the turnoff winding at the cathode of D_1 to back-bias the diode. Current flows from the multivibrator into the base of Q_1, keeping it on until time t, when the core saturates. At this time the turnoff winding voltage drops to zero. D_1 conducts, and base drive is clamped through the winding to ground, turning off Q_1. Diode D_{1A} compensates for the drop across D_1, assuring a firm turnoff. At time T, the multivibrator changes state, turning on Q_2, and the cycle is repeated.

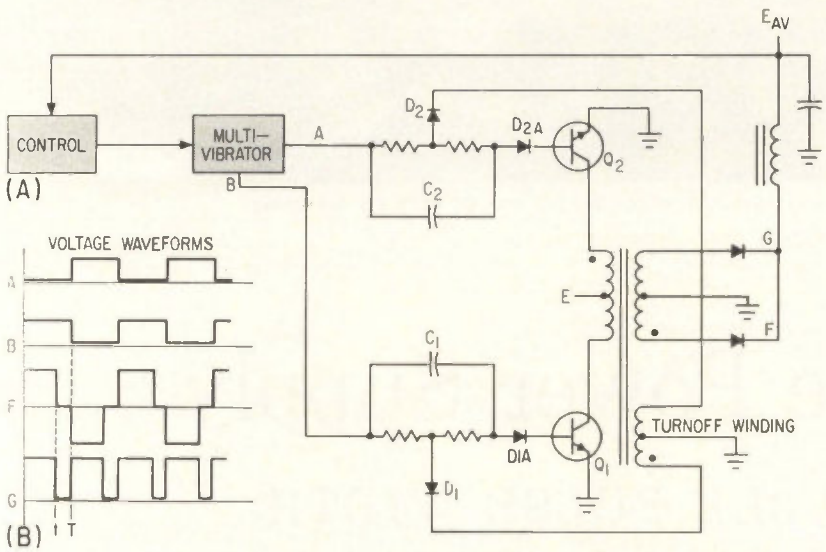


FIG. 1—Waveforms of circuit (B). When the core of the transformer saturates, base drive for the transistors is shunted to ground through D_1 or D_2. Core saturation time is a function of load and supply voltage

The rectified output need only be integrated by an L-C filter to produce a regulated d-c. Regulation is thus accomplished by the transformer core itself, and is sufficient for many applications. However, changes in the output voltage are caused by changes in load, due to choke and rectifier drops; changes in temperature, due to variation of k (k varies about 10 percent from −55 to 100C); or a change in the value of T, caused by multivibrator drift.

Since E_{av} is a function of T, T can be automatically adjusted to provide tighter regulation. The output is sampled and compared to a temperature compensated zener diode in a differential amplifier. Any error signal is used to vary the frequency of the multivibrator, adjusting T to bring the output voltage back to the desired level. Even with unmatched transistors in the differential amplifier, it is feasible to achieve ±1 percent regulation.

Most d-c to d-c converters achieve maximum efficiency at full load only. This is undesirable in a satellite power supply, since full load capability is utilized only during ground contact, a small percentage of the duty cycle.

Declining efficiency is due not so much to the relatively minor fixed lossed in the control circuits, but to the losses in driving the power stage. Since the power transistors must be driven to full-load capability, the drive circuit dissipation can be justified only when the converter is delivering maximum power. It was therefore necessary to provide a base-drive circuit for the switching transistors, that would automatically adjust the base current to the load.

The most desirable base drive mechanism conforms to $I_B = I_C/\beta_{min}$, where I_B is the desired base

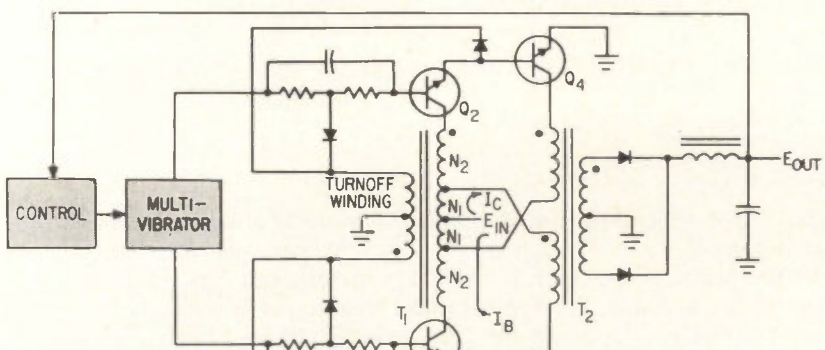


FIG. 2—Efficiency is increased and short-circuit protection is obtained by driving output stage with variable width pulses from Q_1 and Q_2. Only transformer T_1 saturates, not T_2

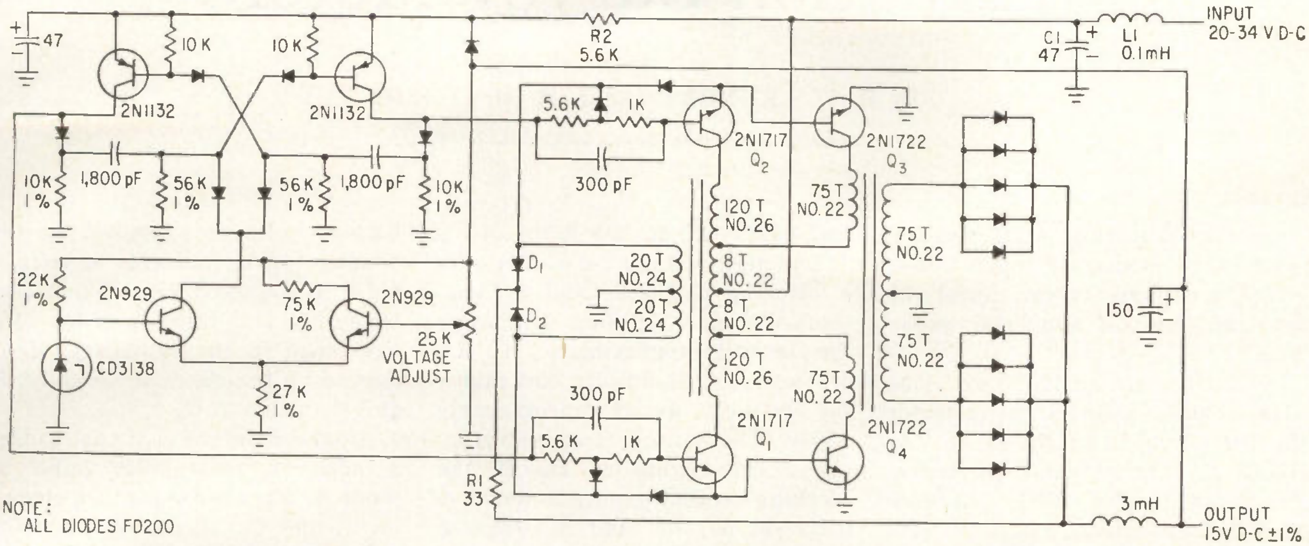


FIG. 3—Complete circuit uses 10-Kc multivibrator and temperature stabilized zener diode

drive current, I_C is the collector or primary current, and β_{min} is the minimum specified current gain of the switching transistor. The load current does not enter into the problem because I_C, the primary current, automatically adjusts itself to the load.

The circuit of Fig. 1 drives a power stage, as shown in Fig. 2. Voltage regulation is accomplished by transformer T_1, and T_2 does not saturate. The input voltage is applied at the primary center tap of T_1 and tapped for the primaries of T_2 as shown. When T_1 primary current is flowing through Q_1, to drive Q_3, the collector current of Q_3 is reflected as a load on transformer T_1, and the T_1 primary current automatically adjusts itself to this load according to the turns ratio. But T_1 primary current is the base drive for Q_3. Hence $I_B = N_1 I_C/(N_1 + N_2)$. By setting $(N_1 + N_2)/N_1 = \beta_{min}$, then $I_B = I_C/\beta_{min}$ $N_2)/N_1 = \beta_{min}$, then $I_B = I_C/\beta_{min}$.

If the load current increases, the immediate result is that current I_C also increases; primary current in transformer T_1 also increases and this in turn causes current I_B to increase. Thus base drive current regulation is both instantaneous and automatic. As a further benefit from the circuit, no power has to be supplied only to be wasted by being dissipated in base drive resistors, and transistors Q_3 and Q_4 are operated at their full power gain.

The complete schematic diagram of the satellite power supply is given in Fig. 3. Operating frequency is set at the relatively high value of 10 Kc, since a high frequency reduces the size and weight of transformers and the components of the filtering portion of the circuit. The circuit is adaptable to frequencies lower than the 10 Kc actually used, and lower frequencies will actually allow somewhat better efficiencies than the curves given in Fig. 4. The input filter to the supply is formed of L_1 and C_1. The main purpose of this filter is to prevent the sharp current steps being drawn by the converter from appearing as hash on the input line.

Diodes D_1, D_2, and resistor R_1 stabilize T_1 by providing a load for the turnoff spike generated at the end of each half cycle. The control circuit is operated from the output voltage, with R_2 for starting.

POWER SUPPLY SPECIFICATIONS

Input voltage—20 to 34 volts dc
Output voltage—15 volts d-c ±1 percent
Output power—5 to 25 watts
Ambient temperature— —55 C to 100 C
Efficiency—80 percent minimum for any operating conditions
Protection—Able to withstand a continuous short circuit without damage. Resume normal operation upon removal of short

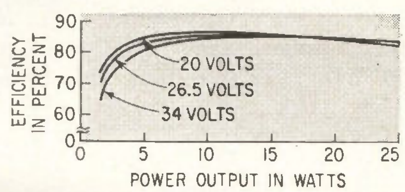


FIG. 4—Efficiency is high, even at low loads, because drive power varies with the load

For a short circuit or overload, Q_1 and Q_2 limit when demands are made for collector current beyond βI_b. In this case no voltage is induced in the turnoff winding of T_1 and the base drive is clamped through the turnoff diode. Hence an attempt is made to fire only during the charging time of the bypass capacitors. Failing this, the power stage remains quiescent for the remainder of the multivibrator half cycle, with no damage to the circuit.

Efficiency is shown in Fig. 4 for three input voltages. A further increase in input voltage serves only to decrease the efficiency. Regulation is within 1 percent until the breakdown voltage of the transistors is reached (about 50 volts input).

The completed breadboard weighs 0.75 lb. Operational size and weight depends on packaging.

The author wishes to acknowledge the assistance and encouragement of C. H. Keller.

Radiation Survey Meter

By R. W. LEHNERT and J. M. McKENZIE

Amperex Electronic Corp., Hicksville, N. Y.

A SMALL RADIATION survey meter with two modes of operation—pulsed and current—can detect the contamination of a nuclear explosion.

In the circuit, an 18503 or 18504 G-M counter tube is the detector for the 0.5 mR to 5 R/hr range. The 18503 is a small gamma-sensitive counter while the 18504 is an end-window beta-sensitive counter with the same gamma sensitivity. The Geiger plateau extends from 425 to 650 v with a slope less than 2 percent per 100 v. Other tube types and their ranges are: 18550—0.5 to 10 R/hr; 18509—6 to 100 R/hr and 18529—20 to 500 R/hr.

The high voltage d-c source uses a blocking oscillator and a Cockcroft-Walton multiplier. Oscillator frequency is approximately 10 Kc. Diodes D_1 to D_4 rectify and multiply the a-c to d-c of approximately 550 v. This output is stabilized by the Zener region of D_1. If the blocking oscillator output tends to increase beyond 140 v, reverse breakdown in diode D_1 occurs.

In pulsed operation (position B of S_2), the G-M pulses are fed to Q_2. Transistor Q_2 acts as a switch, closing every time the G-M tube fires. When firing takes place, full battery voltage is applied to the primary of T_2, inducing a voltage pulse in the secondary. Conduction time of Q_2 and duration of the voltage pulse in the secondary of T_2 depend on the characteristics of T_2 and the value of C_1.

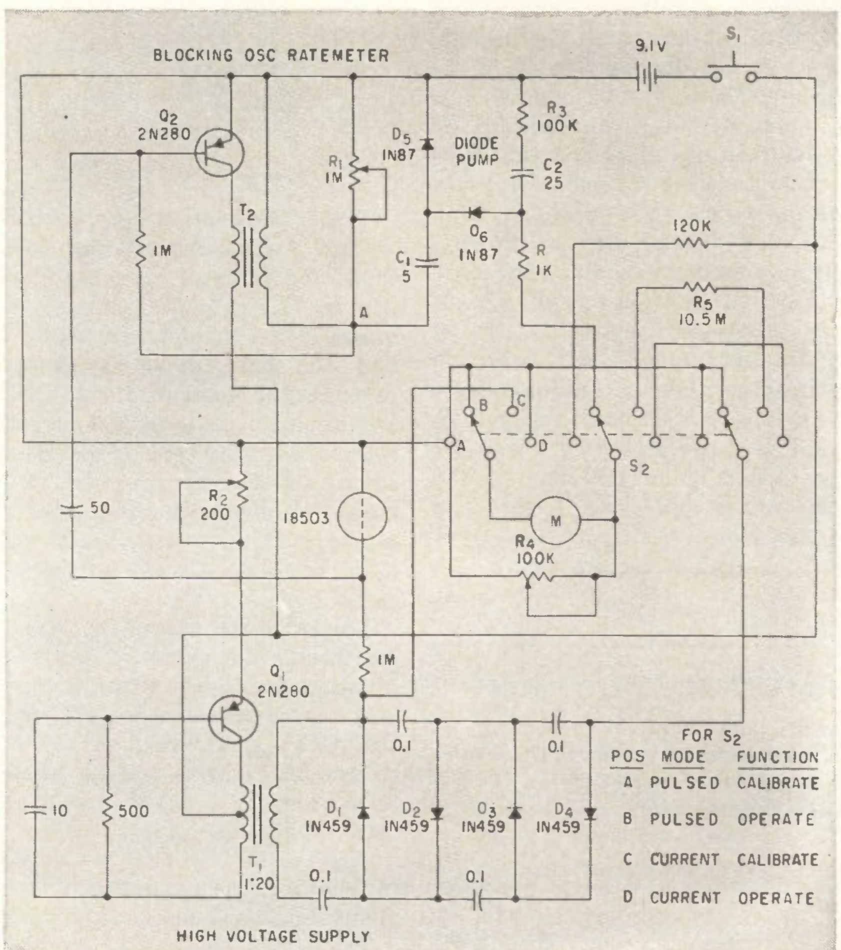
A pulse from the G-M tube causes a negative rectangular pulse at point A. Each pulse places a charge on C_1 and C_2. As pulse repetition rate increases, R_3 slows the charging of C_2. This gives a logarithmic output. (Removing R_3 gives a linear response). The current flows around loop C_2, D_6, C_1 and the secondary of T_2. On the positive half cycle of the blocking oscillator, C_1 discharges through D_5. Capacitor C_2 discharges slowly through R and meter M. At equilibrium, the discharge current of C_2 is equal to the charging current from the pump circuit.

Potentiometer R_4 compensates for a change in battery voltage. To calibrate the instrument, S_2 is placed in position A and R_4 is adjusted until M reads half scale. The instrument is calibrated initially by adjusting R_4 and then setting R_5 to obtain a full scale meter reading in a 50 mR/hr field. Range for pulsed operation is 0.5-50 mR/hr.

In the current mode of operation, the same G-M tube is used and the current in a given radiation field measured. This current in the range of 50 mR to 5R/hr is a logarithmic function of the radiation intensity.

In calibrating in the current mode, meter M in series with R_5 is placed across the high voltage generator when S_1 is in position C. Potentiometer R_2 is varied until the meter reads half scale. There is now 550 v at the output of the high voltage generator.

For a sample of 100 G-M tubes, the probable error of a measurement of radiation field with 550 v anode voltage is 10 percent. The instrument has been packaged in a box 3 in. × 5 in. × 2 in. deep.



Because slope of response curve of both pulsed and current modes are the same, only one meter scale is necessary

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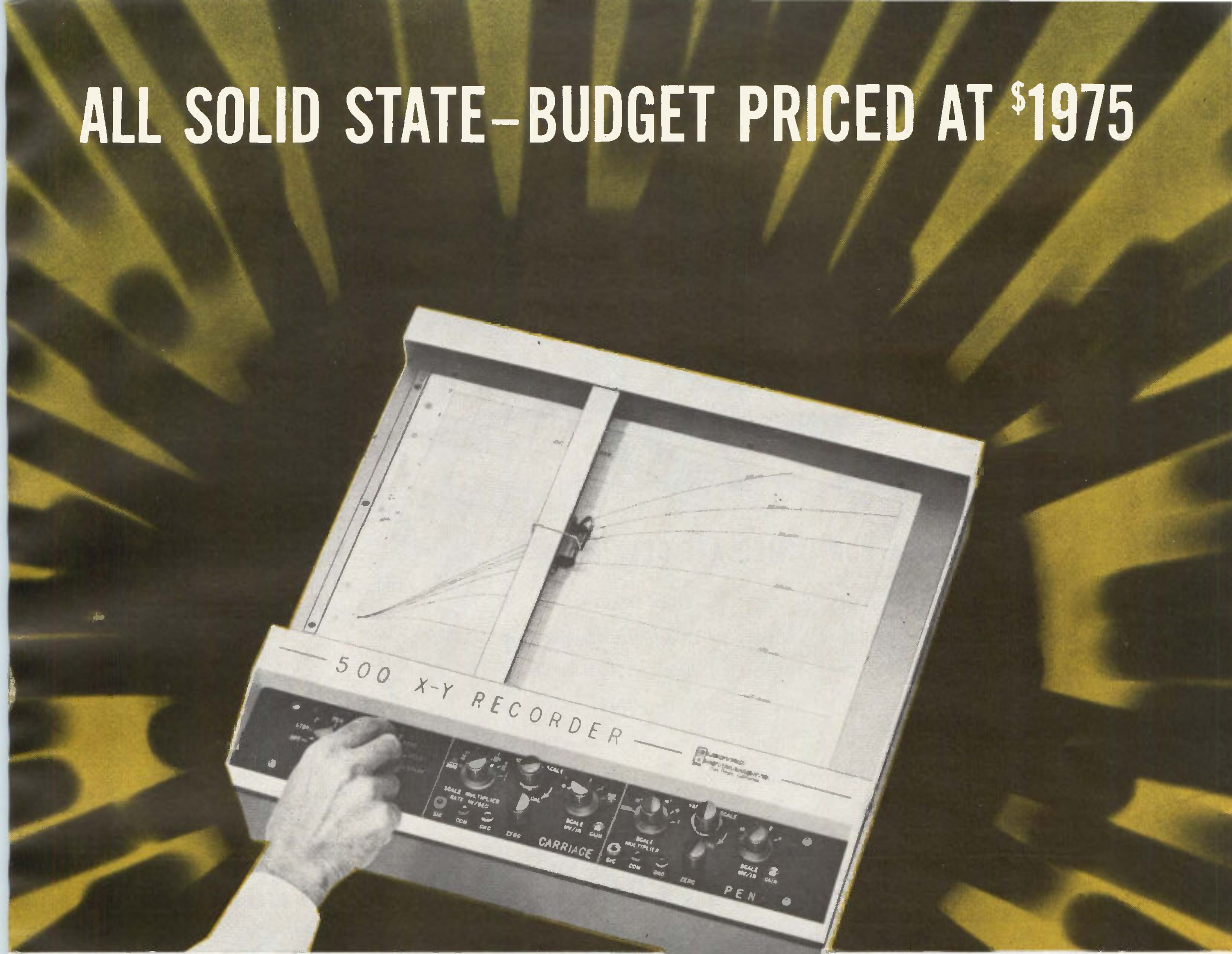

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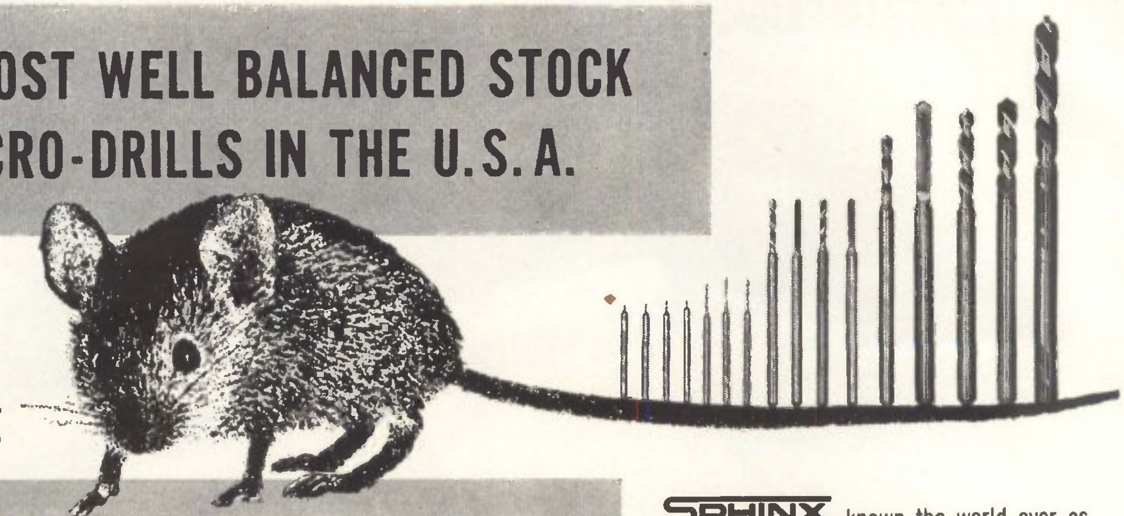

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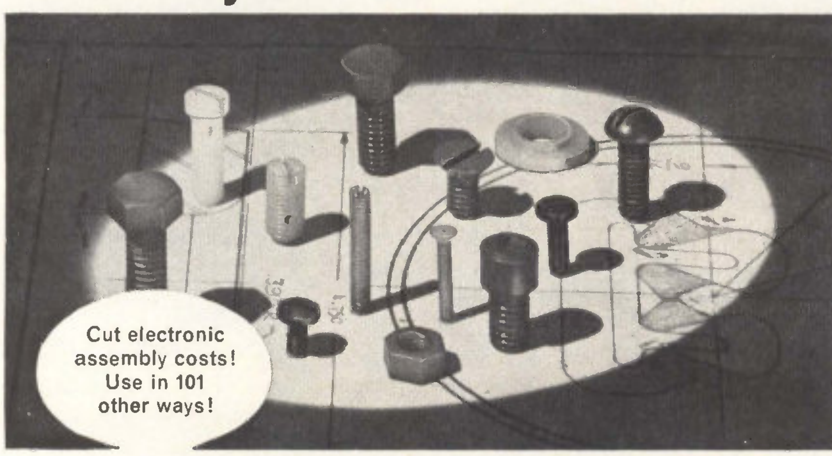

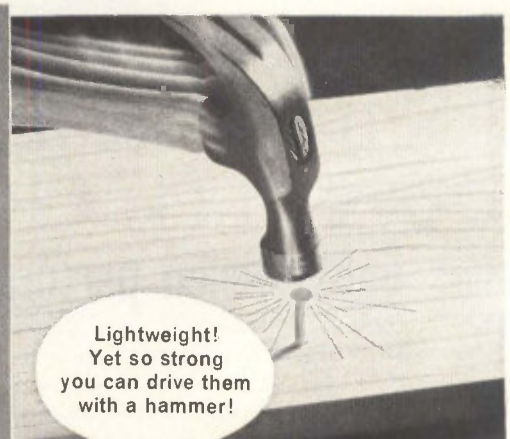

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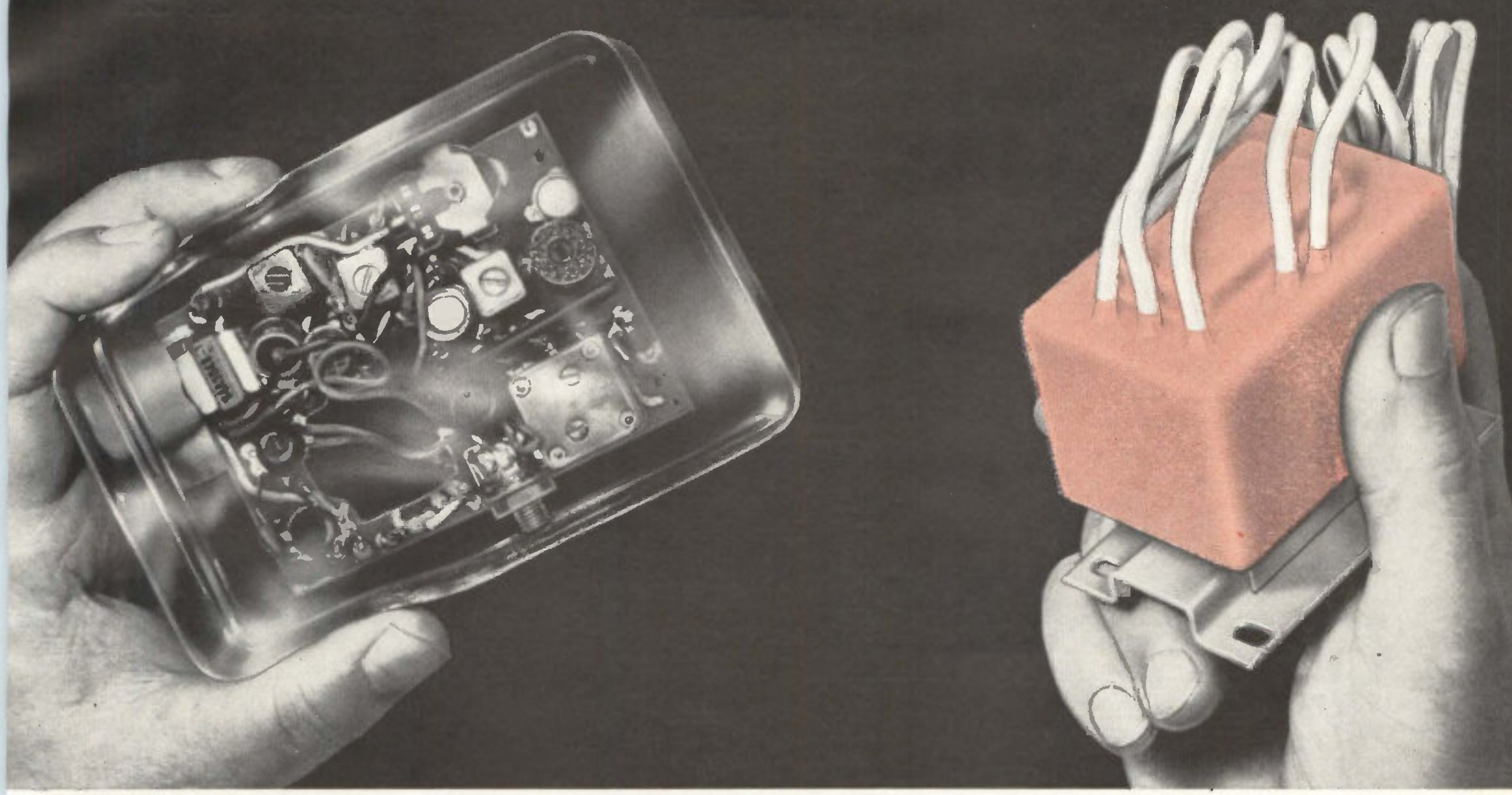

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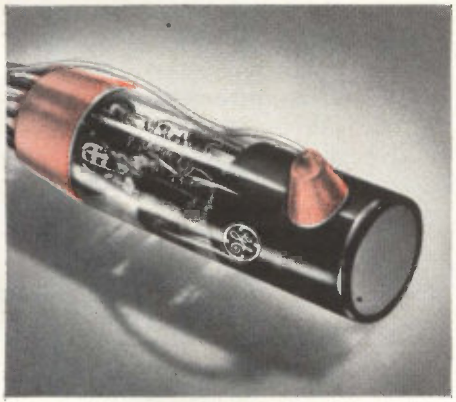

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RTV-20 RTV-40 RTV-60	Pink White Red	300 450 550	Pourable
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RTV-90	Red	12,000	Stiff Paste

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GENERAL ELECTRIC

Experimental Tube Generates Millimeter Waves

EXPERIMENTAL backward wave oscillator tube indicates that existing microwave concepts can be extended to the millimeter wave portion of the spectrum. The tube, designed for operation at frequencies from 50 to 75 Gc, generated 1.6 watts of c-w output power under laboratory conditions.

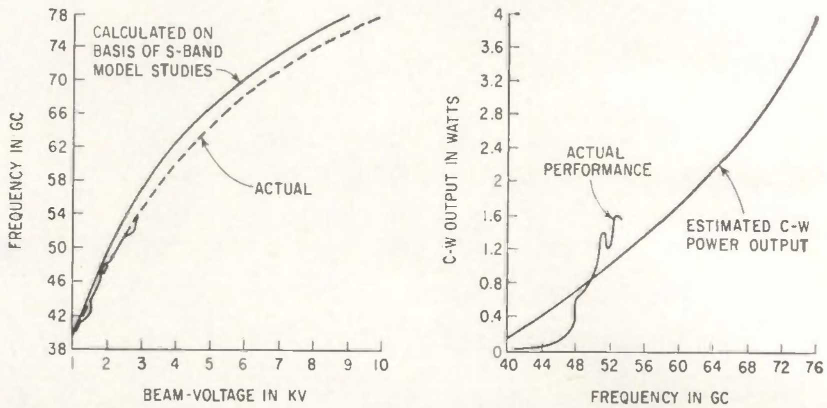

FIG. 1—Frequency as a function of beam voltage is shown at left while at right power output is shown as a function of frequency

It has long been accepted that many interesting and useful systems for research, communications and national defense could be built using the properties of millimeter waves if suitable power sources were available. It has also been assumed that mere extension of existing microwave concepts are entirely inadequate to provide millimeter wave power. Recently it has been shown at Varian Associates, Palo Alto, Calif., that this belief is incorrect. Substantial amounts of c-w power can be generated by judicious extension of present power-tube techniques.

The experiments from which this conclusion was drawn involved testing of the first model of a backward wave oscillator tube. Although the tube was designed to provide one-half watt c-w power in the frequency range from 50 to 75 Gc, it oscillated strongly and generated 1.6 watts c-w in the laboratory tests.

Performance of the experimental tube, designated the VA-171, is shown in Fig. 1. The tube was operated over only part of the desired frequency band because of a faulty ceramic insulator that prevented the application of the full tuning voltage. However, good agreement existed between predicted low-frequency performance and that observed during actual operation. It is therefore reasonable to conclude that subsequent versions of this tube will oscillate at frequencies up to 75 Gc with equal or even greater power output than already obtained.

The significance of the partial success of this tube is that it has given affirmative answers to two basic questions about millimeter-wave power tubes. A small diameter electron beam can be reasonably well focused at power densities of 10^5 watts per cm^2; millimeter-wave circuits capable of withstanding such power densities can be designed and constructed.

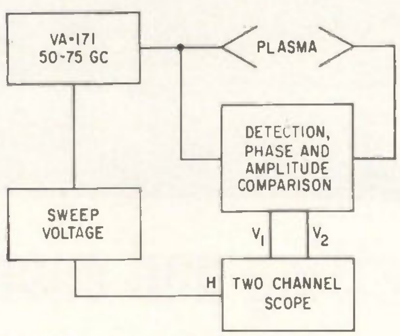

FIG. 2—Typical application of millimeter wave oscillator tube is in plasma profile studies for which a test setup is shown

Both of these affirmative answers were made possible by extending existing microwave tube techniques. For example, the high density electron beam is the result of an almost direct scale change from a 20-Kw, c-w, X-band klystron amplifier, the VA-849[1] also produced by Varian. The beam, with a diameter slightly more than 0.012 inch, was confined to the center of the interaction structure by a powerful electromagnet in the experiments. However, a permanent magnet is being designed for the tube. Unconventional fabricating techniques made possible the realization of a quite small circuit with thermal conductivity comparable to that obtained in megawatt klystrons.

Some interesting predictions have been made by Varian based on the results obtained with the VA-171. Since this device is an oscillator having about one-half percent efficiency, an amplifier of 20 percent efficiency using the same electron beam could easily produce more than 40 watts. Such an amplifier would quite probably provide 100 watts in the frequency range from 50 to 75 Gc with 3 to 5 percent bandwidth. The tube would be only slightly more difficult to achieve than the oscillator. Equally possible but requiring more development effort would be a pulsed amplifier to operate at 5 Kw peak and 500 watts average power output. Beamwidth might be 7 percent.

Among the applications of the VA-171 backward-wave oscillator tube will be plasma profile measurements, which will be made for the first time continuously from 50 to 75 Gc. A typical test setup for such studies is shown in Feb. 2. The tube will also be used for parametric amplifiers and masers and to obtain multi-channel communications in the 60-Gc frequency range both above and within the atmosphere.

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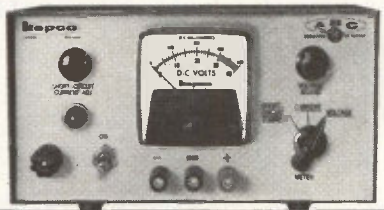

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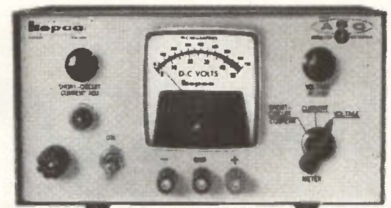

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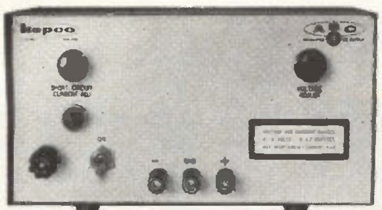

OFF THE SHELF

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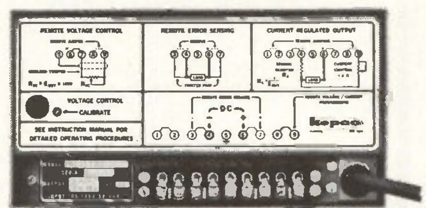

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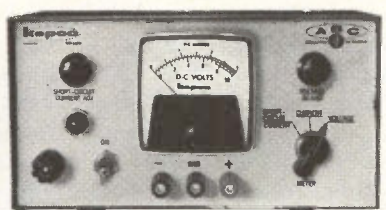
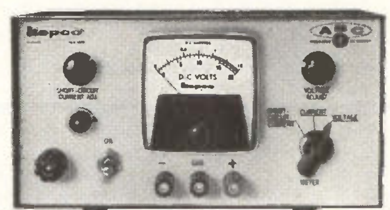
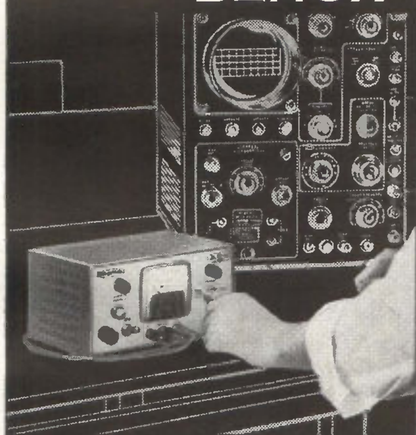


0-15v dc/0-1 amp—**$159.00**



TO YOUR BENCH



OR SYSTEM

MODEL	DC OUTPUT RANGE VOLTS	CURRENT	DIMENSIONS H	W	D	PRICE
ABC 30—0.3	0—30	0—300ma.	4¼″	8 3/32″	5⅝″	$ 99.00
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ABC 7.5—2	0—7.5	0—2 amp	4¼″	8 3/32″	9⅝″	$139.00
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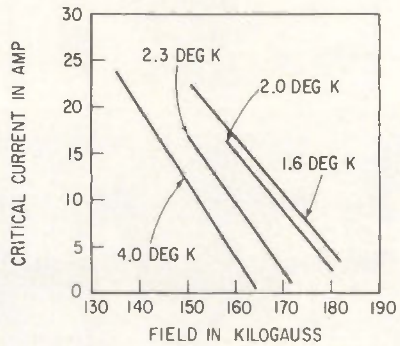
fiers like the VA-171, it should be possible to make high resolution radar for amphibious operations, guided missiles, accurate station keeping in fleet formations, position information in helicopter operation, and precision gun and rocket fire control. For these and other special applications, systems engineers will probably determine the direction of further development by the characteristics they desire in such tubes.

REFERENCES

(1) E. M. McCune, I. Maltzer and L. T. Zitelli, A 20-Kw C-W X-band Klystron Amplifier, *Microwave Jour*, IV, p 74, Aug. 1961.

Wire Is Superconducting in Strong Fields



Critical current versus critical field is plotted at different temperatures for niobium-tin

NIOBIUM-TIN has been shown to remain superconducting in pulsed magnetic fields up to 185 kilogauss. When extrapolated to zero measuring current, the critical field appears to be about 188 kilogauss at 1.6 degrees K. The investigation of superconductivity was conducted by NBS in cooperation with the department of physics, Univ. of Colo. and sponsored by AEC.

High magnetic fields are required for many scientific and industrial purposes, but the electromagnets generally used to produce them consume large amounts of power. By using superconductivity, strong magnetic fields can be produced with limited power. However, most metals do not remain superconductive when even small magnetic fields exceed a critical value. Development of alloys such as Nb_3Sn has resulted in wires that remain superconducting in strong magnetic fields. (See ELECTRONICS, p 9, Feb. 10 and p 96, Nov. 10.)

The niobium-tin wire used in this study was prepared using previously reported procedures[1] except that the wire was swaged rather than drawn to its final diameter of 0.5 mm. Measurements were made with the wire parallel to the field of a pulsed magnet 6.4 cm long and 1.4 cm in inside diameter. The current and potential leads were left outside the magnet. The wire was immersed in a liquid helium bath, and the magnet was placed in a surrounding bath of liquid nitrogen.

Maximum current applied to the sample was 23 amp; 1,100 amp could be applied to the magnet. The critical field was determined by oscilloscope traces of both magnetic field and voltage across the wire. A transient voltage appears when the field pulse is initiated, and superconductivity is destroyed when voltage returns. A peak magnetic field is reached in 7 milliseconds. Results of measurements are shown in the figure, where critical current is plotted against critical magnetic field at different temperatures.

Eddy-current heating of the sample during the field pulse has been estimated. Above the lambda (2.17 K), the sample might warm as much as 1 degree K, but below this temperature, the rise should be less than 0.5 degree K. Attenuation of the pulsed field through the sheath was found to be negligible.[2]

Using niobium-tin wire in superconducting magnets requires knowledge of the critical field transverse to current flow, rather than parallel to it, as it was in these experiments. Therefore, the experiments will continue to observe transverse critical fields. Materials other than Nb_3Sn, such as solid solutions of NbZr, are being studied for possibile use in superconducting magnets.

REFERENCES

(1) J. E. Kunzler, E. Buehler, F. S. Hsu and J. H. Wernick, Superconductivity in Nb_3Sn at High Current Density in a Magnetic Field of 88 Kilogauss, *Phys Rev Letters*, p 89, 6, Feb. 1, 1961.
(2) A. M. Kosevich, *J Theor Phys USSR*, 33, p 735, 1958, Translation: Soviet Phys—JEPT, 6, p 564, 1958.

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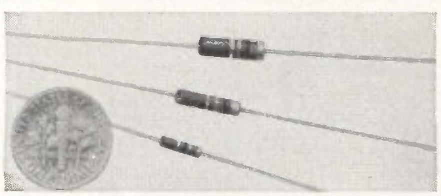
100 volts applied +10% to −35%.
OPERATING TEMPERATURE—
−55°C to 85°C at 100 volts
−55°C to 125°C at 50 volts



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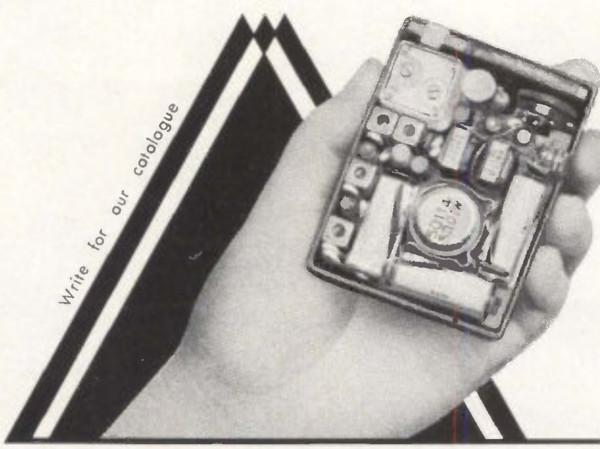

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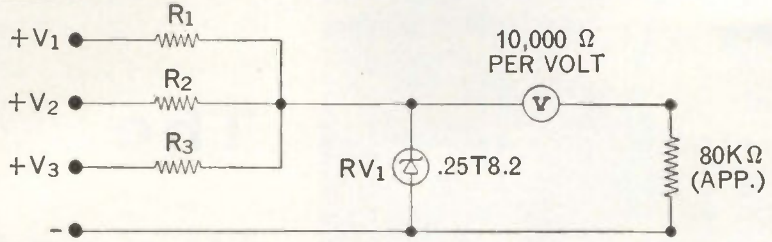

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R_1, R_2, and R_3-Meter Multipliers.
RV_1-Sarkes Tarzian Type .25T8.2 Regulator.
V=100 Microampere Meter Movement.

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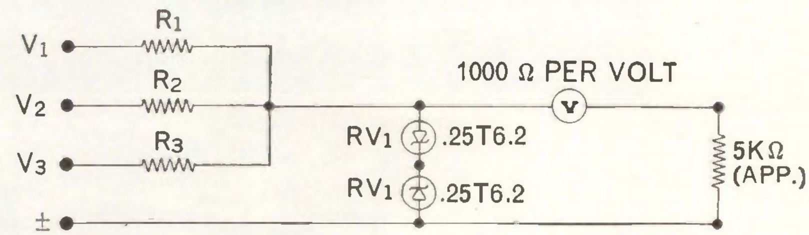

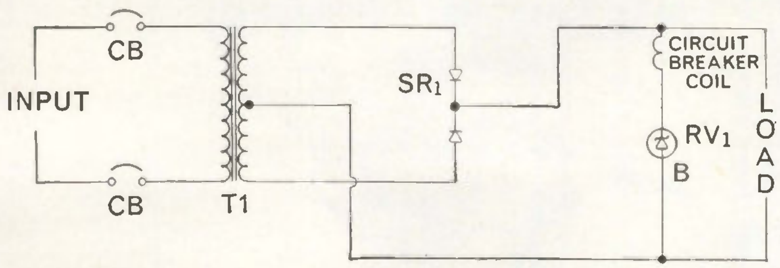

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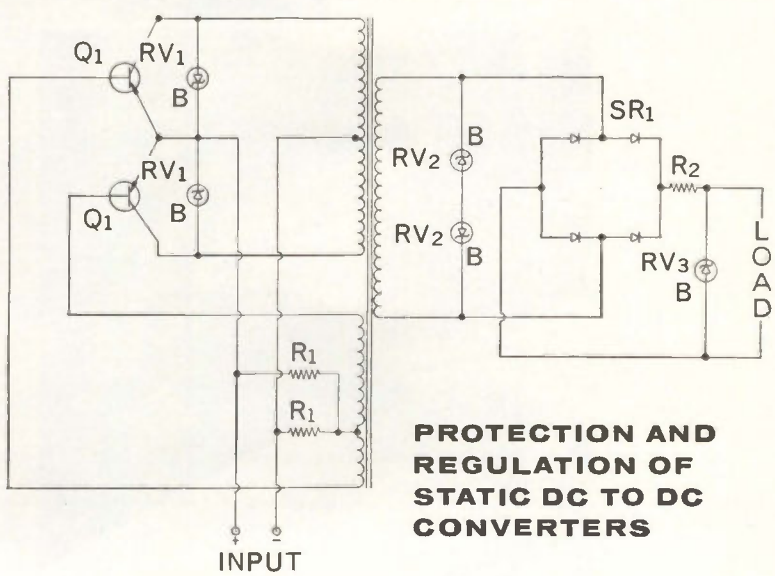

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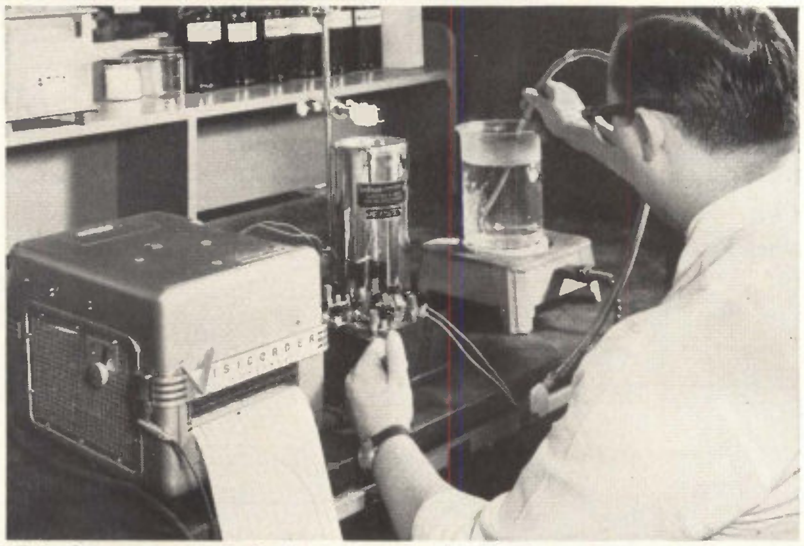

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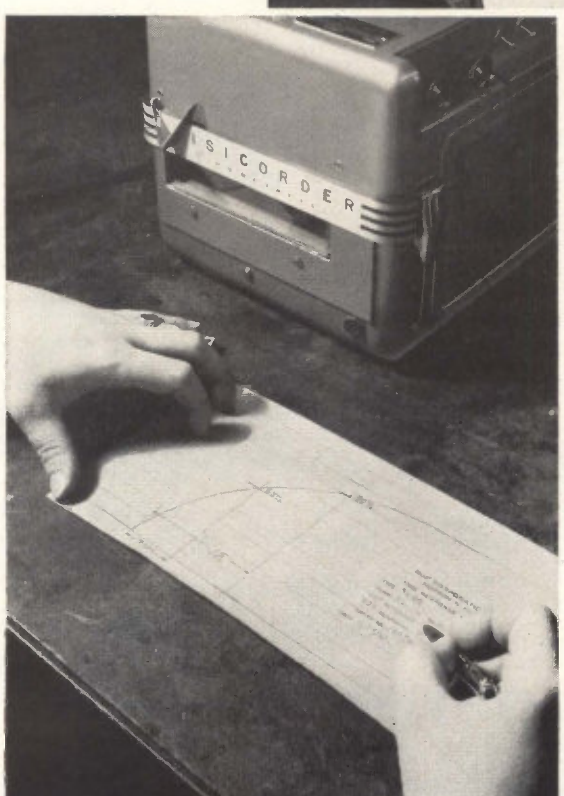

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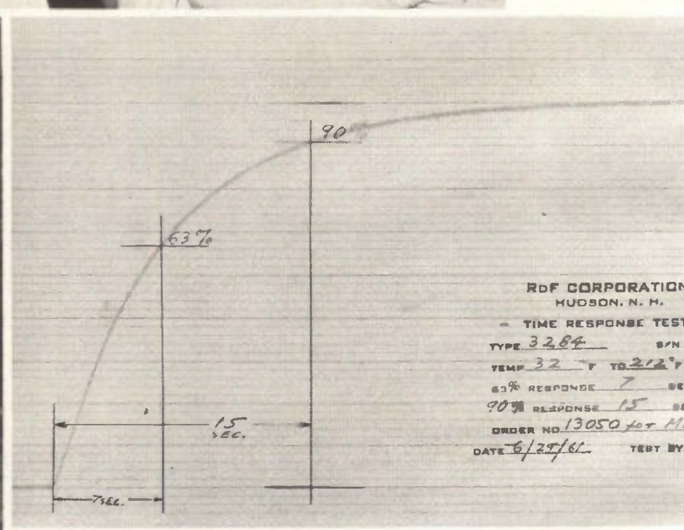

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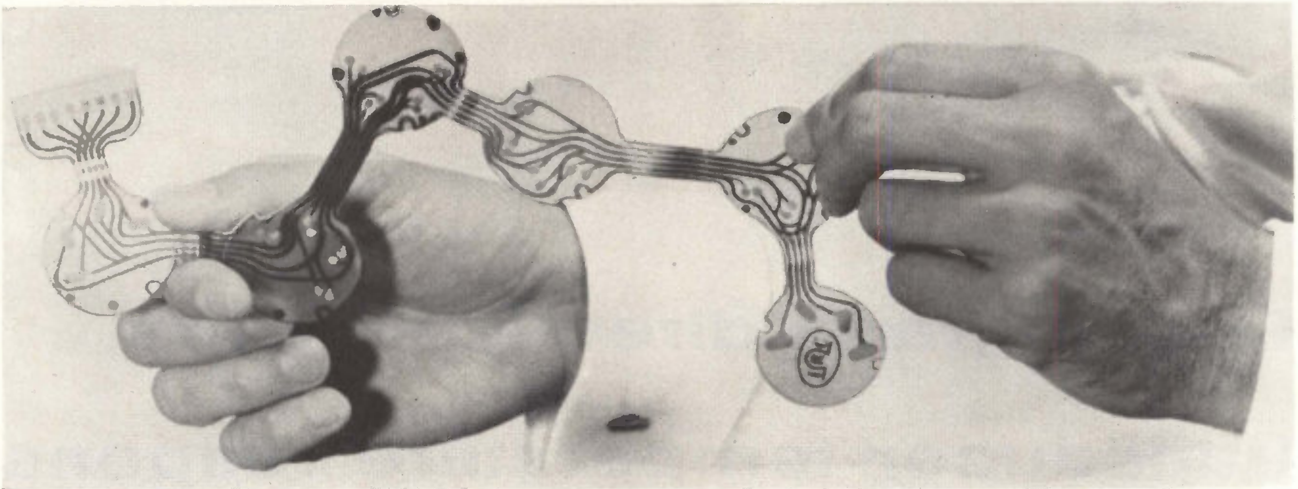


Layers of etched cable fold together, become compact wiring circuit for small switch used in a projectile. Hi-G switch in which this circuit is used, withstands 15,000 times the force of gravity

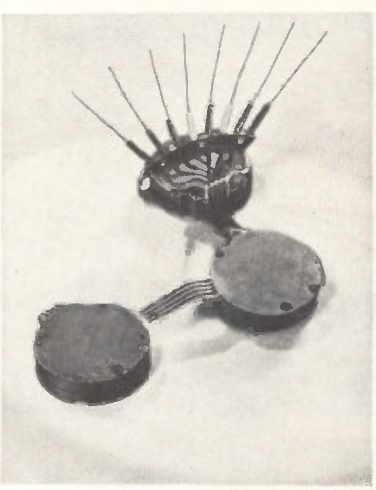
Applying Flat Wires and Cables

SPECIFIC USES IN MODERN ELECTRONIC CIRCUITS

By GEORGE E. METTER
Senior Applications Engineer, International Resistance Co., Philadelphia

DESIGN ADVANTAGES offered by flat wires and conductor cables were outlined last week, (see ELECTRONICS p. 60 Feb. 16). Configurations now available are being specified and custom-designed in missile, rocket and satellite systems (Minuteman, Titan, Echo, Tiros, Polaris), ground support equipment for defense and weapons systems, computers, test equipment, telephones and communications systems, instrument and controls, airborne electronics and wiring harnesses for various other applications.

Designers for these systems find that flat conductor cabling can solve complex wiring and interconnection problems, with imagination increasing the scope of applications.



Etched cable (top of page) is installed in this Hi-G switch. Note flexible connections

Flexible etched cable used in aircraft instrumentation improves reliability, saves space and weight

In the Hi-G switch shown, (bottom, left), the layers of cable are constructed with Kel-F insulation, chosen for its abrasion resistance. Where the cable is later fabricated to cast Kel-F housings, which enclose metal actuators, the cable layers are heat bonded to form a rigid area. The leads between the three components are left unbonded for flexibility. The halves of the cast housings are assembled with the etched cable using an adhesive at the same area of the cable which was formerly heat bonded.

Mylar is used as the insulating film for the two flexible etched cables used in airborne instrumentation. Pads are solder plated to facilitate assembly, and are precisely located. Final assembly is accomplished by dropping the cable unit over conductor pins and hand soldering.

In a key ICBM component, also using Kel-F insulation, certain pads of the etched cable are exposed on one side cable, others are open on the reverse side. Gold-plated pads are of different sizes with holes precisely located so that the cable unit will easily slip onto pins of mated

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t_{total} = 80nsec

V_{CE} (sat) = 0.25V max.

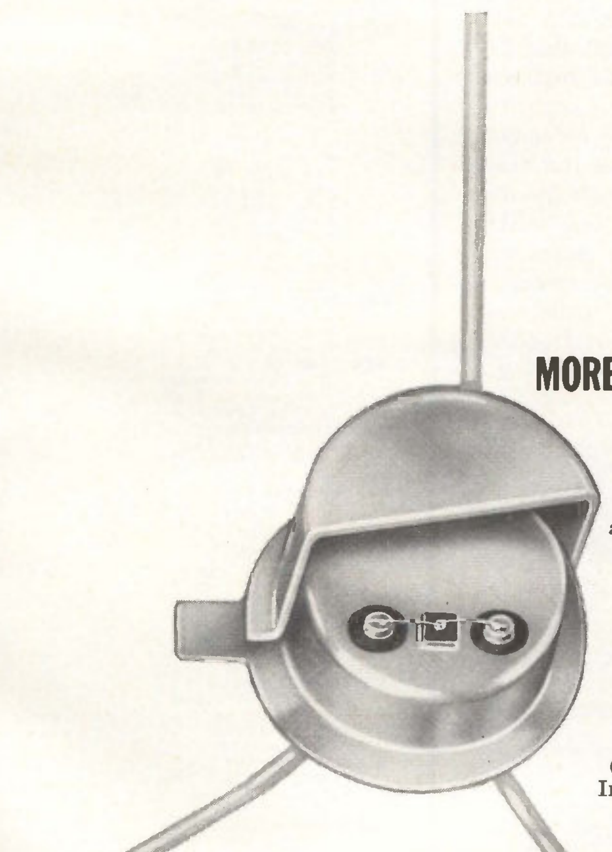
($I_C = 10\ I_B$, $I_C = 1$ ma to 20 ma, $T_A = -55°C$ to $+125°C$)

I_{CBO} = 25mua

($V_{CB} = 20V$, $I_E = 0$)

h_{FE} at −55°C = 12min.

($I_C = 10$ ma, $V_{CE} = 1.0V$)



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PEP transistors in the 2N2192-2195 and "A" series (TO-5 package) can replace standard units without basic circuit changes. PEP diodes feature controlled conductance and ultra-fast switching over a wide current range. Ask your G-E District Sales Manager. Or write Semiconductor Products Department, Section 16B121, General Electric Company, Electronics Park, Syracuse, New York. In Canada: Canadian General Electric, 189 Dufferin Street, Toronto, Ontario. Export: International General Electric, 159 Madison Ave., N.Y. 16, N.Y.

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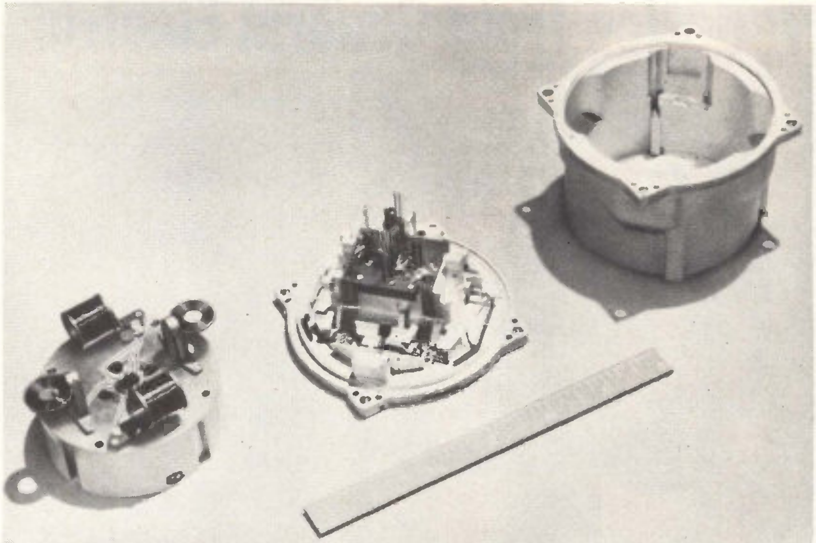
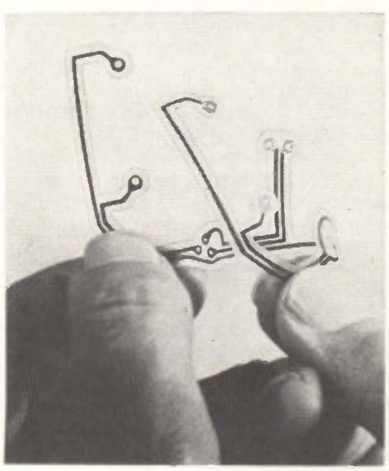


Missile system designed with etched cable. Flat wires drape neatly between components, slip onto mating elements exactly

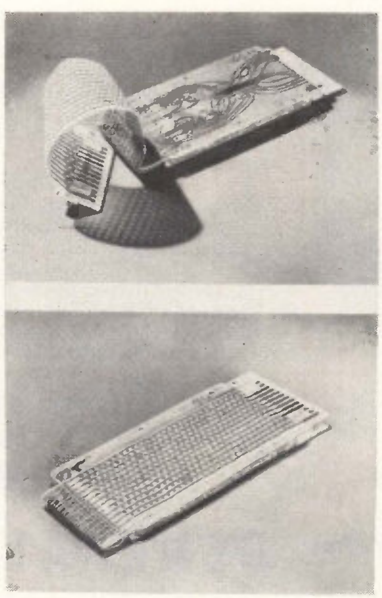
elements in the assembly. Hand soldering completes the electrical connections. In a telephone relay, Lamoflex cable is used to connect a relay stack to internal header pins with significant size reduction of the relay. Cable for this application is constructed with 4-ounce oxidized copper and bonded with Mylar thermoplastic insulation. Cable is furnished in two portions which fit one on top of the other—a high density wiring system replacing 21 round wires. Assembly of this mass of conventional round wire was tedious, with risk of wire breakage and pulled connections.

In anohter application (see photo below, right), a strip of etched cable is used to test computer circuits. The flexible sheet is folded around the module board to be tested. Phosphor bronze conductors, arranged in a high-density array, are exposed on both sides through discrete insulation windows to pick up connections at the chassis socket. Cooling-air flow patterns are not disturbed, circuit electrical characteristics remain fixed, and test results are meaningful.

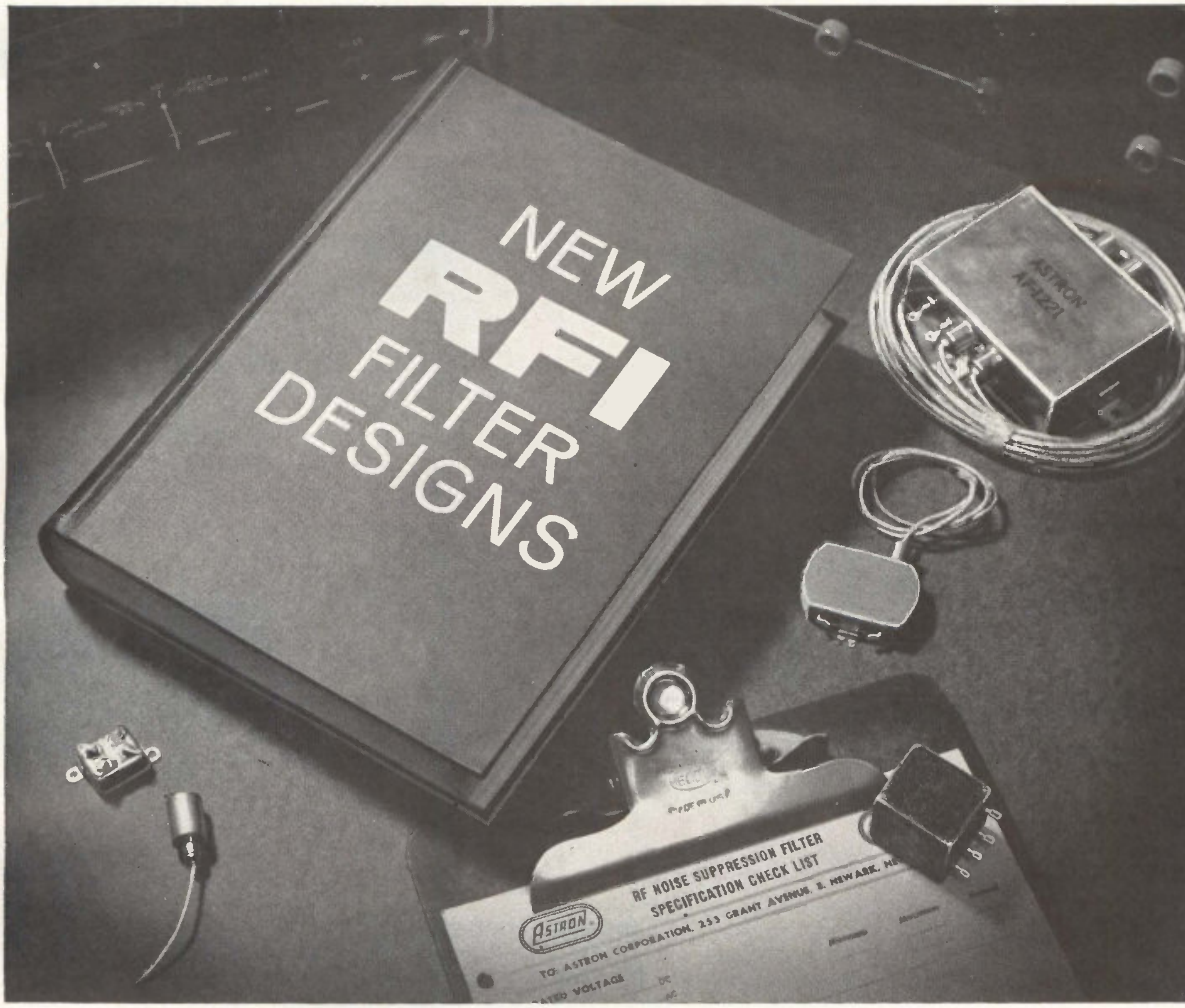
Each conductor in the extender strip becomes a lead from the hidden panel connection to the exposed front of the equipment. Test leads are attached to the extender through a printed-circuit connector and readings are taken while the module is functioning. Extender is used for repeated monitoring.



Wiring units for ICBM component



Flexible strip folds around module, permits in-place testing of printed circuit boards in operating position



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Switching Applications

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TO-5 package.
Base common to case.
150 mw free air
300 ma max

BV_{CBO}		h_{FE} at 1v, 10 ma 20 min	40-200	60-300	80 min	BV_{EBO}
25	NPN	2N1302	2N1304	2N1306	2N1308	25
30	PNP	2N1303	2N1305	2N1307	2N1309	25
	typ fhfb	4.5mc	8mc	12mc	20mc	

PNP low-level logic and switching series.
TO-5 package.
All leads isolated.
150 mw free air
400 ma max
Guaranteed switching times.

BV_{CBO}	h_{FE} at 0.25v, I_B = 1 ma 30-60	40-80	60 min	BV_{EBO}
30	2N426	2N427	2N428	20
	typ fhfb 6mc	10mc	15mc	

General purpose logic and switching series.
TO-5 package.
Base common to case.
150 mw free air
300 ma max.
*All leads isolated.
**200 ma max

BV_{CBO}		h_{FE} at .15v, 12 ma 30 min	h_{FE} at .5v, 30 ma 60-180	BV_{EBO}
25	PNP	2N404*		12
25	PNP	2N1404		20
25	NPN	2N1808		20
25	NPN	2N1605		12
25	NPN		**2N388	15
	typ fhfb	12mc	15mc	

PNP general purpose logic and switching series.
TO-5 package.
Base common to case.
150 mw free air
250 ma max

BV_{CBO}	h_{FE} at 1v, 10 ma 20-150	30-150	40-150	BV_{EBO}
30	2N395	2N396	2N397	20
	typ fhfb 4.5mc	8mc	12mc	

Bi-Directional Switching Applications

NPN Bi-directional switching series.
TO-5 package.
Base common to case.
150 mw free air
300 ma max

BV_{CBO}	FORWARD AND INVERTED h_{FE} at 0.2v, I_B = 1 ma 20 min	35 min	50 min	at 1v, 10 ma 15 min	25 min	35 min	BV_{EBO}
20	2N594	2N595	2N596			2N1996	20
25					2N1995		25
30				2N1994			30
	typ fhfb 8mc	11mc	13mc	8mc	11mc	13mc	

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PNP medium power series.
TO-5 package.
All leads isolated.
250 mw free air
500 ma max

BV_{CBO}	h_{FE} at 1v: 40-200 at 100ma	70-225 at 100ma 50-160 at 200ma	100-350 at 100ma 75-250 at 200ma	BV_{EBO}
45	2N1997			45
35		2N1998		30
30			2N1999	20
	typ fhfb 6mc	10mc	17mc	

PNP medium power series.
TO-5 package.
Base common to case.
300 mw free air
1 amp max

BV_{CBO}	h_{FE} at 0.5v, 500 ma: 50-300	60 min	BV_{EBO}
50	2N2000		20
30		2N2001	20
	typ fhfb 4mc	9mc	

Amplifier Applications

PNP small signal amplifier series.
TO-5 package.
All leads isolated.
150 mw free air
150 ma max
*200 mw free air
*200 ma max.

BV_{CBO}	h_{FE} at 1v, 50 ma: 30-150	50-150	BV_{EBO}
15	2N1273		10
25	2N1274	2N1370	10
45		2N1371	10
25	2N1383*	2N1382*	15
	typ fhfb 5 mc	7 mc	

PNP small signal amplifier series.
TO-5 package.
All leads isolated.
250 mw free air
200 ma max

BV_{CBO}	h_{FE} at 1v, 50 ma: 30-90	50-150	75-150	95-300	30-300	BV_{EBO}
25	2N1372	2N1374	2N1376			15
45	2N1373	2N1375	2N1377			25
12				2N1378	2N1380	7
25				2N1379	2N1381	15
	typ fhfb 6mc	8mc	10mc	13mc	11mc	

High-Frequency Amplifier Applications

DALMESA PNP high frequency amplifier series.
SO-2 package.
All leads isolated.
125 mw free air
30 ma max
1.5 db typ N.F. at 1 mc.

BV_{CBO}	h_{FE} at 6v, 2 ma: 40-180	60-200	BV_{EBO}
40	2N2188	2N2189	2
60	2N2190	2N2191	2
	typ fhfb 125mc	150mc	

process control, and tested by TI's independent and highly experienced Quality and Reliability Assurance department.

Highly mechanized production lines are another reason for the extra reliability of TI transistors. Unique automatic equipment, much of it designed and built by TI's Mechanization department, means lower cost. And . . . continuous production provides you with quick delivery from a source of supply you can count on. Whether your design requirements are industrial or military, there is a TI Germanium Alloy Transistor available to fit your needs. For complete information call your nearest TI Sales Office and Authorized TI Distributor, or fill out and mail the coupon at right.

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INCORPORATED
13500 N. CENTRAL EXPRESSWAY
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The following TI alloy transistors meet military requirements
2N388 Meet MIL-T-19500/65 (NAVY) 2N404 Meet MIL-T-19500/20 (USAF),
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Alloy Transistor Department
Texas Instruments Incorporated
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Company__________

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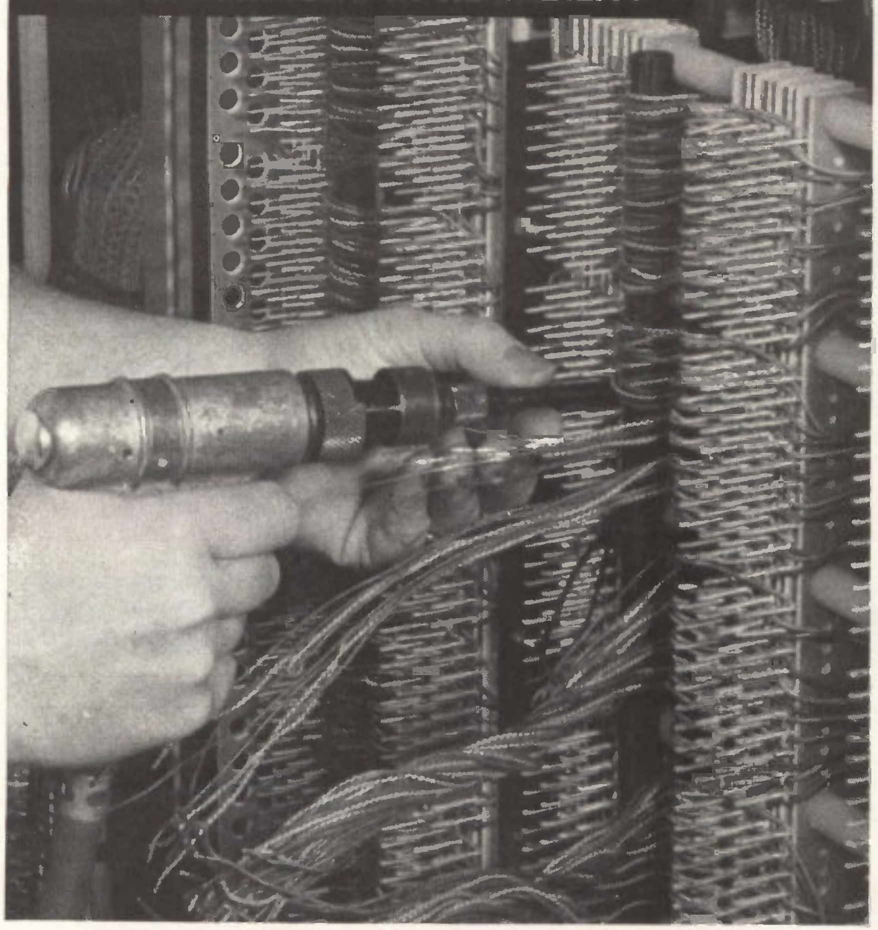

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. . . that's the solderless wrapping method—proved superior by leaders in communications and electronics. What's the proof? Over a billion connections without reported failure.

And the best way to make these connections is with Gardner-Denver "Wire-Wrap"® tools. Every bit is individually tested and inspected—every bit is individually packaged in a plastic tube. And only Gardner-Denver makes a complete line of this type equipment.

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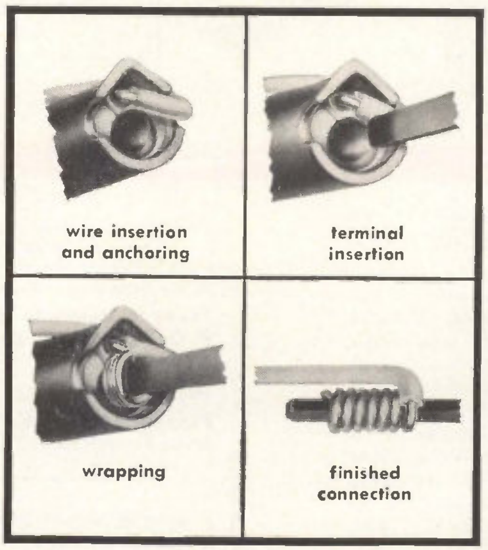

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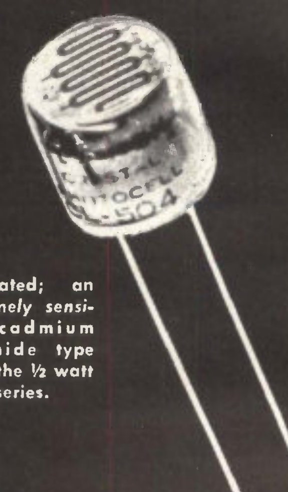

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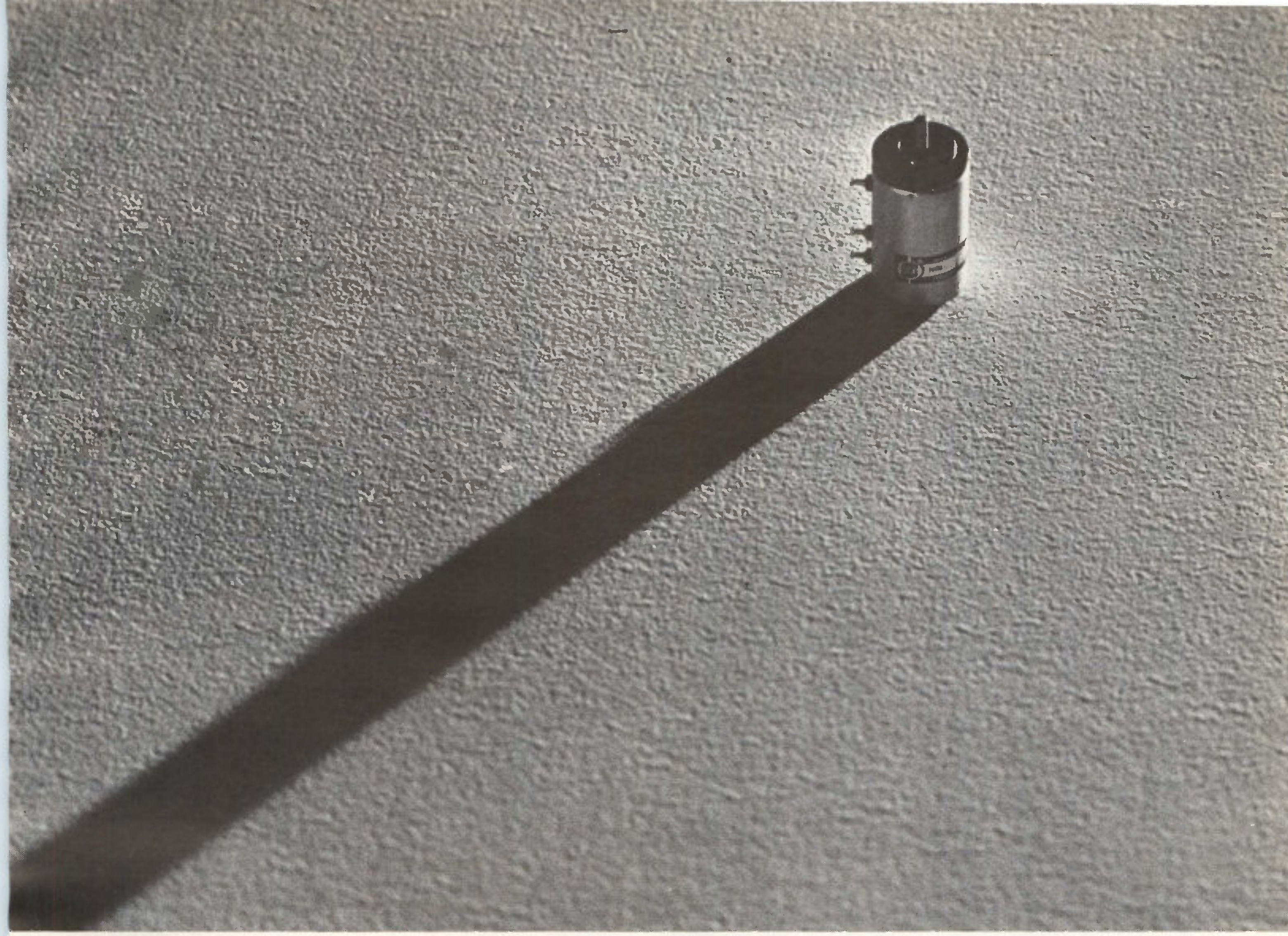
 CIRCLE 70 ON READER SERVICE CARD



How "complete" is a complete line?

Are you as confused about all this complete line talk as we are? What, for example, is a "complete" potentiometer line? This *should* include everything from the *cheap-and-dirty* kind you'll find on a bargain table-radio to the ultra-accurate precision type shown above. By such reckoning, our line of Borg Micropot® potentiometers is far from complete.

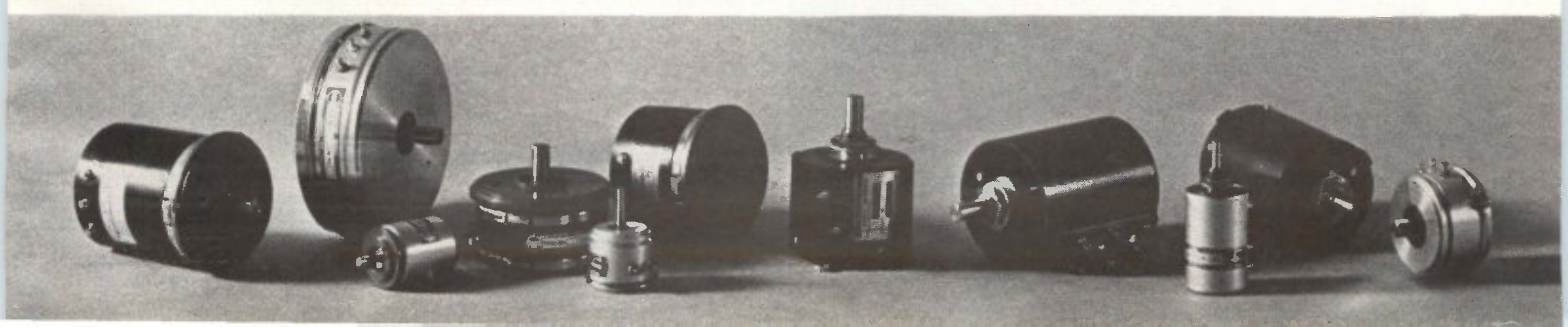
The Borg line is "complete" in a different way. Its range of sizes, ratings, and types makes it applicable to virtually every circuit requiring potentiometers with extreme accuracy, reliability and life expectancy along with small size, wide temperature ranges, and rugged resistance to shock, vibration and atmospheric contaminents.

In other words, the Borg Micropot line *is* a complete line—of precision units for precision applications. This is as true of the new 2100 series shown above as of the many other series in the Borg line. As true of single-turns as of multi-turns. As true of commercial models as of military models.

There's a lot more to the Borg line than its completeness. It is *competitive.* Borg Micropot potentiometers are competitively priced, competitively distributed (through Amphenol Industrial Distributors), and competitively delivered. Find out for yourself. Contact your nearby Borg technical representative, Amphenol Distributor, or write to R. K. Johnson, Sales Manager.

BORG

BORG EQUIPMENT DIVISION
Amphenol-Borg Electronics Corporation,
Janesville, Wisconsin.



Now in production at EMI/US-Los Angeles: Model E-107 PPM-focused, gridded S-Band TWTs delivering a minimum of 1 KW peak pulse power across the band at 1% duty. As compared with competitive glass-type tubes, these TWTs are ⅓ lighter and of rugged, metal-ceramic construction that better withstands military airborne environments. Incorporating an integral ion pump, they meet all the requirements of MIL-E-5400D, Class II. For full details on these and other advanced electron tubes from EMI/US, write Executive Offices: 1750 No. Vine St., Los Angeles 28; or, Field Sales Office: 50 Swalm St., Westbury (L.I.), New York.

ELECTRON TUBE DIVISION

EMI / US

who else makes a 10-lb. metal-ceramic S-Band TWT delivering 1 KW?

nobody.

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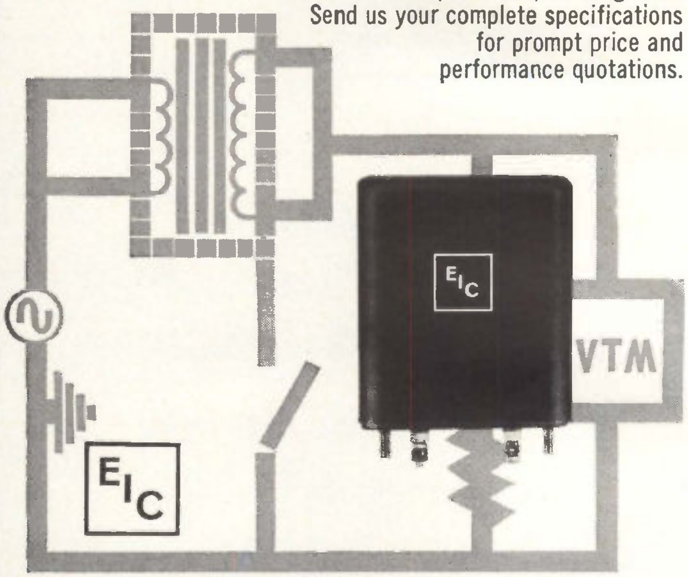

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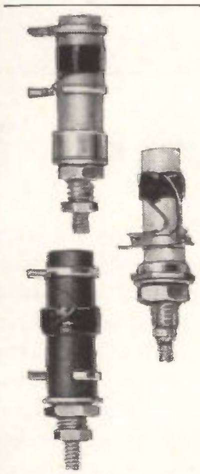

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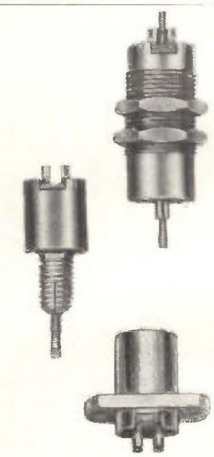

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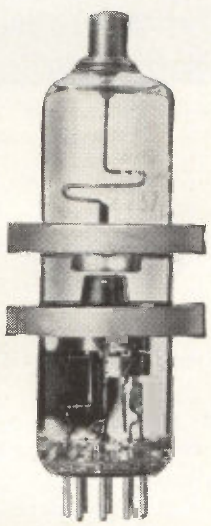

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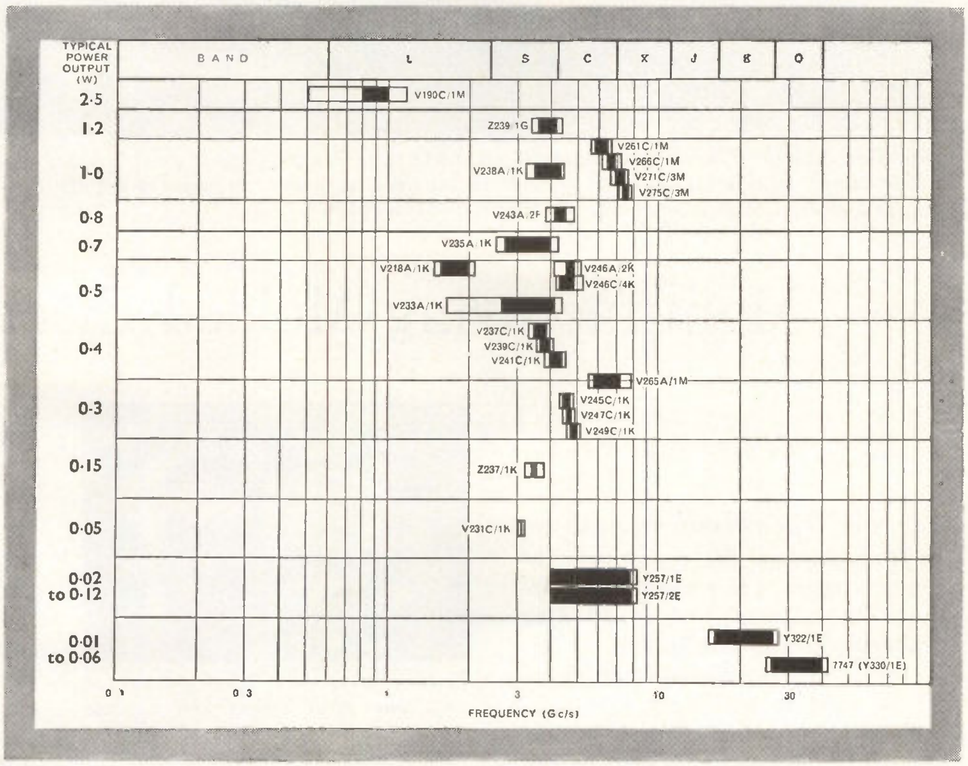

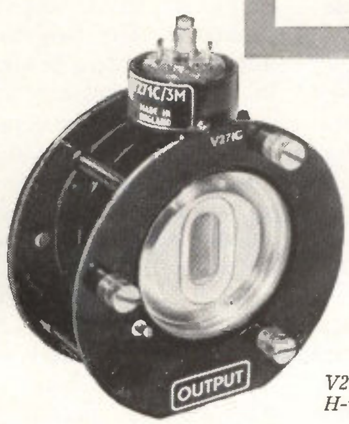

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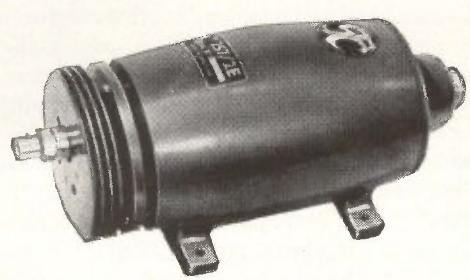

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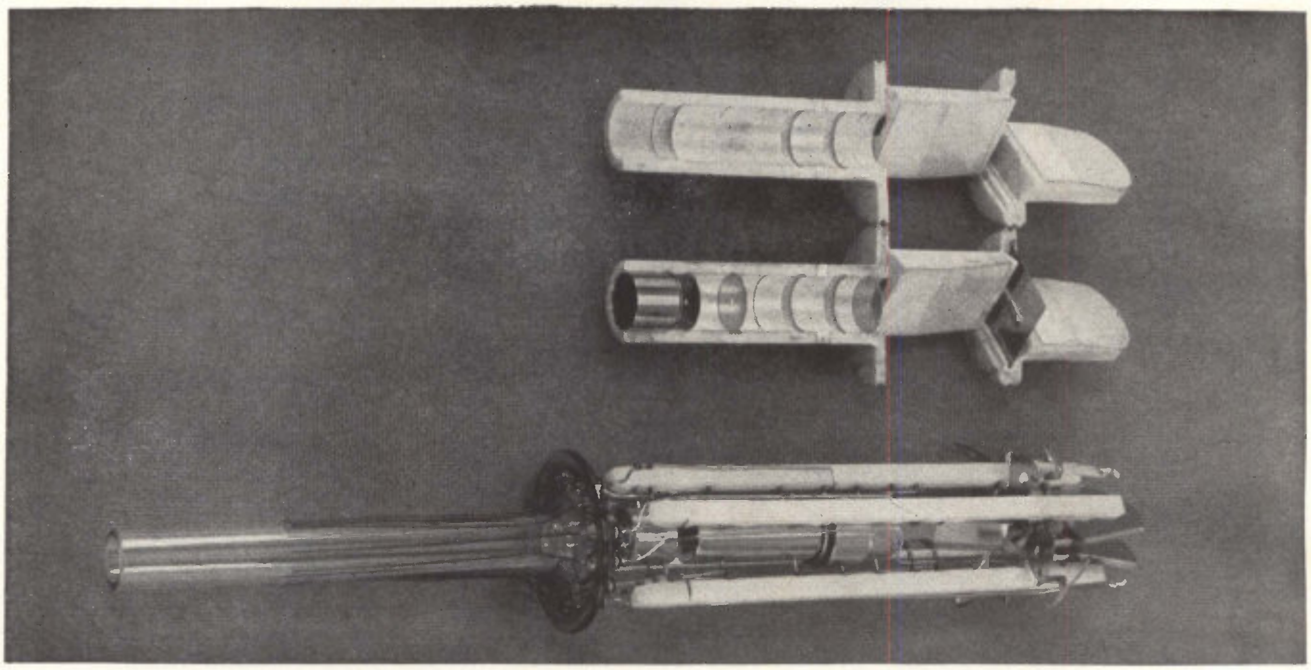


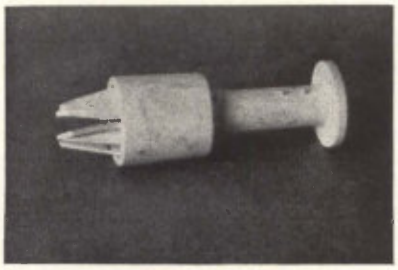
Identical halves of prototype electron for 5AQ tube compared with conventional gun. The molded gun is held together with snap rings in grooves. Although the molded structure requires a higher focus voltage, it is mechanically more rugged and is highly resistant to shock and vibration

Manufacturing Molded Electron Guns

By E. C. GEAR
General Dynamics/Electronics, San Diego, Calif.

IN THE FORMED-GUN method of manufacturing electron guns, the basic structure is molded of an insulating material and functioning elements are either inserts or are formed by techniques similar to those used in making printed circuits. The formed gun is ideally suited to environments that expose the structure to severe vibration and shock, and to those applications that require extreme precision of assembly. But formed guns are not limited to specialized uses, and the technique has possibilities in mass production.

The economic feasibility of formed guns depends on molded parts, and stringent requirements must be placed on the material of the basic structure. The most obvious possible materials are glasses and ceramics, which rate well on most of the desired characteristics, but are poor with respect to molding precision due to a high shrinkage factor that can be compensated for only by costly grinding operations. After extensive investigation, glass-bonded mica was selected as being both suitable and economically practical.



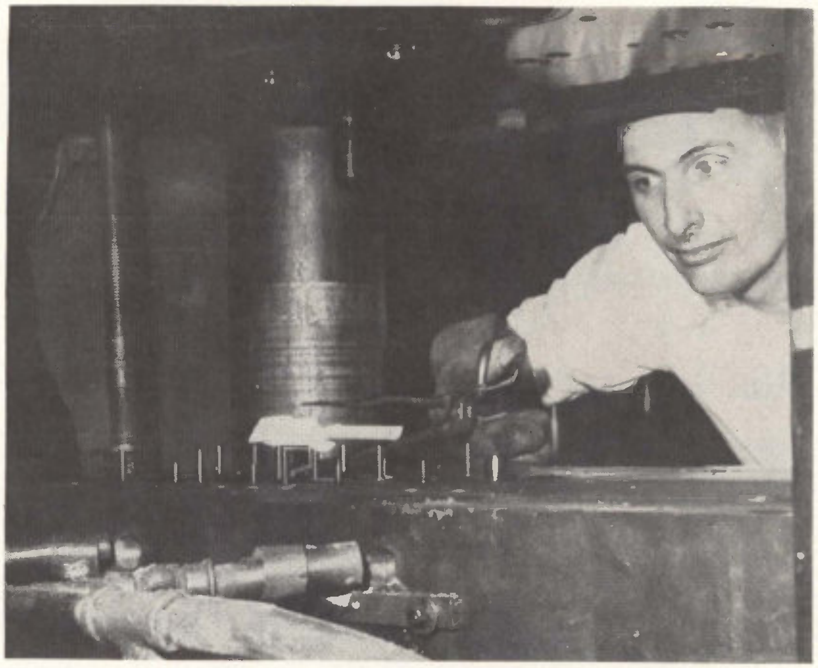
Molded gun now in development uses one piece cylindrical section

Feasibility was first established by machining simple electron guns from solid glass-bonded mica stock. Conductive areas were formed with conductive paint, and metallic apertures were pressed into grooves machined into the interior walls of the gun. Performance and life tests were satisfactory and feasibility was clearly established. The Bureau of Ships then sponsored a program to investigate the possibilities further.

The first molded gun was designed as two identical longitudinal halves, a construction with many advantages in the development phase. The entire gun was produced in a single cavity mold; interior surfaces were accessible and production techniques could be easily explored and the results evaluated. The two halves of the gun are held together by snap rings in formed grooves.

The 5AQ was selected as a typical tube type for the study. But the 5AQ gun uses an immersion lens (a large cylinder that overlaps two smaller cylinders), a configuration with obvious problems in molding and in applying conductive coatings. The lens was redesigned for consecutive cylinders of the same diameter. Additional lens design was necessary because a lens with glass-bonded mica between elements is not equivalent to one with vacuum between elements.

Careful attention was given to the mold, with close cooperation be-



Glass-bonded mica structure is heated in air before assembly

tween Electronic Mechanics Inc. and General Dynamics/Electronics. Draft was allowed wherever necessary to assure easy release of the part; cross sectional areas were kept uniform so that warping was minimized and longitudinal fillets were provided.

Processing of the molded parts into complete electron guns required specialized techniques. Conductive areas of the gun were formed with a fired-on silver composition that proved both durable and adherent. The first molded guns warped at the temperatures required for firing but a change in molding composition and a more precisely controlled firing cycle resolved the difficulty.

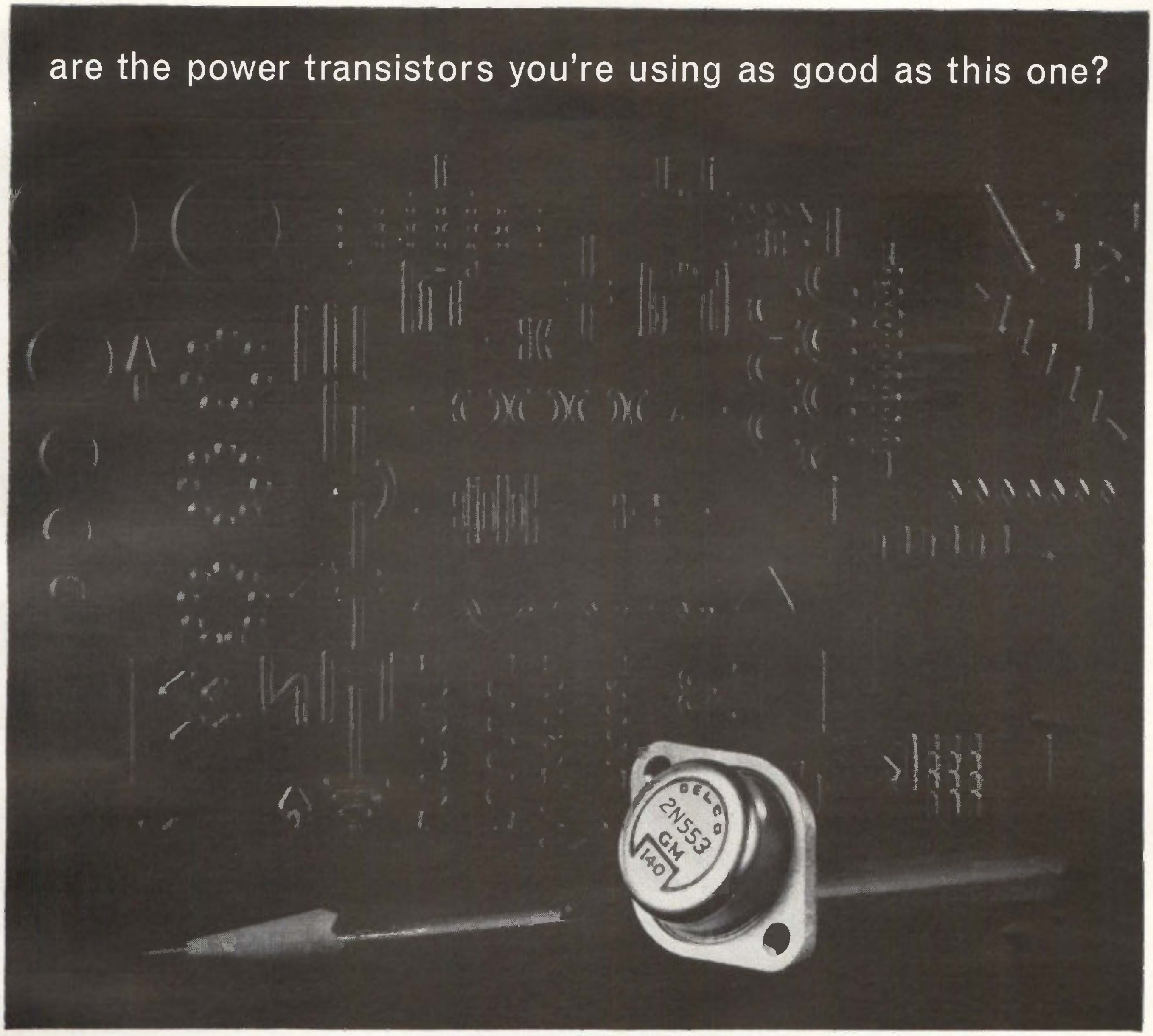
Problems arose due to non-uniform coatings. The slightest ripple on a deflection surface, for example, causes faulty operation. Therefore a special miniature spray gun was divised and very uniform coatings have resulted. Dimensions of the conductive areas are critical and it was necessary to develop precision masking methods.

Early formed-gun tubes were subject to intermittent electrical breakdown. It was found that cleanliness, always essential in vacuum tube production, was even more important for formed guns. Contaminants such as weld spatter can adhere to the insulating material between elements and cause breakdown. Degreasing, electropolishing, and careful control eliminated this problem.

Operation of the formed-gun tubes is essentially equivalent to a high quality 5AQ. The focus voltage however, is about 760 v above cathode—as compared to above 400 v for a conventional tube—probably because of the high dielectric material between the elements instead of a vacuum. Military specifications for shock and vibration were met in tests made at the New York Naval Shipyard.

Although the split molded gun provides an excellent means for exploring techniques and evaluating results, it does not take full advantage of the inherent precision and ruggedness possible. A second molded gun now being tested has a basic structure of complete cylinders, with flanges to ensure rigid mounting in the tube neck.

At the present state-of-the-art, the molded electron gun crt is probably best suited to applications where precision and ruggedness are of first importance. Radar and instrument tubes are typical examples. Future possibilities in producing commercial tubes on a competitive basis will depend upon automation techniques and the need for guns in large volume. With proper tooling, the chances for commercial application are considered excellent.



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2N1971	4A	80V	40V	50μA @ 2V	2MA @ 75° C	.9V @ 3A	25/60 @ .5A	1.5° C/watt
2N665	5A	80V	40V	50μA @ 2V	2MA @ 71° C	.9V @ 3A	40/80 @ .5A	1.5° C/watt
JAN2N665	5A	80V	40V	50μA @ 2V	2MA @ 71° C	.9V @ 3A	40/80 @ .5A	1.5° C/watt
2N297A (Sig. C)	4A	60V	40V	200μA @ 2V	6MA @ 71° C	1V @ 2A	40/100 @ .5A	1.5° C/watt
2N297A	4A	60V	40V	200μA @ 2V	6MA @ 71° C	1V @ 2A	40/100 @ .5A	1.5° C/watt

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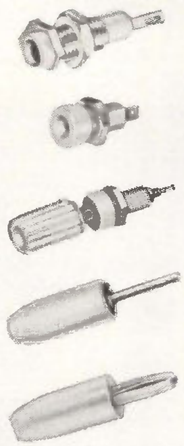

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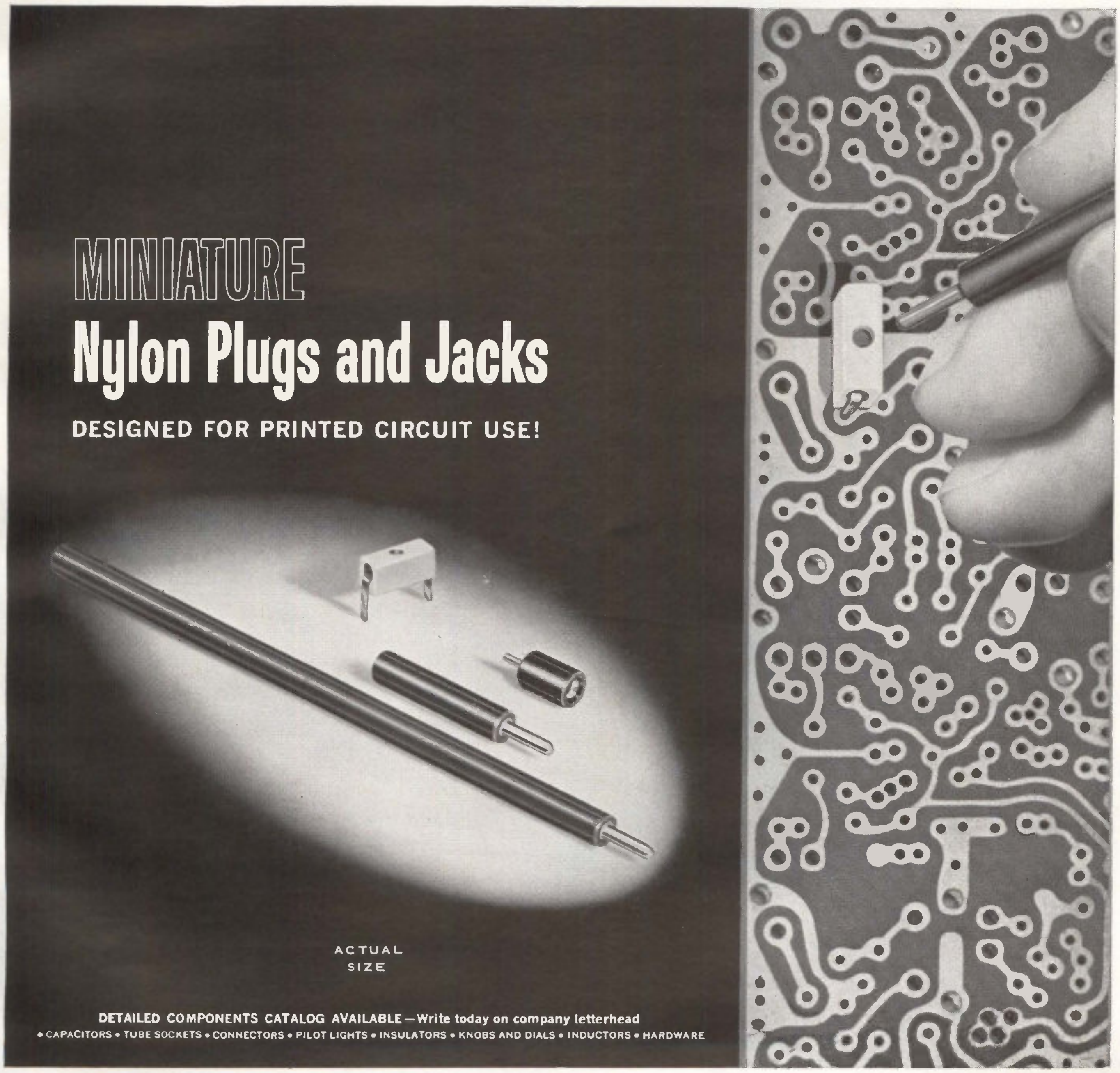

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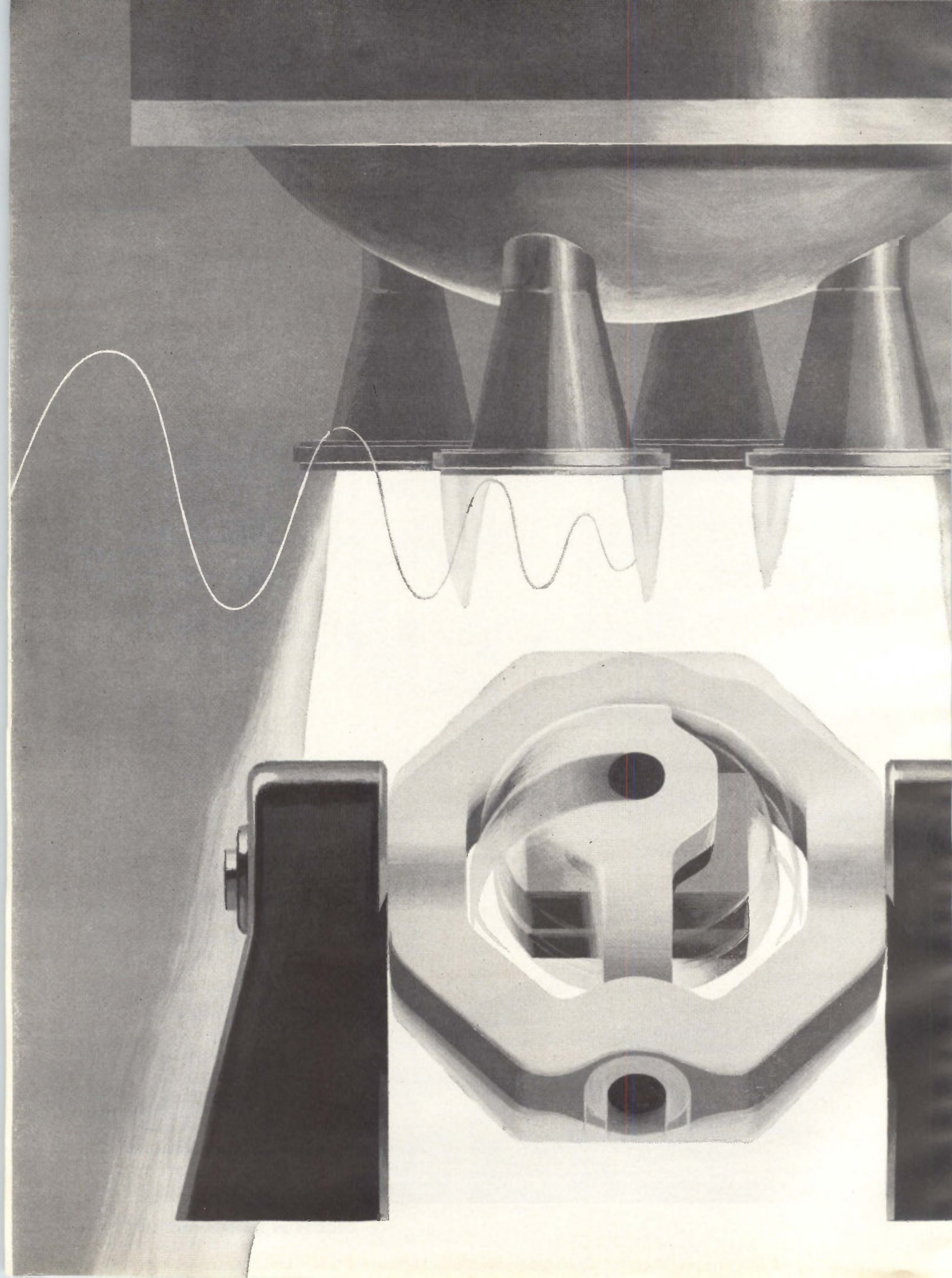

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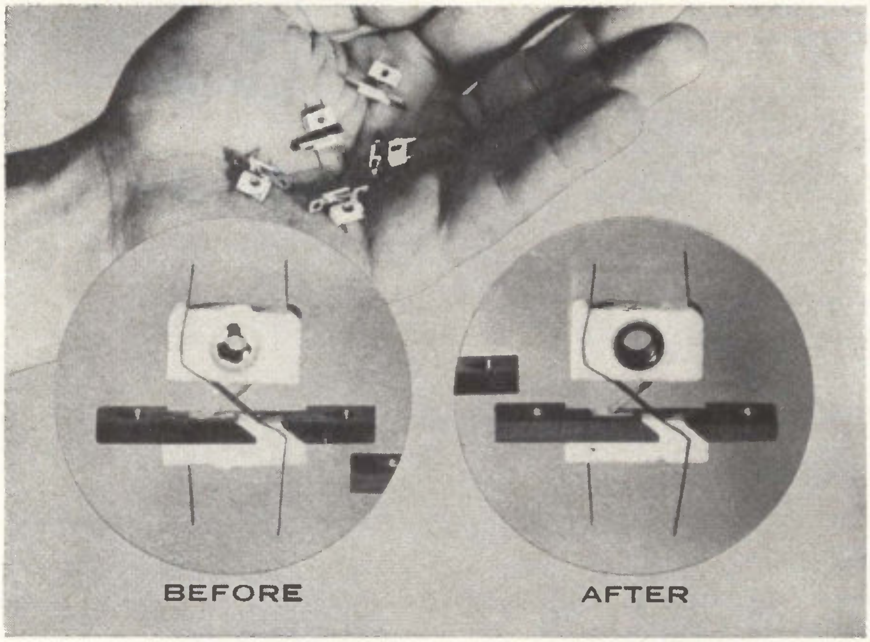

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1 MV to 1000V AC and DC in 10 db steps . . . db scale —20 to +2 • 1% ACCURACY

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Resistance Range: 10 ohms—10 megohms midscale, in decade ranges

Frequency Response: 10 cps—1 mc

Accuracy: 1% of full scale ±0.1 MV, (DC and 20 cps—100 kc scales); 5% of full scale (10-20 cps, 100 kc—1 mc)

DC Calibration: Internal standard cell, provides 1.00 volt on front panel to 10 megohms load

Input Impedance

—Millivolt Scales: 10 megohms shunted by 25 mmf (9 megohms on AC)

—Voltage Scales: 10 megohms shunted by 20 mmf

Power Requirements: 105-125 or 210-250 VAC, 50-60 cps, 60 watts

...this is how Hathaway's R-21 has upgraded performance standards of the electronic voltmeter.

"DC Distend," an exclusive Hathaway development, expands the upper 10% or 1% of any DC volts range to cover the full meter scale. This feature makes the R-21 a perfect choice for measuring the regulation of power supplies, the resolution of potentiometers, and the linearity of amplifiers.

DC upscale readings with polarity indicators give the R-21 twice the scale length of center-zero meters. Residual noise is less than 20 microvolts on the 1 MV AC scale; DC MV drift, less than 50 microvolts after 5 minutes warm-up.

Military reliability is why the R-21 is being specified in the most demanding defense programs. The R-21 is also recommended to the test engineer looking for a more versatile voltmeter.

For more information about the specifications and advantages of the R-21, contact your Hathaway representative, or write to us at the address below.

R E

See our display, including the R-21, at IRE—Booth 1920

- VOLTMETERS
- SIGNAL GENERATORS
- K-1 MICROSOURCE
- T-1A VIBRATION METER
- E-2 COMPARISON BRIDGE
- C-6B RESISTANCE METER
- C-6 OSCILLOSCOPE CAMERA
- A23 CALIVOLTER

Hathaway INSTRUMENTS, INC.
A SUBSIDIARY OF THE LIONEL CORPORATION
5802 EAST JEWELL AVENUE, DENVER 22, COLORADO
SKyline 6-8301
TWX DN 656

LET'S KEEP

Business Help For Our Colleges Going Full Speed Ahead

"Should our company fold up its program of financial help for higher education now that the Kennedy Administration plans to have the federal government provide this kind of help in a big way?" It is clear why, in the light of campaign promises and plans announced since, this question is being raised in many business firms at this juncture.

What seems far clearer, however, is the right answer to the question. It is a resounding NO! **This is no time for the business community to ease up in what have been its notably successful efforts to help our colleges and universities get out of the deep financial hole in which they are operating. On the contrary, this is the time to put more steam than ever behind the drive of business to increase its financial help for higher education.**

Massive Help Needed

It is easy to understand why any individual businessman or firm might have a rather despairing feeling about the prospect of competing with the federal government, with its almost all-embracing tax arm, in providing financial support for higher education or almost anything else for that matter. But this is not a case of competition. It is a case where our colleges and universities must have massive help all along the line if they are to be put squarely back on their feet financially—a goal of crucial and perhaps decisive national importance. **The business community will continue to have both the opportunity and the obligation to keep on increasing its help for higher education as rapidly as possible.**

To underline this proposition take a look at the chart at the top of the next page. It shows how far the salaries of college and university faculty members continue to lag behind those of other occupational groups in the U.S.A. There has been some relative improvement in the average of faculty salaries in recent years. And the salary improvement in some fields, such as those of science and mathematics, has been very pronounced. But the chart makes clear how badly the average salary of college and university faculty members still lags.

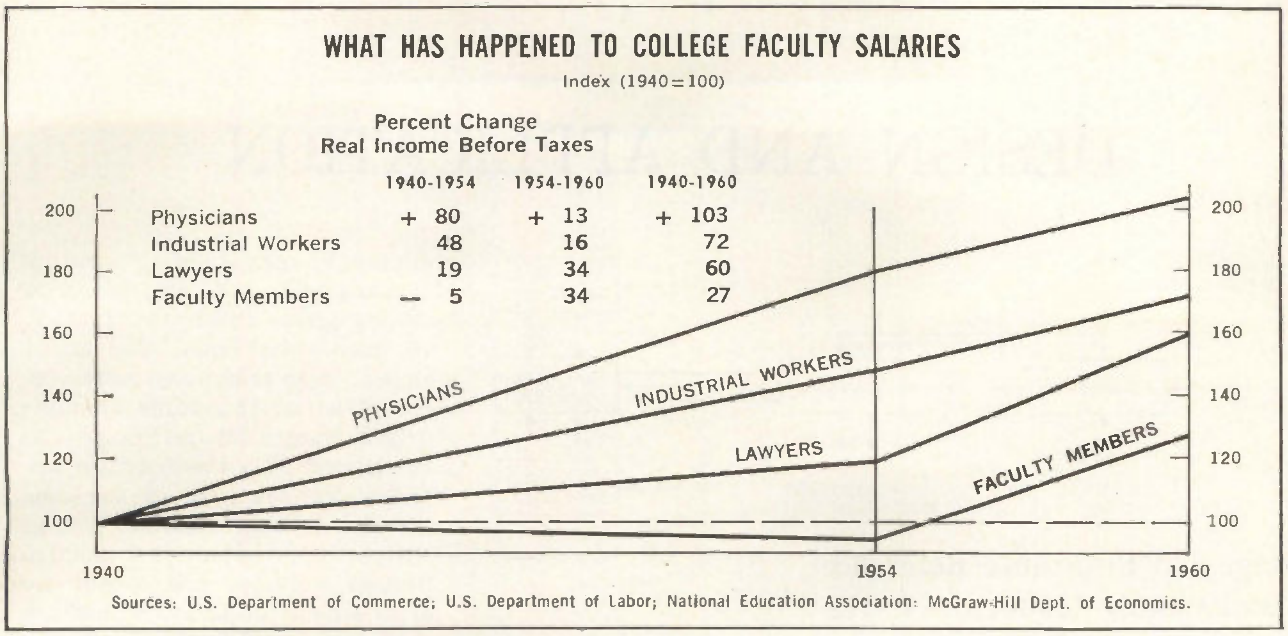
No Federal Funds For Salaries

The plans for increased financial aid for higher education, proposed by President Kennedy, do not contemplate increased expenditure for faculty salaries. This, we believe, is wise whether or not you feel, as many do, that resort to this kind of federal financing would inevitably carry with it federal controls that would ultimately undermine academic independence. The fight over federal appropriations for faculty salaries would be so long and bitter that it would be destructive to the aid program as a whole.

However, what the federal government will not be doing to remedy the deplorable condition of faculty salaries, as reported by the chart, is one indication of the tremendous scope that remains for crucially important help for higher education from business. Manifold other indications are available.

Disaster Escape Route

One of these indications is provided by the careful calculation that the annual income of our colleges and universities must be increased by about \$4½ billion (from about \$4½ billion to about \$9 billion) over the next eight years if the tremendous wave of students



now gathering to descend on these institutions is not to wind up in both a financial and an educational disaster. This wave promises to add more than 2.5 million, or 75%, to college enrollments by 1970.

Thus far, the program for financial help for higher education by business, spearheaded by the Council for Financial Aid to Education, has been a remarkable success in all dimensions. The dollars contributed have increased rapidly—from about $100 million five years ago to about $150 million this year. Contributions of $500 million a year by 1970 are a clear possibility.

One of the inspiring developments increasing this possibility stems out of Cleveland, Ohio. There through their chief executives, an imposing group of business firms have established one per cent of their profits before taxes as their minimum goal for contributions to higher education, to be reached within three years. General acceptance of this goal by business would go most of the way toward getting our colleges and universities firmly on their feet financially.

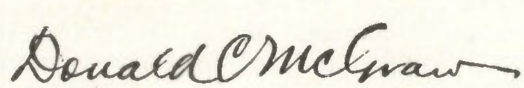
Mutual Respect Increased

The mutual esteem of the academic community and the business community, an element of enormous importance to a free society, has been increased by the manner in which the program of financial aid has been carried out. In making its contribution, there has been no attempt whatsoever on the part of business to encroach upon the academic freedom of the institutions financially benefited. And the program of financial aid has greatly increased the knowledge, understanding and respect which the colleges and universities and business have for each other.

The Kennedy Administration's program to enlarge federal financial support of higher education is certain to arouse strenuous controversy. As proposed by its Task Force, it avoids some of the most controverial areas of principle. However, the very magnitude of the proposed extension of the federal government's already vast program of financing higher education involves fighting issues.

But if the enlargement of federal aid were to be deeply discouraging to the continued expansion of private aid for higher education, it would be a national misfortune of major proportions. There is no good reason why it should be. On the contrary, there is compelling reason for the business community to continue giving higher education all the financial help it possibly can, thus speeding onward a program that has been and continues to be a major constructive force for our colleges and universities, for business and for the nation.

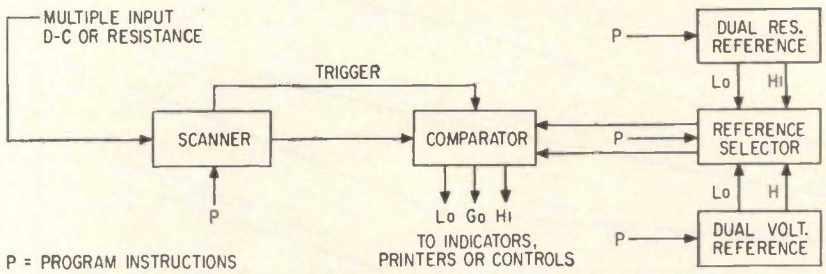
This message was prepared by my staff associates as part of our company-wide effort to report on major new developments in American business and industry. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or part of the text.



PRESIDENT

McGRAW-HILL PUBLISHING COMPANY

DESIGN AND APPLICATION

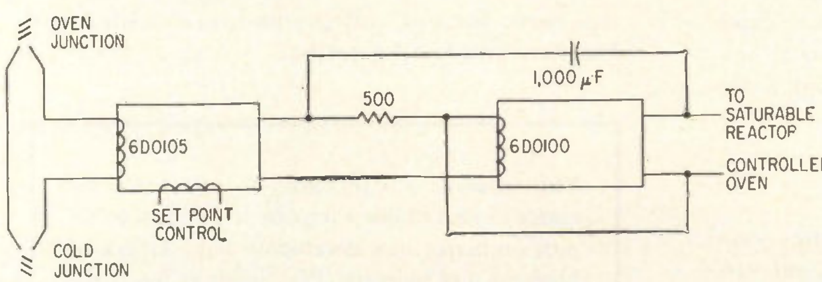


Voltage and Resistance Reference

PROGRAMMED MODULAR UNITS

RECENTLY announced by Binary Electronics, Inc., 30-48 Linden Place, Flushing 54, New York is a modular dual-voltage and dual-resistance reference. In the block diagram shown, the dual-resistance reference features a two-channel output, is programmable and measures zero to 10 megohms with 0.01-percent accuracy. It provides a voltage proportional to resistance under test plus high and low limits in voltage form. It also provides resistance bridge and voltage for null measurements. The dual-voltage reference also has a two-channel output, is programmable and measures zero to ±9.999 v in 1 mv steps with 0.02-percent accuracy. The set-up shows a test system assembled on a resistance go-no go basis and to rapidly check many different d-c voltage inputs. Program command signals control the addressing of the input scanner, selection of reference and settings of high and low reference limits for both resistance and voltage. Decision outputs of go, high or low are given by the comparator in visual, voltage or continuity form at a maximum rate of 10 tests per second.

CIRCLE 301 ON READER SERVICE CARD



Magnetic Amplifiers

SINGLE AND DUAL CONTROL

A NEW LINE of magnetic amplifiers was recently announced by Military and Computer Electronics Corp., 900 N.E. 13th Street, Fort Lauderdale, Florida. The 100 Line Ultramag D series are d-c to d-c magnetic amplifiers powered directly from the 115 v line. Ten different control configurations are available ranging from current sensitivities of 50 μamp for full output to units with voltage gains of 1,000. Single and dual control models are provided for magnetic summing or mixing. Power gain of all units are approximately 43 db delivering ±7.5 v across 1,000 ohms for 1 to 10 microwatts input. The sketch shows a high sensitivity model connected as an integrator amplifier driven from a low-resistance unit being used as a thermocouple amplifier. Voltage gain of the combination is approximately 100,000 with a time constant of 2 minutes. System provides full output for error signals of 75 μv. Stability is ±50 μv referred to the input. Control accuracy is therefore approximately one degree C.

CIRCLE 302 ON READER SERVICE CARD

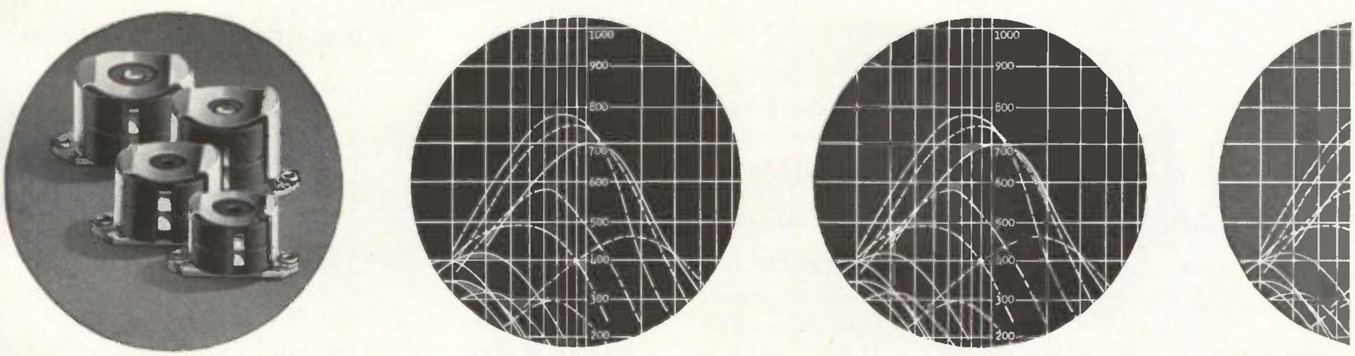
Light Actuated Chopper

ALSO RELAY AND SWITCH

THE Photocom chopper recently announced by James Electronics Inc., 4050 North Rockwell Street, Chicago 18, Illinois, is an all solid-state device for low-level instrument modulator and demodulator service. It operates on the principle of modulating a light source used to illuminate a photoconductor. The photoconductor changes resistance

FILTER DESIGNERS!

WANT TC CORE CURVES?

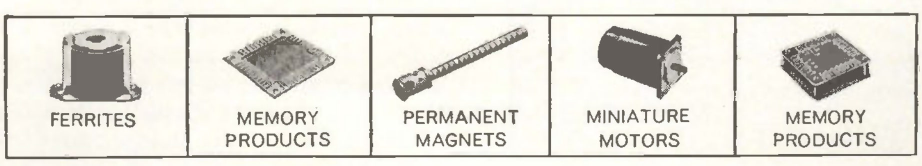


Q VS FREQUENCY

Magnetism is our business . . . so we now offer you another industry first: Complete test standards, specifications and performance curves in the International Series of temperature-compensated FERRAMIC® cup core assemblies. Designed for filter applications requiring a low and linear temperature coefficient with high Q factors, these cup cores are far superior to old-style toroid-shape cores. This detailed test data and specifications are typical of the technical leadership and application assistance we offer you. Our ferrite core experience, specialized manufacturing facilities, highly skilled engineering and production personnel can help you build more reliability into your products. ■ **Phone or write** General Ceramics Division, Keasbey, New Jersey, **for our new engineering data file on our TC cores.**

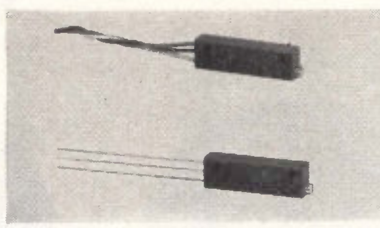
Visit us at the IRE show — Booths 1310-1316

INDIANA GENERAL



in inverse proportion to the level of illumination. The light source is electrically well shielded from the photoconductor resulting in extremely low coupling of drive voltage to signal circuit. Conversion efficiency is improved by using two photoconductive elements illuminated by each half cycle of the modulating voltage. It has a switching efficiency up to 98 percent, no magnetic or chemical switching noise and electrostatic noise less than 3 μv with a 1 megohm load. It can be driven from d-c as a relay to 2,000 cps for extreme response. It also can switch from zero to 300 v and can accommodate signals from d-c to 2 Mc r-f. Typical on resistance is 150 to 400 ohms with typical off resistance greater than 10^8 ohms.

CIRCLE 303 ON READER SERVICE CARD



Subminiature Pot

1 W MAX POWER RATING

BORG EQUIPMENT DIVISION, Amphenol-Borg Electronics Corp., Janesville, Wisc. The 2700 subminiature (1 by $\frac{3}{16}$ by $\frac{5}{16}$ in.) trimming Micropot is able to withstand temperature extremes to 175 C, and is 100 percent humidity and moisture proof. Featuring a wirewound resistance element, the resistance range offers values from 10 to 30,000 ohms. Termination includes color coded Teflon insulated wire leads, and uninsulated copper wire leads. Actuation is leadscrew with a safety idle at each end of the resistance element.

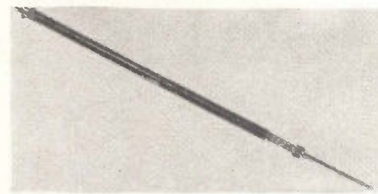
CIRCLE 304 ON READER SERVICE CARD

Wirewound Resistor

SILICONE COATED

DALE ELECTRONICS. INC., Columbus, Neb. Type G resistor has a power rating of 5 w dissipation at 25 C ambient temperature, yet is only $\frac{9}{16}$ in. long by $\frac{3}{32}$ in. in diameter. Max continuous operating temperature is 275 C. Resistance range is from 0.5 ohm to 20,000 ohms, depending on tolerance. Tolerances 0.05, 0.1, 0.25, 0.5, 1 and 3 percent. Temperature coefficient 0.00002/deg C.

CIRCLE 305 ON READER SERVICE CARD

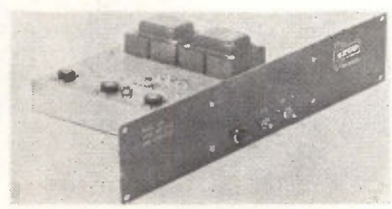


Coax Termination

SLIDING MOVEMENT

RADAR DESIGN CORP., Pickard Drive, Syracuse 11, N. Y. Model D-715 $\frac{7}{8}$ in. coaxial sliding termination has element vswr below 1.1 from 1,000 Mc to 2,000 Mc and below 1.05 from 2,000 Mc to 4,000 Mc. It has sliding movement at least half a wavelength. Connector is UG-45/U or UG-46/U. Price and delivery: $256 each, 4 weeks.

CIRCLE 306 ON READER SERVICE CARD



Wide-Band Amplifier

SOLID-STATE

COMMUNITY ENGINEERING CORP., 234 E. College Ave., State College, Pa. Model 1019 is designed for a frequency response of 5 cps to 12 Mc ±0.5 db. It is able to go 12 Mc under any gain setting and as high as 25 Mc under certain conditions of fixed gain. Unit is also characterized by its high 8-v peak-to-peak output level. Minimum gain is 40 db, continually adjustable; minimum range of gain control is 25 db.

CIRCLE 307 ON READER SERVICE CARD

Parting & Release Agent

GIBRALTAR INDUSTRIES, 251 E. Grand Ave., Chicago 11, Ill. Surfak, a new non-silicone parting and release agent for epoxies, has been developed in aerosol form for the electronics industry. The formula allows the user to deposit a uniform, microscopic film that affords excellent release.

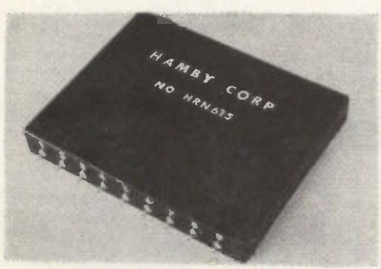
CIRCLE 308 ON READER SERVICE CARD

Transfer Switch

FAST, FAIL-SAFE

QUANTATRON, INC., 2520 Colorado Ave., Santa Monica, Calif. The WS-01 series waveguide transfer switches are electrically-operated devices designed to switch microwave power from two inputs to either of two outputs. Two antennas may be time-shared by alternately connecting them to each of two receivers or transmitters—or one of the transmitters or receivers may be replaced by a dummy load. Switch may be used to reverse direction of power transmission in a repeater (booster) station of a microwave link.

CIRCLE 309 ON READER SERVICE CARD

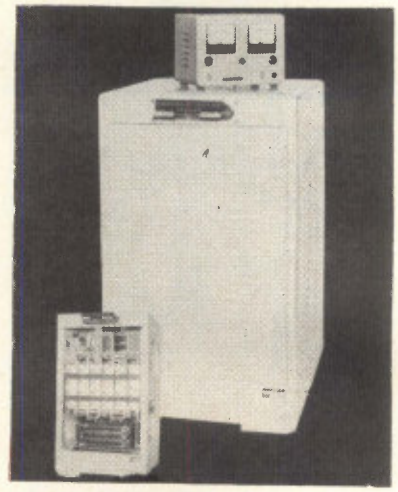


Impedance Network

LOW PHASE

HAMBY CORP., 7241 Eton Ave., Canoga Park, Calif. Model HRN615 is an encapsulated subminiature, low phase shift impedance network. Matched resistors of unequal values are available with tolerances as close as 0.01 percent over a frequency range from d-c to 1 Kc. Resistors of equal value can be matched to 0.001 percent. Temperature coefficients of 2 parts per million are available over a temperature range of −65 C to 0 C or 0 C to 135 C.

CIRCLE 310 ON READER SERVICE CARD

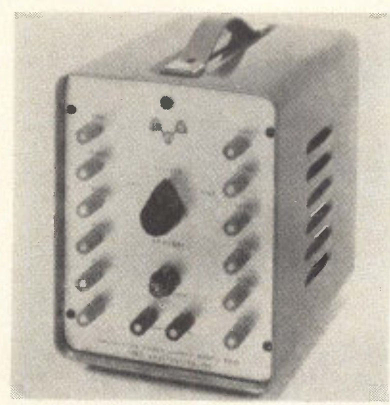


D-C Power Supply

HIGH CURRENT

TYLAN CORP., Torrance, Calif., announces a d-c power supply using scr's that delivers 2,000 amp at 15 v to operate a research furnace or other types of industrial equipment. Current is regulated to ±1 percent from 100 to 2,000 amp by a separate portable control console. Unit is water-cooled, has outside dimensions of 22 by 22 by 36 in., and weighs less than 700 lb.

CIRCLE 311 ON READER SERVICE CARD



Power Supply

FOR TRANSISTORS

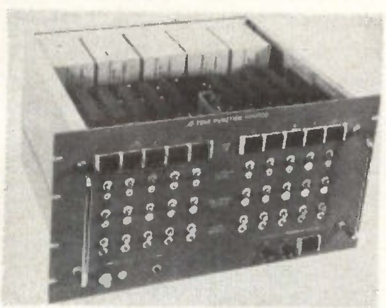
RMS ENGINEERING, INC., P. O. Box 6354, Station H, Atlanta 8, Ga. Model PB-15 consists of 12 nickel-cadmium batteries with a trickle charger. Both positive and negative voltages in steps of 1.25 v are available simultaneously, spanning a range of 15 v. In portable operation, capacity is 3.5 amp-hr, 10 amp peak. In a-c operation, batteries are series charged at 0.24 amp. Power supply is suited to the lab testing of transistor circuits and as an emergency power source in case of power failure.

CIRCLE 312 ON READER SERVICE CARD

Microwave Oscillator

GENERAL RADIO CO., West Concord, Mass. A continuous-tuning microwave oscillator, type 1360-A, can serve as a general-purpose power source for component and system measurements in the 1.7 to 4.1 Gc range.

CIRCLE 313 ON READER SERVICE CARD



Demodulator

TEN-TONE

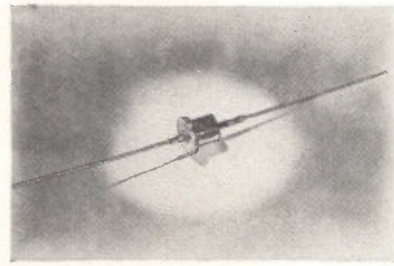
CASA ELECTRONICS CORP., 2233 Barry Ave., Los Angeles 64, Calif. Compact, solid-state ten-tone demodulator provides a ten channel tone separation and demodulation system for use in conjunction with telemetering systems. Each channel is fully self-contained with individual readout, filter, amplifier and precision regulated power supply. Plug-in printed circuits are used throughout. Standard frequencies range from 33 to 402 cps. Bandwidth of each channel is 20 cps.

CIRCLE 314 ON READER SERVICE CARD

Sweep Generator

JERROLD ELECTRONICS CORP., 15th and Lehigh Ave., Philadelphia 32, Pa. Model 707 precision variable rate r-f sweep generator now provides for the use of six different plug-in oscillator heads, permitting measurements in the 20 Kc to 270 Mc range.

CIRCLE 315 ON READER SERVICE CARD

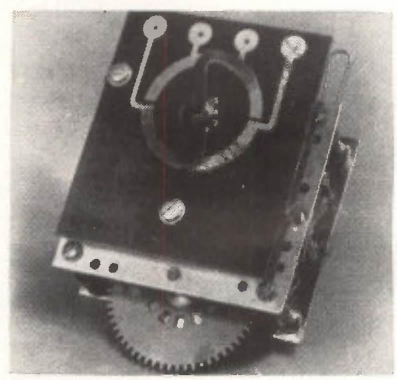


Silicon Rectifier

HIGH VOLTAGE

ELECTRONIC DEVICES, INC., 50 Webster Ave., New Rochelle, N.Y. Line of h-v top-hat silicon rectifiers are designed for medium power applications. Available in ratings from 1400 to 2000 piv, they deliver an output current of 500 ma at 25 C ambient. Maximum reverse leakage is 1.0 μa at 25 C at rated piv. Maximum forward voltage drop at 25 C ambient and 500 ma is 1.8 v d-c. Maximum one cycle (8 μsec) surge is 15 amp at 25 C ambient.

CIRCLE 316 ON READER SERVICE CARD



Commutator Switch

SPRING-DRIVEN

AUTOMATION DYNAMICS CORP., 255 County Road, Tenafly, N.J., offers a 4-oz commutator switch for application to balloon sondes, telemetry, multiplexing and laboratory tests. Model 93 has 4 hr running time from spring-wound motor at 1 rpm. Flush printed circuit is available with 4 conducting segments or alternate arrangements. Unit operates under environmental conditions from sea level to 120,000 ft altitude and is priced for expendable applications.

CIRCLE 317 ON READER SERVICE CARD

PRODUCT BRIEFS

ALUMINUM SHIELDING TAPE 0.004 in. thick. Alpha Wire Corp., 200 Varick St., New York, N. Y. (318)

DYNAMIC CAPACITOR ultrasensitive. The Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, O. (319)

TRANSISTOR TEST ADAPTER heavy duty molded phenolic. Pomona Electronics Co., Inc., 1500 E. Ninth St., Pomona, Calif. (320)

PROGRAMMER-COMPARATOR for automatic checkout. Hycon Mfg. Co., 700 Royal Oaks Drive, Monrovia, Calif. (321)

STRAIN GAGE POWER SUPPLY and calibration unit. Dynamics Instrumentation Co., 583 Monterey Pass Rd., Monterey Park, Calif. (322)

PRECISE ANGLE INDICATOR displays in digital readout. Clifton Precision Products Co., Inc., 5050 State Rd., Drexel Hill, Pa. (323)

VACUUM DEPOSITION SYSTEM dual bell jar. Scientific Engineering Laboratories, Inc., P.O. Box 607, Woodland, Calif. (324)

SERVO MOTORS slotted shaft construction. Bowmar Instrument Corp., 8000 Bluffton Road, Fort Wayne, Ind. (325)

MULTIPOINT DIGITAL SYSTEM automatic. Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif. (326)

BATTERY SEPARATOR gives longer life. Yardney Electric Corp., 40-50 Leonard St., N.Y.C. (327)

PORTABLE SWEEP GENERATORS two improved models. Jerrold Electronics Corp., 15th and Lehigh Ave., Philadelphia 32, Pa. (328)

SHIELDED COIL FORM immersion-proof. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass. (329)

DUAL CENTRIFUGAL BLOWERS four models. McLean Engineering Laboratories, Princeton, N. J. (330)

GENERAL PURPOSE OSCILLOSCOPE for industry. Lavoie Laboratories, Inc., Morganville, N. J. (331)

VULCANIZED FIBRE flame resistant material. Taylor Fibre Co., Norristown, Pa. (332)

Literature of

TRANSDUCER AMPLIFIER-INDICATOR Sanborn Co., 175 Wyman St., Waltham 54, Mass. Bulletin illustrates and describes the model 311 which quickly measures any physical variable to which a transducer can be attached. **(333)**

PACKAGED COOLING EQUIPMENT McLean Engineering Laboratories, P.O. Box 228, Princeton, N. J., has published a 16 page short-form catalog on packaged equipment for electronic rack cooling. **(334)**

MICROPHOTOGRAPHIC CAPABILITIES Itek Laboratories, Lexington 73, Mass. Bulletin announces a custom capability for design and production of micro-images on film, glass or metal. **(335)**

TEMPERATURE CONTROLS Assembly Products, Inc., Chesterland, O. Easy-to-install packages for accurate temperature control are described in bulletin 108-A. **(336)**

DYNAMOMETER TEST STATIONS Dunn Engineering Corp., 225 O'Brien Highway, Cambridge, Mass., has published a brochure on dynamometer test stations for multiple evaluation of inertial gyro spin motors. **(337)**

DIGITAL MODULES Digital Equipment Corp., Maynard, Mass. A complete listing of 86 fully coordinated computer circuit modules is included in a recently published catalog. **(338)**

CERAMIC STANDOFFS Centralab, The Electronics Div. of Globe-Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wisc., has announced a catalog and price list of JAN ceramic standoffs. **(339)**

DELAY LINES PCA Electronics, Inc., 16799 Schoenborn St., Sepulveda, Calif. Catalog sheet covers PCDL series of miniature constant lumped delay lines. **(340)**

INTEGRATING DEVICES Leesona Moos Laboratories, 90-28 VanWyck Expressway, Jamaica 18, N. Y. Data sheet describes the Betachron series 1268 time-pressure integrating devices. **(341)**

SUBMINIATURE SWITCH Micro Switch, a division of Minneapolis-Honeywell Regulator Co., Freeport,

the Week

Ill. Data sheet 192 covers the 1HM1 hermetically sealed subminiature switch. **(342)**

CONTROLLED RECTIFIER Westinghouse Semiconductor Department, Youngwood, Pa. Bulletin 54-564 covers the Trinistor controlled-rectifiers for controlling medium power loads. **(343)**

HEADERS & MODULE PACKAGES Epoxy Products Div., Joseph Waldman & Sons, 137 Coit St., Irvington 11, N. J. Bulletin describes 19 different electronic headers and module packages. **(344)**

TEST INSTRUMENTS Sperry Microwave Electronics Co., Clearwater, Fla., announces a 112-page catalog entitled "Sperry Microline Test Instruments." **(345)**

ALPHANUMERIC LINE PRINTERS Potter Instrument Co., Inc., Sunnyside, Blvd., Plainview, N. Y. Data sheet covers the LP-600 series transistorized high speed alphanumeric line printers. **(346)**

DIODE TESTING National Transistor Mfg., Inc., 500 Broadway, Lawrence, Mass. Bulletin covers environmental testing of gold bonded germanium diodes. **(347)**

EPOXY CASTING RESIN Emerson & Cuming, Inc., Canton, Mass. Technical bulletin 7-2-26 describes Stycast 1264, a transparent high impact epoxy casting resin. **(348)**

VOLTMETER APPLICATIONS Boonton Electronics Corp., 738 Speedwell Ave., Morris Plans, N. J. A brochure presents engineering notes on the applications of a series of r-f voltmeters. **(349)**

LEVER-TYPE SWITCHES Switchcraft, Inc., 5555 N. Elston Ave., Chicago 30, Ill. Catalog S-307 covers lever-type switches. **(350)**

SILICON RECTIFIERS Diodes, Inc., Canoga Park, Calif. A two-page bulletin describes miniature ¾ amp silicon rectifiers designed to withstand dipsolder range temperature conditions. **(351)**

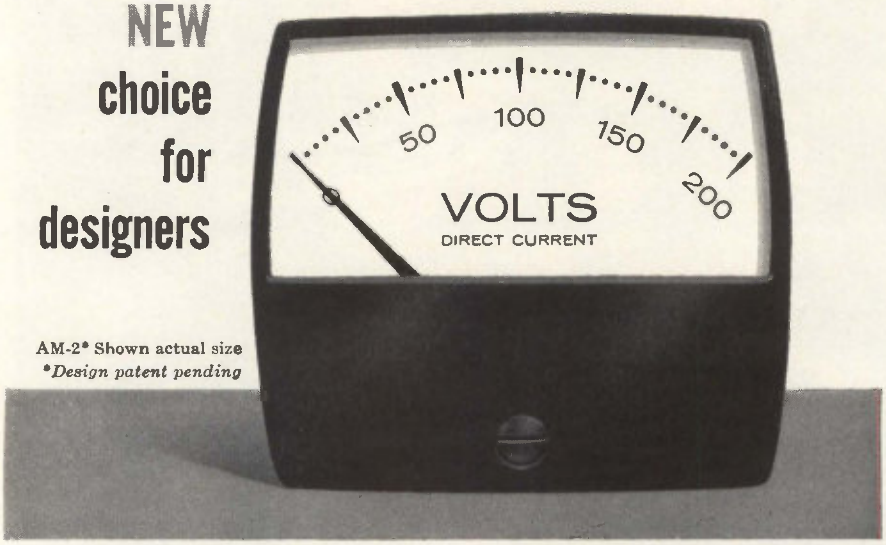
DECIMAL COUNTERS Bowmar Instrument Corp., 8000 Bluffton Road, Fort Wayne, Ind. Brochure covers series LC modular type decimal counters. **(352)**

Ammon meters reflect careful attention to design criteria, to achieve higher standards of performance with crisp new styling. Features include *self-shielded mechanism* (not a core magnet) for exceptional linearity and accuracy, allowing magnetic or non-magnetic panel mounting... *cluster mounting* bezel-to-bezel without interaction . . . *negligible effects* from stray fields . . . *gasket sealed*... non-magnetic pivots... *high torque-to-weight* ratio . . . long, easily-read scale with distinctive markings.

Case sizes conform to ASA/MIL mounting dimensions. Aluminum bezel in glare-free satin black or other colors. Any practical DC range, AC rectifier-types including VU. Bulletin on request. Ammon Instruments, Inc., 345 Kelley St., Manchester, N. H.

AMMON
INSTRUMENTS, INC.

NEW choice for designers



AM-2* Shown actual size
**Design patent pending*

CIRCLE 213 ON READER SERVICE CARD

NEW FAMILY DC AMPLIFIERS

LOW COST

ALL SOLID STATE

All units come compactly packaged in durable aluminum cases, 5½" L x 2½" W x 1¼" D. Also, two or more of the same or different types can be furnished in a single package for meeting special design requirements.

OPERATIONAL AMPLIFIER A-2 . . . an exceptionally *fast* DC amplifier for satisfying your more exacting requirements in instrumentation, analog computing, and complex data-handling and control systems.
OPEN LOOP GAIN — 100,000
GAIN-BANDWIDTH PRODUCT — 200 KC
RISE TIME — Less than 10 μsec. at unity gain and gain of ten; less than 100 μsec. at gain of one hundred.
PRICE — $195

POWER BOOSTER G-2 . . . a compatible plug-in unit for use with the A-2 in driving heavy instrument systems, small DC servos, rotary amplifiers, etc., in process and machine control applications.
CURRENT OUTPUT — 100mA @ ±10V
PRICE — $75

CHOPPER AMPLIFIER C-2 . . . a special low drift plug-in DC amplifier for use with the wide-bandwidth A-2 where microvolt stability is required in operational amplifier and pre-amplifier applications.
DRIFT (25°-50°C) — Less than 0.5 μV/°C
PRICE — $195

For complete details, request Bulletins 031, 032, and 033.

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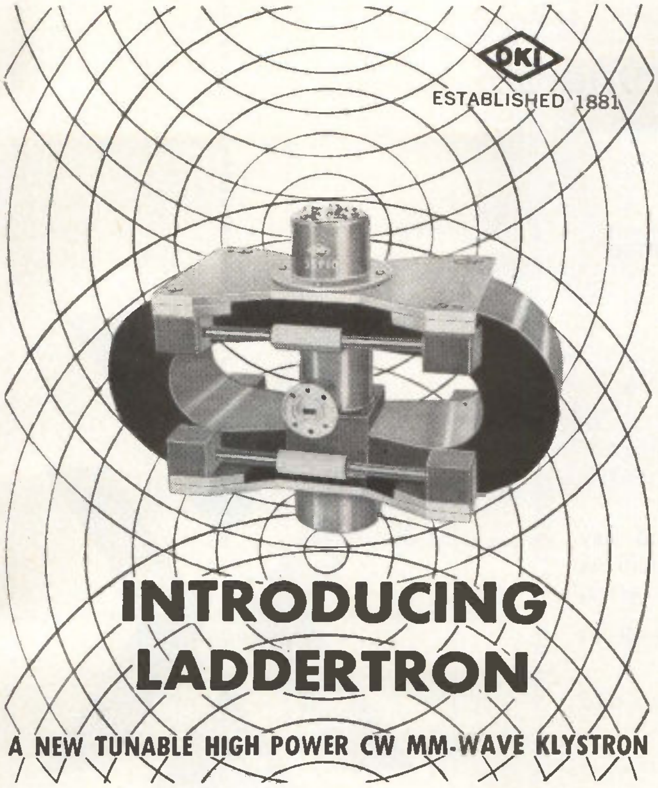
electronics BUYERS' GUIDE and REFERENCE ISSUE



INTRODUCING LADDERTRON

A NEW TUNABLE HIGH POWER CW MM-WAVE KLYSTRON

LADDERTRON, a single cavity, multi-gap klystron, employs a strip beam system, that permits LOWER BEAM VOLTAGE CW OPERATION FOR VERY HIGH POWER USE. The frequency of the LADDERTRON is mechanically tunable over a range of 1,000 Mc, and the control electrode modulation enables the electronic tuning in a range of 40 Mc.

The 2 models now in production are the 35F10 with a frequency of 35 K Mc and an output of 5 watts, and the 50F10 with a frequency of 50 K Mc and an output of 5 watts.

Model No.	35F10	50F10
Output Power	5W	5W
Center Frequency	34,000 Mc	50,000 Mc
Mechanical Tuning Range	±750 Mc	±1,000 Mc
Resonator Voltage	1,850V	2,140V
Cathode Current	110 mA	120 mA
Electrical Tuning Range	40 M c/s	40 M c/s
Water Cooling	0.5 ℓ/min.	0.5 ℓ/min.

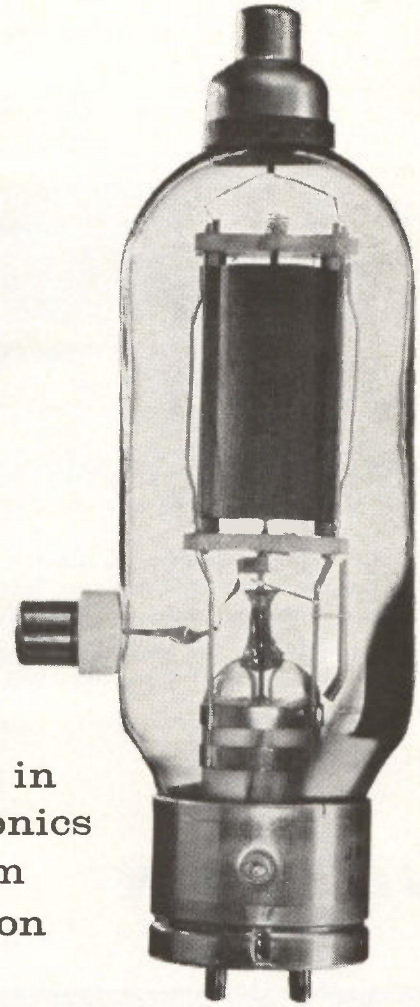
OKI
electric industry co., ltd. TOKYO JAPAN

FOR DETAILS, WRITE TO:

Sole Distributor in U.S.A.
Butler Roberts Associates, Inc.

4471, N.W. 36th Street, Miami Springs, Fla.
202 East 44th Street, New York 17, N.Y.
Frank Thomas P.O. Box 1377, Santa Barbara, Calif.

CIRCLE 210 ON READER SERVICE CARD



Ideas in Electronics from Norton

The electronics industry became a giant before it became a baby.

This outstanding growth has been largely due to the development of new materials — *refractory* materials with a great range of electrical properties. The prime source of these *idea refractories* is Norton Company.

For example, refractory fused alumina has high constant resistivity, to assure minimum leakage between elements in TV, radio and radar tubes. The same material is a recent innovation for transistor potting. Norton silicon carbide is an essential component in lightning arrestors and other non-linear resistors because of its variable voltage-current relationship. Silicon carbide is also finding new uses in microwave absorption, and as single crystals in high temperature rectifiers and transistors.

Fused magnesium oxide, used in most heating elements for electric ranges, has gained acceptance in such areas as advanced thermocouple design and infrared transmission.

Norton offers a wide choice of super-refined refractories, including oxides, borides, nitrides and carbides, and is ready to work with you in engineering materials to meet your needs. But above all, Norton offers ideas in every field in which refractory materials play a part.

Write NORTON COMPANY, Refractories Division, 681 New Bond Street, Worcester, Massachusetts.

NORTON
REFRACTORIES
Crystallizing ideas into products

CIRCLE 97 ON READER SERVICE CARD

Help put surveyor on the moon

Sometime in 1963, the first of several Hughes-built SURVEYOR vehicles will be put into lunar-impact trajectory for a soft landing on the moon. Surveyor instruments will perform a variety of scientific tasks: drills will pierce and analyze the moon's surface; high quality television pictures will be transmitted to earth; other instruments will measure the moon's magnetic and radiation characteristics. ■ To accomplish this step into space, Project Surveyor requires the talents of imaginative junior and senior engineers and physicists to augment its outstanding staff. Experience is preferred, but not required. ■ Unprecedented opportunities now exist on Surveyor and other projects, such as: ARPAT (terminal anti-ballistic missile defense system), BAMBI (anti-ballistic missile feasibility study), SYNCOM (synchronous communications satellites), POLARIS guidance and others.

CONTROL ENGINEERS—with experience in such areas as hydraulics, airborne computers, control circuitry, microwave antennas and other areas related to controls for the following areas of work: Missiles & Space Vehicles (attitude control—roll, pitch and yaw); Satellites (orbital control); Radar Tracking (hydraulic control of vertical and azimuth); Control Circuitry (preliminary and breadboard design); Control Systems (adaptive space control systems); Control Techniques (advanced non-linear); Equalization Networks (transistorized); Control Servomechanisms (design and debugging of controls, servomechanisms, sensors and other components); Missile Defense Systems (airborne computers and analog simulations of anti-ballistic missile defense systems).

SYSTEMS ANALYSTS—should be graduate physicists or engineers with a minimum of three years experience in weapon systems analysis, operation analysis, IR, physics of space, signal processing or communication theory. Involves the consideration of many basic problems such as: the proper mix of manned vs. unmanned satellites; the requirements of manned space flight; justification of system choice in terms of cost effectiveness; automatic target recognition requirements for high speed strike reconnaissance systems or unmanned satellites; IR systems requirements for ballistic missile defense; signal processing techniques for interplanetary telecommunications; analysis of weapon systems from conception through development, test and customer use; design concepts for new airborne weapon systems.

CIRCUIT DESIGN ENGINEERS—should be experienced systems engineers capable of analysis and synthesis of systems involving the following types of circuits and components: high power airborne radar transmitters; low noise radar receivers using parametric amplifiers, solid state masers and other advanced microwave components; radar data processing circuit design, including range and speed trackers and crystal filter circuitry; high efficiency power supplies for airborne and space electronic systems; telemetering and command circuits for space vehicles; timing, control and display circuits for COLIDAR (Coherent Light Detection and Ranging).

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

Immediate openings also exist for Power and Propulsion Engineers, Analytical and Design Engineers, Structures Engineers, Heat Transfer Engineers, Equipment Installation Engineers, Electromagnetic Theory Specialists and Antenna Specialists.

Reply today: Your inquiry will be treated with strict confidence. Please airmail your resume to: **Robert A. Martin**, Supervisor of Scientific Employment, Hughes Aircraft Co., 11940 West Jefferson Blvd., Culver City 61, California.

WE PROMISE YOU A REPLY WITHIN ONE WEEK

Creating a new world with ELECTRONICS

HUGHES

HUGHES AIRCRAFT COMPANY

AEROSPACE DIVISIONS

An equal opportunity employer.

Does he know what time it really is?

It's time to close ranks behind our country. And you are the one who can best tell your employees how, with your promotion of the Payroll Savings Plan for U.S. Savings Bonds. Sure, you talk in terms of their own personal stake in savings that give them security and peace of mind. You show them how easy it is. How completely painless. But then you owe it to the bigger purpose to show how much savings also help the individual's community—and his country. You can get all the facts and help you need by calling your State Savings Bonds Director. Or write to Treasury Dept., U.S. Savings Bonds Division, Washington 25, D.C.

Keep Freedom in Your Future... **U.S. SAVINGS BONDS**

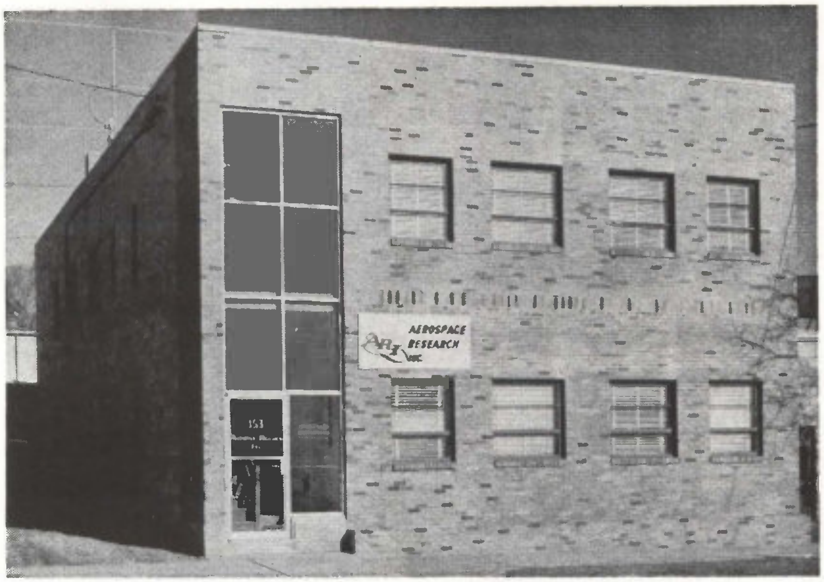
We're living in a needing, buying, growing America—a time for new and improved products and services—the creation of new jobs. More than ever, a businessman with an idea, with the urge for something better will move ahead with our expanding economy.

But after the idea, what follows can be a costly period of research and development. Not necessarily—if you use the immense 9-billion-dollar fund of research and patent information that's available at your U. S. Department of Commerce. Think of the saving—in time and money.

For example: there are reports on extensive research by your Government in new products and processes. A translation of data on inventions and discoveries abroad—information on over 3 million patents—a fortune in patents owned by your Government. All this is yours—for your use and your benefit.

Take advantage of the many ways in which your business can grow. In developing new products and services. In the lucrative foreign markets. In new U.S. markets. In attracting new industry to your local community. Just phone or write the U.S. Department of Commerce Office of Field Services in your city, or Washington 25, D.C. Your U.S. Department of Commerce is always ready to help you grow with America!

NOW'S THE TIME TO GET GROWING IN A GROWING AMERICA!



Aerospace Research Opens New Plant

AEROSPACE RESEARCH, INC., formerly of Cambridge, recently opened new laboratory, production, and office facilities at Newton, Mass. Rapid expansion in the wake of new research contracts and the necessity of production line manufacturing of company products prompted the move.

The company is engaged in research and development in radio propagation, communications, solid state instrumentation and ionospheric physics. Prime contract activity is largely with the Air Force Cambridge Research Laboratories in Bedford, Mass.

ARI manufactures products used in timing systems and in radio propagation research. Very low frequency equipment is a specialty. Company says items such as an electrostatically shielded loop antenna, and the Caliverter, a vlf to h-f broadband converter, have found a wide market.

The company's latest development for the Air Force is an improved Riometer (Relative Ionospheric Opacity Meter), for detecting ionospheric changes. ARI is presently manufacturing these for the general industry.

L. Dennis Shapiro, president and director of research, says that the company will continue to expand along the same lines, balancing R&D and product sales.

Granger Associates Expands Staff

THREE ADDITIONS to its senior engineering staff have been announced by Granger Associates, Palo Alto, Calif.

Bernard M. Schiffman and Willis E. Moore have been assigned to the antenna department, to develop and design log periodic antennas for h-f communications and other applications.

Wayne A. Downie is engaged in new product development in the aviation products department.

Schiffman joins Granger Associates from Varian Associates. Moore was previously associated with Convair Div. of General Dynamics. Downie was formerly with Pan American World Airways.

Victoreen Elects Vice President

JAMES P. MCMAHON, president of Tullamore Electronics Corp., a subsidiary of The Victoreen Instrument Co., New York City, has been elected a vice president of that company.

After nine years with the AEC's Argonne National Laboratory as an electronics instrument designer, McMahon left to found Tullamore Electronics Corp., which early in 1959 became a wholly owned subsidiary of Victoreen.

Three Engineers Join TRG-West

TRG, INC., Syosset, N. Y., announces the appointment of Mogens Andreasen, Eugene Sharp and G. R. Hilbers to the staff of TRG.West, Menlo Park, Calif.

All were formerly with Stanford Research Institute.

Hirsch Assumes New Position

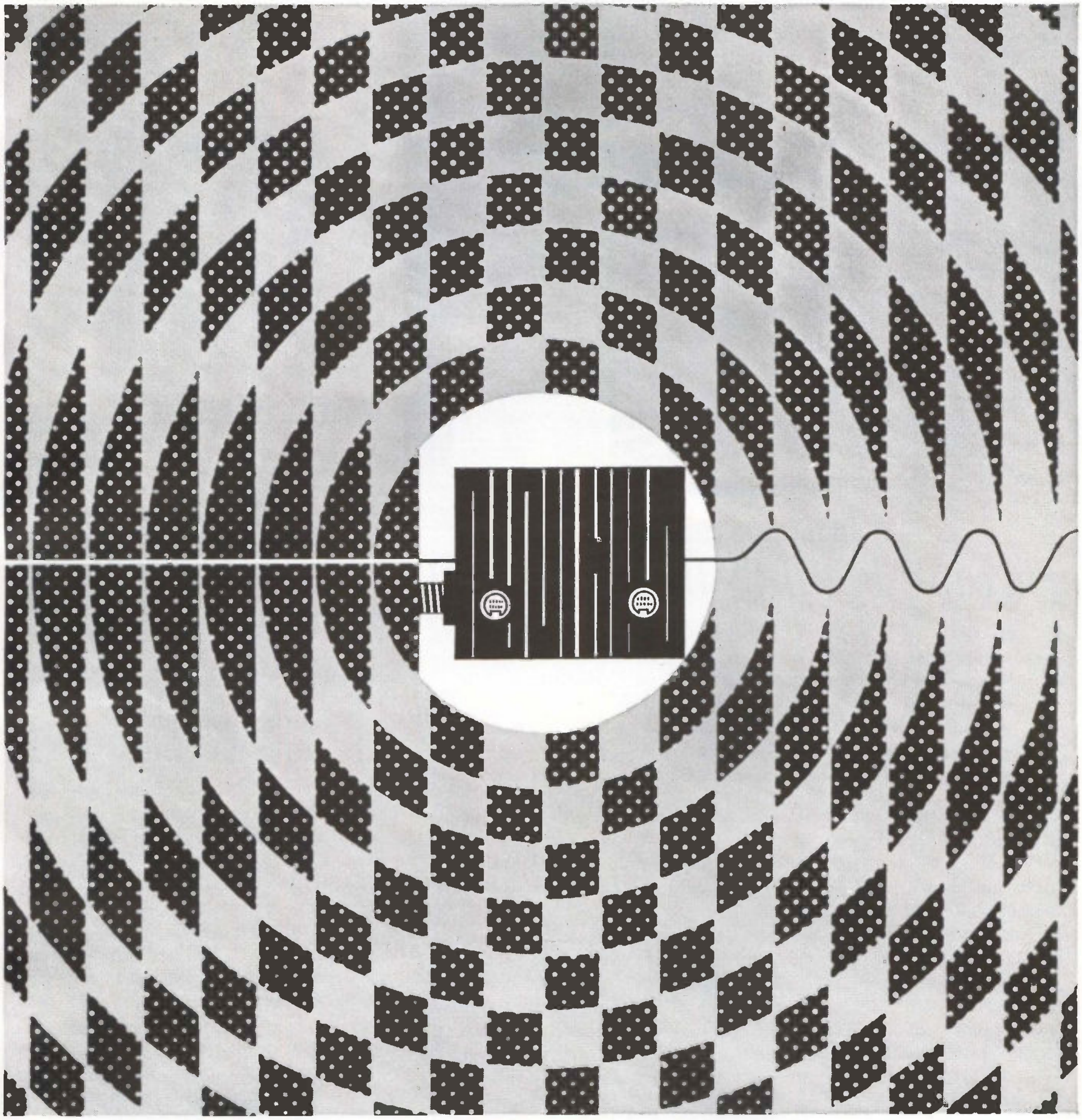
MILTON D. HIRSCH has been appointed contracts manager for Western Design & Electronics, a division of U. S. Industries, Inc., Santa Barbara, Calif.

Prior to joining WD&E, he was director of engineering liaison at Radiatronics Inc. in Van Nuys, Calif. He has also been associated with the Schutter Microwave Corp., Lindenhurst, N. Y., as executive vice president.

Hughes Aircraft Promotes Lutz

SAMUEL G. LUTZ has been appointed chief scientist of Hughes Aircraft Company's research laboratories in Malibu, Calif., where he will direct studies of satellite communications.

Since 1958 Lutz has been a senior scientist at the laboratories;



HOW 6 TRANSISTORS CAN WORK 7 TIMES HARDER WITH ONLY HALF TRYING

(a report from Delco Radio)

Sound like a riddle? Well, it was . . . almost. Here's the story.

Delco Radio engineers wanted to build a precision static inverter that was smaller, simpler, lighter, more economical and considerably more powerful than previous models.

Research hit on the idea of current feedback. Following this principle, the engineers designed an amazing inverter using only 6 transistors. Transistor utilization is stepped up 7 times, yet the transistors work at less than 50% of their capacity, run cooler, last longer.

SEE YOU AT IRE SHOW, BOOTH 1423

This new Delco 250 VA power supply converts 28 volts DC to 115 volts, 400 cps. Its circuits are a model of simplicity.

The unit is designed for continuous full-load operation at 71 degrees C. still air, yet weighs only 10 lbs., measures 6¼" x 7⅜" x 5". A minimum of components assures extra-high reliability.

The 250 VA Static Inverter is practical hardware today, awaiting your inquiry. Delco Radio may be able to solve your problem in miniaturization, modules, inverters or converters, too. Write to Delco Radio Military Sales Department, Kokomo, Indiana.

DELCO RADIO
Dependability
Reliability

Division of General Motors • Kokomo, Indiana

CIRCLE 105 ON READER SERVICE CARD

before that, he directed the company's communications engineering from 1951 to 1958.

Research-Cottrell Names Division Mgr.

CHARLES N. HOOD II was recently appointed manager of the new electronics division of Research-Cottrell, Inc., Bound Brook, N. J.

Hood comes to his new post from Airborne Accessories Corp., Hillside, N. J., where he was engineering director.

Loral Electronics Hires Horowitz

LES HOROWITZ has been appointed product line manager at Loral Electronics Corp., New York City.

Prior to joining Loral, and since 1950, Horowitz held various supervisory engineering positions at Picatinny Arsenal. His last post was as chief, Atomic Ammunition Development Laboratory, Special Weapons Group.

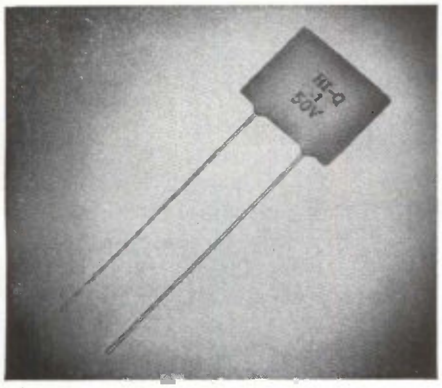
MSI, Inc., Appoints Wallace Anderson

MICROWAVE SERVICES INTERNATIONAL, INC., Denville, N. J., has appointed Wallace L. Anderson to the post of chief consultant in radio

PRODUCT NEWS FROM AEROVOX

NEW SQUARE TRANSISTOR PLATE CAPACITORS

permit maximum circuit component density at low cost



Hi-Q capabilities and advanced manufacturing facilities have once again produced an improved capacitor design to meet today's critical demands for high reliability and space savings. This new square, slim design permits maximum circuit component density, yet it is nearly in the same cost range as conventional disc capacitors.

SPECIFICATIONS

Units are available in a capacity range from .005 mfd. to .1 mfd., in sizes from .280″ square to .780″ square x .125″ maximum thickness. Coating is a durez phenolic, wax impregnation.

- Tolerance: +80% −20% standard; others available.
- Working Voltage: 50 VDC
- Flash Test Voltage: 150 VDC
- Power Factor: 3% max. at 1 KC
- Insulation Resistance: 5000 Megohms min.

Prototype Samples are available from your Hi-Q Representative or direct from the factory.

HI-Q® DIVISION

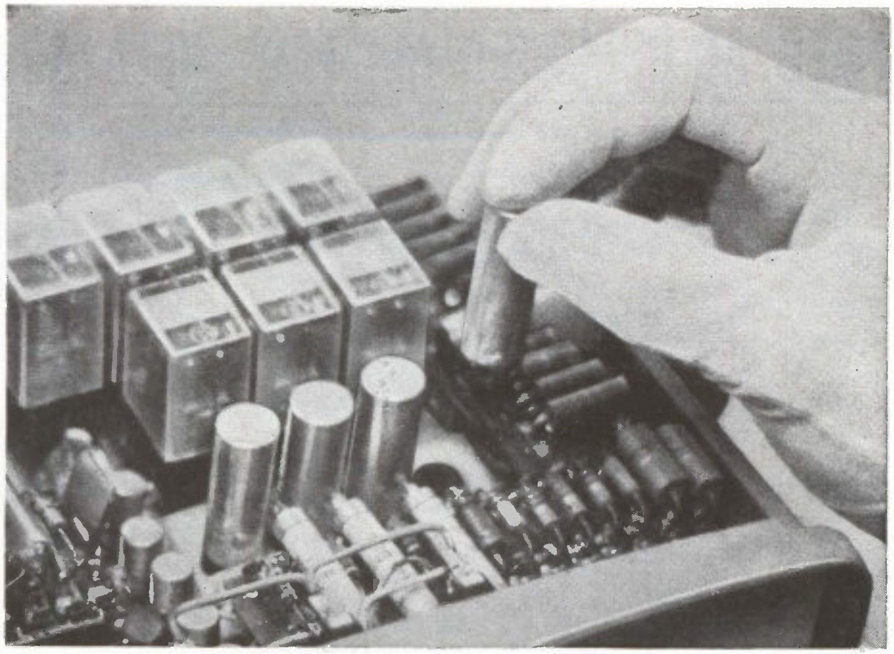
COMPLETE TECHNICAL DATA—Write, wire or phone today for our latest catalog sheet.

AEROVOX CORPORATION

Hi-Q Division, Myrtle Beach, S.C.

Technical Leadership – Manufacturing Excellence

CIRCLE 209 ON READER SERVICE CARD



MINIATURE RESONANT REED SELECTORS

These miniaturized selectors are useful in multiplex telemetry, mobile communications, and other applications where space and weight are at a premium. Their secret is a new electro-mechanical driving system that allows both the reed and driving coil to be sealed in a case only 36mm long and 12.6mm in diameter. Each selector will respond to one of 40 audio frequencies spaced at 15 cps intervals from 262.5 to 847.5 cps, and actuate signals, counters, controls or other devices. Normal drive current is 2.5mA. Selectivity is ±1.5 cps from standard frequency, and stability is within ±0.5 cps of calibrated frequency from −10 to +50°C. Detailed specifications and application information are available from our representatives listed below.

FUJI TSUSHINKI SEIZO K.K. Tokyo, Japan

Represented by:

■ **The Nissho American Corporation** □ New York 5, 80 Pine St., WH 3-7840 □ Chicago 3, 140 S. Dearborn St., CE 6-1950 ■ **The Nissho Pacific Corporation** □ San Francisco 4, 120 Montgomery St., YU 2-7901 □ Los Angeles 14, 649 S. Olive St., MA 7-7691

CIRCLE 107 ON READER SERVICE CARD

Is your advertising se the same four key buyers your salesmen call on? Competition demands it! Only advertising in electronics reaches and sells the electronics man *wherever* he is: in *Research*, *Design*, *Production*, *and Management*. Put your advertising where it works *hardest*...

TODAY YOU MUST SELL ALL FOUR!

in **electronics**

wave propagation.

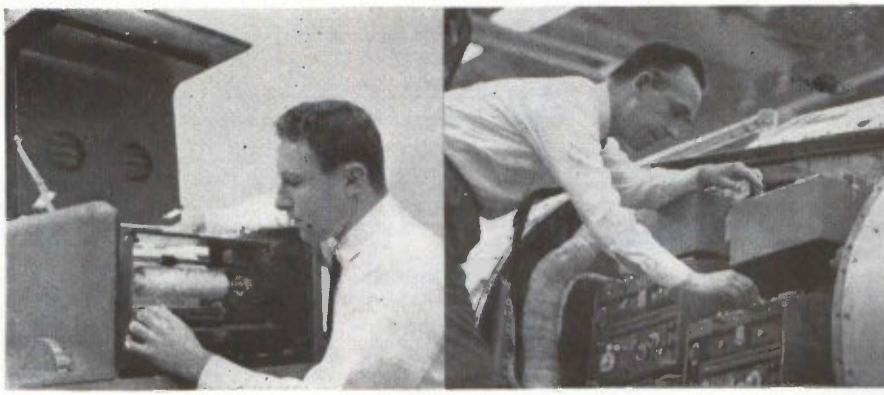
Anderson is currently an associate professor of electrical engineering at New York University.

Aerospace Corp. Promotes Hansen

ROBERT C. HANSEN has been appointed associate director for satellite control in the engineering division at Aerospace Corp., El Segundo, Calif. He previously worked as senior staff scientist in the company's electronics laboratory.

PEOPLE IN BRIEF

Henry W. McMurtray, formerly with Raytheon, appointed director of quality control and reliability at Microwave Associates, Inc. **Andrew E. Trolio** and **Boyce M. Adams,** both ex-Omnitronics, Inc., are now president and vice president, respectively, of the newly formed Adtrol Electronics, Inc., in Philadelphia. **B. Cletus Kirchner,** previously with RCA, Electrons, Inc. and Cetron Electronics, has joined the Thyratron and Rectifier div. of National Electronics, Inc., as production mgr. **Herman H. Frahme,** president of Alberox Corp., has been elected chairman of the electronics division of American Ceramic Society for the year beginning in April. **Joseph P. O'Reilly** moves up from v-p and g-m to president of Ferroxcube Corp. of America. **Maurice M. Rosen,** president of Progress Mfg. Co., Inc., is also named president of Progress Webster Electronics Corp. **Ivan L. Brandt,** from Rescon Electronics Corp. to Erie Resistor Corp. as director of R&D. **Morris Cohen** rejoins PRD Electronics, Inc. from Loral Electronics Corp. in the position of microwave dept. head of the Products and Components div. **G. R. Gunther-Mohr** is promoted to director of solid state engineering, International Business Machines Corp. **Urner Liddel** leaves the Department of Defense to become asst. director of Hughes Aircraft Co.'s Research Laboratories. **W. Robert Wilson,** formerly with Texas Instruments, is hired by Data-Control Systems, Inc., as mgr. of systems programs.



PHOTOGRAPHS – COURTESY: REPUBLIC AVIATION

The Case For Pinpoint Recruiting

Pinpoint Recruiting (the act of going directly to the most concentrated source of supply to find 'the right man' for the job) can be termed the most efficient method of recruiting engineers, and yet it is the simplest of all methods.

If you bear in mind the fact that the cream of the engineering talent you seek are presently employed and generally happy in their work, you realize that you must arouse their interest in YOUR company. As you know, engineers change jobs more frequently than does the average job holder . . . And so you ask yourself, "What motivates the engineer to do this?" To some, the answer may be surprising.

Studies in recent years have shown that the motivating factors are as follows:

1. Potential growth of company.
2. Challenging opportunity.
3. Starting salary.
4. Progressive research and development.
5. Company's prestige, reputation.
6. Regular salary increases.
7. Geographic location.
8. Permanent position.

Eight points to ponder, to weave into your recruitment advertising with skill, to attract the qualified engineers you need. When you have it all wrapped up, run your advertising in a technical publication that keeps the engineer abreast of technological developments in the industry to which he contributes his talents. It is simple reasoning that the publication the engineer pays his money to read is the one he reads most thoroughly and values most highly as his technical journal.

And there lies that "—most concentrated source of supply—" . . . of the experienced engineers you need. This is Pinpoint Recruiting. Simple, isn't it? . . . Effective, too.

*Write for the new 52-page booklet "**Recruiting Engineers**"*
Address: David Hawksby, Classified Advertising Division,
electronics, Post Office Box 12, New York 36, N. Y.

electronics
A McGRAW-HILL PUBLICATION
CLASSIFIED ADVERTISING DIVISION
POST OFFICE BOX 12 NEW YORK 36, NEW YORK

electronics

WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

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

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

STRICTLY CONFIDENTIAL

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

WHAT TO DO

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

COMPANY	SEE PAGE	KEY #
COLUMBIA UNIVERSITY Nevis Laboratories Irvington, New York	94*	1
ESQUIRE PERSONNEL SERVICE INC. Chicago, Illinois	111	2
GENERAL DYNAMICS/ELECTRONICS Military Products Div. San Diego, California	111	3
GILLETTE SAFETY RAZOR CO. Boston, Massachusetts	96*	4
HAMILTON STANDARD Div. of United Aircraft Corp. Windsor Locks, Connecticut	115	5
INTERNATIONAL BUSINESS MACHINES CORP. Supplies Division Vestal, New York	96*	6
INTERNATIONAL ELECTRIC CORPORATION Div. of International Telephone & Telegraph Corp. Paramus, New Jersey	82	7
LABORATORY FOR ELECTRONICS Boston, Massachusetts	78	8
LOCKHEED-GEORGIA CO. Div. of Lockheed Aircraft Corp. Atlanta, Georgia	85*	9
LOCKHEED MISSILES & SPACE CO. Div. of Lockheed Aircraft Corp. Sunnyvale, California	80, 81	10
LORAL ELECTRONICS CORP. Bronx, New York	95*	11
MARTIN MARIETTA Aerospace Division Orlando, Florida	94*	12
MICROWAVE SERVICES INTERNATIONAL, INC. Denville, New Jersey	111	13
MOTOROLA, INC. Military Electronics Div. Western Center Scottsdale, Arizona	113	14
OHIO STATE UNIVERSITY Radio Observatory Columbus, Ohio	112	15

CONTINUED ON PAGE 112

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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)

2232

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

CATEGORY OF SPECIALIZATION

Please indicate number of months experience 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

EMPLOYMENT OPPORTUNITIES

The advertisements in this section include all employment opportunities — executive, management, technical, selling, office, skilled, manual, etc.

Look in the forward section of the magazine for additional Employment Opportunities advertising.

— RATES —

DISPLAYED: The advertising rate is $40.17 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

An advertising inch is measured ⅞" vertically on a column—3 columns—30 inches to a page.

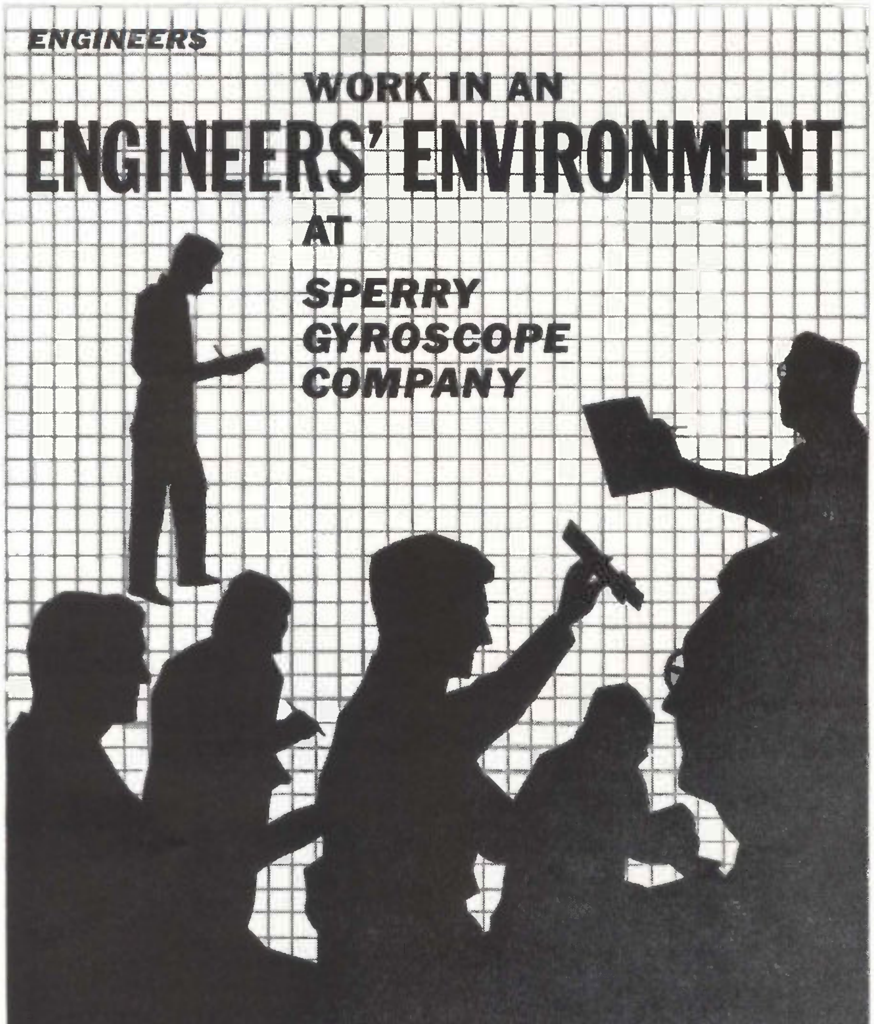
Subject to Agency Commission.

UNDISPLAYED: $2.70 per line, minimum 3 lines. To figure advance payment count 5 average words as a line.

Box numbers—count as 1 line.

Discount of 10% if full payment is made in advance for 4 consecutive insertions.

Not subject to Agency Commission.



For more than fifty years engineers have acknowledged that Sperry is a good place to work. The reason? Simply stated it's because Sperry possesses a true **engineers' environment.** Here you will find the broad range of programs that insures stability and because of their advanced nature you can forget "off-the-shelf" concepts and start using your creative imagination. At Sperry you will be working with the top men in your specialty and from these men you will gain increased professional competence. Finally Sperry's management is technical management that knows an engineer's problems and recognizes his contributions.

Gain the many advantages of an engineers' environment by joining the Technical Staff at Sperry. Openings are currently available for engineers experienced in one or more of these areas:

• GYROS AND INERTIAL COMPONENTS • DIGITAL COMPUTERS • CIRCUITRY • PACKAGING • COMMUNICATIONS • SONAR • RADARS • ASW • STAR TRACKERS • CELESTIAL AND INERTIAL NAVIGATION SYSTEMS • PRECISION GEAR TRAINS • STRESS ANALYSIS • RANGE INSTRUMENTATION • MISSILE INSTRUMENTATION • FIELD ENGINEERING

Inquiries may be sent in complete confidence to:
Mr. J. W. Dwyer, Employment Manager

SPERRY *GYROSCOPE COMPANY*
Division of Sperry Rand Corp.
Great Neck, Long Island, N.Y.
An Equal Opportunity Employer

ELECTRONICS TECHNICIANS

Excellent opportunities for experienced electronic technicians at large university radio observatory in development and operation of low noise radio-meters with digitized output operating at UHF and microwave frequencies. Give resume of experience, references, and salary desired. Address correspondence to:

Director
Ohio State University Radio Observatory
2024 Neil Avenue
Columbus 10, Ohio

ELECTRONIC ENGINEER

For analog to digital circuit design. Should have E.E. and 5 to 10 years experience with at least 2 years in solid state. Top position. Salary $10,000 to $12,000 and stock options. Philadelphia area.

P-8290, Electronics
Class. Adv. Div., P.O. Box 12, N.Y. 36, N.Y.

POSITION VACANT

The position of Chairman of the Faculty of Electronic Technology is open at Arizona State University. Electronic Technology is devoted to the preparation of Engineering Technicians in a four-year program which leads to a Bachelor of Science degree. Interested persons holding a M.A., M.S., or Ph.D., having teaching, industrial and administration experience in electronics are invited to correspond with the Division of Industrial Education, Arizona State University, Tempe, Arizona.

SELLING OPPORTUNITY WANTED

Sales Engineers—New Group Engineers to represent equipment manufacturer. Territory —Texas, Kansas, Oklahoma, Missouri—retainer or commission. RA-8391, Electronics, Classified Adv. Div., 645 N. Michigan Ave., Chic. 11, Ill.

electronics

WEEKLY QUALIFICATIONS FORM FOR POSITIONS AVAILABLE

(Continued from page 110)

COMPANY	SEE PAGE	KEY #
PAN AMERICAN WORLD AIRWAYS INC. Guided Missiles Range Div. Patrick AFB, Florida	16*	16
SCOPE PROFESSIONAL PLACEMENT CENTER Waltham, Massachusetts	115	17
SPERRY GYROSCOPE COMPANY Div of Sperry Rand Corp. Great Neck, L.I., New York	112	18
SYLVANIA MOUNTAIN VIEW OPERATIONS Mountain View, California	114	19
THIOKOL CHEMICAL CORPORATION Bristol, Pennsylvania	95*	20
P-7950	111	21
P-8290	112	22

* These advertisements appeared in the 2/16/62 issue.

SCIENTISTS/ENGINEERS

Career opportunities in:

- DESIGN
- RESEARCH
- DEVELOPMENT
- SALES
- MARKETING
- APPLICATION

Submit resume in confidence to:

- Alan Glou .....Technical/Scientific
- Sid Hopner.....Sales/Marketing

Specialists in the personalized placement of Electronic Engineers and Scientists, on a national basis, who have a BS or advanced degrée. Client companies assume fee and relocation costs.

SCOPE

PROFESSIONAL PLACEMENT CENTER
1277 MAIN ST. WALTHAM, MASS

MANUFACTURERS' REPRESENTATIVES

IN THE ELECTRONIC INDUSTRY

23 Years of Sales Success in Electronics Products
NEW YORK • NEW JERSEY
PENNSYLVANIA
KENNETH E. HUGHES Co., Inc.
4808 Bergenline Ave., Union City, N. J.

SEARCHLIGHT SECTION
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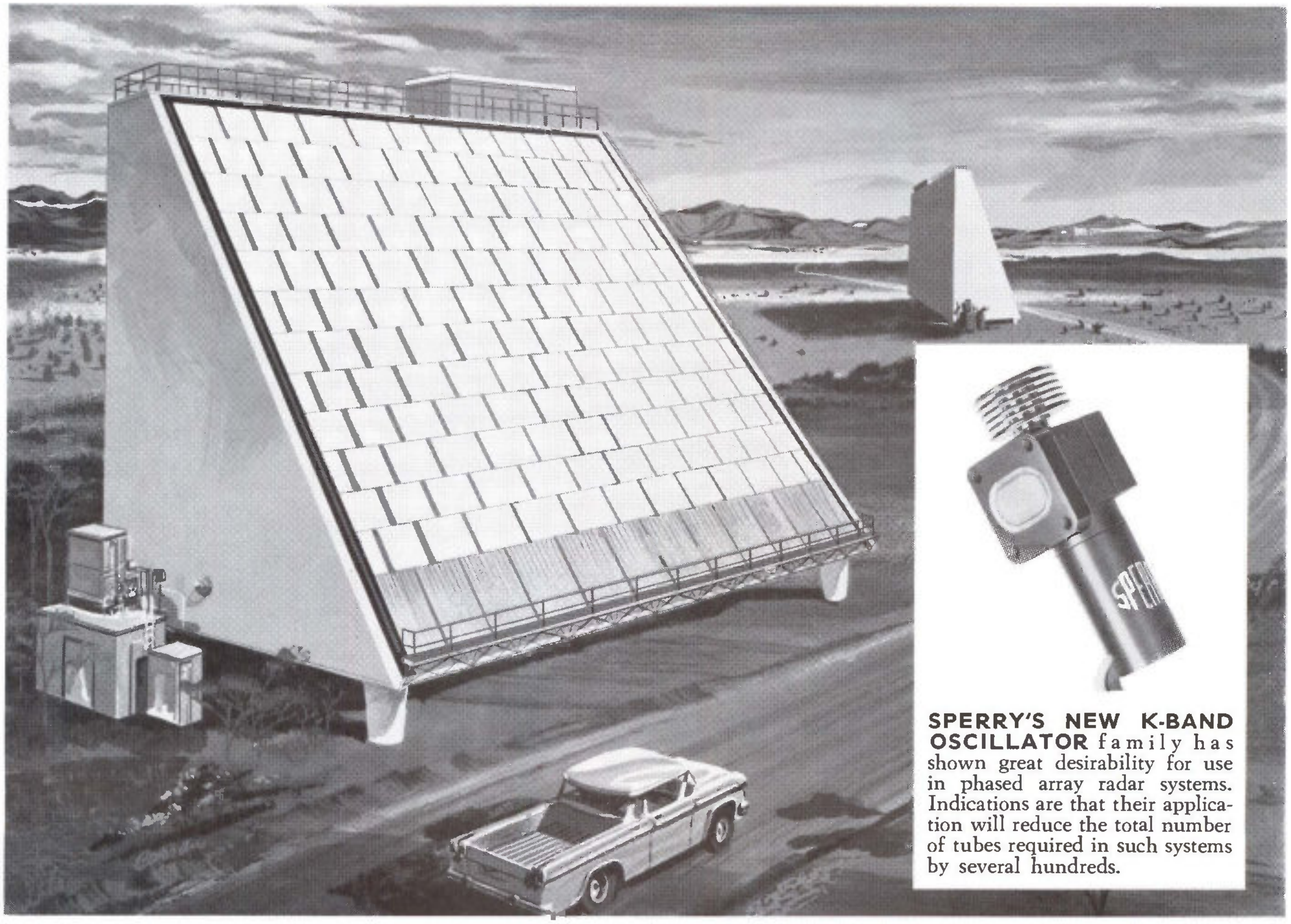

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COMPONENT SAVINGS POSSIBLE

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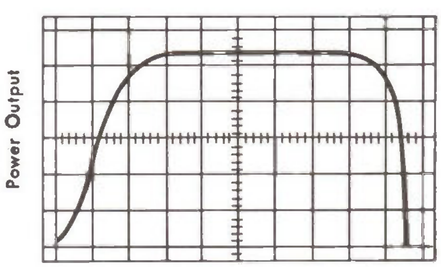

A typical main mode, adjusted for optimum flat-top operation

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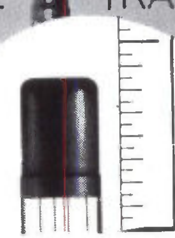

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