December 8, 1961

electronics

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Photo at right

SATELLITE ORBITS

traced on scope. Gun calls up more data. *See p 74*

How to design

MAGNET SYSTEMS

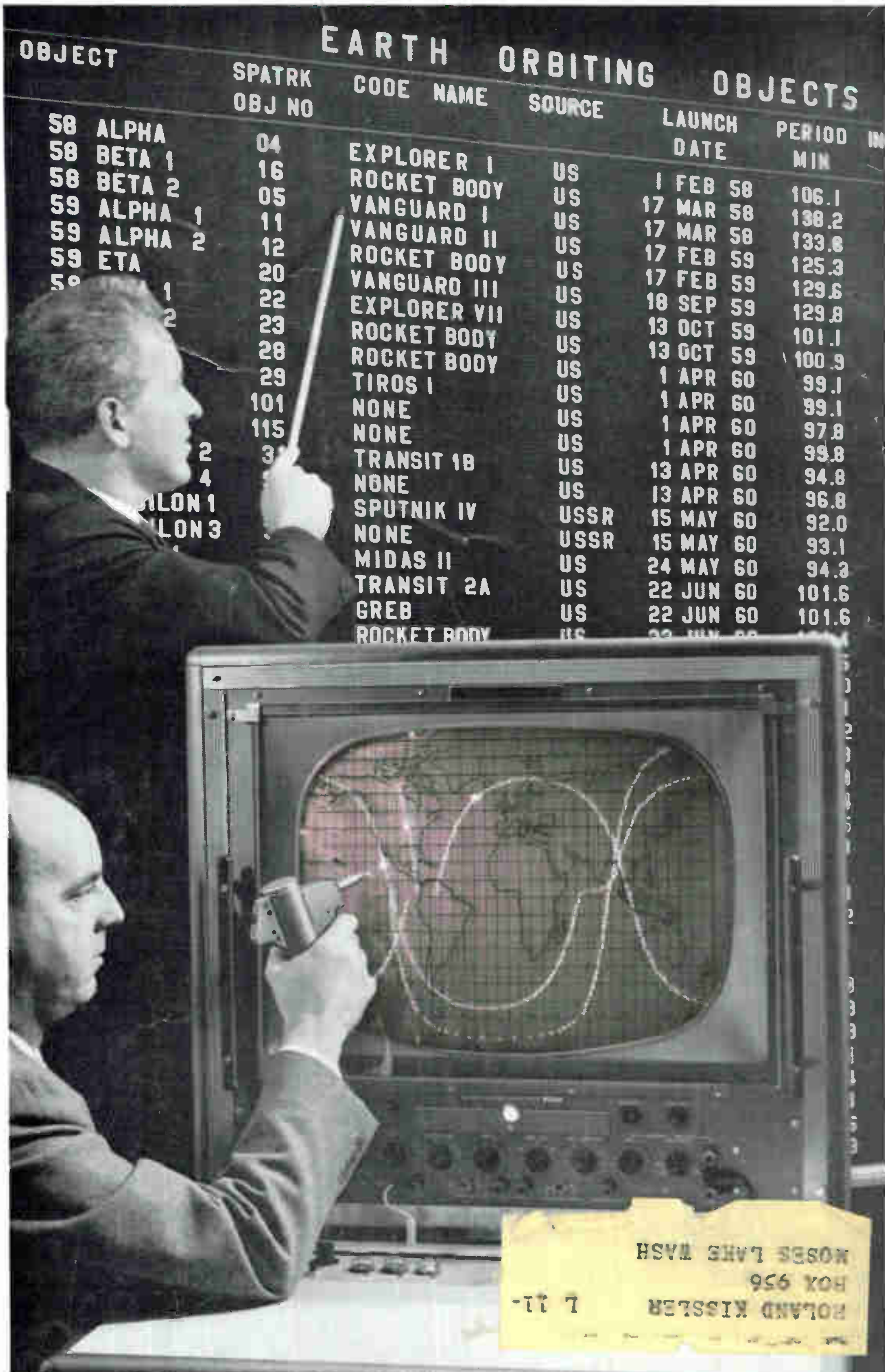
for traveling-wave tubes and klystrons, *p 66*

SOLID-STATE PANELS

display pulse waveforms, *p 53*

POWER TRANSFORMERS

a quick way to select them, *p 72*



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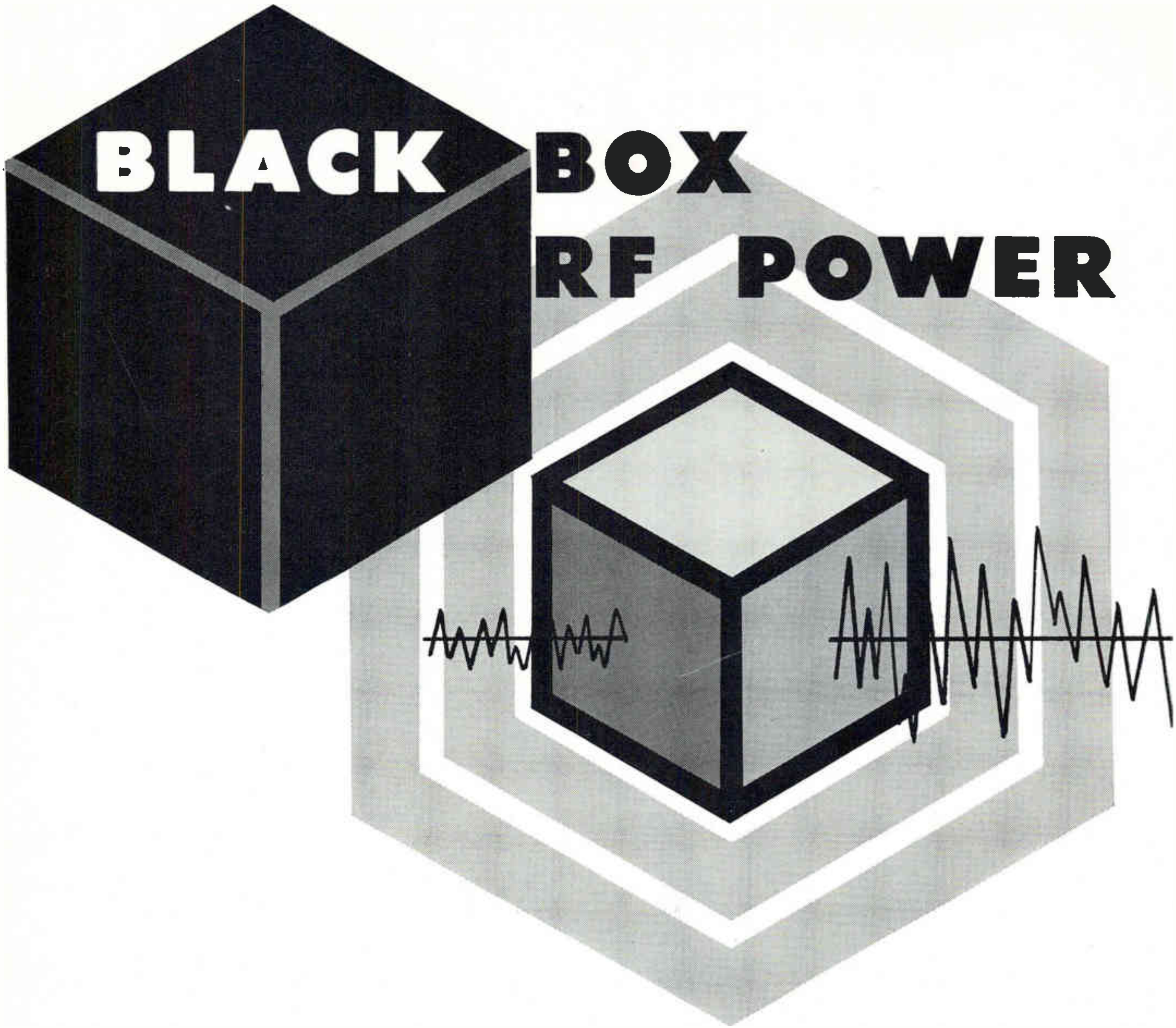

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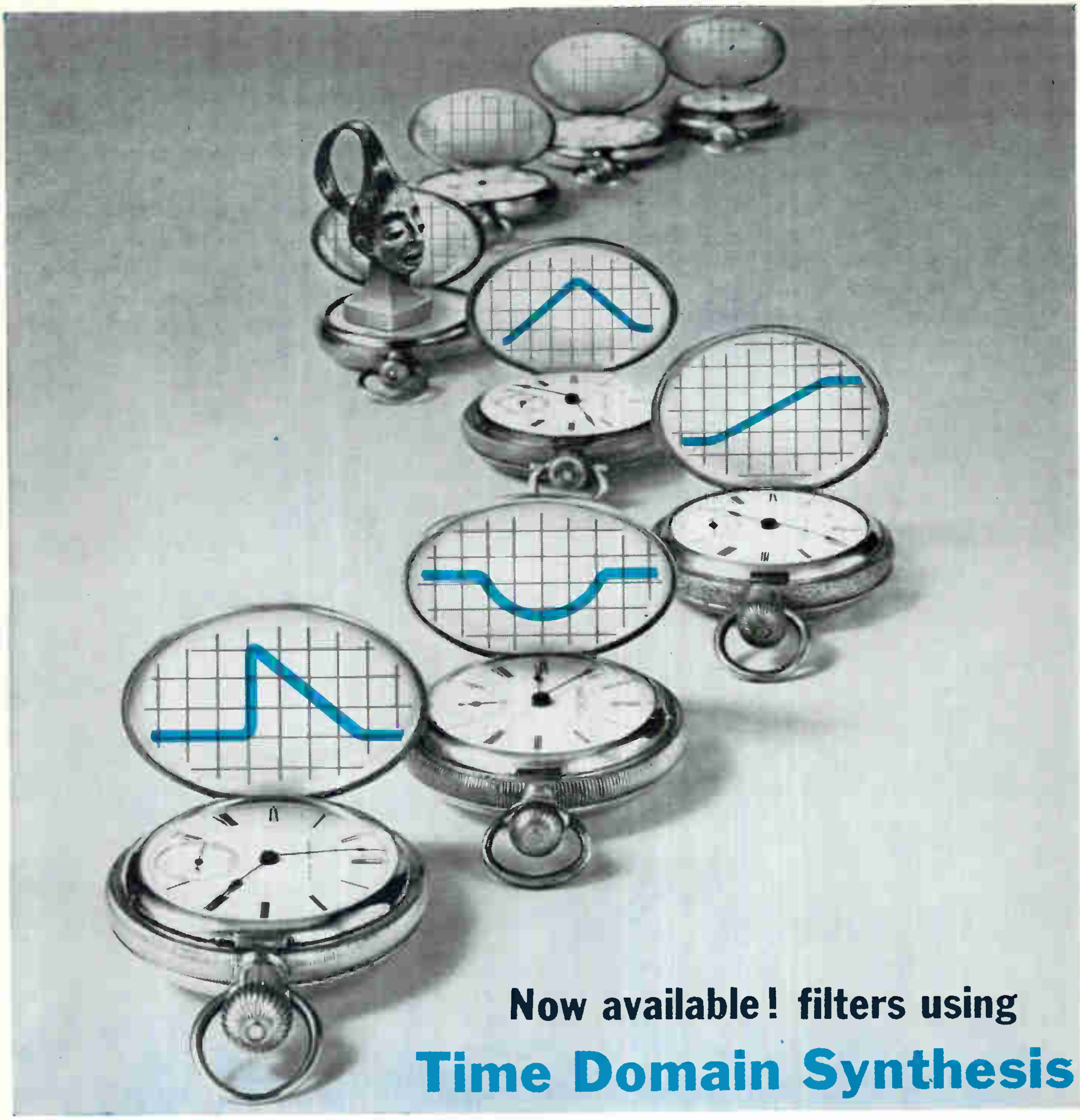

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CIRCLE 3 ON READER SERVICE CARD

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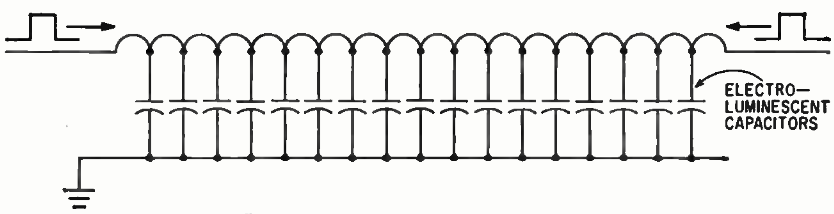
CROSSTALK

FLAT SCREEN electroluminescent displays may, when perfected, give in a solid-state device the picture clarity and definition now obtained in cathode-ray tubes. Since the viewing screen need be no more than a fraction of an inch thick, a tv screen—for example—could be hung on the wall like a painting while the circuit is hidden away in a black box in the attic. The same basic setup could be used to reduce the airplane panel volume occupied by a radar set or to ruggedize industrial monitoring equipment.

Even now, rudimentary electroluminescent screens are being used for alphanumeric display and large-scale plotting and tracking panels.



There are several approaches to designing such displays. One of the more ingenious is described in this issue on p 53 by R. W. Windebank, of G. V. Planar, Ltd. It does not need a conductor to each point to be illuminated. Instead, delay line principles are used to build up a voltage pulse at the desired spot.

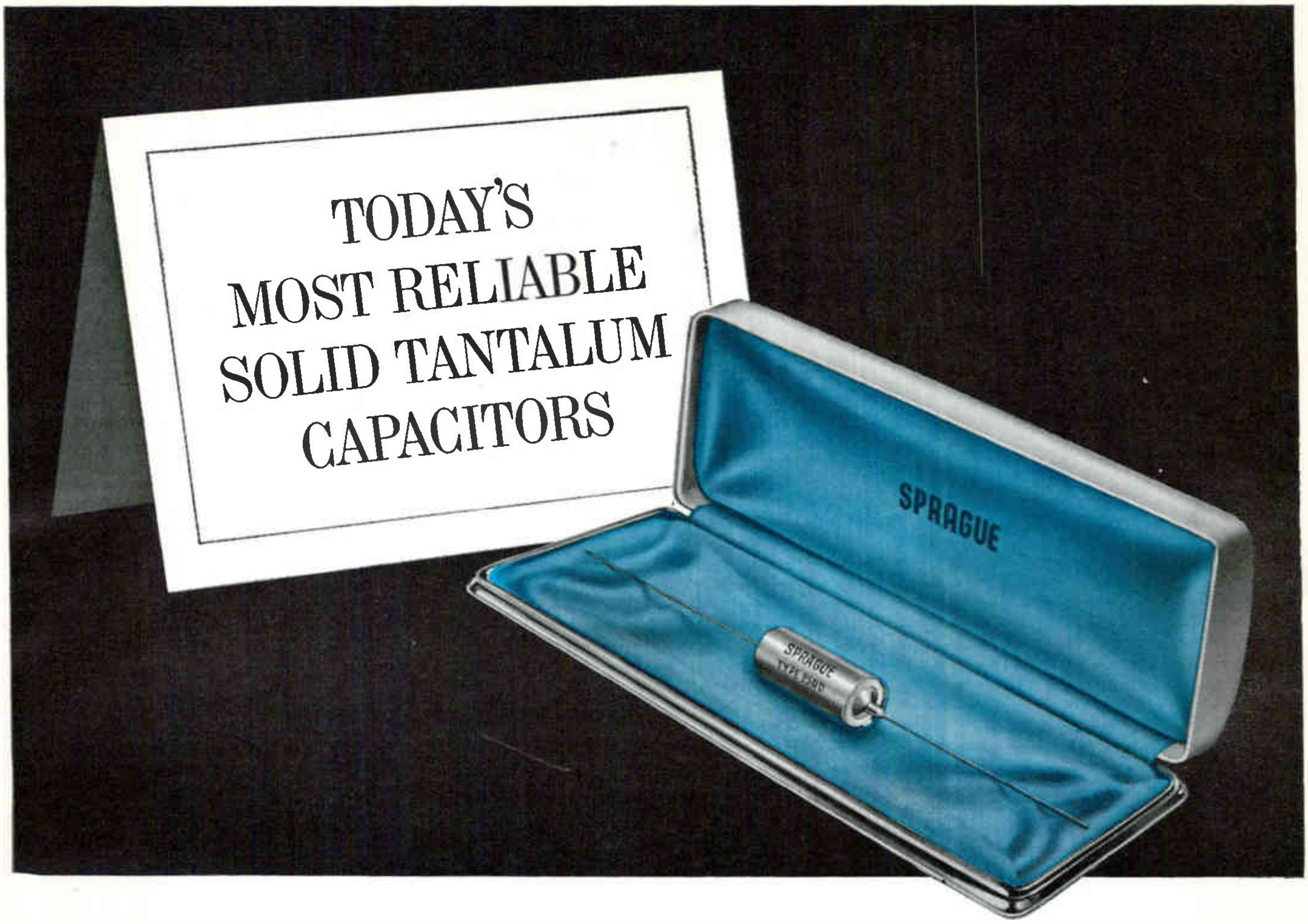
Pulses are introduced at each end of the line (see sketch). Since the delay line capacitive sections are also the electroluminescent display elements, the point at which the pulses coincide is the point illuminated. The doubling of voltage turns them on. Pulse coincidence is controlled through the relative phasing of the pulses.

The basic linear display is converted fairly easily to a square or rectangular panel by folding a long delay line into parallel segments. A further sophistication is a matrix control method that permits higher pulse rates and a four-fold increase in coincident pulse amplitude, for greater brightness.

Coming In Our December 15 Issue

MEDICAL ELECTRONICS. After covering diagnostic, clinical and prosthetic medical electronics equipment in five articles published earlier this year, Senior Associate Editor Bushor now reports on the instruments being used to probe life processes. Among the instruments employed are infrared, ultraviolet, x-ray and ultrasonic microscopes, nuclear magnetic resonance and electron precession spectrometers, cell counters, gas analyzers, photometers and many more, in two more articles.

Other reports in this issue include a roundup of new electron tubes, by Associate Editor Solomon; a hybrid electronic ignition system, by H. P. Quinn, of Tung-Sol; an avalanche-detecting telemetry system, by G. Neal and S. A. Stone, of the Canadian National Research Council, and a degenerate parametric amplifier design, by R. J. Mayer, of Boeing.



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CIRCLE 5 ON READER SERVICE CARD

COMMENT

Proprietary Rights

I enjoyed reading your editorial, Whose Proprietary Rights? (p 98, Oct. 27). I am pleased to see that you speak out on this subject.

In order to clear any ambiguity that there may be in my mind, what do you mean by the term *rights* in the sentence "There is no question but what the government is entitled to know-how and patent rights resulting from government-financed development and research"? I have interpreted that you mean rights to license under a privately-owned patent versus the right to own a patent resulting from government-funded work.

I feel strongly that the NASA contract provisions on patent ownership should be repealed and that the government should only have the privilege of free licensing under the privately-owned patent.

ROBERT W. GALVIN
President
Motorola Inc.
Franklin Park, Illinois

Yes, we do mean what reader Galvin means, that "the government should only have the privilege of free licensing under the privately-owned patent."

Electronics in the Midwest

As a resident of Chicago, and as a financial consultant, the current controversy as to the Midwest's lack of research, as expressed in your October 6 issue (p 22), is naturally of interest.

We certainly need research, but we also need, as the industry seems to be finally realizing, however painfully, large, solid companies who *buy* the products of others in *quantity*, *sell* in *quantity*, and are financially sound enough to pay their way, support the industry, and weather the storm.

Far from apologizing for the Midwest, I am as proud of its place as an increasingly solid electronics center as I am of its increasingly solid position as a financial center.

DAVID L. KEITH
Chicago, Illinois

Semiconductors

I have just read the recent article, What's New in Semiconductors (p 89, Sept. 29), and I wish to relate to you some opinions on the same. I find the article informative especially on subjects such as growth techniques not generally found in technical electronics and management journals. I found particularly interesting the descriptions of construction for the various types of diodes and transistors.

With constant pressure to advance the state of the art, we are actively engaged in applied research and development toward compact, lighter, reliable and faster electronic circuits to meet our customers' needs. In this respect, I found the section on microminiature developments of great interest. It is especially timely in that we now are pursuing a packaging technique that requires the removal of cans from transistors to achieve ultimate compactness.

F. H. SHEPPHIRD
Litton Systems, Inc.
Woodland Hills, California

Traveling Wave Tube

Page 114 of your Nov. 10 issue carried an announcement of our electronic tube division's new STX-186 miniature traveling wave tube.

In stating the db of the tube, 4.0 was printed instead of the proper 40 db.

We would like to call your attention to this error.

R. W. CORNES
Sperry Gyroscope Company
Great Neck, New York

Required Reading

We have selected as required reading for War College students an article by [Associate Editor] John F. Mason entitled Our Defense Against Attack From Space, which appeared in the May 13, 1960 issue (p 36).

Request permission to reprint and use this article for the purpose stated above, royalty free. Appropriate credit to the author and magazine will appear on the cover of each copy.

CHATHAM P. BUSSELLS
Lt. Colonel
War College
Air University
Maxwell Air Force Base, Alabama

Permission granted.

All Popular TO-36, 15-Amp POWER TRANSISTORS Compared

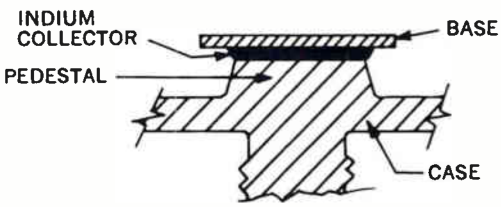
Tests show that internal construction differences of devices on the market are responsible for wide variation in junction-to-case thermal resistance (θ_{JC}) . . . prove big difference in device reliability and maximum possible power.

As every design engineer knows, the maximum power a transistor will dissipate and the performance of the device are directly related to its capability of removing heat from the collector junction . . . with the impedance to heat removal being the thermal resistance.

Any transistor with *lower* thermal resistance will naturally permit greater power dissipation, and will insure greater device reliability because of the cooler junction temperature at any power level.

KEYS TO LOWER THERMAL RESISTANCE

Variation in thermal resistance of the TO-36 power transistors on the market is due primarily to the differences in two internal components — the indium collector and the copper pedestal . . . with the major variation resulting from differences in the thickness and effective area of the indium collector.



The thinner the indium through which heat must be conducted, and the better the heat conductance design of the copper pedestal — the lower the thermal resistance.

Actual measurements of the indium thickness in 15-Amp TO-36 transistors from six semiconductor manufacturers showed that the indium slab in the Motorola device was from 17% to 85% thinner than the others . . . resulting in a comparably lower thermal resistance.

Manufacturer	Indium Thickness
A	16.0
*B	4.0
C	11.0
D	14.0
E	3.0
Motorola (#1)	1.5
Motorola (#2)	1.5

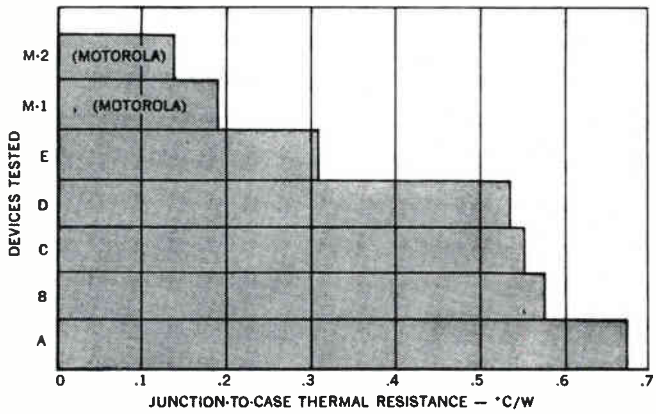
*Although the indium thickness was comparatively thin, the cross-sectional area of the heat path was so small that thermal resistance was greatly increased.

To avoid the possibility of error in the results of the comparative tests, two methods of determining θ_{JC} were used: . . . by thermal-electric measurement; and by calculation of the metallic heat paths using the equation:

$$\theta_{JC} = \frac{V_I L_1}{A_1} + \frac{V_C L_2}{A_2} = \theta_{JP} + \theta_{PC}$$

where . . .
- V_I = thermal resistivity — Indium
- V_C = thermal resistivity — Copper
- L_1 = indium thickness
- A_1 = effective area of indium
- L_2 = pedestal thickness
- A_2 = entire pedestal area
- θ_{JP} = junction-to-pedestal thermal resistance
- θ_{PC} = pedestal-to-case thermal resistance

Calculated Junction-to-Case Thermal Resistance (θ_{JC}) (Two Motorola devices and one each from five other manufacturers)

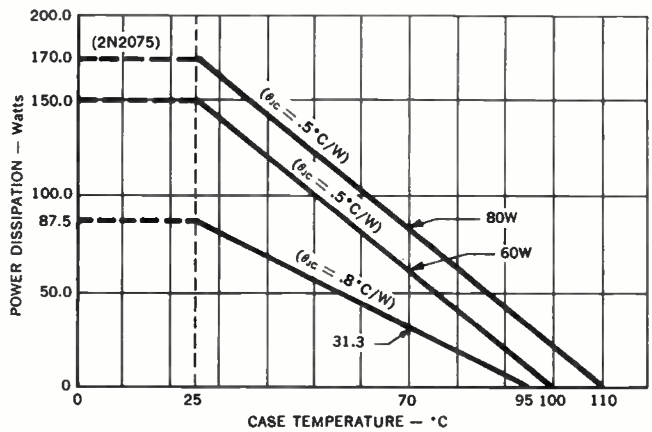


RELATIONSHIP OF THERMAL RESISTANCE TO MAXIMUM POSSIBLE POWER DISSIPATION

Examination of recent data sheets for all the power transistors tested showed that the specified maximum thermal resistance for most TO-36 transistors was established at .8°C/Watt; whereas the specified maximum thermal resistance of the standard Motorola TO-36 units is only .5°C/Watt . . . and the typical is .35°C/Watt.

The difference in performance resulting from this variation in thermal resistance is clearly illustrated in the derating curves below based on normal maximum junction temperatures ($T_{J\ max}$) of 95°C and 100°C.

(For comparison, a derating curve is also shown for Motorola's new 2N2075 Series 15-Amp, TO-36 transistors with a thermal resistance of .5°C/W and a MAXIMUM JUNCTION TEMPERATURE of 110°C).



If you would like complete design and specification data for the low-thermal-resistance Motorola TO-36 devices — contact the Motorola Semiconductor District Office in your area, or write to the Technical Information Center at the address below.

MOTOROLA Semiconductor Products Inc.

5005 EAST McDOWELL ROAD PHOENIX 8, ARIZONA A SUBSIDIARY OF MOTOROLA INC.

ELECTRONICS NEWSLETTER

ELF-VLF Propagation May Be Bomb-Proof

SURVIVAL of communications in an era of 50-megaton bombs (ELECTRONICS, p 9, Nov. 10)—sharpening focus on propagation methods immune to man-made ionospheric disturbances—adds significance to long-term Air Force research on elf (from a few cps to 3 Kc) and vlf (3-30 Kc) communications.

Projects Argus and Hardtack indicated vulnerability of ionosphere-dependent communications to high-altitude nuclear explosions. Elf, vlf, meteor trail facsimile, exospheric forward scatter and multilobe techniques may provide solutions.

Elf and vlf advantages appear to be: low transmission losses in earth-ionosphere space, relative immunity to artificial disturbances, possibility of using subsurface paths.

The ionosphere blankets elf-vlf radiation. This may provide secure communications above the ionosphere and free spacecraft from terrestrial radiation interference. Also, some vlf modes are phase-sensitive to ionosphere height changes and might aid world-wide nuclear test surveillance.

Air Force Cambridge Research Labs is experimenting with elf-vlf propagation on a short baseline network in New England. Master station is at Mt. Wachuset, Mass., and slave stations are in Vermont, New Hampshire and Rhode Island.

EIA Sees Growth in Major Markets in '62

FACTORY SALES of electronics will reach a record total of $10.15 billion this year and climb to $10.8 billion in 1962, L. Berkeley Davis, Electronics Industry Association president, reported at EIA's winter conference in Los Angeles last week.

Consumer electronics skidded a bit this year, to $2 billion, but will go back up to $2.1 billion in 1962. Other 1961 and 1962 figures—all increases from 1960—are: industrial electronics, $1.9 and 2.1 billion; military, $5.3 and $5.6 billion; replacement components, $0.95 and $1 billion, and totals, $10.15 and $10.8 billion.

Other predictions: after 1964 aircraft will give way to missile and space systems as dominant military procurement category; component sales this year will match or slightly exceed 1960's $3 billion, but price declines will probably keep transistors and diode-rectifier sales at or below 1960's $525 million. Davis expects the upswing in the national economy to continue, providing fruitful conditions for expansion.

Burns Resigns, RCA Elects New President

ELECTION of Elmer W. Engstrom as president of RCA was announced last Friday after the regular monthly meeting of the board of directors. The resignation of John L. Burns as president, a director and as director of subsidiary companies was accepted by the board on the same day, according to an announcement by David Sarnoff, chairman.

Burns said that his resignation was based on personal reasons. He had been president since March 1, 1957. He will continue to serve RCA, on special assignments from Sarnoff, the announcement said.

Engstrom was senior executive vice president since 1955 and has been an RCA employee 31 years. As president, he will have supervision of all company operations, reporting to Sarnoff.

Engstrom started his career with GE in 1923. When GE's radio engineering and manufacturing activities were transferred to RCA in 1930, he went along. He was active in development of tv and later headed RCA Laboratories.

Hams Want 160 Meters

INDEPENDENT GROUP of radio operators in the Midwest is urging return of the 160-meter band to amateur.

Hams are being asked to send their QSL card with call, signature and comments to "160 Meters," Cleveland 33, Ohio.

Object: to obtain a hearing before the Federal Communications Commission

Defense Supply Agency Plan Nearly Completed

DETAILED PLAN for placing procurement of electronic components under the new Defense Supply Agency will be submitted to Secretary of Defense McNamara before the end of the month.

A member of the planning staff said this week that management integration plans include more than 500,000 components, including such items as resistors, capacitors, switches, connectors, relays, coils, crystals and tubes.

Complete plans will relate organization, manpower, other resources and time schedules for absorption of the function by the agency. Maj. Gen. Charles B. Root, USAF, with a working group from Army, Navy, Air Force, Marine Corps and the Joint Staff began working on the report Oct. 23.

Loudspeaker Makers Plan R&D Foundation

CHICAGO—Loudspeaker and speaker parts section of EIA approved creation of an R&D foundation at the section's semiannual meeting here. The meeting was attended by 118 industry representatives.

Projects include: a public information program to promote sales of American-made loudspeakers, an industry R&D center, improved industry-wide credit policies, increased standardization of loudspeakers and parts, and a new marketing data program.

The center will conduct confidential studies for individual firms. It will also evaluate new ideas and distribute them to the industry. The library will include U. S. and foreign patents and all available technical information.

Financing of the center was started with pledges of $5,000 from Hawley Products and $1,000 from Arnold Engineering.

Resonant-V Rod Antenna Gets All VHF Tv Channels

ANTENNA designed to receive all vhf tv channels equally well is reported by University of Illinois Antenna Research Lab. The inventors, Paul Mayes and Robert Carrell, say it is especially useful in fringe areas served by two or more cities and for pulling in signals over long distances.

Operational model uses 14 aluminum rods attached diagonally to two central eight-foot rods and swept forward in V configuration. The central rods are supported on a pole at right angles. Design was derived from work on log-periodic antennas.

Guided Bus Line May Go Into Operation in 1965

CHICAGO—The Transit Authority is testing an electronically-guided, driverless bus this month on an unused, one-mile stretch of road. CTA hopes to operate guided buses when an expressway with separate transit lanes is ready in 1965.

Sensing units under the test bus pick up low frequency (10Kc) signals from low-voltage cable in the road. Modified Barrett Electronics industrial self-guiding devices control the bus' hydraulic steering mechanism and at programmed intervals sound the horn, stop the bus and open and shut the doors.

Chicago Area to Create Permanent R&D Council

CHICAGO—Chicago area conference on R&D wound up last week with a decision to create a permanent R&D council, made up from university, industrial and financial communities and coordinated by the Chicago Association of Commerce and Industry.

Three-way program will be developed to improve public relations, better the scientific atmosphere of the area and increase interest and activity in electronics and aerospace defense contracts.

Number of Midwest R&D labs has dropped from 27 percent of national total, in 1950, to 24 percent while West Coast facilities have increased 12 percent, Haldon Leedy, Armour Research Foundation said. Midwest overemphasisis on hardware manufacturing and disinterest in R&D is to blame, he said. Failing to keep up with technology will affect the area's industrial growth, he said.

Experimental BWO Gives High Millimeter Power

EXPERIMENTAL backward wave oscillator developed by Varian Associates delivers 1.6 watts of c-w power in the 50-Gc to 75-Gc band. The company thinks that further development of techniques used may lead to oscillator-amplifier chains capable of hundreds of watts of c-w power at 50-75 Gc and tens of watts c-w in the vicinity of 150 Gc.

The device emits a 0.012-inch diameter beam from an impregnated tungsten dispenser cathode. The prototype uses a powerful electromagnet to confine the beam to the center of the interaction structure. Permanent magnets would be used in production units. Design reportedly enables strong interaction with the high-density electron beam without drawing excessive cathode current.

FCC Starts UHF Tv Tests in New York City

FCC TEST of uhf tv in New York got underway last week when Chairman Newton Minow flipped a switch on the 86th floor of the Empire State Building. The experiment, planned more than a year and costing $2 million, could lead the way to an uhf television system in the U.S.

WUHF will broadcast on channel 31 in the metropolitan area. Educational and institutional programs will be monitored by home sets and professional equipment. Receivers and monitors will be relocated on a monthly schedule, to blanket the region thoroughly during a two-year period.

In Brief . . .

AEROSPACE Industries Association has selected Armour Research Foundation to direct its Automatically Programmed Tools (APT) program.

PHILCO'S TechRep division will supply 84 instructors to Navy electronics school, reportedly first use of contract instructors for Navy rate training programs.

MOTOROLA has received R&D contract for the Mariner R Venus spacecraft flight command subsystem and test console.

MIT INSTRUMENTATION Lab has begun development of gyros for Apollo.

ARMY has awarded Raytheon $5 million in contracts for ground support equipment and continued development of Hawk missiles.

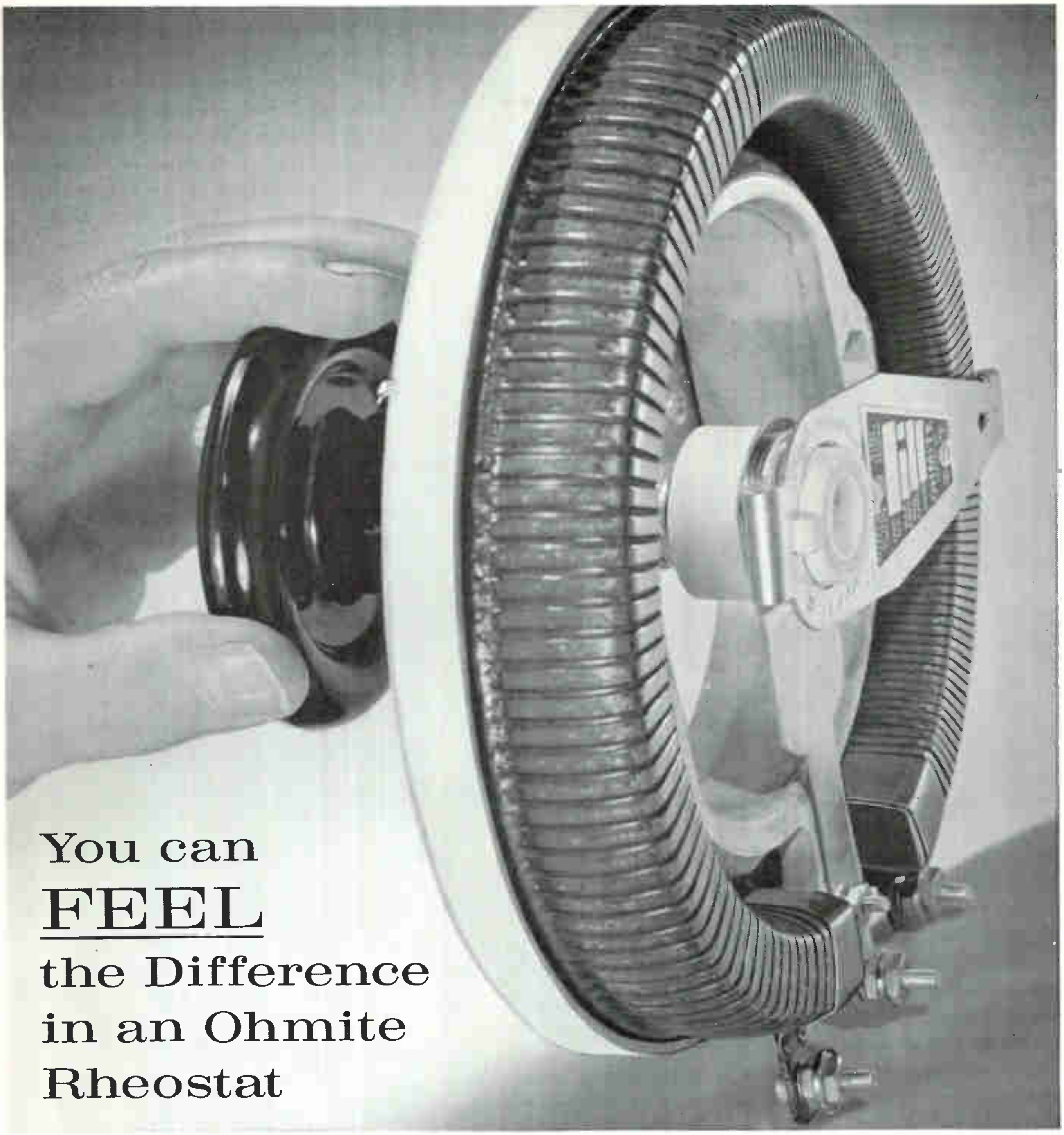
AIR FORCE is awarding Space Technology Laboratory a $10 million contract for research in detecting nuclear explosions by instruments in spacecraft.

OTHER Air Force awards include $2 million to Bosch Arma for R&D on Atlas Guidance; $1.8 million to IBM for production tooling for B-52 bomb-nav system; $10.4 million to Avco for more FPS-26 radars; $800,000 to GPL, mostly for doppler radar.

NAVY contracts include $1.8 million to DuKane Corp for electronic components of a new type sea mine; $1.2 million to Lear for guidance and electrical components of the antisubmarine DSN-3 drone helicopter.

RYAN Electronics has sold $320,000 in military aircraft doppler navigation radar to Australia and Japan.

RECENT military and space contracts also include $600,000 to Consolidated Electrodynamics for recorders for Surveyor; $500,000 to Magnetic Amplifiers division of Siegler for airborne power supplies; $595,000 to Taffet Electronics for mobile telephones and pulse generator sets; $300,000 to Kin Tel for closed-circuit tv.



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TRY IT YOURSELF! Note the smooth, silent glide of the contact over the windings . . . and of the contact moving off and on the terminal bands. There's absolutely no raspy grinding to cause premature wear . . . no aggravating "jerk" points that make you hunt for a setting.

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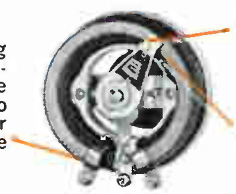

SMOOTHNESS FROM ATTENTION TO DETAIL

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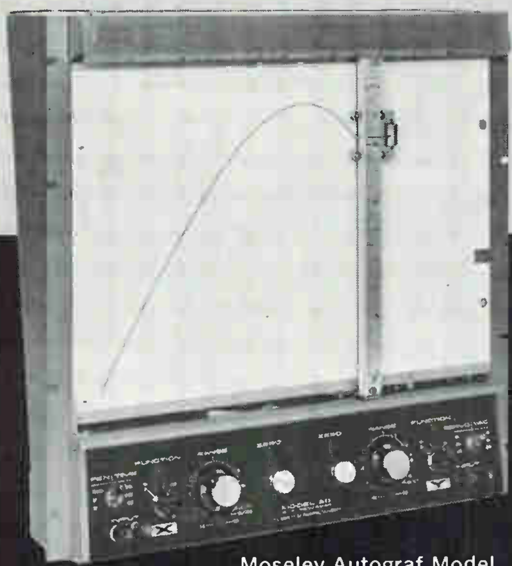

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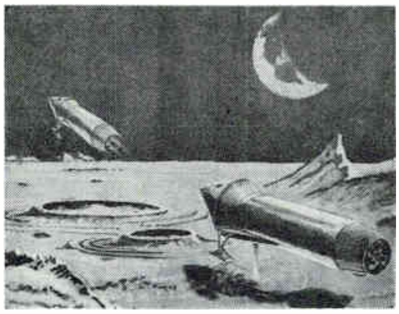
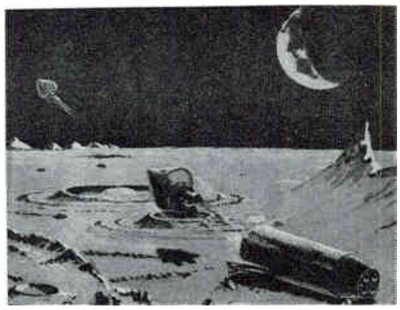
WASHINGTON OUTLOOK





ELECTRONIC COMPANIES are scrambling for Project Apollo subcontracts now that NASA has named North American Aviation prime contractor. Subcontractor selections should start in a few weeks. Other prime contract bidders were Martin and teams headed by GE, General Dynamics and McDonnell Aircraft.

The spacecraft is to send a trio of astronauts to the moon and back by 1967-69. Apollo is expected to cost several billion dollars before the first lunar landing. NAA's share will tally well over $1 billion, NASA experts predict.

Apollo is to be built in three modules (sketches are artist's conception of lunar landing, left, and takeoff): a command center module for the astronauts with controls, much like those used in Mercury capsules; a second carrying fuel, electrical power supplies and takeoff propulsion units; a third with landing deceleration rockets.

North American will build the first two modules. Selection of a contractor for the third module is expected within six months. Initial plans call for NAA to build 10 to 15 capsules. A mockup model, for NASA acceptance testing, is due by late 1962. Flight models to check out the system are to be ready by 1964. Circumlunar manned flight will then be made before the attempt is made to land on the moon around 1967-69.

Final negotiations of the cost-plus-fixed-fee prime contracts are underway now between NASA and NAA. The project will be handled by the company's Space and Information Systems division at Downey, Calif.

NEXT YEAR'S Pentagon budget, nearing final shape, will boost new orders for electronics procurement and R&D. This year, procurement appropriations run about $5 billion: $1.4 billion for "pure" electronics and communications, the remainder lumped in with aircraft and missiles. Current R&D is about $1.2 billion.

Electronics programs likeliest to gain are Minuteman, Polaris, Skybolt and Pershing missiles; Nike Zeus anti-ICBM system; tactical battlefield equipment; Midas, Samos and Advent satellites; electronic support systems like 480-L air communication, 473-L and 465-L Air Force control, and 496-L space surveillance systems.

Aircraft budget will be heavily trimmed from this year's $5.9 billion. Air Force will cut combat type plane procurement, increase transport planes and buy large quantities of the Navy's Douglas A4D fighter-bombers. Missile orders will be substantially higher than this year's $4.2 billion. NASA is expected to get twice this year's $1.7 billion.

Type 161 TBS Portable Instrument—11.2-inch scale

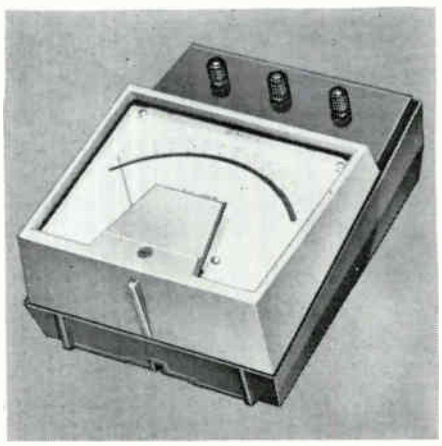
New, rugged Westinghouse portable instruments give long-term accuracy never before possible

There's no need to treat them gently. These new Westinghouse portable instruments have neither pivots nor jewels. There is no friction in the movement—no wear—nothing to get out of adjustment. The secret is a unique development—Westinghouse Taut Band Suspension. The moving element is suspended between strong metal bands under high tension. These bands carry the current to the coil and provide torsion against rotation.

In the Westinghouse instrument laboratory, this rugged instrument movement has withstood over 200 shock tests of 2400 G's and retained accuracy within ½%. After 24 million full-scale deflections, repeatability remained within 1/20 of 1%. By contrast, pivot and jewel instruments, after only one million deflections, will have so much friction their accuracy will be questionable. Conclusion: Westinghouse *tbs** portable instruments are the toughest precision portables ever made. Maintenance, recalibration and other adjustments are practically eliminated.

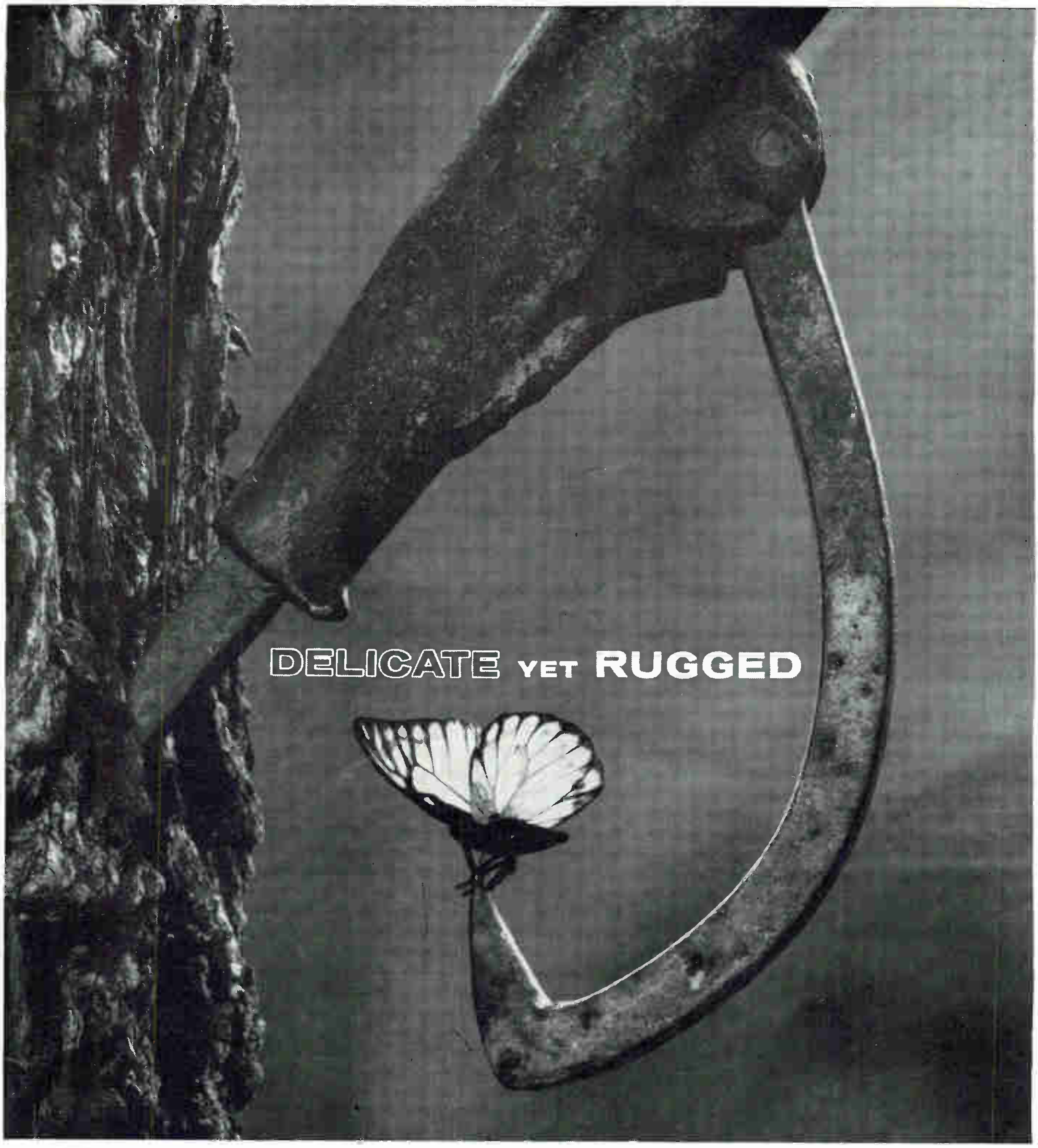
Westinghouse TBS portable instruments are available as a-c or d-c ammeters or voltmeters, with single or multi-range scales for practically any precision applications. Full-scale deflection as low as 1 microampere is available. Shatterproof glass window, high impact molded case and insulated retractable handle are standard features. Accuracy rating is ½% or ¼%. All Westinghouse portable instruments meet or exceed the requirements of ASA standard C-39.1. Write for complete specifications and a sample of Taut Band Suspension. Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania. *You can be sure . . . if it's Westinghouse.* J-40541

*Trademark of Westinghouse Taut Band Suspension Instruments



Type 151 TBS Portable Instrument—6.0-inch scale

Westinghouse



Not a usual combination. The sensitivity and toughness included in every Honeywell panel instrument is a result of the infinite patience and superior technical know-how of our designers and engineers. ☐ Ruggedized Honeywell panel instruments are available with external zero adjuster. They are sealed, dustproof, moistureproof and immune to the hazards of climate and atmosphere. Built to withstand the most severe tests of shock, vibration and strain — and still give accurate, reliable readings — they're another reason why the name Honeywell and the word dependability are synonymous. ☐ Perhaps a quality instrument from Honeywell can help you do a job better and faster. Just get in touch with our representative in your area — he's listed in the classified pages of your telephone directory. Or contact us direct: PRECISION METER DIVISION, Minneapolis-Honeywell Regulator Company, Manchester, New Hampshire, U. S. A. In Canada, Honeywell Controls Limited, Toronto 17, Ontario. Honeywell International Sales and service offices in all principal cities of the world.

Honeywell

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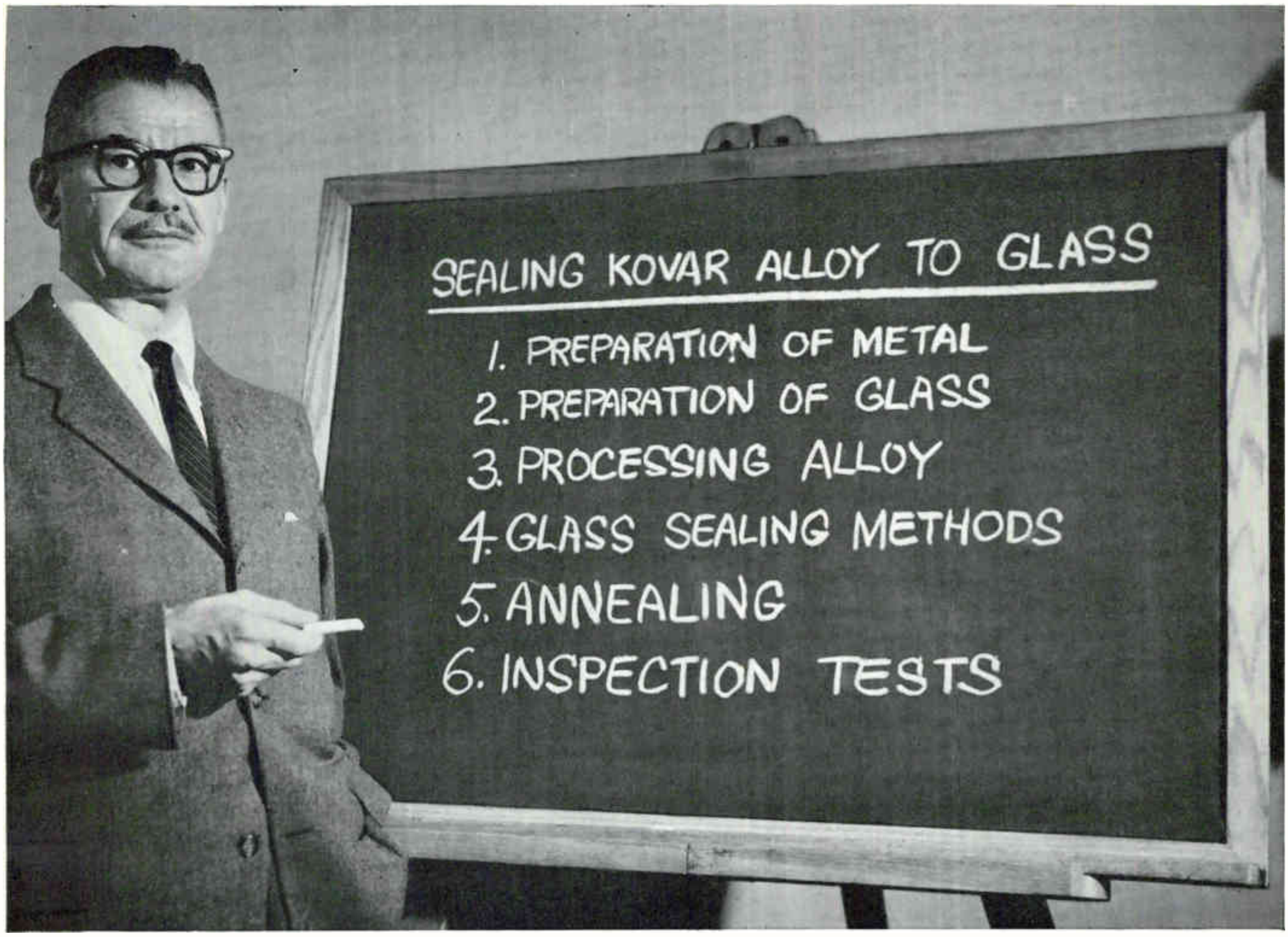

Engineering hints from Carborundum

6 steps to better glass-to-metal seals with KOVAR® Alloy

KOVAR® is the original iron-nickel-cobalt alloy with correct thermal expansion characteristics for making seals with several hard glasses. Procedures for obtaining a satisfactory seal—with optimum production yields—will vary according to the nature of the end product. This may range from large electron tubes to the smallest semi-conductor devices. The following hints typify recommendations for the more critical electron tubes; they can be modified for other products according to need.

1. KOVAR should be scratch-free. Polish with 180-grit aluminum oxide cloth, followed by 260-grit—never emery or carbide. Round edges of edge-type seals with a radius of about half metal thickness. Sand-blasted matt finish, using pure alumina, is preferable for butt type seals.
2. REMOVE DUST FROM GLASS with lint-free cloth. Rinse in 10% hydrofluoric acid solution, then in running tap water, finally in distilled water. Dip in methanol and hot air dry.
3. CLEAN KOVAR prior to sealing by trichlorethylene vapor degreasing, immersion in concentrated HCl, followed by rinses in tap and distilled water. Methanol dip and hot air dry. Heat treat in wet hydrogen atmosphere.
4. SEALING EQUIPMENT includes gas-oxygen burner and glass lathe. Oxidize surfaces by heating metal and glass to 850° C in air. Bring parts together by pressure. For strong seal, glass edge should approach 90° angle where it meets KOVAR alloy.
5. ANNEAL SEAL using flame or furnace program, advancing to annealing temperature for 30 mins. Reduce to 50° C below strain point at 1° per minute, then 10° per minute to room temperature.
6. INSPECTION may include stress analysis by polariscope viewing or other method. Examination under 10x to 15x magnification should show that glass is free from excessive bubbles. Glass color should be grayish or mouse brown.

FIND OUT ABOUT KOVAR—WHERE IT IS USED AND WHY
Bulletin 5134 gives data on composition, properties and applications of KOVAR Alloy. For data on sealing procedures, ask also for Technical Data Bulletin 100-EB6. Write Dept. E-121, Latrobe Plant, Carborundum Co., Latrobe, Pa.

THERE IS NO TRUE SUBSTITUTE FOR KOVAR ALLOY
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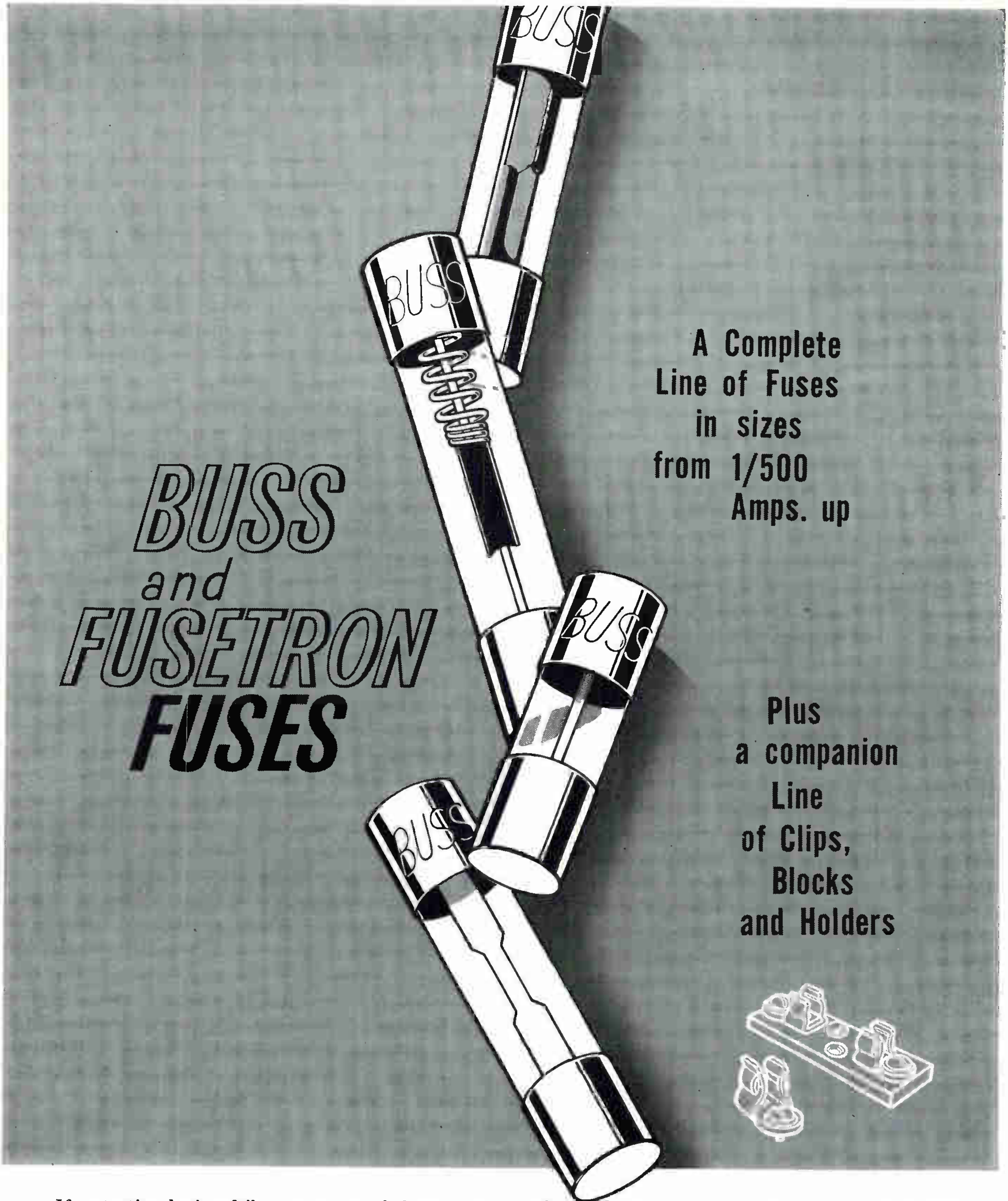


If protective devices fail to protect, costly burnouts may result. Or, if they open needlessly, equipment is put out-of-service. In either case, users may blame the trouble on the equipment and not on the faulty protective device.

To guard against this happening to your equipment, specify BUSS and FUSETRON fuses. Each and every fuse is tested in a sensitive electronic device that automatically rejects any fuse not correctly calibrated, properly constructed and right in all physical dimensions.

Should you have a special problem in electrical protection, where you might be in doubt as to the proper fuse to use, BUSS places at your service the facilities of the world's largest fuse research laboratory and its staff of engineers.

To get full data for your files, write for the BUSS bulletin on small dimension fuses and fuseholders. Form SFB.

1261

BUSSMANN MFG. DIVISION, *McGraw-Edison Co.,* **UNIVERSITY AT JEFFERSON, ST. LOUIS 7, MO.**

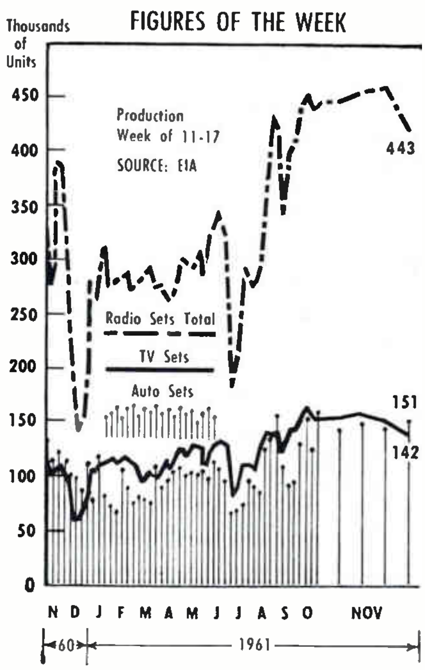
More Phones for Cars, Planes

VEHICULAR COMMUNICATIONS boom during the next 10 years was predicted recently by A. J. Runft, director of commercial electronics engineering for AC Spark Plug division of General Motors. He thinks that the number of telephones in autos will grow from 18,000 this year to about five million.

In addition, he says that commercial aircraft will be offering air-ground telephone service to passengers as a routine travel accommodation. Plans are well underway to expand this service, now being offered on a limited basis.

Major factor in growth of the automobile radiotelephone market will be increased desire for communications as more and more people take to the roads for business, pleasure and commutation. Runft points out that there will be about 100 million autos on U. S. roads by 1970. The trend will be accelerated, he says, by an increase in FCC channel allocations for auto telephone service, a reduction in equipment size and power drain and innovations in selective signaling decoders.

AC's present auto telephone, the AChieverfone, has a decoder with a capability 25 times greater than its 1947 counterpart, for example, and is one-quarter the size. Runft expects that before 1970 a unit with 10 million codes, occupying 4½ cu. in. will be available.



At present, equipment gives no problems as long as calls are placed within the area intended for its use. However, if the car is driven to another area, the auto telephone might receive a call placed to a local resident with the same channel and code. Units with a great number of codes would solve this problem. Runft said that he could even conceive of the day when people would be assigned permanent telephone numbers (like a Social Security number).

More Base Stations

Expectations are that telephone companies will install many more auto telephone base stations throughout the nation, to provide complete coverage.

Other obstacles besides technical ones need to be overcome. In some states, for example New York and Massachusetts, drivers who want to use their telephones must pull over to the side of the road. The new GM phone is hands-free, using a boom-mounted microphone and a foot-actuated operating switch. Developments like this may help change driving regulations.

In the air, Runft said, some 20 commercial airplanes have been trying out the GM Skyphone. Passengers can use the telephones now within 200 miles of New York City, Washington, D. C., Pittsburgh, Chicago and Detroit, and contact virtually any phone in the world via the Bell System. Other cities will be joining the network shortly.

Telephone companies, he said, plan to add about 70 more ground stations by 1964 in the U. S. and about 12 more in Canada. Permanent frequency allocations for this service have been made by FCC. The production model of the Skyphone will be a multichannel set which will automatically tune to the channel of the proper ground station.

Runft also outlined a number of other feasible vehicular electronic systems with future market potential. These include several types of road guidance, safety and warning systems; radio and computer-controlled unmanned vehicles and heavy equipment for mining and farming; highway construction bulldozers which would grade on planes established by radio beams.

Small Firm's Best Bet Industrial and Military

STANFORD Research Institute survey conducted for the Small Business Administration finds that electronics companies with annual sales of less than $10 million account for half of the total 1960 industry figure of $10 billion.

Indications are that the most promising product areas for small businesses are military and industrial. The survey listed equipment for reconnaissance and surveillance, countermeasures, checkout, detection, tracking and data reduction as the most likely to catch the government's fancy. Test and measuring instruments of relatively small size and high technical complexity are the most appealing to industry.

About 30 percent of the industry's output, $3 billion a year, is spent in government and industry R&D. Since production quantities involved are relatively low, expensive, automated equipment is less important and lower capital requirements make it possible for smaller firms to compete effectively with industry giants.

Generally, competition is based on quality or uniqueness of product rather than price.

MILITARY CONTRACTING

COMPLETE DEFENSE SYSTEMS

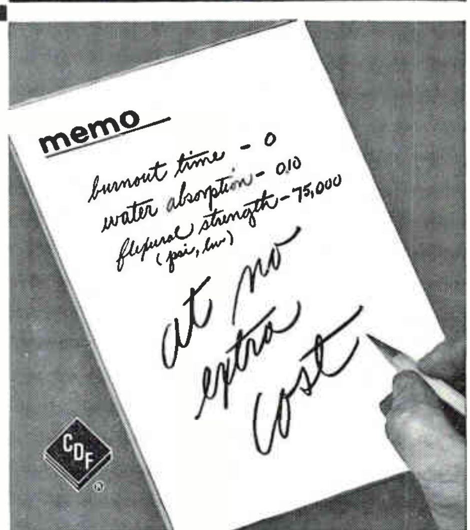
FIRST QUARTER FISCAL 1962

	Total Prime Contractors	Total Subcontractors
Aircraft Systems	$1,067,508,000	$31,704,000
Communications	161,944,000	13,028,000
Components	69,447,000	1,672,000
Data Processing	25,383,000	5,710,000
Electronic Warfare	214,160,000	7,506,000
Meteorology	1,309,000	....
Missiles	1,510,824,000	183,561,000
Navigation	124,286,000	1,259,000
Research	82,885,000	242,000
Services	161,702,000	......
Vehicles	500,616,000	13,373,000
TOTALS	$3,920,064,000	$258,055,000

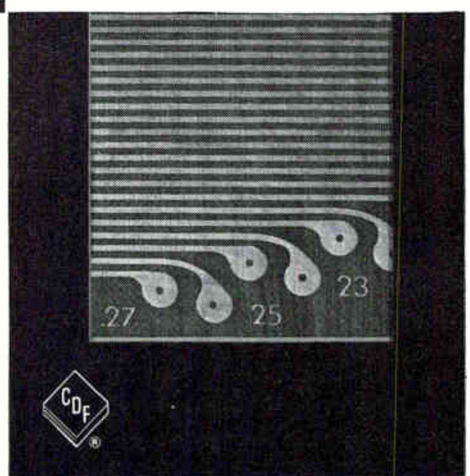
The above figures represent prime military systems awards. They are recorded for ELECTRONICS by Frost & Sullivan, Inc., of New York City, defense marketing specialists.

New Copper-Clad *Reliability*

In March, 1961, CDF Grade 614, glass-epoxy laminate, was announced . . . and met with almost overnight acceptance. Particular electronics and electrical manufacturers wasted no time in specifying this premium performance material with zero burnout and minimum "haloing."

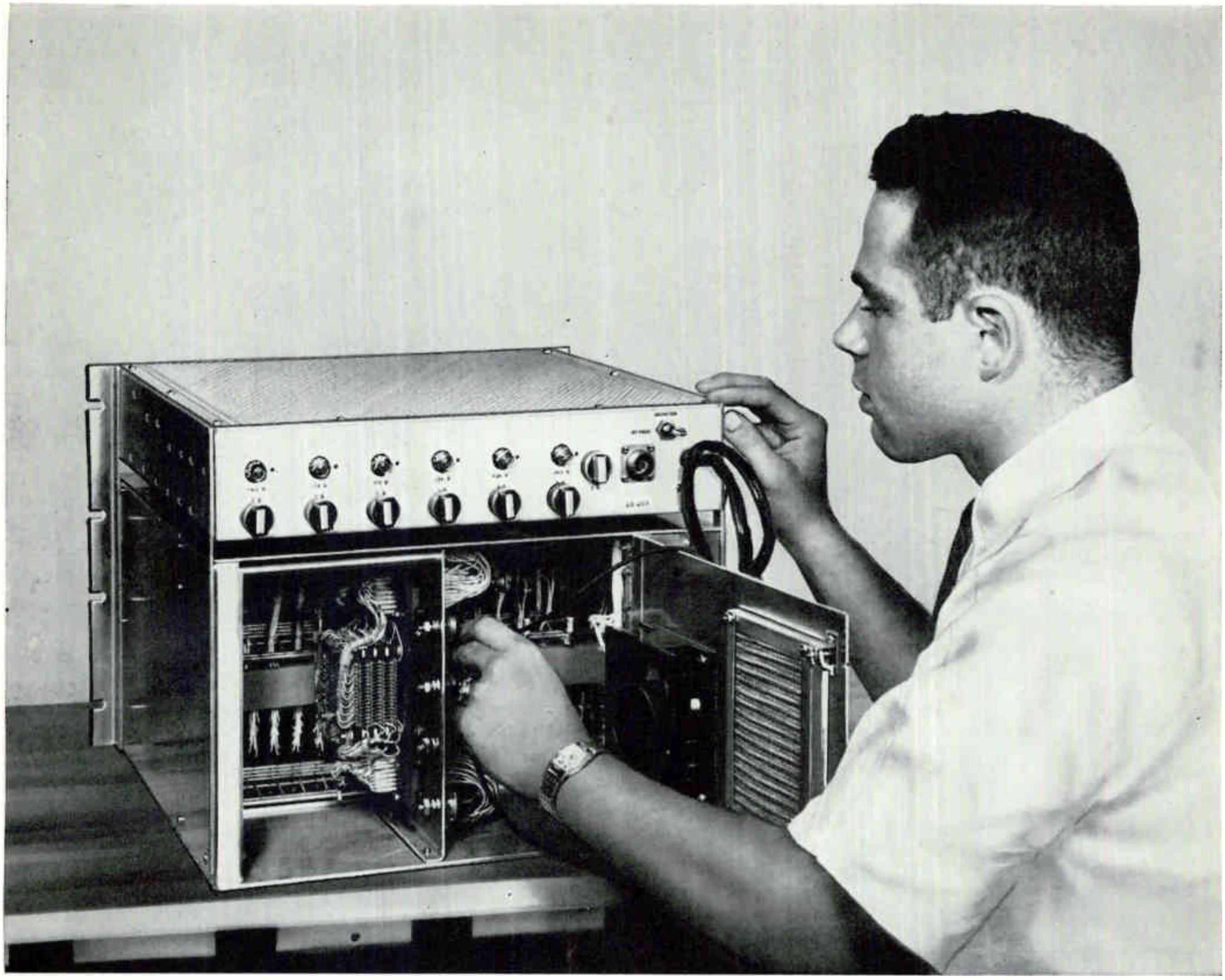


By June, 1961, CDF Grade 614 had become the new standard of comparison for applications in critical ground and air-borne circuitry. Designers like its specifications, production men like the way it handles, management likes its reasonable price.



Now, CDF Grade 614 Copper-Clad is setting a new pace among particular producers of printed circuits . . . offering a new high in reliability for high packaging densities . . . and offering researchers a new tool in the investigation of molecular and submicro-circuitry.

You can take advantage of 614 Copper-Clad's unique features right now . . . in research, development or production operations. Continental-Diamond Fibre Corporation, Newark, Delaware. A Subsidiary of the Budd Company.



Here's Custom Memory Flexibility in a Standard Package

RCA 5 μSEC MODULAR MEMORY SYSTEM

Compact, high-capacity systems now available with the word lengths you specify—available for quick delivery

Now you can bring a new standard of operating efficiency, servicing flexibility and plug-in convenience to your computer designs with RCA's complete modular memory system. It utilizes new, compact modular design throughout. All circuits and elements, as well as the complete system plug in for easy maintenance and reduced computer down-time.

This rugged RCA memory system, encased in an aluminum cabinet, has a capacity of 256 to 2048 words and up to 20 bits per word. It incorporates RCA ferrite memory cores and planes, with specified wide margins of operation...up to ±8%...to cope with broad variations of voltage levels over a wide temperature range.

All RCA Complete Memory Systems are available in a broad range of standard types and custom designs. RCA is ready, willing, and able to meet the most stringent custom requirements for voltage, current, temperature range, and speed of operation to make the memory system fully compatible with your equipment.

Here are some of the outstanding features of complete RCA Memory Systems:

- Specified Wider Margins of Operation...Up to ± 8 per cent...to cope with broad variations in voltage levels.
- Custom Design Service...RCA's engineering staff will custom-design a memory system to your specifications.
- Complete Information Retention...even in case of primary power loss.
- Wide Temperature Range...0°C to 50°C.

Systems Engineering Service—Your local RCA Semiconductor and Materials Division Field Representative is prepared to provide a completely coordinated application service, covering transistors, semiconductor diodes, ferrites and memory systems. For further technical information, write RCA Semiconductor and Materials Division, Commercial Engineering Division, Section L-19-NF2, Somerville, N.J.

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HIGH SPEED WITH LOWEST V_{CE} (sat) RATINGS

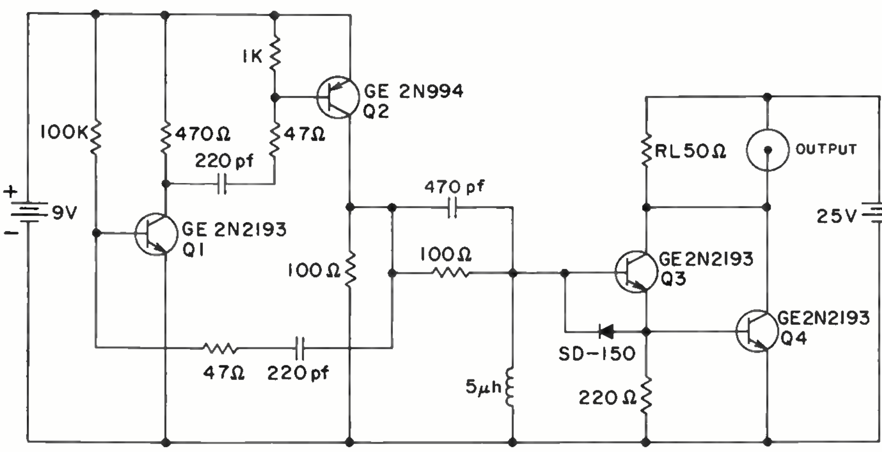
PLANAR EPITAXIAL PASSIVATED

PUT PEP IN YOUR DESIGNS

The new G-E 2N2193-2195 and "A" series combines three of the most advanced processes in semiconductor technology to bring you new standards of silicon transistor performance, reliability and stability. This series of PEP transistors features greatly improved V_{CE} (sat.) ratings, and can replace standard units without basic circuit changes.

Planar Passivated 2N696-2N699, 2N1613, 2N1711, and 2N1893 silicon transistors are also available. They feature superior h_{FE} holdup at low currents, lower I_{CBO} and I_{EBO}, and remarkable reliability of performance and stability of parameters due to planar passivation.

TYPICAL PULSE GENERATOR CIRCUIT WITH *PEP* TRANSISTORS SWITCHES ½ AMP IN 25 NANOSECONDS



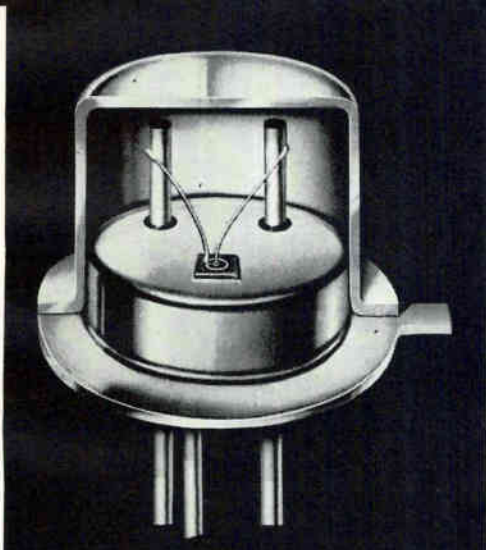
PULSE GENERATOR

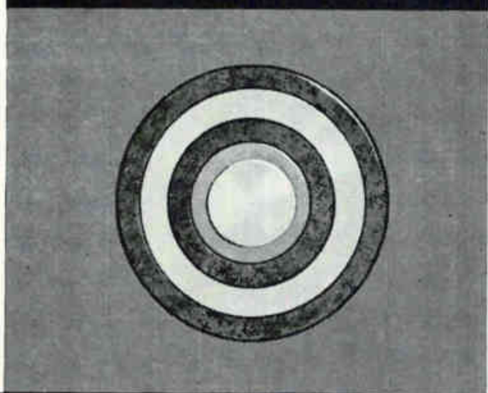
Pulse Characteristics:

Amplitude	25 volts
Width	200 nanoseconds
Rise Time	25 nanoseconds
Fall Time	30 nanoseconds
Impedance	50 ohms
Repetition rate	100 kilocycles

Unprecedented versatility is still another unique advantage of General Electric PEP transistors in new and/or existing applications. The pulse generator circuit shown illustrates the versatility of 2N2193 in an existing circuit, without the need for redesigning. Also, by combining low saturation resistance, high voltage, dissipation and frequency response, controlled gain over four decades of current, and low leakage, with the stability of passivation, the 2N2193 approaches "ideal" transistor characteristics. These characteristics make the 2N2193 equally effective in linear or switching applications. Examples: direct conversions of germanium transistor circuits, low level linear amplifiers, power stages, and computer type switching applications.

SILICON TRANSISTORS





PEP *(PLANAR EPITAXIAL PASSIVATED)* TRANSISTORS

Type No.	Description	Notable Advantage
2N2193	Similar to 2N1613 (see chart below)	**V_{CE} (sat) = 0.35 V max.** (@ I_C = 150 ma, I_B = 15 ma) **V_{CEO} = 50 V *min.***
2N2193A	Similar to 2N1613 (see chart below)	**V_{CE} (sat) = 0.16 V Typ.; 0.25 V max.** (@ I_C = 150 ma, I_B = 15 ma) **V_{CEO} = 50 V *min.***
2N2194	Similar to 2N696 (see chart below)	**V_{CE} (sat) = 0.35 V max.** (@ I_C = 150 ma, I_B = 15 ma) **V_{CEO} = 40 V *min.***
2N2194A	Similar to 2N696 (see chart below)	**V_{CE} (sat) = 0.16 V Typ.; 0.25 V max.** (@ I_C = 150 ma, I_B = 15 ma) **V_{CEO} = 40 V *min.***
2N2195	General Purpose Industrial Type	**V_{CE} (sat) = 0.35 V max.** (@ I_C = 150 ma, I_B = 15 ma) **V_{CEO} = 25 V *min.***
2N2195A	General Purpose Industrial Type	**V_{CE} (sat) = 0.16 V Typ.; 0.25 V max.** (@ I_C = 150 ma, I_B = 15 ma) **V_{CEO} = 25 V *min.***

PLANAR PASSIVATED TRANSISTORS

Type No.	h_{FE} @ I_C = 150 ma V_{CE} = 10 V	V_{CE} (sat) (max.) @ I_C = 150 ma I_B = 15 ma	V_{CER} (min.) @ I_C = 100 ma R_{BE} = 10	I_{CBO} (max.)
2N696	20-60	1.5V	40V	1 μa @ 30 V
2N697	40-120	1.5V	40V	1 μa @ 30 V
2N698	20-60	5V	80V	5 mμa @ 75 V
2N699	40-120	5V	80V	2 μa @ 60 V
2N1613	40-120*	1.5V	50V	10 mμa @ 60 V
2N1711	100-300*	1.5V	40V	10 mμa @ 60 V
2N1893	40-120*	5V	100V	10 mμa @ 90 V

* plus guaranteed minimum h_{FE}'s at several other currents

The silicon oxide is thermally grown during the planar diffusion process. It forms a passivated surface over the junction that provides maximum protection against contamination and degradation of characteristics during the entire life of the transistor. The thin epitaxial layer on low resistivity substrate gives negligible body drop resulting in extremely low saturation resistance and increased uniformity from unit to unit.

For complete technical data on the new PEP and Planar Passivated silicon transistors, call your G-E Semiconductor Products District Sales Manager. Or Write Semiconductor Products Department, Section 16L113, General Electric Company, Electronics Park, Syracuse, New York. In Canada: Canadian General Electric, 189 Dufferin St., Toronto, Ont. Export: International General Electric, 159 Madison Avenue, New York 16, New York.

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CIRCLE 27 ON READER SERVICE CARD

Telemetry Studies Pollution

By CLETUS M. WILEY,
Midwest Editor

CHICAGO—Telemetering apparatus which, developers feel, could be applied to large-scale oceanographic experiments is being used by the Public Health Service in a long-range study of Lake Michigan pollution factors.

Basic data on water flow is recorded and transmitted to shore by an instrumentation capsule which trails a string of sensors at various depths in the lake.

Data will produce a mathematical model which can predict where currents will carry pollutants and how much debris can safely be dumped in the lake. The $500,000 program is aimed at bringing pollution under control and making the best use of water resources in the Great Lakes basin.

The lake sampling system may eventually be coordinated with Tiros weather satellites to correlate cloud formations, surface wave patterns, temperatures and current data. This will improve accuracy of the mathematical model.

The prototype capsule, costing $25,000, was designed at the Vicksburg, Miss., station of the Army Corps of Engineers, under direction of Francis Hanes. If the capsule proves out in tests this winter, when ice will prevent maintenance by ship, 25 more systems will be planted in the lake.

The capsule contains a modified 5-w, 170-Mc, f-m transceiver (Motorola), a seven-channel punched tape recorder (Friden) and eight 12-volt, lead-acid batteries. Weight is 700 pounds. Hanes says a 50-lb fuel cell may eventually replace the batteries.

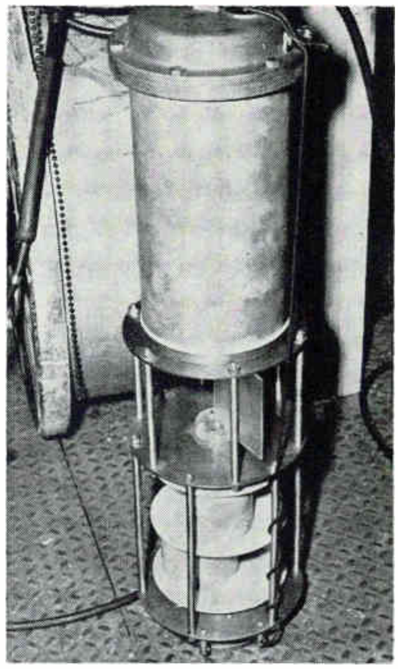
Pods containing current and direction meters and digitizers are suspended at depths of 40, 120 and 200 feet (see sketch). Currents as sluggish as a foot a minute turn Savonius rotors. Contacts riding on printed circuits develop pulses which are digitized for recording. A magnetic compass in each pod is the direction reference. As the pod turns in the current, a disc divided into 3.6-degree segments is optically scanned. Counting away from a mirror, the number of pulses gives the heading.

This information is stored on six tape channels. The seventh channel is reserved for programming. Every four hours, a shore station signal triggers the transmitter. Accumulated data is rerecorded on shore for computer analysis. The buoy's receiver remains on briefly after each transmission, to receive instructions or repeat transmission.

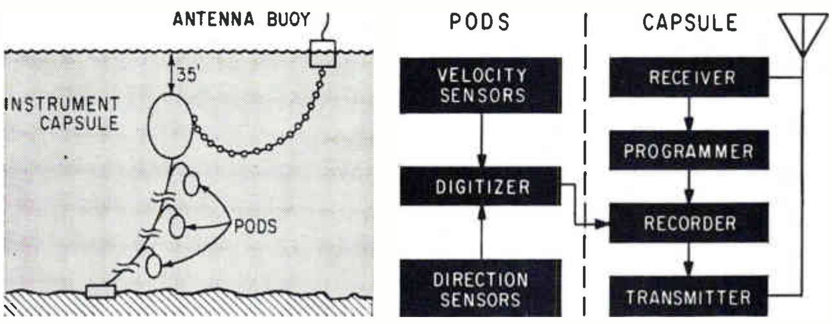
Planned improvements include increasing range from the present 20 miles to 40 miles. A temperature sensor will be added.

Public Health Service reports that airborne pollution mapping experiments using military infrared gear have met with "mixed success" this year. Runs have been made over the Missouri, Kansas and Blue Rivers to detect sources, types of wastes and flow patterns. However, the equipment, designed to pick up land details, fail to detect half-degree differences in water temperature, needed for PHS mapping.

Advanced pollution mapping projects are also underway at the University of Michigan, Northwestern and Penn State. Sensing devices working with photographable visual displays are reported under development.



Pod parts are (from top) digitizer, direction sensor and rotor



Data collected by instrument capsule (left) is transmitted on command to shore station

NBS Establishes Radio Refractive Data Center

NATIONAL BUREAU OF STANDARDS has established a Radio Refractive Index Data Center at its Boulder, Colo., Laboratories to assist studies of radio propagation in the earth's atmosphere. Data is made available to scientific, government and industrial groups, NBS says.

Data on meteorological parameters affecting refractivity is sent to Boulder by more than 300 weather stations and ships around the world. More than seven million punched cards recording data have been prepared to date. The center can compute index profiles for certain areas or make card sets available.

Missile Technique May Control Air Traffic

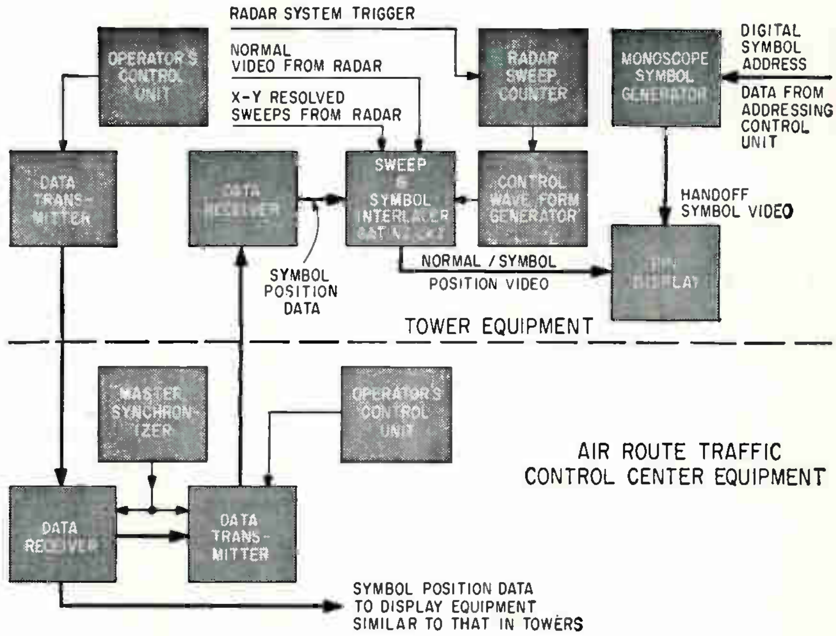
ADAPTATION of missile battery air defense coordination systems to civil air traffic control has been proposed to the Federal Aviation Agency by the Martin Co. Martin says digital data links like those in its AN/FSG-5 (Birdie) system could transfer radar handoff data between Air Route Traffic Control Centers (ARTCC) and their airport towers.

Transmission rate with a modified version would be 750 bits a second using pulse code modulation techniques and standard commercial private line circuits. Major system components would include special purpose computers, modulators and demodulators, telephone line switching gear and a master synchronizer.

Transmitters and receivers would use registers to store messages prior to encoding, transmission or display. Receivers would accept only data addressed to that tower. The ARTCC receiver would also transfer handoff messages to the proper tower.

Each pulse-code data frame would consist of three groups of three subframes each, with interrogation signals between each group. Each frame transmits up to six sets of handoff data from the center to the towers and three sets of data between towers. Subframes consist of x and y coordinates of the radar handoff flight and a group of 15 auxiliary bits for other flight information.

Handoff symbols would be displayed on tower radar screens. For



Simplified functional diagram of data link and radar handoff display

scan-converted displays, symbols would be produced by a marker generator of the type being developed for FAA by Hazeltine. Handoff data is converted to tv form and mixed with the video from the readout circuits of the scan converter. The marker generator would use dot matrices for character generation.

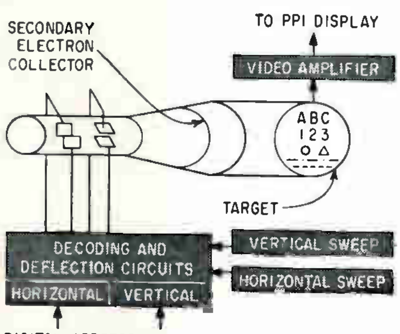
In ppi displays, symbols would be interlaced with radar signals. This technique of periodically inserting a character display in a radar display is used in a number of military systems.

Buffer-stored digital x and y position data establishing location of the handoff symbols are converted to d-c voltages which position the crt beam. Address information selects from a symbol generator the symbols to be displayed. Symbol generator video signals modulate the ppi beam as it traverses the symbol raster.

Martin recommends a monoscope symbol generator for ppi displays. As the electron beam scans carbon ink characters on an aluminum plate, variations in secondary emission produce modulating signals.

No modification of ASR-1 or ASR-4 radars would be needed. ASR-2 and ASR-3 radars would have to be fitted with resolved sweep, fixed-yoke deflection instead of rotating yokes.

A report on the study made by Martin for FAA was presented at the Air Traffic Control Association's recent convention in Miami Beach, by George F. Romano. Romano pointed out that other companies have come up with similar concepts.



Monoscope generates handoff symbol video for ppi radar

Three Universities Get Nuclear Research Gear

AMONG RECENT National Science Foundation grants for nuclear research are three which will underwrite purchase of particle accelerators at Michigan State, Pennsylvania and Ohio State Universities.

Michigan got $700,000 for a 50-mev sector-focused cyclotron with a new system for extracting particles in a thin beam. It also has a $400,000 grant for a new computer.

Penn is getting $1.6- million for a 12-mev tandem accelerator. Ohio has purchased a 5.5-mev machine from High Voltage Engineering.

Battery of two-transport recorders at FAA center in Oberlin, Ohio

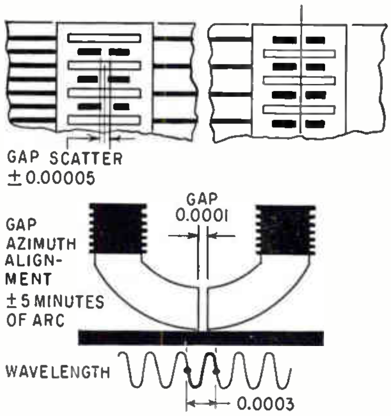
Investigator at playback console

Interlaced Heads Double Recording Density

MAGNETIC TAPE storage requirements at Federal Aviation Agency traffic control centers have been cut in half by a high-density recording system developed for FAA by Webcor. The centers must store for 30 days all low-frequency data.

Tape capacity was increased in the width (1½ in.) by recording 22 channels, and in the length by reducing speed to 15/16 ips and recording at higher density. Each recorder has two transports with a 16-hour tape supply, enabling them to record 32 hours unattended.

Each of the 22 amplifiers can supply identical audio signals to both transports simultaneously, through circuits which split the signals to the grids of each half of a single tube. Transports are linked by monitoring, failure control and automatic transfer circuits. If a tape should break or stop, transfer from the first to second transport is instantaneous.



Tape passes from right to left through dual heads

Companion playback equipment will playback any three channels simultaneously. Maximum variation in signal strength is 3 db over a dynamic range of more than 35 db.

Magnetic Head Design

Crosstalk and other problems created by closeness of recording channels and slow speed were resolved by record and playback heads recently developed for this type of application by Brush Instruments, a division of Clevite Corp.

The heads are built with two cartridges, with interlaced channels, mounted on an H-block. Brush says this design nearly doubles the number of channels which can be recorded on a tape while avoiding crosstalk.

Interlacing allows more shielding. Although energy produced at 15/16 ips is only about 200 μv, wider track width and increased winding permitted by interlacing gives a high signal-to-noise ratio, Brush says. Track width is 0.044 in. and track spacing is 0.0624 in.

At 15/16 ips, the upper frequency recorded, 3 Kc, represents a wavelength of less than 0.0003 in. compared to 0.0005 in. for most instrumentation recorders. The slow-speed heads use a gap of 0.0001 in. to obtain high resolution.

German Tv Tricks of the Trade

THIS YEAR'S CROP of German tv receiver circuits include three apparently novel solutions to fine tuning, turnoff spot and warmup hum problems.

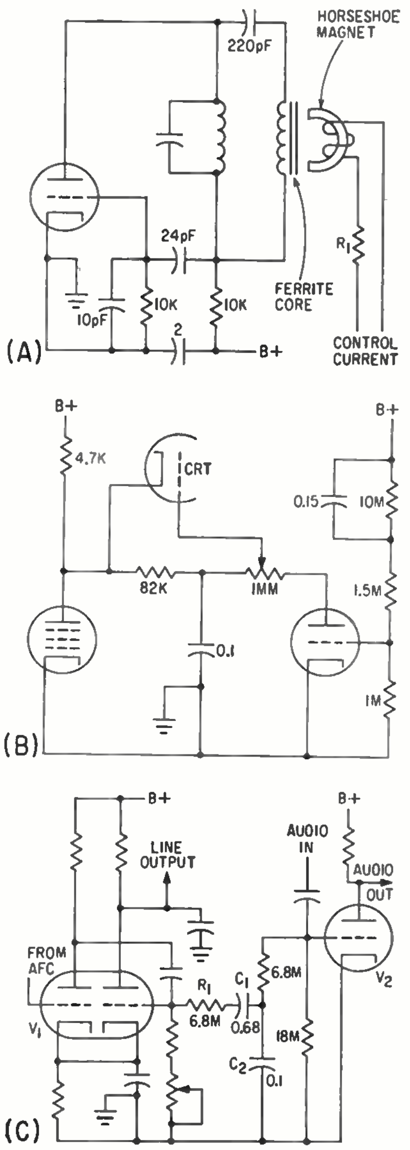
Grundig's method for fine tuning is shown in Fig. A. The local oscillator uses a premagnetized ferrite-cored coil connected in parallel with the oscillator coil. The inductance of the second coil depends on the magnetization of the ferrite which in turn is controlled by the current flowing through the coil.

The bright spot that remains on the crt for a few moments when the set has been turned off is removed by the Telefunken circuit seen in Fig. B. Brightness control is connected in series with a triode. When the set is operating, the triode conducts and has a low internal resistance. When the set is turned off, the R-C combination in the triode grid circuit differentiates the switching transient and causes a negative pulse to be applied to the triode. This cuts off the triode and the voltage at the crt control grid becomes positive thus causing a large current flow to discharge the crt anode.

Some tv sets are bothered by hum in the sound channel during the few moments of warm up after being switched on. Loewe Opta uses the build-up transient of the line deflection circuit to mute the output audio stage during this time.

The circuit, shown in Fig. C, uses the build-up transient of line multivibrator V_1 to charge capacitor C_1 to about −10 v to −15 v. This voltage is used to cut off first audio amplifier V_2. The negative voltage is discharged through the long time constant in the control grid so that the output stage has its normal operating bias after 30 seconds.

By this time, the line multivibrator is operating normally and its output pulses (on this muting line) are bypassed to ground through C_2. Switching the set off causes a positive voltage pulse to appear across C_1. R_1 is high to prevent rapid buildup of positive voltage. The positive voltage at the grid is delayed until anode voltage is zero.



Circuits used by Grundig to fine tune (A), by Telefunken to erase turn-off spot (B) and by Loewe Opta to prevent warmup hum (C)

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As Executive Vice President Emerson Radio & Phonograph Corporation

As vice president in charge of engineering and production

As development engineer

Consoles include patrol zone maps. Lights on map indicate availability of each of 80 patrol cars in the zone

System Blends Radio, Telephone

CHICAGO—Crossbanding and exploitation of telephone exchanges as radio patrol zones enable Chicago's new police communications system to transmit a call for help to a patrol car within 10 seconds. The system serves more than 1,400 vehicles in an area of 224 sq mi.

Doubling up on uhf and vhf replaced four former police channels with a new array of 22 frequencies, half in the 453-Mc range, half in the 158-Mc range.

Vehicle antennas are ¾-wave for receiving, ¼-wave for transmitting. Intermodulation between some adjacent bands is minimized by a squelch line set so patrol receivers won't pass a signal unless they are tripped by a coded tone.

Integrating telephone exchanges as radio patrol zones speeds toll-free incoming calls directly to one of three communications center consoles assigned each zone. Switchboard screening is bypassed. There are 36 special consoles to take zone calls, coordinate message traffic, answer overflow calls and monitor the system. One console links Chicago with suburban and state police.

Motorola, the prime contractor, worked with Illinois Bell on the telephone net switching system. Among developments were a three-stage, transistor compressor amplifier which adds 50 db of gain to a dynamic microphone feeding into consoles.

Civil Defense and disaster communications provisions include means for shifting operations to any of 11 alternate base stations with standby storage battery power. Redundancy provisions extend from standby base stations at each of the eight city zones, through three city-wide channels.

The system cost $2 million. Motorola's share, $1.4 million, included 885 transistor mobile units and conversion kits for 604 previously in use. Automatic Electric developed a switching system to automate teletypes. Dictaphone supplied 13 five-channel recorders.

City-wide consoles coordinate police action in several zones

MEETINGS AHEAD

COMPUTER Conference, Eastern Joint, PGEC of IRE, AIEE, ACM; Sheraton-Park Hotel, Wash., D.C., **Dec. 12-14.**

RELIABILITY AND QUALITY CONTROL, 8th National Symposium, PGRQC of IRE, AIEE, ASQC, EIA; Statler Hilton Hotel, Wash., D.C., **Jan. 9-11, 1962.**

OPTICAL CHARACTER RECOGNITION Symposium, National Bureau of Standards; Department of the Interior Aud., Washington, D.C., **January 15-17, 1962.**

ELECTRICAL ENGINEERING Exposition for electrical-electronics industry, AIEE; New York Colisium, N.Y.C., **January 29-February 2, 1962.**

REDUNDANCY TECHNIQUES FOR COMPUTING SYSTEMS, Information Systems Branch of Office of Naval Research; Department of Interior Aud., Washington, D.C., **February 6-7, 1962.**

MILITARY ELECTRONICS, 3rd Winter Convention PGMIL of IRE (L.A. Section); Ambassador Hotel, Los Angeles, Calif., **Feb. 7-9, 1962.**

SOLID STATE CIRCUITS, International Conference, PGCT of IRE, AIEE; Sheraton Hotel and U. of Penn., Philadelphia, Pa., **Feb. 14-16, 1962.**

APPLICATION OF SWITCHING THEORY TO SPACE TECHNOLOGY Symposium, USAF, Lockheed Missiles & Space; at Lockheed, Sunnyvale, Calif., **Feb. 27-Mar. 1962.**

SCINTILLATION AND SEMICONDUCTOR Counter Symp, PGNS of IRE, AIEE, AEC, NBS; Shoreham Hotel, Washington D.C. **Mar 1-3, 1962.**

MISSILES & ROCKET TESTING Symposium, Armed Forces Communications and Electronics Association; Cocoa Beach, Fla., **March 6-8, 1962.**

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

QUALITY CONTROL Clinic, Rochester Soc. for Quality Control; Univer of Rochester, Rochester, N. Y., **March 27, 1962.**

ENGINEERING ASPECTS OF MAGNETOHYDRODYNAMICS, AIEE, IAS, IRE, Univ of Rochester; Univ of Rochester, Rochester, N. Y., **March 28-29, 1962.**

SOUTHWEST IRE CONFERENCE AND SHOW; Rice Hotel, Houston, Texas, **April 11-13, 1962.**

HUMAN FACTORS in Electronics, PGHFE of IRE; Los Angeles, Calif., **May 3-4, 1962.**

JOINT COMPUTER CONFERENCE, PGEC of IRE, AIEE, ACM; Fairmont Hotel San Francisco, Calif., **May 1-3, 1962.**

ELECTRONIC COMPONENTS CONFERENCE, PGCP of IRE, AIEE, EIA; Marriott Twin Bridges Hotel, Washington, D. C., **May 8-10, 1962.**

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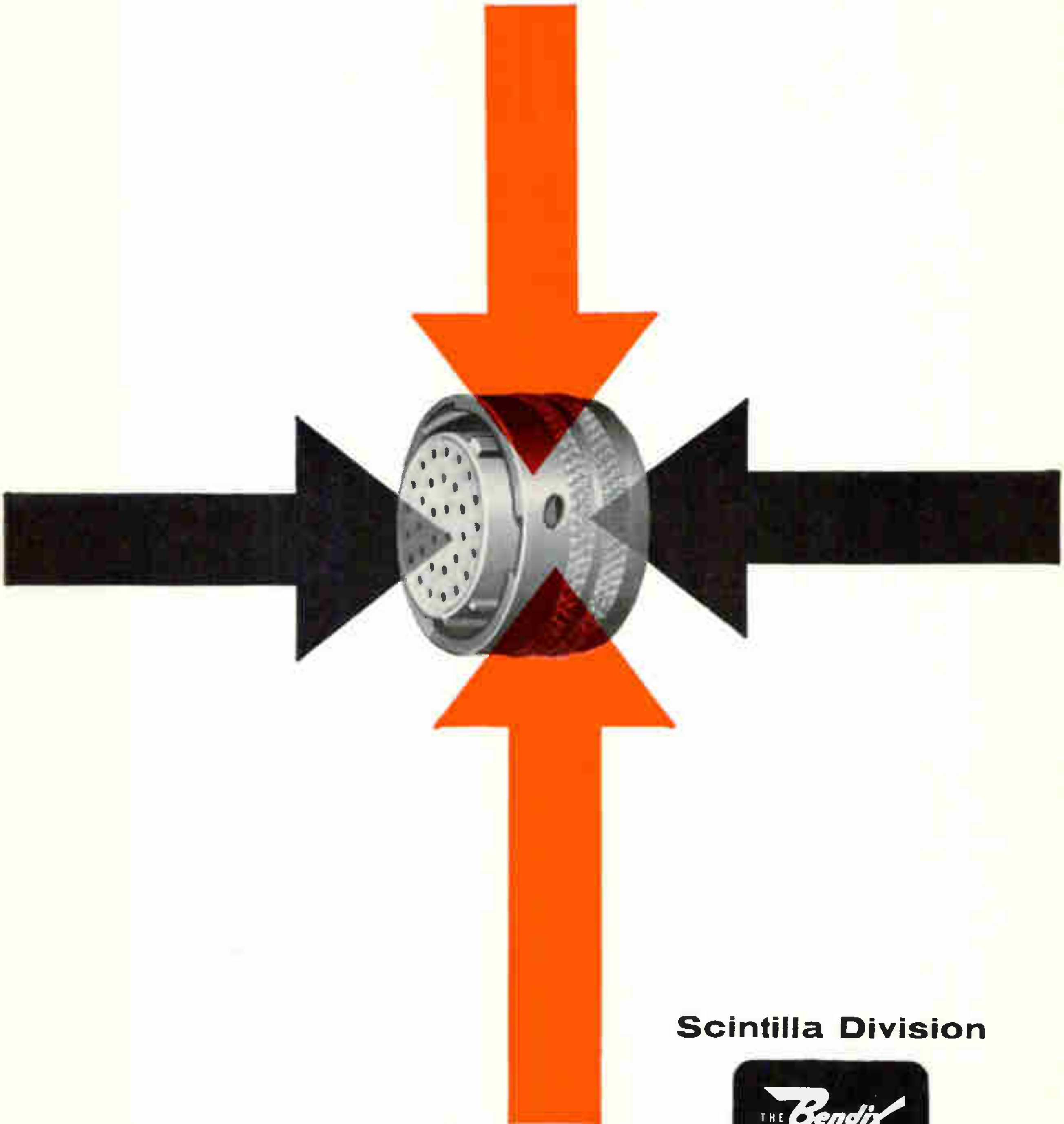

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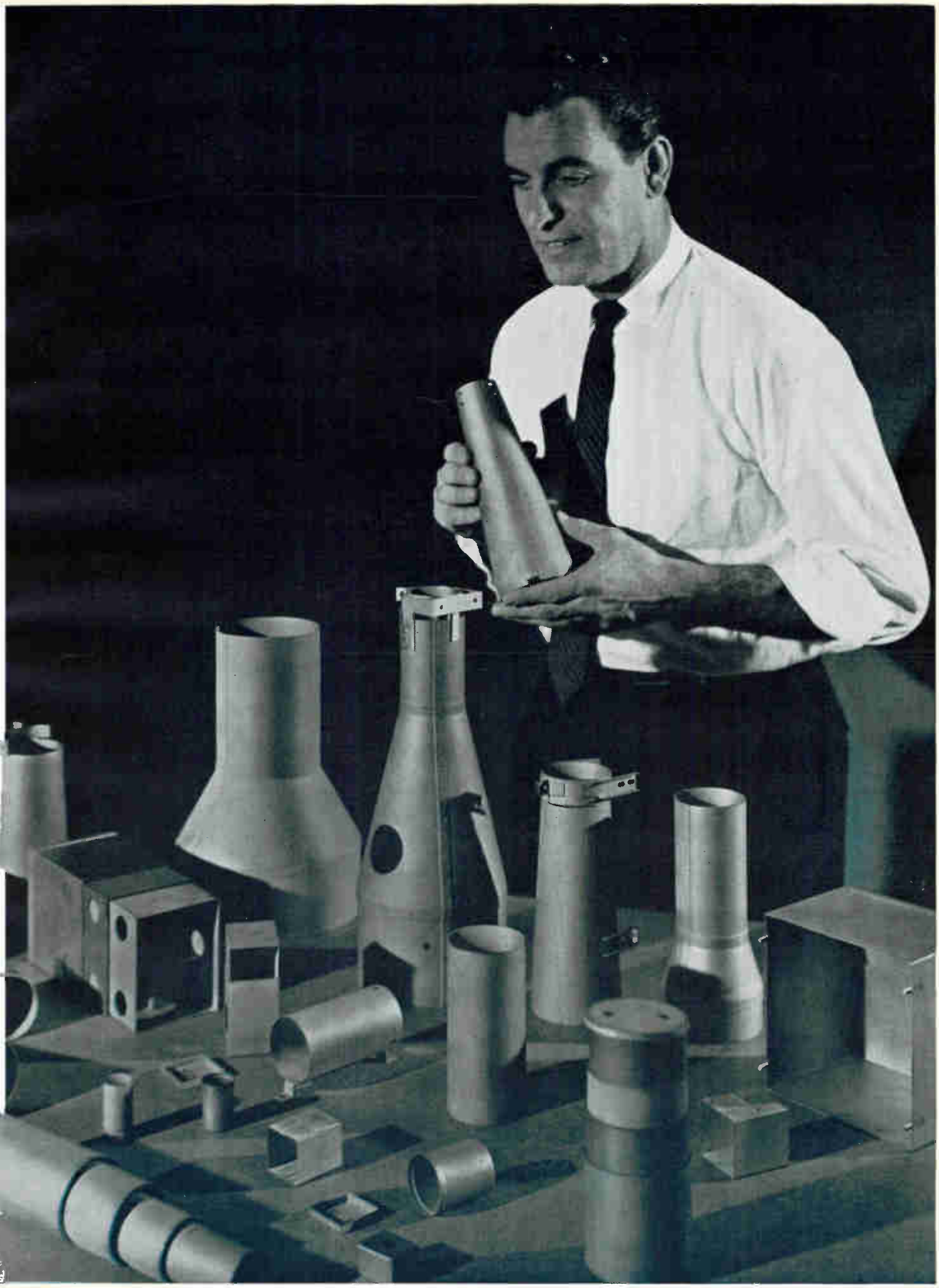

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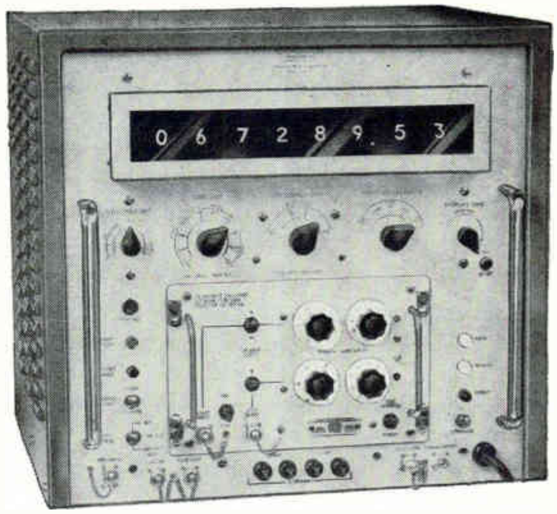

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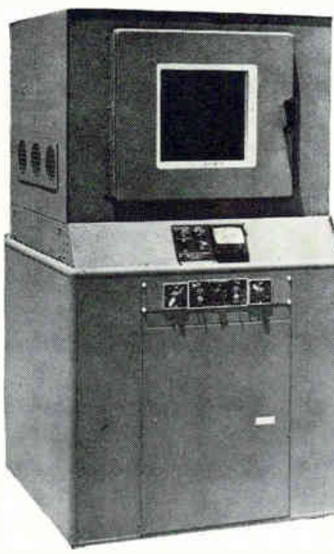

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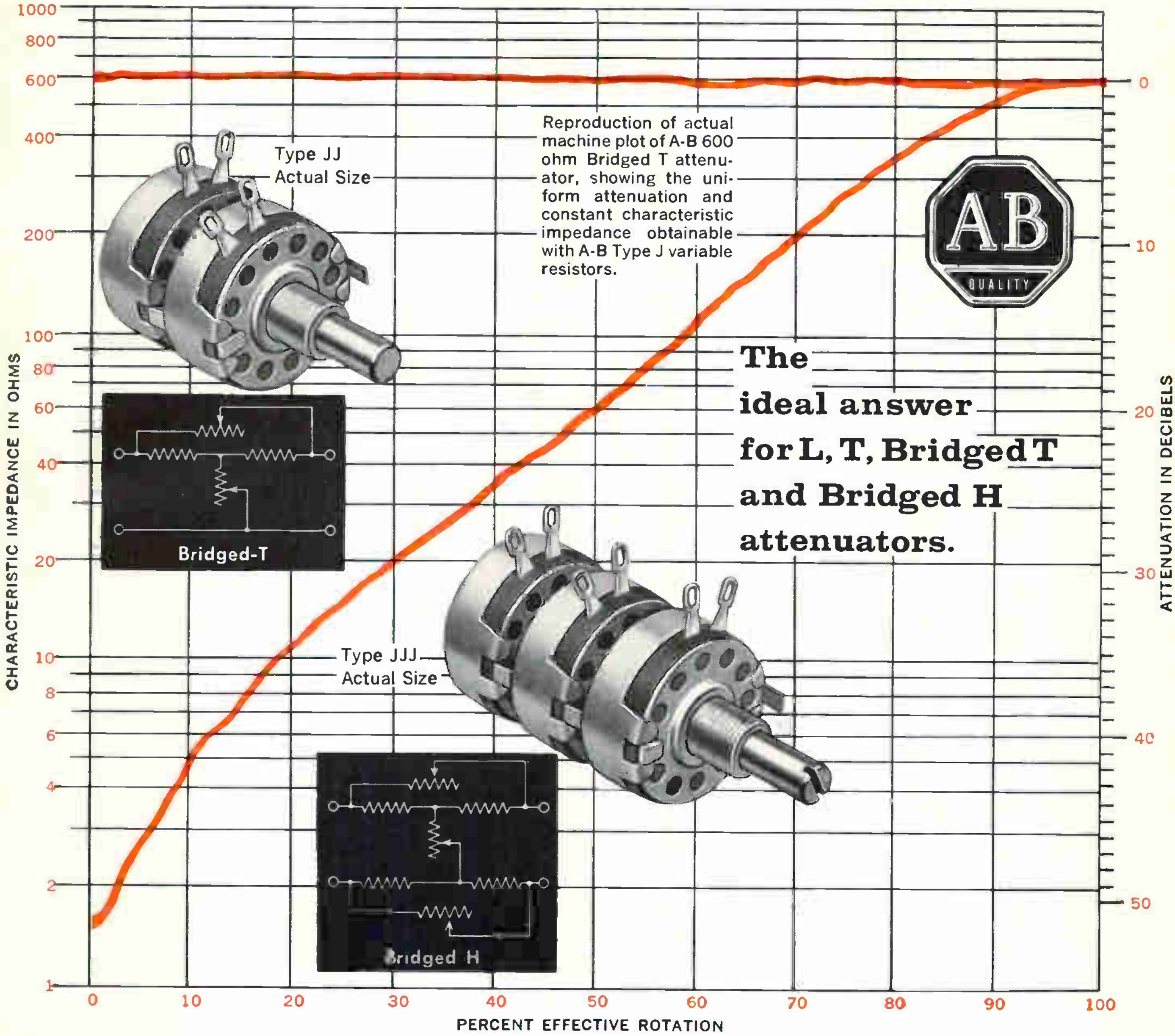

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10 mV (f.s.d.) - 10 V divided into 7 ranges in a 1-3-10 sequence.

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The overall accuracy is better than 5% with respect to full scale.

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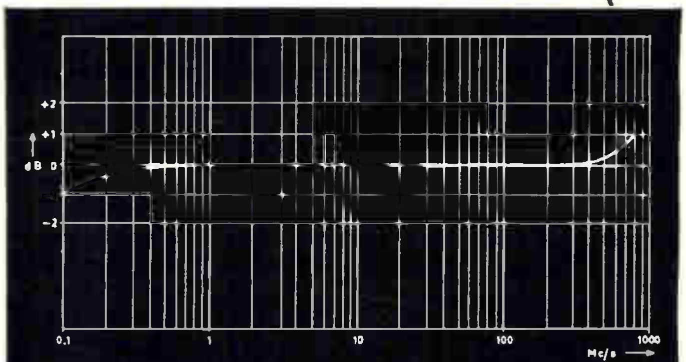

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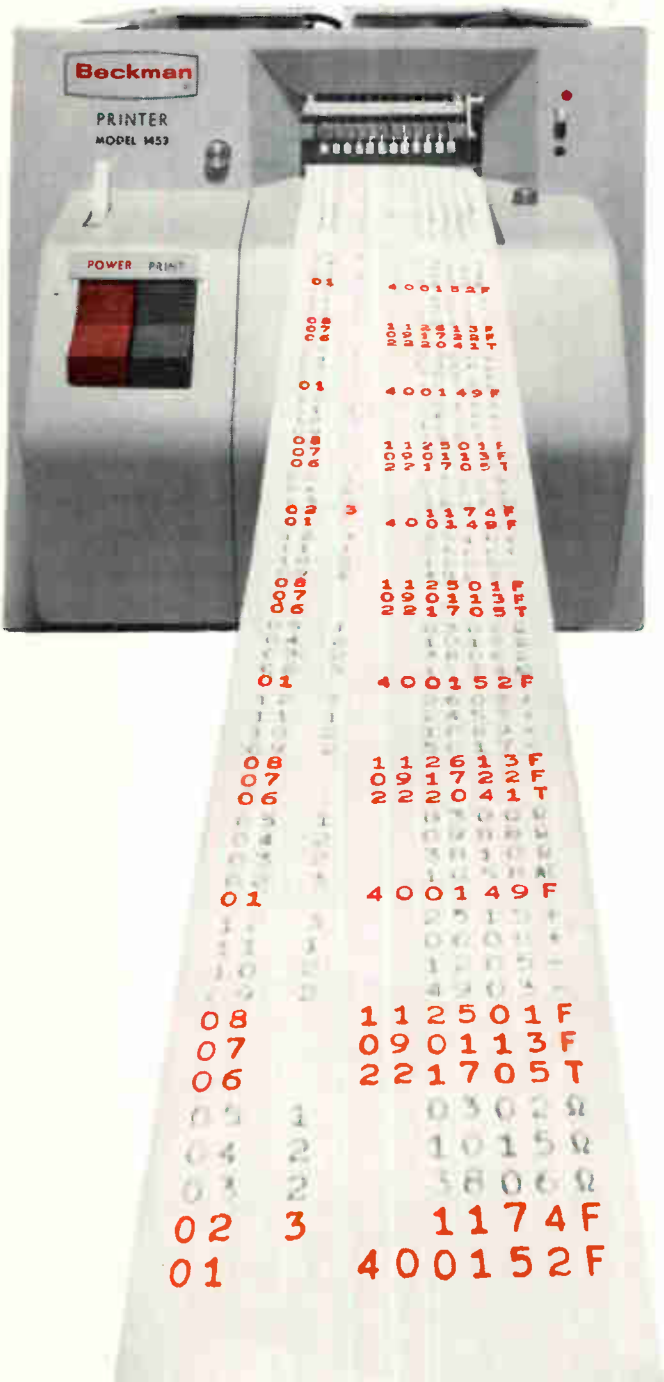
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This CLARE TYPE HGS is the fastest operating, most sensitive mercury-wetted contact relay obtainable. It will operate at speeds to 200 cps with sensitivity as low as 2.5 milliwatts with a contact rating of 2 amperes, 500 volts (100va max.). Two permanent magnets provide, single-side stable and bi-stable adjustments. Available with Form D (bridging) contacts.

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The Clare Mercury-Wetted Relay Principle

The remarkably long life of CLARE mercury-wetted relays is the result of a design principle whereby a film of mercury on the contacts is constantly renewed, by capillary action, from a mercury pool. Both CLARE HGS and HG switch capsules employ this principle. Both switches are sealed in high-pressure hydrogen atmosphere. Certain construction differences, however, give greater speed and sensitivity to the HGS switch.

FOR BILLIONS OF OPERATIONS

Choice of three convenient packages

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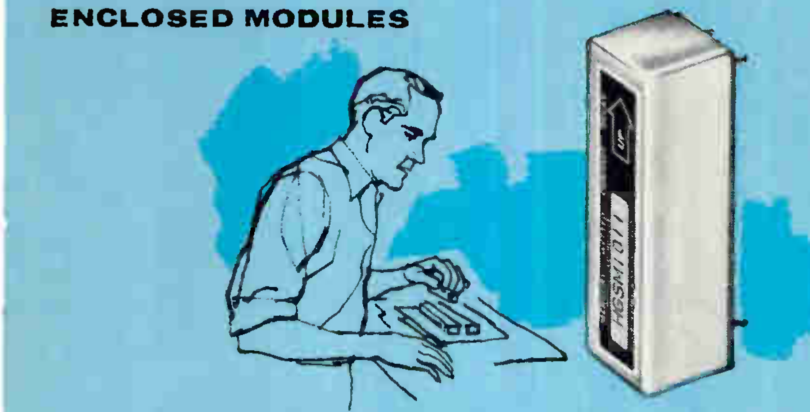

Both CLARE HGS and HG switch capsules are available in steel-enclosed modules for convenient mounting on printed circuit boards in the same manner as resistors, capacitors and similar components. The enclosure is ruggedly designed and provides both excellent mechanical protection and magnetic shielding. These modules are ideal for design and prototype work.

CONVENTIONAL PLUG-IN RELAYS

CLARE HGS switch capsules are available in single switch units, surrounded by a coil, mounted in high-melting point wax and encased in cylindrical steel containers provided with plug-in base. A smaller type (HGSS) is designed for use where space is limited. HG relays are available with one, two, three, or four capsules, surrounded by a single coil. Also with permanent magnets (HGP) for single-side stable, bi-stable or chopper operation.

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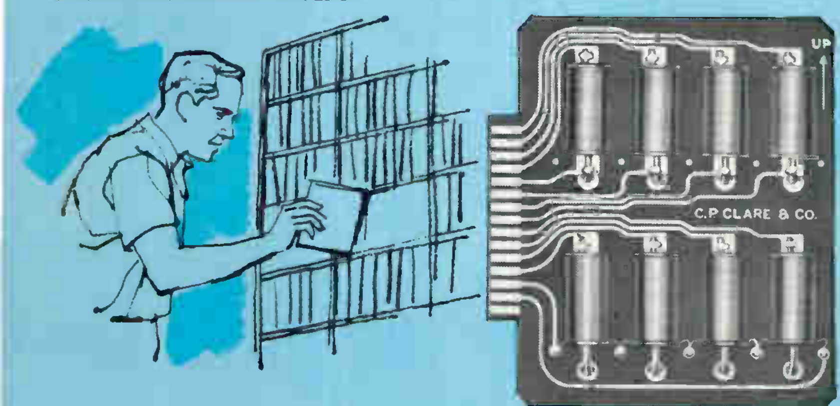

Printed circuit board assemblies are available with either HGS or HG switch capsules to meet design specifications. These may be designed to customer specifications by CLARE or mounted on boards supplied by the customer. Number of relays is limited only by the dimensions of the printed circuit board.

NEW! Design Manual 201A

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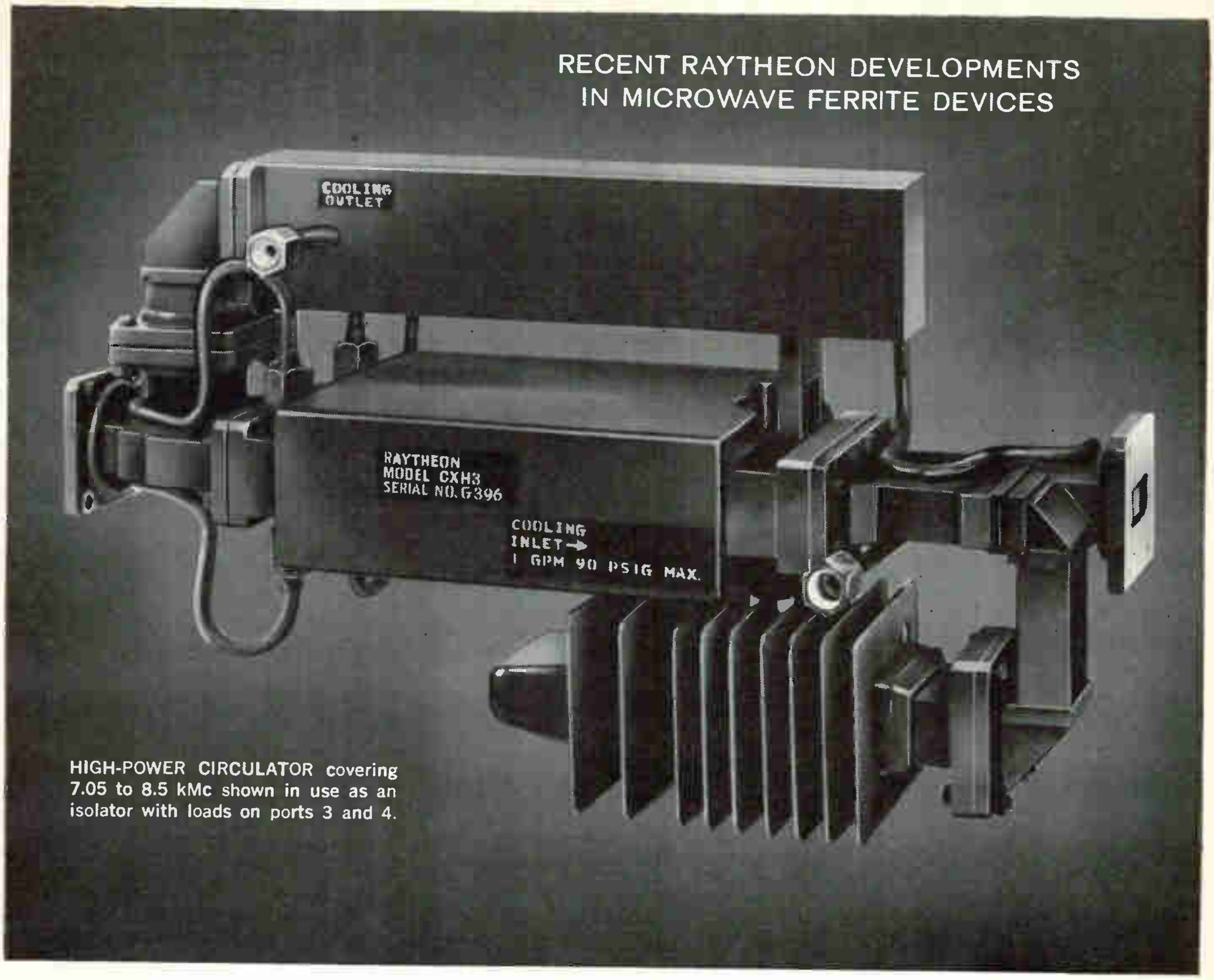
Relays and related control components



HIGH-POWER CIRCULATOR covering 7.05 to 8.5 kMc shown in use as an isolator with loads on ports 3 and 4.

X-band circulators take 20 kW CW to match state of the art in tubes

New unit tested at 20 kW continuous power; can be used as isolator or duplexer

This high-power CXH3 circulator provides greater than 20 db of isolation over the 7.05 to 8.5 kMc band with a maximum insertion loss of less than 0.3 db. The CXH3—developed under U. S. Army Signal Corps contract number DA-36-039-SC-85372—is typical of circulators Raytheon can supply for any X-band segment at power levels up to 25 kilowatts average and 2 megawatts peak.

Write for technical details on this and other significant developments in high-power microwave ferrite devices to Special Microwave Devices Operation, Raytheon Company, Waltham Industrial Park, Waltham 54, Massachusetts.

TYPICAL SPECIFICATIONS
MODEL CXH3 CIRCULATOR

Frequency Range	7.05-8.5 kMc
Power (CW)	20kW
Isolation	20 db min.
Insertion loss	0.3 db max.
VSWR	1.15 max.
Length	14.5 inches
Flanges	UG 51/U
Waveguide	RG 51/U
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Excl. loads	12.5 lbs.
Cooling	1 gpm @ 90 psi max.
Recommended Pressurization	10-15 psig nitrogen or dry air

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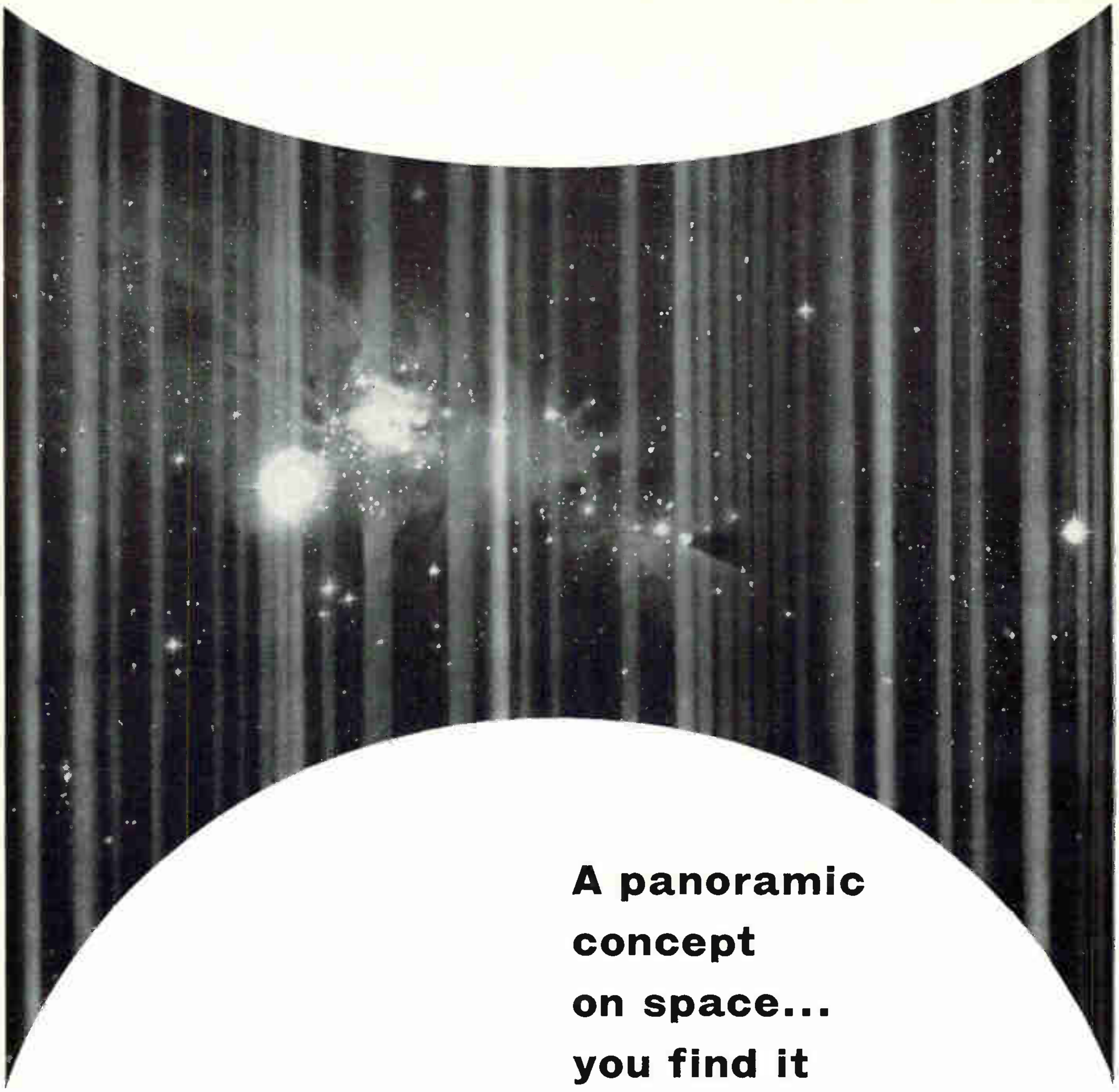

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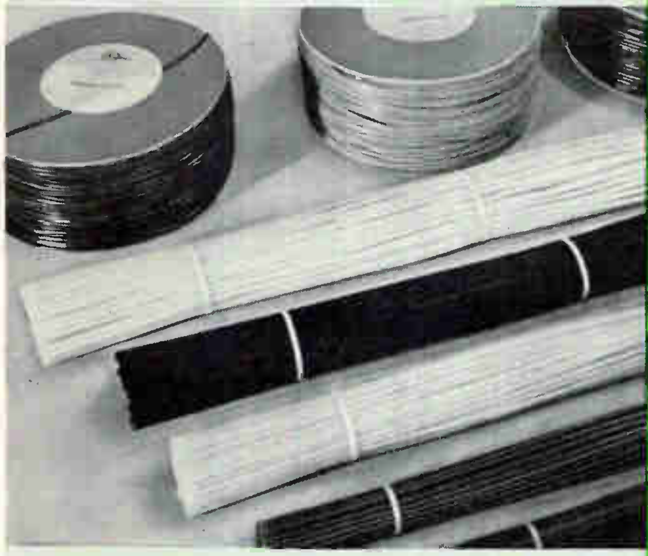

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Electroluminescent elements are capacitive. Their properties enable them to act as capacitance in a delay line. Pulses sent down the line control the voltage distribution over the elements, thus selecting the regions to be excited

Operator prepares to display pulse waveforms on the small square screen

Electroluminescent Display Presents Nanosecond Pulses

By R. W. WINDEBANK,
G. V. Planer Limited, Windmill Road, Sunbury on Thames, England

A NEW PRINCIPLE in flat-screen electroluminescent displays makes possible the presentation of short-duration pulses using a minimum of electronics and in a fashion that is easy to interpret. In common with other electroluminescent displays it is essentially robust in construction and uses no moving parts or fragile heater elements.

The display gives information about the time duration of input pulses down to nanosecond widths, and gives the timing of these pulses relative to some fixed reference. A special form of the display can also be constructed to show pulse amplitude.

The principle of the display is to build up the voltage at selected electroluminescent elements so that it exceeds the level necessary to produce illumination. Since the electroluminescent elements also double as the capacitive elements in a delay line, the excitation voltage is produced by coincidence of oppositely travelling pulses — where these pulses meet they produce a higher voltage than either of them could produce alone and thus illuminate the electroluminescent elements at that point.

The display element, shown in Fig. 1 uses an electroluminescent panel with its phosphor-containing layer sandwiched between a transparent electrode deposited on a glass sheet, and a counterelectrode system consisting of a number of narrow separate conductive strips. An electric delay line formed by a multi-turn winding on an insulating tube has each of its taps connected to one of the electrode strips. In this arrangement, the inductive winding, with the series of discrete capacitances set up between the electrode strips and the transparent electrode layer, make up a conventional delay line structure.

The pulse whose time-duration is to be displayed is applied simultaneously to the two terminals of the device. The pulse inputs at each end of the line travel along the line at the predetermined rate of propagation, and by arranging the voltage amplitude of each pulse input to be somewhat greater than half the voltage required to produce a suitable luminescent display, the luminescent phosphor layer is excited to the level of visual display beneath those strips upon which the two oppositely travelling pulses coincide. Thus, there is a visual display extending over part of the central region of the panel whose width depends on the duration of the applied pulse. By making the delay time of each section of the delay line a suitable known value, say 10 nanoseconds, the length of the pulse can be readily determined by measuring the length of the resultant visual display.

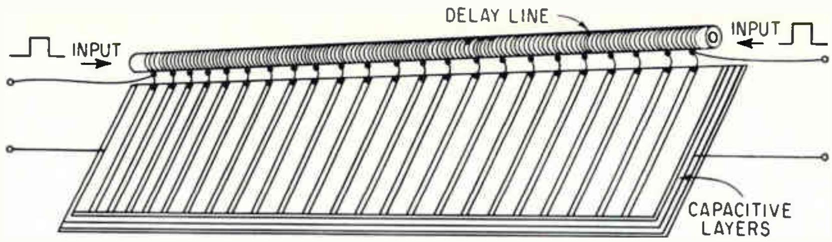


FIG. 1—Pulses fed into both ends of the delay line build up voltage at their point of coincidence and light the electroluminescent elements at that point

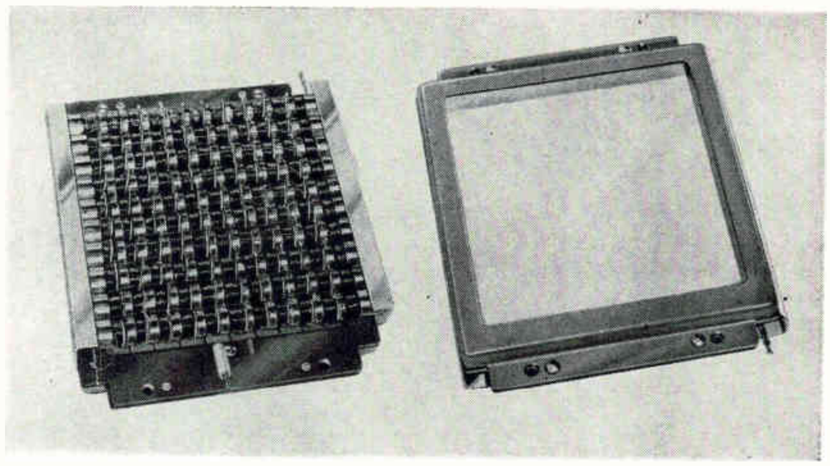


FIG. 2—A long delay-line is folded into several sections of equal length to make an area type display

Where pulse amplitude is to be measured, a modification of the device is used, in which the phosphor layer is wedge shaped in cross-section to give progressively increasing separation between the transparent electrode layer and the opposing separate electrode strips along its length. The height of the luminescent column produced along each of the strips is then dependent upon the voltage of the applied pulses.

A slightly different form of a display device is shown in Fig. 2. Here the delay-line is folded into 10 series connected lengths each placed side-by-side in a square pattern, with connections to a multi-element electroluminescent panel in which the phosphor layer is subdivided into 100 discrete sections. By applying pulses at each of the two terminals of the device and by controlling pulse timing, the panel may be scanned using only two input signals. This method compares favorably with existing commercial devices that use multi-input matrix principles to scan similar areas.

A refinement of the construction of Fig. 2 consists of an electroluminescent panel having two sets of electrode strips, one on each side of the phosphor layer, with the strips of one set at right angles to those of the other set (Fig. 3). The uppermost set of electrodes is preferably transparent. The strips on each side are connected to tap points of a delay line associated with each of the sets, and pulses of opposing polarity are applied to the two lines. By appropriate adjustment of the timing relationship between the applied pulses, a visual display may be produced at any chosen intersection of a strip of one set with a strip of the other set over the whole display area of the panel.

In operation, if positive pulses of amplitude V are applied across one of the delay lines, and negative pulses of equal amplitude across the other, the intersection area between the two sets of strips will have an impressed potential of $4V$ due to the coincidence of the travelling pulses. This voltage compares with a voltage of $2V$ at certain other intersection points and a voltage of only V at the remaining intersection points. By appropriate adjustment of the timing relationship between the input pulses, the $4V$ intersection can be caused to scan the entire panel. This method permits a faster pulse-rate than that of Fig. 2.

Capacitance between any of the oppositely situated strips should be small compared with the capacitive components of the delay lines, hence these strips may be of the distributed capacitance type having a common electrode as indicated in Fig. 3.

Characteristics of the electroluminescent elements are substantially those of conventional types, except that the resistance of the transparent electrode should be lower than usual, that is, about 10 ohms per sq as opposed to the usual value of 100-200 ohms per sq. To achieve this lower resistance the electrodes are applied by spraying a tin chloride solution onto the glass base and by using a small percentage of doping agent in alcoholic solution. The material is treated to form the oxide at 600 C.

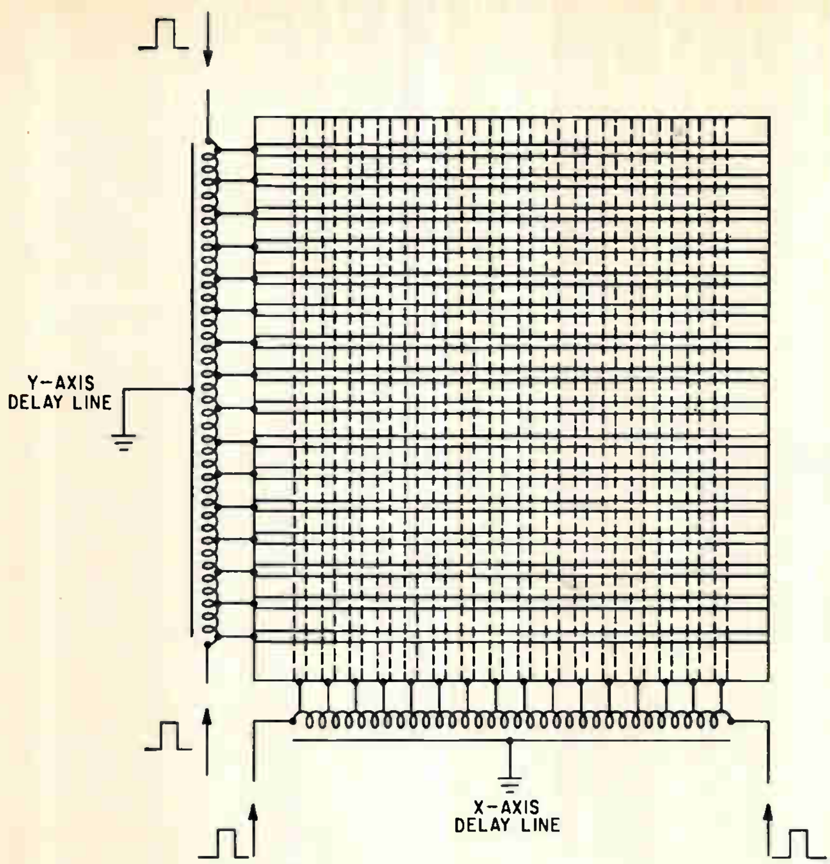


FIG. 3—Matrix type control enables higher pulse rates to be used with square panel than folded line permits

The phosphor layer is a zinc sulphide dispersion in an organic binder.

Experimental models of the basic display, Fig. 1, had 50 discrete phosphor sections each ⅛ inch wide. Synchronized pulses applied to both ends of the delay line caused one section of the display to light up for every 10 nanoseconds of applied pulse. When using synchronized 50-nanosecond pulses instead of 10-ns ones, 5 consecutive sections were lit up at the center of the panel. On introducing a delay in either pulse, the luminous region could be displaced to the left or right of center.

The 100-section folded-line panel in Fig. 2, was scanned by continuously varying the delay in both applied pulses. A 2-second scan was used and pulse heights were between 300 and 1,000 V, with pulse lengths between 20 and 500 nanoseconds. The pulse repetition frequencies were varied from 10 to 1,000 cps.

Pulses of the rate of 1 to 10,000 cps could be used, while the transmission line could be designed for 1 to 10-ns pulses.

The resolution obtained in the laboratory models was approximately 2 percent; that is, a ratio of line length to pulse length of 50:1. With improvements in phosphor and delay line characteristics this ratio can no doubt be increased.

With the techniques established so far, it would be possible to produce a rectangular display using X and Y delay lines each divided into 50 sections, to give 2,500 individual points. Any point could be illuminated by using two pulses of 20 nanosecond duration, each having amplitudes of 300 to 500 V and a pulse repetition frequency of 10 cps or more. Increase in the pulse repetition frequency would increase the brilliance and the scan rates.

An interesting future development would be to extend the system shown in Fig. 2 by employing a delay line of sinuous or raster-like form, disposed over the underside of the panel. With this type of construction, the delay line is preferably made up of a single conductor, rather than a helically coiled conductor, and may be formed by normal electrodeposition methods. To obtain the correct inductance value for the line, magnetic loading with ferrite may be used. Similarly, the capacitive value could be adjusted to a suitable order by using a dielectric, with these magnetic and capacitive modifying materials applied in layer form.

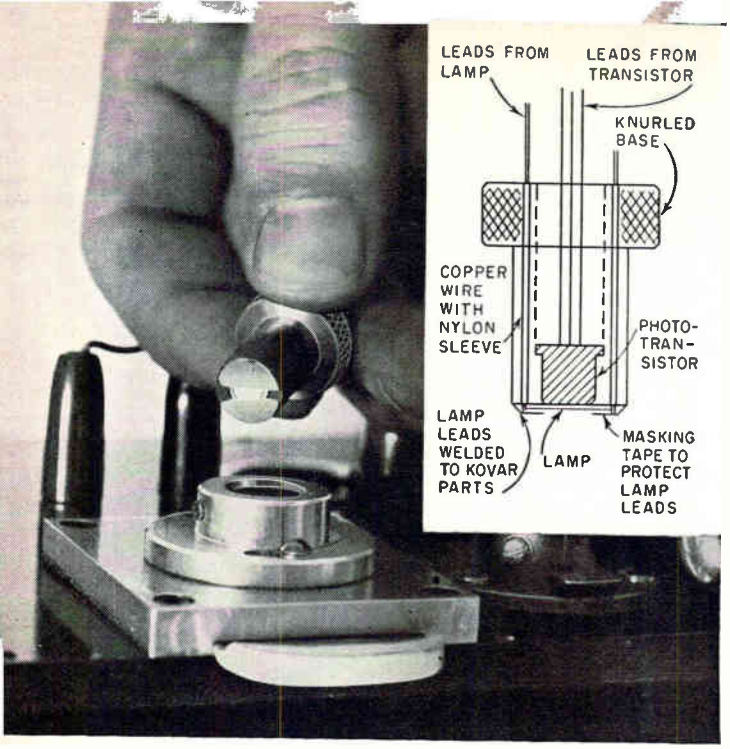
Such a panel might be used to give a television-type display of either a simple pulse input or of a complex video waveform. In the latter case, the video signal would be applied to one end of the delay line structure and a single exploring pulse of short duration to the opposite end. If the electrical length of the line were equal to half the time duration of the complex waveform and the short exploring pulse applied to one end just when the leading edge of the complex waveform had reached that same end, the exploring pulse would coincide in turn with all of the separate elements of the complex waveform as both waveforms travelled in opposite directions down the line, so producing a video signal pattern.

Alternatively, two pulses suitably spaced in time can be applied to the line from the same end, provided the opposite end is not correctly terminated. Coincidence of the second pulse with the reflection of the first pulse would then produce the required visual display. If a short-circuit termination were used the pulse polarities would be opposed.

A video or equivalent display could also be built up by applying discrete pulse sections of the complex waveform in turn to the delay line in suitably timed relationship with a series of appropriately time-displaced pulses at the opposite end, so as to produce, by time coincidence, a visual marking spot at each of the different points of the line raster in turn.

For a color display, two, three or more interlaced sinuous line conductors would be used, in combination with suitable color filter strips on the viewed side of the panel.

The author is indebted to L. S. Phillips, and D. F. A. MacLachlan, both of G. V. Planer Ltd. for their assistance in the construction of the display panels.



Details of phototransistor mount showing miniature lamp lying across window of phototransistor

Designing

Two versions of measuring device for high temperature. One, without feedback, features high threshold sensitivity and wide dynamic range. Feedback device is linear and has good calibration stability

By SAMUEL A. ELDER,
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AUTOMATIC RECORDING of surface temperature in missile and rocket environments requires a compact, rugged instrument. The completely transistorized recording pyrometer shown in Fig. 1 is the first version of such a device. Here, the design emphasis was on simplicity, since it was felt the instrument's reliability would be enhanced by having as few parts as possible. The control box is hand held and is ordinarily separated from the test area by a 50 ft. cable. Output of the control box may be fed directly to a d-c oscillograph.

Figure 2 is a schematic of the optical system. The telescope lens mounted in the end of a projecting tube focuses an image of a small portion of the source on a 0.020 in. field stop aperture, behind which a phototransistor is flush-mounted. Linear magnification is approximately 1. To avoid d-c drift and noise in the transistor circuit, the light beam is mechanically chopped at 750 cps by the toothed wheel placed just in front of the aperture. A silicon filter restricts the wavelength of the incoming light to a small band around 1.4 μ, where the phototransistor has maximum sensitivity.

When aligning, the phototransistor may be removed, permitting the image in the aperture plane to be examined by the microscope mounted in the lid. Field illumination is provided by the projection lamp. A standard tungsten ribbon lamp is used for calibration.

The circuits used are shown in Fig. 3. The optical box contains only seven components, including the phototransistor and battery. The phototransistor, connected in common emitter mode, requires no preamp. A low output impedance is provided by a miniature transformer, good ground loop isolation being obtained at the same time.

The control box circuit consists of the decade amplifier and demodulator. Gain stability is assured by the application of 34 db of feedback through R_1. The high input impedance generated by the feedback

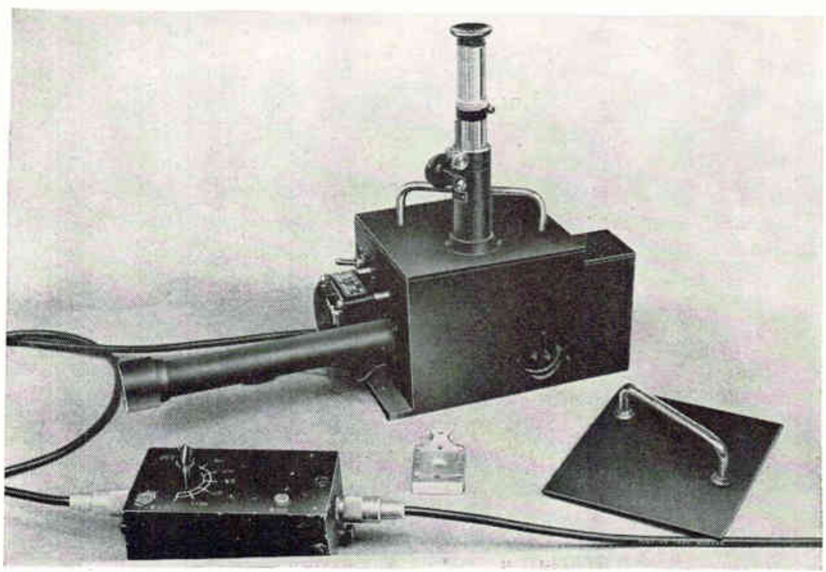


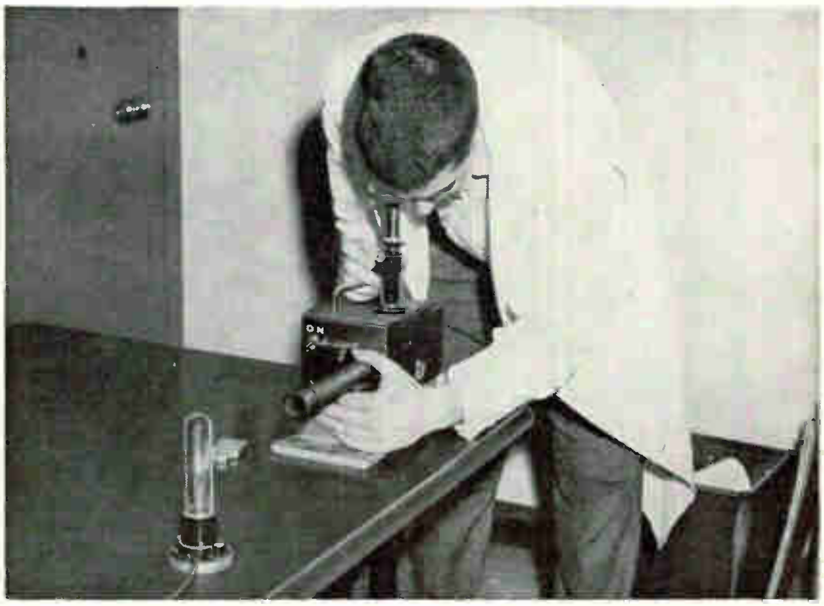
FIG. 1—Pyrometer's optical box is made from ¼ in. aluminum. Filter is in center foreground

Phototransistor Pyrometers

WITH AND WITHOUT FEEDBACK

means a simple voltage divider network can be used in the decade switch. Direct coupling is used in the common emitter cascade to reduce the phase shift at low frequency.

The diode demodulator transformer-coupled to the last transistor stage gives d-c output for recording on an oscillograph. The small bias voltage in series with the detector makes the output voltage exactly proportional to the input voltage. Minimum signal smoothing is employed, so as not to limit the rise time of the instrument any more than necessary. With the filtering shown, the device takes about 20 millisec to come up to 90 percent of a step input. A filter with a shorter time constant could be used if the light beam were chopped at a higher rate. For low-speed oscillograph recording, 20 ms is fast enough. Output signal level for full-scale deflection of the oscillograph pen is 250 mv d-c, corresponding to a line input of 2.5 mv rms. Noise level referred to the input of the decade amplifier is about 50 μv rms at maximum gain.



Aligning pyrometer for calibration with tungsten ribbon lamp standard

By the decade attenuator, a large linear dynamic range (about 4000 times referred to noise level) can be attained, the upper limit being imposed by clipping in the phototransistor. The dynamic temperature range of the pyrometer is affected by the dynamic voltage range of the electronics and by the efficiency of the optical system. This is shown in Fig. 4 where typical calibration curves are plotted on log-reciprocal axes. The temperatures given are black body temperatures (that is, corrected for the emissivity of the tungsten calibration lamp.)

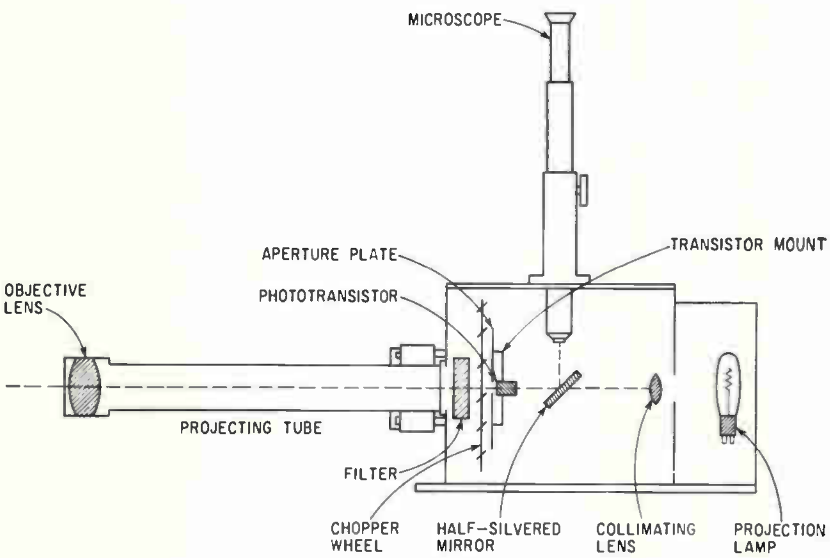


FIG. 2—In nonfeedback version the phototransistor is located near chopper wheel

With wide open telescope objective (Curve C) the linear range extends from about 725 K to about 1,400 K. By stopping down the telescope opening, the temperature range may be shifted upward as shown in curve B, where it extends from 950 K to 3,000 K. The straight line portion of the curve corresponds to the linear portion of the electronic dynamic range. Over this region the output signal is nearly proportional to the light intensity, which in accordance with Wien's Law, varies exponentially with the reciprocal of the absolute

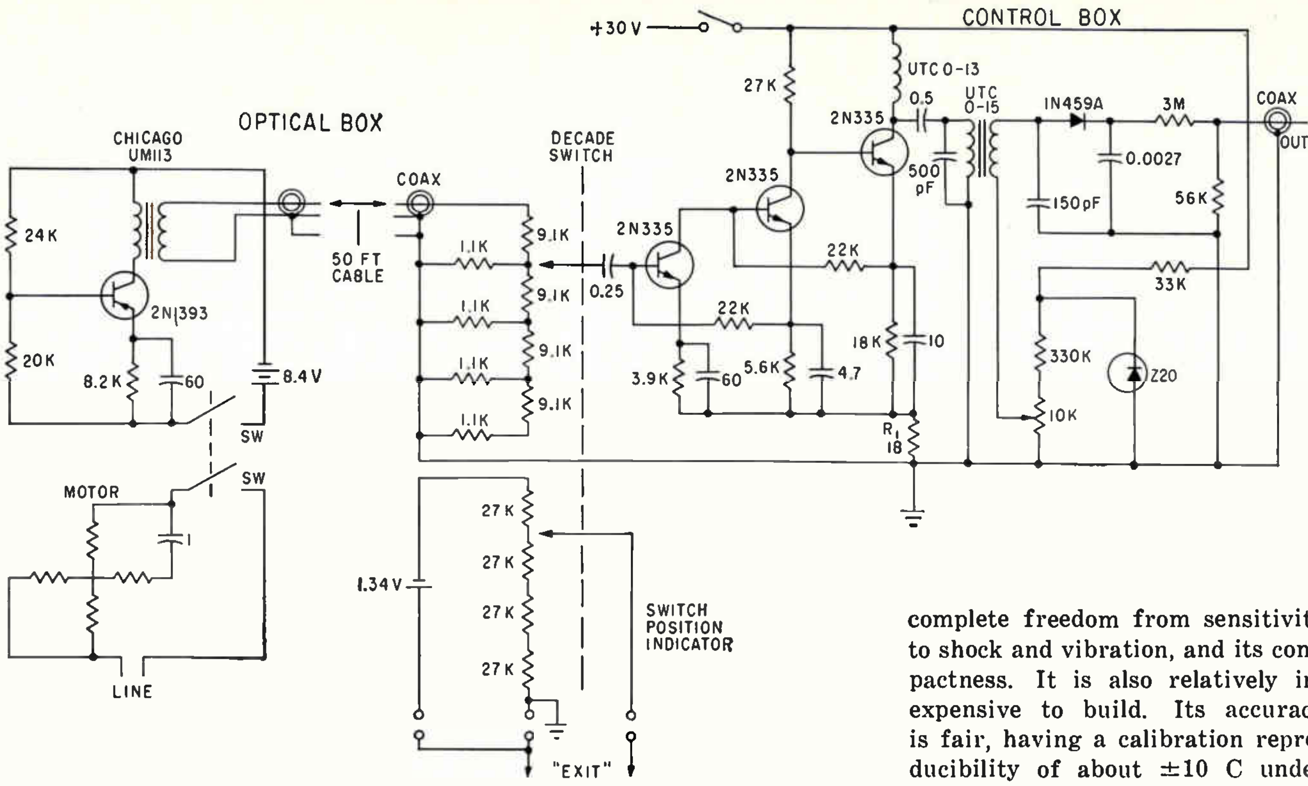


FIG. 3—Control and optical boxes are interconnected by microphone cable

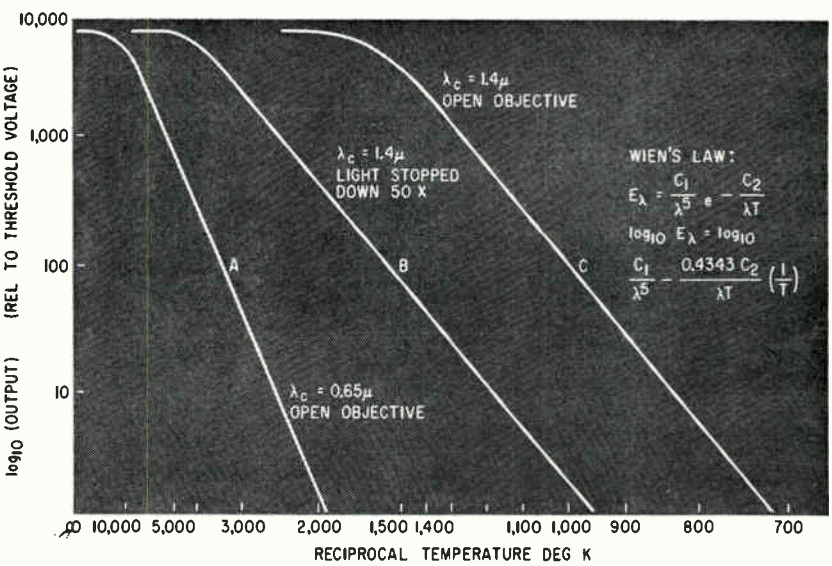


FIG. 4—Calibration curves show effects of stopping down objective lens and of changing filter

temperature. The slope of the straight-line portion depends on the center wavelength of the band-pass of light being received (curve A). Here a light filter with center wavelength in the visible spectrum was used in place of the infrared filter. Actually, the phototransistor current is not proportional to input light intensity so that the slope of the calibration curve if off by a few percent from that which would be expected from Wien's Law. For the particular phototransistor used, at ambient temperature of about 70 F, the output current varies as the 1.1 power of the input light intensity.

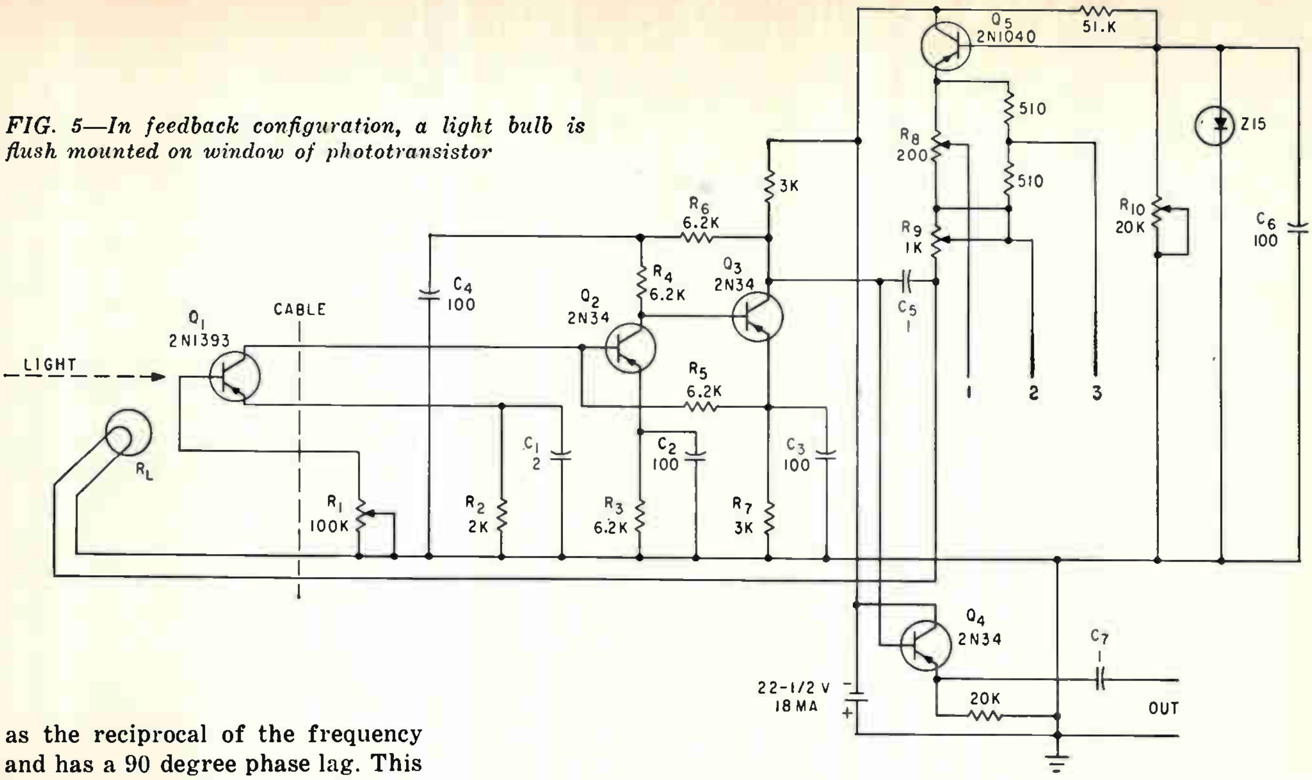
The chief advantages of the pyrometer system are its nearly complete freedom from sensitivity to shock and vibration, and its compactness. It is also relatively inexpensive to build. Its accuracy is fair, having a calibration reproducibility of about ±10 C under ordinary laboratory conditions.

The chief disadvantage is that the response of the phototransistor varies with ambient temperature. Since both the slope and threshold abscissa of the calibration curve are affected by changes in ambient temperature, the pyrometer must be calibrated under conditions identical to that in which it is to be used. This is not always a convenient procedure for field use.

A second version of the prometer in which the electro-optical response of the phototransistor has been stabilized by photofeedback overcomes this disadvantage. The photofeedback is accomplished by flush mounting a subminiature tungsten-filament lamp on the window of the phototransistor. The complete circuit is given in Fig. 5. Here the phototransistor becomes part of a direct coupled common emitter cascade. Base bias for the phototransistor is supplied by the d-c component of the light from the feedback lamp. The lamp is biased at a steady 12 ma current so as to have linear transducer response.

The static transducer characteristic of the feedback lamp is given in Fig. 6A. The dynamic transducer response of the lamp at a fixed bias current of 12 ma is shown in Fig. 6B. Over most of the audio range the lamp response falls off

FIG. 5—In feedback configuration, a light bulb is flush mounted on window of phototransistor



as the reciprocal of the frequency and has a 90 degree phase lag. This behavior is to be expected from elementary thermodynamic considerations. The energy equation for small perturbations in the temperature of a (lumped-parameter) light filament is

$$\frac{V_o}{R_o}\Delta V = AC_v\frac{\Delta T}{\Delta t} + BT_o^3\Delta T \quad (1)$$

where ΔV is applied signal voltage, R_o is lamp resistance at bias voltage V_o, ΔT is temperature change of the filament, C_v is heat capacity, t is time, A and B are constants.

Equation 1 states that of the heat energy supplied to the filament by the signal current, a part raises the filament temperature while the rest is radiated away. At a large enough bias temperature, T_o, conductive and convective heat losses may be ignored. The heat capacity term behaves like a reactance and at high enough frequency dominates the equation, producing the observed response:

$$\frac{\Delta T}{\Delta V} = \frac{V_o}{j2\pi fAC_vR_o} \quad (2)$$

or $$f\frac{\Delta I}{\Delta V} = -j \times (\text{constant}) \quad (3)$$

where ΔI is the intensity of the radiated light in the band $\Delta\lambda$ around λ_c. The corner frequency is of the order of 100 cps for the lamp used. At high audio frequencies the lumped-parameter approximation breaks down and the lamp response begins to fall off faster than $1/f$. The upper corner is near 2200 cps, as may be seen in Fig. 6B. There is only a slight deviation from $1/f$ response up to 10 kc, however.

Both the static and dynamic lamp response are important. A steady 12 ma bias current is supplied to the lamp by a current regulator transistor Q_5 (Fig. 5). The current setting may be varied to allow for battery aging by adjusting R_{10}. The Zener diode across R_{10} protects the lamp from burnout when batteries are replaced. The maximum permissible current may be set by adjusting R_9.

Lamp current may be checked at

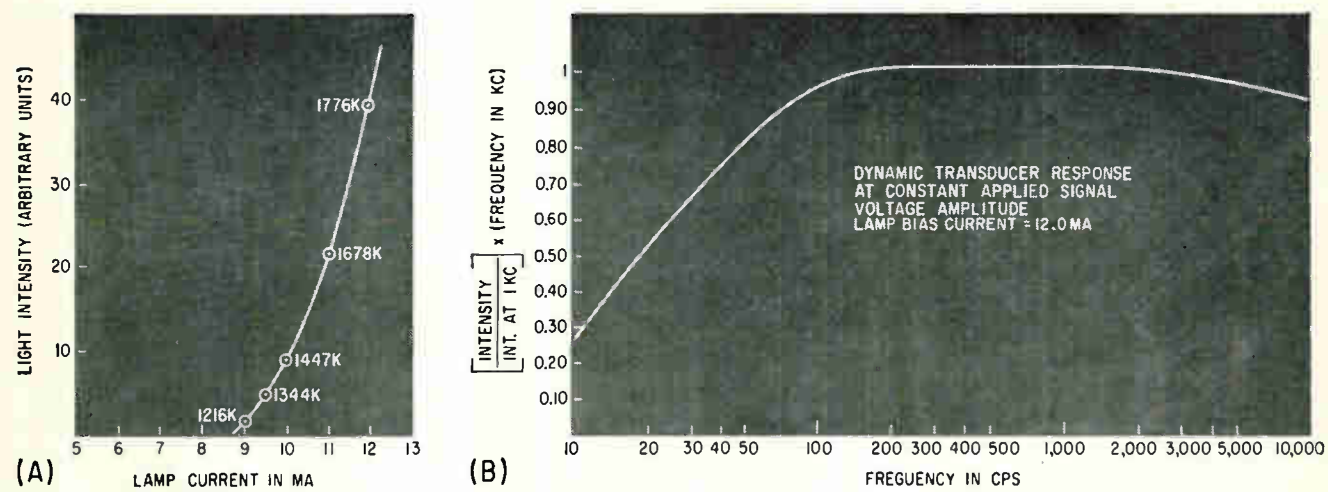


FIG. 6—Static (A) and dynamic (B) transducer characteristics of Pinlite 15-15. Curve in (B) is obtained by disconnecting C_5 in Fig. 5 and driving the feedback lamp from external oscillator

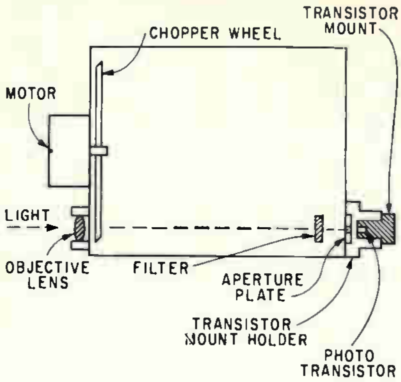


FIG. 7—Feedback version has phototransistor mounted at rear of box

any time by inserting a potentiometer at terminal 1 and 2. The lamp current is standardized by a portable potentiometer that uses a mercury cell as reference. Aging of the mercury cell may be calibrated out by adjusting R_8. To counter-act phase shift and sloping frequency response of the lamp, coupling capacitor C_5 is used. This gives good compensation up to about 1.7 Kc without excessive attenuation of the feedback signal. The overall feedback is 28 db at the signal frequency. This is equivalent to a 1 megohm voltage-feedback resistor.

The need for wide-band amplifier response was eliminated by mechanically chopping the light beam into a sine wave rather than the usual square wave. This was accomplished by placing the chopper blades close to the plane of the objective lens and making the lens aperture equal to blade width. The optical system is shown in Fig. 7. A 180-cps chopping frequency places the signal in the passband of the amplifier.

Low-frequency response is heavily damped by an undersized bypass capacitor (C_1 of Fig. 5) to avoid ringing due to transients. Bias current to the first stage is set by adjusting R_1. The origin of the bias current is the photon input from the lamp itself, which behaves as an infinite impedance source. To secure low output impedance to line with minimum reaction back on the amplifier, an emitter follower stage Q_4 is added at the collector of Q_3.

The decade amplifier in the original pyrometer was unsuitable for the photofeedback version, since it did not have enough feedback at low frequencies. The circuit was modified by removing the output transformer and load inductor as shown in Fig. 8. To obtain linear operation of the detector without a step-up transformer, it was necessary to operate at higher supply voltage. A bootstrap emitter follower stage was added as an output buffer to improve the circuit stability.

The photofeedback version of the pyrometer gives greater precision as well as greater calibration stability. The voltage calibration of the feedback version is reproducible to better than 1 percent resulting in a temperature reproducibility of better than ±1 C at 1,000 K and ±4 C at 2,000 K. Precision could be improved further by redesigning for a greater amount of feedback, although the stability of the feedback lamp characteristics may impose a practical limit. The threshold temperature is about 840 K (as compared with 725 K for the nonfeedback version).

The most important advantage of the feedback pyrometer is that after an initial absolute calibration using a standard black body, it does not need to be optically calibrated again. This makes it useful as a field instrument. Another advantage is that the feedback improves the linearity of the phototransistor response. The photofeedback principle described here should be useful for photometric devices in general.

Compared to the feedback version, the nonfeedback pyrometer works at higher chopping frequency, has somewhat better threshold sensitivity and dynamic range, and is less affected by microphonic pickup in severe vibration environments. Refinements in the photofeedback circuit, however, may neutralize these differences.

Both instruments are currently being used in rocket tunnel experiments at the APL hypersonic research facility.

The author acknowledges the help of T. Kahn who aided in the mechanical design. This work was supported by the Bureau of Naval Weapons, Department of the Navy, under Contract NOrd 7386.

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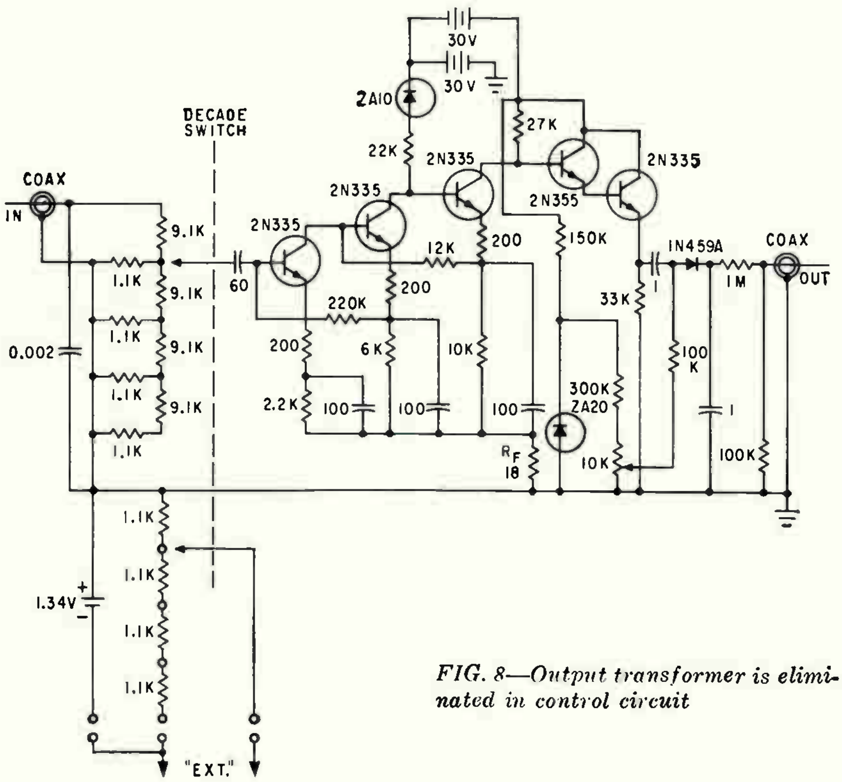

FIG. 8—Output transformer is eliminated in control circuit

Point of the heated vertical probe is applied to the sample between lower clamps. Control on right monitors probe temperature through thermistors, also feeds thermoelectric voltage to an external differential meter that indicates junction polarity

Hot Probe Measures Semiconductor Thermoelectric Power

Temperature-stabilized probe determines the thermoelectric power of semiconductor samples without sample preparation or shaping. Permits point measurement of Seebeck coefficient

By NEIL BOBSON,
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THE RECENT rapid growth in semiconductors for thermoelectric energy conversion requires the basic semiconductor materials to be speedily available for production use, and available in uniform and known quality. Since thermoelectric power alone (Seebeck effect) may vary from −300 microvolts per degree C to +300 microvolts per degree C within a single semiconductor crystal, rapid nondestructive testing methods must be available to sort out which sections of a given semiconductor sample can be used.

Semiconductors for thermoelectric applications, have three quantities of interest: electrical conductivity, thermal conductivity and thermoelectric power. These three combine to give the figure of merit for the whole semiconductor, which is a measure of its usefulness as a thermoelectric material. Electrical conductivity is measured by the two and four-probe techniques[1,2] that permit rapid, nondestructive resistivity measurement without requiring special sample preparation or shaping.

The thermal conductivity, while equally important in the determination of the figure of merit, is the quantity least likely to be variable. Presently, several programs are developing a probe technique for measuring thermal diffusivity—a factor that is related to thermal conductivity through the specific heat. Though this measurement has been shown to be practical, development work is still required.

The widely varying thermoelectric power coefficient on the other hand, should be measured to give a sample's thermoelectric power profile, which, coupled with the resistivity profile, indicates those portions of the sample deserving close examination. Such profiles allow selection of the more interesting sections of an ingot for detailed experiment and also provide homogeneity data on crystal growth techniques. To fill this profile need, a probe measuring-scheme has been devised to measure the thermoelectric power of a semiconductor without preliminary sample preparation.

When a hot probe is placed on

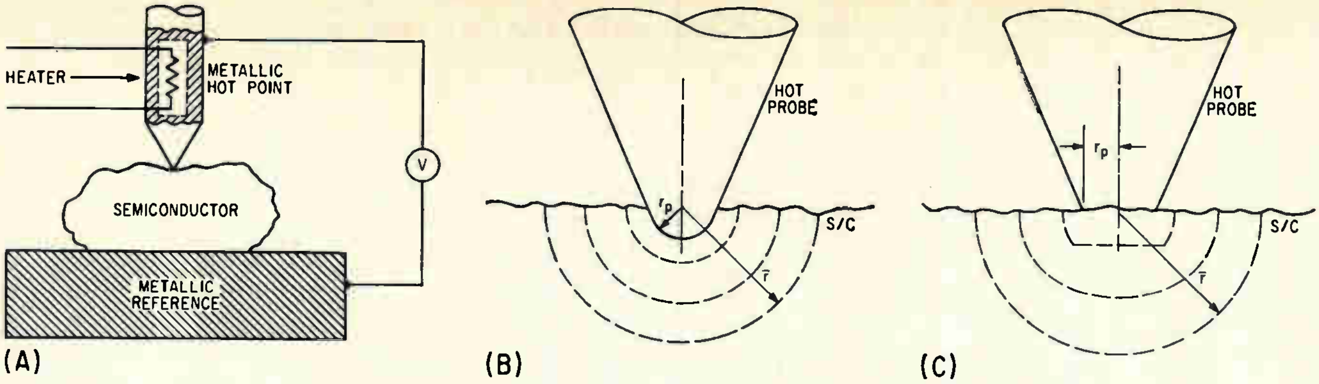

FIG. 1—Complete system (A). Hemispherical probe (B) produces hemispherical isothermal surfaces while temperature distribution of flat probe (C) assumes hemispherical shape several radii from the surface

the surface of a thermoelectric semiconductor a voltage is generated between the hot probe and some cooler reference point in an undisturbed region of the semiconductor. Since polarity of the voltage changes sign with a change from *p* to *n* conductivity, a thermoelectric probe has often been used to detect *p-n* junctions. If in addition the temperature of the probe is known and the magnitude of the thermoelectric voltage is measured, a semiconductor's Seebeck coefficient can be determined directly. Since sample preparation is not usually required, that is, no cutting or soldering of leads is necessary, a hot probe can be used for the rapid evaluation of thermoelectric semiconductors.

The experimental situation is illustrated in Fig. 1, with the specimen on a metallic reference electrode at temperature T_c. The hot probe at a temperature T_h is placed on an arbitrary point of the sample and the thermoelectrically generated voltage measured between reference and hot electrodes. It is assumed that the thermoelectric power generated by the reference and hot electrodes, as well as by the leads connected to the voltmeter, is negligible compared with the thermoelectric power of the semiconductor specimen.

The Seebeck coefficient or thermoelectric power α is defined by

$$\nabla\phi = -\alpha\Delta T \qquad (1)$$

where ϕ and T are the voltage and temperature, respectively. In this simplified analysis, it will be assumed that α is isotropic, independent of temperature and independent of position. Thermal conductivity K, is likewise assumed to be isotropic, temperature and space independent. These assumptions are restrictive and seldom realized in practice, however, the analysis carried out on this basis can lead to useful results.

The Seebeck coefficient is defined under open-circuited conditions. Consequently, the density of heat sources in the uniform bulk semiconductor with no currents flowing must be zero. This condition leads to a differential equation for the temperature distribution

$$\nabla^2 T = 0 \qquad (2)$$

Equation 1, in view of the uniform α approximation, indicates that the voltage distribution is governed by the same differential equation

$$\nabla^2\phi = 0 \qquad (3)$$

The metallic electrodes can be chosen so that their electrical and thermal conductivity is far greater than that of the conductor being measured to ensure identical thermal and electrical equipotentials where the electrodes contact the semiconductor. Boundaries of the specimen not enclosed by the electrodes are electrically open-circuited. Since the thermal conductivity of still air (0.00023 watts per deg C-cm-sec) is two or three orders of magnitude less than the thermal conductivity of thermoelectric semiconductors, the electrically open-circuited boundaries can be regarded as being also thermally open-circuited. Heat flow across the open surfaces could be further reduced by immersing the sample in some low thermal-conductivity medium or possibly vacuum, but this technique would destroy some of the device's facility. Even in a still-air medium, it is a valid approximation to consider the open surfaces as being completely open-circuited—both electrically and thermally. Consequently, the voltage and temperature distributions are governed by identical differential equations and identical boundary conditions.

Integrating the temperature gradient along an arbitrary path between the electrodes

$$\Delta T = \int_{T_c}^{T_h} \nabla T \cdot dl = T_h - T_c \qquad (4)$$

Performing a similar integration for the E field

$$\begin{aligned} \nabla\phi &= \int_{T_c}^{T_h} \nabla\phi \cdot dl \\ &= -\alpha \int_{T_c}^{T_h} \nabla T \cdot dl \\ &= -\alpha(T_h - T_c) \end{aligned} \qquad (5)$$

Therefore, the thermoelectric power is

$$\alpha = -\frac{\Delta\phi}{\Delta T} \qquad (6)$$

Equation 6 demonstrates that within the limitations imposed by the assumed boundary conditions and the assumed semiconductor uniformity, the thermoelectric power is the quotient of the thermoelectrically generated voltage divided by temperature drop. This result is unaffected by electrode or sample geometry.

This conclusion is the result of some drastic over-simplications.

The effect of temperature variations of α and K can be minimized by keeping the temperature drop $(T_h - T_c)$ as small as possible. This dictates voltage-measuring equipment with a high sensitivity. It is also assumed that the semiconductor being measured is isotropic. A thermoelectric power

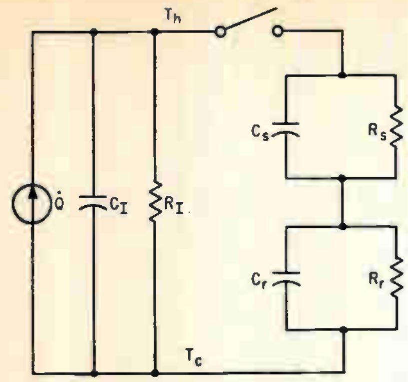

FIG. 2—Equivalent thermal circuit of hot-probe measuring technique

measurement by a hot probe on an anisotropic semiconductor would be difficult to intepret. Generally, anisotropy causes circulating currents, and additional information must be known about the thermal and electrical conductivity tensors before making conclusions about the thermoelectric power tensor. Consequently, a hot probe cannot be used to evaluate an anisotropic semiconductor. The effect of possible spatial variations of α and K can be minimized by the choice of probe geometries and dimensions.

Consider the two following probe geometries that make contact to the semiinfinite semiconductor: a hemispherical and a plane circular contact. With the hemispherical point, Fig. 1A, the temperature distribution in the semiconductor is

$$T = \frac{r_p}{r}(T_h - T_c) + T_c \qquad (7)$$

where r_p is the radius of the point. The isothermal surfaces indicated by the dotted lines, of the geometry indicated in Fig. 1C are oblate spheroids, but at distances a few radii into the bulk, the isotherms become spherical and similar to those indicated by Fig. 1B. Equation 7 demonstrates that with these small point geometries the major temperature drop occurs in a small volume immediately under the point. The magnitude of the thermoelectrically generated voltage then is governed predominantly by the thermoelectric power of the semiconductor near the hot probe. This property allows α and K to be assumed spatially constant, because the point dimensions are small enough for variations in α and K over the volume being measured to be negligible. Furthermore, with specimens of suspected grading, the hot point can be used to probe and measure the variation of α.

The size of the hot point is important. Aside from resolution there are other considerations that limit the magnitude of r_p. Large r_p's are limited by temperature-regulation requirements. In using a hot probe, it is desirable to maintain the temperature drop $(T_h - T_c)$ constant. The thermal loading produced in measuring applications can be demonstrated by the equivalent thermal circuit in Fig. 2. Here, ϕ is the heat flux supplied to the hot point, which has a thermal resistance and capacitance R_I and C_I respectively. C_r and R_r are the thermal capacitance and resistance of the reference block. In practice, C_r is large. C_s and R_s refer to the sample being measured.

The switch is closed when the hot point is applied to the specimen, and open when the hot point is removed. Although ϕ is regulated to maintain a constant $(T_h - T_c)$, the instantaneous temperature will not vary with opening and closing of the switch if R_s is much greater than R_I. Analog R_I is governed by the surface area of the entire hot-probe assembly and the thermal conductivity of still air; R_s can be computed exactly for the two types of contacts.

$$R_s = \frac{1}{2\pi r_p K} \quad \text{(Hemispherical contact)}$$

$$R_s = \frac{1}{4 r_p K} \quad \text{(Plane-circular contact)}$$

If a hot-probe-assembly length of 10 cm is convenient, then r_p must be chosen at least three orders of magnitude smaller to compensate for the lesser thermal conductivity of still air. Consequently, an r_p of 10^{-2} cm or less would result in an R_s greater than R_I.

For reasons of thermal loading, r_p's much less than 10^{-2} cm would be advantageous. Vanishingly small points, however, are not desirable since surface properties rather than bulk properties would then be measured. Semiconductor surfaces may be covered by oxide layers or inversion layers arising from surface states. The thickness of an oxide layer is a variable factor but inversion layers are of the order of several Debye lengths thick—about 10^{-6} to 10^{-5} cm in most semiconductors. If the bulk rather than surface properties are desired, the point should be made large enough so that a major portion of the temperature drop occurs in the bulk.

Thermoelectric power is measured by a three-element instrument. It includes a temperature-regulated hot probe and reference block assembly; also required is a mechanical fixture for positioning the sample and for applying the hot probe to the sample in uniform fashion. A sensitive high-impedance d-c voltmeter is needed to measure the generated emf, and this meter should preferably be of the differential type and calibrated in microvolts per degree C.

The photograph shows the instrument system. An electronic proportional controller maintains the hot probe at a fixed temperature above the ambient or reference. A 20 degree C temperature difference is adequate. The error signal for the proportional controller is developed from bridge-connected thermistors located in the probe and reference block. The probe and reference block are also equipped with differentially connected thermocouples to provide exact monitoring of the temperature difference. The probe and reference block are made of nickel-plated copper for maximum thermal stability and minimum sample contamination.

A d-c voltmeter indicates alpha (α) when the probe is depressed onto the sample. A differential meter identifies the junction polarity and eliminates continuous switching of meter leads. A switch connects the d-c meter to the thermocouples and permits the temperature differential to be monitored without an expensive potentiometer.

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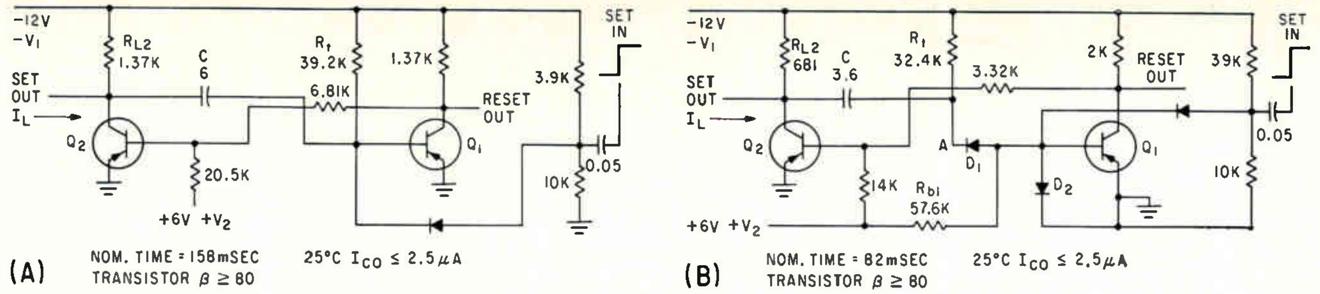

FIG. 1—Conventional monostable multivibrator (A) compared with isolating-diode type (B)

Monostable Multivibrators

GENERATING accurate delays in the 1 to 300-millisecond range with transistor monostable multivibrators is easy under laboratory conditions but difficult in production runs. Bulky capacitors and large timing resistors are the two major difficulties. Large stable capacitors are expensive, while large timing resistors accentuate the variable effects of transistor I_{co}. To design a monostable that will maintain timing within 5 percent with changes in temperature, supply voltage and component variation requires consideration of all timing parameters.

Two circuits will be analyzed. Although these circuits were analyzed with germanium transistors, the analysis holds true with silicon transistors.

The circuit shown in Fig. 1A is the common monostable and its operation is similar to the vacuum-tube type.[1] The difference is that during the timing interval, capacitor C discharges into the base of Q_1 due to I_{co} in addition to the usual path through R_t. Large errors may result if this parameter is not considered.

Circuit operation of the isolating monostable, shown in Fig. 1B is not as obvious. Diode D_1 is added[2] to reduce timing variation caused by the variable I_{co} of Q_1.[2] Diode D_1 disconnects C from Q_1 during t_1 of the timing period and Fig. 2 shows typical waveforms.

The reverse leakage of D_1 can be neglected if a good quality silicon diode is chosen. During time t_1, Q_1 is off and I_{co} is supplied by base resistor R_{b1} and bias supply V_2. Diode D_2 clamps the base of Q_1 maintaining the uniform base-emitter voltage required to realize the benefits of isolating diode D_1. Time t_1 ends when the voltage at point A equals the forward drop of D_2. At this point, D_1 begins conducting. From this time until the monostable resets to its quiescent state (time t_2), the capacitor C discharge depends on the I_{co} of Q_1, R_{b1}, R_t, V_1 and V_2.

Before capacitor C and timing resistor R_t are chosen to produce the time delay, the designer must satisfy the requirements of the external circuits. Usually it is good practice to derate components and chose nominal values so that the circuit will operate with any combination of tolerances expected. This worst-case design technique is described elsewhere.[3] A graphical method may also be used.[4] In either case, the design procedure will end with R_t specified to fall below a maximum value. It is desirable to use a resistance near this maximum so that the capacitor size (and cost) may be reduced. Capacitor C and resistor R_t combination may be chosen to give the desired timing using the following equations. The effects of parameters varying may also be calculated from these equations.

The monostable shown in Fig. 1A uses the following timing equation

$$T = R_t C \log_e \frac{I_{co1} R_t + 2V_1 - V_s - R_{L2}(I_L + I_{co2}) - V_{BEon}}{V_1 + I_{co1} R_t - V_B}$$

where C = timing capacitor, I_{co1} = I_{co} of Q_1, I_{co2} = I_{co} of Q_2, V_s = collector saturation voltage of Q_2, V_{BEon} = base-emitter voltage at the quiescent state of Q_1, V_B = base-emitter cutoff voltage of Q_1, V_1 = negative supply voltage, R_t = timing resistor, R_{L2} = collector resistor of Q_2 and I_L = current into R_{L2}, quiescent state, observe sign on current. Magnitudes are used on all terms except I_L.

The monostable shown in Fig. 1B has the following equations. The time period must be calculated in two steps. Figure 2 shows t_1 and t_2.

$$t_1 = R_t C \log_e \frac{I_{cod} R_t + 2V_1 - V_s - R_{L2}(I_L + I_{co2}) - V_{D1} - V_{BEon}}{V_{D2} + I_{cod} R_t + V_1}$$

definitions same as previous equation plus V_{D1} = diode drop of D_1 quiescent state, V_{D2} = diode drop of D_2 during t_1, V_2 = positive supply voltage and I_{cod} = I_{co} of D_1. Use magnitudes on all terms except I_L.

$$t_2 = R_{eq} C \log_e \frac{I_{co1} R_{eq} + V_{eq} + V_{D2} - V_s}{I_{co1} R_{eq} + V_{eq} - V_{D2} - V_B}$$

where $R_{eq} = (R_t R_{b1})/(R_t + R_{b1})$ and $V_{eq} = [R_t (V_2 - V_{D1} - R_{b1} I_{co1} - R_{b1} V_1]/(R_{b1} + R_t)$ and the total period is $t_1 + t_2$

A number of observations may be made from these equations to give further insight into circuit operation. For the circuit of Fig. 1A, the term $I_{co1} R_t$ appears in both numerator and denominator of the log term. By using typical values of components and supply voltages shown in Fig. 1A, and calculating the time period with no I_{co1} and then with

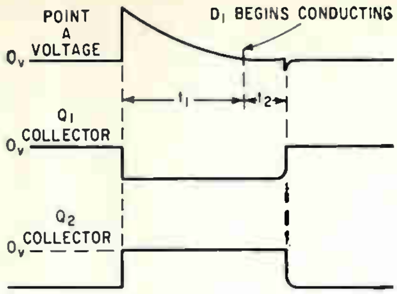

FIG. 2—Timing waveforms of isolating diode type monostable time delay

Maintaining accuracy in production-run transistor monostables often presents problems. Analysis of factors affecting timing shows how to alleviate them

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With Stable Delay Times

80 μa I_{co}, the timing decreases approximately 16 percent. Varying supply voltage V_1 produces less than 1-percent timing change. These two points are typical of this monostable.

For the circuit of Fig. 1B, the equations are more complex. The major variation with change in I_{co1} comes from the second part of the time period, t_2. During this tailout time, transistor Q_1 is connected to capacitor C via diode D_1 therefore I_{co} does affect the time period. Using the typical values shown in the circuit, this effect has been reduced slightly more than 2:1. The interplay of R_t and R_{b1} is important. As it is desirable to keep the tailout period small, R_t must be small and R_{b1} large, but R_{b1} cannot be increased above the point at which insufficient I_{co} is supplied to Q_1. Diode D_2 with a low forward drop makes t_2 occur at a later time thus reducing the variable tailout period. Since period t_2 depends on V_1 and V_2 in addition to the resistors and diodes, timing is also dependent on the supply voltages.

Using typical values from Fig. 1B, a 10-percent supply voltage change nets about 1 percent timing change. The worst case is when one supply voltage increases while the other decreases. This monostable is dependent on many variables but the major cause of timing change (I_{co1}) has been greatly reduced, even in the worst case.

Calculated and measured data were found to agree within ½ percent when accurate values were used in the equations. Values for diode and transistor drops can be estimated from data sheets with sufficient accuracy. To obtain good agreement, I_{col} should be measured in the setup. For design it is more useful to calculate the maximum timing change with variable I_{co} by using the maximum expected value. Two minor assumptions were made in the derivations; the period of time required to turn a transistor on and off is negligible when considering delays in the order of milliseconds, and the I_{co} of Q_1 is the reverse bias current of the transistor.[5]

To realize accurate timing from a monostable, its use in a circuit must be considered. To maintain less than 2-percent timing jitter, a recovery time of $4R_{L2}C$ must be allowed before the next trigger pulse is applied. Cascading two monostable in series will overcome this problem in critical cases. Driving other circuits from the set output of either type monostable should be avoided. Noise pickup on a lead connected to this point may trigger the monostable. A variable load (I_L) will directly vary the time period. Still another difficulty can be the slow fall of the set output waveform when working into logic gates. This is caused by capacitor C recharging through R_{L2}. Another point which should not be overlooked is the power supply as good regulation and low ripple are requisite. Fluctuations will feed through R_{L2} and the capacitor to the base of Q_1 causing instability or false triggering; 50 mv of this noise can cause trouble.

Equipment containing both types of monostables have been constructed. Over 350 monostables, assembled and tested on a production basis, proved the analysis. A simple production procedure was devised to adjust for the initial tolerance of the capacitors. Incoming capacitors were measured in a test monostable circuit. Standard 1-percent resistors were switched into the R_t position. The resistor value that gave the nearest to desired timing was marked on the capacitor for later assembly. A digital time interval counter measured the time interval. With no other selections or adjustments, 99 percent of the monostables were within ±2.5 percent from nominal. A large portion of this may be attributed to two chances for R_t to be off from nominal. Temperature tests at 65 C proved the isolating diode circuit to be about 2:1 less sensitive to I_{co} changes than the conventional circuit. Between 2- and 4-percent decrease with temperature was typical with the isolating diode circuit and after four months of service, no signs of drift have been observed.

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Solenoids for Traveling-Wave Tubes

Survey of the principal design aspects of electromagnetic systems for microwave tubes and the mechanical techniques of cooling microwave tube solenoids

THE INCREASE in use of traveling-wave tubes and high-powered klystrons has created a demand for focusing solenoids for these tubes. Previously it was enough for the focusing solenoids to meet electrical and magnetic considerations, but packaging of electronic systems has produced additional demands with regard to the mechanical aspects, heating problems, environmental conditions and weight.

The electromagnet solenoid provides a magnetic field of sufficient intensity and length to control the path of the electron stream inside the tube. This magnetic field must be within a given intensity range; it must be uniform, of maximum length in the space alloted, and be homogeneous, that is, have a minimum of magnetic fields perpendicular to the main field. The more usual type of tube requires a constant magnetic field throughout its length. A constant field is generally identified as an unchanging plateau that the magnetic field achieves between dropoff points at each end. This is shown on a typical solenoid chart in Fig. 1A.

A variable magnetic field may be desired and is specified in field intensity at critical locations along the length of the solenoid as shown in Fig. 1B. The variable field can be obtained by varying either the number of turns in each section or the current in each section. These field changes are generally not abrupt and the pattern has been to provide the strongest field for a relatively short distance at one end. Concentration of power at one end creates a heat dissipation problem in this area, which can be handled either by using more wafers for more cooling area or by using copper wafers for these sections to reduce the power needed.

Field length of a solenoid between dropoff points is not only a function of the physical length of the unit but also depends on the internal diameter of the solenoid. As a rule of thumb, the dropoff at each end begins at a point 1½ times the opening of the end pole pieces, see Fig. 1C. If the id of the coils is appreciably larger than the pole piece opening, then there may also be a dropoff of intensity towards the center. See Fig. 1D.

It is possible to make the end dropoff more abrupt by additional turns immediately adjacent to the end plate thereby increasing the field at this point, see Fig. 1E. The effect of too large an increase of turns in this area is to overshoot the field level beyond the normal solenoid level. Also important are the additional losses created, which must be considered in the cooling design of the solenoid.

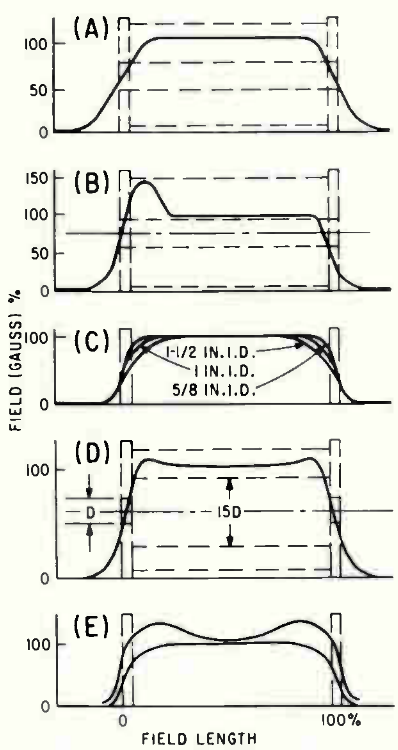

FIG. 1—Typical curve of a constant magnetic field (A); curve showing a patterned magnetic field (B); effect of the opening diameter in end plate (C); the effect of a large variation between coil i-d and end-plate i-d (D); effect of additional turns on end wafers (E)

The magnetic field is also affected by the construction of the twt or klystron. The tubes are built with magnetic pole pieces matching the solenoid end plate holes so that the magnetic field is continued without interruption. If there is an air gap between the solenoid pole piece and tube pole piece, then the magnetic field will be altered. The tube cables or wave guides also affect the magnetic field when these are brought directly through the solenoid, (see Fig. 2). To allow room for entrances, the wafer coils are notched or holes drilled through the wafers. In most cases the effect of the cutouts on the magnetic field cannot be detected by normal magnetic tests but may be picked up during tube operation. The openings are necessary on one side only but to minimize the magnetic-field effect, a matching notch or hole is made directly on the opposite side. This balances the transverse fields created and cross fields are nullified at the center of the solenoid.

For accurate tube focusing, solenoid cross fields must be minimum. Cross fields are created by eccentricities in the winding, variation of physical location of each turn, variations in mechanical parts, magnetic characteristics and, to some degree, heating of the windings.

The oldest method of solenoid construction uses a metal bobbin wound with the number of turns of wire to provide the desired field strength through the center hole of the bobbin. Until recently, insulated copper magnet wire was used exclusively but many designs have now been converted to aluminum. With care in winding and precision of metal parts, a uniform field can

and Klystrons

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be obtained. The inherent drawback to wirewound units is inefficient heat transfer through the windings, which limits the power that can be handled or makes the unit large. To overcome the heat transfer drawback, the wafer-coil technique[1] is used for most twt and klystron solenoids.

Ocasionally the edge-wound foil technique[2] is considered because it is then possible to have the od at the same temperature as the id, providing a method for dissipating the heat by air flow or heat sinks around the od. The major drawbacks are the difficulty of production and the space factor of insulation between turns. This technique is limited to high current and low voltage and has not been developed for production.

The wafer technique provides versatility to match different power supplies available. Most wafer windings use laminated plastic and foil, either aluminum or copper. This technique has proven to be the most reliable and simplest to control. Occasionally units are constructed with anodized foil to eliminate the plastic insulation; drawback to anodized foil is its fragility during winding. Providing strength requires heavy layers of anodic film, and the space factor then is no improvement over plastic films. The temperature range of anodized foil is not helpful because the solenoid power increase due to higher operating temperatures is less acceptable than the increase in size necessary for reduced operating temperatures. Another drawback to higher operating temperatures is the adverse effect on twt and klystron tubes that are limited in temperature range. As tube operating temperatures are increased, higher operating temperatures for the solenoid become important. Work now being carried out on high-temperature insulations[3] up to 600 C should provide the insulations for these developments of the future.

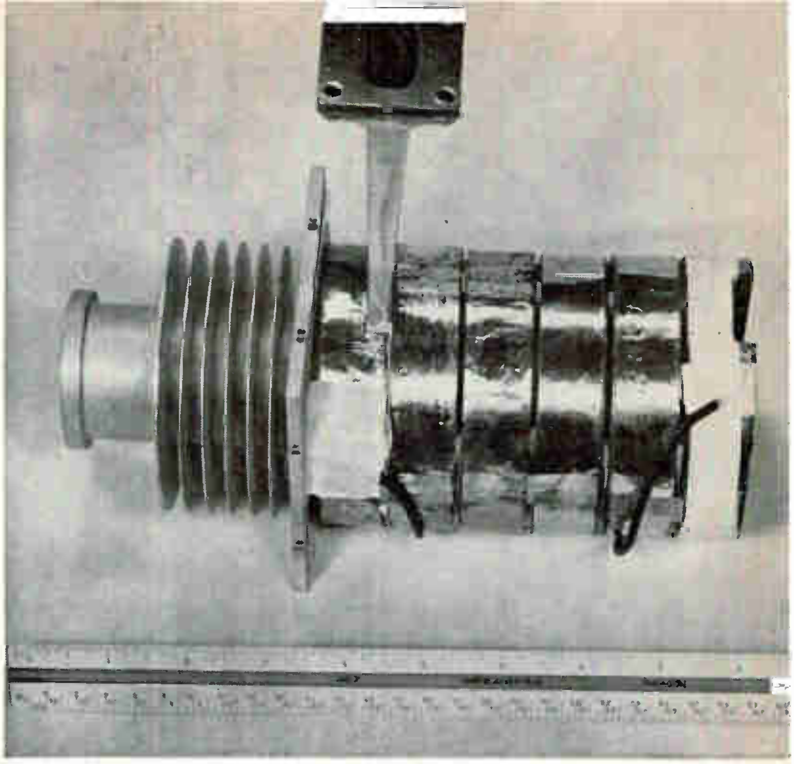
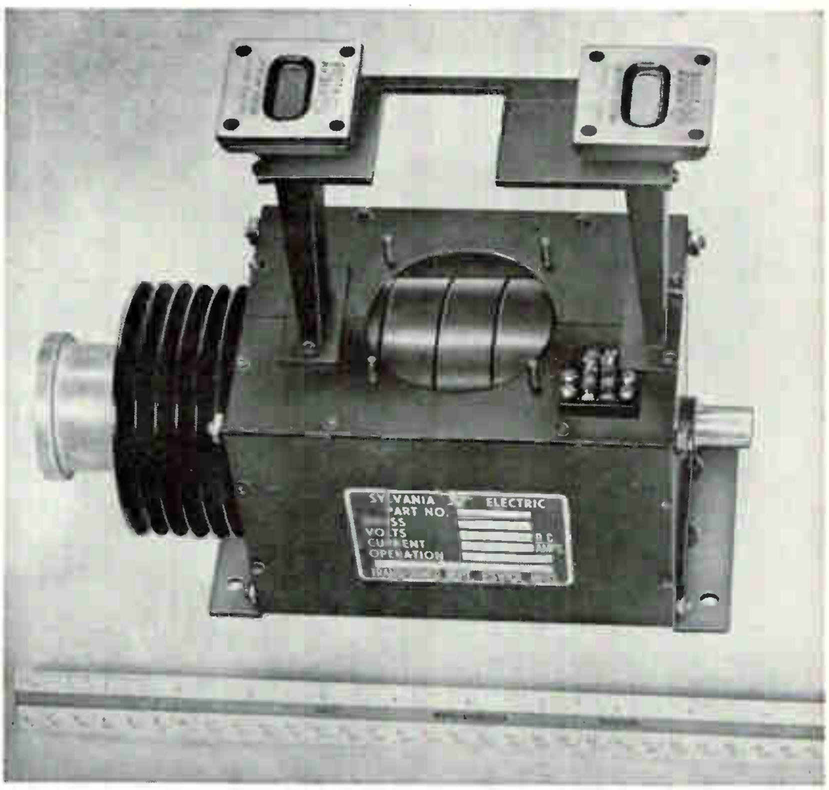


FIG. 2—Focusing solenoid with waveguides as an integral part of the assembly, shown without cover (above) and with cover, (below)



Besides the advantage of improved heat transfer, another wafer coil detail helpful for solenoid work is that slots or openings can be machined for cables or other interferences; see Fig. 2. Thus the magnetic field can remain continuous and still allow room for the tube construction details.

Where patterned fields are required, the wafer method provides an effective way of using copper in critical areas to minimize power losses and still use aluminum in noncritical low-power areas.

Because the construction of wafer coils in so compact with each turn sealed internally, they can be used in immersed liquid-cooled designs.

All solenoid designs center around the cooling system. Cooling is by natural convection, forced air flow, liquid immersion with forced liquid flow, water-cooled heat sinks, or a combination. Unless other requirements override, such as limited power consumption, the goal is the smallest and lightest solenoid to produce the field required with a minimum of power and cooling.

The cooling method may be dictated by the availability of a type of cooling. For instance in many klystrons, water or liquid cooling is needed for tube operation; thus most klystron solenoids use liquid or water cooling. In airborne systems where air flow is available the designs are built around this method.

Where weight is a controlling factor, aluminum foil is generally used, the penalty being extra power consumption. As a rule, for a given size the weight of an aluminum design will be approximately half of the equivalent copper design. The power dissipation of aluminum will be about 1½ times that of copper foil; however, if the metal parts are a large percentage of the overall weight, the coil weight savings of aluminum may be reduced. Then copper foil may be preferable because of smaller overall size. Cost is proportional to the weight of the solenoid.

In wirewound solenoids whose length is large compared to the buildup of wire layers, it is possible to force air over the od and maintain reasonable operating temperatures. In some wire designs where the layer buildup is large, additional cooling is provided by liquid cooling on the id. However, all wire designs are limited in the amount of power they can dissipate.

Wafer designs use two basic methods of air cooling—air passage over or through cooling fins placed between wafers, see Figs. 3A and 3B, and air passage through spaces between wafer coils, see Fig. 3C. Each method has advantages. Where air flow is over the od the air duct tie-in is simplified and the configuration follows the overall solenoid pattern. This type requires metal cooling plates between wafers. In spaced wafer designs, a transverse air flow is used; this cools efficiently and has less metal parts. A disadvantage is more difficulty in packaging the wafers particularly for vibration and shock.

Air-cooled wafer designs effectively dissipate as much as 5 watts per square inch of wafer coil cooling surface. Designs are generally tailored to particular air systems with regard to maximum pressure drop across the solenoid for the amount of air available. In cooling fin designs, the amount of air space between the coil od and case id plus restrictions due to fin configuration generally determine the air pressure drop. Where a large amount of fin cooling area is required, the air pressure drop is controlled by the cooling fin design. In spaced wafer designs, the pressure drop is controlled by the air space between wafers, although the air entrance pattern is a factor.

Most air-cooled solenoid designs operate at 1 to 2 in. of pressure drop across the solenoid package, although back pressures up to 4 in. may be encountered. Back pressures beyond this are difficult to obtain, particularly if the air supply is provided by self-contained blowers. Low back pressures require an excessive amount of air space.

Solenoid designs using air cooling for sea-level operations will necessarily be less effective at high altitudes because of the change in air density. If adequate air flow is available at the high altitude, this method of cooling is satisfactory. Where individual blowers are used, the designs are aimed at the highest altitude rating where the blower is least effective.

Various types of blowers have been used to obtain air flow for cooling. Brush type motors are generally avoided because of possible noise effect on tube operation; capacitor start or inductive type motors have worked satisfactorily. Both 60-cps and 400-cps blowers are used, with 60-cps types limited by their size. The most effective types readily available are three-phase 400-cps vane axial blowers that perform well with reasonable back pressures, and are suitable for either longitudinal or transverse air flow. Propeller blowers are occasionally used for longitudinal air flow. Propeller types have poor back pressure characteristics but are cheaper.

For transverse air flow, the squirrel-cage or centrifugal type of blower is suitable. For long solenoids the dual type centrifugal blower provides a better distribution of air.

Design of cooling fins is correlated with the air flow characteristics of the blower system. The simplest types are aluminum or copper foil cut into a pattern. See Fig. 3A. Where the cooling requirement is severe, fins are designed as shown in Fig. 3B. Fins are placed between wafers to conduct the heat to the od of the wafer where the air flow pattern is established. The problems of heat exchangers are involved in cooling of solenoids: to transfer a given amount of heat from the coils to the air. The controlling factor is generally the coil temperature, which is kept to an average of 360 F or less. Temperature is monitored by measurement of the start voltage and stabilized voltage at a constant current, see Fig. 4.

The distinction between water cooling and liquid cooling is that in water-cooled designs, the wafer coils are physically isolated from the coolant, whereas in liquid-cooled designs, the coils are immersed in the coolant. Water-cooled designs may be operated with other coolants in preference to water, assuming equivalent heat transfer, but in liquid-cooled designs, the designed coolant must be used to be sure that the coil insulations are compatible.

A conventional method of water cooling is shown in Fig. 5. The cooling fins are placed between wafers and tubing is soldered to the od of the fin. The tubing around each cooling fin is connected in series creating a water-flow pattern to keep the od of the fin cool. The inlet and outlet tubing positions can be positioned wherever needed. The limitation of this cooling method is the temperature drop from the id to the od of the cooling fin which can become excessive if the coil buildup is large. Space is needed on the od for the water tubing increasing unit size. To counteract the temperature drop, thicker plates are needed but this has a limited effect. One solution is to spiral tubing, Fig. 6A, from id to od. This is limited to single or double wafer designs of only two cooling fins or where the spacing will not affect the magnetic field. Another solution is special cooling fins as shown in Fig. 6B. Here two metal plates are fastened together with spacers to allow a sheet of water to flow, thus providing a heat sink for the entire face of the wafers. This method can handle heat densities of the order of 15 watts per square inch.

For immersed liquid cooled designs, the wafers can be spaced to allow liquid flow pattern as shown in Fig. 6C. Physical blocks prevent any coolant flow around the od, thereby forcing the liquid through the wafer spaces. Also effective are cooling fins that bring the heat to the outside thereby allowing the liquid flow to pass only over the od of the wafer. This method is less effective in cooling but has the advantage of a solid winding assembly for vibration or shock. Liquid cooling is effective for wafer coils since the coolant is in intimate contact with each turn. The cooling systems, however, are generally closed systems, requiring a second heat exchanger to remove the collected heat and therefore may not always be suitable.

Another method is a combination of cooling fins and water jacket as shown in Fig. 6D. The cooling fins move the heat to the od or id, where physical contact is made to a water jacket which is cooled by liquid flow. This method minimizes the increased dimension requirement for cooling without physically immersing the wafers.

Most solenoid designs are based on constant-current systems where variation in resistance due to heating of the wafers is reflected in voltage increase. The magnetic field in these designs is constant over the entire range of environmental conditions, assuming the current controls can handle the changes in resistance. This is the preferred method of tube operation. The disadvantage is that a current regulator is needed that is capable of handling the required currents. The range in solenoid designs uses current from 0.5 amp to over 100 amp with voltages ranging from 500 V to 10 V. The majority of designs range between 2 and 20 amp.

Where current regulators cannot be incorporated, the electrical design depends on the cooling characteristics and has to stabilize for

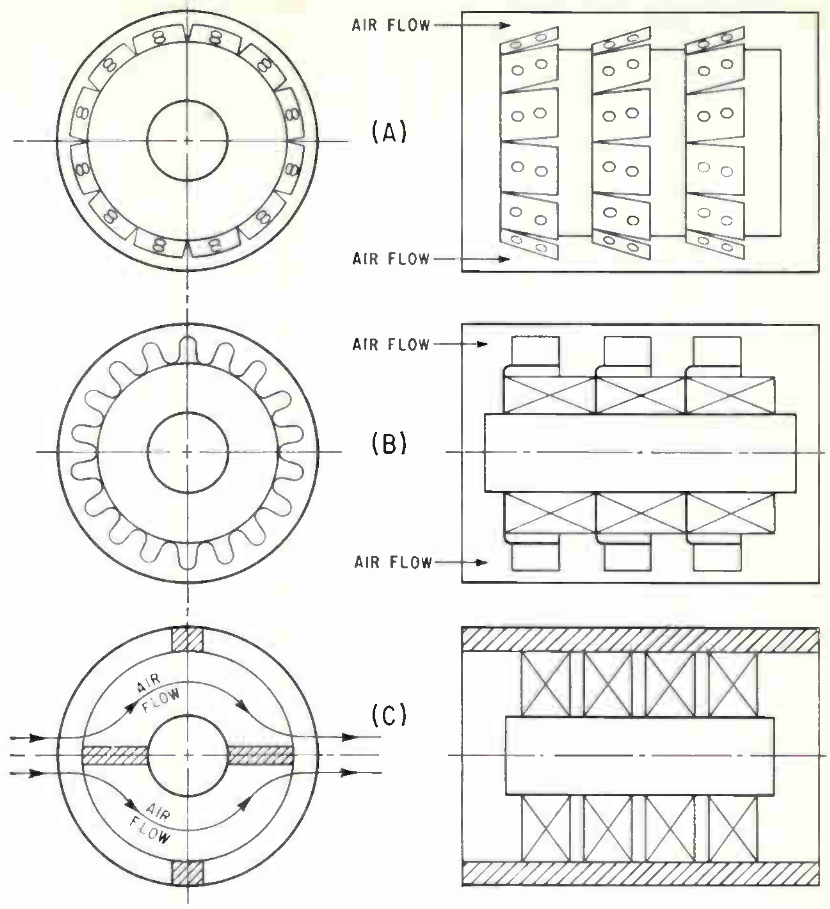


FIG. 3—Folded-tab cooling fin design (A); extended-surface cooling fins (B) spaced-wafer cooling design (C)

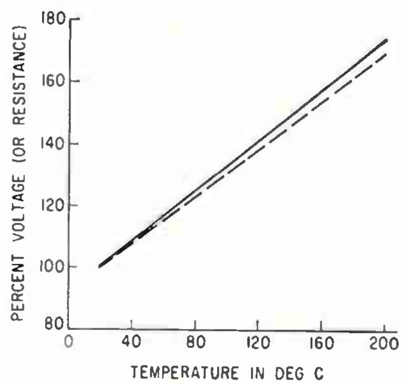
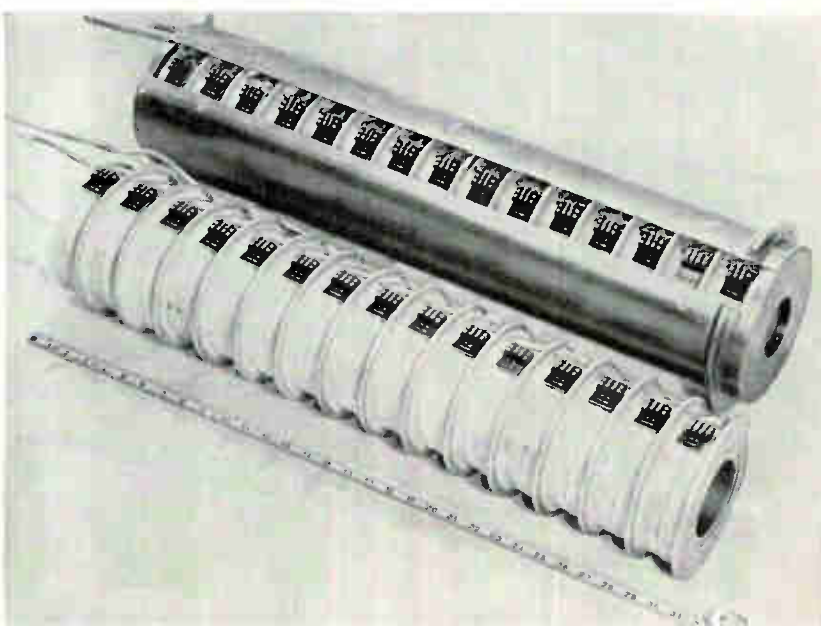


FIG. 4—Voltage increases due to temperature, plotted for aluminum (solid line) and copper (dotted line)

FIG. 5—Water-cooled solenoid using cooling fins between wafers



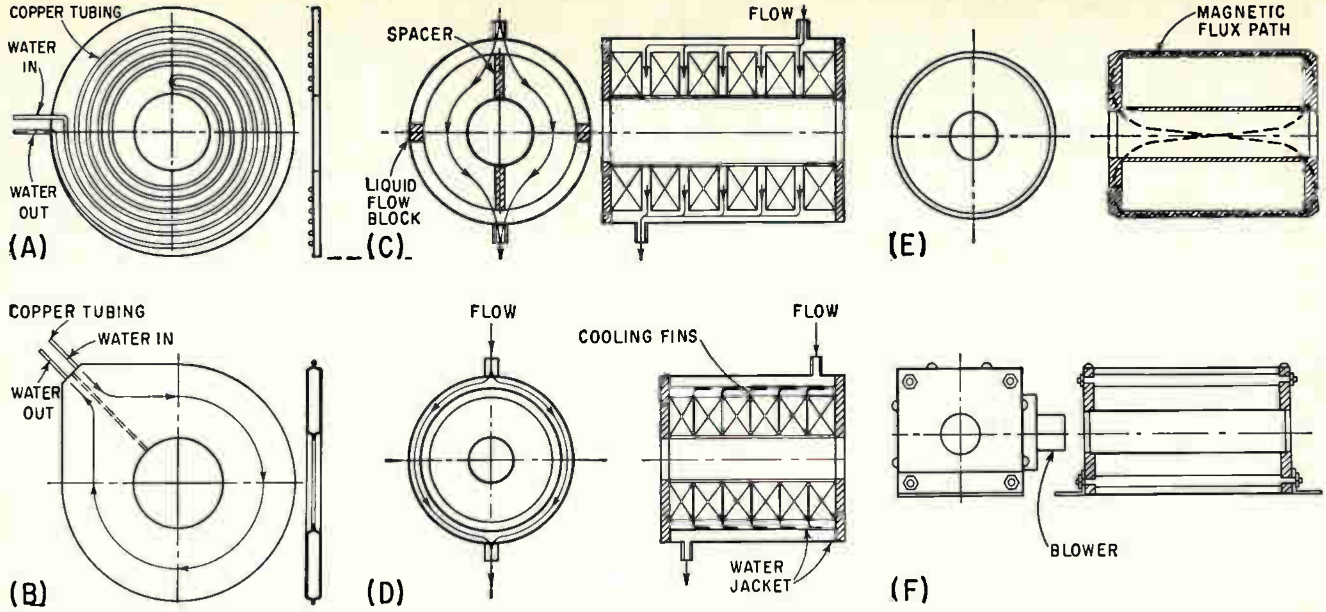


FIG. 6—Cooling fin for wafer coil using spiral tubing soldered to metal plate (A); laminated cooling fin for wafer coil (B); liquid-cooled spaced-wafer design: cooling by intimate contact with wafer sides (C); water-jacket cooling design: cooling by transfer of heat from wafer sides through cooling fin to water jacket (D); round case with case peened over on ends to eliminate screws (E); square case with spacer rods (F)

a minimum magnetic field (lowest current condition) at the worst environmental condition. These designs use a fixed voltage and allow the current to vary from a maximum at start to a minimum at the stabilized condition. Because a current regulator is not used, the fixed voltage system allows a large variation in magnetic field. For example, in a fixed voltage system that allows a variation of plus or minus 10 percent in voltage along with a plus or minus 5 percent resistance tolerance of the solenoid, an increase (or decrease) of 15 percent in current can be encountered. In addition the starting resistance of a solenoid may be up to 60 percent less than its final stabilized resistance. Thus the magnetic field can start at a level 75 percent greater than the nominal field. In certain cases this variation is not critical; in others, the high magnetic field is objectionable because it will reduce the r-f power output.

Present materials for interturn insulation are epoxy coatings or Mylar film. The operating range is approxiamtely 180 C. Although the materials are rated at 150 C, (based on the insulation limit at the maximum temperature), the turn-to-turn voltage is less than 0.1 volt; thus the limting factor for wafer coils is the melting or carbonizing point of the insulation.

Work is being carried out to develop materials for higher operating temperatures (350 C to 600 C). Some materials for 350 C are relatively heavy (0.0006 in. thickness). Coated foils seem to be more practical.

Although increased temperature range will reduce solenoid size, it also means increased power; therefore, care must be taken to ensure system gain. Another disadvantage to high-temperature coil operation is that the tubes must be subjected to these temperatures. Present tubes will not operate above 150 C; the higher temperatures require forced cooling. New designs in ceramic tubes will undoubtedly increase the temperature range.

The physical size of solenoids requires bulky metal parts to provide mechanical stability. Thus the iron parts are adequate for carrying the flux densities. Ocasionally where physical size is extremely limited, the metal parts are smaller and care must be given to saturation.

Although saturation densities are seldom reached, flux leakage can still be a problem because of air gaps at the ends. In certain applications, stray external fields can affect tube operation and must be shielded out.

The magnetic circuit for a solenoid is shown in Fig. 6E. The matching of the magnetic circuit through the tube shunts depends on the air gap allowed. The shunt may mate with the end plate; or the tube can have an air gap between tube and end plate.

For wafer coils, a metal bobbin design can be used except that one end plate must be left free to allow mounting the individual wafer coils. This end plate is machined to allow a mechanical fit over the core tube. The outside case can be a slip fit over the end plates, or can be made with a shoulder as shown in Fig. 6E. This provides for mechanical peening of the case to the end plate and eliminating screws and adding strength.

Round shapes lend themselves to the use of conventional tubing. One disadvantage is the mounting problem; this is generally handled by providing a matching cradle and then strapping around the od to the cradle. For heavier units, it is possible to weld mounting brackets that can be mounted conventionally. Where blowers are needed, special mounting brackets are needed for round units. Thus square or rectangular units are sometimes preferred. The flat sides allow mounting both of the solenoid and the blower, Fig. 6F.

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CALCULATING VOLTAGE REQUIREMENTS FOR

Power-Supply Transformers

By WILLIAM J. BATES,
Special Products Div.,
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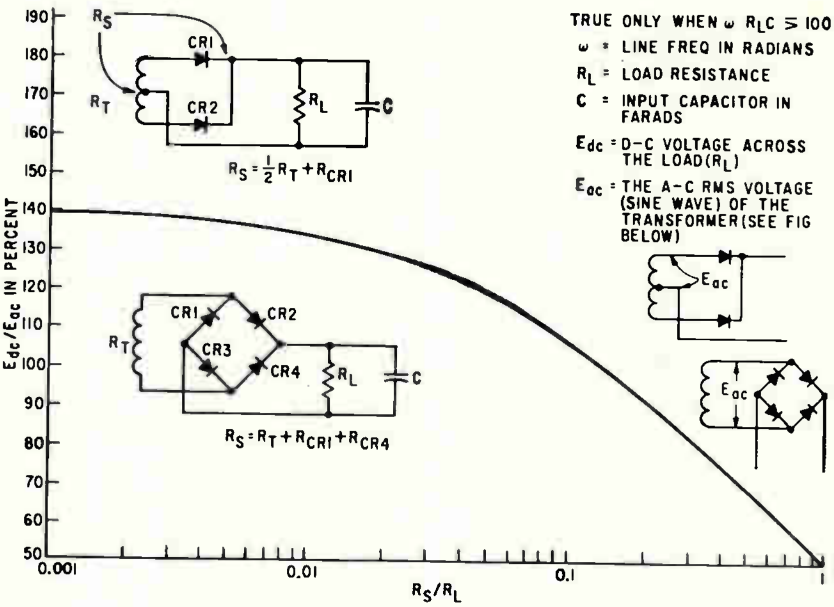

How $E_{d\text{-}c}/E_{a\text{-}c}$ varies with R_s/R_L for full-wave rectifiers

TRANSFORMER OUTPUT VOLTAGES required to achieve given d-c output voltages can be determined accurately by a simple, rapid method. In a full-wave capacitor-input filter circuit for a d-c power supply, the magnitude of the d-c output voltage, as related to the rms value of the a-c input to the transformer, is a function of four independent variables: capacitance of the input capacitor, C, in farads; powerline frequency, ω, in radians; load resistance, R_L, in ohms; and series resistance, R_s, in ohms.

If the product of ωR_LC exceeds a certain value, it may be considered a constant, and a system of mathematics may be employed that simplifies computation. Such errors as arise from this approximation are negligible in practical applications owing to the tolerance variation in components.

The plot assumes $\omega R_LC \geqq 100$. With the availability of silicon rectifiers and high-capacitance electrolytic capacitors, the product of ωR_LC can be made $\geqq 100$, that is, variations in R_L may be compensated for by C.

The load resistance of the circuit is determined by the voltage and current requirements so it cannot be changed to achieve this end. Also, power-line frequency cannot be changed readily.

The series resistance is the sum of transformer resistance and rectifier forward resistance. With silicon rectifiers, the rectifier forward resistance is usually negligible compared to the transformer resistance. Transformer resistance, determined by the turns ratio and wire size, can be predicted accurately if the transformer output current and approximate a-c voltage are given.

With the above information and with the aid of the curve, the a-c output voltage of the transformer can be specified.

Example 1: A 250-v, 50-ma source voltage is required for the unregulated portion of a regulated power supply. It is to be operated from a 60 cps source. Therefore $R_L = 250/(50 \times 10^{-3}) = 5{,}000$, $\omega = 2\pi \times 60 = 377$, Minimum $C = 53$ μF so that $\omega R_LC = 377 \times 5{,}000 \times 53 \times 10^{-6} = 100$. Experience predicts a series resistance of 40 to 80 ohms. This means R_s/R_L will vary between 0.008 and 0.06. The E_{dc}/E_{ac} ratio will vary between 1.35 and 1.31, which means that the rms transformer voltage required will be between 185 and 191 v rms. This is about 2 percent accuracy — a typical transformer tolerance. Therefore, the center value of 188 volts would be chosen.

Example 2: Given a rectifier filter circuit with a series resistance (R_s) of 100 ohms, an output voltage of 250v at 50 ma, and with $\omega R_LC \geqq 100$, what is the percent of regulation if the load is reduced to 25 ma?

$$R_{L1} = \frac{250}{(50 \times 10^{-3})} = 5{,}000 \text{ ohms}$$

$$R_{L2} = \frac{250}{(25 \times 10^{-3})} = 10{,}000 \text{ ohms}$$

The R_s/R_L ratio would vary between 0.02 and 0.01. On the curve, E_{dc}/E_{ac} will vary between 1.29 and 1.34. If transformer voltage is 188v, the d-c voltage will be $188 \times 1.34 = 251.9$ or $188 \times 1.29 = 242.5$. The regulation would be 3.7 percent with the 50 percent load change.

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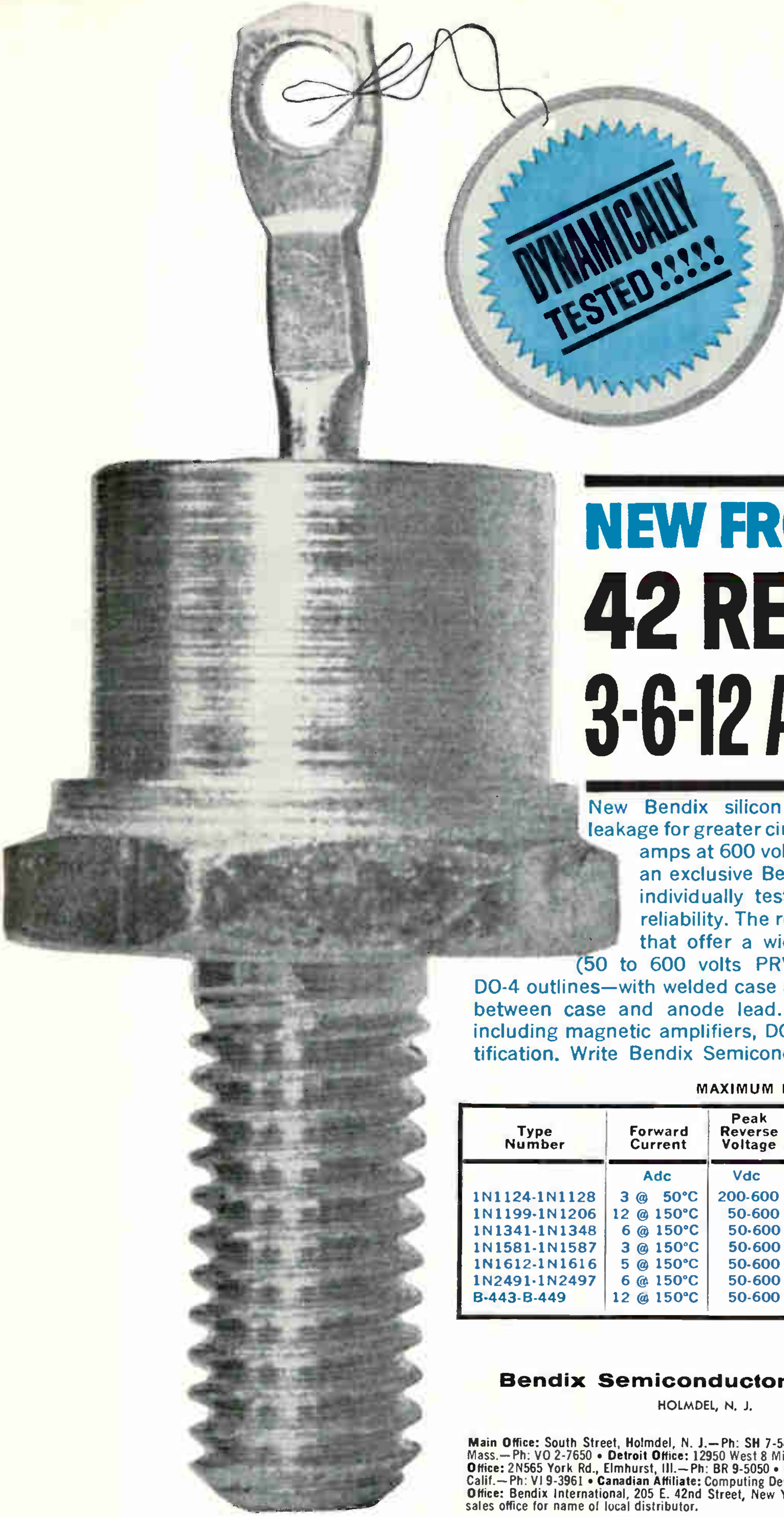

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1N1199-1N1206	12 @ 150°C	50-600	10.0 mAdc	—	1.25 @ 12 Adc
1N1341-1N1348	6 @ 150°C	50-600	10.0	—	1.15 @ 6 Adc
1N1581-1N1587	3 @ 150°C	50-600	0.5	—	1.5 @ 6 Adc
1N1612-1N1616	5 @ 150°C	50-600	1.0	—	1.5 @ 10 Adc
1N2491-1N2497	6 @ 150°C	50-600	2.0	—	1.1 @ 6 Adc
B-443-B-449	12 @ 150°C	50-600	2.0	—	1.2 @ 12 Adc

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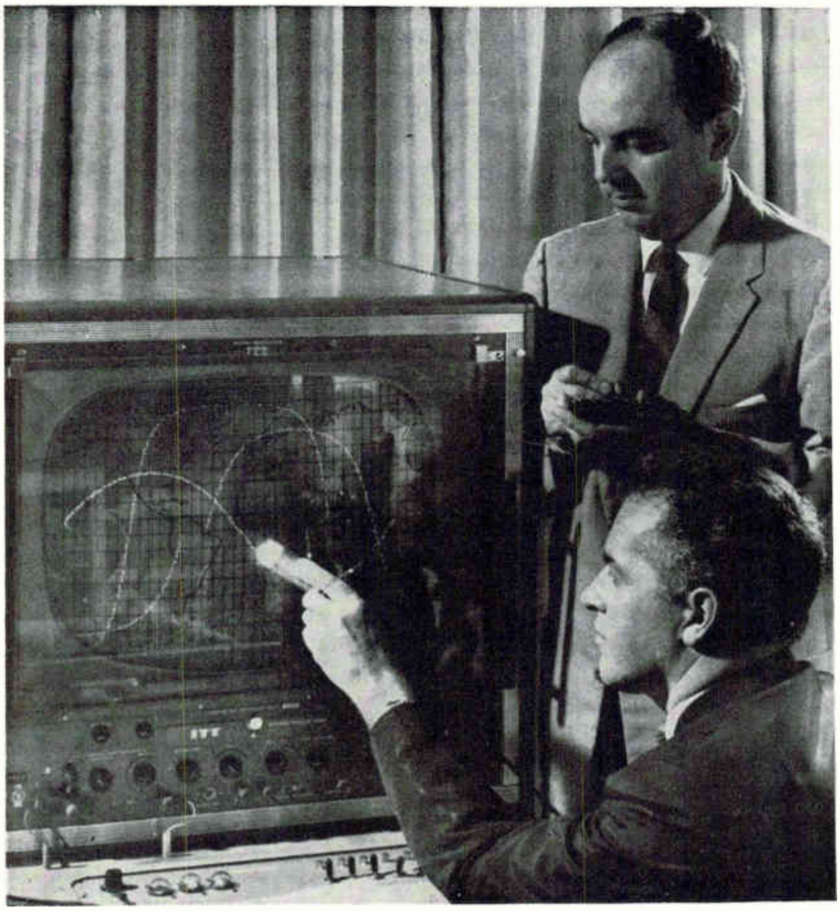
System Displays Satellite Tracks



THE FRONT COVER. Final tests of prototype satellite display system are made by F. Slack (seated) and F. Mellow of Air Force Cambridge Research Laboratories

OPERATIONAL model of a display system provides up-to-the-minute positional information about orbiting earth satellites. The system is undergoing final testing at the Spacetrack R & D Facility at Hanscom Field, Mass. After final testing, the unit will be used as an aid in the development of advanced display systems for use in the space detection and tracking system of the North American Air Defense Command.

The prototype was designed at the Air Force Cambridge Research Laboratories at Hanscom. The operational model was constructed by the Pastoriza Electronics Co., Boston.

Satellite tracks are presented visually on the face of a large-screen crt on which a transparent Mercator's projection overlay of the earth is superimposed. Six satellite tracks can be displayed simultaneously. Real-time satellite positions are shown as intensified spots on their respective tracks.

Satellite information is converted to punched teletype tape and stored in a computer. The data includes identification of a specific satellite, time and longitude of each south-to-north equator crossing, time and longitude of each degree of latitude the satellite will cross and satellite altitude at each degree of latitude.

A console operator can command information about the status of a particular satellite being shown on the screen by directing a light beam at the target of interest. Additional information stored in the computer, such as satellite identification and altitude, then appears on the screen.

The system is sufficiently flexible to allow time to be moved forward or backward in time for periods up to nine days. This capability is particularly significant when the need exists for determining the position of a communication or surveillance satellite with reference to a specific region of the earth.

Electron Field Emission Depends on Temperature

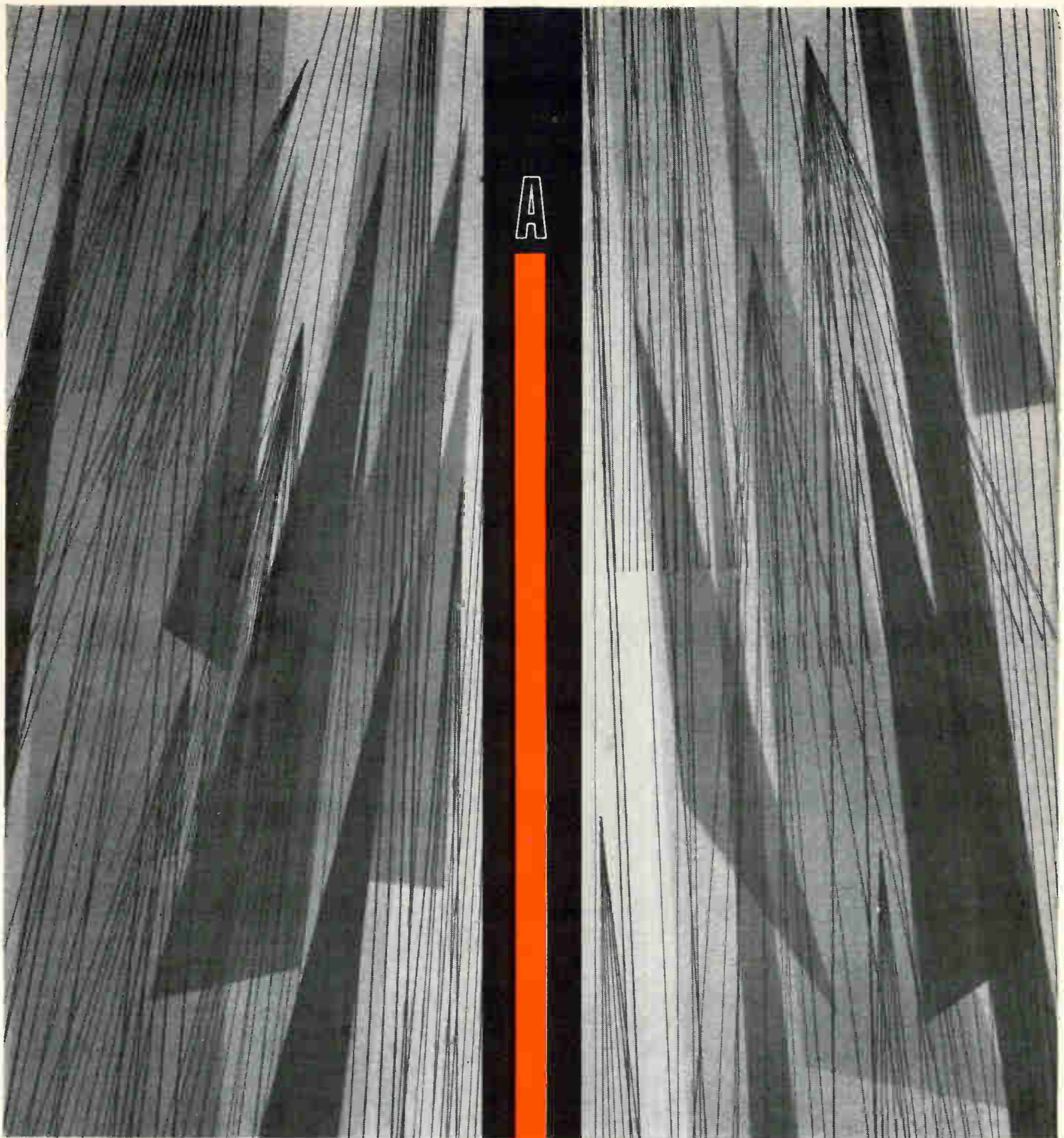
TEMPERATURE dependence of electron emission from metals in the field emission region has been verified. In a constant field, the incremental increase in current is nearly linear with the square of absolute temperature of the emitter.

The experiments were conducted by the National Bureau of Standards over the temperature range of 4.2 to 400 K with a field emission microscope using tungsten as the emitter. Similar measurements were made with niobium, which is superconducting below 9.2 K.

In the region of thermionic emission, electrons in metals acquire sufficient thermal energy to surmount the potential barrier at the metal surface. Field emission, which can ocur near absolute zero, requires a field of about 10^7 volts per cm^2. Electron emission results from quantum tunneling through an approximately triangular barrier at the metal surface. In the transition region, both types of electron emission can take place.

The temperature range is about 0 to 400 K for field emission, 400 to 800 K for the transition region and above 1,200 K for thermionic emission. Although the thermionic and transition regions have been studied, the effect of temperature in the field emission region had not been experimentally checked with theoretical prediction.

Temperature dependence in the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field emission region was determined using a specially designed field emission tube operated in liquid helium. The emitting tungsten tip was attached to a tantalum loop that served as the thermometer, and resistance was measured by a four-terminal network.

The resistance-temperature curve was determined by calibration at several constant-temperature points. Required temperatures were obtained by heating the loop resistively using an adjustable current source. The field applied to the tungsten emitter at 4.2 K was sufficient for an emission of 2.6×10^{-10} amp. Current flow through the measuring device was nulled and emitter temperature was raised. The current increment, which was as small as 10^{-13} amp at low temperatures, was measured as a function of the temperature. The measurements confirmed the theoretical expectation that the current increment would vary approximately linearly with the square of absolute temperature.

The investigation also showed that field at the emitter surface can be calculated from the slope of the plot of emission current as a function of temperature squared. Field determined in this way was in excellent agreement with that calculated from electron microscope pictures of the emitter. Average field can be determined in-place from the line slope, avoiding the complexities of calculation from irregularly shaped tips.

When the temperature of a niobium emitter is raised from 4.2 K to above 9.2 K, a current increment should arise from the effect of temperature on field emission and also from the elimination of the energy band gap in the superconducting-to-normal transition. This band gap, predicted theoretically, has been demonstrated experimentally in other laboratories with low field tunneling experiments. In the present investigation, calculations for the current increment of the niobium emitter resulting from the superconducting-to-normal transition indicated an easily measurable effect. However the current increment attributable to the transition was absent in the experiments, suggesting either that the emitter surface had not been superconducting even in the absence of the field, or that superconductivity in high fields can be quenched at the surface.

Crystal Growing Process Makes Silicon Ribbons

THIN RIBBONS of silicon are being produced by a new form of crystal growth that could have a significant affect on the production of semiconductor devices. The near-perfect crystals are uniform in thickness and width.

The process, developed at Bell Laboratories by E. S. Greiner, J. A. Gutowski and W. C. Ellis, was reported at a meeting of the Metallurgical Society of AIME. The ribbons of silicon grown from vapor are so thin that they are semitransparent. Thickness is typically one micron and ranges from 0.1 to 15 microns, and the ribbons are about 0.1 mm wide and 1 to 3 cm long.

In the process, silicon is reacted with iodine and hydrogen, with small amounts of arsenic and nickel, at high temperatures in a closed tube. The ribbons, together with silicon whiskers of a hexagonal cross-section, grow rapidly in the hot tube.

The ribbons contain few or no crystal defects except for a single twin plane (junction of mirror-image crystals) parallel to the ribbon surface. The crystalline perfection makes the ribbons quite strong, and their extreme thinness makes them quite flexible.

The single twin plane existing in all ribbons observed is a central part of a theory developed by R. W. Wagner and R. G. Treuting of Bell Labs that explains some of the main mechanisms of ribbon growth. The twin plane with an apparent growth-poisoning effect of certain impurities causes rapid growth in the length of the ribbon but relatively slow growth in width and thickness.

The nearly perfect surface and the uniform thickness and width suggest the possibility of incorporating the crystal ribbons directly into semiconductor devices with little or no mechanical preparation. However, considerable development would be required before the ribbon process could be used in commercial devices.

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Ferrite Improvements Extend Core Use

By C. J. KUNZ, JR.,
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LARGE QUANTITIES of ferrites are now being used in a variety of applications operating in a frequency range of a few hundred cycles per second to several hundred megacycles per second.

These applications include transformers, filters, delay lines, loading coils, modulation reactors, chokes, accelerators, pulse networks, pulse transformers, amplifiers, oscillators, antenna tuning devices, variable inductors, decoder and encoder discs, recording heads, memory cores, switch cores, tuning slugs, a-c d-c, and d-c d-c converters, high-frequency lighting, and other specialized electronic devices.

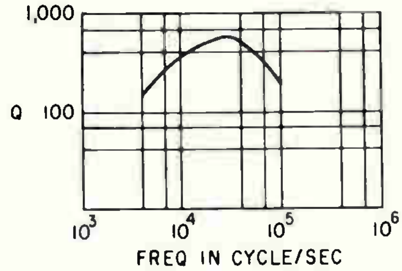
The growing popularity of ferrites is attributed to their desirable electrical or magnetic properties and to the ultimate cost of the component utilizing a ferrite core.

Higher Permeabilities

Continuing material advancements are succeeding in extending the frequency range over which metals offer equal or better performance. A few years ago, ferrites with permeabilities from 500 to 700 were the best that could be obtained. Today, permeabilities of ferrites range from 2,700 to 5,000. In the not too distant future, materials are promised with initial permeabilities in the range of 15,000. And it is apparent that we are at the stage where more careful evaluation should be given to ferrites before the core is selected for a particular design.

The use of a non-ferrite core in a magnetic application often results in higher associated core losses. The largest part of this total core loss is caused by eddy current flow in the core itself; in other words, the I^2R loss, where I is the effective value of the eddy current and R is the d-c resistance of the core material.

This eddy current loss becomes



Typical Q curve for a particular pot core configuration

prohibitive as the frequency is increased—and for the non-ferrite materials, a reasonable limit is reached at a relatively low value of frequency. Extension of the useful frequency range can be obtained by laminating the core or by using powdered iron, but still a practical frequency limit is reached far below that required by fast, present day circuits.

In addition to the power losses, eddy currents can produce other undesirable effects. In recording heads, for example, they reduce the effective permeability and flux density in the region of the gap.

The outstanding advantage of ferrite is that it almost entirely eliminates these eddy current problems because its material resistivity is from 10^6 to 10^{11} higher than other present day metal type cores.

Another advantage of ferrite is that its permeability is constant as a function of frequency over a wide frequency range. Some ferrite materials have a relatively constant permeability from a few hundred cycles to several hundred megacycles and this results in a constant flux density, or constant inductance, as a function of frequency.

In most laminated or powdered iron cores, the permeability starts to drop off immediately above several hundred cycles, or a few kilocycles per second. This change in permeability, flux or inductance as a function of frequency is actually related to the eddy current flow in the core.

This eddy current flow gives rise to an imaginary component of permeability. Although the core is driven with a constant magnetizing force, the magnitude of the real component of the permeability drops off as the imaginary component increases. Iron and steel have high losses at low frequencies and therefore, the real component of the permeability which is of interest, must start to drop off immediately at these low frequencies.

The lower losses of ferrite also give rise to higher Q components. In recording heads, and especially in erase heads, less driving power is required. Ferrites are also extremely well suited to low-power transistor applications.

In analyzing component construction costs, use of one piece of ferrite core assembly results in a considerable cost advantage over laminations. In many cases, there will also be a considerable saving in the size of the component.

Ferrite Applications

In general, there are no restrictions as to ferrite core shapes. Laminated cores are often subject to definite shape restrictions. And laminated matting surfaces, cold worked in the finishing process, can result in the loss of magnetic properties at the surface of the material. This effect is the equivalent of an enlarged inherent air gap in the magnetic path and a consequent reduction in the value of the effective permeability for the core assembly over that of the bulk material.

Certain types of steel are subject to magnetic deterioration as a result of shock, a characteristic not present in ferrite materials.

Considerable savings in wattage, reduction in required power drive and increase in efficiency occurs in the component employing a ferrite core. As the frequencies increase from the higher audio to lower r-f range, the loss reduction is particularly significant.

Special consideration should be given to the wide frequency range over which permeability of the fer-

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ELECTROLYTIC CAPACITORS—*Reliability is our first ingredient*

Actual size 50V (1 uf)

The "space saver" of Tantalytic* Capacitors

Because it packs the most uf into the smallest package, the General Electric 62F510 Porous Anode Tantalytic Capacitor frees up valuable circuit space. It's the smallest (.075" x .250"), lightest (15 grams) 85C tantalum capacitor.

Though small, it provides more V-uf than larger units. In fact, it has almost four times greater volumetric efficiency than the smallest solid type.

* Reg. Trade-mark of General Electric Co.

But it offers superior reliability because of these special features:

1. **Non-acid electrolyte**. No free liquids are used. "Gel" electrolyte eliminates acid-attack problems.
2. **Paper spacer** between case and anode prevents impurity migration and scintillation at the anode.
3. **Re-healing capability** contributes to long life in rugged applications including high ripple and low impedance. And it's used at full-rated voltage at 85C!

Yet, this G-E unit is lower in price than other tantalum types, and the low price includes insulated sleeving.

Ask your G-E Sales Engineer about the five case sizes rated from 60V (2.5uf) to 6V (325uf). Or write for bulletin GEA-7008 to General Electric Co., Schenectady, N. Y. *Capacitor Dept., Irmo, S. C.* 430-04

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General Electric also offers these reliable Tantalytic capacitors

HIGH-RELIABILITY FOIL AND SOLID CAPACITORS
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Bulletin GEA-7226

125C KSR* TANTALYTIC CAPACITORS
Bulletin GEA-6258

HIGH-VOLTAGE TANTALYTIC CAPACITORS
Bulletin GEA-7065

125C CYLINDRICAL TANTALYTIC CAPACITORS
Bulletin GEA-7085

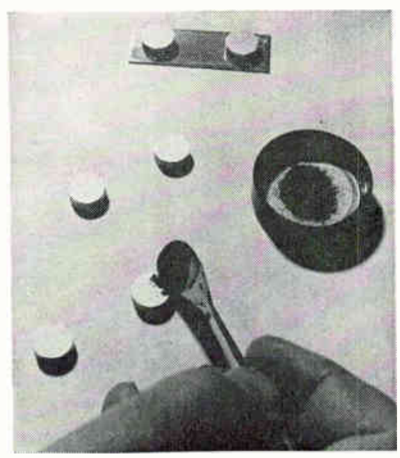
rite remains constant. Also reasonably high Q values at relatively low frequencies are possible when ferrite cores are employed.

Compromises which are made in selecting ferrite for lower frequency applications sacrifice permeability to obtain the advantages of lower losses, constant permeability, and perhaps higher Q.

At the present time, ferrite is not the answer to all design problems. However, in the light of the present rate of industry growth and advancements which have been made in the state of the art, the ferrite application potential should be reviewed by design engineers.

A check list to consider when selecting a material for inductance or magnetic application requiring a magnetic core includes: core costs, efficiency, ease of installation, required accuracy in the duplication of parts, size of core, possible core configurations, power requirements, frequency of operation, power losses, environmental effects, mechanical requirements, cost of assembly, overall initial and long range cost of the component.

Joining Thermoelement To Ohmic Contacts



A NEW material for bonding lead telluride was announced last week by General Instrument Corporation, as a development in the field of thermoelectric power generation. Lead telluride is today's leading thermoelectric material.

Bonding lead telluride has been a major problem. Because a thermoelectric generator uses many thermocouples in series, the ohmic resistance loss of the bimetal joints adds up and limits over-all efficiency. Mechanical joints are expensive and unreliable; present brazing methods tend to pollute the telluride by "doping" and thus further reduce efficiency. Because of these losses, thermoelectric generators have to be heavily over-designed.

The new material, called Generalock, makes joints with resistance of the order of 10 microohms per square centimeter; this is claimed to be an improvement of one or two orders of magnitude over present methods. The new bonds are mechanically stronger than metal, and thus reliable. Company claims there are no detrimental effects on the lead telluride.

Main effect of the new development will be to reduce the cost, size and weight of thermoelectric generators by eliminating most of the ohmic losses and thus saving thermoelectric material. Company has built generators with capacity of 150 watts per pound of material, compared to previous best of 40 watts per pound. Thermal conversion efficiencies are 7 to 8 percent.

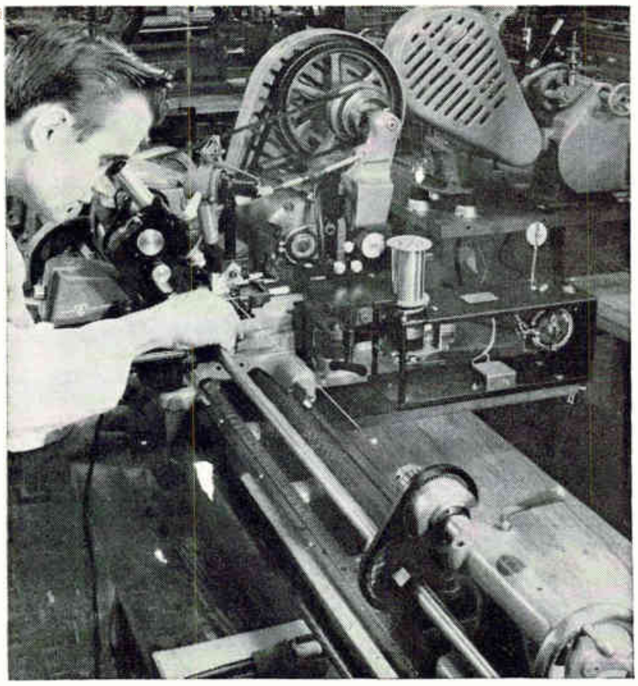
The company predicts that it will manufacture generators to sell at $10 per watt of capacity, a five to ten times reduction over present prices. Eventually the bonding process is to be made available under license to other manufacturers. Bonding powder is applied to basic element of thermoelectric generator. Powder melts under heat, provides strong joint. Thermocouple at rear consists of two pellets of semiconductor material joined by metallic strip.

New Getter Coatings

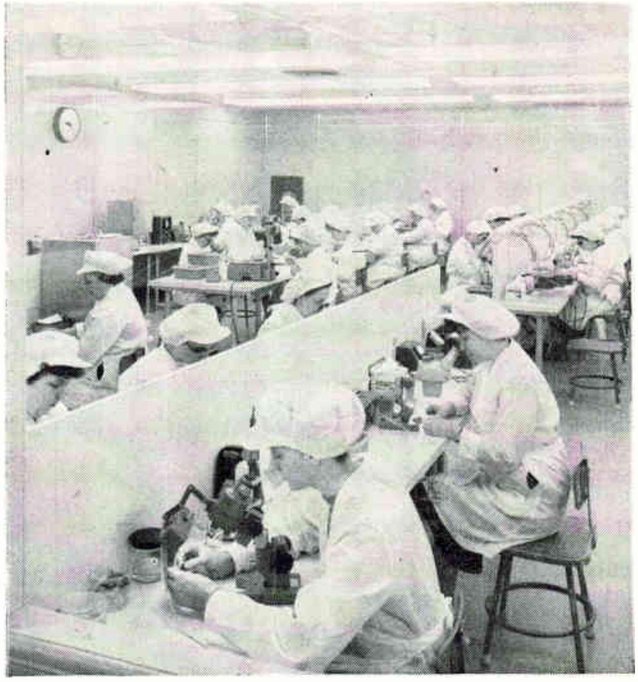
THE NON-FLASH getter, Ceralloy 400, is now available in the form of vacuum sintered coatings on molybdenum, kovar, and inconel, in addition to nickel which was previously available.

These products were developed at the request of vacuum tube engineers who require uniformly reproducible coatings, vacuum sintered to suitable substrates.

The new getters are available, in production quantities, as strips measuring 1 × 0.005 × 9.0 in., coated on one or both sides with Ceralloy 400.



Groove-cutting and element winding machine is a specially designed lathe



Precision trimmer potentiometers are assembled in "clean room"

Diamond Cuts Groove for Linear Potentiometers

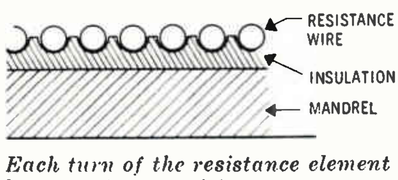
TO PRODUCE good linearity in precision trimmer potentiometers, Daystrom Potentiometer Div., Archbald, Pa., makes sure that the winding itself is highly linear. Since there are residual non-linearities in element wire stock, the problem boils down to controlling the spacing between each of the windings of the resistance element on the mandrel.

The problem in winding a highly linear element in the conventional way is the uneven surface of the insulation on the mandrel. While irregularities can be minimized, they cannot be completely eliminated. Consequently, wire spacing varies slightly and, in addition, some wires are high, some low. This can cause uneven wear and eventually an open element.

While linearity is reduced by an uneven mandrel surface, forming the element into a circle or a helix after winding allows the wire to move again. A wire not quite in a surface "valley" may slip into the valley during the bending operation. To minimize this effect, the element wires are often cemented in position before the element is formed. If too hard a cement is used, however, strain gauge effects will be noted in the completed potentiometer and the temperature coefficient will be high and nonlinear. Moreover, when the cement covers the element portion to be contracted by the wiper, it must be removed by buffing.

To remove cement from a low wire, it may be necessary to buff off part of the high wires next to it. This increases the resistance of that turn and causes more nonlinearity.

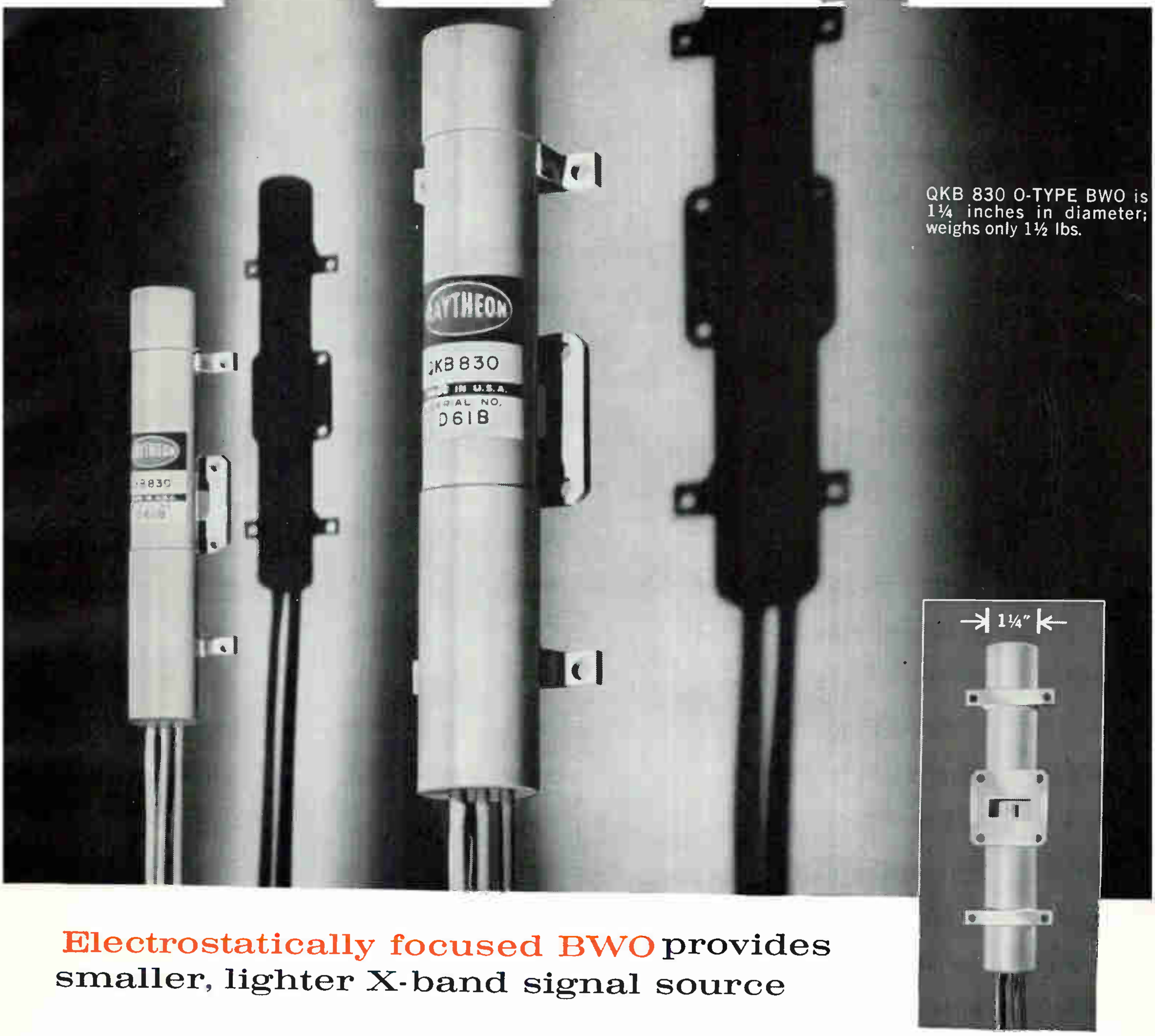
To eliminate the above problems, Daystrom developed a special process for winding the element. The insulated mandrel is fed into the winding machine where a diamond tool cuts a groove, producing an endless helix or screw thread on the mandrel. The uninsulated resistance wire is wound tightly, using electronic controls, into this continuous groove.



Each turn of the resistance element lies in its precision-cut groove. After the element is wound, it is formed into a circle or helix

The tight fit between groove and wire essentially locks the wire in place. No movement is caused by forming and no cement of any sort is required. The result is an element whose linearity depends solely on the accuracy to which the circle or helix is formed; linearity of the completed potentiometer depends on its mechanical design (Squaretrim or rotary). Linearity remains good through rated temperature, cycling, shock, and vibration specifications.

The wire-winding machine is a specially designed, patented lathe. The mandrel is made from copper wire, from 0.025 to 0.085 inch diameter. Mandrel insulation is Thermaleze or Teflon and the resistance wire is either Cupron, Evenohm or Karma, from 0.004 to 0.010 inch



Electrostatically focused BWO provides smaller, lighter X-band signal source

New Raytheon tube combines advantages of backward wave oscillators in rugged compact package ideal for airborne and missile use.

The QKB 830 is especially suitable for local oscillator service in airborne, shipboard, or ground-based equipment such as anti-jam radar receivers. A wide-range tube, it can be tuned from 8.5 to 9.6 kMc by varying a single electrode voltage.

The small size and low voltages of the QKB 830 permit its use as a direct replacement for mechanically tuned klystrons in existing systems. It is also adaptable to many other applications requiring a voltage tunable source having provision for low-voltage pulsed or amplitude modulation.

Write today for technical data or application service to Microwave and Power Tube Division, Raytheon Company, Waltham 54, Massachusetts. In Canada: Waterloo, Ontario.

QKB 830 GENERAL CHARACTERISTICS
(Typical CW Operation)

Power Output	15-30mW
Frequency	8.5-9.6 kMc
Voltage Requirements	
Tuning Voltage	150-250 Vdc
Focus Voltage	300 Vdc
Filament Voltage	6.3 V
Shock	50 G's
Cooling	convection
Overall Length	7.5 in.
Weight	1.5 lb. Max.

RAYTHEON COMPANY

MICROWAVE AND POWER TUBE DIVISION

RAYTHEON

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diameter. Spacing between turns runs from 0.001 to 0.005 inch.

Because of the care with which all potentiometer parts are treated, rejects at final inspection are low. Potentiometers have a guaranteed 1 percent maximum defect A.Q.L. per MIL Standard 105, proposed MIL R27208A. All potentiometers are inspected for at least 25 electrical, physical, and environmental characteristics. As a result, potentiometer A.Q.L. is only a fraction of 1 percent.

Automatic Driller For Printed Circuits

FULLY ANTOMATIC printed circuit drill for drill component fixing holes in printed circuit boards, has been developed by Ferranti Ltd., Hollinwood, Lanc., England. Two-stage positioning and drilling to a grid system speeds drilling and increases accuracy.

Machine has twin drilling heads, allowing either tandem or single spindle operation, a hydraulically operated coordinate table, and a control system that enables machine to work unattended except for loading and unloading.

Drilling table is moved on both X and Y axes by hydraulic jacks. Rough positioning is by perforated template and photocell, fine positioning by a mechanical indexing system using the meshing of a half-nut and precision rack. Positional accuracy is to 0.001 inch, and repeatability is also to within 0.001 inch. Drilling is carried out to a grid system, holes being drilled in a systematic pattern of rows and columns. Basic spacing between rows of the grid system is determined by the pitch of the precision rack thread associated with row alignment. A similar rack is used for column alignment.

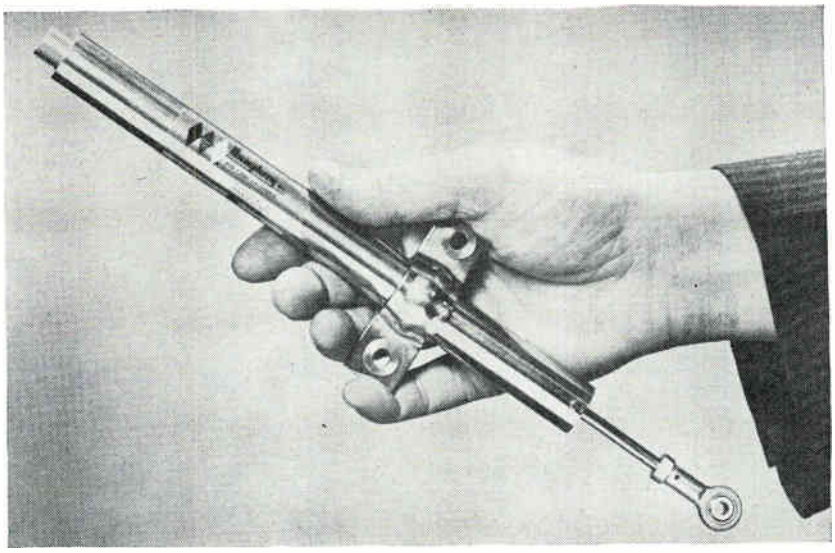
A perforated template is mounted on an extension of the 20 × 14 in. drilling table; wherever a hole in the template coincides with the light beam, the photocell is stimulated to give a signal to the control system. This signal initiates stopping the table, locking it in position and starts drilling action. When drilling is complete, the table is moved automatically for the next drilling operation. Each row of the drilling pattern has a marker hole to make the table move to the next row after one row has been completed.

The machine can accommodate a stack of boards up to 12½ by 18 in., with maximum drilling dimensions of 11½ by 17½ in., or two stacks of smaller boards for simultaneous drilling. A typical application, drilling 288 holes in each of two stacks of four boards, required 14½ minutes.

Circuit Overlay Spots Solder Bridges

Solder bridges can occasionally pass undetected through visual inspection of printed circuit boards when inspectors develop eyestrain or fatigue, or when the solder bridge has the shape of a land. Kollsman Instrument Corporation, Syosset, New York, detects false lands by using a positive of the conductor pattern as a test pattern. When the positive, clear film, is placed over the board, the black pattern hides the conductors. Any bridges are readily seen through the clear areas of the film. The visual aid also speeds up board inspection, since, with the board known to be free of bridges, only a few seconds are needed to scan for misrouted patterns

New On The Market



Differential Transformer
FOR INDUSTRIAL AND MILITARY USE

HUMPHREY, INC., 2805 Canon St., San Diego 6, Calif. Differential transformer converts linear movement into an easily read a-c signal. Typical applications include use in hydraulic actuators, feedback devices and other servo systems used on missiles. Unit provides an integral self-aligning mounting bracket, eliminating transformer coupling errors caused by placing a metal ring around the instrument to mount it. Characteristics include output voltage scale factor constant to within ± 3db from 60 cps to 20 Kc, low output impedance.

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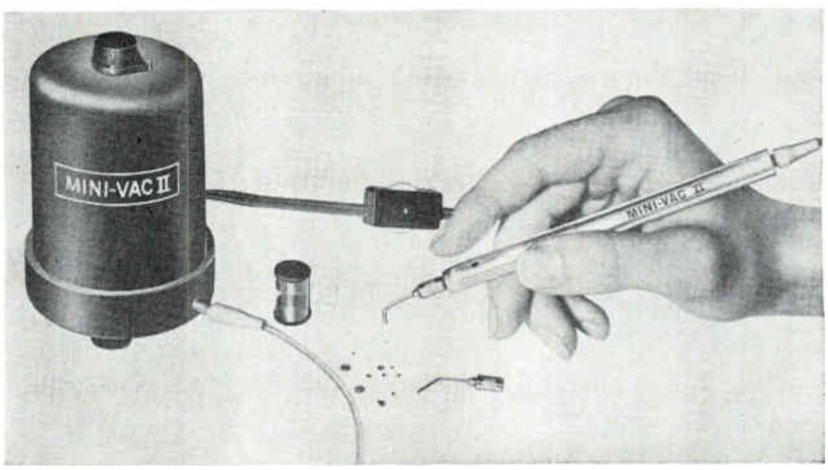
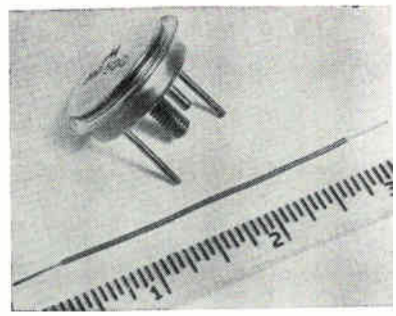


Miniature Parts Handler
VERSATILE AND DEPENDABLE

MINI-TOOL INDUSTRIES, Box 84, Highbridge Station, New York 52, N. Y. The Mini-Vac II parts handling system uses vacuum suction to move and manipulate tiny, delicate components quickly and safely. Electromagnetic vacuum pump, Tygon tubing, stainless steel pickup tips, suction cup adapters and finger-actuated pickup pencil comprise the basic system. Vacuum is fingertip controlled by covering, or uncovering, the by-pass opening in pickup pencil.

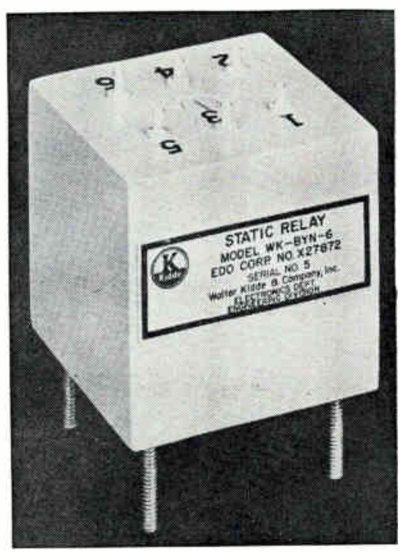
CIRCLE 302 ON READER SERVICE CARD



Power Transistors
GERMANIUM TYPE

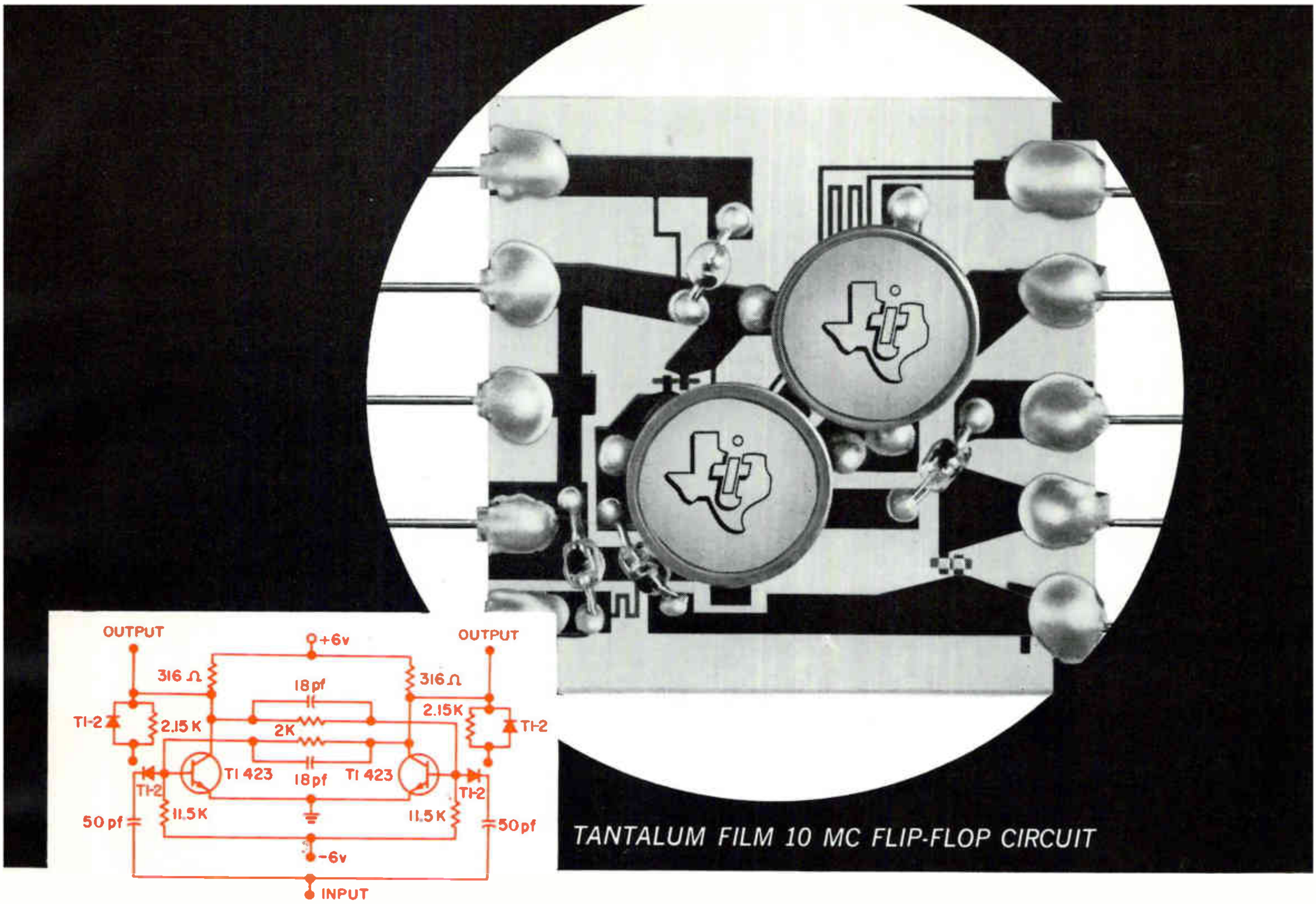
MOTOROLA SEMICONDUCTOR PRODUCTS INC., 5005 E. McDowell Rd., Phoenix, Ariz., announces 30 and 60 amp germanium power transistors with saturation resistance as low as 0.009 ohm, the approximate equivalent of a 3-in. length of No. 26 copper wire. Units are suited for regulator purposes in power supplies and for switching applications where only small voltage drops across the transistor can be tolerated, even at exceptionally high currents.

CIRCLE 303 ON READER SERVICE CARD



Static Relay
SOLENOID-ACTUATING

KIDDE ELECTRONIC LABORATORIES, Walter Kidde & Co., Inc., Belleville 9, N. J. Model WK-BYN-6 static relay eliminates problems of arcing in the switching of heavy inductive loads. Contact employed is a bistable semiconductor. Its sole stable states are a low-impedance or "on" state and a high-impedance or "off" state. Absence of moving parts and elimination of arcing assure reliability and long-life operation. Relay

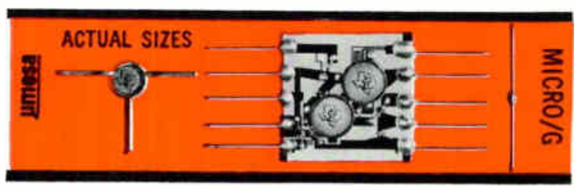


TANTALUM FILM 10 MC FLIP-FLOP CIRCUIT

HERE'S HOW TI MICRO MINIATURIZATION CAN HELP YOU NOW!

EXTENDED PERFORMANCE—Yes, you can have extended performance TI Tantalum Film Circuits today—Circuits giving you 3 major benefits: **1.** Reliable semiconductor components— umesa* the highest power/volume silicon transistor available today— MICRO/G* diode for space saving economics with all the electrical parameters of the famous MOLY/G* diode; **2.** Passive components are tailored precisely to your individual circuit requirements—Tantalum Film techniques allow precision control of resistor and capacitor elements; **3.** TI Tantalum Film Circuits manufacturing facility is now in production . . . utilizing single Tantalum Film technique and hermetically sealed active components . . . to give you the potential for improved circuit performance. **CIRCUIT VERSATILITY**—Your particular low-level circuit requirements can be fabricated for rapid delivery. **PRECISION CIRCUITS**—TI Tantalum Film Circuits, with precise control of all components, offer you custom-quality circuits with space savings not previously available. ■ Let TI help you adapt your designs to Tantalum Film Circuits at surprisingly low costs. Write today for more information: Texas Instruments Incorporated, Department 588, P. O. Box 5012, Dallas 22, Texas.

*Trademarks of Texas Instruments Incorporated



COMPONENTS DIVISION
CAPACITORS, DIODES,
RECTIFIERS, RESISTORS,
SEMICONDUCTOR NETWORKS,
SILICON CONTROLLED RECTIFIERS

TEXAS INSTRUMENTS
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operates in a range of line voltages from 105 to 127 v at 60 cps, over an ambient temperature range of 0 to 50 C.

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Selenium Stacks

HIGHLY VERSATILE

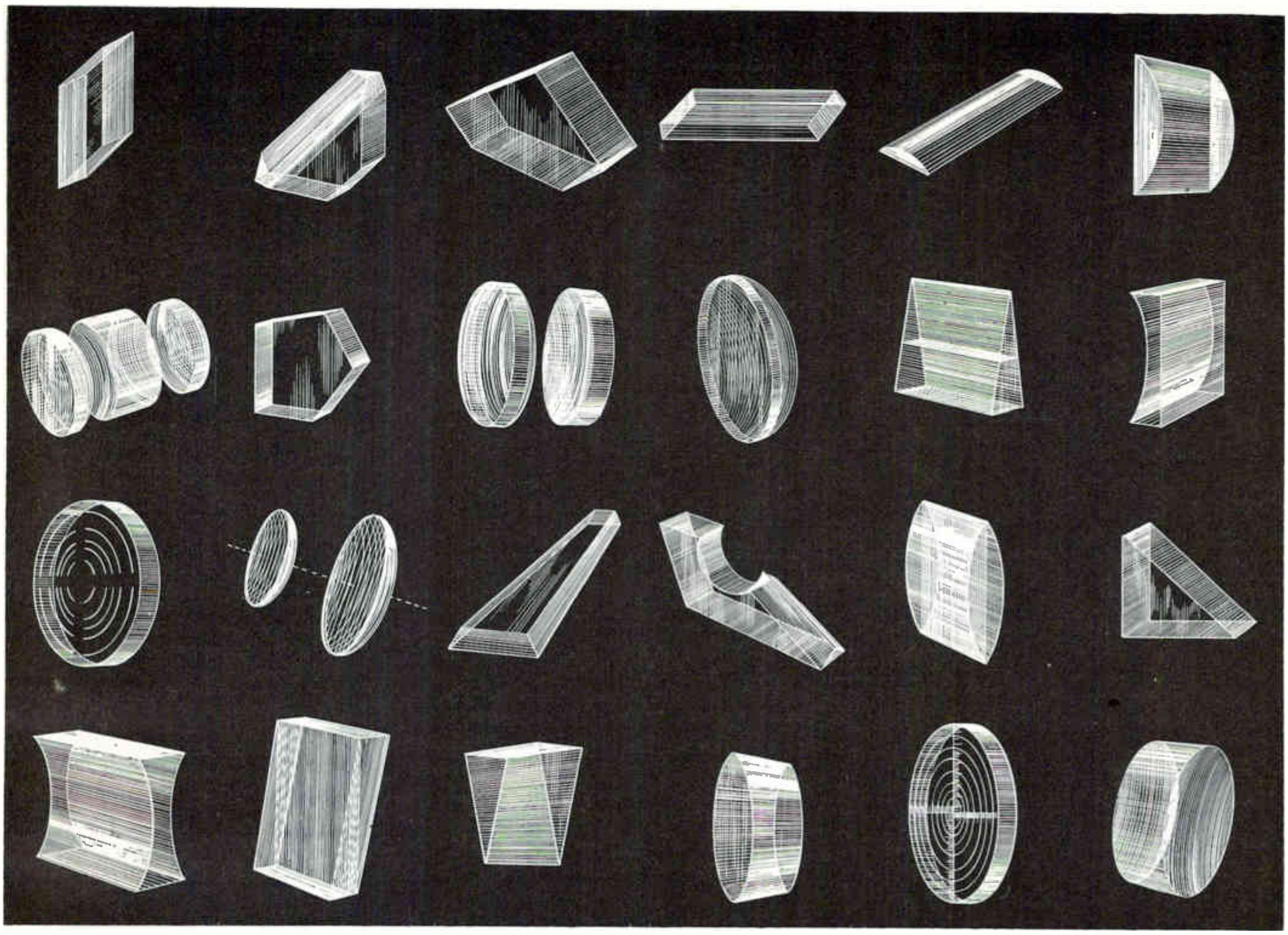
RADIO RECEPTOR CO., INC., 240 Wythe Ave., Brooklyn 11, N. Y. A compact type of selenium rectifier package is announced. Package resembles a cylinder with a length proportionate to the voltage to be encountered —plus (for extreme voltages) corona-suppressing rings at each end, all mounted as an integral, rugged unit. Each stack is composed of a series of flat cylindrical modules, studded together through a metallic, threaded insert in the center of each face. Each cylinder is individually rated at 20,000 v.

CIRCLE 305 ON READER SERVICE CARD

Power Supply

ADJUSTABLE UNIT

MATRIX RESEARCH AND DEVELOPMENT CORP., Nashua, N. H. Model AH all solid state, well regulated power supply, employing rugged high density packaging suitable for missile and space vehicle application is available, over a wide range of out-



OPTICS FOR ELECTRONICS . . .

Components and systems for visible, ultraviolet, and infrared radiation. GEC's Astro-Optics Division specializes in design, development, and manufacturing of optical components and systems for the ultraviolet through infrared spectrum.

Here are a few of the optical components you can order from Astro-Optics: prisms, flats, spherical, aspherical and parabolic surfaces, reticles, information choppers, encoders, precision vacuum coating, and optically polished synthetic crystals.

Also available from Astro-Optics are infrared and optical-electronic systems.

For complete information regarding your precision optical requirements, write today to:

ASTRO OPTICS DIVISION

. . . precision optics at work

G E C **GENERAL ELECTRODYNAMICS CORPORATION**

4430 FOREST LANE • GARLAND, TEXAS

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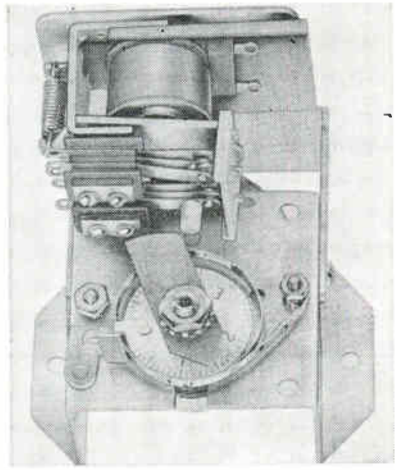
put voltages (700-1,500). Designed for use with photomultiplier tubes, the supply has built-in overload and protector circuits, together with multiple external taps so that different voltages are available, depending upon the particular application.

CIRCLE 306 ON READER SERVICE CARD



Delay Timer
SIMPLIFIED DESIGN

HAYDON DIVISION of General Time Corp., 245 E. Elm St., Torrington, Conn. Series BN21 delay timer eliminates the need for auxiliary relays and can be used for interval or delay timing. Unit measures 2.938 in. deep, 3.375 in. wide and 3.750 in. high. It is designed for rear mounting in any position, and is equipped with a calibrated dial for easy adjustment of the timing interval by lock-nut.

CIRCLE 307 ON READER SERVICE CARD

Static Inverter
D-C TO SINE WAVE

ABBOTT TRANSISTOR LABORATORIES, INC., 3055 Buckingham Road, Los

For the man to see, go to EBG

One more reason **electronics buyers' guide** and Reference Issue is your most valuable reference book when you're buying:

For the first time, the 1961 EBG lists in the Green Section the actual name of the man to see in the company from which you want to buy . . . the man designated by the company who knows prices, delivery dates, specifications, etc. This valuable new feature is only one of many in this year's Manufacturers' Index. The same EBG section tells you the number of engineers, number of employees, dollar volume of business of each manufacturer, etc. And there's still more . . .

Guide to military and government procurement . . . Complete, most useful guide for the man who is doing business with the government. Lists the military and government agencies that buy electronic equipment and services, with phone numbers, addresses, procurement officers' names, and what they buy.

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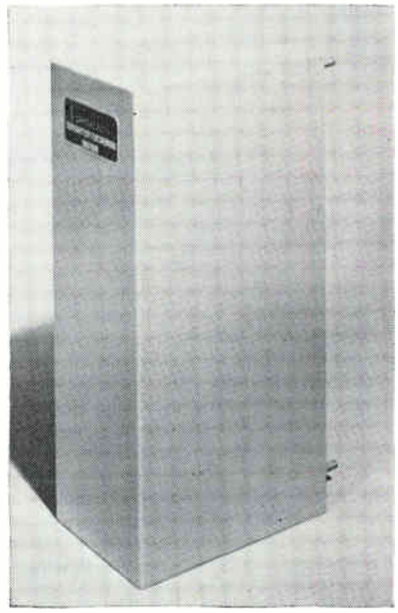
A McGRAW-HILL PUBLICATION 330 West 42nd St., New York 36, N. Y.

Angeles, Calif. Transistorized static inverter converts d-c to sine wave 400 cps power, from a 28-v source. Unit is rated up to 50 v-a with less than 3 percent total harmonic distortion. Model N3A1 is closely regulated for input variations and is protected against short circuits, polarity reversals and transient spikes. It meets environmental requirements of MIL-E-5272C, is suited for use in missile, aircraft and space fields.

CIRCLE 308 ON READER SERVICE CARD



Crystal Filters
PRECISION DEVICES

SYSTEMS INC., 2400 Diversified Way, Orlando, Fla. Model BS-100-.012 has a rejection of more than 100 db over a bandwidth of greater than 12 cps and a 2 db bandwidth of less than 40 cps at a center frequency of 100 Kc. Response on either side of the rejection band is essentially flat or 100 cps beyond the center frequency. Insertion loss is less than 1 db. Input/output impedance is 8,000 ohms.

CIRCLE 309 ON READER SERVICE CARD

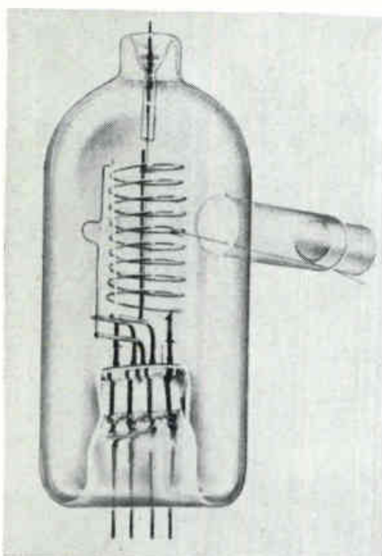
Silicon Transistors
HIGH BETA

RHEEM SEMICONDUCTOR CORP., 350 Ellis St., Mountain View, Calif. The RT5401, -2, -3 and -4 series provides typical betas from 210 to 300 at 50 ma and from 100 to 120 at 500 ma. Beta spread is very tightly

controlled with a max/min ratio of only 2 to 1. These high betas at high current make possible design improvements in Class A and B amplifiers.
CIRCLE 310 ON READER SERVICE CARD

Full Adder

ENGINEERED ELECTRONICS CO., 1441 E. Chestnut Ave., Santa Ana, Calif. Full adder T-441, a binary circuit module for arithmetic applications, is packaged in a container measuring $\frac{7}{8}$ in. diameter by 2$\frac{3}{16}$ in. seated height, and plugs into a standard 9-pin miniature tube socket.
CIRCLE 311 ON READER SERVICE CARD



Ionization Gage Tubes
BURN-OUT PROOF

NUCLEAR CORP. OF AMERICA, Central Electronic Mfrs. Division, Denville, N. J. Type CEM-75 is capable of vacuum measurement in the range of 10^{-4} to 10^{-10} mm of mercury. Filament voltage is 3-5 v a-c; filament current 4-6 amp a-c; grid voltage + 150 v; collector voltage − 30 v. The grid is degasable by passing current through it. The burn-out proof filament makes it desirable for use in systems that are repeatedly open to the air.
CIRCLE 312 ON READER SERVICE CARD

Magnetic Switch

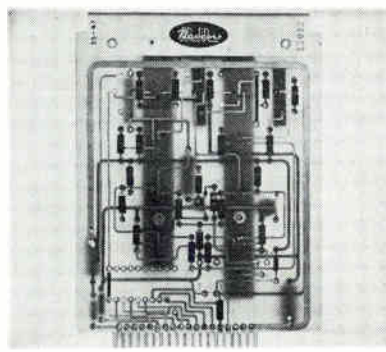
MAGNETICS INC., Butler, Pa., announces a low-priced completely-static switch rated at 40 w, with output of 0.4 amp at 100 v a-c.

CIRCLE 316 ON READER SERVICE CARD

Zener Diodes
VERSATILE UNITS

AMERICAN SEMICONDUCTOR CORP., 3940 N. Kilpatrick Ave., Chicago 41, Ill., announces a line of subminiature glass diffused Zener diodes with 2, 5, 10 and 20 percent voltage tolerances for a variety of circuits. All range from 5.9 to 300 v in 400 mw ratings at temperatures ranging from −55 to +150 C.

CIRCLE 317 ON READER SERVICE CARD



Multiplexing Modules
SOLID-STATE

NAVIGATION COMPUTER CORP., Valley Forge Industrial Park, Norristown, Pa. Models 371 (illustrated) and 372 solid-state modules multiplex information from several single-ended analog circuits. Input range is 0 to 10 v. A long-term accuracy of 1 percent is ensured by using a matched pair of transistors in the input stage of each channel, and cementing each pair in a common heat sink. The 371 contains two channels of input gates and amplifiers and an output amplifier. The 372 contains four channels of input gates and amplifiers. It is used to extend the capacity of the 371.

CIRCLE 318 ON READER SERVICE CARD

Vacuum System

ULTEK CORP., 920 Commercial St., Palo Alto, Calif. Clean vacuums to 5×10^{-9} mm Hg in 4 hr or less, without bakeout, are achieveable in a glass bell jar, with the Boostivac-equipped, ion pumped high vacuum system.

CIRCLE 319 ON READER SERVICE CARD

Integrator

GENERAL PURPOSE

TEXAS RESEARCH AND ELECTRONIC CORP., Meadows Building, Dallas, Texas. The GPI-100 utilizes a solion tetrode as the integrating element. Battery-powered and portable, it weighs 5½ lb and measures 6½ by 8 by 8 in. Accurate to 1 percent, it has an input impedance of 10,000 ohms, a frequency response from d-c to 10 Kc, and accepts inputs to 1 v. The integral is read out on a 1 percent meter with both a 100 v-sec and 1,000 v-sec range.

CIRCLE 320 ON READER SERVICE CARD

Pressure Switch

EXPLOSION-PROOF

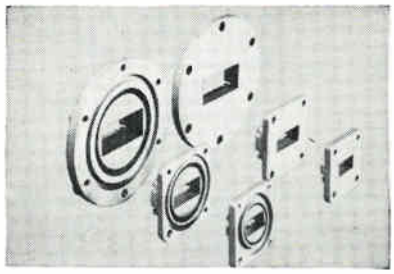
CUSTOM COMPONENT SWITCHES, INC., 3137 Kenwood St., Burbank, Calif. Model 610GE explosion-proof pressure switch meets the demand for miniature industrial components. The low-priced switch is listed by UL, Inc. for use in hazardous locations Class I Groups A, B, C and D as well as Class II Groups E, F and G. The Dual-Snap switch design provides a positive setting and eliminates drifting of actuation point due to varying temperatures. The hermetically sealed unit is not affected by pump ripple or pulsation.

CIRCLE 321 ON READER SERVICE CARD

Voltage Integrator

HARVEY-WELLS ELECTRONICS, INC., 14 Huron Drive, Natick, Mass. Multichannel voltage integrator sums and prints out after specified time.

CIRCLE 322 ON READER SERVICE CARD



Waveguide Flanges

AT C, X, AND P BANDS

MICROWAVE COMPONENTS & SYSTEMS CORP., 1001 S. Mountain Ave., Monrovia, Calif., has available wave guide flanges at C, X, and P bands. Cover, choke and butt flanges are available in either brass or aluminum in production quantities at production prices. Meeting all requirements applicable to MIL-SPEC F-3922A, the flanges are forged, broached and precision ground for flatness.

CIRCLE 323 ON READER SERVICE CARD

Voltage Reference

SOLID STATE

DYNAGE, INC., 390 Capitol Ave., Hartford, Conn., announces d-c voltage references for satellite pcm telemetry applications. Input current is 10 ma or less with an input voltage of 20 v d-c ± 1 v d-c. Output voltage is 5.0 v d-c and output current is zero, that is for null circuit. Overall stability is better than ± 0.2 percent over a temperature range of −20 to + 60 C and with an input voltage variation of ± 5 percent.

CIRCLE 324 ON READER SERVICE CARD

Pattern Generator

CYBETRONICS, INC., 132 Calvary St., Waltham, Mass. Model B digital pulse-pattern generator works

 CIRCLE 96 ON READER SERVICE CARD

CIRCLE 202 ON READER SERVICE CARD

without switches, contacts or patch cords.

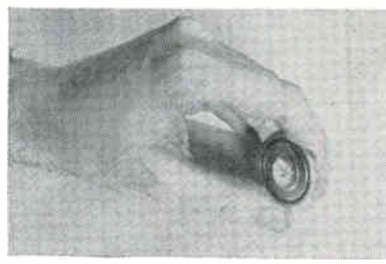
CIRCLE 325 ON READER SERVICE CARD

MADT Transistors

VERY LOW NOISE

PHILCO CORP., Lansdale, Pa. Three MADT transistors exhibit very low noise characteristics. The T2028, T2029 and T2030 are designed for vhf-uhf, r-f amplifiers, mixers and oscillators used in military communications equipment, mobile radios and transistorized tv.

CIRCLE 326 ON READER SERVICE CARD



Button Cell

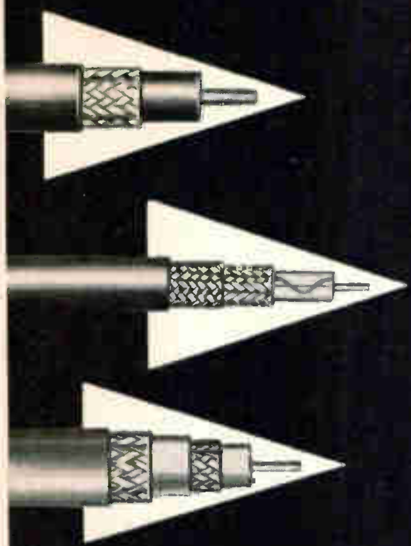
SILVER-CADMIUM

YARDNEY ELECTRIC CORP., 40 Leonard St., New York 13, N.Y., announces Silcad (silver-cadmium) button cells for use in all types of portable equipment requiring high energy outputs from small, lightweight power packs. The 0.25-ampere hr unit shown provides up to 75 percent more capacity than ordinary rechargeable button cells of the same weight and volume, and has a cycle life almost 60 percent greater. Open-circuit cell voltage is 1.4 v; nominal voltage under load, 1.1 v.

CIRCLE 327 ON READER SERVICE CARD

Infrared Material

SEMITRONICS, INC., P. O. Box 46, Winchester, Mass., has available



ROYAL COAXIAL CABLES*

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

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

ROYAL ELECTRIC CORPORATION
301 Saratoga Avenue
PAWTUCKET • RHODE ISLAND

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

ROYAL ELECTRIC

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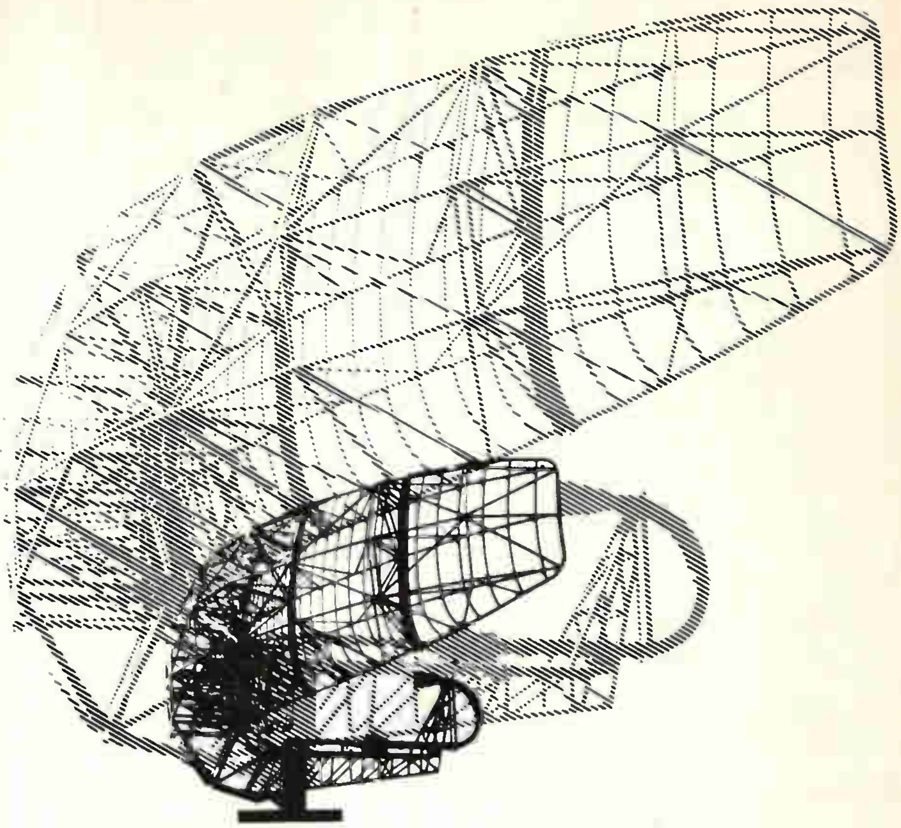
CIRCLE 204 ON READER SERVICE CARD



SAFETY OF LIFE IN THE AIR

SELENIA AIR TRAFFIC CONTROL RADAR OFFERS:

SOLID LONG RANGE, HIGH ALTITUDE DETECTION OF EVEN THE SMALLEST TYPES OF AIRCRAFT THROUGH THE USE OF HIGH AVERAGE POWER AND A PARAMETRIC AMPLIFIER RECEIVER.

THE MOST ADVANCED TRUE MTI SYSTEM IN THE WORLD WITH THREE PULSE CANCELLATION FOR CLUTTER-FREE PRESENTATION AND STAGGERED REPETITION RATE FOR BLIND SPEEDS ELIMINATION.

THE USE OF L-BAND ASSURES SHARP AZIMUTH DISCRIMINATION AND LOW PRECIPITATION ATTENUATION WITH REASONABLY SIZED ANTENNA STRUCTURES.

SPECIAL HIGH-LOBE ANTENNA FOR GREATLY IMPROVED SUBCLUTTER VISIBILITY FOR CLOSE-IN TARGETS AND CIRCULAR POLARIZATION FOR NEARLY COMPLETE CANCELLATION OF RETURNS FROM PRECIPITATION.

A RADAR COMPLETELY COMPA TIBLE WITH JET AGE REQUIREMENTS.

A DIRECT SUCCESSOR OF THE PROVEN RAYTHEON AIRPORT AND AIRWAYS RADARS CHOSEN BY THE AIR TRAFFIC CONTROL AUTHORITIES IN CANADA, THE UNITED STATES AND SWITZERLAND

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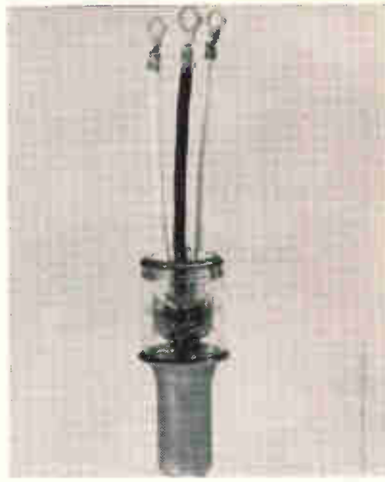
CIRCLE 99 ON READER SERVICE CARD

vertically grown, single crystal indium antimonide p-n junctions for infrared detector applications.

CIRCLE 328 ON READER SERVICE CARD



High-Mu Triode
HIGH VACUUM

UNITED ELECTRONICS CO., 42 Spring St., Newark, N.J. The No. 581 is a miniature high vacuum high-mu triode designed for pulse modulator service. In this service it can deliver 13 Kw pulse power output. Maximum anode voltage is 20 Kv, peak plate current is 1.2 amperes, and grid bias is 300 v. Length of the tube is 2.75 in. and the diameter is 1.13 in.

CIRCLE 329 ON READER SERVICE CARD

D-C Power Modules
HIGH TEMPERATURE

TECHNIPOWER INC., 18 Marshall St., South Norwalk, Conn. Using all silicon semiconductors and tantalum capacitors, these d-c power modules have a temperature rating of −40 C to +100 C. Over 90 models are available ranging from 2.8 to 52 v at powers of 1.0 to 20 w. Ripple is 1 mv rms for 0.05 percent regulation; 5 mv rms for 0.5 percent regulation.

CIRCLE 330 ON READER SERVICE CARD

ACCELEROMETER versatile unit. Giannini Controls Corp., 1600 S. Mountain Ave., Duarte, Calif. (331)

CHOPPER INPUT TRANSFORMER high impedance. James Electronics, Inc., 4050 No. Rockwell St., Chicago 18, Ill. (332)

DUMET WIRE CLEANER safe to handle. Fidelity Chemical Products Corp., 470 Frelinghuysen Ave., Newark 14, N.J. (333)

RIGID TRANSMISSION LINE for high power signals. Technical Appliance Corp., Sherburne, N.Y. (334)

COAXIAL SLOTTED LINE with parallel-plane design. General Microwave Corp., 47 Gazza Blvd., Farmingdale, N. Y. (335)

P-C BOARD angular construction. R. G. Circuits Co., 15216 Mansel Ave., Lawndale, Calif. (336)

MICROWAVE ATTENUATOR solenoid actuated. Hathaway Denver, 5800 E. Jewell Ave., Denver, Col. (337)

COMPUTER SIMULATOR low-cost. Scientific Development Corp., 372 Main St., Watertown, Mass. (338)

STRIPPING MACHINE for shielding braid. Ewald Instruments, Route 7, Kent, Conn. (339)

BATTERY CHARGER for space vehicle batteries. Mid-Eastern Electronics, Inc., Springfield, N.J. (340)

STRAIN GAGE POWER SUPPLY fully transistorized. Cubic Corp., San Diego 11, Calif. (341)

LONG SCALE METER limited panel space. The Triplett Electrical Instrument Co., Bluffton, O. (342)

SUPERHET RECEIVER tunes 10 to 600 Kc. Marconi Instruments, 111 Cedar Lane, Englewood, N.J. (343)

HEART MONITOR portable. Electronic Medical Systems, Inc., 1449 University Ave., St. Paul, Minn. (344)

CURRENT GOVERNOR programmable. North Hills Electronics, Inc. Alexander Place, Glen Cove, N.Y. (345)

LASER MATERIAL strontium fluoride. Semi-Elements Inc., Saxonburg Blvd., Saxonburg, Pa. (346)

Literature of the Week

FACILITIES BROCHURE F. J. Stokes Corp., 5500 Tabor Road, Philadelphia 20, Pa., offers a brochure discussing its people, purpose and varied facilities. (347)

INSTRUMENT LIGHTING Monroe Industries, Inc., 934 Thirty-Sixth St., S.E., Grand Rapids 8, Mich. An illustrated brochure describes the company's facilities for the manufacture of precision illuminated parts for military integral lighting. (348)

ULTRASONIC FLOWMETER Gulton Industries, Inc., 212 Durham Ave., Metuchen, N.J. A 4-page bulletin describes and illustrates the Glennite ultrasonic flowmeter. (349)

HIGH RELIABILITY CAPACITORS General Electric Co., Schenectady 5, N. Y. Bulletin GEA-7240 covers high reliability Tantalytic solid capacitors. (350)

INFRARED TRANSMITTING GLASSES Bausch & Lomb Optical Co., Rochester 2, N. Y., offers a progress report on calcium aluminate infrared transmitting glasses. (351)

METALIZED ENCLOSURE TUBES Corning Electronic Components, Bradford, Pa. Metalized glass enclosure tubes that can withstand downshock from 275 C to ice water are discussed in file CE-6.00. (352)

ENERGY DISCHARGE CAPACITORS Sangamo Electric Co., Springfield, Ill. H-V low inductance energy discharge capacitors are discussed in a 12-page bulletin. (353)

MAGNETIC HEAD ASSEMBLIES Westrex Recording Equipment division of Litton Systems, Inc., 335 No. Maple Drive, Beverly Hills, Calif. Details of 14-track in-line or interleaved magnetic head assemblies are covered in a bulletin. (354)

GLASS-TO-METAL SEALS Glass Instruments Inc., 2285 E. Foothill Blvd., Pasadena, Calif. Bulletin covers glass-to-metal seals that will withstand environmentals of from +420 C to −80 C. (355)

ELECTRICAL TAPES Johns-Manville, Dutch Brand Division, 22 E. 40th St., New York 16, N.Y. Selection chart contains samples of 15 different insulating tapes, as well as data on each. (356)

PULSE GENERATORS, REFERENCE SOURCES Bulova Watch Co., Inc., 40-01 61st St., Woodside 77, N. Y. Two-color catalog sheet describes pulse generators and voltage reference sources. (357)

METER RELAYS Weston Instruments Div., Daystrom, Inc., 614 Frelinghuysen Ave., Newark, N. J. Bulletin 02-106 contains features and specifications of the model 1073 MagTrak double-action meter relays. (358)

EPOXY PELLETS Epoxy Products Division, Joseph Waldman & Sons, 137 Coit St., Irvington 11, N.J. Bulletin No. 8 describes the use of epoxy pellets for protecting tantalum capacitors. (359)

PHASE ANGLE VOLTMETER North Atlantic Industries, Inc., Terminal Drive, Plainview, N.Y., offers a data sheet on an all-transistorized multiple-function phase angle voltmeter. (360)

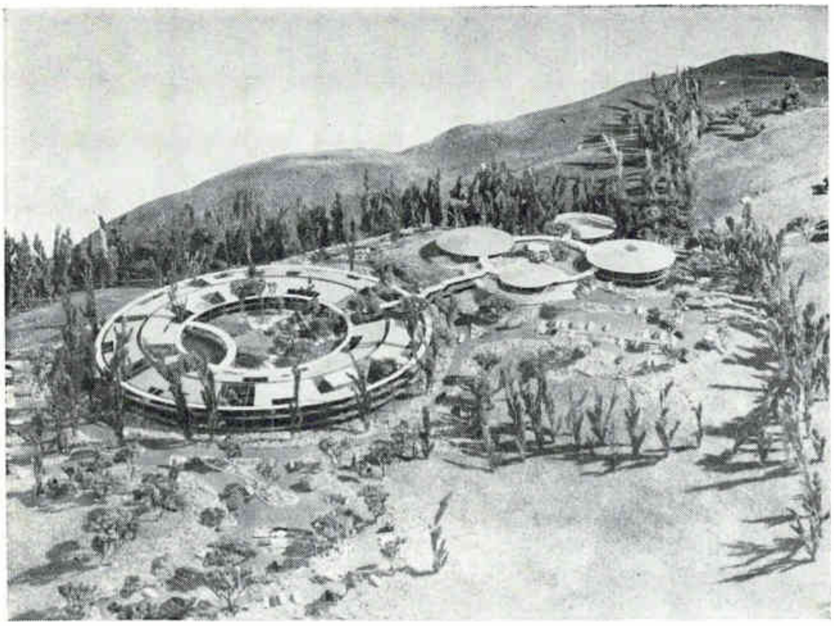
GLASS-TO-METAL SEALS Chromalloy Corp., 171 Western Highway, West Nyack, N.Y. Bulletin describes a new method of achieving hermetic glass-to-metal seals. (361)

MICROWAVE OPTICS Cenco Instruments Corp., 6450 W. Cortland St., Chicago 35, Ill. A 24-page illustrated booklet describes the company's microwave optics demonstration apparatus and outlines operating instructions. (362)

CLIP-ON CURRENT MEASUREMENTS Dawe Instruments Ltd., Western Ave., Acton, London, W.3, England. A technical leaflet illustrates and describes type 618 a-c Milliclamp from which readings can be taken without interruption of the circuit under test. (363)

BROADBAND AMPLIFIERS Applied Research Inc., 76 South Bayles Ave., Port Washington, N.Y., has published a data sheet on its 500 to 1,000 Mc broadband amplifier series. (364)

I-F AMPLIFIERS Ferrotran Electronics Co., Inc., 693 Broadway, New York 12, N.Y. Bulletin 576 gives the characteristics of cascaded amplifiers with gains as high as 80 db and operating from 455 Kc to 30 Mc. (365)



Research Center Under Construction

GENERAL TELEPHONE AND ELECTRONICS LABORATORIES, INC., a subsidiary of General Telephone and Electronics Corp., is building a new research center at Palo Alto, Calif. Facility will occupy a 77-acre site immediately southwest of the Stanford University campus.

The main building will be ring-shaped, containing laboratories and offices for the technical staff. It has been designed for quick rearrangement of office and laboratory combinations, to allow for changes in research projects and aims. A special supported floor system allows for rearrangement of conduit, storage and ducts in connection with other changes.

Four separate round buildings will house library, auditorium, cafeteria, and administrative offices.

The facility will have a total of 67,000 sq ft at a cost of approximately $2.6 million in its first stage (somewhat less than half of the laboratory ring), and will provide office and laboratory space for a core staff of 175.

Liquidometer Names Evans a V-P

CAREY A. EVANS has been named vice president in charge of engineering by the Liquidometer Corp., Long Island City, N.Y.

Prior to joining Liquidometer, Evans was director of operations for the marine equipment department of the Northrop Corporation's Nortronics Division.

Pickering Elected Astrosonics President

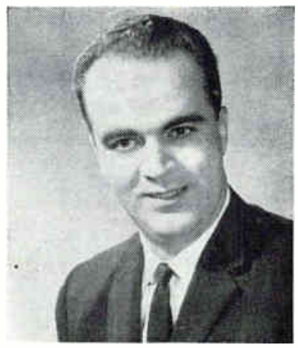
ELECTION of Norman C. Pickering as president and director of Astrosonics, Inc., Syosset, N. Y., is announced. He was formerly vice president and technical director of Avien, Inc., president of Charles Denning, Ltd., founder and president of Pickering & Co.

Astrosonics' laboratories and plant include advanced facilities for measurement, testing and product development, utilizing high-intensity sonic phenomena.

Sah, Ferguson Take New Posts

FAIRCHILD SEMICONDUCTOR'S Research & Development Laboratory, Palo Alto, Calif., has promoted C. T. Sah and Phillip Ferguson to section heads.

Sah will head the laboratory's physics section; Ferguson, the device development section.



General Microwave Appoints Pizzutiello

APPOINTMENT of Robert Pizzutiello to the position of applications engineer is announced by General Microwave Corp., Farmingdale, N. Y.

Pizzutiello was formerly with Microwave Dynamics Corp. as sales engineer.

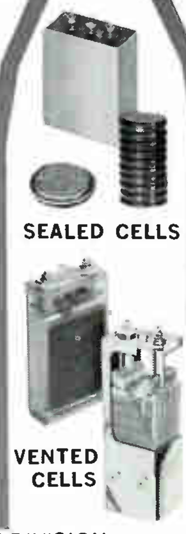
Warriner Moves Up At Raytheon

BEN WARRINER has been named manager, product programs for

When you need **POWER...**

choose NICAD®

NEW Nickel Cadmium Rechargeable Batteries



SEALED CELLS

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

VENTED CELLS

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

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NICAD BATTERY DIVISION
GOULD-NATIONAL
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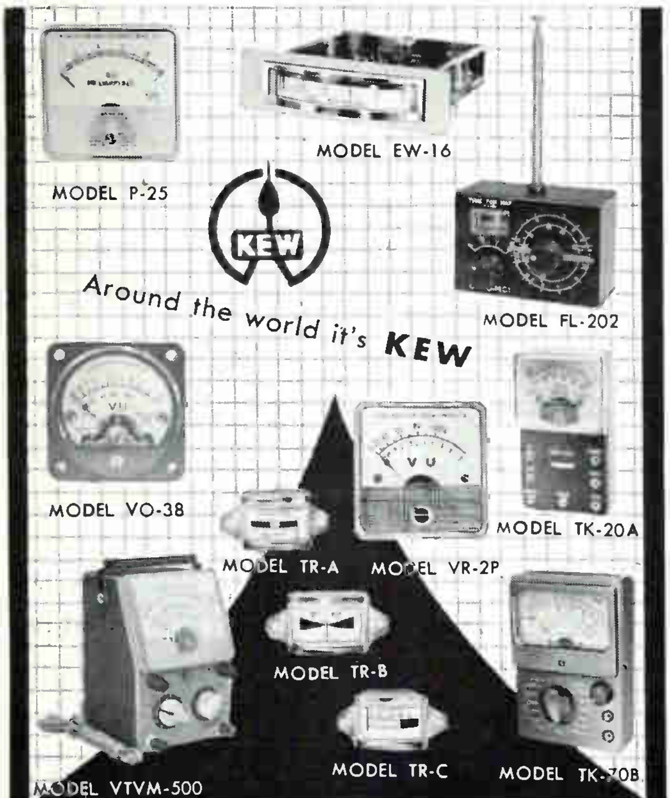
CIRCLE 206 ON READER SERVICE CARD



KYORITSU ELECTRICAL INST. WORKS, LTD.

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Tel: (717) 0131~5

CIRCLE 207 ON READER SERVICE CARD

For Military and Commercial Applications

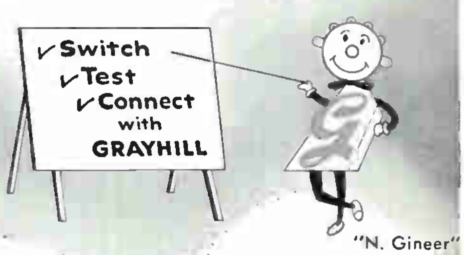
Grayhill Miniature Rotary Tap Switches

These switches are designed to meet military and commercial specifications and ruggedly built to precision standards.

Grayhill No. 5000, No. 12, and No. 24 Series. 1.01" dia. Break 1 amp., 115 VAC, resistive. Carry 5 amps. 1 to 10 decks, 2 to 10 positions per deck—1 or 2 poles per deck—shorting or non-shorting. Life 100,000 cycles. Also No. 24 Series, spring return switch.

Concentric Shaft. No. 6 (1 to 3 decks per shaft—Total 6 decks) and No. 36 Series (1 or 2 decks per shaft. Total 4 decks). 1.01" dia. 2 to 10 positions per deck. Break 1 amp., 115 VAC, resistive. Carry 5 amps. Two switches in one. ¼" shaft controls ½ of the decks, ⅛" shaft controls the other half.

No. 45 Series Midget. .640" dia. Single deck only. 60° indexing. Break 1 amp., 115 VAC, resistive. Carry 5 amps. Life 100,000 cycles.



Grayhill offers a full line of Rotary Tap Switches, Push Button Switches, Test Clips, Binding Posts, and other miniature electrical and electronic components.

ASK FOR CURRENT CATALOG.

Grayhill INC.

Phone: FLeetwood 4-1040
523 Hillgrove Avenue
LaGrange, Illinois

"PIONEERS IN MINIATURIZATION"

CIRCLE 107 ON READER SERVICE CARD

Raytheon Company's Microwave and Power Tube Division, Burlington, Mass.

Warriner joined Raytheon in January of this year. Earlier he had been with Collins Radio Co. as manager of the research and development division and as its government representative at Hanscom Air Force Base, Bedford, Mass.

Form New Company In Massachusetts

FORMATION of Damon Engineering, Inc., Needham Heights, Mass., is announced. Co-founders of the new company are: David I. Kosowsky (picture), president and treasurer; Carl R. Hurtig, vice president; and Austen H. Madeson, sales manager. All were previously associated with Hermes Electronics Co.

Products of Damon Engineering, Inc. include quartz crystal filters, oscillators and other frequency selection and control networks. Custom built systems for spectrum analysis and telemetry will also be offered

Levin Advances At Power Designs

JOHN K. LEVIN is appointed vice president in charge of manufacturing at Power Designs, Inc., Westbury, L.I., N.Y. He will continue to fulfill the responsibilities of plant

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" problems. Interested? Write for the full story.

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SYNCHRO NEWS!

VERNITRON 3-MINUTE CONTROL SYNCHROS DELIVERED ON REGULAR PRODUCTION BASIS

60 & 400 CYCLE

ALL SIZES—11 through 23
ALL TYPES—Transformers, Transmitters, Differential Transmitters — Thru-Bore and Standard
ALL ENGINEERED & MANUFACTURED TO:
MIL-S-2335 MIL-S-16892 FXS-1066
MIL-S-12472 MIL-S-20708A
ALL AVAILABLE WITH MAXIMUM ELECTRICAL ERROR OF ±3 MINUTES! A major break-through, made possible by VERNITRON specialization in precision synchro component design and manufacture.

***WRITE, WIRE, PHONE NOW** for complete price, delivery and specification data; ask for new Vernitron Catalog*

VERNITRON CORPORATION

THE QUALITY NAME IN PRECISION SERVO COMPONENTS

606 Old Country Rd., Garden City, N.Y. Pioneer 1-4130 TWX: G-CY-NY-1147
West Coast Plant: 1742 So. Crenshaw Blvd., Torrance, Cal.—FAirfax 8-2504 TWX: TNC-4301

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Acoustical Components of Superior Quality

JAPAN PIEZO supplies 80% of Japan's crystal product requirements. Here are a few examples of our capabilities.

STEREO CARTRIDGE
Crystal—"PIEZO" Y-130
X'TAL STEREO CARTRIDGE
At 20°C, response: 50 to 10,000 c/s with a separation of 16.5db. 0.6V output at 50 mm/sec. Tracking force: 6±1gm. Compliance: 1.5×10^{-6} cm/dyne. Termination: 1MΩ+150pF.

MICROPHONE
Crystal — X-29
At 20°C, 1KC/s, Sensitivity is −58 ±5db. Impedence: 100KΩ. Capacitance: 1,500 pF.

PHONOGRAPH MOTOR—DC
PM—31-1
9V, 2,500 RPM: No-load current, 35 mA; load current, 80 mA. Starting torque, 13 g-cm; load torque, 5g-m. Size: 2.4cm×4.6cm. Weight: 100 gm.

Write for detailed catalog to:

PIEZO

JAPAN PIEZO ELECTRIC CO., LTD.

Kami-renjaku, Mitaka, Tokyo, Japan

CIRCLE 109 ON READER SERVICE CARD

manager, a position he has held with the company since 1959.

Power Designs, Inc., is engaged in the design and manufacture of high reliability power supplies for defense, industry and research laboratories.

Donald Chrisman Takes New Post

DONALD W. CHRISMAN has been appointed director of planning for the Martin Electronic Systems and Products division, Baltimore, Md. He will be responsible for the division's operational and long-range planning.

Chrisman formerly was on the Martin corporate staff.

PEOPLE IN BRIEF

Charles Terrey, formerly with Bailey Meter Co., has joined Datex Corp. as a development engineer in the electronic products group. **Harold Rind**, of Republic Aviation Corp., is named chief of its Space Environment Laboratory. **Robert Neyman** previously with Elgin Micronics, is appointed technical manager, electronics and communications projects, at Cannon Electric Co. **Paul Gallagher** leaves Transitron Electronics Corp. to become section head, preproduction engineering, at Rheem Semiconductor Corp. **Paul F. Radue**, ex-ITT Kellogg, now applications engineer in the marketing division of Lynch Communications Systems Inc. **Earl M. Underhill** advances at Crucible Steel Co.'s Magnet Div. to manager of engineering. **William A. Matthews** moves from Kollsman Instrument Corp. to Winchester Electronics, Inc., as general mgr. **Robert B. Martin** from Airpax, Inc. to Colin Campbell Co. as chief engineer. **Richard M. Mock**, Lear Inc. executive, elected a director of Astrodata, Inc. **Robert W. Brooks**, former president of Computer Control Co., Inc., named product department mgr. of Adage, Inc. Sylvania Electric Products Inc. ups **James O. Lawson** to manager of quality control for the Parts Div. **Ward C. Low**, ex-Mitre Corp., joins LFE Electronics as technical director for the Systems Div.

CIRCUIT DESIGN

If this is your career interest, we have projects involving digital computers of extremely small size. Let us tell you more about this — confidentially. Write to Mr. Harry Laur — Research and Engineering Staff.

Qualified applicants will be considered regardless of race, creed, color or national origin.

LITTON SYSTEMS, INC. Data Systems Division
Canoga Park, California

Model 1313

$590

1/4% ACCURACY WANTED?

This new Universal Bridge adds to the wide variety from which an engineer must choose. But Model 1313 has **both** ¼% Accuracy and Direct Readout; combines high discrimination with exceptional ease of use. Detector AGC, variable frequency operation and functional styling are all plus features.

- L: . . . . 1µH to 110H, 7 decades
- C: . . . . 1µµF to 110µF, 7 decades
- R: . . . . .01Ω to 110MΩ, 8 Decades
- Accuracy: . . . ¼%
- Discrimination: 5000 div'ns/Decade
- Frequency: 1Kc, 10Kc. 100 cps to 20Kc with ext. osc.
- Readout: . . . . Direct—no multiplying factors

MAKE NO MISTAKE MEASURE WITH :

MARCONI INSTRUMENTS

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CIRCLE 212 ON READER SERVICE CARD

looking for better than **jewelry quality** in precious metal tubing?

If you are a nuclear or electronics engineer looking for a supply of jewelry quality small tubing in silver, gold, palladium or their alloys, here's good news! The quality tubing you seek is available from UNIFORM TUBES with O.D.'s from 0.005" to ⅜". What's more, you can order this tubing precision drawn to any wall thickness from 0.035" down to 0.001" within tolerances of ±0.0005" . . . ±0.00025" on the smallest sizes!

UNIFORM cuts this tubing to specified lengths with ends square and free of burrs. UNIFORM's experience in working precious metals is also available for the fabrication of tubular parts. Flaring, coining, bending and other fabricating steps are completed with the same precision and skill applied to drawing the precious metal tubing.

Where the corrosion resistance or special properties of a precious metal are needed on either O.D. or I.D. only, UNIFORM supplies COMPOSITE TUBING with the precious metal drawn over a precision tube of a less expensive base metal or vice versa.

Composite tubing meets the same close tolerances and quality standards UNIFORM sets for tubing of silver, gold, palladium or their alloys.

Phone, wire or write today for details and a quotation. Delivery is normally less than three weeks.

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electronics

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2. Select those for which you qualify.
3. Notice the key numbers.
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ELECTRO-MECHANICAL RESEARCH INC. Sarasota, Florida	114	3
ERIE ELECTRONICS DIV. Erie Resistor Corp. Erie, Pennsylvania	116	4
GARRETT CORPORATION AiResearch Manufacturing Div. Los Angeles, California	114	5
GENERAL DYNAMICS/ASTRONAUTICS San Diego, California	17, 18*	6
GENERAL DYNAMICS/ELECTRONICS Military Products Div. San Diego, California	116	7
GENERAL ELECTRIC CO. Missile & Space Vehicle Dept. Philadelphia, Pa.	113	8
HUGHES AIRCRAFT COMPANY Space Systems Div. Culver City, California	17, 18	9
HUGHES AIRCRAFT COMPANY El Segundo, California	84*	10
HUGHES AIRCRAFT COMPANY Tuscon Engineering Lab. Tuscon, Arizona	80*	11
I B M CORPORATION New York, New York	115	12
LAWRENCE RADIATION LABORATORY Livermore, California	88*	13
LINK DIVISION General Precision Inc. Binghamton, New York	92	14
LITTON SYSTEMS INC. Data Systems Div. Canoga Park, California	111	15
LOCKHEED CALIFORNIA CO. A Div. of Lockheed Aircraft Corp. Burbank, California	50	16

CONTINUED ON PAGE 116

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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) 1281

☐ 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	☐ ....

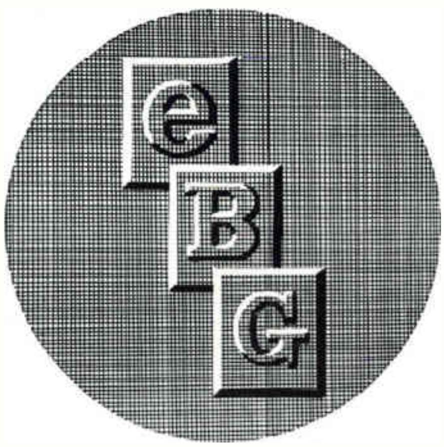
CATEGORY OF SPECIALIZATION

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



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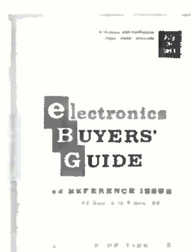

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WEEKLY QUALIFICATIONS FORM FOR POSITIONS AVAILABLE

(Continued from page 112)

COMPANY	SEE PAGE	KEY #
MICROWAVE SERVICES INTERNATIONAL, INC. Denville, New Jersey	88*	17
NATIONAL CASH REGISTER CO. Electronics Division Hawthorne, California	55*	18
NATIONAL CASH REGISTER CO. Dayton, Ohio	88*	19
NATIONAL SCIENTIFIC LABORATORY INC. Washington, D. C.	88*	20
REMINGTON RAND UNIVAC Div. of Sperry Rand Corp. St. Paul, Minnesota	83*	21
SCIENTISTS, ENGINEERS & EXECUTIVES INC. Washington, D. C.	116	22
P-7843	116	23

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10KW 3 CM. X BAND RADAR

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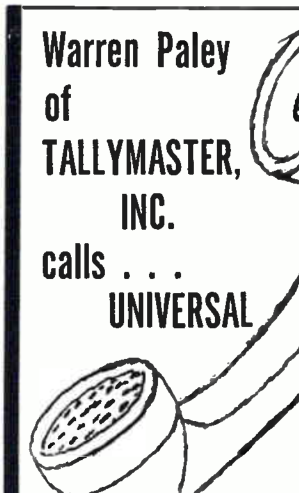

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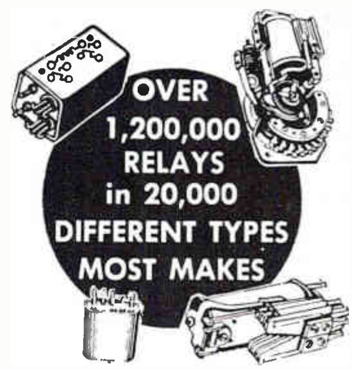

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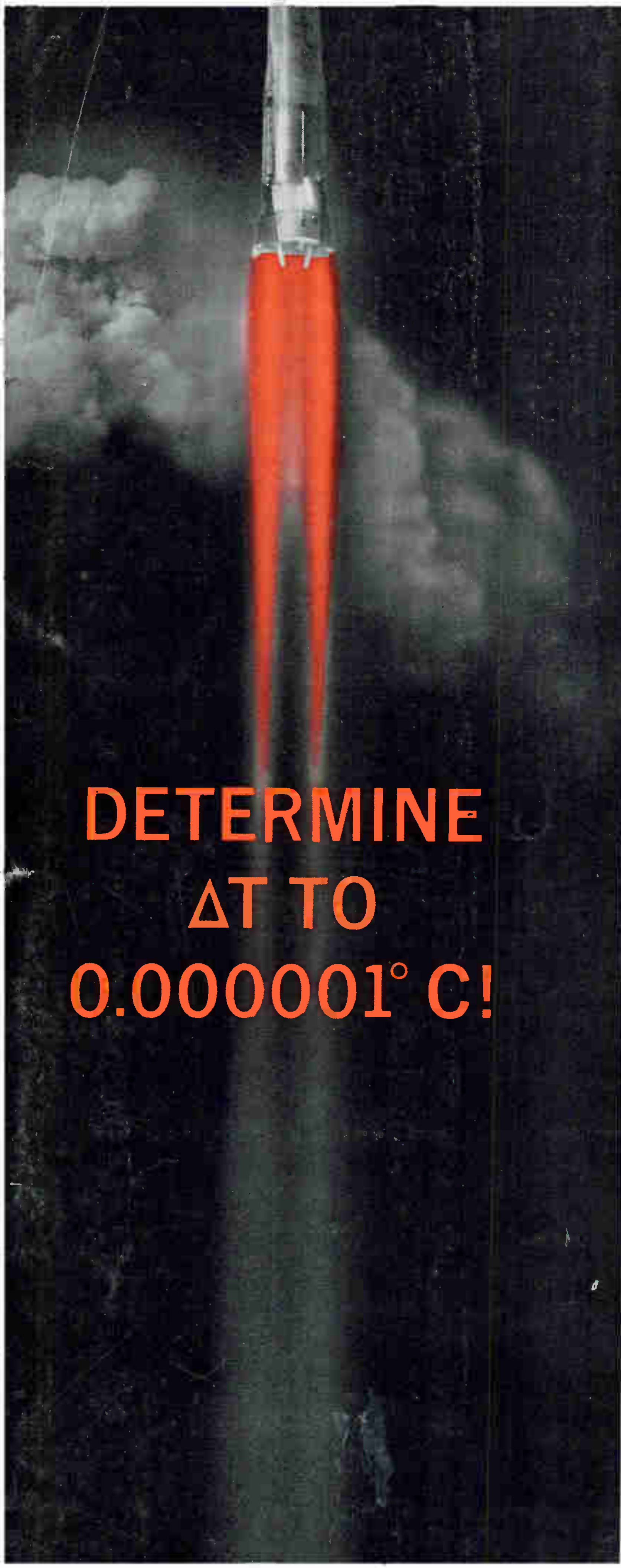

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C70201—A head-on metal-Dewar type photocell. Detector: p-type gold-doped germanium silicon alloy. Spectral response: 2 to 14 microns. Unit employs cryostat. Coolant: pumped liquid nitrogen (for detector temperature of 50°K) or liquid neon (for detector temperature of 27°K).

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Basic Material	Doping Element	Carrier Type	Long Wavelength Cutoff Microns	Typical Detectivity $(D^*)^a$ cm $(cps)^{1/2}$ watt^{-1} x 10^9	Detector Temperature °K	Liquid Coolant (at atmosphere pressure)
In Sb	—	—	5.5	10	77	N_2
Ge	Au	n	5	1	77	N_2
Ge	Au	p	9	5	77	N_2
Ge	Hg	p	14	20	20	H_2
Ge Si	Au	p	14	5	50	N_2 (at reduced pressure)
Ge Si	Au	p	14	5	27	N_2
Ge Si	Au	p	14	5	21	H_2
Ge Si	Zm	p	14	10	50	N_2 (at reduced pressure)
Ge Si	Zm	p	14	10	27	N_2
Ge Si	Zm	p	14	10	20	H_2
Ge	Cu	p	30	50	4	H_2
Ge	Au	p	25	—	4	H_2
Ge	Zm	p	40	4	4	H_2
Ge	Sb	n	120	—	Less than 4	H_2 (at reduced pressure)

[a]Under following conditions: Bandwidth 1 cps; black-body source operated at a color temperature of 500°K interrupted at 900 pulses per second to produce incident-radiation pulses alternating between on and off.

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