April 13, 1962

# electronics

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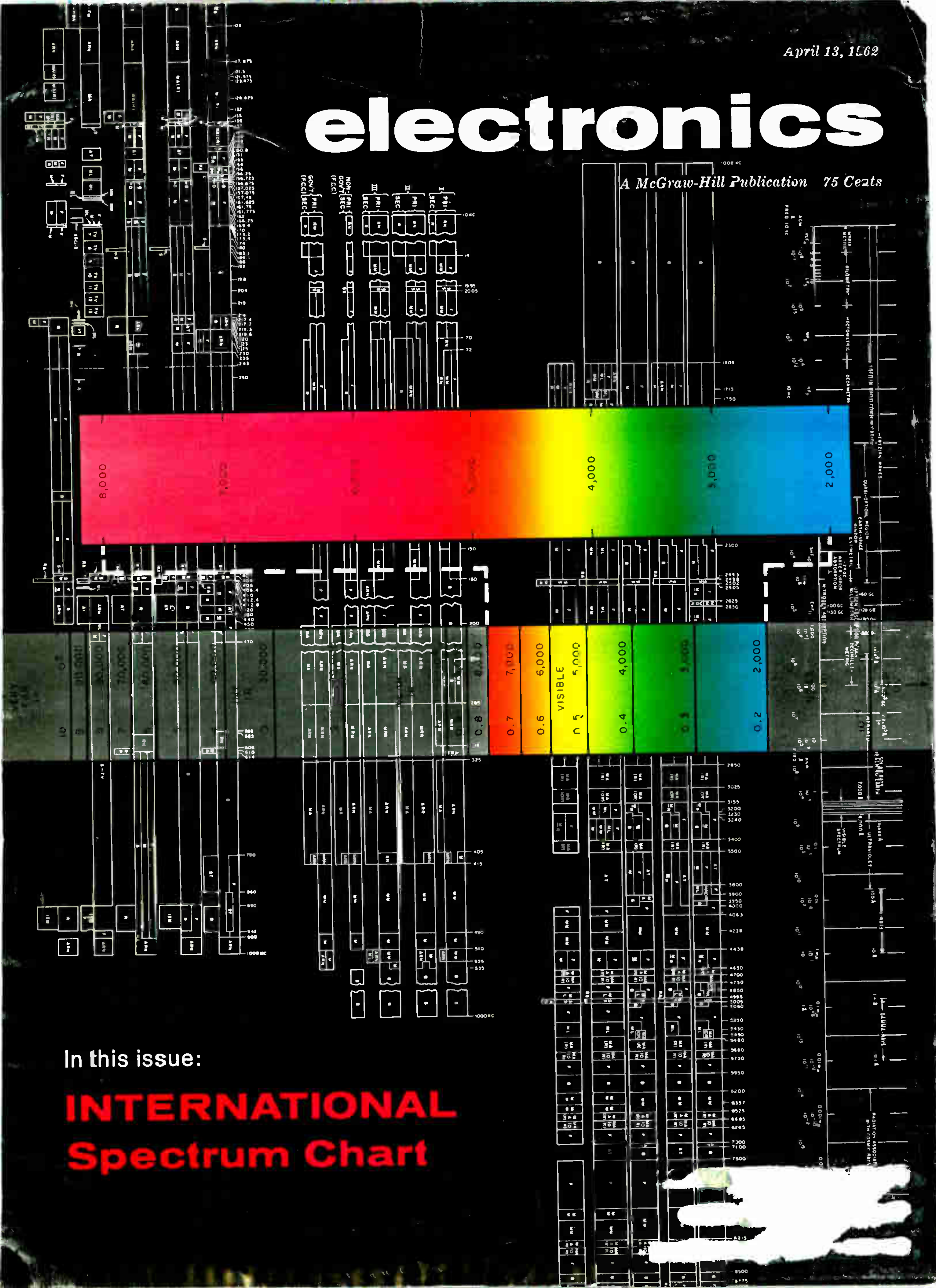


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## INTERNATIONAL Spectrum Chart

April 13, 1962

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W. W. MacDONALD, Editor





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**electronics**

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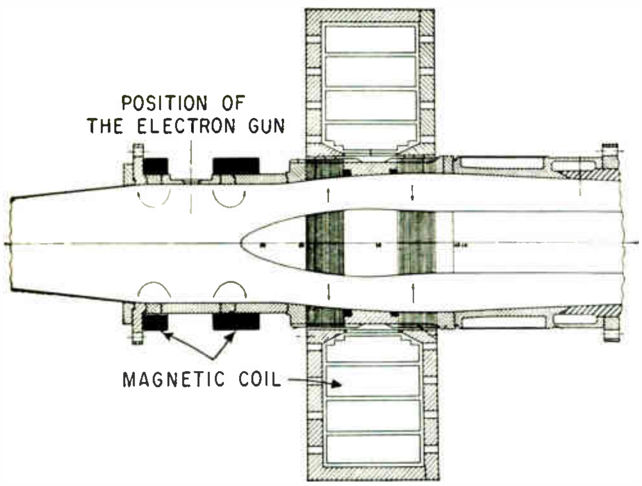
## DEPARTMENTS

# CROSSTALK




GUEST EDITOR. The rapidly expanding fields of electric propulsion, energy conversion, plasma diagnostics and communications, and controlled thermonuclear fusion research linked by the thread of magnetohydrodynamics (MHD) is of considerable interest to our industry. The potential impact, both technological and financial, is incalculable at present.

Best guess is that MHD research will generate numerous advances in hardware (measuring and control instrumentation), in space systems (longer range and more maneuverability), in defense (coping with the plasma sheath surrounding reentry vehicles), and in theory (electron optics, cosmology, and the action of magnetic fields upon gases).

But, let's face it, MHD is still a fairly esoteric field and keeping up with developments is hard work. Not that we are shirkers—we ran a three-part series on plasma engineering last year (p 47, July 14; p 33, Aug. 4; p 29, Sept. 1) and have had numerous articles and news items before and since then.

So we were delighted to learn that an acquaintance of one of our editors was chairman of the program committee of a national symposium on MHD and would be willing to cover the conference for us. The report, by George W. Sutton, a visiting professor at MIT, appears on page 26. Sutton is on leave of absence from GE, where he started an MHD power conversion program in 1958.

One of the interesting papers at the conference was a report by Bela Karlovitz on attempts made during 1932 to 1947 to develop an MHD generator. The engine, illustrated at left, did work, but its power output was too small. This is one problem that present-day experimenters seem well on their way to solving.

SHOELEATHER. Most everybody on our staff spent a day or so at the IRE Show last month. And most of us were content to dismiss the topic of mileage covered with the comment, "My feet hurt."

But not Assistant Editor Gray. He turned in a technical note:

Floor 1: 1.75 miles
Floor 2: 1.50 miles
Floor 3: 0.75 mile
Floor 4: 0.60 mile
Total: 4.60 miles

Mileage was recorded by a pedometer set for a 30-inch stride. However, Gray adds, since a 30-inch stride was difficult to achieve in the crowded aisles of the Coliseum and since the pedometer didn't register on-feet time spent in talking, a finagle factor must be applied. The factor depends on whether one wishes to maximize ("Boss, I really wore out my shoes covering that show") or minimize ("Doesn't take long for an experienced editor").

Not included in the total mileage are the steps at both ends of a bus trip to the Waldorf-Astoria to attend a technical session and then, because taxis were scarce and it was the nicest day in a month, walking back to the office: 2.1 miles.

## Coming in Our April 20 Issue

SWEPT FREQUENCY. Of increasing import because of the design flexibility that they permit are frequency-independent antennas. Next week, J. D. Dyson, of the University of Illinois, gives a lucid account of the development of these antennas and an outline of some of the problems yet to be overcome.

Another article, interesting for its humane as well as its engineering overtones, is a description by C. D. Valz, of the U. S. Bureau of Fisheries, of an underwater electric fence. The fence guides salmon to prevent them getting trapped in hydroelectric power turbines.

Other reports include a tunnel diode switching-time tester, by J. E. Gersbach and I. Lieber, of IBM, and preventing gaseous breakdown in microwave systems, by R. M. White and R. H. Stone, of GE.

## COMMENT

### Bionics: Models

One point I wish more people would make (though I think it would have been out of place in ELECTRONICS) is that when we make models, of the nervous system for example, we are limited by (at least) two factors: (1) the problem we are interested in and (2) the level of technology. Both of these being obvious, why insist? I think I can make my point clearer by analogy.

Art fakes that pass the best connoisseurs of one generation are easily detected by the ordinary interested amateur of the next. Not because there has been an elevation of taste or knowledge, but because the counterfeiter has provided only those elements in the picture which his contemporaries are looking for as "characteristic" of X, the artist he is faking.

The next generation sees how bad the counterfeit is, because it will be obsessed by something else, and will see as important some other characteristic of X. The counterfeiter cannot know and probably does not care what will obsess the next generation and so in these aspects will reveal himself, exposing the fraud.

When *we* think of the eye as an encoder rather than the optical instrument of 19th century physiology, do we do so because the eye is *really* one rather than the other, or because "encoder" better describes the answers to the questions *we* ask about the eye?

In both cases we are model-making and by its nature a model is incomplete, telling us as much or more about the interests of its creator than it does about the object it was constructed to explain.

The second point is only a different aspect of the first.

Lucretius described the motion of the stars in terms of a water wheel, which seems to have been introduced into the Mediterranean area during his lifetime (always include a classical reference for tone) and *we* describe the brain as a computer. If there are people still around 2,000 years from now, will his model seem any more primitive than ours?

I am not trying to denigrate what's being done in bionics, only trying to say that there should be a more conscious realization on the part of the people who are model-making (I realize this is only one part of bionics) of what it is they are doing.

There is such a neat illustration from moth behavior that I can't help quoting it, though it is only tenuously connected with the proceeding:

A moth flies by orienting himself with respect to light rays, that is, a moth "wanting" to go at a particular angle will fly so that the light rays incident on his receptors are all cut at this same angle. Now this works very well when the light source is infinitely distant, as the sun or moon, and the light rays consequently parallel. But when the light source is a candle or bulb, the rays diverge from a point and the locus that cuts each of these radii at the same angle will be a logarithmic spiral, either into the flame or out into space. Human beings, being more versatile, seem to be doing both at once.

Rereading the letter, I see I did not say that I liked the Bionics articles. It doesn't go without saying; I did.

LEONARD GREENSTONE
San Francisco, California

### Not a Ring Counter

Congratulations to your editors on a good job of condensing my report to the article, Magnetic-Core Ring Counter Needs No Drive (p 52, Mar. 23).

However, the title is incorrect. This circuit is not a ring-counter as commonly used. A ring-counter circuit accepts a series of input pulses and separates them in successive stages to provide sequenced output pulses or a single output pulse for each *n* input pulses. My circuit does not use any input pulses. It is an oscillator, which generates its own pulses and provides an output of timed and sequenced pulses suitable for triggering other circuits.

J. M. MARZOLF
U. S. Naval Research Laboratory
Washington, D. C.

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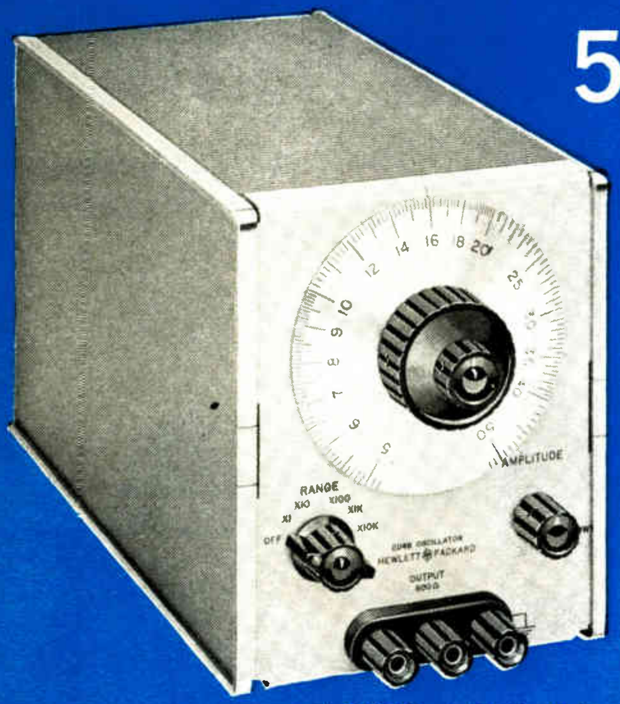


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Frequency stability over the entire 5 cps to 500 KC range is better than ±0.03%/°C from 0° to 55°C. Amplitude stability over rated frequency range and output levels is better than ±0.1% over 8 hours of operation at constant line voltage and temperature*; better than ±0.2% for line voltage changes of ±10%; better than ±0.1%/°C, 0-55°C.

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Designed in the new hp instrument module packaging, the 204B is only 6-3/32″ high, 5⅛″ wide and 8″ deep; weighs just 6 pounds! A new rack mount adapter holds three 204B oscillators or other hp instruments of the new modular design.

*On battery operation, stability −1% during battery depolarization, less than 30 minutes.

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| **Frequency Response:** | ± 3% with rated load |
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| **Noise:** | Less than 0.05% |
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# ELECTRONICS NEWSLETTER

## Space-Tracking System Expansion Planned

WASHINGTON—National Aeronautics and Space Administration plans to spend $158.4 million in fiscal year 1963 to beef up its tracking and data acquisition system, in preparation for a schedule that will produce at least 40 major space launchings annually by 1964. If Congress approves NASA's request, the money will be spent on:

Five new tracking stations costing, in all, $33.6 million; stations, not yet located, for the Gemini and Apollo manned space programs, $18.1 million; and for additional equipment at existing stations, $75 million. The rest of the money will be spread among other tracking and data acquisition projects.

The five new station locations are: Goldstone, Calif., $14.1 million; Rosman, N. C., $3 million; Woomera, Australia, and Johannesburg, South Africa, $5 million each; a Far Eastern station, $6.5 million. Where the station in the Far East will be located hasn't been decided. A NASA team is scouting possible sites.

## Phased Array Radar Ordered for Spadats

MULTIMILLION-DOLLAR contract to develop and test a phased array radar system to detect hostile satellites has been awarded Bendix's Radio division by the Air Force. When fully developed, the radar would become part of Spadats, the Space Detection and Tracking System (p 32, Nov. 24, 1961). The radar reportedly will be located in Florida so it can watch the equator.

## NAB Conventioneers See Four-Color tv Camera

CHICAGO—RCA showed an experimental fourth-color tv camera last week at the National Association of Broadcasters convention. A 4½-in. image orthicon, used in combination with three 1-in. chroma vidicons, is reported to supply the luminance needed for the sharp definition of four-color printing.

The bigger image orthicon is also used in a new monochrome camera that, RCA says, improves picture resolution, signal-to-noise ratio and gray scale rendition. A single zoom lens is used to avoid color balance problems, to reduce camera dollying and to facilitate remote control.

GE displayed a 4½-in. image orthicon studio camera that is convertible to a 3-in. tube for operating economy. The company's video switcher switches in a vertical blanking interval to eliminate transients for improved picture quality.

## Air Collision Avoidance System Is Under Study

LATEST ACTION by the Federal Aviation Agency in its long hunt for a system to prevent impending midair collisions: a $300,000 contract to Sperry Gyroscope to study a proposed system.

If successful, the system would predict collision courses between aircraft. An escape maneuver would be fed the autopilot. This would be done fast enough to avoid a crash with a third plane if the manuever is made in a high-density air traffic area.

Interrogator-transponder techniques would enable aircraft to exchange relative position and velocity data. One part of the system, an antenna with sufficient beam area and accuracy, has been successfully flight tested.

The system could also be used to display range and relative bearing of other planes for the pilot's evaluation.

## Next Window to Heaven A Big Venetian Blind?

STANFORD Radio Astronomy Institute is making a study, under a $222,000 grant from National Science Foundation, of radio telescope designs that would provide better resolution at lower cost. A proposed design is an echelon antenna resembling a huge venetian blind.

The "slats" would be independently tiltable, concave-faced elements with thin sheet metal surfaces, each 30 ft wide and 2,400 ft long. Sixty elements would have a total area of 90 acres, requiring a ground area of 130 acres—more space than Stanford has on its own antenna farm.

One advantage would be that while the telescope was being used, elements could be lengthened, new ones built or remote ones added.

## Hardened Antenna Rams Through Bomb Debris

DALLAS—Collins Radio has designed, to civil defense specifications, a retractable antenna for back-up voice communications after an atomic attack. The antenna is in

## Conelrad System to Be Superseded?

CHICAGO—A new national emergency communications network will be announced soon to supersede Conelrad, FCC Commissioner Robert Bartley reported at the NAB convention.

No firm announcement can be made at present, he said, because the system falls in the classified area of U. S.-Canadian relations.

Operated largely by private broadcasters, the new net would give the President direct access to radio communications from at least five locations in each state.

The FCC believes the government should pay for equipment required to set up the new civil defense network in privately owned stations, Bartley said a steel crib that fits into an underground concrete silo. Before the antenna is extended, a ram with a 5-ton thrust rises to clear away any rubble.

The antenna, a monopole, operates at 3 to 30 Mc without inductive loading or impedance matching devices. Instead, height is adjusted so it is ¼ wavelength at the operating frequency. Height is sensed by a dual-selsyn system that measures passage of a cable attached to the top of the telescoping element. Full height is 76 ft.

One peaceful use was suggested by Collins. Modified, it could be used on ships that have to pass under low bridges.

## Superconducting Magnet Goes in Telstar Maser

BOSTON—A maser using a superconducting magnet is being built by British Post Office engineers for the Telstar and Relay experimental satellite receiver under construction at Goonhilly Downs, England (p 26, Feb. 6).

Meanwhile, at the U. S. station in Andover, Me., the 340-ton horn antenna was checked out successfully. It picked up a signal bounced from a target six miles away.

This receiver uses a traveling-wave ruby maser. A closed-cycle system to provide a continuous supply of liquid helium to its dewar is being built by A. D. Little.

## FAA Tries Weather Net, Cockpit Voice Recorders

EXPERIMENTAL weather warning network, for short period forecasting at airports, is being studied at the Federal Aviation Agency's National Aviation Facilities Experimental Center, Atlantic City, N. J.

Digital data equipment, including 13 trailer-installed, semiautomatic weather stations linked to a central recording and control console, has been delivered to the center. The equipment was built by Datex Corp., under contracts totaling $842,000.

The unmanned mobile units will be stationed around an airport. Planes could be told earlier to land at alternate fields when the local weather conditions change.

The center is also evaluating cockpit voice recorders with magnetic cartridges in crash-proof housings. These would aid in determining crash causes. Four prototypes of one recorder have been delivered by United Data Control, Inc., under a $31,533 contract, and others are being designed by Lockheed Aircraft Service Co., Fairchild Camera and Instrument Corp. and Spec Tool Co.

## British Announce Pay Tv System Using Wire Lines

LONDON—Marconi's Wireless Telegraph, Ltd., has developed a closed-circuit wireline pay tv system for PayVision, Ltd.

The customer is connected into a wideband coaxial network by a program selector box plugged into the antenna socket. When he selects a program, with pushbuttons and by turning a key, the purchase information is telemetered back along the line to a central office.

Marconi says the technique will allow the network to carry up to 20 programs without the use of "on air" channels. Three channels will be offered initially. Programs can be transmitted in color or black and white.

## Japanese and American Joint Venture OK'd

TOKYO—Japan's Foreign Investment Council last week approved a joint venture here by General Precision and Mitsubishi Electric. Authorized capital is $4.05 million. Mitsubishi is contributing capital and manufacturing facilities, will own 60 percent of the new company. General Precision will contribute know-how and technical assistance and will own 40 percent.

The company, to be known as Mitsubishi Precision, Inc., will produce all General Precision products except tv and certain industrial control equipment. It will have exclusive manufacturing rights in Japan and marketing rights throughout the free world. Manufacturing will be done at Mitsubishi Electric facilities until a new plant under construction near Tokyo is completed.

# In Brief . . .

AFTER SEVERAL years of testing, Navy is going ahead with Ampex's pilot landing aid tv system to monitor and direct aircraft landings on carriers. Ampex has $270,000 contract.

MINNEAPOLIS-HONEYWELL has announced a magentic tape system for computers that reads and writes 186,000 decimal digits a second. It is compatible with company's slower-speed units.

AVCO will study advanced target discrimination techniques for Nike Zeus, under Bell Labs contract.

PHILIPS, The Netherlands, is raising its capital to 822 million guilders with a stock issue for 137 million guilders.

ELECTRO NUCLEAR Systems Corp. has $85,000 Navy contract for R&D on display system to present digital information in real time and in variety of colors.

ALUMINIUM LTD. will link its plants in Canada, U. S. and England with an ITT automatic data exchange.

AIR FORCE has given GE an additional contract for $4.8 million for production of Advent communications satellite vehicles.

MAJOR MISSILE contracts include $3.6 million to Ford Motor for Shillelagh R&D; $1.9 million to Martin for Pershing simulator components; $1.5 million to Sylvania for communications at Atlas bases; over $1 million to Guidance Technology for spring-driven gyros for Bullpup.

AUTONETICS has a $1.5 million contract from Minneapolis-Honeywell for computers and guidance equipment for DynaSoar.

NATIONAL CO. has a $2.4 million Air Force contract for troposcatter communications equipment.

HUGHES has ordered a $1 million space simulation chamber from Clauser Technology.

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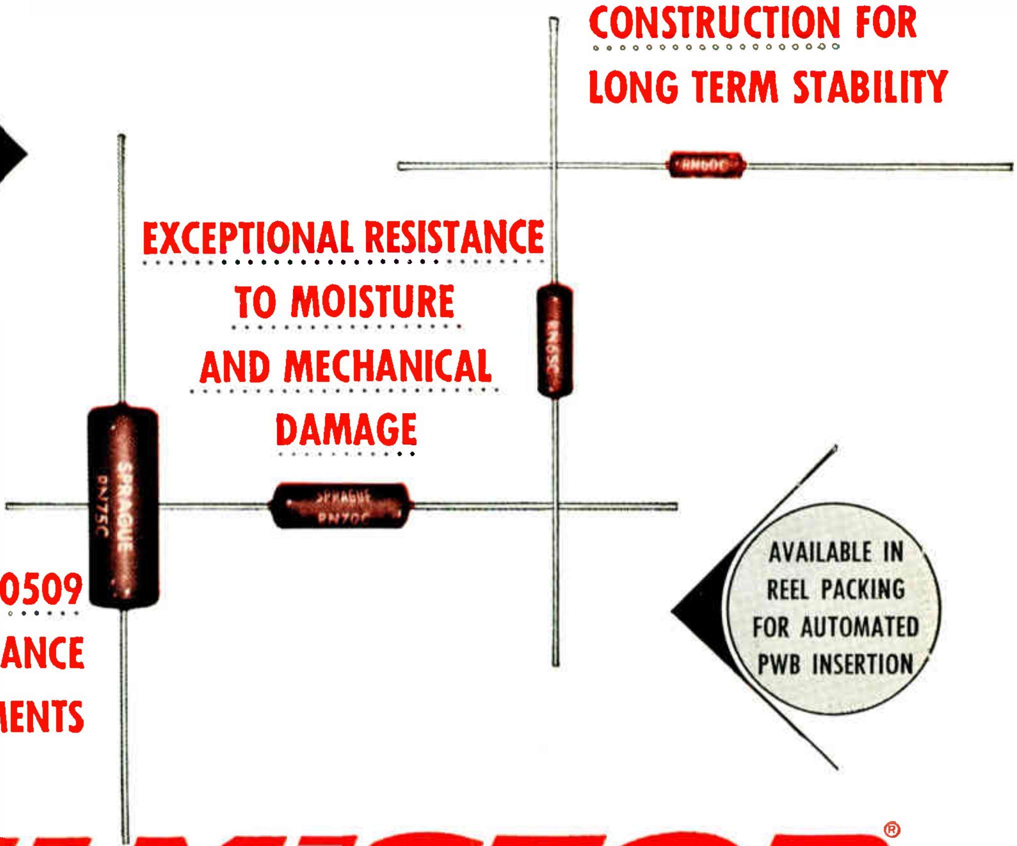

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# WASHINGTON OUTLOOK

**EIA LISTS TRADE LAW PROTESTS**

ELECTRONIC INDUSTRIES ASSOCIATION supports "in principle" the objectives of the new trade bill, H.R. 9900, but "strongly opposes" many of its major provisions, Robert C. Sprague, of Sprague Electric, chairman of EIA's Imports Committee, told the House Ways and Means Committee last week. He cited these specific objections:

Unprecedented economic authority is given the President, who could reduce tariffs without review or veto by Congress; there is no guarantee that tariffs and other concessions will be negotiated under rules assuring true reciprocity—elimination of such restrictions as quotas, extra taxes and import licenses, imposed by other countries; escape clause and peril point protective procedures to safeguard industry are practically eliminated; subsidy approach to help companies hurt by imports is impractical and objectionable.

**TARIFF POWERS MAY BE REDUCED**

CONTROVERSIAL SECTIONS of the trade bill, constantly criticized during the hearings, may be resolved by compromises or more precise language before the House committee sends the bill to the floor sometime next month. Here are some potential changes:

H.R. 9990 makes it much tougher than present laws for a company injured by imports to get a hearing for higher tariffs. Entire industries must be affected and a company needs a strong case. Many congressmen think it unfair to vastly increase tariff-cutting powers and then limit a company's chance for import protection. An escape clause may be added.

The President could in five years eliminate tariffs on a product if the U. S. and European Common Market control 80 percent of trade in that product. The committee may set more precise limitations and directives on what products are affected.

Industrial witnesses fear government negotiators, if inexperienced in an industry's problem, may make disastrous concessions. The committee may require an industry advisor on the negotiating team whenever that industry's products are up for possible tariff cuts.

Language in the "trade adjustment" section may be spelled out more carefully, with modifications in the power to subsidize industries injured by imports.

**INDUSTRY ADVISORS PROPOSED**

ALMOST UNQUALIFIED SUPPORT for H.R. 9900 was given by Charles F. Adams, Raytheon president. By reducing European tariffs, considerable business can be gained there, he said, and to get tariffs down, the President must have ample authority to negotiate. Adams was concerned about giving the President so much power, but thought that effective restrictions could place U. S. negotiators "in a sort of strait jacket." He suggested this dilemma could be at least partially solved by the use of industry advisors on the negotiating team.

**PENTAGON PURCHASES?**

PRESSURES ARE BEING GENERATED to have the Pentagon order major system components directly from producers instead of allowing prime contractors to buy them from subcontractors. How this might be done hasn't yet been proposed. Origin of the pressures is the much-publicized inquiry by the Senate Investigations Subcommittee probing the alleged "pyramiding" of profits on missile work.

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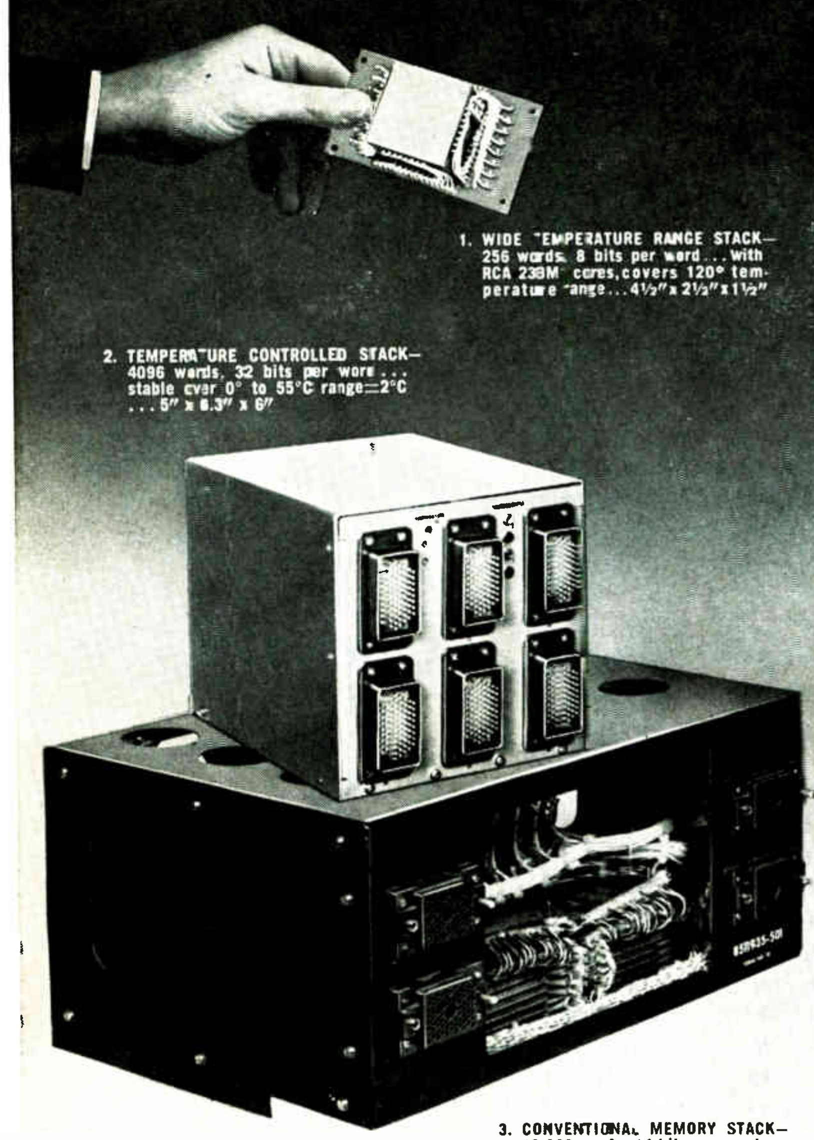


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1. **Wide-Temperature-Range Stacks.** New RCA temperature-stable ferrite core 233M1 permits the construction of planes and stacks that require no peripheral temperature-control equipment. In those applications where small size, minimum weight and reduced peripheral equipment are required, these devices can achieve vital space and cost savings.

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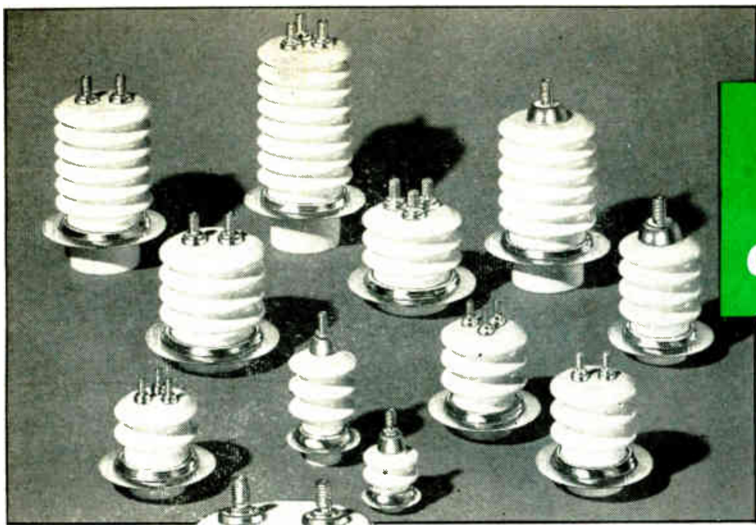

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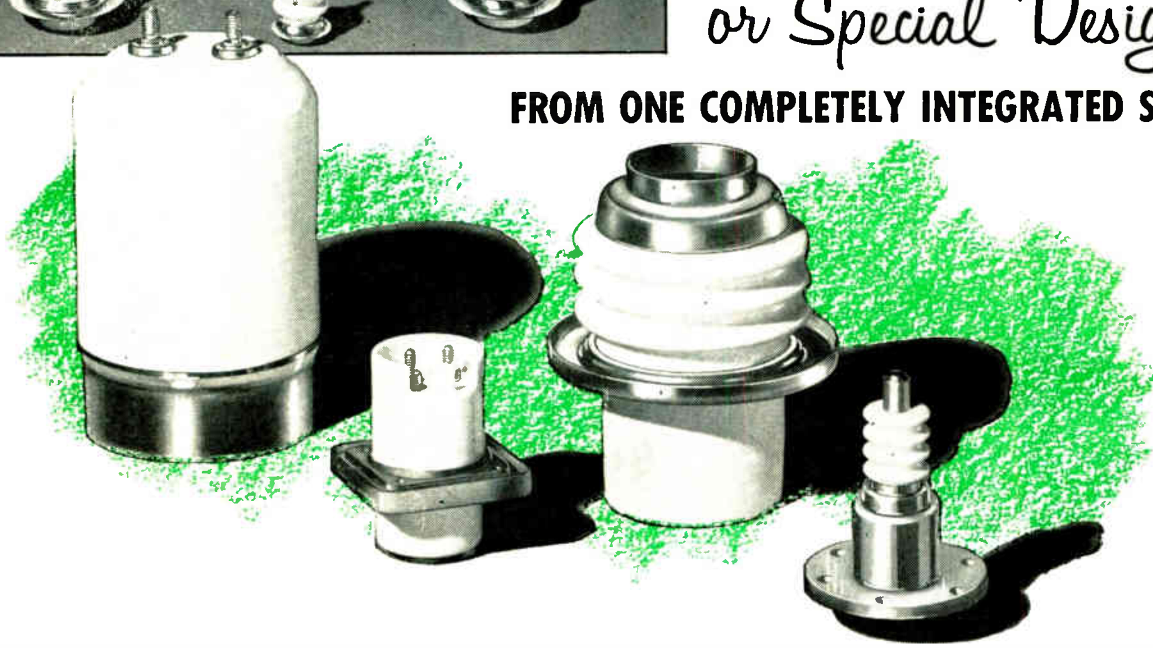

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*The old and the new: 60-ft precision parabolic antenna for orbital scatter experiments stands next to idle troposcatter antenna*

# Dicon Will Test Orbiting Dipoles as Path for Data

BOSTON—One experiment awaiting resumption of Project West Ford (ELECTRONICS, p 7, Mar. 16) is Dicon (Digital Communications through Orbiting Needles). Dicon is designed to demonstrate applicability of the West Ford channel as a high-capacity digital data link and to measure performance under a variety of modulation signals.

Ready at MIT Lincoln Lab's field site at Camp Parks, Calif., is a transmitter with 33 frequency oscillators. A 35-channel receiver has been built at the Millstone Hill station, in Westford, Mass. Dicon has 32 information channels. The 33rd transmitter oscillator is for synchronization pulses. Of the three extra receiver channels one is for timing and two are for frequency control.

Dicon's maximum data rate is 50,000 bits/sec, using 20 $\mu$sec pulses for each digit and cycling through as many as 16 pairs of frequencies to avoid intersymbol interference due to multipath and to combat selective fading.

It is expected that the principal sources of signal corruption in the West Ford channel will be multipath delay and Doppler shift and spread. The receiver uses the 33rd or sync frequency to compensate for changes in Doppler shift and path length.

For any given information digit, a rectangular r-f pulse is transmitted by using one of a pair of frequencies, depending on whether the digit is ZERO or ONE. A receiver channel tuned to each of the two frequencies measures the energy received. That channel detecting the larger energy is judged to be the one containing the signal.

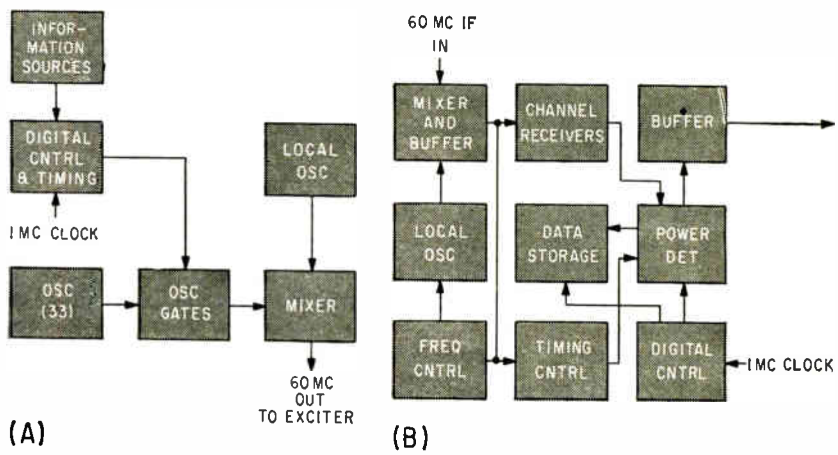
The information signal at the transmitter can be derived from a fixed 16-bit word, which is used for error-rate measurements; from a standard 60-wpm teletypewriter through code-matching logic; from digital voice-encoding equipment; or from any other live source transmitting at a suitable rate.

The basic Dicon word contains 17 pulse intervals of identical duration, called bauds after the traditional unit of telegraph signal speed. The first baud contains the sync frequency; and the remaining 16 contain selections from the data frequency pairs. Baud lengths vary from a minimum of 20 $\mu$sec to a maximum of 2.56 msec by factors of two.

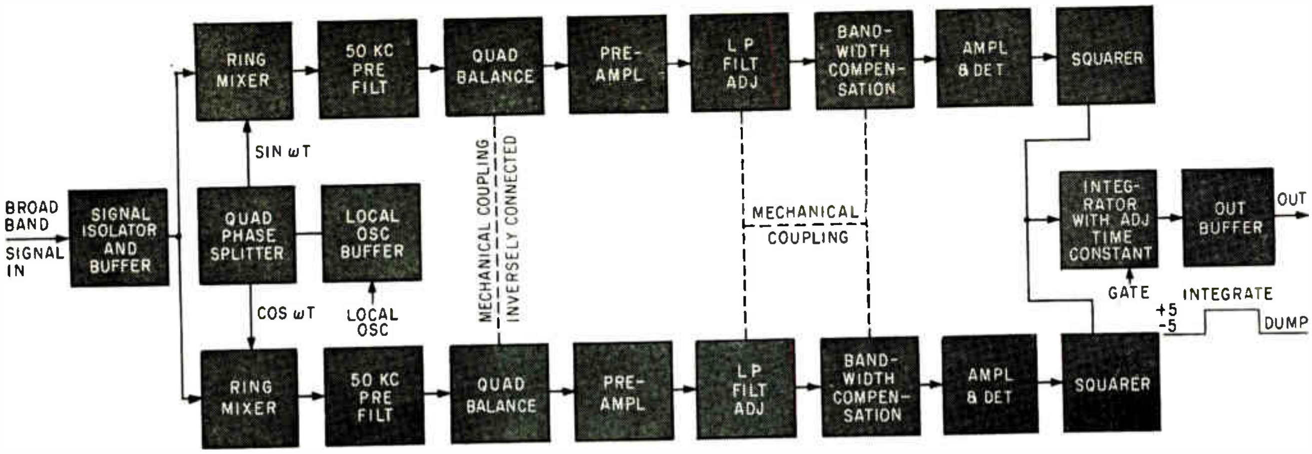
The transmitter, which generates fsk-type modulation, consists of 33 oscillators for transmitting data and sync bauds and a digital control for selecting the appropriate oscillator outputs during each baud interval. Modulation is generated in a band of about 4 Mc, centered at 8 Mc, and then translated up to the intermediate frequency of 60 Mc, at which it is fed to the r-f exciter.

In the Dicon receiver the signal obtained from the r-f receiver is centered at $60+f_D$ Mc, where $f_D$ is the Doppler shift. It is converted to a signal of the same bandwidth but centered at 8 Mc, the band in which it was generated. At this point the signals are at the correct center frequencies for the bank of channel receivers.

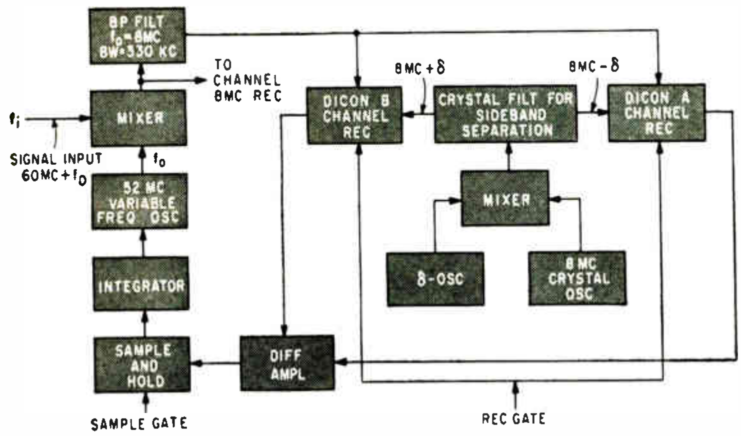
Acquisition is performed by frequency searching for the sync signal. The frequency control loop is opened and the frequency of the variable frequency oscillator is controlled by a locally-generated triangular sweep waveform. Sweep range and rate are adjustable. If the time tracking circuit detects



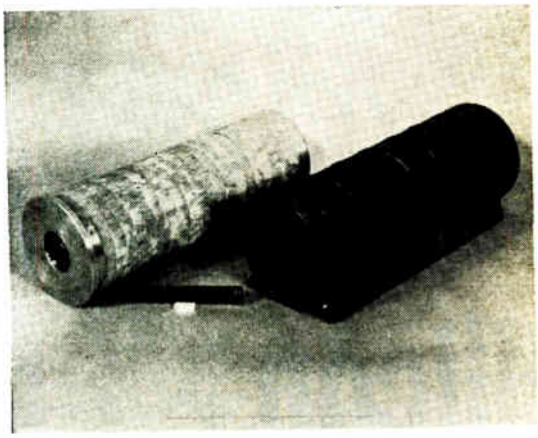

*Fsk-modulated transmitter (A) and receiver (B). Receiver is designed to recover signal and measure errors*




*Preselection of channel receivers is accomplished in a group of 35 bandpass filters external to the receivers*




*Dicon frequency-tracking circuit. Frequency discriminator section at right measures the energy difference in two equal and adjacent frequency bands*



*Dipole dispenser used in first trial. New dispenser will be instrumented to disperse fibers on command and monitor dispersal*

the presence of the sync pulse, it generates a signal which is fed back to the frequency tracking circuit. This feedback signal interrupts the search mode of the variable frequency oscillator and closes the frequency control loop, thereby enabling automatic frequency control.

The Dicon system uses agc to keep the output of the sync receiver constant, as required by the digital integrator, and simultaneously to maintain a satisfactory signal level at the inputs to the 32 channel receivers. The receivers are designed to measure r-f energy within a given bandwidth, manually adjustable, and during a selected interval of time, controlled by an externally generated gate.

The power detector and bit decision section sample the receiver at the proper times and transmit to the data-processing equipment the sequence of received binary digits. Decisions are based on energy measurements.

The channel receiver outputs are selected by a set of 32 analog gates, controlled by logic levels. The frequency assignment and frequency selection plugboards determine the sequence in which the gates are opened. Sixteen channel receivers are tuned to frequencies designating ONES and these are connected to the 16 gates that make up the ONE selector. Depending upon the mode of operation, one, two, or four gates may be open at a time. The gate outputs feed through averaging resistors to the high impedance input of a voltage follower. Closed gates have a high impedance and do not affect the average. The 16 ZERO channels are connected to the ZERO selector in the same way. The outputs of the two voltage followers are subtracted in a difference amplifier whose output voltage is between −10 and +10 volts. The absolute value of this voltage depends on the signal-to-noise ratio, and its polarity determines the decision of the output bit.

This description was abstracted from a Lincoln Laboratory report edited by N. L. Dagget.—TM

---

*LUNAR SUBSTITUTE*

*After the first West Ford trial failed because the dipole dispenser did not spin and disperse the dipoles, Dicon was tested using the moon as a relay. Digital data was transmitted at 50,000 bits a second. Tests with live teletypewriter signals have not approached the system's capacity. Highly redundant and correspondingly reliable transmissions were made at rates of 780 bits a second, equivalent to about 21 channels*

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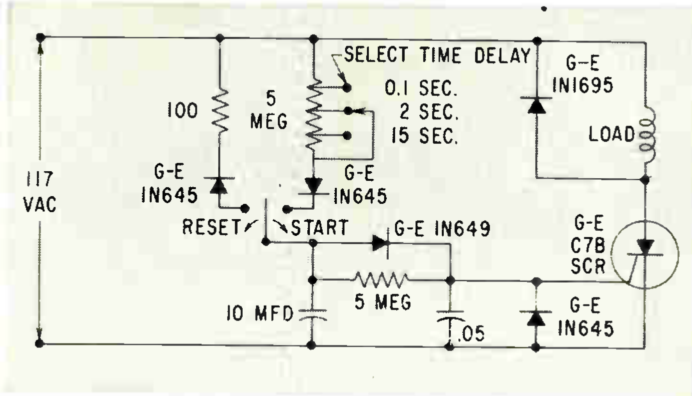


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- operates directly from standard 117 volt AC line
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- circuits also available for DC supplies
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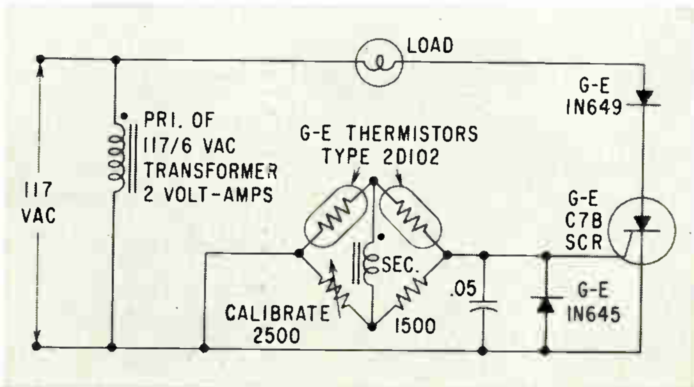


**TYPICAL SENSING/SWITCHING CIRCUIT APPLICATIONS:**

- constant temperature controls
- differential temperature controls
- flow controls
- light level controls
- position controls
- proximity switches
- alarm system
- radiation detectors
- liquid level controls
- stress detectors

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In addition to the C7, General Electric offers two other levels of gate sensitivity in the TO-5 package: the C5 series (200 ua max. gate current to fire) and the 2N1595-99 series (10 ma max. gate supply current to fire). Your G-E Semiconductor Products District Sales Manager can give you complete technical information on these TO-5 packaged SCR's. Or write Rectifier Components Department, Section 16067, General Electric Company, Auburn, 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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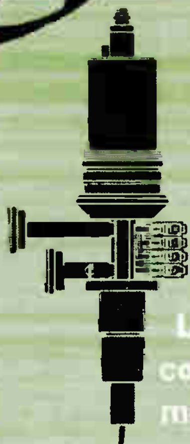

**This Arabic script means "Long Life." For people who deal with complex microwave problems, "long life" means Varian klystrons—pulse, CW, reflex.**

Simplicity of design, ruggedness, and precision manufacture make possible these histories: On Spruce Mountain, Nevada, a VA-220 reflex oscillator klystron was installed in 1956 in a TV transmission system. It has been operating unattended for more than 33,000 hours. Near the Arctic Circle, VA-842 super-power klystrons were installed in 1960 in a classified radar network. Eight tubes had reached 10,000 hours operation by December, 1961. In Norway, VA-800C CW amplifier klystrons were installed in 1958 in HOTLINE, a link in a NATO troposcatter system. Six tubes are still going after 10,000 hours; one has reached 20,000 hours. If your microwave system design calls for tubes that *last,* contact Tube Division.

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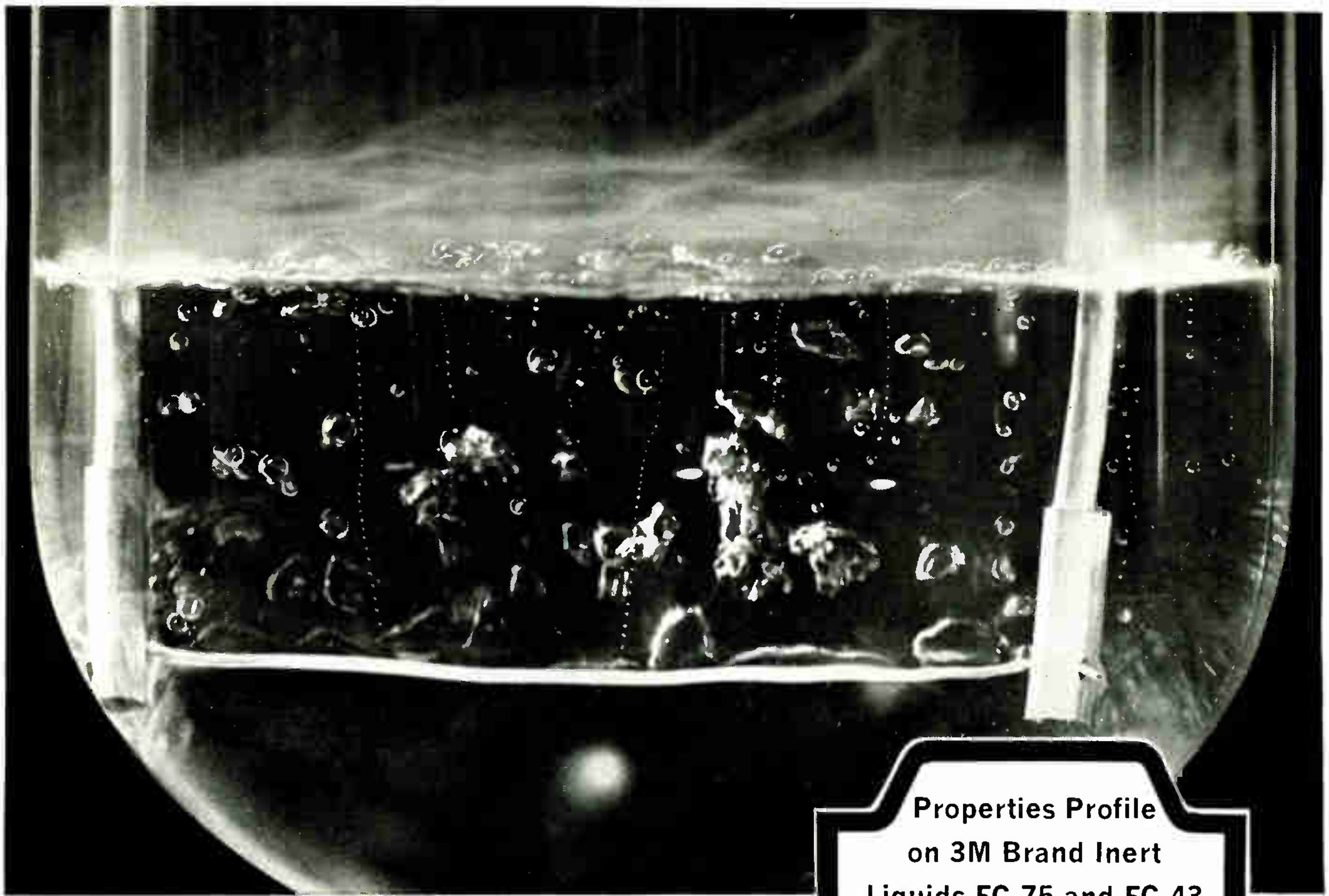
**CIRCLE 23 ON READER SERVICE CARD**

Chemical Division 3M COMPANY



# Heat Fluxes (150-500 watts/in.$^2$) no problem when FC-75 cools components!

Using Inert Fluorochemical Liquid FC-75 as a heat transfer medium for cooling electronic gear, designers can practically eliminate hot-spot problems. Heat fluxes—from 150 to 500 watts per square inch, for example—can be handled by this coolant with minimal changes in temperature of components.

FC-75's low boiling point (214°F) permits a high heat transfer rate by evaporation, as illustrated above. Hot spots in a component part attain a temperature above the boiling point of the FC-75, then remain relatively constant. Because of the rapid transfer of heat from the component by the boiling FC-75, burn-out dangers are minimized.

FC-75, as well as its companion product FC-43, are at their best when equipment is specifically designed around their remarkable cooling abilities. FC-75 can remove up to 10 times more heat than such coolants as transformer oil. Thus new designs using FC-75 can drastically reduce the size of electronic units. Design space-savings up to a factor of six have been achieved.

FC-75 is stable up to 750°F and is completely compatible with most materials. It is non-explosive, non-flammable, non-toxic, odorless, and non-corrosive. Unimpaired by arcing, it heals itself in either the liquid or vapor state. Because of its thermal stability, no sludges are formed. Write for further information, and for specific application details.

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## Properties Profile on 3M Brand Inert Liquids FC-75 and FC-43

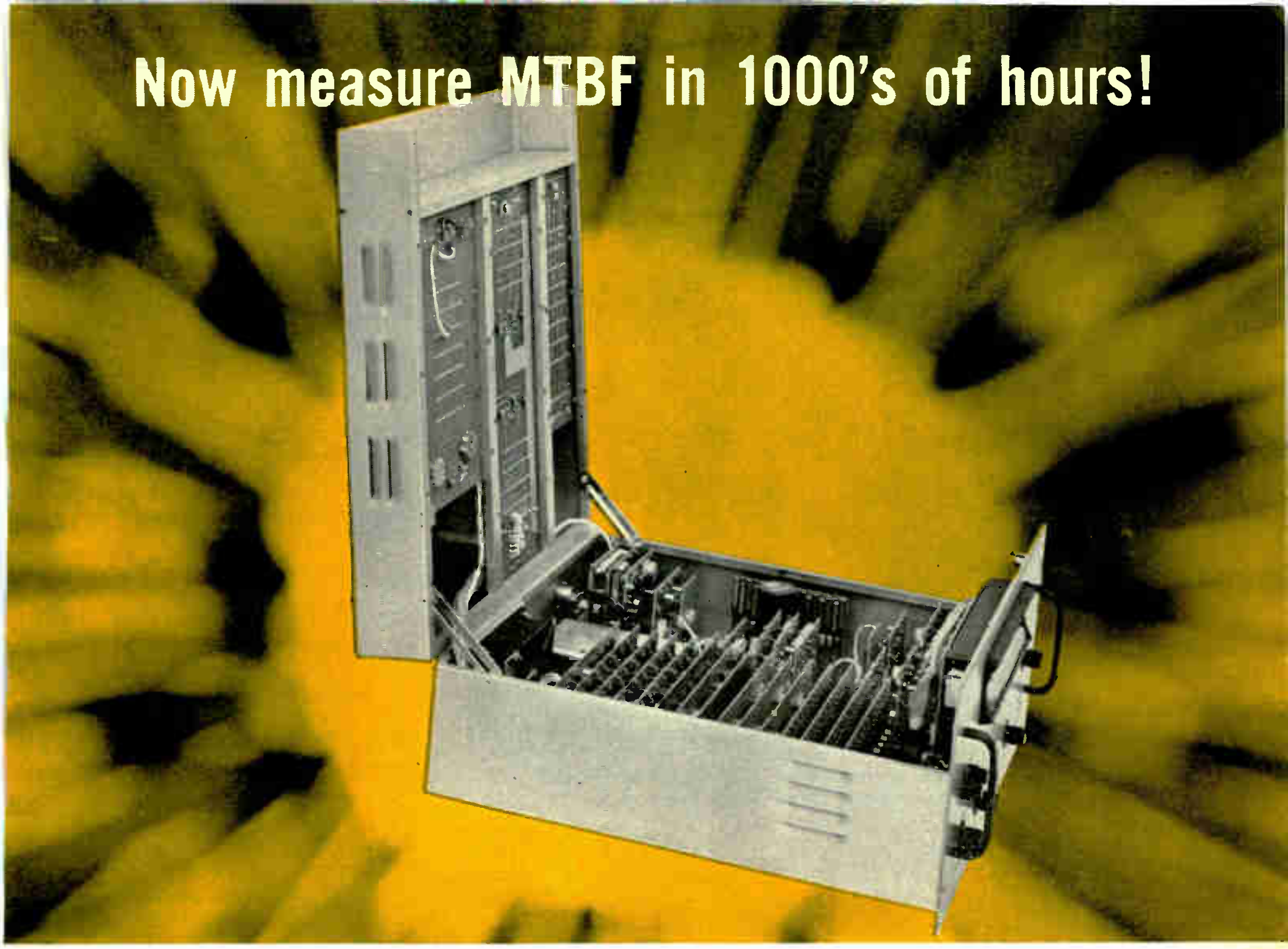
### ELECTRICAL PROPERTIES

| | FC-75 | FC-43 |
|---|---|---|
| Electrical Strength | 35KV | 35KV |
| Dielectric Constant (1 to 40 KC @ 75°F) | 1.86 | 1.86 |
| Dissipation Factor (1000 cycles) | <0.0005 | <0.0005 |

### TYPICAL PHYSICAL PROPERTIES

| | FC-75 | FC-43 |
|---|---|---|
| Pour Point | <−100°F | -58°F |
| Boiling Point | 212°F | 340°F |
| Density | 1.77 | 1.88 |
| Surface Tension (77°F) (dynes/cm) | 15 | 16 |
| Viscosity Centistokes (77°F) | 0.65 Min. | 2.74 |
| Thermal Stability | 750°F | 600°F |
| Chemical Stability | Inert | Inert |
| Radiation Resistance | 25% change @ 1 x $10^8$ rads | 25% change @ 1 x $10^8$ rads |

*For more information on FC-75 and FC-43, write today, stating area of interest to: 3M Chemical Division, Dept. KAX-42, St. Paul 1, Minn.*




# These 7 Eitronic design concepts set a new standard for digital instrument reliability

*Accelerated aging, equivalent to 100 hours of actual use, eliminates 98% of possible component failures*

**All-Electronic Switching**—Eitronic logic is all solid state. No rotating elements, no metal fatigue, no contacts to clatter and wear. Just cool, silent, reliable operation.

**Conductance Adder Logic**—Eitronic logic operates continuously without errors or downtime due to wear. Varying voltages are quietly tracked. Operator reads *exact* voltages instantly.

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**Careful Component Selection**—The costlier, high quality components used in Eitronic instruments are carefully selected based upon the findings of our own component evaluation tests. Completed circuit boards are then rigorously tested numerous times during assembly.

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**Modular Internal Design**—The modular approach permits exhaustive "pyramid" testing of components and assemblies during manufacture to assure field reliability.

**Unique Mechanical Design**—Use of an exclusive "fliptop" design permits multiple measuring functions within a single package. Heat sinks coupled with built-in cooling devices insure component operation within rated temperature tolerances.

Your EI field engineer will be pleased to demonstrate any of the models in the Eitronic Series: Single and multiple function instruments capable of measuring AC volts, DC volts, DC ratios and resistance in either 4 or 5 digit models.

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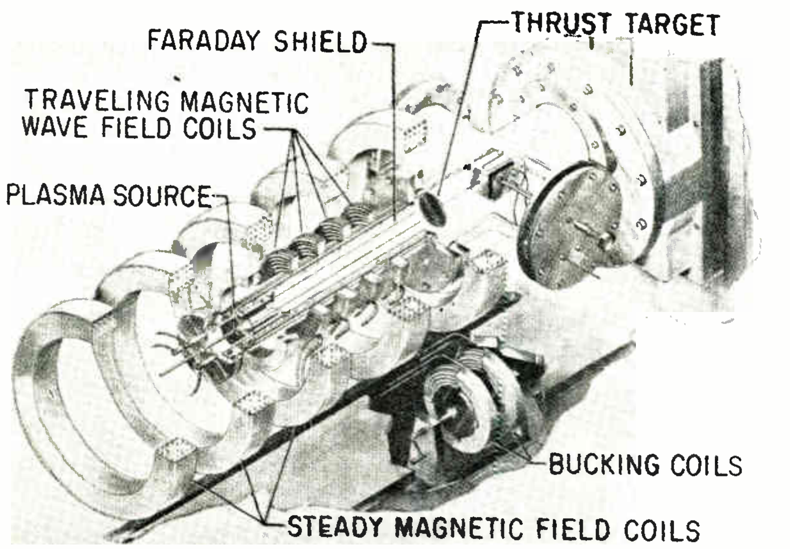
*Engineers: Challenging opportunity now available. Contact Mr. Harvey Fleming.*

# MHD Engine Uses Traveling Wave

*Efficiency of developmental magnetohydrodynamic device is now only three percent, compared to 50 to 60 percent for pulsed-type accelerators*




*Traveling magnetic wave plasma engine under development at National Aeronautic's and Space Administration's Lewis Research Center*


By GEORGE W. SUTTON

Associate Professor of Mechanical Engineering, (Visiting)*, Massachusetts Institute of Technology


ROCHESTER—New data on applications of magnetohydrodynamics to flight and power conversion highlighted the recent Third Annual Symposium on the Engineering Aspects of Magnetohydrodynamics. Sponsored by the AIEE, Institute of the Aerospace Sciences, IRE and University of Rochester, the symposium featured a round table discussion on high current particle beams and sessions on flight applications, energy conversion, diagnostics and communications, and fusion. It drew approximately 300 engineers and scientists.

At the session on flight applications, R. E. Jones and R. W. Palmer, of NASA's Lewis Research Center, presented measurements of energy efficiency of up to 3 percent and specific impulse of 1,000 in a traveling-wave engine. The engine has four 150-Kc field coils mounted coaxially around a discharge tube (see figure). They provide a time-varying magnetic field which induces currents in the ionized gas that result in a repulsive force to accelerate the plasma. A new engine is being designed to give higher efficiencies.

A novel MHD engine was described by David Miller, of GE's Space Science laboratory. Gas is

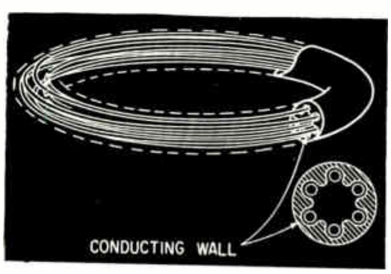
*On leave of absence from GE Space Science Laboratory

## Multipole Toroid Confines Plasma

TECHNIQUE that may solve some key problems in controlled thermonuclear fusion was described at the recent American Power Conference in Chicago by D. W. Kerst, of General Dynamics. Kerst suggested that a toroidal multipole structure developed by T. Ohkawa of the General Atomic division should be able to contain a high plasma pressure.

In the toroidal multipole structure (see sketch) internal conductors are used to form a simple multipole magnetic field that will confine the plasma. The system is similar to a stellarator (ELECTRONICS, p 29, Sept. 1, 1961) without a circumferential field through the plasma. It reportedly overcomes the drift problems associated with stellarators and other toroidal systems.

Stellarators use external conductors. Using internal conductors in the toroidal multipole system will pose construction problems different from those of stellarators. But the problems are not expected to be serious obstacles to this confinement method.




*Transparent view of multipole structure developed at General Atomic*

The work was carried out under a joint General Atomic-Texas Atomic Energy Research Foundation program on controlled thermonuclear reactions.

admitted into the high magnetic field end of a magnetic mirror, and then ionized and heated by electron cyclotron resonance. The diverging magnetic lines act as a nozzle for the electrons. The ions are then accelerated by the resulting space charge.

Two papers on pulsed-type accelerators, by Michel Maes, of Rocket Research Corp., and Per Gloersen, of GE's Space Science Laboratory, indicate specific impulses of 5,000 to 10,000 at 50 to 60 percent efficiencies have been achieved for runs up to several days with little component problems.

W. T. Hogan, of the MIT Magnetogasdynamics Laboratory, described experiments on a crossed-field Lorentz-force accelerator in a shock tube. Using a megawatt of power, Hogan was able to triple the gas velocity to 12,000 meters a second, with an efficiency of 60 percent.

The round table discussion centered on high energy ion beams, used for ion propulsion and to inject plasmas into magnetic mirrors for studies of controlled thermonuclear fusion. All agreed that in laboratory experiments beam neutralization was no problem, but there is still disagreement as to whether this may be a problem for an ion engine that is used in outer space.

John Luce, of Aerojet General, and Russell Meyerand, Jr., of United Aircraft, showed that the Langmuir-Childs limitation on current can be circumvented by injecting electrons with the correct energy which neutralizes the space-charge effect. In the Penning-type discharge under development by Meyerand, (ELECTRONICS, p 47, July 14, 1961) ion reflectors at the forward end can be used to increase the efficiency when used as an ion propulsion engine.

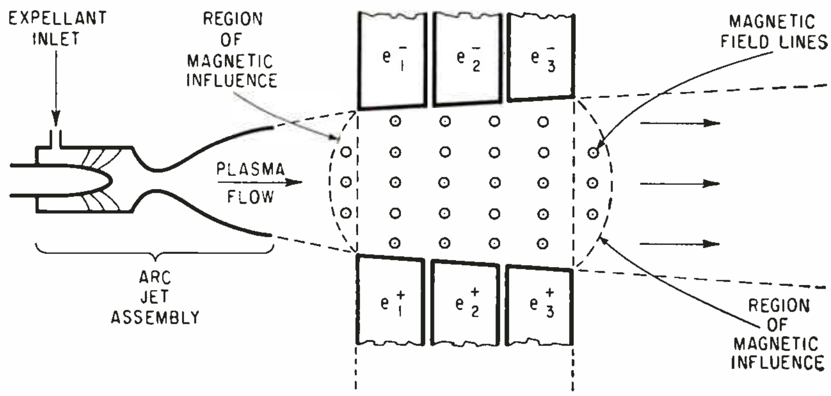
Several investigators described recent work with duoplasmatron (Von Ardenne) ion sources. T. Forrester, of Electro-Optical, pointed out the geometric similarity of the duoplasmatron to an ion engine which uses a porous tungsten plate as the ionizing source. Forrester claimed that with a porous tungsten ionizer there is no upper limit to the beam current, while with the duoplasmatron, beam currents up to ½ amp have been achieved at 600 Kv, with a goal of 10 amps.

The early history of experiments on MHD power generation was given by Bela Karlovitz, of Combustion and Explosive Research, who described his work from 1932 to 1947 at Westinghouse. The generator design was extremely sophisticated even by today's standards, but the power generated was small because of insufficient ionization of the gas. The present ionization technique is thermal ionization which is obtained by increasing the combustion temperature by preheating and oxygen enrichment; using this technique, T. R. Brogan, of Avco Research Laboratory has generated 600 kilowatts for a short time. A materials test stand is being built for use in solving materials problems. Although the overall thermal efficiency is predicted to be 52.5 percent, a study by J. J. W. Brown, of GE, showed that the capital cost is too high to make MHD power economic at present, but according to Brogan cost estimates cannot yet be made.

A different method of achieving sufficient ionization was described by E. J. Sternglass, of Westinghouse. Here the working gas selected has a low electron deionization time and ionization is achieved by high energy electron beams. This is similar to the technique unsuccessfully tried by Karlovitz.

Successful operation of a Hall generator was reported by L. P. Harris, of GE Research Lab. In a Hall generator, Hall current is tapped off and fed to the load instead of the Faraday current as in most generators. Performance agreed with theoretical predictions.

# "Afterburner" Improves Plasma Engine




*Accelerator increases thrust of plasma stream*

ADDING a magnetogasdynamic accelerator to a thermal arc jet plasma generator may result in a practical space propulsion engine having a thrust of 1 to 10 pounds, reports Northrop's Space Propulsion and Power Lab. The plasma generator's propulsion performance is increased by converting electrical input immediately into kinetic energy instead of thermal energy.

At present, the plasma generator works at about 50 percent efficiency in heating a propellant gas with a continuous electrical discharge before expanding it through a nozzle. The accelerator acts like an afterburner on a turbojet engine, to attain higher velocity thrust.

Conducting gas from the generator is exposed to currents between electrode pairs perpendicularly oriented to gas flow and an applied magnetic field. A Lorentz force on the plasma, in a direction paralleling flow direction, increases thrust by increasing plasma pressure.

High thrust levels at high efficiency, are obtained with high electrode currents and moderate magnetic fields. Thrust and efficiency were found to increase with magnetic flux until flux reaches almost three kilogauss. Further increases in magnetic flux sharply lower thrust and efficiency.

Forty percent of the accelerator's energy input is figured as going into increasing the kinetic energy of the plasma gas, 30 percent heats the electrodes and 30 percent dissociates or ionizes the plasma.

Cooling the electrodes may make the accelerator an efficient, long-life propulsion device (aluminum electrode holders acted as heat sinks).

During studies of electrode discharge characteristics, electrode current was observed to actually pass through the plasma stream even though the main plasma core was a half inch from electrode surfaces. This implies that the luminous core is surrounded by a conducting sheath of outwardly diffused electrons. Existence of the conducting sheath was verified by measuring gap conductance and electrode drag as a function of electrode spacing.

Effect of electrode configuration on discharge stability, thrust and efficiency was studied using one inch-square pure tungsten bars. Arraying bars in a staircase pattern and using a serrated cathode were found to improve stability.

# NASA Tries Telemetry Firsts

RECORD IN MISSILE telemetry is planned for the first Centaur launch vehicle test. The big booster was scheduled for firing atop an Atlas at Cape Canaveral this week.

Some 540 channels of information—a new high, NASA says—were to be radioed back from the rocket during its 15-min, 1,175-mi flight down the Atlantic Missile Range. In addition, the first known attempt was to be made to receive and record tv images of an internal vehicle function.

Of the 540 telemetry channels, about 400 are devoted to the upper stage of the vehicle. The 140 booster measurements are primarily to record engine and guidance functions, plus standard vibration, bending and temperature measurements.

Most top stage instruments gather data on engine sequencing, autopilot operation and the reaction of a partial tank of hydrogen at zero gravity. A "Christmas tree," in the hydrogen tank will indicate fuel movements. The tree is a metal skeleton extending the length of the tank. Each of its limbs is equipped with liquid sensors.

A small, cylindrical tv camera mounted in the tank bulkhead monitors hydrogen reaction. It takes a picture every two seconds. The signal transmitted to ground is recorded on tape, then converted to tv and motion pictures for study. A 100-Kw strobe lights each exposure.

The inertial guidance system is primarily a four-gimbal platform stabilized by three gyros, plus a general purpose digital computer with a 2,560-word memory. Autopilot commands are computed by position, velocity and acceleration data comparisons with precalculated mission requirements. The autopilot steers the vehicle through the engine gimbals until sustainer engine cutoff.

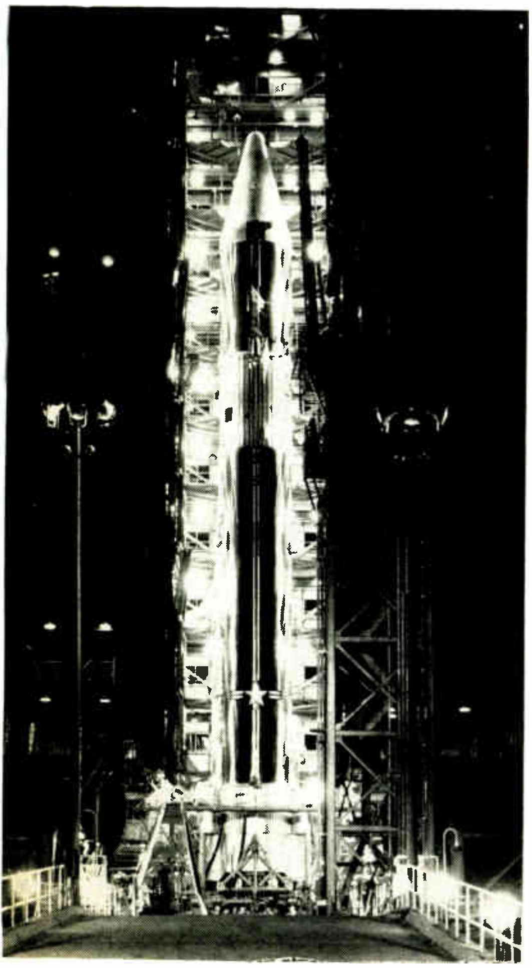
After first stage separation, the autopilot is responsible for second stage flight control. It accepts signals from the guidance system and initiates such events as engine starts and payload separation (the latter does not occur in this first test). During coast periods the guidance system is cut off, except for a timer.

Minneapolis-Honeywell designed the inertial guidance system and built the stabilized platform. Librascope provided the guidance computer; Texas Instruments, the telemetry; Hallamore Electronics, the tv camera, and Bell Aerospace, the $H_2O_2$ attitude controls.

Centaur is being developed by General Dynamics/Astronautics under technical direction of Marshall Space Flight Center.

At present, R&D flights are scheduled for Centaur through 1963. Later flights will launch a variety of spacecraft including NASA's Mariner interplanetary probes and Surveyor lunar soft-landing craft and the Army's Advent synchronous-orbit communications satellite.

Centaur will place some 8,500 lb into a low earth orbit, send some 2,300 lb on an escape trajectory to the moon, or about 1,300 lb to Venus and Mars. The vehicle stands about 105 ft, is ten ft in diameter, and weighs about 150 tons at liftoff. The first U.S. liquid hydrogen-fueled rocket, it is expected to provide 40 percent more thrust than hydrocarbon-fueled rockets.



◀ *Centaur sits atop modified Atlas at Cape Canaveral*

## British May Use UHF-Tv In Line Standard Change

CHICAGO—Impending move by BBC to obtain more tv channel space by using uhf is sharing top priority with a change in line standards from 405 to 625, Sir Harold Bishop, director of engineering for BBC, told broadcast engineers at their annual conference here last week.

"We are on the verge of expansion, and it is now or never," Bishop said. A government committee has urged Britain to line up with the 20 organizations and 16 countries using the 625-line standard within the Eurovision system.

This change would mean replacement of 12 million existing 405-line receivers, he said. The 8-Mc channel width required for the higher standard won't leave enough room in the vhf band for both commercial and BBC national coverage. Channel allocations at uhf will be needed to maintain national coverage after the change, Bishop said.

The uhf band promises to provide space for four national programs. BBC plans to extend field trials, using two and possibly three uhf transmitters. Four uhf channels were allocated London under the Stockholm plan.

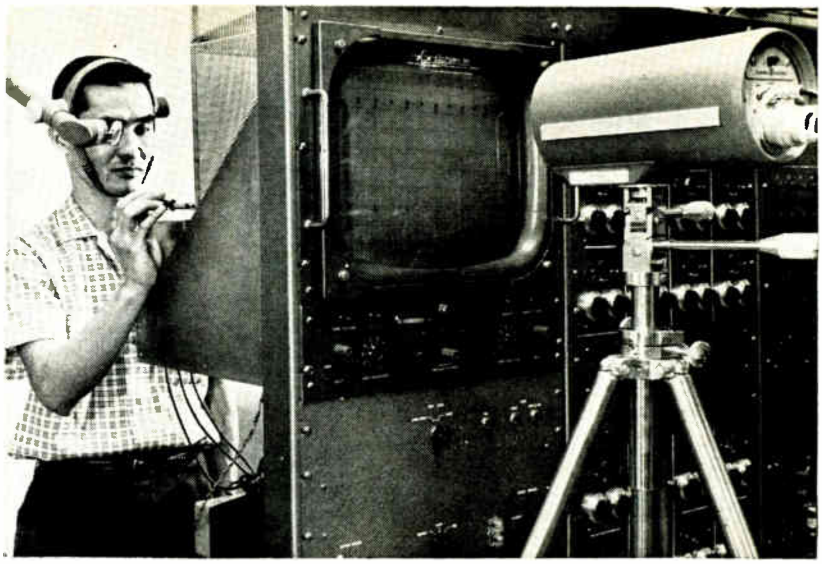
Expecting trouble, particularly in color transmission and differential fading, the British believe the current New York FCC trials should use at least two transmitters —with appropriate channel spacing—to find out the extent of interference from second channel and other sources.

The British are continuing test transmissions and industry has made great strides in color receiver designs, Bishop said. But it may be three years before the nation starts full development of color tv.

Bishop described the U.S. f-m stereo system as excellent. He saw "a considerable future" for stereo in Britain. Despite the predominance of television, public interest in radio is growing there, he said.

## Harbor Radar-Tv

*Under an experimental Coast Guard program, radar view of New York harbor is transmitted over uhf-tv channel 47. System uses a Raytheon storage tube which gives a persistent trace of moving ships. Craft in harbor equipped with tv set can determine their own position by maneuvering and watching their trace*



*Engineer wearing viewer can adjust equipment in rear while tv camera watches the front*

## Tv Screen Is Worn Like a Monocle

NEW YORK—Remote viewing device that allows the wearer to watch any kind of cathode-ray tube picture and his surroundings at the same time was demonstrated here last week by Hughes Aircraft.

The headpiece consists of a L-shaped housing containing a miniature crt and a mirror to deflect the image onto a transparent eyepiece. Dichroic filters in the eyepiece selectively filter background illumination, so the image can be seen in normal lighting. Minimum operating brightness is 25 ft-lamberts, Hughes said.

The apparent diameter of the image can be adjusted up to 8 ft at a distance of 20 ft. The viewer weighs 30 oz. Earphones can be added for audio reception.

Image sources may be radar, instrument or computer data, or any scene that can be transmitted by closed-circuit tv.

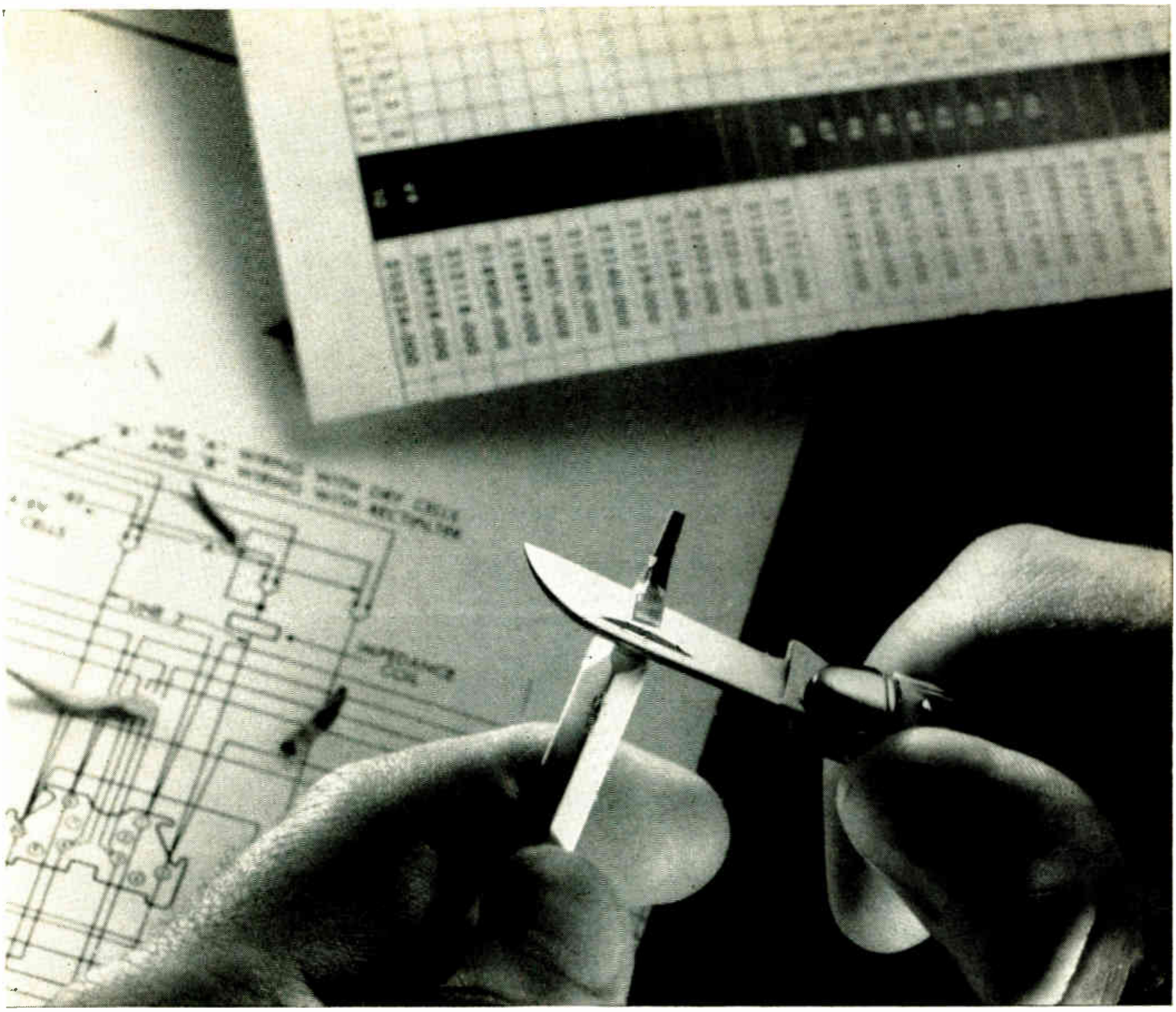
Hughes listed a number of potential military, aviation, industrial and space applications: as a walk-around radar monitor for aircraft traffic controllers, supplying military personnel with personalized briefings or sections of complex battle displays; remote viewing of instruments, instructing assemblers of complex equipment, and so on.

*Viewer is transparent*

## Communications Company Sells a Computer System

DALLAS—Collins Radio, which announced recently it would enter computer field (p 7, Jan. 12), has sold its first data communications switching system to Aeronautical Radio, Inc., for $2 million.

System will handle routine and priority messages in ground radio station network operated by ARINC for major airlines, which includes 105 multiparty telegraph lines. Major parts of system are dual solid-state data processors and random access message files, magnetic tape handlers for message storage, and control console.



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|---|---|---|---|
| NF (Meets Mil-R-10509D) | 60<br>65 | 100 to 100K<br>100 to 348K | 3% |
| N (Meets Mil-R-10509D) | 60<br>65<br>70 | 10 to 133K<br>10 to 499K<br>10 to 1 meg. | 3% |
| C (Meets Mil-R-22684) | 20<br>32<br>42S | 51 to 150K<br>51 to 470K<br>10 to 1.3 meg. | 5% (plus purchase tolerance of either 2% or 5%) |

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CIRCLE 31 ON READER SERVICE CARD

## MEETINGS AHEAD

AEROSPACE SYSTEMS RELIABILITY SYMPOSIUM, IAS; Salt Lake City, Utah, **April 16-18.**

MICROWAVE MEASUREMENTS LECTURES, IRE-PGMT&T; Babson Institute, Wellesley, Mass., **April 18, 25.**

IONIZATION RADIATION, HEALTH ASPECTS OF, Institution of Electrical Engineers (British); Savoy Pl., London, **April 25.**

FREQUENCY CONTROL SYMPOSIUM, U. S. Army Signal Research and Development Laboratory; Shelburne Hotel, Atlantic City, N. J., **April 25-27.**

WESTERN SPACE AGE INDUSTRIES & ENGINEERING EXPOSITION/CONFERENCE, sponsored by various business and governmental organizations; Cow Palace, San Francisco. **April 25-29.**

PULP & PAPER INSTRUMENTATION SYMPOSIUM, Instrument Society of America; Jacksonville, Fla., **April 26-27.**

MOTION PICTURE & TELEVISION ENGINEERS CONVENTION AND EQUIPMENT EXPOSITION, SMPTE; Ambassador Hotel, Los Angeles, **April 29-May 4.**

MANNED SPACE FLIGHT SYMPOSIUM, IAS; Chase Hotel, St. Louis, Mo., **April 30-May 2.**

INSTRUMENTAL METHODS OF ANALYSIS SYMPOSIUM, Instrument Society of America; Daniel Boone Hotel, Charleston, W. Va., **April 30-May 2.**

SPECTROSCOPY SYMPOSIUM, Society for Applied Spectroscopy; Conrad Hilton Hotel, Chicago, **April 30-May 3.**

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

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

POWER INSTRUMENTATION SYMPOSIUM, ISA; Hotel Texas, Fort Worth Tex., **May 6-9.**

COMPUTER CONFERENCE, Michigan State University; at the University, East Lansing, Michigan, **May 7-8.**

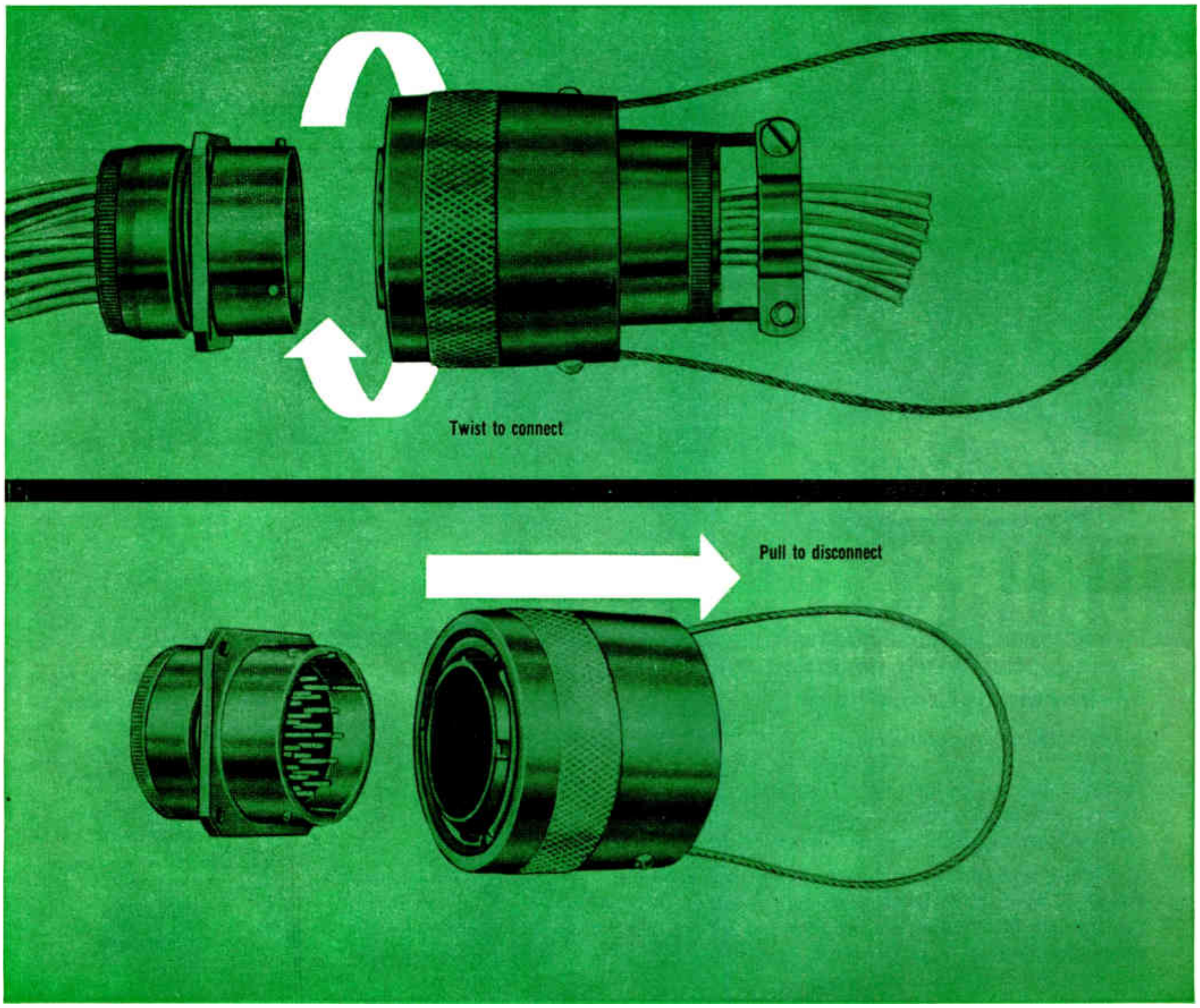
ELECTRONIC COMPONENTS CONFERENCE, IRE-PGCP, AIEE, EIA; Marriott Twin Bridges Hotel, Washington, D. C., **May 8-10.**

WESTERN ELECTRONICS SHOW AND CONFERENCE, WEMA, IRE; Los Angeles, Calif., **Aug. 21-24.**

### *ADVANCE REPORT*

NATIONAL CONFERENCE ON TUBE TECHNIQUES, *Advisory Group on Electron Devices in the Office of the Director of Defense Research and Engineering; Western Union Auditorium, NYC, Sept. 19-21. May 15 is the deadline for submission of one-page abstracts (single-spaced) to: Mr. David Slater, NY University Engineering Research Division, Electron Device Group, 346 Broadway—8th Floor, New York 13, N. Y. The program will cover all phases of electron tube making techniques, processes, and materials.*

*Here's a new "twist" for the specialized application:*

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CIRCLE 33 ON READER SERVICE CARD


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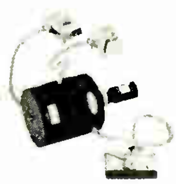

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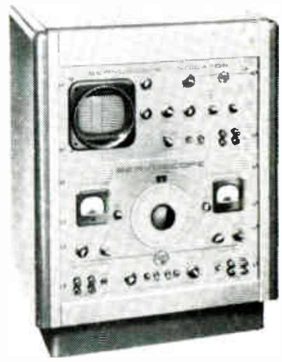
## servo system analyzer



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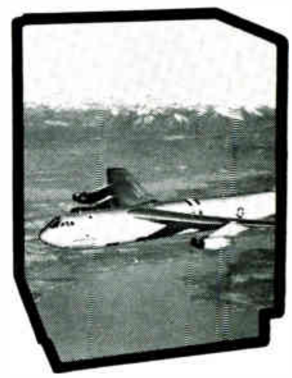

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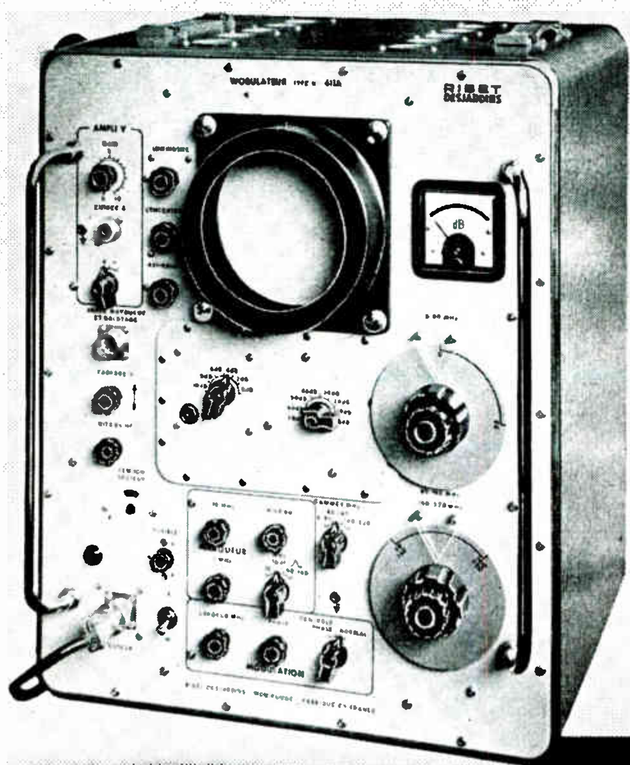

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**Frequency range :** 0 to 320 Mcs in 3 sub-ranges.

**Wobbulation amplitude :** from 0 to ± 25 Mcs, according to frequency.

**Marker (patented) :** continuous scaling every 1 and 10 Mcs.

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2 attenuators :
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| MAXIMUM RATINGS: | PHILCO 2N2400 | 2N711 | PHILCO 2N2401 | 2N711A | PHILCO 2N2402 | 2N711B |
|---|---|---|---|---|---|---|
| $V_{CBO}$ | −12 v | Same | −15 v | Same | −18 v | Same |
| $V_{CES}$ | −12 v | Same | −15 v | −14 v | −15 v | Same |
| $V_{CEO}$ | −7 v | NONE | −10 v | −1 v | −12 v | −7 v |
| $V_{EBO}$ | −1 v | Same | −1.5 v | Same | −2 v | Same |
| Dissipation | 150 mw | Same | 150 mw | Same | 150 mw | Same |
| **ELECTRICAL CHARACTERISTICS:** | | | | | | |
| $I_{CBO}$ ($V_{CB}$ = −5v) | 3 μa max | Same | 1.5 μa max | Same | 1.5 μa max | Same @ −10 $V_{CB}$ |
| $h_{FE}$ ($V_{CE}$ = −0.5 v) ($I_C$ = −10 ma) | 30 min | 20 min | 50 min | 25 min | 60 min | 30 min |
| $h_{FE}$ ($V_{CE}$ = −0.5 v) ($I_C$ = −50 ma) | | | 40 | 40@−0.7 $V_{CE}$ | 50 | 40@−0.7 $V_{CE}$ |
| $V_{CE}$ (SAT) ($I_C$ = −10 ma, $I_B$ = −0.4 ma) | 0.22 v max | 0.50 v max | 0.20 v max | 0.30 v max | 0.20 v max | 0.25 v max |
| $V_{CE}$ (SAT) ($I_C$ = −50 ma, $I_B$ = −2 ma) | | | 0.30 v max | 0.55 v max | 0.25 v max | 0.45 v max |
| $V_{BE}$ ($I_C$ = −10 ma, $I_B$ = −0.4 ma) | 0.27 min 0.36 max | 0.24 min 0.50 max | 0.27 min 0.36 max | 0.34 min 0.50 max | 0.27 min 0.36 max | 0.34 min 0.40 max |
| $V_{BE}$ ($I_C$ = −50 ma, $I_B$ = −2 ma) | | | 0.38 min 0.49 max | 0.45 min 0.75 max | 0.38 min 0.48 max | 0.45 min 0.70 max |
| $C_{ob}$ ($V_{CB}$ = −5 v, $I_E$ = 0, f = 4 mc) | 4.0 pf max | 5.5 pf max | 4.0 pf max | 5.0 pf max | 4.0 pf max | 5.0 pf max |
| $f_T$ ($V_{CE}$ = −7 v, $I_C$ = −10 ma) | 150 mc min | Same @ −5 $V_{CE}$ | 200 mc min | 150 mc min @ −5 $V_{CE}$ | 250 mc min | 150 mc min @ −5 $V_{CE}$ |
| $t_d$ (nsec) | 15 max | 100 max | 15 max | Same | 15 max | Same |
| $t_s$ (nsec) | 140 max | 200 max | 120 max | Same | 100 max | Same |
| $t_f$ (nsec) | 150 max | 150 max | 110 max | Same | 100 max | Same |


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*April 13, 1962*

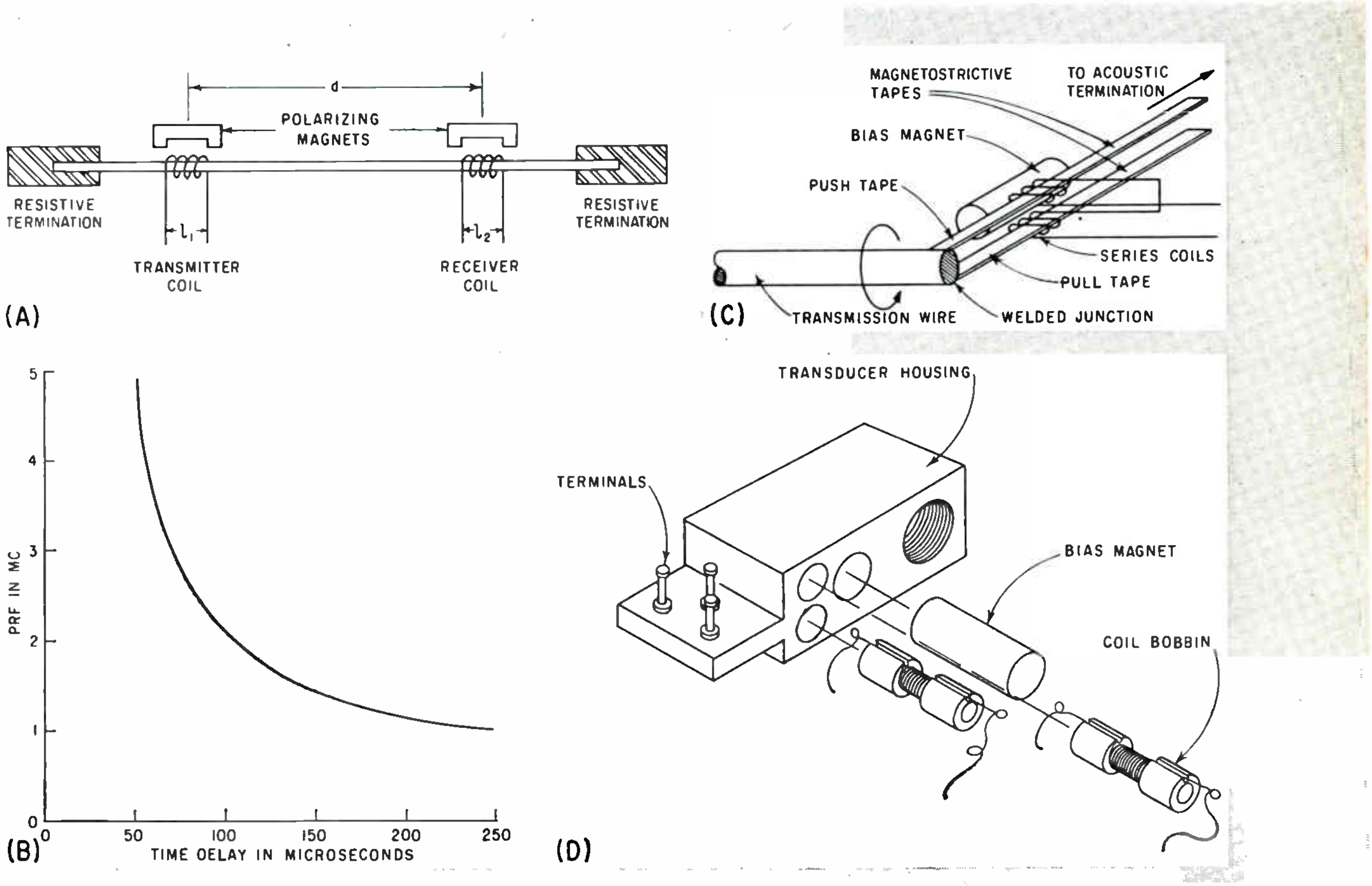


*FIG. 1—Basic magnetostriction delay line (A), pulse repetition frequency against time delay in the longitudinal mode (B), longitudinal to torsional mode converter (C) and typical transducer assembly (D)*

WHAT DESIGNERS SHOULD KNOW ABOUT

# Magnetostrictive Delay Lines

*New designs are resulting in increased use of this component. Performance and design features of some commercially available longitudinal and torsional magnetostrictive delay lines are explained*

By ARTHUR ROTHBART, Consulting Engineer, New York
ALAN J. BROWN, Airborne Instruments Lab., Deer Park, New York

IMPROVED performance and reliability of magnetostrictive delay lines have resulted in their increasing military and commercial use in missiles, aircraft navigation, radar, sonar, data processing and automation. This trend has been particularly evident in the small digital computer where the advantages of this type of pulse storage—economy, temperature stability, high operating speed and expandable capacity—have enabled magnetostrictive delay lines to displace magnetic drums and cores.

This article will present information on performance and design features of some commercially available longitudinal and torsional magnetostrictive delay lines.

The early development work on magnetostrictive delay lines was concerned solely with the straight longitudinal line shown in Fig. 1A. To avoid pulse dispersion, thin-wall tubing, thin tapes and fine wires were used as the media of propagation. Multiple tapes and bundles of fine wires were used to achieve high magnetic efficiency in wide-band transducer operation.

The limiting factor, which controls the resolution of such a line, is the effective length of magnetic field under the transducer coils.[1] To obtain maximum delay-line resolution, this field should be short with minimum flux fringing at the ends. Although the coils can be fitted into ferrite cups, which theoretically sharply define the edges of the field, too much fringing is still present in the practical application.

The maximum pulse repetition frequency of presently available straight longitudinal lines is shown in Fig. 1B as a function of time delay. Lines less than 50 $\mu$sec long can be made to operate at a prf as high as 5 Mc.[2] Since the digital bit rate can be made twice the prf by using non-return-to-zero techniques,[3] a digital bit rate of 10 Mc is possible for such a line. As the delay time is increased above 50 $\mu$sec, the maximum prf decreases because of dispersion, becoming 1 Mc at 250 $\mu$sec. However, a 250-$\mu$sec line will have an overall length of four feet. If this line is coiled to save space, the dispersive effects are accentuated, with a consequent decrease in the maximum prf.

The delay-line manufacturer prefers to supply straight longitudinal lines up to a 100-$\mu$sec delay. Beyond this point, coiled delay lines which operate in a nondispersive torsional mode are available. Torsional lines are used to a much greater extent. The one great advantage of the longitudinal line is that it is much easier to build efficient magnetostrictive transducers for longitudinal rather than for torsional operation. However, with a longitudinal-to-torsional mode converter[4], shown in Fig. 1C, it is possible to obtain the advantages of longitudinal transducer operation with torsional propagation. This converter operates as a bilateral device for either pulse generation or detection. During pulse generation, the two tapes are excited in a push-pull longitudinal mode by an applied current pulse to the coils. As the tapes move, they rotate the wire to which the tapes are welded. To avoid mechanical reflections at the welded joint, the cross-sectional area of the wire must have a definite relationship to that of the tapes.

An assembly drawing of a commercial torsional line is shown in Fig. 2. A desirable convenience of this line is that each transducer assembly can be moved by a lead screw to adjust time delay.

The performance to be expected of this type of torsional line is shown in Fig. 3A by two curves of prf versus time delay. Curve *A*, which is pertinent up to a 1,000 $\mu$sec delay, shows that lines less than 200 $\mu$sec long can operate at a maximum prf of 1.5 Mc. This value drops to 1.25 Mc at a millisecond. Curve *B* illustrates performance from 1 to 10 milliseconds of delay. At 3 milliseconds, the maximum prf is 1 Mc. The prf drops to 600 Kc at 5 milliseconds, and 400 Kc at 10 milliseconds.

The factor which limits the prf of the shorter lines is the pulse widening or stretching effect of the mode converter. The factors controlling the performance of the longer lines are the small amount of dispersion present even in a torsional mode, and the resistive losses introduced both by the wire supports and the finite mechanical Q of the wire.

PRACTICAL WINDING DATA

| Delay (in $\mu$sec) | Diameter (in inches) Mean | Inner | Flat Spiral | Vertical Helix |
|---|---|---|---|---|
| Below 500 | 5 | 4 | x | |
| 500-1,000 | 6 | 5 | x | |
| 1,000-2,000 | 8 | 6 | x | |
| 2,000-3,000 | 10 | 8 | x | x |
| Above 3,000 | 10 | — | | x |

The push-pull transducer technique using thin magnetostrictive tapes, which is a necessary feature of the mode converter in the torsional line, has been applied to the straight longitudinal line to obtain larger output signals than can be realized in single-ended transducer operation. The maximum prf of the push-pull longitudinal line is about 2 Mc, high enough for most applications. Therefore, some degree of standardization is possible in the manufacture of both types of lines.

The advantages resulting from standardization in transducer design, specifications for magnetostrictive tapes, and methods of acoustic termination are reduced cost of manufacture, improved performance, and increased reliability.

A typical transducer assembly is shown in Fig. 1D. The material of the transducer housing and the coil bobbins is a machinable dielectric, unaffected by high temperature. The length of the undercut section of the bobbin containing the coil, which varies with the rated prf, is usually specified in standard sizes of 25, 50, 75 or 100 mils.

To avoid the effects of flux fringing at the ends of the coil, the mean coil diameter should be as small as possible. Accordingly, the bobbin hole diameter need only be large enough to pass the specified tape width. In practice, the hole size may vary from 20 to 30 mils. To insure tight magnetic coupling between the coil and the tape, the bobbin thickness next to the coil is held to 5 mils. With the same end in view, the coils are wound with No. 50 AWG wire to keep the coil height to a minimum. The wire should have a polyurethane coating that is easy to strip.

For the torsional and the short longitudinal lines, two types of tape materials are commonly used. One type is Grade-A Nickel, which is 99-percent pure. The other type is an alloy of nickel with small amounts of manganese and silicon, known as R-63 alloy, which is usually specified for delay lines in which large variations in output amplitude with temperature cannot be tolerated. Since the temperature coefficient of delay of

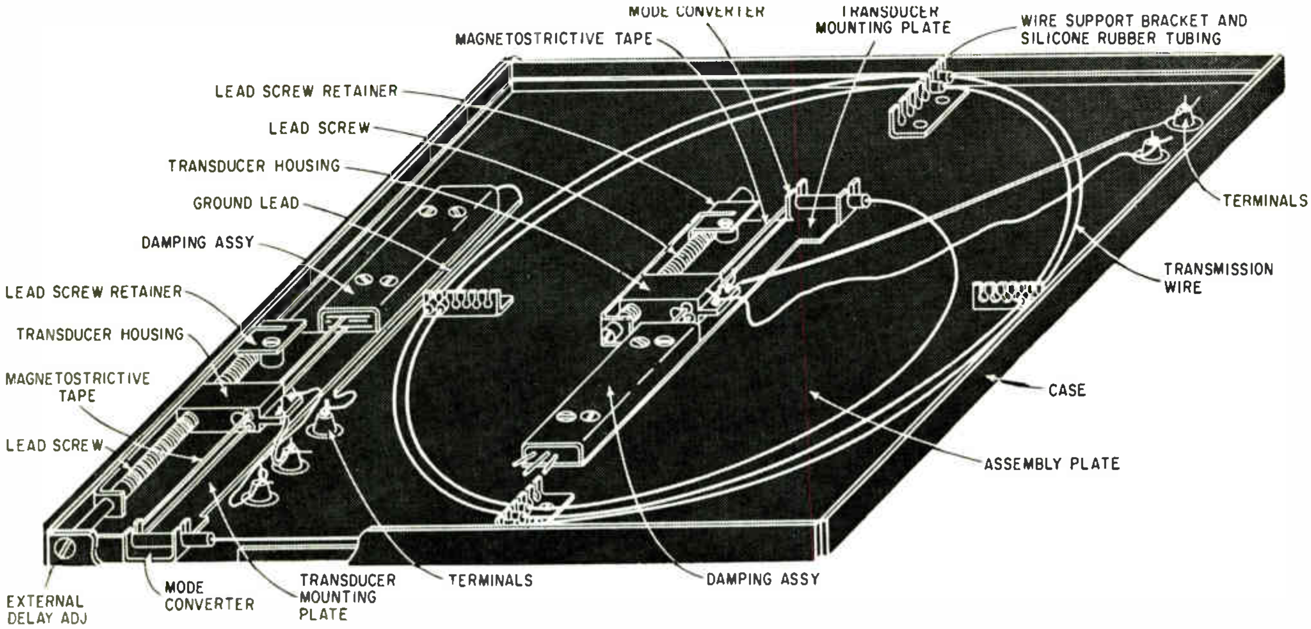


*FIG. 2—Typical commercially available torsional delay line. Each transducer can be moved with a lead screw to adjust time delay*

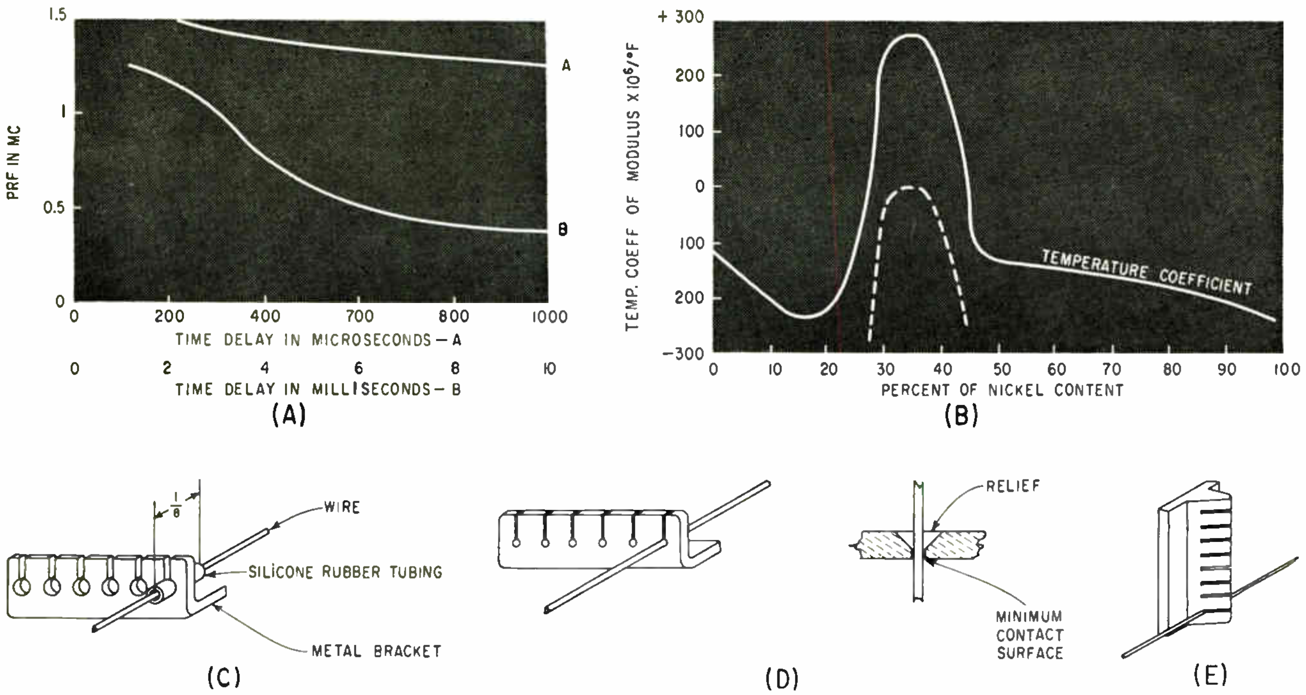


*FIG. 3—Pulse repetition frequency against time delay in the torsional mode (A), temperature coefficient of the modulus of elasticity (B), simple wire support (C), general-purpose polyethylene support (D) and molded rubber support (E)*

these two materials is 160 ppm/degree C, they cannot be used for the longer longitudinal lines. Tapes of a constant-modulus alloy, such as Ni-Span C, can be substituted at the expense of output amplitude.

Tapes are usually ordered from the supplier in a half-hard conditions as a compromise between high mechanical Q and ease of handling. However, to achieve the highest possible magnetostrictive coefficient, the tape sections underneath the transducer coils are flame annealed.

A thickness of two mils is specified for the tape material to provide good frequency response by reduction of eddy current losses. Instead of a single tape, 2, 3 or 4 tapes may be welded to form a single set with a desired cross-sectional area. The use of multiple tapes increases the magnetic efficiency in wideband transducer operation. The choice of tape width is a compromise between the high prf obtained with narrow tapes and the high output obtained with wide tapes. The actual tape widths in a practical delay line may vary between 10 and 20 mils. The most common width for a prf of 1 Mc is 15 mils.

An important design problem in magnetostrictive delay lines is that of obtaining minimum reflections from the tape ends. Reflection coefficients better than 20 to 1 can be realized in production without undue care. A practical technique for damping the ends of the tapes is illustrated in Fig. 4.

A rectangular piece of $\frac{1}{16}$-in. silicone rubber, $1\frac{1}{2}$-in. long and $\frac{3}{4}$-in. wide, is placed down on the damping area on the transducer mounting plate. Then, the individual tapes of the bottom set are separated to form a narrow V. A piece of two-mil Teflon ribbon, $\frac{3}{4}$-in. long and $\frac{1}{2}$-in. wide, is folded lengthwise over the tapes, at an angle to avoid the possibility of coherent reflections. The Teflon-enclosed tapes are then placed over the bottom piece of silicone rubber. Another piece of rubber is placed over the tapes to form a sandwich. The same procedure is repeated for the top set of tapes. The entire assembly is then clamped by a top metal plate.

The Teflon provides a hard termination that absorbs almost all the transmitted acoustic energy. The rubber acts as a soft termination in combination with the Teflon to provide a tapered mechanical resistance. Since mechanical energy is contained uniformly throughout the cross-section of the material, and damping occurs only at the periphery, the use of tapes (having a low ratio of cross-sectional area to periphery) results in more efficient damping of the mechanical signal than can be achieved by wires or tubes.

Besides the mode converter, there are a number of major design features in commercial torsional lines which have no counterparts in longitudinal lines. These features are the characteristics of the wire material and its heat treatment, the form and diameter to which the wire is wound, and the wire supports.

An important advantage of the torsional magnetostrictive delay lines over other forms of ultrasonic delay lines is their stability of delay with large variations in temperature. This stability is obtained by using wires composed of materials in which the modulus of elasticity is independent of temperature. These materials belong to a group of constant modulus alloys, which contain nickel and iron in the proper proportion. Figure 3B is a curve[5] of the temperature coefficient of the modulus of elasticity for nickel-iron alloys of different percentages. This curve shows that the alloys containing 27- or 44-percent nickel have zero temperature coefficients of the modulus of elasticity. Since these percentages are critical, a small amount of chromium added to the alloy will shift the peak of the curve downwards as shown by the dashed curve. This addition provides a flat composition range of zero coefficient alloys, and is the basis of the constant modulus alloys known as Iso-elastic and Elinvar. In these alloys, the thermal coefficient of the modulus of elasticity is determined solely by chemical composition and may differ from one batch of material to another due to commercial variations in melting and alloying. This class of alloys is unsuitable for wire delay lines.

However, if a small amount of titanium is added to a nickel-iron alloy of the proper proportion, the effective nickel content of the alloy can be controlled by heat treatment. During the heat treatment, nickel is precipitated out of the alloy as an intermetallic compound of nickel and titanium. Thus, it is possible to obtain a wire whose thermal coefficient of the modulus of elasticity has the magnitude and polarity to cancel the effects of other factors on thermal delay-line stability. This results in a delay line whose temperature coefficient of delay is nearly zero. The other factors affecting overall delay are the change in delay in the end tapes and the linear expansion of the wire.

Another advantageous effect on delay-line performance occurs during heat treatment. As the nickel precipitates, the alloy becomes hard, thus increasing its mechanical Q. The higher the Q, the greater is the bandwidth and output of the delay line. These precipitation-hardening constant modulus alloys are known as the nickel-iron-titanium alloys. If chromium is added to an alloy of this type to make the heat treatment less critical, the alloy known as Ni-Span C is obtained. However, chromium acts as a damping agent to lower the Q of the wire.

Heat treatment may be accomplished either in a furnace or by passing an electric current through the wire. The electrical process is superior from both an economic and an engineering point of view. Since the average delay-line manufacturer cannot afford the expense of operating his own furnace, he must send his wire to an outside facility for treatment, thus losing control over the operation. By contrast, an electrical facility can be installed in the manufacturer's own plant for less than $2,000.

Another point to consider is that the wire must be naturally straight[4] before heat treatment to obtain nondispersive delay-line performance. Since the wire usually arrives from the supplier on 9-in. diameter spools, straightening must be done mechanically if the wire is to be heat treated in a furnace. Where heat treatment is accomplished electrically, straightening can be achieved by stretching the wire in a straight line during heating. For normal electrical heat treatment, the process may be carried out in air without damaging the surface or finish of the treated wire. A mild oxide coating, usually not detrimental to delay-line performance, will form on the wire.

The choice of wire diameter is a compromise between delay-line resolution and output. The finer the wire, the less will be the dispersion and the better the resolution. The larger the wire, the higher will be the output. Practical wire diameters in commercial delay lines may vary from 10 to 30 mils. The most common choice for a prf of 1 Mc is 20 mils.

Only Ni-Span C and nickel-iron-titanium wires are used commercially because of the usual requirements for extreme thermal stability. Its lower mechanical Q[4] restricts the use of Ni-Span C to lines with a delay of less than 2 milliseconds at a prf of 1 Mc. On the other hand, lines using nickel-iron-titanium wires have been built with delays greater than 3 milliseconds at the same prf.

Where temperature stability is not required, the higher Q of commercial piano wire makes its use attractive as a standard against which to compare the performance of the other materials. The temperature coefficient of delay of piano wire is about 125 ppm/degree-C.

The form (flat spiral or vertical helix), and the diameter of the coiled wire are functions of the delay length and the prf. To obtain the high resolution and performance required in digital operation, the winding diameter should be large to avoid the problems associated with wire support reaction. If the wire is wound on too small a diameter, undesirable effects may occur because of the excessive forces exerted on the wire by the supports. These are: introduction of mechanical discontinuities causing reflections that will degrade the signal-to-noise ratio; increase of resistive mechanical loading that will attenuate the signal and reduce the bandwidth; and possible deformation of the wire beyond its elastic limit, forcing the natural radius of curvature of the wire to assume a finite value with introduction of dispersion.

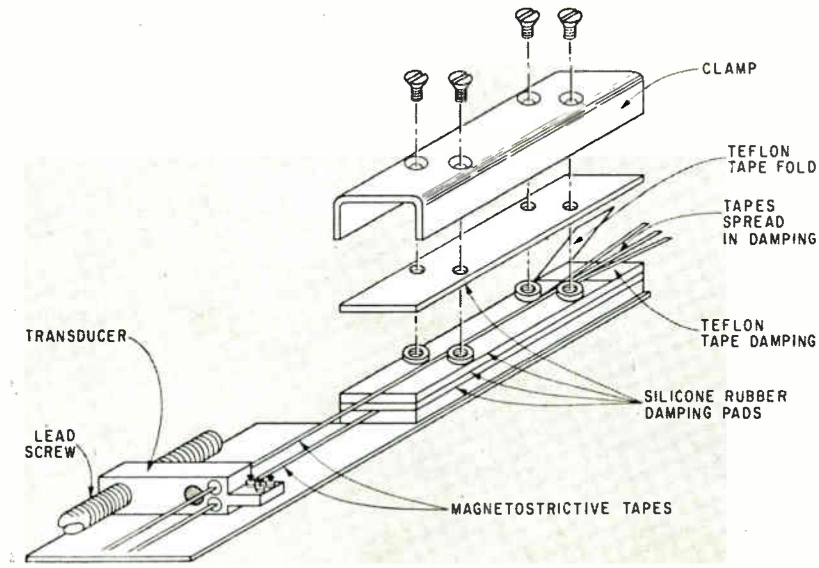


*FIG. 4—Acoustic termination dampens ends of tapes*

Practical minimum winding diameters and standard winding forms are listed in the table.

The wire supports should cause minimum absorption or reflection of the mechanical pulse at the point of support. The contact surface between the wire and the support should be a minimum. A knife-edge support is not used since the materials suitable for knife-edge support are hard enough to cause mechanical discontinuities. A rigid fixed support should not be used because the wire will tend to flex about the point of support under shock and vibration, thus generating undesirable noise.

A support of a soft material in which the wire is loosely retained has been found most suitable. A simple and effective support of this type is shown in Fig. 3C. The wire is threaded through a short length of silicone rubber tubing held in a slightly undersized hole in a metal bracket.

This support is suitable for extreme environmental conditions, and for the longer lines operating at the higher prf's.

For high-volume production of commercial lines where cost is a factor, a support molded from general-purpose polyethylene as shown in Fig. 3D, is satisfactory. The wire hole is recessed to minimize the contact surface between the polyethylene and the wire. This support is not recommended for shock and vibration.

These two supports are suitable for windings that are either flat spirals or vertical helices.

Under conditions of volume production, high density packaging, and shock and vibration, the molded rubber support shown in Fig. 3E, can be specified. Because of difficulty in molding the wire slots, these supports may be used only with windings of a vertical helix.

Because of the rapid growth in the use of magnetostrictive delay lines, there has been insufficient time for industry to agree on standard definitions and measurement procedures for such delay line parameters as resolution, signal-to-noise ratio, input impedance, terminating impedance and attentuation figure.

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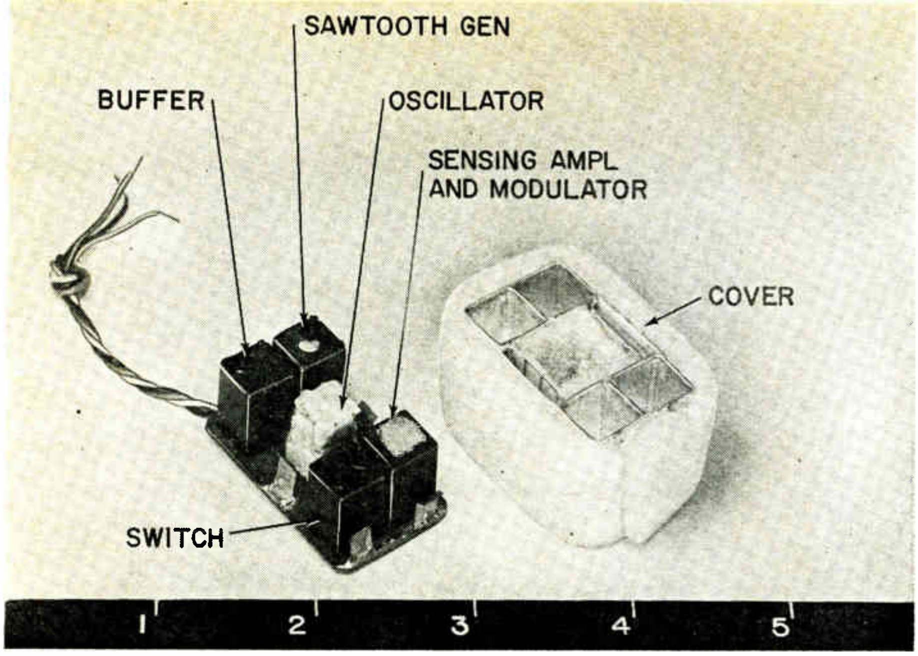


*FIG. 1—In this laboratory model, the oscillator cavity is part of the heat-sink enclosure for the rest of the modules*

# Microminiature

*Designing with micromodules permits compact packaging with close thermal coupling for precise frequency stability*

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MICROMODULE COMPONENTS are used in a quartz crystal oscillator for use in military single-sideband equipment, communications devices, missile tracking, telemetering and sound ranging equipment. The oscillator has low power drain (600 mw at room temperature), fast warm-up time, miniature size and weight and meets specified military requirements. Short and long-term stability is $1.8 \times 10^{-7}$ per day. The five-module assembly including oscillator module cavity measures only $0.7 \times 0.85 \times 1.4$ inches. It can be made as small as 1.5 cu. in. including insulating foam and outer cover.

A laboratory model, Fig. 1, probably will not be the final physical form, but indicates what can be achieved in size and power consumption. The measured stability of $1.8 \times 10^{-7}$ per day with presently available micro-element crystals may be improved one and a half orders of magnitude by using microelement crystals now under development.

Because of the extreme compactness that can be accomplished with micromodules, the heater and temperature sensing elements were actually built into the module. This design approach insures close thermal coupling between the heat source and temperature controlled mass and would not have been possible using conventional components. Higher gain in the temperature control amplifier was possible and heater power requirement were reduced.

The operating temperature of the crystal is about 80 C and the maximum anticipated operating ambient was 70 C; therefore the amount of controlled heater power was further reduced by heat sinking the power dissipating controller modules, thus effectively reducing the temperature differential between the temperature controlled oscillator module and the outside.

The controller circuit accepts readily available micromodular components. It uses, with one exception, 2N404 transistors throughout, has high gain and low output transistor dissipation as a result of improved rise and fall times of the switching pulse. Total power consumption measured at room temperature with no special thermal insulation is 600 mw.

The crystal, Fig. 2, is a 10-Mc fundamental mode unit in a microelement form. Collector voltage of 2N706 is kept low and is stabilized by $D_1$, a Zener diode. $D_2$ is a voltage sensitive capacitor used for fine frequency adjustments with a variable voltage divider, $R_1$ (Fig. 2). Output of the oscillator is decoupled from the following buffer-amplifier stages by a capacitive voltage divider.

Temperature is controlled using a pulse-width modulator. In this control the output transistor is switched between on and off states at a fixed repetition frequency. On-time within the cycle is varied depending on power demand. In the circuit, Fig. 3, $Q_3$ and $Q_4$ are an

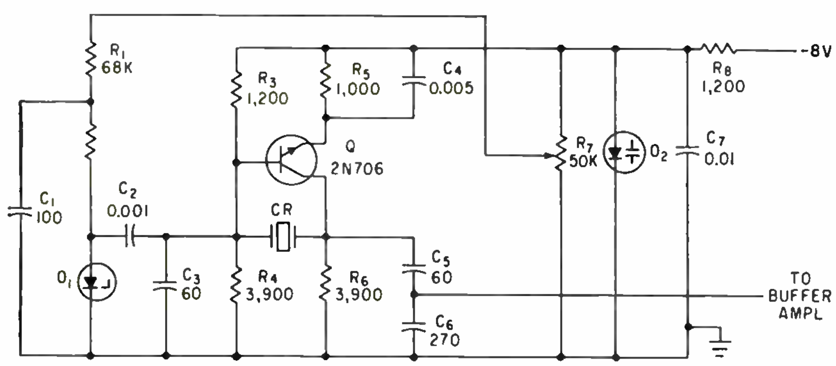


*FIG. 2—Crystal used in this 10-Mc oscillator is a 10-Mc fundamental mode unit in wafer form*

# Crystal Oscillator Using Wafer Modules

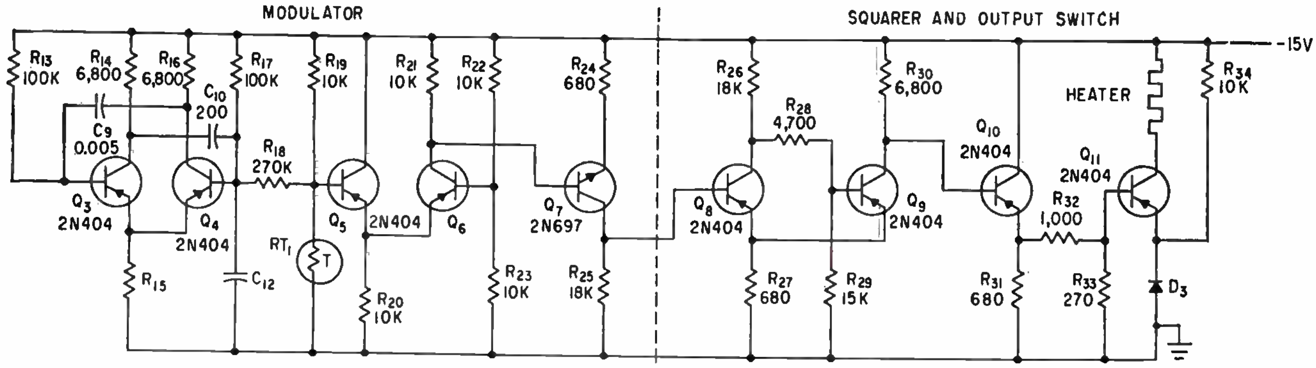


*FIG. 3—Thermistor in the modulator, left, senses temperature variation and establishes conduction time of the temperature sensing amplifier $Q_5$ and $Q_6$*

asymmetric, free-running multivibrator whose output is integrated by $C_{12}$; $Q_5$ and $Q_6$ with a thermistor and resistors $R_{18}$, $R_{22}$ and $R_{23}$ produce a temperature-sensitive amplifier arrangement.

Following the modulator is an additional stage of amplification and a four-transistor switch. To improve the switching waveforms and reduce dissipation in the switch proper, $Q_{11}$ is preceded by a squarer and emitter follower, $Q_8$, $Q_9$ and $Q_{10}$ respectively. Diode $D_3$ in the emitter circuit of $Q_{11}$ holds it in cutoff until $Q_{10}$ starts conducting. If a portion of the multivibrator output is applied to the base of $Q_5$, the control loop functions as follows: depending on the preset heater temperature (as sensed by the thermistor placed in close proximity) the conduction time of the temperature sensing amplifier, (pick-off point on the slope of the sawtooth input and therefore the ON time of the output switch) will be established to keep error at a minimum.

In design, most consideration was given to thermal properties such as power consumption, warm-up time, ambient reduction capabilities of the temperature control and the frequency characteristics. Power is consumed by the heater to maintain the required oven temperature, and by the circuit elements. Heater power will change with changing ambient temperature. The power, however, used by circuit elements changes little.

Thermal warm-up is the time from the moment the unit is switched on to the point where the preset oven temperature is first approached. Outwardly it will manifest itself in a rapid decrease of the heater supply current.

Ambient reduction factor is a measure of temperature control quality with changing ambient temperature as: $A_R = S_R/Q_R$ where $S_R$ is controller sensitivity measured in watts of heater power change per ohm of sensing resistor change (translated into equivalent ambient temperature change), and $Q_R$ is oven quality factor measured as heater power increment per degree C over temperature rise. The calculated value holds only for the condition that both $S_R$ and $Q_R$ remain constant within the interval of interest.

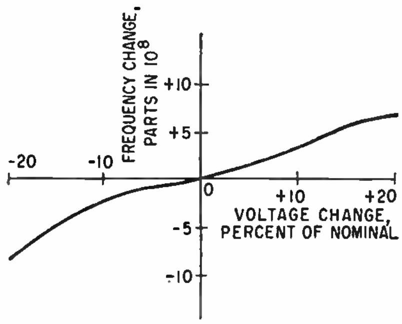


*FIG. 4—Variation of oscillator frequency with changing supply voltage is a reversible characteristic*

Reversible and irreversible frequency changes take place in operation. The former are mainly due to operational and environmental conditions; the latter are caused by internal crystal parameter changes. Frequency changes with changing supply voltage and changing ambient can be considered reversible; frequency reverts back after removal of the cause of the shift. Long-term frequency drift is caused by internal changes of the resonator and is irreversible. Results of checks of frequency drift and the effect of voltage variation are shown in Fig. 4.

To detect frequency changes of the order of parts in $10^8$, a secondary frequency standard is required. A 100-Kc signal with certified stability of $10^{10}$ parts per day was used in all frequency measurements.

In the packaging of the oscillator, care was necessary in the arrangement and thermal layout of the temperature-sensitive frequency-determining elements. Because of the low power, the problem of heat leaks and thermal gradients becomes prominent. This is alleviated by close thermal coupling of the heat source and heated elements (using heavy thermal shunts wherever possible) and minimization of lead and other direct losses.

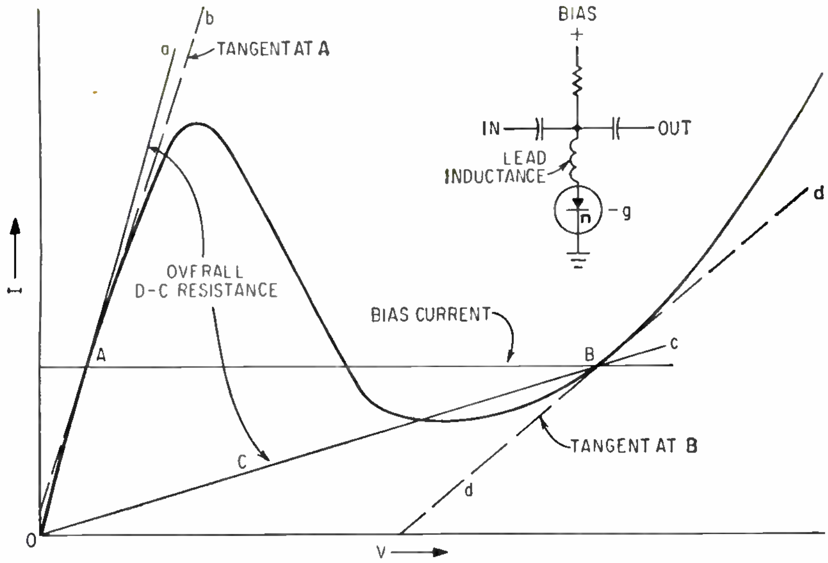


*FIG. 1—Conventional tunnel diode circuit (inset) with output taken as a voltage pulse and a typical curve*

# Tunnel-Diode

*Application of tunnel-diode switching between stable states to signal gating and data storage may produce computers with clock rates in excess of 500 Mc*


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A BIASED tunnel diode can be forced to switch between two stable states corresponding to two different voltages (Fig. 1.) Presently it is necessary to load the tunnel diode with some form of output indicator to determine the state of the diode; this load generally increases the switching time.

As shown in Fig. 1, the tunnel diode is biased to the current represented by line *AB* and switches between states *A* and *B*. The d-c resistances of these two states are represented by lines *a* and *c* drawn to them from the origin. Small-signal a-c impedances are represented by the tangents to the curve at points *A* and *B* respectively. Characteristics of these a-c impedances corresponding to *A* and *B* show that the a-c impedance is not necessarily the same as the d-c resistance and that the small-signal

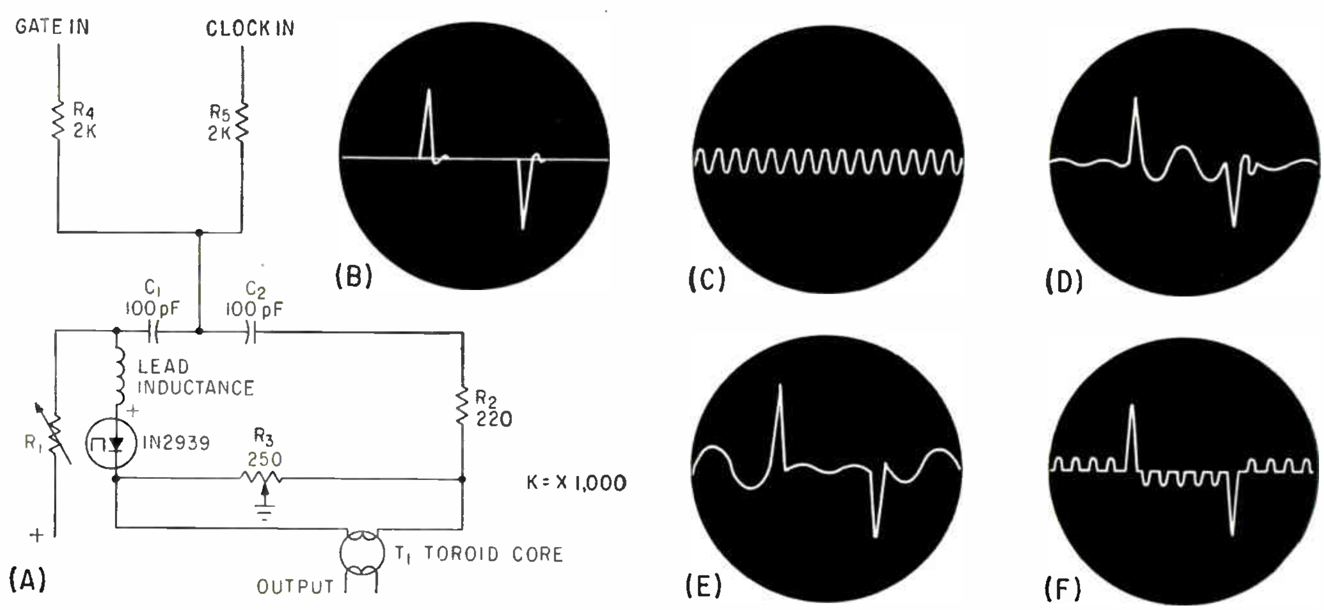


*FIG. 2—Bridge test circuit (A) with double pulse gate (B), 300 Mc clock (C), output with $R_1$ balanced for low-impedance state (D), output with $R_2$ balanced for high-impedance state (E) and pulse inversion with pulse signals replacing sine-wave clock (F).*

# Gate Has Subnanosecond Rise Time

impedance of state $B$ can be made as high as desired (the tangent to the curve can be made as close to horizontal as necessary) by choice of bias current. The ratio of the small-signal impedances can be large and the state determined by observing these impedances.

The first test circuit was the a-c bridge shown in Fig. 2 using a tunnel diode as one arm. Potentiometer $R_1$ provides bias for the diode, which is d-c blocked from the inputs by $C_1$. Capacitor $C_2$ was added to preserve the symmetry of the bridge, with $R_2$ completing the symmetrical arm. Potentiometer $R_3$ is a carbon-film unit for balance adjustment while $R_4$ and $R_5$ were added to separate the two signal sources. Transformer $T_1$ was 1:1 wound on a ferrite toroid and was added to permit one side of the output to be grounded for observation on an osilloscope.

The bias was adjusted so that a current slightly above the valley-point current passed through the tunnel diode. With this bias, a small-signal impedance ratio of about five to one was obtained. Some difficulty was encountered with instability when the ratio was made higher, but for test 5:1 sufficed. The rest of the circuits were also adjusted to an impedance ratio of about 5:1 between states. A 0.1-v peak-to-peak 300-Mc clock signal was fed in and the bridge was balanced with $R_3$. A double pulser was used to produce first a positive and then a negative gating pulse, which were shortened with shorted cable. Pulses of approximately 2-v amplitude and about 1-nanosecond long were used for gating or changing the state of the tunnel diode. How much of this voltage appeared across the tunnel diode is not known because stray capacitance may have produced additional coupling. Both test circuits were breadboards. The test traces obtained with $R_3$ set for balance in the low-impedance state of the tunnel diode are shown in Fig. 2. Figure 2B is the pair of gating pulses as seen from the output, Fig. 2C is the clock signal which was gated and Fig. 2D is the output of the gate circuit. Potentiometer $R_3$ was then set for balance in the high-impedance state and the output in Fig. 2E was obtained.

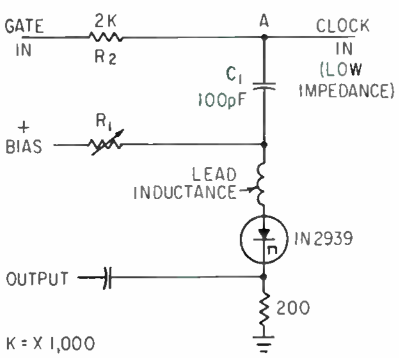


*FIG. 3—Using the impedance of a tunnel diode as part of a voltage divider*

The circuit was then operated with $R_3$ adjusted to a point between the balance positions for the two states. Thus, a change in state of the tunnel diode produced an inverted output. The sine-wave clock unit was replaced with a pulse input; Fig. 2F shows the output. Inversion is obtained because with the tunnel diode in one state the bridge is unbalanced one way, and with the tunnel diode in the other state the bridge is unbalanced towards the other arm.

A second test circuit, shown in Fig. 3, was built to use the change in impedance directly without a bridge. Resistor $R_1$ provides the bias, $R_2$ is used to separate the sources and $C_1$ provides d-c blocking. The gate and clock, measured

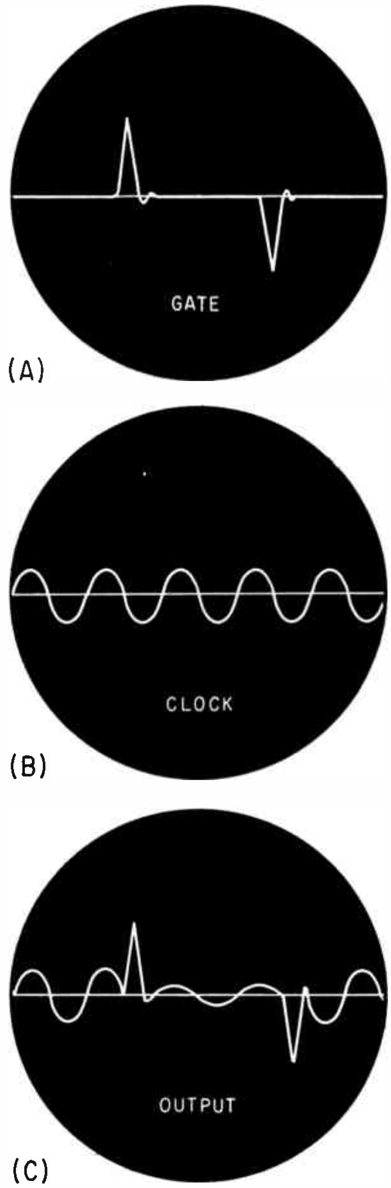


*FIG. 4—Gate (A) and clock (B) measured at A of Fig. 3. Output is shown at (C)*

at $A$, and the output, are shown in Fig. 4. The gating voltage at $A$ was about 1 v, and the clock voltage was 0.1 v peak-to-peak. With the bias adjusted, the ratio between the output with the tunnel diode in the low-impedance state to the output with the tunnel diode in the high-impedance state was better than 3:1.

Several refinements on the original bridge circuit were tried. The principal difficulty with the bridge circuit was that the gating pulse appeared in the output. This was corrected in two ways by the circuits shown in Fig. 5. In Fig. 5A, a portion of the gate signal is fed to a wire threading the output toroid so that the output spike is cancelled. Resistors $R_{2A}$ and $R_{2B}$ replace potentiometer $R_3$ of Fig. 2. Because the impedance of the tunnel diode can be varied by varying bias current, the bridge can be balanced by selection of $R_1$ as well as by selection of $R_3$. In Fig. 5B, $R_3$ of Fig. 2 has been replaced by a tapped winding on the toroid and $R_6$ of Fig. 5A has been eliminated by threading the gate input through the output toroid. Winding $W_1$ and $W_2$ were kept in a 1:1 ratio, and the number of turns on both was adjusted so that the flux produced by the spike after it had passed through the circuit was cancelled by the flux produced by the gate input threading the core. Thus, the output did not have a spike. Balance was obtained by adjusting $R_3$ and bias was adjusted for stable switching.

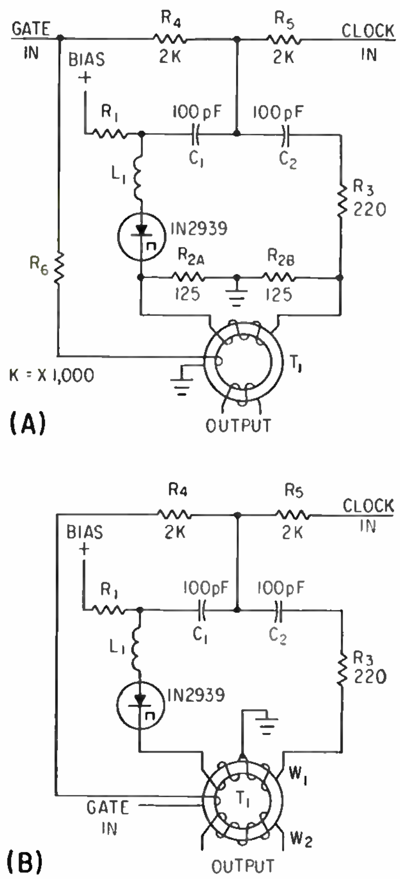


*FIG. 5—First modification of bridge to cancel output spike (A) and second modification (B). Lead inductance $L_1$ is important in switching time*

The bridge circuit can be used as a gate when it is balanced in one of the two states. A piece of cable can be connected to the gate input, shorted at the far end and terminated at the near end, to act as a delay line and pulse inverter. This produces a precisely controlled gate. The state of the bridge can be used to control the polarity of output pulses. The output can be stepped up at the output toroid and directed by two diodes into two different outputs. Thus the state of the tunnel diode can be used to direct an input to either of two outputs, similar to a spdt switch.

This gate offers several advantages for work in nuclear instrumentation. The tunnel diode in the gate acts as a pulse height discriminator simplifying the circuit. The gate has a fast rise time. Although no satisfactory measurement of the rise time was obtained it is less than one nanosecond with the minimal triggering pulse and is smaller for larger pulses. Because of the discriminator action, the rise time is good for minimal drive pulses which is important in nuclear instrumentation where an accurate gate is required even when input pulses are sloppy. The device can be used for pulse direction, thereby replacing several discriminators and gates.

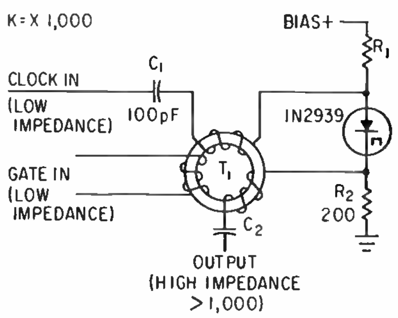


*FIG. 6—Modification of voltage divider configuration to reduce gate spike in output*

The circuit of Fig. 3 was modified to obtain the circuit of Fig. 6. Resistor $R_1$ provides bias which is d-c blocked from the input by $C_1$. The clock input has a low impedance, so it is possible to use it in series with the secondary of toroid $T_1$. A tertiary winding cancels the gating spike which would otherwise appear in the output. The output can be fed to a discriminator so that total blocking of the smaller signal is obtained. This gate acts as a discriminator for its gate control pulses and has a rise time faster than the bridge because the tunnel diode is not loaded at all during switching.

One application of this gate is as a memory with extremely fast readout. Since readout consists of measuring the impedance of the tunnel diode, readout speed is limited only by the rate of propagation of the signal along the wires leading to and from the tunnel diode. Because the readout is nondestructive there is no cycle time. The discriminating action of the tunnel diode should make it possible to use matrix arrays with an addressing system similar to that used for core read in.

Tunnel diodes operated in a chain for counting are usually switched from a low-impedance state to a high-impedance state. This means that to get to the next tunnel diode, a pulse has to travel through one or more high-impedance diodes. It may be possible to make considerably longer chains of tunnel diodes if they are started in a high-impedance state and switched to a low-impedance state.

All of the devices make use of the fact that small-signal impedances of a tunnel diode in its two stable states can be made significantly different. This mode of operation should be feasible for other negative-resistance devices, notably superconducting thin films separated by 50 anstroms or so of insulation. This mode of operation may make possible computers with clock rates in excess of 500 Mc.

ANALOG TECHNIQUE DERIVES

# Correlation Functions

*Fast and accurate technique for computing autocorrelation functions of time-varying signals is based on general-purpose analog computer and storage tubes, provides a practical method of solving random-signal problems*

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CORRELATION FUNCTIONS are familiar to statisticians, who have been concerned for many years with measuring the dependence of one set of numbers upon another. Originally, the use of correlation functions was confined exclusively to real data. No attempts were made to go from the real, or time, domain into a frequency domain by transform relationships. Thus, while engineers were analyzing frequencies and power spectra with Fourier series and complex Fourier integrals, statisticians were noting properties of correlation functions. The two concepts, however, were not associated.

Under certain conditions, power spectral density functions and correlation functions are Fourier transforms of each other, except for a constant factor. The two concepts are significant in communications and automatic controls. Both communications and automatic controls operate on, or through, statistical signals that carry information and commands between a mechanistic system and its environment. Both must overcome other statistical signals that enter the system as undesirable but unavoidable disturbances.

The classical definition of the cross-correlation function between two signals, $f_1(t)$ and $f_2(t)$, that are functions of time, $t$, is

$$R(\tau) = \lim_{T \to \infty} \frac{1}{2T} \int_{-T}^{T} f_1(t) f_2(t+\tau) dt \qquad (1)$$

where $\tau$ is a displacement along the time axis and $2T$ is the length of time over which averaging of the product $f_1(t) \cdot f_2(t+\tau)$ is done.

When $f_1(t) = f_2(t) = f(t)$, Eq. 1 becomes the autocorrelation function of $f(t)$.

$$R(\tau) = \lim_{T \to \infty} \frac{1}{2T} \int_{-T}^{T} f(t) f(t+\tau) dt \qquad (2)$$

The correspondence between $R(\tau)$ and the power-spectral or cross-spectral density, $F(j\omega)$, is given by the Fourier pair

$$F(j\omega) = \int_{-\infty}^{\infty} R(\tau) e^{-j\omega\tau} d\tau \qquad (3)$$

$$R(\tau) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(j\omega) e^{-j\omega\tau} d\omega \qquad (4)$$

This quality is reflected in any analysis of dynamic systems in that they may be studied in either the time domain or frequency domain. The frequency domain procedure is advantageous because of its long standing in the analysis of control loops, particularly of the linear type. Measurements in the frequency domain are easy to make when dealing with sinusoidal inputs, and the instrumentation is simple and available.

Special analyzers are needed, however, to deal with situations in which the signals are random rather than deterministic. Available analyzers, while they provide direct calculation of cross-spectra, have serious shortcomings. It is difficult to predict what an anlyzer will do, because the result is affected by the transfer characteristic between the paired inputs as well as by the nature of the inputs themselves. When dealing with random processes, the first step—which seems to have been bypassed in the cases of most machines avail-

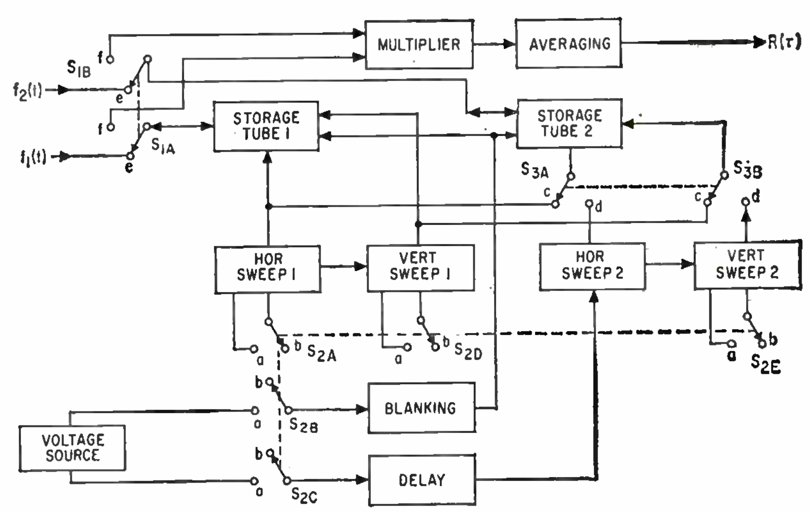


*FIG. 1—Autocorrelator amplifiers are of the operational type that satisfy analog computer requirements*

able—is to determine what the analyzer is doing. This means that it is necessary to classify the machine data with respect to input processes, to input processes transmitted through known linear networks, and to input processes through known nonlinear networks.[1]

Classification of machine data with respect to input processes through nonlinear networks often is impossible since the equivalent nonlinear network of most systems under study usually is unknown. Hence, spectral data often may be obtained more conveniently and accurately, by correlation and Fourier transformation. The process of lagged multiplications and averaging need not be arduous and little time is required.

Any technique for the evaluation of correlation functions has to be founded on the definition given by Eq. 1 or its equivalent

$$R(\tau) = \lim_{T \to \infty} \frac{1}{T} \int_0^T f_1(t) f_2(t+\tau) dt \quad (5)$$

This indicates that the measurement requires: (1) shifting the time axis to generate $f_2(t+\tau)$, (2) multiplying, and (3) averaging.

It is necessary to implement a reliable memory in which the functions $f_1(t)$ and $f_2(t)$ can be stored and read out for the formation of the lagged product in the integrand of Eq. 5. Steps must be taken to overcome the self-generation of process errors, which usually plagues conventional correlator storage mechanism, and to avoid the lengthy computation time associated with existing machine designs. A memory unit with an electronic storage tube used as part of an analog computer system has been investigated. The basic feasibility premises for such a system include adequate amplitude resolution in the memory and compensation for any nonlinearities.

As shown in Fig. 1 and 2 the two signals to be correlated are brought into the memory unit as voltages varying in time. They are made to modulate the writing beams of the storage tubes while the beams scan the storage matrices. Memorization begins when switch $S_1$ is turned to position *e*, connecting the modulating voltages $f_1(t)$ and $f_2(t)$ to the control grids. This initiates the sweep generator and applies the sweep to the deflection coils.

If a 3-inch storage tube and a raster-type scan are used, a stored, square-shaped image of an area $A = 2 \times 2$ inch can easily be accommodated. By assuming that the length of the signal is $T$ seconds and that the highest frequency component of interest is $N$ cps, the number of cells that should be stored distinctly over the area $A$ can be obtained by application of the basic theorem of information theory (according to which the signal must be sampled at a rate equal to $2N$). The resolution required, then, is $2NT/A$ cells per square inch. Since the resolution of available storage tubes is 200 lines per linear inch or $200 \times 200$ cells per square inch,

$$\frac{2NT}{A} = 4 \times 10^4 \text{ cycles per sq. in.} \quad (6)$$

that is

$$NT = 8 \times 10^4 \text{ cycles} \quad (7)$$

Thus, a control system having a band pass of $N = 50$ cps may be tested for as long as $T = 1{,}600$ sec $= 26.6$ min.

Since the signal will be stored in $200\sqrt{A} = 400$ lines and since write-in will occur during the spot's travel in both directions along the horizontal axis, a triangular sweep will be required

$$f = \left(\frac{400}{2}\right)\left(\frac{1}{T}\right) = \frac{200}{T} \text{ cps} \quad (8)$$

Therefore, $f = 0.125$ cps. Precise timing of the sweep is necessary to ensure accurate generation of the time offset, $\tau$, that enters basic Eq. 5.

This may be accomplished by the circuits shown in Fig. 1. The basic element is a three-amplifier triangular-wave generator, the output voltage of which is a train of triangular pulses of repetition frequency

$$f = \frac{R_4}{4R_3} \text{ cps} \quad (9)$$

and of peak-to-peak amplitude

$$V = \frac{2R_2}{R_1} E \quad (10)$$

The train is initiated as soon as switch $S_{2A}$ frees output integrator 3. Thus, to store signals $f_1(t)$ and $f_2(t)$, switch $S_3$ is kept in position *c* while switch $S_1$ is in position *e*. Starting switch $S_{2A}$, $S_{2B}$, $S_{2C}$ is turned to position *a*, initiating the horizontal sweep for both storage tubes and timer integrator 9, which closes the relay that applies a blanking voltage to both beams at

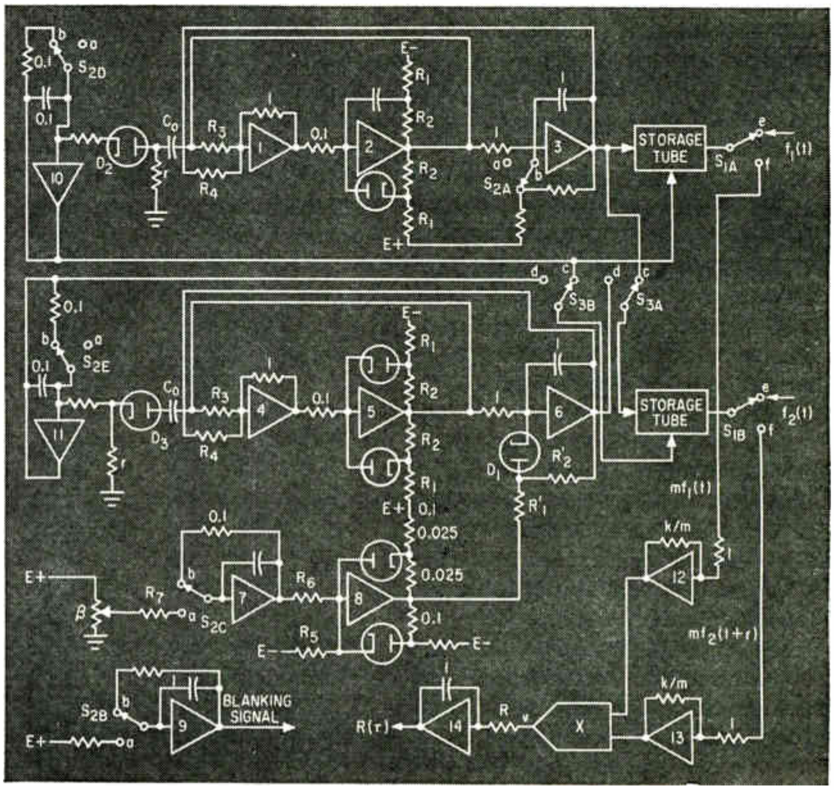


*FIG. 2—Autocorrelator storage tube can be the Westinghouse WX-4293*

the end of time $T$. Switch $S_{1A}$, $S_{1B}$, $S_{2C}$ is then returned to position $b$. Throughout the interval $T$ the signals $f_1(t)$ and $f_2(t)$ are being stored in the tube matrices.

To read the stored signals into the multiplier, switch $S_1$ is turned to the $f$ position, which puts the storage tubes in the read-out mode. Switch $S_3$ is turned to the $d$ position, which connects a second triangular wave generator to one of the tubes. At this stage, switch $S_{2A}$, $S_{2B}$, $S_{2C}$ is turned to $a$ to start horizontal sweep 1, as before, while sweep 2 is delayed by an interval $\tau$. The delay of sweep 2 is accomplished as follows: the output of amplifier 8, because of the voltage $E+$ fed into it, is maintained at $-50$ v; this keeps diode $D_1$ in its conducting state and biases output integrator 6 to the voltage indicated in Eq. 10, or

$$V = 50 \frac{R'_2}{R'_1} \qquad (11)$$

As $S_{2C}$ frees integrator 7, the integrator output starts to increase linearly with time as

$$\frac{\beta E}{R_7 C} t$$

where $\beta$ is the potentiometer setting.

The circuit is so adjusted that when $t = \tau$, the boundary condition

$$\frac{\beta E}{R_7 R_6 C} \tau = \frac{E}{R_5} \qquad (12)$$

is met; at this instant, amplifier 8 flips to its second stable state of $+100$-volt output. Thus, diode $D_1$ is cut off and sweep 2 is initiated after a delay $\tau$, which from Eq. 12 is

$$\tau = \frac{R_6 C}{\beta R_5} R_7 \qquad (13)$$

By varying $\beta$, the desired offset, $\tau$, is obtained.

The successive values of $\tau$ and their range are dependent on the characteristics of the system that produces the signal for which the power spectrum is desired. If an appreciable amount of energy is generated by the system at a maximum frequency of $N$ cps, the correlation computation process must be capable of specifying the system's performance at $N$ cps. Since a periodic function can be completely determined by two measurements per cycle at the highest frequency, the spacing between the successive values of $\tau$ should be at least

$$\tau_{i+1} - \tau_i = \frac{1}{2N} \text{ sec} \qquad (14)$$

To maintain the fine detail in the power spectrum, however, it is necessary to use high values of the maximum delay, $\tau_m$. The maximum resolvable detail, $\Delta N$, in the power spectrum is related to the maximum time lag, $\tau_m$, of the correlation by

$$\Delta N = \frac{1}{2\tau_m} \qquad (15)$$

This relationship can be grasped readily by recalling that when measuring the difference between two single-frequency oscillators, it is necessary to wait longer periods as the frequencies become closer together because the periods of the beats become longer as the two frequencies approach one another.

Once $\tau_m$ has been decided upon, the interval of integration $T$ should, as a general rule, be

$$T > 15\tau_m \qquad (16)$$

If $T$ is too small, the autocorrelation function usually does not converge smoothly to its asymptote.

The same triangular wave generators that produce the horizontal sweeps are made to generate the vertical sweeps. Advantage can be taken of the fact that the outputs of amplifiers 2 and 5 are square waves of constant amplitude. A differentiating circuit, $rc_o$, following each amplifier will produce a pulse of constant strength every time the corresponding square wave switches polarity. Through a polarity-discriminating diode, $D_2$ or $D_3$, pulses corresponding only to the end of each horizontal sweep step up, by a preassigned quantum, the outputs of integrators 10 and 11, which feed the vertical deflection coils.

In this way precisely timed horizontal and vertical sweeps are generated. If $m$ is the associated attenuation factor, the signals $mf_1(t)$ and $mf_2(t+\tau)$, as read out of the storage tubes, are amplified in amplifiers 12 and 13 (having gains k/m) and are sent to the multiplier. The outputs of the multiplier then will be

$$v = \frac{k^2}{k_o} f_1(t) f_2(t+\tau) \qquad (17)$$

where $k_o$ is its gain factor.

After integration, the desired correlation function point (that which corresponds to the selected delay $\tau$) is obtained as the output $P(\tau)$ of end integrator 14

$$P(\tau) = \frac{k^2}{k_o R} \int_0^T f_1(t) f_2(t+\tau) dt \qquad (18)$$

Hence, from Eq. 5 and 18

$$R(\tau) = \frac{k_o R}{k^2 T} P(\tau) \qquad (19)$$

Repetition of the procedure for the successive values $\tau_i$ of $\tau$, as required by Eq. 14 and 15, will yield $R(\tau)$ with the desired accuracy.

The read-out time of the functions $f_1(t)$ and $f_2(t)$ may be made much shorter than the original signal length $T$. This may be implemented by reducing all capacitor values of the circuit by the same factor, say $n$, during read out; this will automatically speed up the computation of each point $R(\tau_i)$ by the same factor. The limiting element for such a speed-up will be the frequency response of the multiplier, since the bandwidth of the signals $f_1(t)$ and $f_2(t)$ is also augmented by a factor $n$.

A correlator of adequate accuracy and speed may be built around general-purpose analog computer equipment provided that a storage tube of sufficient grey-level resolution is available. Preliminary estimates indicate that the computation time of the correlation function will be about 0.5 min per correlation point and may be reduced further if a dynamic storage analog computer is used, thus allowing on-line operation.

The described technique features convenience and speed surpassing other methods that use storage equipment involving mechanical motion; it is immune to the shortcomings of conventional spectrum analyzers in that it does not require any classification of the machine in regard to the effect of the tested system on its input signals. Thus, the only critical factor to be considered with this approach is the amplitude resolution of the storage tubes. Electronic type storage tubes presently available are capable of resolving about one hundred levels.

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# Transistor Amplifier With

*Circuit uses both positive and negative feedback; these can be balanced to obtain desired input characteristics. Unit is suitable for mounting in microphone case*

By J. J. TIEMANN
General Electric Research Laboratory, Schenectady, N. Y.

A SMALL, SELF-CONTAINED amplifier with a high input impedance and low output impedance can be useful when used with a high-impedance microphone. Whenever stray pickup or other interference is a problem, such an amplifier can be placed in the microphone case to raise the power level of the signal above that of the interference.

The transistor amplifier here presented has an input impedance of over 1 megohm, a bandpass from 10 cps to 100 Kc and a power requirement of 1.3 ma at 9 volts.

A number of compromises must be faced in the design of a transistor amplifier. One of the most serious of these is thermal stability against noise figure. Thermal stability can be obtained by increasing the bias current until it is large compared to the leakage currents at the highest operating temperature, but this sacrifices the noise figure and the operating economy of the circuit.

In this amplifier, thermal stability at low bias current was obtained by including a d-c amplifier to regulate the bias supplied to the amplifying transistors. In this way, bias currents of the same order as the leakage currents can be used while still maintaining large operating temperature range. A capacitive input coupling was anticipated, and the second amplifier stage is directly coupled to the first; this eliminates all transformers, and consequently a large bandwidth is obtained. For the amplifier to have good low frequency response, it must have a long input time constant. To accomplish this without raising the input capacitance above that of a piezoelectric microphone (about 0.01 mfd) the input impedance must be high. This was accomplished by combined use of positive and negative feedback. The negative feedback is applied to the emitter of the first transistor so that the emitter-base junction impedance is raised. The positive feedback is applied to the base. The positive feedback is equivalent to connecting a negative conductance across the base of the input transistor, and by adjustment a value can be found that nearly cancels the positive conductances. This cancellation must be independent of temperature if the amplifier is to have an input impedance that is independent of temperature. The use of thermistors would upset the balance between negative and positive conductance.

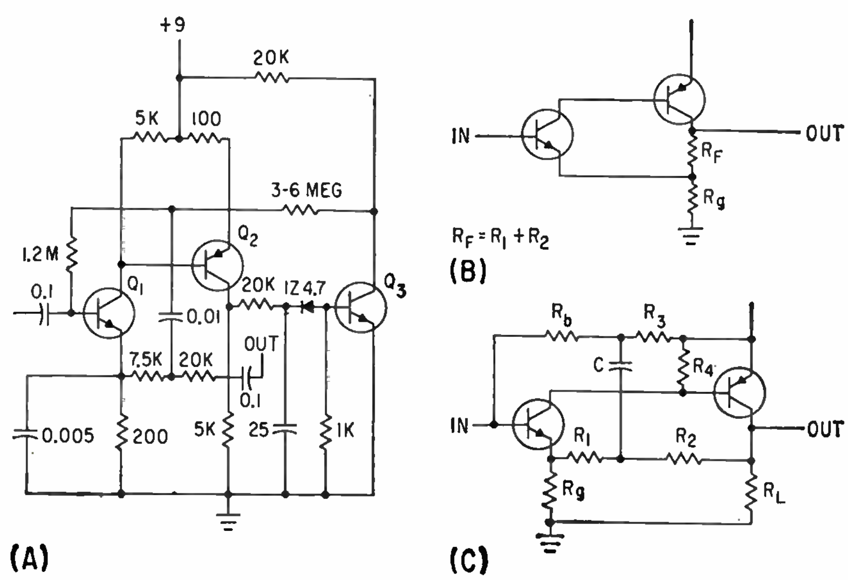


*FIG. 1—Schematic diagram of amplifier, (A). The parameters given are chosen for the following transistors: $Q_1$, $Q_2$—2N1086A; $Q_3$—2N414. Feedback loops are illustrated in (B) and (C)*

Ignoring the positive feedback path and concentrating on the negative feedback loop, the diagram can be simplified to Fig. 1B. Bias resistances and the load resistance have been ignored since their effect is equivalent to a decrease in the current gain of the transistors.

If a voltage is applied to the base of the first transistor, a current

$$i = \frac{V - V_e}{R_{be}} \qquad (1)$$

will flow across the emitter junction. When $R_{be}$ is the slope of the $V$-$I$ characteristic of the emitter-base diode at the operating point, $V$ is the applied voltage and $V_e$ is the corresponding voltage at the emitter terminal. This current is multiplied by $\beta_1\beta_2$ by the cascaded transistors and, with the current flowing in the first transistor, pro-

# Adjustable Impedance and Gain

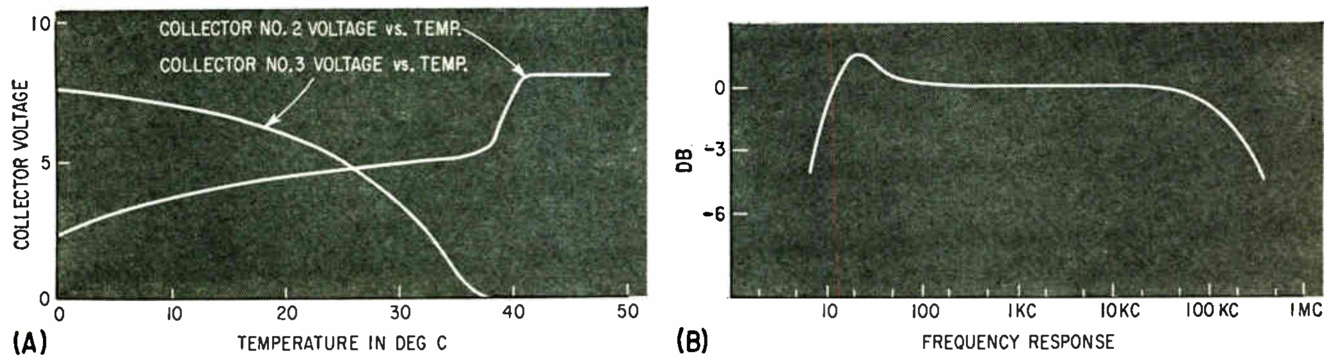


*FIG. 2—Variation of output transistor voltage and the compensating transistor voltage against temperature, (A); frequency response characteristic of the amplifier, (B)*

duces an IR drop across $R_g$ of

$$V_o = ([1 + \beta_1] + \beta_1\beta_2) i R_g \qquad (2)$$

if both $\beta_1 >> 1$ and $\beta_2 >> 1$, neglect the contribution of the first transistor and combine Eq. 1 and 2

$$V_o = \beta_1\beta_2\left(\frac{V - V_o}{R_{be}}\right)R_g \qquad (3)$$

Solving for $V_o$,

$$V_o\left(1 + \frac{\beta_1\beta_2 R_g}{R_{be}}\right) = \beta_1\beta_2 \frac{R_g}{R_{be}} V$$

or

$$V_o = \frac{\alpha'}{1 + \alpha'} V \qquad (4)$$

where

$$\alpha' = \frac{\beta_1\beta_2 R_g}{R_{be}}$$

is the voltage feedback ratio.

When $\alpha' >> 1$, $V_o \approx V$, and the output voltage gain is

$$A = \frac{R_F + R_g}{R_g} \qquad (5)$$

which can be varied by varying $R_F/R_g$. The input impedance is

$$Z_i = \frac{V}{i} = \beta_1\beta_2 R_g \qquad (6)$$

and if $\beta_1\beta_2 >> 1$ it can be large.

Return now to the complete circuit and consider the positive feedback.

The overall current gain from the base of $T_1$ to the collector of $T_2$ is

$$K = \frac{R_{cb}}{R_{cb} + Z_1} \times \beta_1 \times \frac{R_4}{R_4 + Z_2} \qquad (7)$$

where $R_{cb}$ is the collector-base resistance of the first transistor and $Z_1$ and $Z_2$ are the base input impedances of $T_1$ and $T_2$ respectively. If $R_3$ is much larger than all other resistances, the loop gain for the positive feedback is then, assuming $C$ is large

$$G_L \cong K\left(\frac{R_L}{R_1 + R_2 + R_g}\right)\frac{R_1}{R_b} \qquad (8)$$

The input impedance will be infinite if $G_L = 1$. This reduces to

$$\frac{R_2}{R_1} = K\frac{R_L}{R_b} \text{ for the case } K \gg 1 \qquad (9)$$

This condition is independent of $R_g$; thus the gain can be varied without upsetting the input impedance by varying $R_g$.

The operation of the temperature compensating circuit is straightforward. The R-C combination filters out the audio frequency component, and any excess voltage over the breakdown voltage of the zener diode causes current to flow in $Q_3$. This in turn causes the collector voltage to drop, and consequently less bias is delivered to $Q_1$. This will decrease the current in $Q_2$, and hence the operating point will return to the knee of the zener diode characteristic.

The amplifier in Fig. 1C can be adjusted for a wide variety of operating conditions. The output impedance can be raised or lowered by raising or lowering $R_L$. The voltage gain can be varied by varying $R_g$ or $R_g$ and $R_2$. For best results, the voltage gain should be kept below one half of the voltage gain with no feedback. The preferred value is around ⅓ the open loop gain. Having determined $R_L$, $R_2$ and $R_g$, the bias resistor $R_3$ can be set by observing the voltage at the collector of $Q_3$. This voltage should be 5 volts when the temperature of the amplifier is at the center of its operating range.

When this value has been set, the input impedance can be raised by inserting the positive-feedback resistor $R_1$. This resistor must be chosen precisely; a simple method is to apply a square wave at the input and watch the droop on an oscilloscope as $R_1$ is gradually raised. At some point $R_1$ will become too large, and the amplifier will oscillate. Leave that value of resistance in the circuit and shunt it with another resistor. Gradually raise the value of the shunt until the adjustment is complete. This procedure is more accurate than picking a single resistor.

Figure 2 summarizes the performance of the amplifier by showing how the output voltage varies with temperature, and the flatness of the frequency response curve.

# Low-Cost Pulse Generator

*Neon tube and transistor relaxation oscillator can cover 0.05 to 7,000 cps with less than 1-ma current drain*

By REGINALD D. RYAN,
School of Physiology, University of New South Wales, Sidney, Australia

ONE of the simplest and cheapest negative-resistance devices is the common neon tube. A relaxation oscillator using the neon tube is shown in (A). One limitation is the 20-v difference between ignition and extinction voltages, which also may vary appreciably between various neons.

An advantage possessed by the neon tube compared with other and more expensive negative resistance devices such as the four-layer diode, is the low current (less than 5 $\mu$a) prior to breakdown. This permits $R_1$, Fig 1A, to have values as high as 10 megohms giving very-low-frequency operation with relatively small value charging capacitors.

An improved circuit is obtained by adding a transistor as shown in (B). Here, the neon tube operates as a low-current switch driving $Q_1$ to completely discharge capacitor $C_1$ through diode $D_1$ and current limiting resistor $R_2$. Diode $D_1$ should be silicon to insure low leakage current during the charging period. Duration of the discharge pulse is determined by $C_2$ and $R_3$ and must be long enough to allow $C_1$ to be discharged. Diode $D_2$ is cut off during the discharge to prevent premature extinction of the neon tube but it clamps $C_1$ and $C_2$ in parallel during charge period. To a first approximation, period between pulses is $T \cong 0.6\, R_1\, (C_1 + C_2)$. Sawtooth amplitude is equal to ignition voltage and circuit stability is mainly determined by this voltage. A low impedance 100-v output pulse is available at $Q_1$ collector. The average supply current is a fraction of 1 ma.

The circuit can operate over the range of 0.05 to 7,000 cps with the lower limit being set by available low-leakage capacitors. A number of interdependent factors are involved in determination of maximum frequency. They are glow discharge maintaining current, deionization time, average neon current and transistor switching time. With an NT-2 and 2N398, the practical limit is approximately 7,000 cps. Since average neon current is about 20 $\mu$a, an operating life in excess of 10,000 hours can be expected.

The circuit in (C) forms part of a stimulator for neurophysiology research. An increased sawtooth amplitude, greater than ignition voltage, is obtained by returning the neon tube to a lower voltage than the transistor emitter. The neon tube is then biased in the reverse direction at the start of the sawtooth. Collector breakdown is now the limiting parameter of sawtooth amplitude. Larger sawtooth excursion improves timing stability by decreasing percentage effects of variations in ignition voltage.

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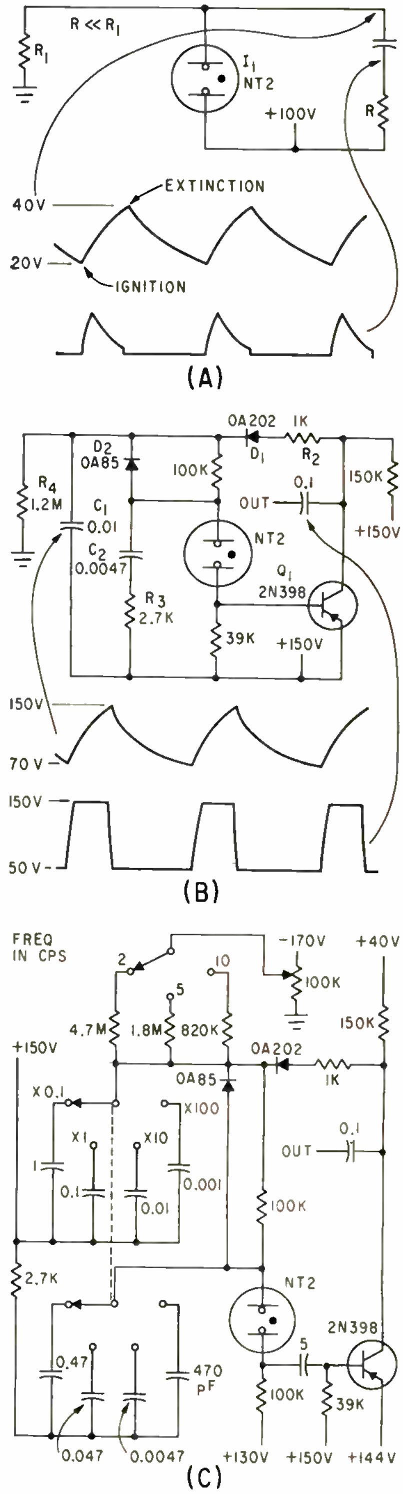
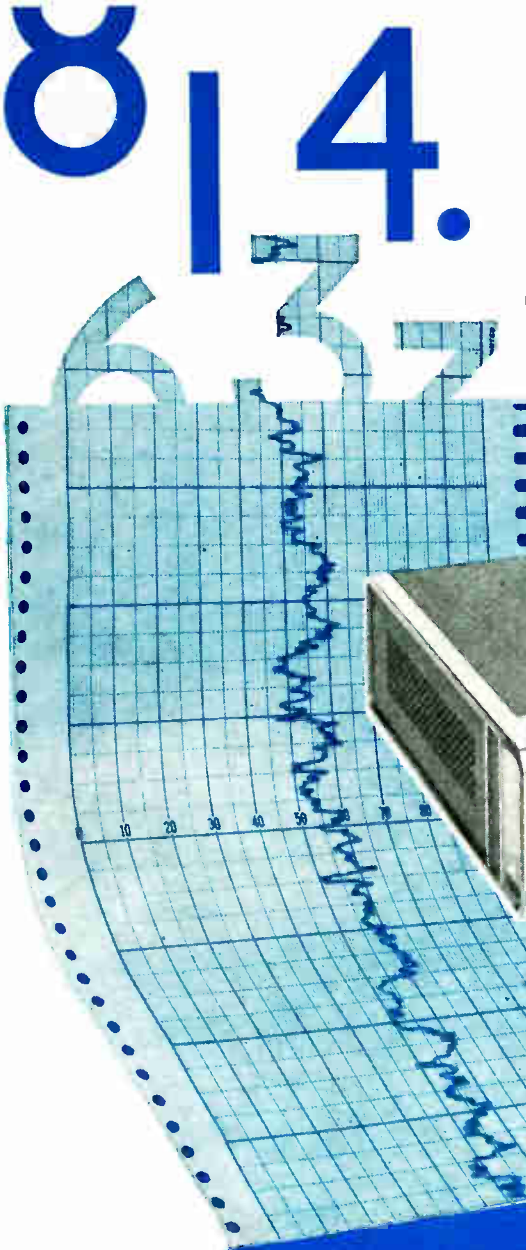



*Simple neon tube relaxation oscillator with associated waveforms (A), transistor-neon tube 100-cps pulse generator (B) and a practical pulse generator covering the range from 0.2 to 2,500 cps as used in a neurophysiology stimulator (C)*



# High-Resolution Analog Recording from Frequency Counters

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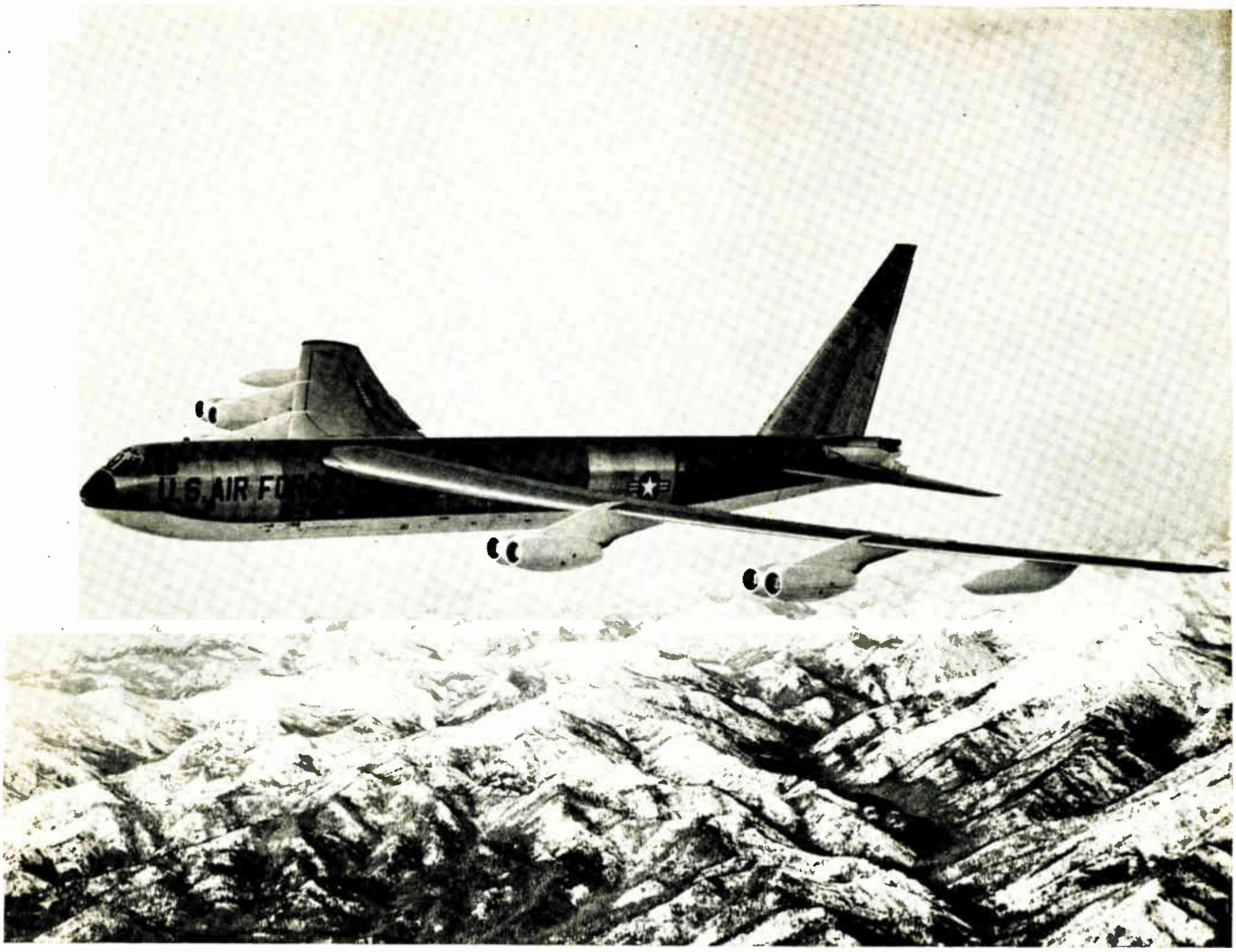

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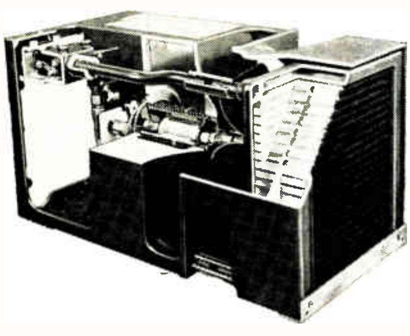

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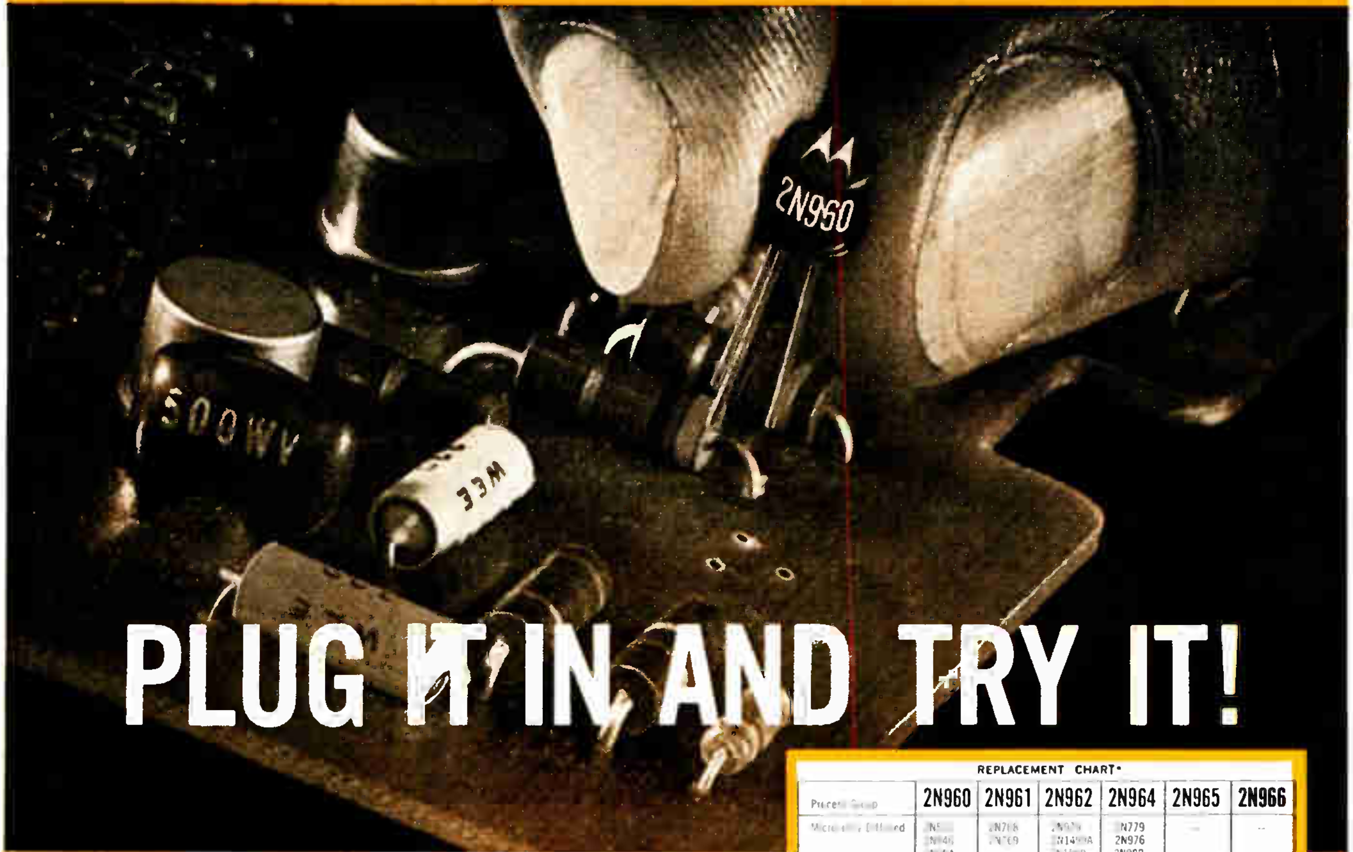


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**REPLACEMENT CHART***

| Process Group | 2N960 | 2N961 | 2N962 | 2N964 | 2N965 | 2N966 |
|---|---|---|---|---|---|---|
| Micro-alloy Diffused | [illegible] | 2N768<br>2N769 | [illegible]<br>2N1499A<br>2N1500 | 2N779<br>2N976<br>2N982<br>2N983 | — | — |
| Mesa | [illegible]<br>2N711B<br>[illegible] | 2N711<br>2N711A | 2N782 | 2N795<br>2N934<br>2N994<br>2N1301 | 2N796<br>2N1683 | 2N1300<br>2N794 |
| [illegible] | [illegible] | 2N1122 | 2N1411<br>2N1427 | — | — | 2N393 |
| Alloy | [illegible] | — | — | 2N582<br>2N584 | — | — |
| Drift | | 2N643<br>2N644<br>2N645 | 2N602<br>2N1450 | — | 2N609 | 2N603 |

*[illegible] on the basis of performance in most switching circuit applications

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|---|---|---|---|---|---|---|---|
| $h_{FE}$ (MIN) 10, 50, 100 mA | 20 | 20 | 20 | 40 | 40 | 40 | — |
| $V_{CE}$ (SAT) MAX @ 10 mA | .20 | .20 | .20 | .18 | 18 | .18 | Volts |
| @ 50 mA | .40 | .40 | .40 | .35 | .35 | 35 | Volts |
| @ 100 mA | .70 | .70 | .70 | .60 | .60 | 60 | Volts |
| $f_T$ (MIN) $I_E$=20 mAdc $V_{CB}$=1.0 Vdc | 300 mc all types | | | | | | |
| $Q_T$ (MAX) $I_C$=10 mAdc $I_B$=1 mAdc | 80 | 80 | 90 | 80 | 80 | 90 | pc |
| $I_C$=100 mAdc $I_B$=5 mAdc | 125 | 125 | 150 | 125 | 125 | 150 | pc |
| $\tau_{RE}$ | 0.6 nsec typical all types | | | | | | |
| $\tau_{FE}$ | 0.5 nsec typical all types | | | | | | |
| All types have 150 mW dissipation in free air, 300 mW at 25°C case temperature | | | | | | | |

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# Biasing Adds Life to Electrostatic Recordings

PERMANENT electrostatic recordings can be provided by charging that penetrates into an insulating material. Such records can have storage life of hundreds of years and can be played back hundreds of times with little loss of signal. The recording methods said to provide these advantages were described at the IRE Convention in a paper by D. E. Richardson, J. J. Brophy and H. Seiwatz of Armour Research Foundation and J. E. Dickens and R. J. Kerr of E. I. du Pont de Nemours and Company.

Early experiments indicated the desirability of charge injection in which equal charges of opposite polarity were produced at points opposite each other through the plastic film recording medium. Bias and signal voltages are applied to a knife-edge electrode and resilient backing electrode between which the tape is drawn. The tape is played back by passing it between similar electrodes, as shown in Fig. 1A.

Little charge is injected into the tape until bias exceeds a threshold. Applying a reverse-polarity prebias before the tape reaches the bias and signal electrodes measurably improves s/n and other properties. With no signal, correct prebias and bias potentials produce an essentially neutral tape. Applying a signal produces a coresponding charge pattern, which can be erased by subsequent re-recording.

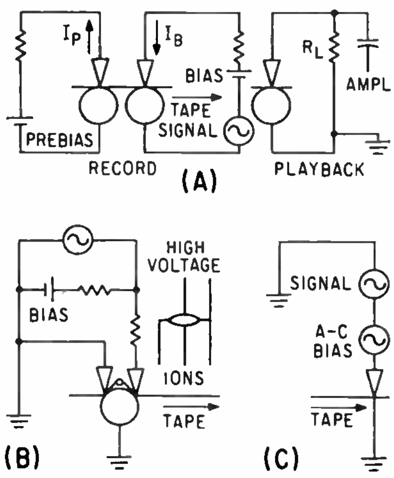



*FIG. 1—Prebias (A) improves s/n and circuit (B) establishes equal prebias and bias currents and also neutralizes tape. A-c bias (C) has similar effect*

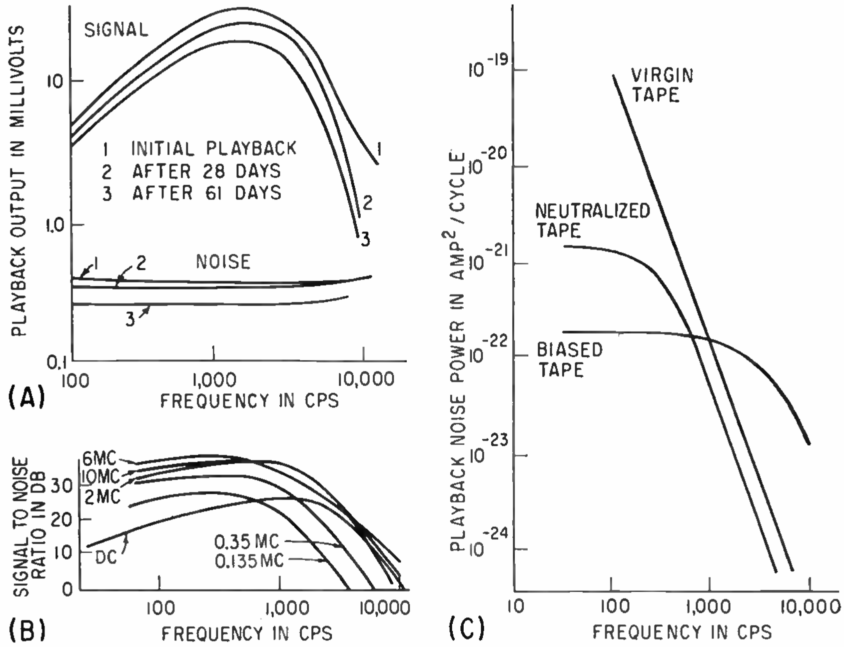


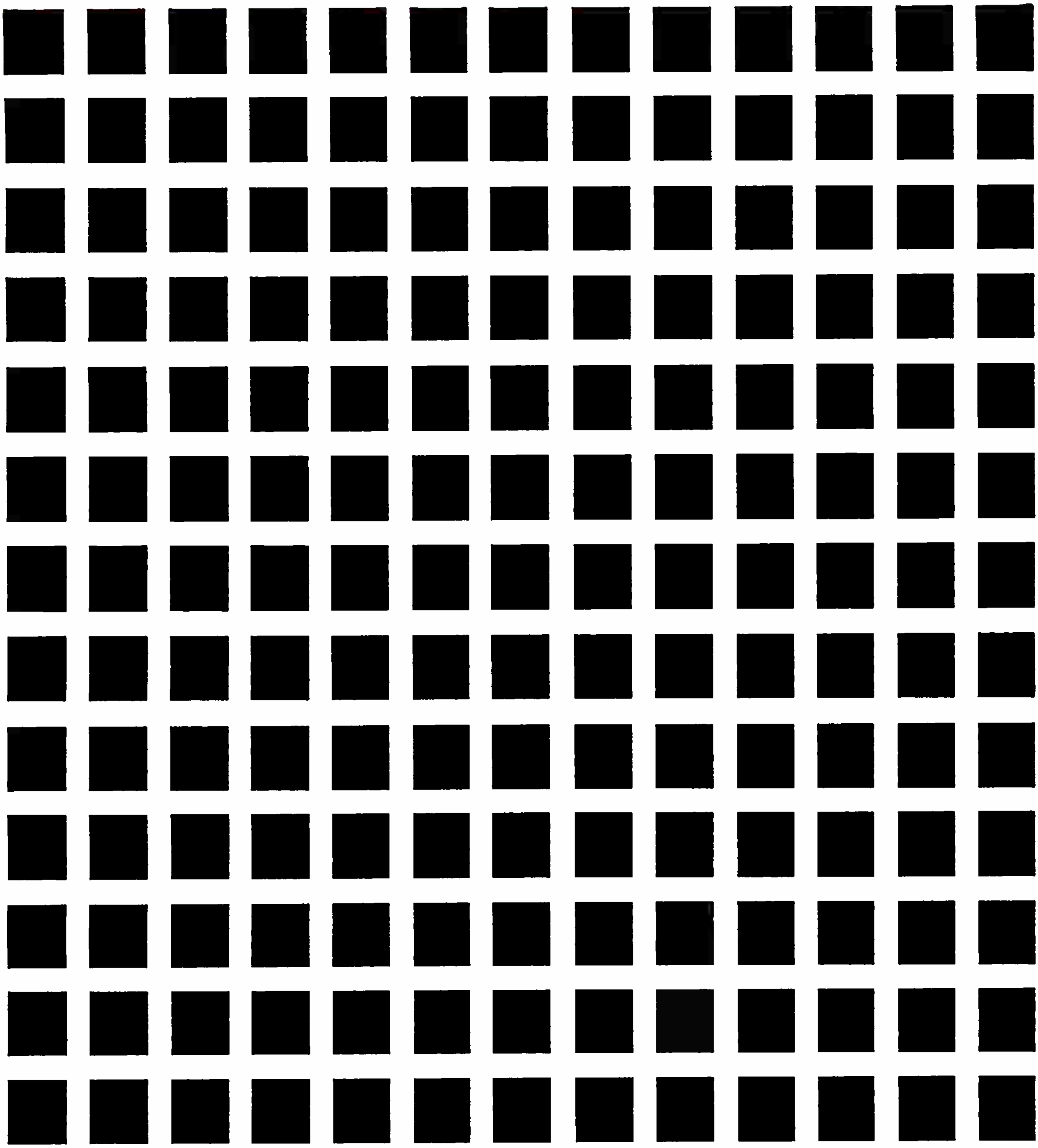

*FIG. 2—Playback output is shown (A) for 22-ips record initially and after 28 and 61 days. Affect of a-c bias (B) is shown for 7.5-ips record, while noise of virgin, neutralized and biased tape played back at 11-ips is shown at (C)*

In experiments, maximum s/n and record life and minimum playback distortion were obtained with equal prebias and bias currents. Voltage from the single source in Fig. 1B is divided to produce generally equal prebias and bias currents. Typical bias is 1,500 v d-c and signal level is 100 v rms.

During playback, the signal charges induce potentials in the electrodes that can be amplified. Signal magnitude depends on $R_L$ in Fig. 1A and is about 40 mv for a 10-megohm load. Typical frequency response is shown in Fig. 2A with noise for a 10-cps to 20-Kc bandwidth taken immediately before and after each signal point on adjacent parts of the tape.

A-c bias applied at a single pair of opposed knife-edge electrodes as in Fig. 1C has a similar effect. As shown in Fig. 2B, s/n is larger than for d-c bias and apparently there is less second-order distortion. After both recording and playback, an atmospheric ion bath neutralizes net charge on the tape produced by triboelectric charging and by the recording process. The ion bath, applied each time the tape passes the electrodes, improves permanence and greatly reduces print-through between layers during storage. It is produced by a high-voltage corona discharge from pointed electrodes between the recording electrodes and the take-up spool in Fig. 1B. A bath between the feed reel and the electrodes can also be used but is often unnecessary.

The low-frequency noise component of virgin tape in Fig. 2C is presumably caused by triboelectric charging during handling and spooling and is greatly reduced by ion neutralization. The reproducible noise of neutralized tape can be interpreted in terms of a stable random array of charged spots produced by air breakdown at the tape



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surface caused by triboelectric charging. This charge pattern is altered by prebias and bias.

Recorded noise can be analyzed in terms of a random array of much smaller charged spots produced by the recording process. The spots correspond with the observed spot-like character of gas discharge at the electrodes during recording. Although wideband noise of biased tape exceeds that of neutralized tape, low-frequency noise is much reduced.

Resolution is influenced by and can be analyzed in terms of effective width of recording and playback electrodes. For the simple knife-edge playback electrode, minimum wavelength is about 0.7 mil. Resolution is improved by a close fitting electrostatic shield on each side of a center pickup electrode. The tape region that induces signals in the active electrode is restricted so that resolution is equal to the distance between the shields. The capacitive loading effect of the shields can be reduced by driving them with a cathode follower.

Gas discharge at the recording electrodes seems to be associated with resolution limits. The finite size of charged spots produced in d-c bias recording and the spread of discharge away from the knife edge tend to limit wavelength. Ambient atmosphere is also known to affect resolution.

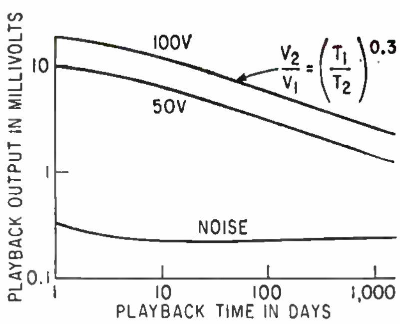


*FIG. 3—Permanence is shown for electrostatic recordings made with equal prebias and bias currents after room storage*

Long record life is attributed to charge distribution in the tape. Typical signal and noise decay in tape stored under ambient conditions is shown in Fig. 3. After an initial period, noise increases somewhat, possibly because of noise print-through. Signal decay can be represented approximately by a power law with an exponent of 0.3 on this curve. This exponent has been as large as 0.7 for recordings made under adverse conditions such as unequal prebias and bias currents. Tapes stored in dry air have had exponents as low as 0.07 or a life of hundreds of years.

Ion treatment apparently affects playback life. Suitably neutralized records can be played back hundreds of times with relatively little signal loss.

# Cadmium-Sulfide Solar Battery Is Flexible

EXPERIMENTAL CADMIUM-SULFIDE solar battery can be rolled up. Such batteries might be carried into orbit in a satellite and then unrolled to intercept maximum sunlight. The battery promises a four-fold increase in power-to-weight ratio, and its cost may be only a small fraction of the cost of present solar batteries.

The first experimental batteries were produced by Harshaw Chemical Co. under contract to the Flight Accessories Laboratory, Aeronautical Systems Division. The work was monitored by the Aeronautical Research Laboratory, U. S. Air Force Office of Aerospace Research.

The solar battery is an unexpected dividend of an ARL basic research program begun in 1952 involving compound semiconductors. Purer and larger cadmium sulfide crystals had been grown and studies were being conducted to learn more about their fundamental structure. Progress was made in several directions and in one case led to awarding an applied research contract to Harshaw Chemical for the design of solar cells having higher efficiency and higher power-to-weight ratios.

Since the photovoltaic effect occurs at a thin surface barrier, an effort was made to produce cadium-sulfide thin-film barriers supported on a light-weight substrate. Although a number of problems have


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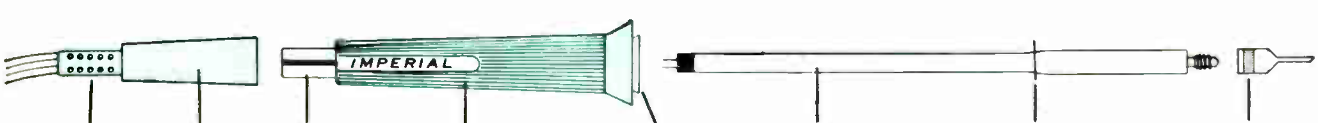

been encountered and the research is continuing, films were developed that it was practical to bend. The significance of such solar batteries for space applications was apparent.

*Battery Efficiency*

Measured efficiency of the solar batteries in their present state of development depends on area. Efficiency for large areas is about 1 percent. For small area, efficiency is about 5 percent, compared to about 10 percent for the best single-crystal silicon cells in use in satellites or 8 percent for the best single-crystal cadmium-sulfide cells made in the laboratory.

Power-to-weight ratio of the new solar batteries at the large-area 1-percent efficiency is about equal to that of present cells. However, preliminary estimates of manufacturing costs are from 25 to 75 percent lower. It is believed that weight of the film cells can be reduced to half. This weight reduction combined with a large-area efficiency of only 2 percent improve power-to-weight ratio by a factor of four. In addition, cost of the film solar battery would only be a small fraction of present solar batteries.

## Battlefield Laser Will Measure Target Range

LASER-RANGER is being developed for battlefield use. Operation is similar to conventional radar except that a narrow, high-intensity light beam is used instead of microwaves.

The lightweight system, under development at the Orlando Division of the Martin Company, will be used to pinpoint targets such as tanks and artillery. The laser ranger is intended for use in conjunction with antitank weapons.

Light is generated by a crystal laser, and the system is said to enable highly accurate measurements of range. The 35-pound unit is attached to a tripod and can easily be carried by a soldier. To measure range, the portable device about the size of a breadbox is set up on the tripod. With the laser-ranger aimed at the target, a button is pressed and range is indicated directly on a panel meter.

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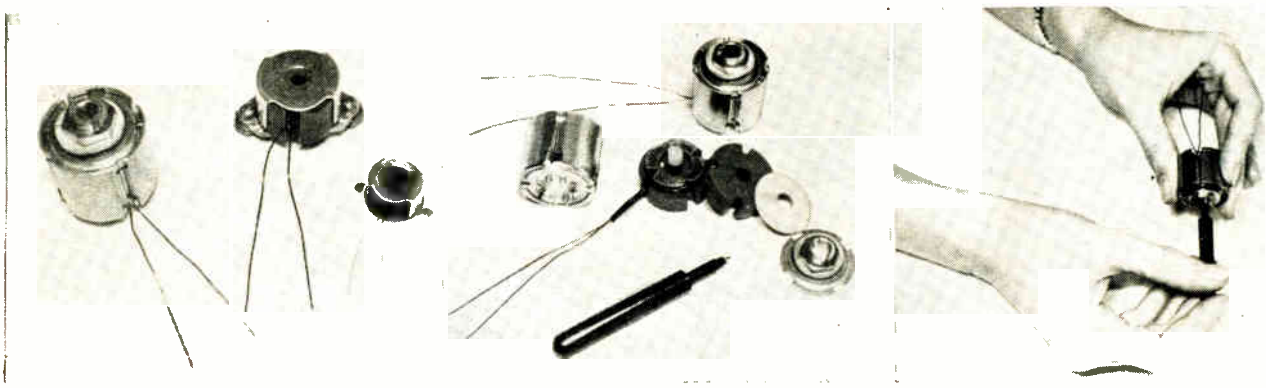

*Choice of the class of pot core is easy to determine. It is simply based on the inductance tolerance desired, if possible by adjusting the number of turns on the coil vs the cost of having it built into the core itself*

# Pot Cores Offer Design Advantages

By C. J. KUNZ, JR.
Chief Engineer
Ferroxcube Corp., of America
Saugerties, New York

IN THE LAST DECADE, with the advent of ferrite materials and the possibility of molding an almost infinite variety of magnetic core configurations, there has evolved a simple, inexpensive, compact inductive core shape known as a pot core. Performance advantages, which are not common in the older style U, E or toroid form. These include improved temperature stability, ease of inductance adjustment, adjustment to 0.02% of a desired inductance value and inherent 40 to 50 db magnetic shielding between side-by-side units.

These advantages, as well as the low losses and high frequency application potential of the ferrite material, are common in all devices, whether it be a filter component, tuned circuit, loading coil, delay line component, transformer, or just an inductive unit.

The complete assembly consists of two ferrite pieces and a coil, usually wound on a plastic bobbin, which is inserted in the space provided in the center of the ferrite. Simple modifications of this consist of using a self-supporting coil and/or one ferrite pot core and a ferrite cover plate. The assembly is relatively simple and the coils used in such a unit can be wound at minimum cost on inexpensive multi-coil winding machines.

### *Inductance Value Variations*

All magnetic materials are made to permeability tolerance of ±20%. Higher accuracy is obtained by modifying turns on the coil. Precision and temperature stability is improved by inclusion of an air gap in magnetic path.

Resultant flux and possible values are explained by Fig. A. The flux that would flow thru a reluctance, R, as a result of a constant applied magnetic driving force. The resultant flux and possible values it may have as the result of variations in R, due either to material variation or temperature instability, give a picture of the tolerance one might expect on the inductance. Looking at Fig. A, p 83, it is clear that if the core reluctance $R_1$ has a tolerance of ±20%, then the flux and inductance will also have this same tolerance, ±20%. For the sake of discussion, let's associate a number, 1,000 with $R_1$. This means $R_1$ can be any value between 800 and 1,200. Now, if an air gap is introduced in the circuit, Fig. B, and has a fixed constant value, $R_2$—say equal to 5,000, then the total reluctance, which is $R_1 + R_2$, can have values between 5,800 and 6,200. This is equivalent to $R_{total}$ equal to 6,000 ±200 or ±3.3%. To go to the extreme of compensation, we could theoretically adjust the air gap value to exactly offset the variations in $R_1$. That is, if $R_1$ were 800, we could make $R_2$ = 5,200, or if $R_1$ were 1,200, we could make $R_2$ = 4,800. All values in between 800 and 1,200 for $R_1$ would likewise have a suitable value of $R_2$, which in effect could make $R_{total}$ equal to 6,000 ±0%. On paper then, we have shown the possibility of completely compensating for material variations from one unit to the next or from one material batch to another. Temperature instability is, in effect, the same as a tolerance on $R_1$. It should be evident that since the air gap reluctance $R_2$ is temperature independent, that although we cannot go to the extreme of perfect compensation for the temperature variation, we can reduce the temperature dependence in the same ratio as we reduced the tolerance in Fig. B from ±20% to ±3.3%. In pot core manufacture, the air gap is introduced by recessing the center post. This is done in a subsequent grinding operation after the basic core has been completely formed.

Considering things now from the practical point of view, it is obvious that the reluctance of the air gap, $R_2$, cannot be added to the core without some tolerance. The magnitude of what tolerance one might reasonably expect depends on the magnitude of the physical length of the air gap and the degree of precision that one can measure and maintain in the grinding operation. Practical considerations, therefore,

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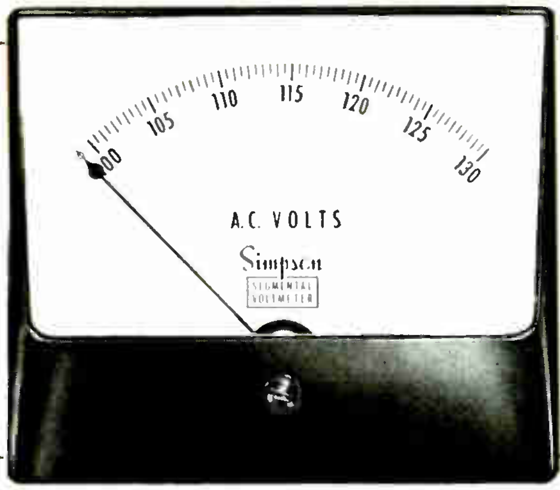


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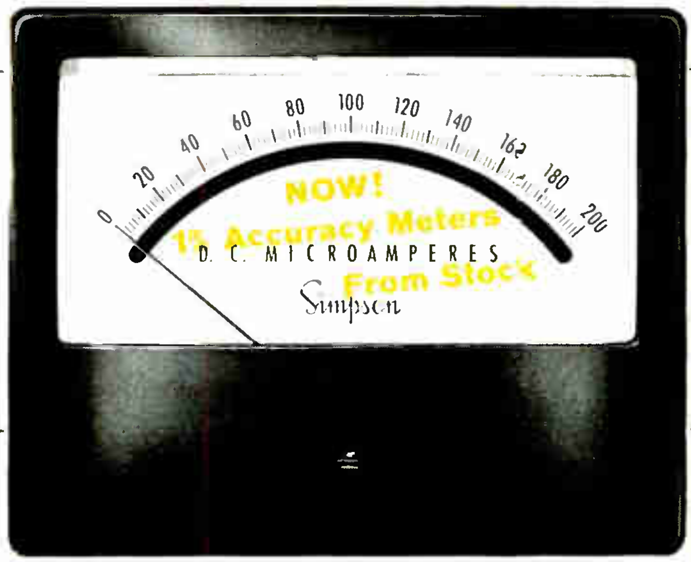


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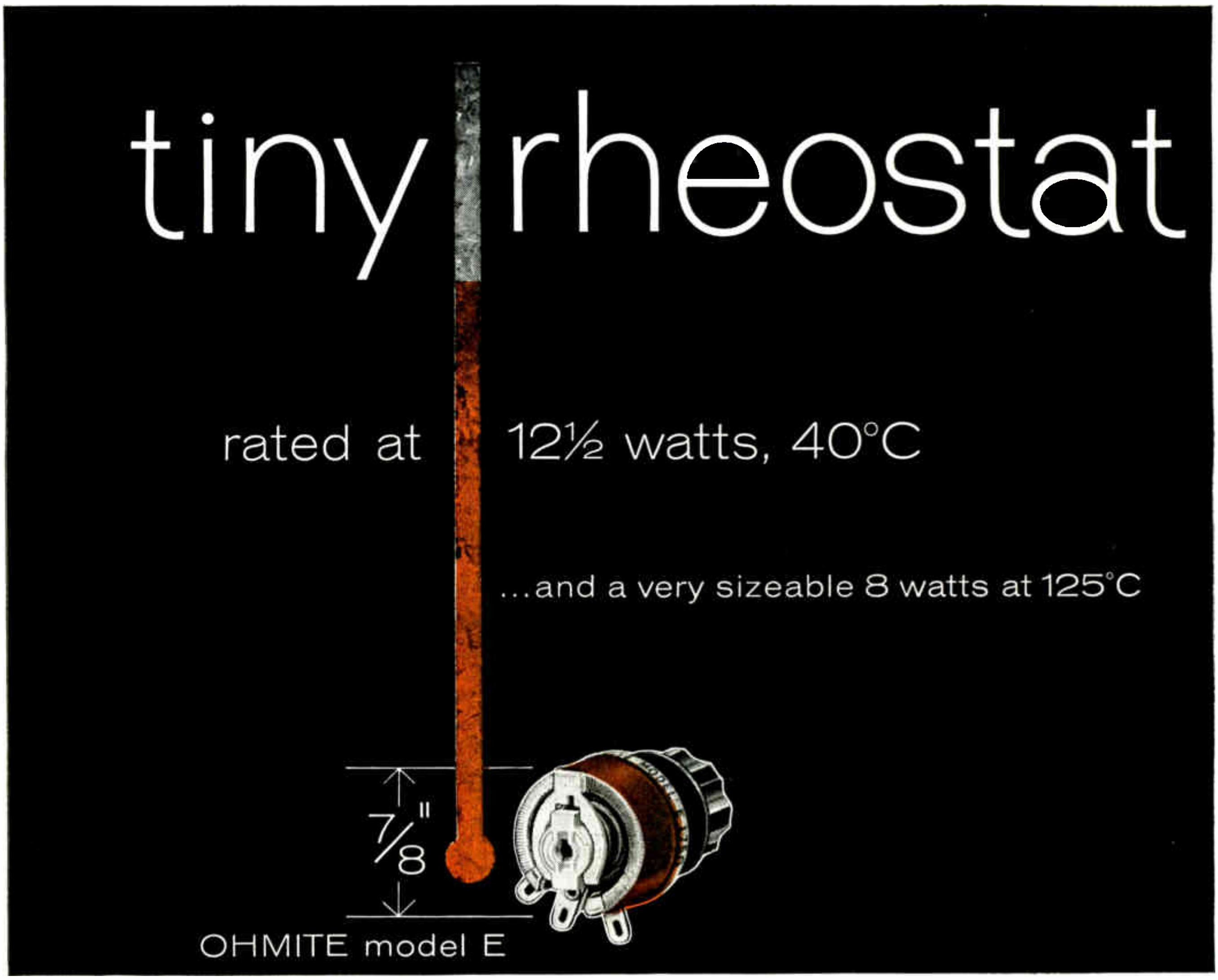


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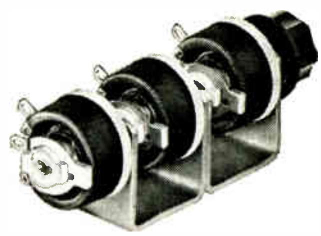

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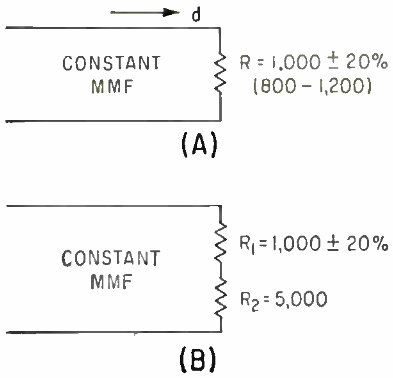



*Flux through a reluctance*

lead to three classes of pot cores, each progressively more precise in magnetic quality and equally slightly more expensive to manufacture and purchase.

In the non-adjustable category, (fixed inductance) one can purchase three classes or groups of cores. Class 1 is a group of cores with no added air gap. The tolerance on effective permeability is usually ±20%, which is the material tolerance. The pot core pair usually has an effective permeability slightly lower than the material permeability. This slight reduction is the result of the "inherent" air gap that is always present when two parts are mated together. One has some selection on available effective permeability by his choice of basic material usable in the frequency range of interest. The core size is primarily dictated by the required inductance.

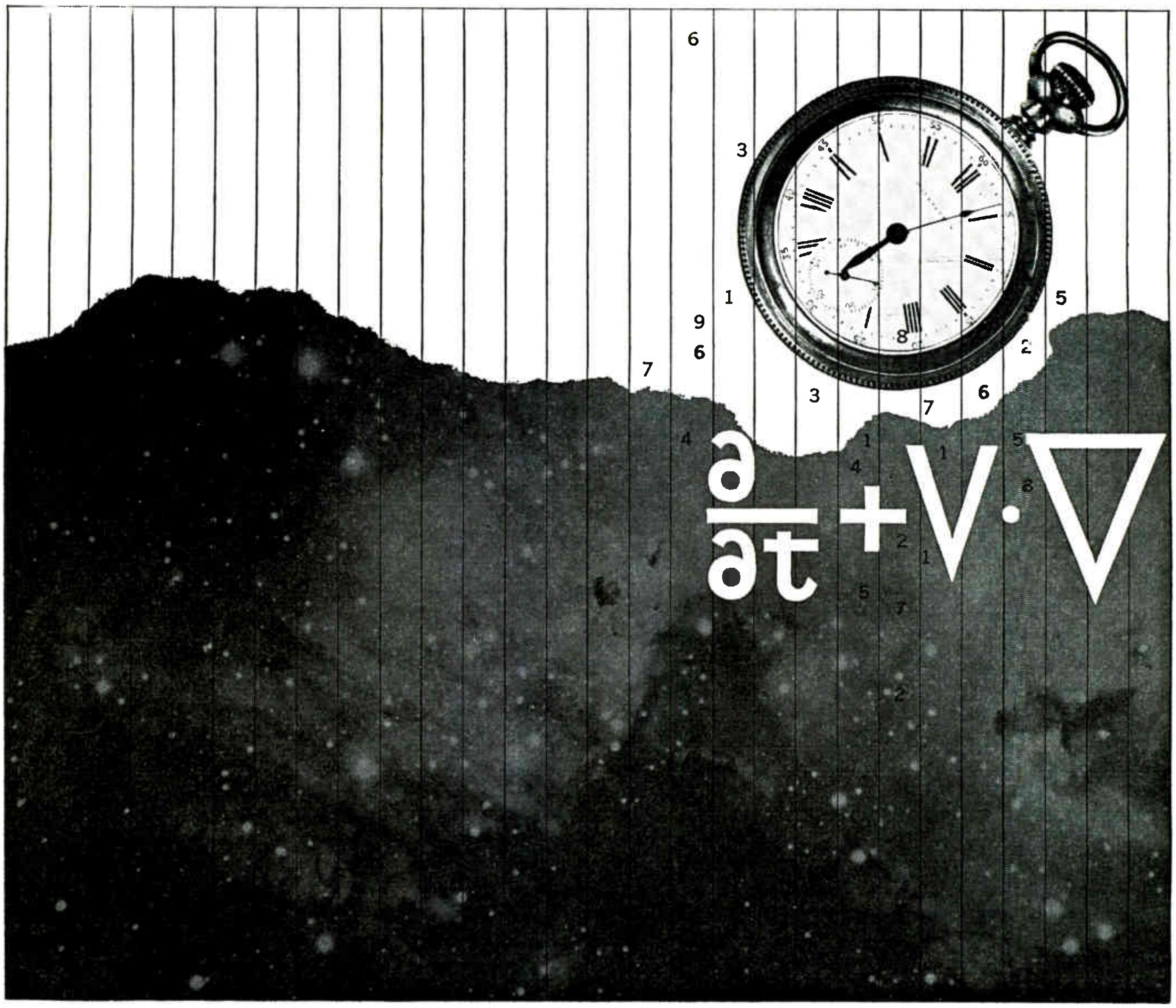
*Gapped Pot Cores*

In mechanically pre-adjusted or gapped pot cores, Class II, all cores are gapped (center post recessed) to a fixed dimension, plus or minus some mechanical allowance. With this class of cores, tolerances on effective permeability usually run from 5 to 10%. Cores are available in a range of fixed gap lengths and can be selected on the basis of the permeability or inductance desired with a given number of turns on the coil. Core size is then selected on the basis of winding volume needed for the given number of turns of a certain size wire. In effect, this gives the designer one more degree of freedom, since he can now select the material on the basis of characteristics other than permeability. Class III is a group of pre-adjusted or gapped pot cores. In this group, each core is tested as it is recessed. The amount of grind is varied to account for material variation. The pot cores are segregated and prepared for sale as mated pairs. In this way, magnetic tolerances can be reduced to as little as 2%. This group is likewise sold in ranges of effective permeabilities in different materials and gives the designer the same benefits as Class II.

Finally, there is one more general category of pot cores, called adjustable pot cores (inductance can be varied by a tuning mechanism). In this category, which includes Class III above, a threaded adjusting slug is provided with suitable mounting hardware to allow up to ±10% variation on the mean value of effective permeability and inductance. In this configuration, a ferrite slug is inserted in the center hole of the pot core pair and effectively spoils to some extent the effect of the air gap in the center post.

It is important to note that this adjustable variety of cores is not solely for circuit applications where adjustment is necessary or desired. They are more often used in fixed inductor applications, the adjustment merely facilitates attaining a precised value of inductance. Units with this arrangement can be adjusted, disassembled and re-assembled to an inductance accuracy of 0.02%. These units in commercial applications allow use of a wider tolerance and, consequently, less expensive associated capacitors. For example, in a resonant circuit of a filter, which might ordinarily require a 1% capacitor to go with a 1% toroid inductor to give a required tuning accuracy, a 5% capacitor could be used with an adjustable pot core and the combination tuned to resonance to within .014%. Not only can the adjustment accuracy be improved, but the complete tuned circuit, considering the cost of the precision capacitor and the cost of winding and adjusting a toroid inductor, will be considerably less expensive.

Frequently, engineers are to some extent at a loss in selecting proper core material, class of cores, size of gap, and size of pot core. This is not surprising, since the number of variables involved leads to a large selection of cores.

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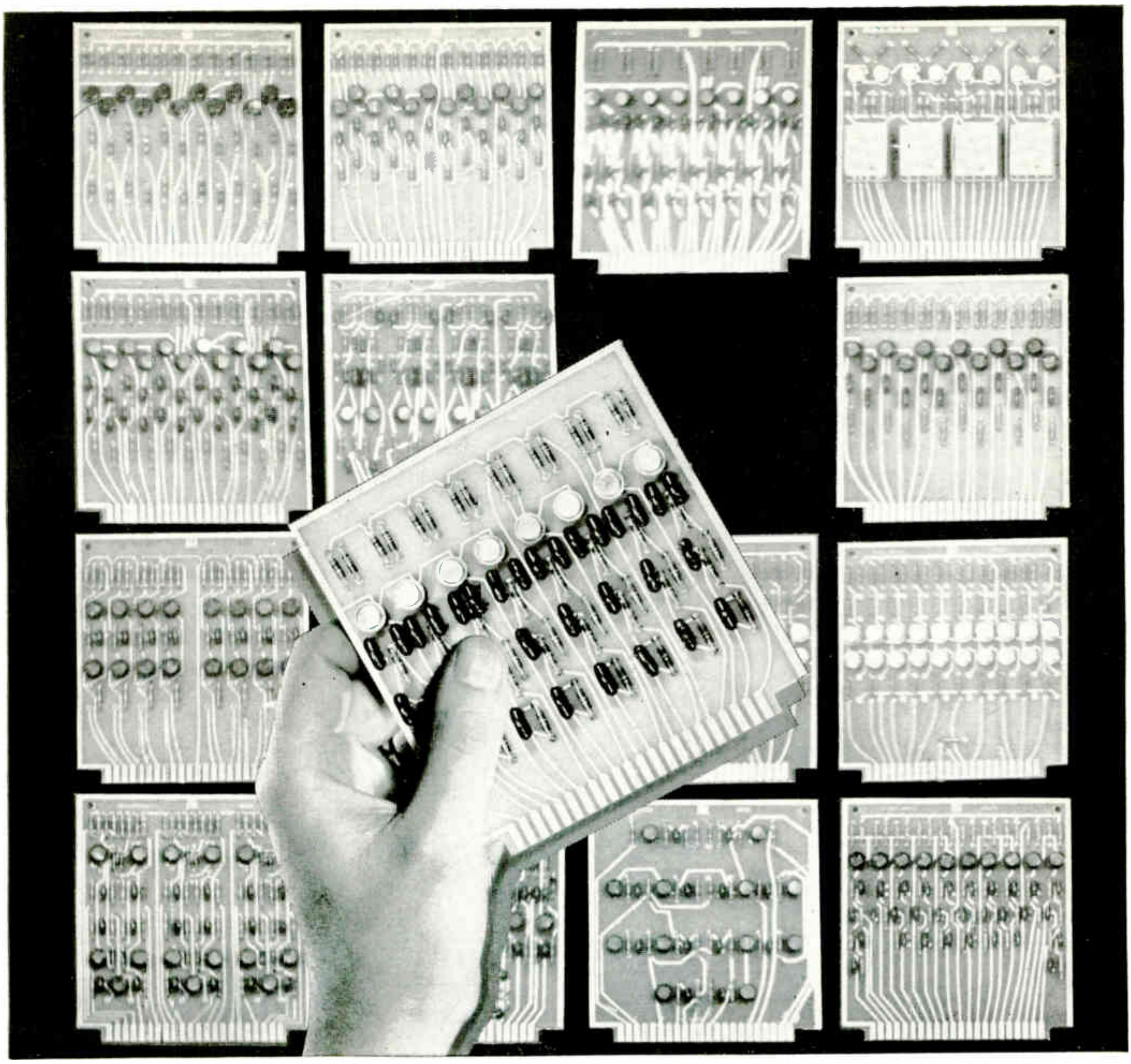

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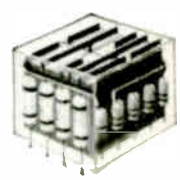

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# Control Pulse Polarity for Weld Strength

By JOHN SOSOKA,
Weldmatic Div.,
Unitek Corp.,
Monrovia, Calif.

FOR HIGH RELIABILITY welding with single-pulse welders, electrode polarity must be considered, since it can be as important as proper energy and pressure settings.

Stored energy welding has become increasingly popular because of the high degree of control it allows. This, in combination with a relatively short weld cycle, allows many dissimilar materials to be joined. But welding dissimilar materials usually presents the problem of electrode polarity.

Welded electronic modules are typical of the type of application where polarity must be carefully controlled. The great variety of lead materials on the components results in a number of dissimilar material combinations. This situation combined with the need for high reliability demands strict polarity control.

Tests show that the direction of flow of the welding current through some combinations of dissimilar materials have a dramatic effect on the quality and strength of the bond. The data shown in the table is typical of polarity-sensitive combinations of material. Simply reversing the direction of the welding current reduces the strength of some bonds by 50 percent. If the operator reverses the material between the electrodes, or if a welder is installed with the equipment polarity reversed, only a partial weld of uncertain consistency will result.

Operator error is the major problem because it is apt to be random. Thus it is imperative that the operators be made aware of polarity effects and that proper polarity be clearly specified in their instructions. This is especially true where similar electrode materials are used for both electrodes.

The problem of improper polarity can easily be avoided once its significance is recognized. Since most stored energy welders are unipolar it is only necessary to check the direction of the welding pulse, which can be done with an oscilloscope if the power supply terminals are not marked positive and negative. To check pulse polarity with an oscilloscope, a nonconductive material can be used between the electrodes.

Another method of establishing polarity of the equipment is to weld a material combination known to be polarity sensitive. The materials should be welded in one direction and then with the polarity reversed. For simplicity, both electrodes should be of the same material. The welded samples can then be pull-tested to determine which polarity

HOW ELECTRODE POLARITY AFFECTS WELD STRENGTH

Non-polarity-sensitive material combination

Nickel wire (0.025 in. dia.) cross-wire welded to nickel ribbon (0.010 × 0.031 in.)

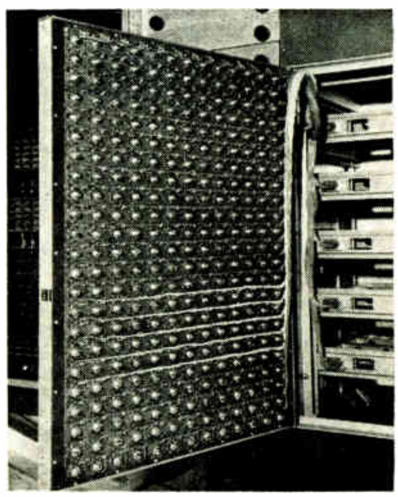
| Electrode Force in pounds | Weld Energy in watt-seconds | Average Pull Strength in pounds (Torsional shear test) | | Percentage of Normal Pull Strength with Polarity Reversed. |
|---|---|---|---|---|
| | | Normal Polarity Nickel Ribbon (−) | Reverse Polarity Nickel Ribbon (+) | |
| 8 | 10 | 18.1 | 18.0 | 98 |
| 8 | 12 | 17.6 | 17.3 | 98 |
| 8 | 11 | 16.9 | 16.6 | 98 |
| 8 | 16 | 16.4 | 15.9 | 97 |

Polarity sensitive material combination

Tinned-copper wire (0.026 in. dia.) cross-wire welded to nickel ribbon (0.010 × 0.031 in.)

| Electrode Force | Weld Energy | Average Pull Strength | | Percentage of Normal Pull Strength with Polarity Reversed |
|---|---|---|---|---|
| | | Normal Polarity Nickel Ribbon (−) | Reverse Polarity Nickel Ribbon (+) | |
| 7 | 32 | 12.9 | 6.3 | 49 |
| 7 | 31 | 12.4 | 8.1 | 68 |
| 7 | 36 | 13.3 | 7.5 | 56 |
| 7 | 38 | 12.3 | 2.6 | 21 |

## Large Size PC Board

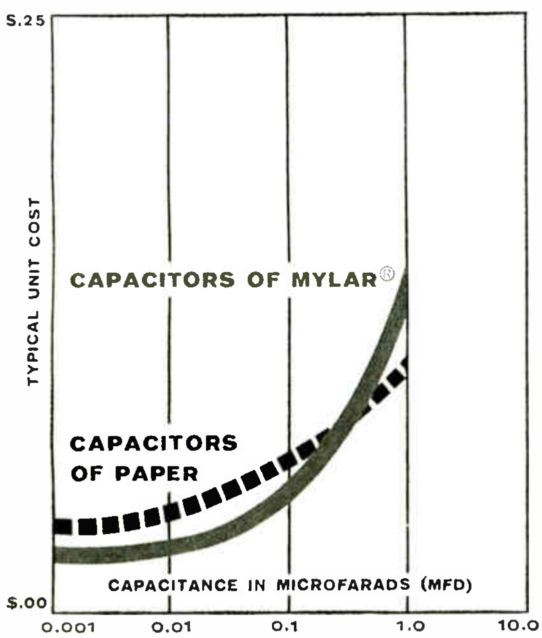


*One of the world's largest printed circuit boards is used at the Bremerton Naval Yard, Bremerton, Washington in a read-out panel for an acoustic tone analyzer. The board, 41 by 31 inches, was manufactured by Automated Controls Co., Alderwood Manor, Washington, using 1/4-inch thick Formica XXXP-36 laminate, holds 290 light sockets*

# CAPACITORS OF MYLAR®

# SAME PRICE RANGE AS PAPER

# BUT WITH EXTRA RELIABILITY




You may not realize it, but you can benefit from the higher dielectric strength, moisture resistance and reduced size of capacitors of "Mylar"* polyester film without paying a premium price. An industry study of manufacturer prices shows THAT OVER A RANGE OF SIMILAR CAPACITANCES AND RATINGS, UNITS OF "MYLAR" COMPARE CLOSELY IN COST WITH THOSE OF PAPER.

According to a recent survey, few engineers are aware of this close price comparison . . . although they recognize the outstanding properties of "Mylar". Look into it yourself. Before specifying capacitors for your design, get this free booklet study with performance facts and price charts. Write: Du Pont Co., Film Dept., Wilmington 98, Delaware.

*Du Pont's registered trademark for its polyester film.

only DU PONT makes
MYLAR®
POLYESTER FILM

DU PONT
REG. U.S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

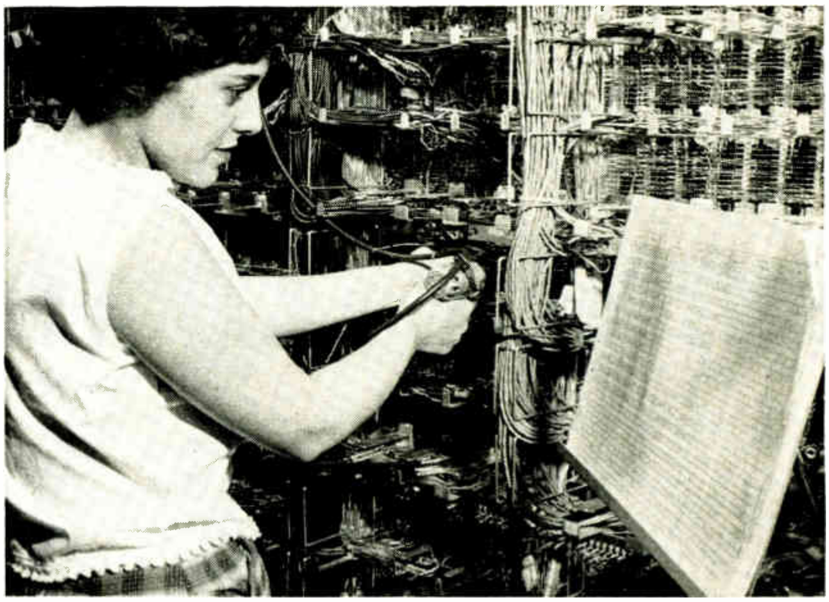
resulted in the strongest welds.

Polarity effects have been somewhat slighted primarily because of the tremendous increase of stored energy welding in the electronics industry, and the use of capacitor discharge welding for the fabrication of welded circuits. The phenomena is unique with single-pulse welding and is not a problem with a-c resistance welding. In a-c resistance welding a number of cycles are usually used and polarity cannot be controlled.

Evidence to date indicates that the polarity effect is the result of either a semiconductor effect at the interface or the result of an electrical potential between the materials being welded. Since the voltage applied across the materials during the weld is only a few volts, either of these effects could account for the polarity phenomena.

In some cases, the preferred polarity cannot be used. During the weld, a voltage is generated across the interface of the conductors being welded and if this voltage is applied incorrectly to a semiconductor device, it can damage it. The effects of having to use the wrong polarity can be somewhat offset by increasing weld energy.

## Where Computers Come From



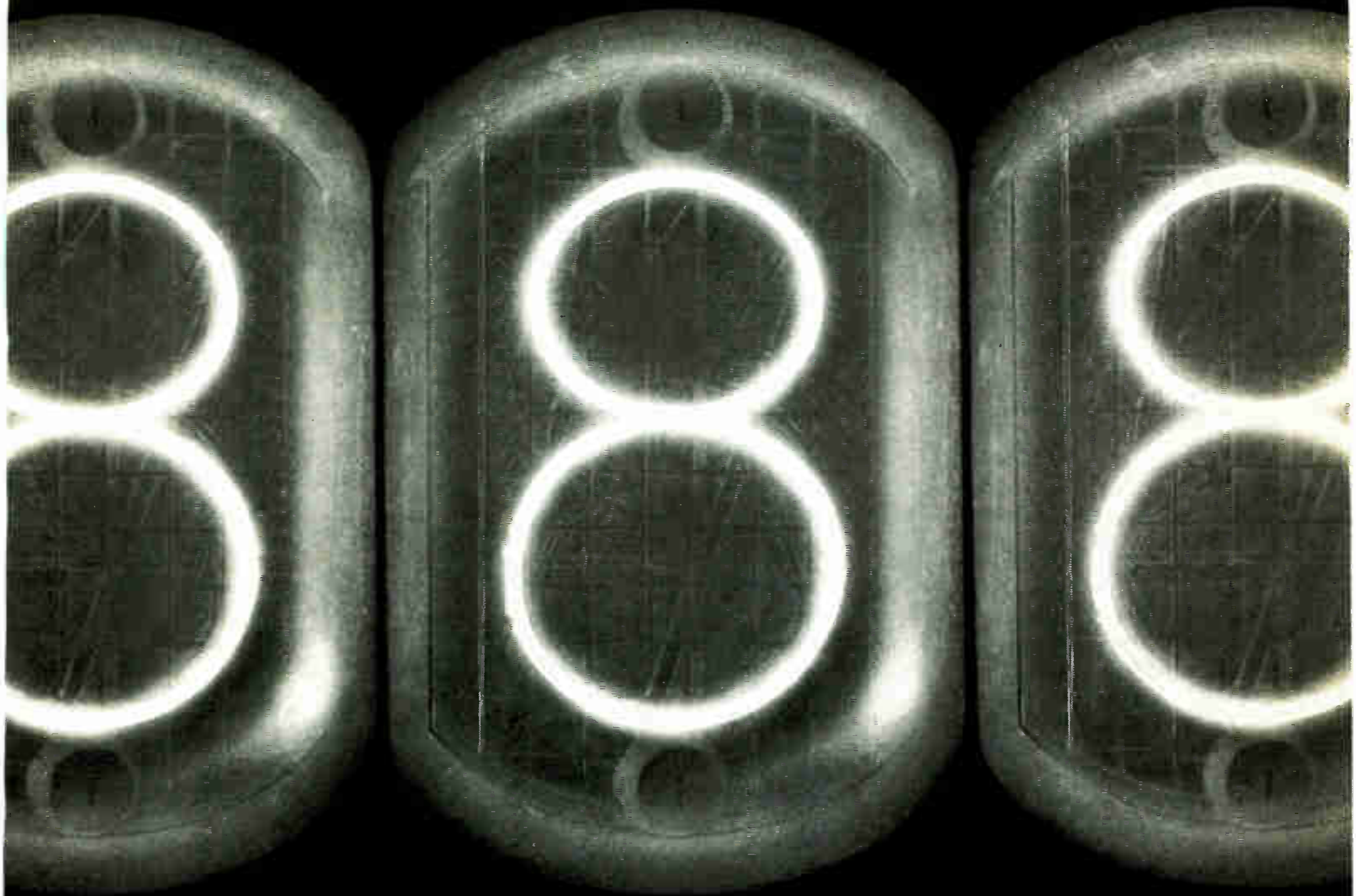
MACHINE GENERATION of wiring specifications and production-line instructions is becoming one of the most valuable benefits of design automation principles, particularly in the manufacture of circuit packages for large computers.

Among examples of "computers breeding computers" is the technique used at the Electronic Data Processing Division of Minneapolis-Honeywell in Brighton, Mass. There the Honeywell D-1000, a first-generation computer, turns out wiring specifications and production instructions for manufacture of units of the Honeywell 800 and 400 computers.

From basic inputs such as statements of the purely logical design of a unit, skeletal information as to logic and circuit placement, and descriptions of circuit types, the D-1000 generates outputs which range from analysis of the logical design to wiring instructions for production workers and punched-card decks to operate automatic wirewrapping machinery.

Initially, the D-1000 produces on tape the logic files, universal package-type files, and allocation files. From these is generated the engineering wire list, or "backboard file," which is the source of production documents, ring-out documents (for verification of wiring from and to correct pins) and quality control documents. It also produces documents that show wire runs.

For wire-wrapping machines, the design automation technique gen-



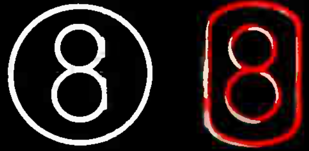
# the new rectangular NIXIE® tube

There's a new addition to the Nixie Tube Line . . . the Rectangular Nixie Indicator Tube. This latest advance in Nixie Tube design provides a major reduction in the over-all width and depth of the readout, but the same character size is maintained.

To the design engineer this means: Greater freedom for equipment miniaturization • Design flexibility, including the use of smaller drive circuits • The ability to add features without increasing space.

And the new Rectangular Tube retains all of the advantages which have made Nixie Tubes industry's most popular readout . . . longest life, lowest cost, smallest size (now smaller than ever!), and greatest readability.

Write today for complete technical information on the entire line of Nixie Indicator Tubes . . . including the new Rectangular Nixie Tube.



REGULAR CYLINDRICAL    NEW RECTANGULAR

ANOTHER ELECTRONIC CONTRIBUTION BY
**Burroughs Corporation**
ELECTRONIC COMPONENTS DIVISION
PLAINFIELD, NEW JERSEY

erates flow charts and the do-list for wrapping sequence.

Production instructions can be updated in a matter of hours to incorporate substantial engineering changes, affecting either manual wiring by production workers or changes in the automatic wire-wrapping sequence.

Production engineers have access to the wiring files, enabling them to make minimal changes to a package already under construction without effecting programming changes all the way back to basic logic files. Production supervisors say instruction sheets generated by machine enable girls to tackle wiring jobs with only one week of training.

Use of ring-out documents have proven so effective that 98 percent of wiring errors are caught before computer systems go to dynamic test.

For automatic wire-wrap, the computer program processes data so as to produce the most efficient operation in terms of path configuration, color, length, number of wraps on pin, etc. Also, production designers can determine how to minimize total wire length in a given run.

The present system concentrates on the problem of backboard wiring interconnections. Expansion of the system will enable machine processing to go inside the package, or outside to the major unit complex.

## Wire Stripper Raises Insulation to Cut It

BOEING'S Aero-Space Div., Seattle, Wash., has developed a stripper that avoids danger of wire damage. The tool raises a section of insulation and cuts it without touching the wire. The technique prevents a small nicks or cut strands, which could induce wire failure under vibration.

Two mechanical jaws, a fraction of an inch apart, grasp the insulation firmly. Pushed together, the jaws slide the insulation along the wire and raise it. When the jaws meet, they cut through the insulation and complete the action.

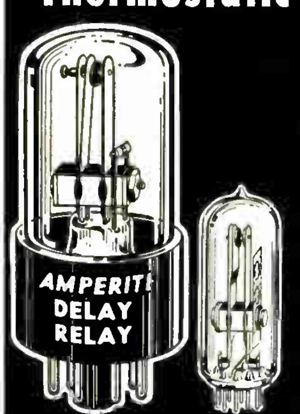
Boeing has made several prototypes, now is studying marketing possibilities.


1348

*Large production gives you low prices!*
*– that's why...*

# Over 100 O.E.Ms have standardized on AMPERITE

## Thermostatic DELAY RELAYS




### 2 to 180 Seconds

Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.

**Hermetically sealed.** Not affected by altitude, moisture, or climate changes.

**SPST only**—normally open or closed.

Compensated for ambient temperature changes from —55° to +80° C. Heaters consume approximately 2 W. and may be operated continuously. The units are **rugged, explosion-proof, long-lived, and—inexpensive!**

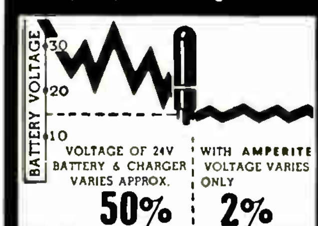
**TYPES:** Standard Radio Octal, and 9-Pin Miniature . . . **List Price, $4.00.**

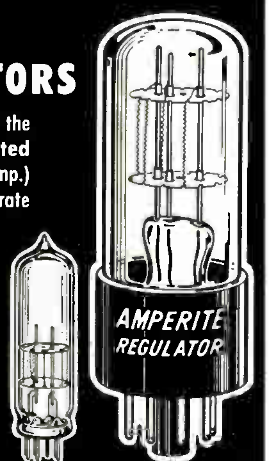
Also — Amperite Differential Relays: Used for automatic overload, under-voltage or under-current protection.

***PROBLEM? Send for Bulletin No. TR-81***

## BALLAST REGULATORS

Amperite Regulators are designed to keep the current in a circuit **automatically regulated** at a definite value (for example, 0.5 amp.) ...For currents of 60 ma. to 5 amps. Operate on A.C., D.C., or Pulsating Current.




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

***Write for 4-page Technical Bulletin No. AB-51***

# AMPERITE

**561 Broadway, New York 12, N. Y. . . . CAnal 6-1446**
**In Canada: Atlas Radio Corp., Ltd., 50 Wingold Ave., Toronto 10**

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TKK

# TKK INDUSTRIAL MOTORS

**Lowest Drain, Minimum Noise, Longest Life — at Low Cost**


**APPLICATIONS**

* Tape-recorders
* Record-players
* Clocks
* Shavers
* Music Boxes
* Cinecameras
* Turntables
* Automations
* Other Appliances

| type | voltage (D.C.) |
|---|---|
| RM-170 T models | 1.5 ~ 3.0 V |
| RM-170 S models | 1.5 ~ 6.0 V |
| RM-170 SC models | 3.0 ~ 12 V |
| FM-250 N models | 1.5 ~ 4.5 V |
| FM-250 R models | 1.5 ~ 6.0 V |

Large orders executed reliably and on schedule by the world's largest factory specializing in D.C. magnetic low current motors (Output: up to 2½ million units per month!) Your detailed inquiry is invited — your satisfaction guaranteed.

## MABUCHI SHOJI K.K.

37, Kabuto-cho 2-chome, Nihonbashi, Chuo-ku, Tokyo, Japan
C.P.O. Box 1084, Tokyo Cables: "NIHONKAKOCO TOKYO"

CIRCLE 200 ON READER SERVICE CARD

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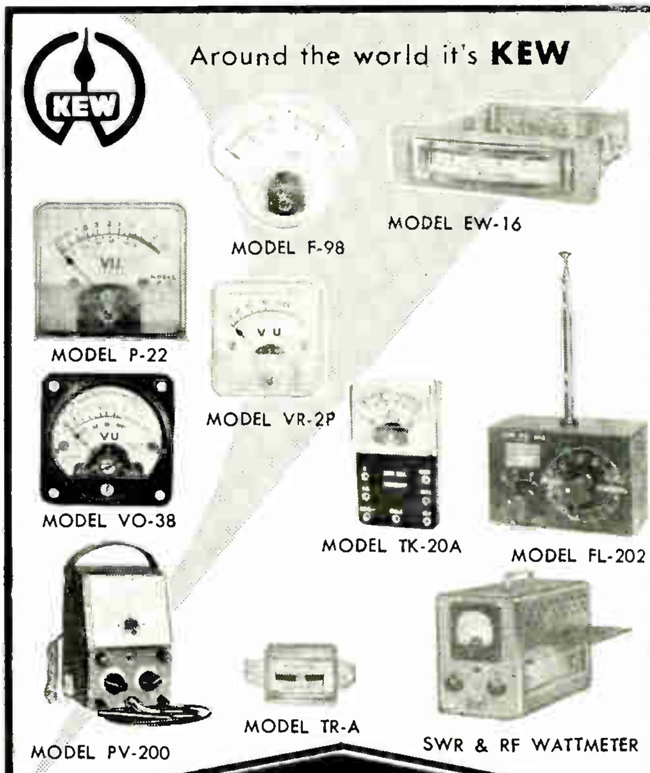
KEW

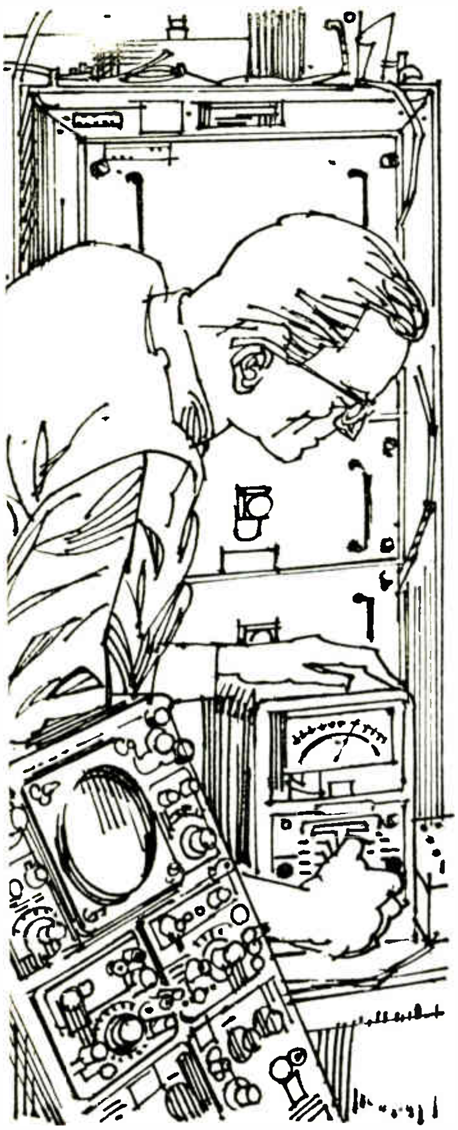
Around the world it's **KEW**

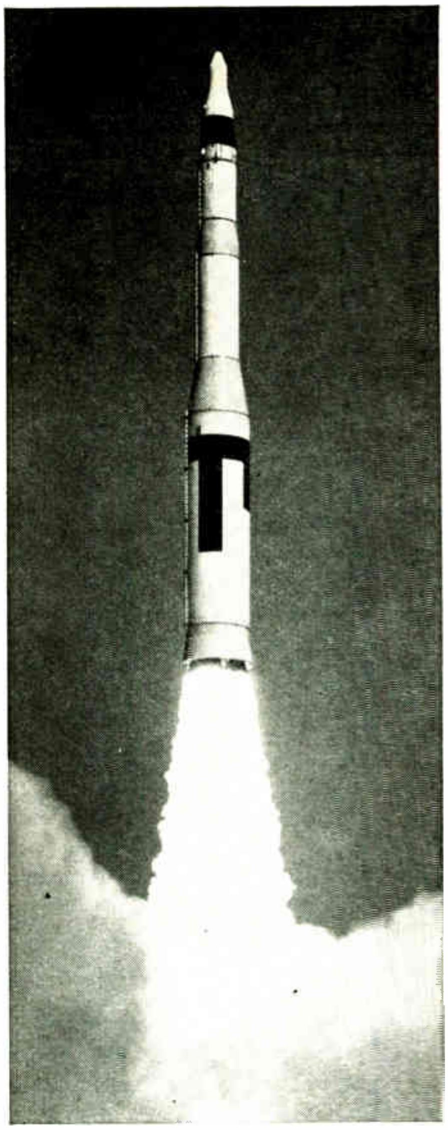



## KYORITSU ELECTRICAL INST. WORKS, LTD.

No. 120, Nakane-cho, Meguro-ku, Tokyo, Japan
Cable Address: "KYORITSUKEIKI TOKYO"
Tel: (717) 0131 ~ 5 · 0151 ~ 3

CIRCLE 201 ON READER SERVICE CARD



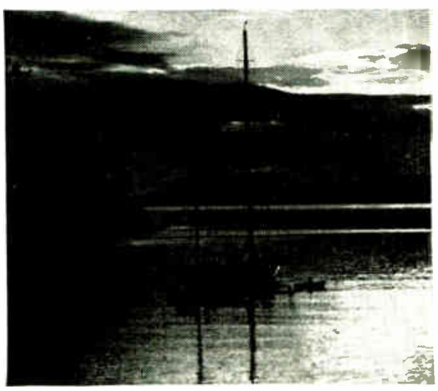


# BOEING OPENINGS FOR ELECTRONIC/ELECTRICAL ENGINEERS

Boeing's Aero-Space Division, holder of major contracts on such advanced space programs as SATURN, DYNA-SOAR and MINUTEMAN, has a number of immediate, long-range openings offering professional challenge, and in many instances, unique ground-floor opportunities in newly-formed divisional organizations.

ELECTRONIC/ELECTRICAL engineering assignments are available in many areas, including the design of electronic equipment, the development of improved design techniques, electronic parts, electronic packaging techniques and the design and development of improved electronic systems.

Salaries are commensurate with all levels of education and experience. Minimum requirements are a B.S. degree in any applicable scientific discipline. Most of the assignments are in the uncongested Pacific Northwest, offering outstanding family living and recreational advantages.



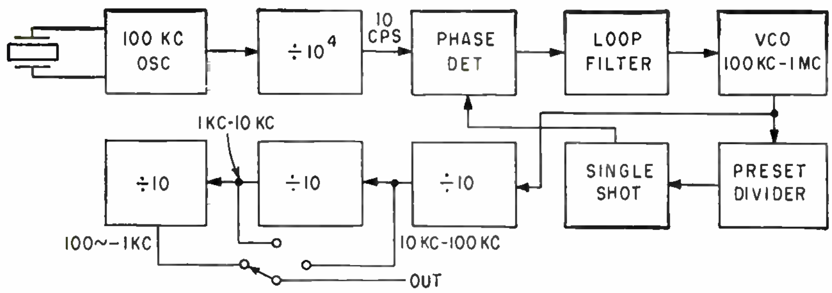
*Send your resume, today, to Mr. Carl Anderson, The Boeing Company, P.O. Box 3707-ECG, Seattle 24, Washington. The Boeing Company is an equal opportunity employer.*

P.S. Seattle is the scene, April 21 to October 21, of the science-oriented Century 21 World's Fair. The Fair's Boeing-sponsored Spacearium in the Science Pavilion offers simulated flights through outer space. Fair visitors are invited to stop in at the Boeing Professional Employment Information Center, near the Fair's Science Pavilion entrance.

**BOEING**

Divisions: Military Aircraft Systems • Transport • Vertol • **AERO-SPACE** • Industrial Products—Boeing Scientific Research Laboratories

# DESIGN AND APPLICATION

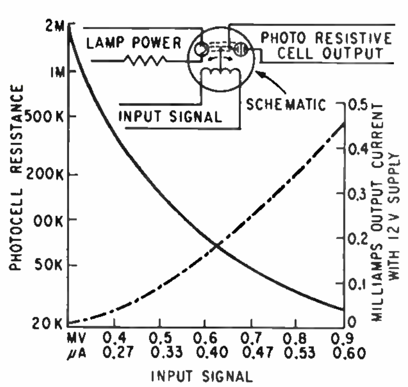



## Ultra Stable Oscillator

### 5 DIGIT SETABILITY

MANUFACTURED by Hull Instruments, 1128 Mission St., South Pasadena, Calif., is the Decalock Oscillator having a frequency range from 0.001 to 999.99 Kc with 5 digit setability and a long term stability of up to 1 part in $10^9$ or better. The output is a sine wave with 0-1 v rms or a square wave having 0-10 v rms. It can be used for rapid generation of precise calibration points without the use of a frequency counter. The circuit, shown in the sketch, is basically a phase-coherent frequency multiplier where the input to the loop is a crystal-controlled frequency. The divider is a five decade preset counter preset by knobs on the front panel. The output of the crystal oscillator is divided down to derive a reference source that is compared to the output of a vco divided by some preset factor. Synchronization of the two comparison frequencies requires that the vco operate at a frequency equal to that of the reference multiplied by a preset factor. Five digit accuracy and setability of the preset divider is then reflected directly in the vco output. Long term stability is a direct function of the reference source. Short term stability of one part in $10^5$ is fixed due to noise in the apc loop.

**CIRCLE 301 ON READER SERVICE CARD**

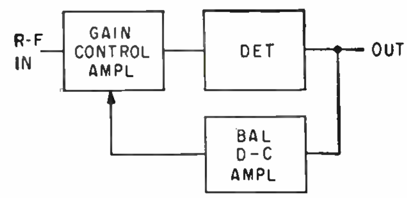



## Microsignal Amplifier

### WORKS ON LIGHT

ANNOUNCED by F & M Scientific Corp., Starr Rd and Rt 41, Avondale, Pa., is the model 210 microsignal amplifier-converter that can be used as either a d-c to d-c amplifier or a d-c to a-c converter. The unit is recommended for all applications where a low-level d-c must be converted and/or amplified. The sketch shows the operating principles. The pointer of a sensitive d-c meter cuts a light beam falling on a photoresistive cell, changing the resistance of the secondary circuit. There is complete isolation between input and output. With 12 v d-c on the photocell, current amplification is over 1,000. Noise level is less than 2$\mu$v equivalent input with drift less than 5$\mu$v over four hours. Reproduceability is better than 5 $\mu$v and the device has a time constant of about one second. Input resistance is 1,500 ohms and basic sensitivity is about 2 $\times$ $10^{-11}$ watts.

**CIRCLE 302 ON READER SERVICE CARD**




## Logarithmic Amplifier

### 400 KC TO 100 MC

RECENTLY announced by Jerrold Electronics Corp., 15th and Lehigh, Philadelphia 32, Pa., is the model LA-5100 r-f precision log amplifier covering the range between 400 Kc and 100 Mc with dynamic ranges to 90 db. As the sketch shows, the amplifier consists of a nine stage bandpass amplifier, d-c automatic gain control amplifier and detectors for output meter and external oscilloscope use. The system develops the required gain in a precise logarithmic manner to permit total response characteristic of the device under test to be linearly displayed in db on a conventional d-c oscilloscope. There are four calibrated ranges. These are: a linear range equivalent to a 20 db calibrated range, a 0 to 40 db, 0 to 60 db and a 0 to 80 db. Adjustment of linear gain permits uncalibrated linear viewing of the response characteristic down to 80 db. The other ranges are internally calibrated, and have an associated expander function to permit uncompressed or linear viewing of the top 5 db of each range.

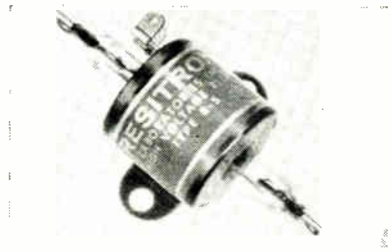
**CIRCLE 303 ON READER SERVICE CARD**

## Polycarbonate Resin

GENERAL ELECTRIC CO., 1 Plastics Ave., Pittsfield, Mass. Giving in-

creased miniaturization, Lexan polycarbonate resin is specified for the dielectric body of microminiature 3 amp connectors which feature simplified wire termination, low contact resistance and low noise.

**CIRCLE 304 ON READER SERVICE CARD**



## High Vacuum Relay
MINIATURIZED

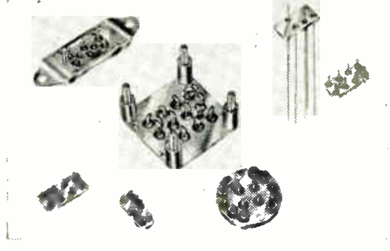
RESITRON LABORATORIES, INC., 2908 Nebraska Ave., Santa Monica, Calif. The Minivac R-5 is capable of switching up to 5,000 v d-c and of handling up to 1,000 v-a. It is actuated by means of a 26.5 v d-c coil. Max length is 2 in. and it is $\frac{7}{8}$ in. in diameter. It weighs 1 oz and is suited for airborne applications and for instrumentation where high reliability is required.

**CIRCLE 305 ON READER SERVICE CARD**

## R-F Connectors
TRIAXIAL

GREMAR MFG. CO., INC., 7 North Ave., Wakefield, Mass. Designed for use with triaxial r-f cables, these connectors are a solution to ground loop problems by providing a double shielding and prevent random r-f noise in electronic equipment.

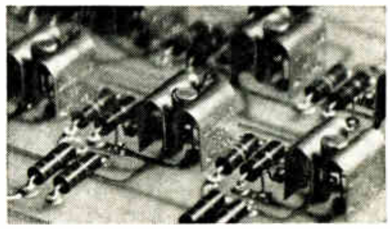
**CIRCLE 306 ON READER SERVICE CARD**



## Relay Headers
HERMETICALLY SEALED

ELECTRICAL INDUSTRIES, 691 Central Ave., Murray Hill, N. J. These headers, featuring rugged compression seals, can be produced to exact specifications to meet practically any type of relay application. Brazed contacts are available if required. Standard finishes available include hot solder dipped, electro-tin, nickel and gold. Special plating on order. Special headers featuring spaded wire leads, can be supplied at lower cost than round types. Spaded pins are precision formed.

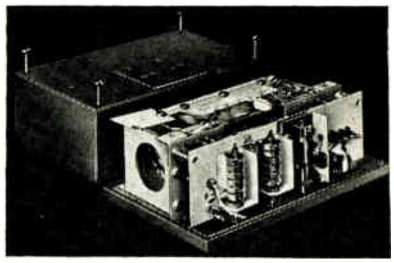
**CIRCLE 307 ON READER SERVICE CARD**



## Heat Sink
FOR P-C APPLICATION

DAEDALUS CO., 21901 DeLaGuerra St., Woodland Hills, Calif. Part No. CS-1 Clipsink is designed for the TO-18 transistor case. Being a single piece copper stamping, it provides extensive cooling surface within a small volume. Design permits the use of pure copper of the highest thermal conductivity. The CS-1 requires p-c board space of ½ in. by ½ in. with a total height of less than ½ in. Completed assembly is proof against extreme conditions of shock and vibration. In still air the CS-1 lowers external thermal resistance of the transistor to less than 50 C/w; in moderately moving air, to less than 15 C/w.

**CIRCLE 308 ON READER SERVICE CARD**



## Airborne Oscillator
CRYSTAL CONTROLLED

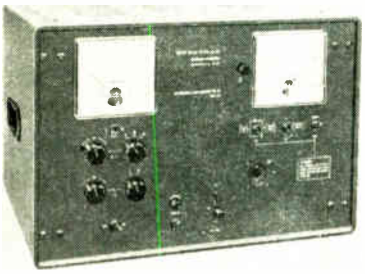
REEVES HOFFMAN DIVISION, Dynamics Corp. of America, Carlisle, Pa. Model S-1397 is a highly rugged oscillator that will withstand acceleration of 11 g, shock of 20 g, vibration at 5 g from 1 to 500 cps, altitude up to 55,000 ft and operating temperature in the range from −55 C to 100 C. It contains an oven-controlled crystal and transistor oscillator, plus cathode follower and grounded grid amplifier.

**CIRCLE 309 ON READER SERVICE CARD**

## Quartz Crystal
### GLASS MOUNTED

BLILEY ELECTRIC CO., Union Station Building, Erie, Pa. In primary standards, this glass mounted, optically polished, gold-plated fifth overtone quartz crystal at 2.5 Mc provides a stability of 1 part in $10^{9}$ with aging of only 5 parts in $10^{10}$. Known as Bliley type BG11AH-5, the average Q is 4,500,000.

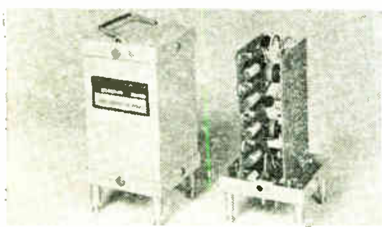
**CIRCLE 310 ON READER SERVICE CARD**



## Test Set
### DIRECT READING

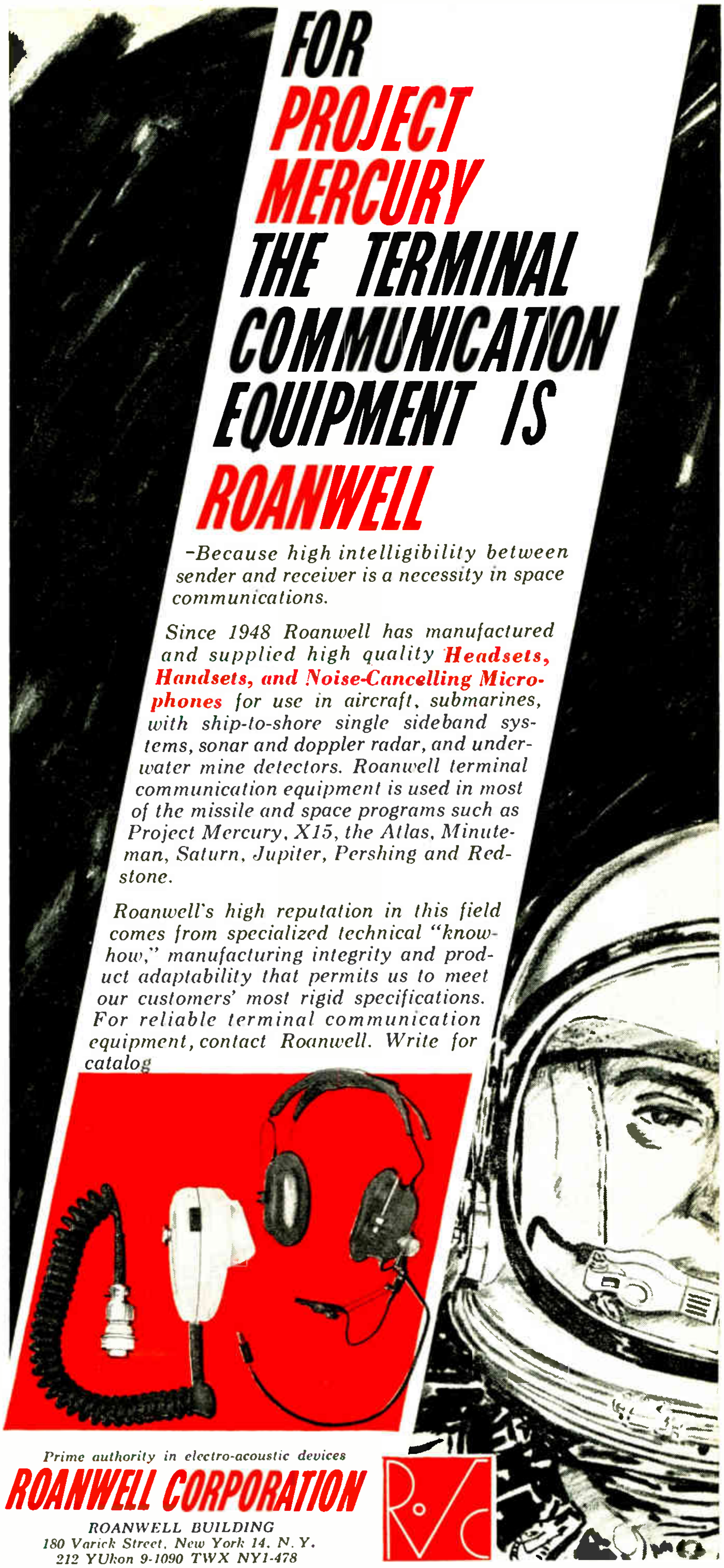
DYNATRAN ELECTRONICS CORP., 178 Herricks Road, Mineola, N.Y. Model 1818A provides direct readings of the 100 Mc gain for both *npn* and *pnp* transistors; also provides direct readings of the gain bandwidth product up to 1,000 Mc. Instrument features a high impedance 100 Mc current source and a very low impedance 100 Mc collector load. Price is \$840.

**CIRCLE 311 ON READER SERVICE CARD**



## Signalling Device
### HIGH-SPEED

RIXON ELECTRONICS, INC., 2121 Industrial Parkway, Montgomery In-

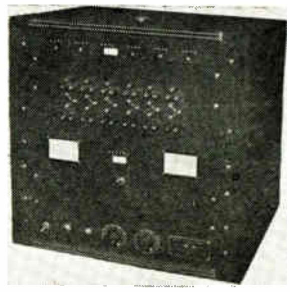





**CIRCLE 97 ON READER SERVICE CARD**

dustrial Park, Silver Spring, Md. The SCR601 semiconductor relay is a high-speed, solid state switch for controlling signal currents in teletypewriter and similar circuits. Its complete freedom from mechanical adjustment eliminates expensive service and maintenance costs. Its absence of radio interfering radiation makes it useful in many applications where a mechanical relay's interference was intolerable.

**CIRCLE 312 ON READER SERVICE CARD**

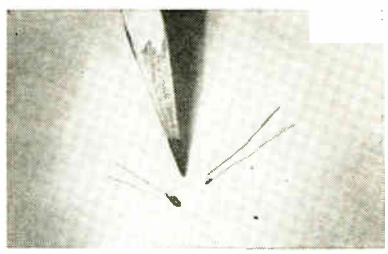


## Relay Tester

### DRY-CIRCUIT

FLEETWOOD LABORATORIES INC., 35 Rockwood Place, New Rochelle, N. Y. Models R-5 and R-6 feature cycling speeds down to 2 and up to 300 cycles per minute. When requested, two-phase cycling of relay coils is provided, so that latching or bi-polar relays may be tested. Sensitivity can be as high as 80 $\mu$v, so that contact resistance down to 80 ohms at 1 $\mu$a of current may be detected, in model R-6. Also featured are quiet operation and automatic shutdown in case of miss detection.

**CIRCLE 313 ON READER SERVICE CARD**



## Thermistors

### VARIED SHAPES

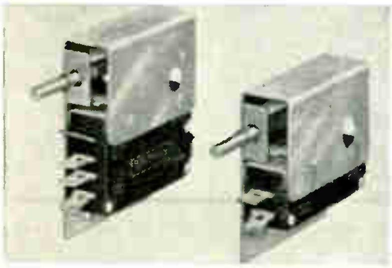
GULTON INDUSTRIES, INC., 212 Durham Ave., Metuchen, N. J., offers wafer, disk, washer, rod and bead configuration thermistors. They are supplied in resistances from 1 ohm to 1,000 megohms and in a range of temperature coefficients of resistance from −3.4 percent per deg C to −6.8 percent per deg C. The wafer type is used in missile and satellite applications. Smallest wafer presently made by the company is 0.6 in. square.

**CIRCLE 314 ON READER SERVICE CARD**

## Silicon Rectifiers

INTERNATIONAL RECTIFIER CORP., 1521 E. Grand Ave., El Segundo, Calif. Ten flangeless diffused junction rectifier types provide 2 amp d-c output, voltage range from 50 to 1,000 v prv.

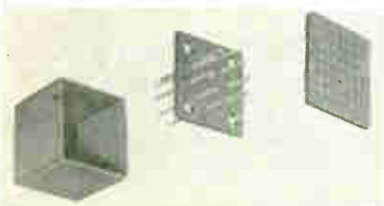
**CIRCLE 315 ON READER SERVICE CARD**



## Snap-Acting Switches
### D-P AND S-P

UNIMAX SWITCH, Ives Road, Wallingford, Conn. Low-cost snap-acting switches, with ratchet-drive plunger mechanism that gives alternate-stroke operation, provide convenient, single-button control of loads up to 15 amp 125/250 v a-c and up to $1\frac{1}{2}$ h-p at 250 v a-c. Both dpdt and spdt switches are available in this design, which is suitable for manual, mechanical, or solenoid operation.

**CIRCLE 316 ON READER SERVICE CARD**



## Module Case Header
### & TERMINAL BOARD

GRAYHILL MOLDTRONICS, INC., 229 Burlington Ave., Clarendon Hills, Ill., offers the 3B2143 miniature module case with mating 3B2040-1 Deci-board, or 3YY2039 header

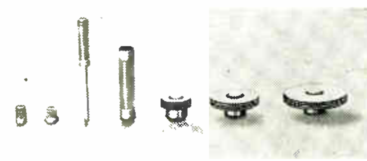
Case is 0.750 deep over all by 0.840 square. Header is available with either 9 or 10 pins. Header pins are on a 0.468 circle of centers for a standard 9-pin miniature tube socket for plug-in applications. The Deci-board has 49 flash covered holes on 0.100 in. grid. All that is required is to punch out the desired holes, and the remainder stay sealed.

**CIRCLE 317 ON READER SERVICE CARD**

## Dielectric Sheets

CUSTOM MATERIALS, INC., Alpha Industrial Park, Chelmsford, Mass., has available Custom High-K 707S, copper clad dielectric sheets with a range of dielectric constants from 2.5 to 25.

**CIRCLE 318 ON READER SERVICE CARD**

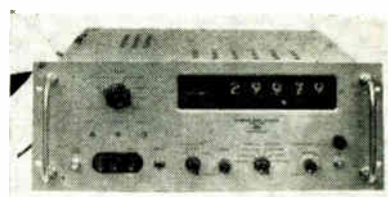


## Bellows Contacts

### HIGHLY RELIABLE

SERVOMETER CORP., 222 Main Ave., Passaic, N. J., offers a line of bellows contacts that serve as noninductive springs for electronic assemblies, provide repeatability for any number of re-assemblies, and have low microwave resistance and d-c electrical resistance. Manufactured of nickel metal, they are 24 carat gold surface plated 0.00004 in. thick, providing excellent contact and microwave characteristics.

**CIRCLE 319 ON READER SERVICE CARD**



## Digital Voltmeter

### HIGH STABILITY

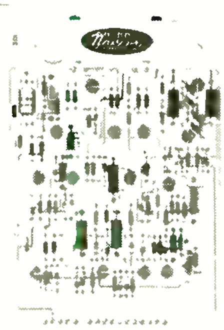
DYMEC, a Division of Hewlett-Packard Co., 395 Page Mill Road, Palo Alto, Calif. The DY-2401A integrating digital voltmeter features fully floated and guarded input and measuring circuitry, in combination with an integration process to provide an effective 140 db common mode rejection at all frequencies, including d-c. The integrating technique provides an average reading of the input voltage over a selected, crystal-controlled sample period. Price is $3,950.

**CIRCLE 320 ON READER SERVICE CARD**

## Electronic Counter

BECKMAN INSTRUMENTS, INC., Berkeley Div., 2200 Wright Ave., Richmond 3, Calif. Model 8370, a 10 Mc counter, displays digital data in electroluminescence. Price is $2,175.

**CIRCLE 321 ON READER SERVICE CARD**



## Gated Clock

### BUILDING MODULE

NAVIGATION COMPUTER CORP., Valley Forge Industrial Park, Norristown, Pa. As the heart of a 0.1 percent analog-to-digital converter, model 301 contains a gated 100 Kc oscillator, a master reset generator, gating to provide set and reset strobe pulses, and a sign flip-flop. Price is $183.

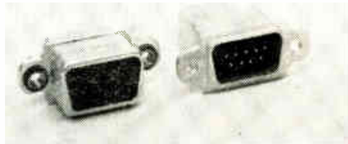
**CIRCLE 322 ON READER SERVICE CARD**

## Magnetic Shield

### FOR DISPLAY TUBES

MAGNETIC SHIELD DIV. Perfection Mica Co., 1322 N. Elston Ave., Chicago 22, Ill., has developed a Netic Co-Netic magnetic shield for close fit and retrofit display tube applications. All exposed edges of the dual lamina shield are completely sealed by a new fusion process. The sealed edges prevent electroplating solution from collecting between the laminates, eliminating possibility of corrosive activity starting at a future date.

**CIRCLE 323 ON READER SERVICE CARD**



## Subminiature Plug

MEETS MIL-C-8384

CANNON ELECTRIC CO., 3208 Humboldt St., Los Angeles 31, Calif. The DEDR is a sealed version of the retangular D subminiature plugs, and is sealed by a grommet that is cemented to the insulator. This eliminates need for potting, and the crimp snap-in contacts can be easily installed or replaced without damaging the seal, thus cutting installation and maintenance time. Contacts are a copper alloy with a gold or silver plating, and are spaced on 0.108 in. centers.

**CIRCLE 324 ON READER SERVICE CARD**

## Gold Alloy Preforms

ALPHA METALS, INC., 56 Water St., Jersey City 4, N. J., has available a new series of Au/Ge and Au/Si alloys in washers, disks, rectangles and spheres.

**CIRCLE 325 ON READER SERVICE CARD**

## Dual Power Supply

SOLID STATE

MODERN DESIGN, Div. of H. C. Schloer Inc., Vestal, N. Y. The 121D provides two independent outputs of either 12 or 15 v d-c at 1 amp in a package of approximately 7 by 7 by 4½ in. The desired voltages are obtained by inserting the proper circuit-regulating card for each output. Simple to remove and install, the glass epoxy cards speed trouble-shooting and offer maximum maintenance ease. Module is designed for l-v transistor and solid state computer applications and is packaged for easy access to components.

**CIRCLE 326 ON READER SERVICE CARD**

## Pulse Counter

PRESIN CO., INC., 2014 Broadway, Santa Monica, Calif. Model F108 electromagnetic pulse counter has a life of 1 billion steps and a maximum counting rate of 100 pulses per sec.

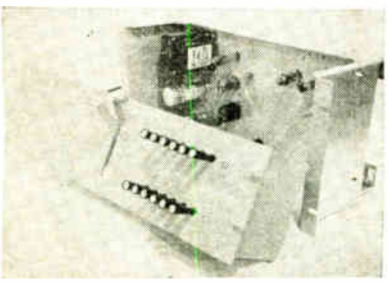
**CIRCLE 327 ON READER SERVICE CARD**

## Subcarrier Oscillator

MODULAR SYSTEM

PACE ENGINEERING CO., 13035 Saticoy St., N. Hollywood, Calif. Model CT 13 universal subcarrier oscillator system accepts inputs from a number of transducers and other input devices for f-m/f-m telemetry. Use of modular construction with plug-in function cards minimizes the complications and cost in problems involving a variety of physical measurements.

**CIRCLE 328 ON READER SERVICE CARD**



## Switcher-Fader

FOR C-C TV USE

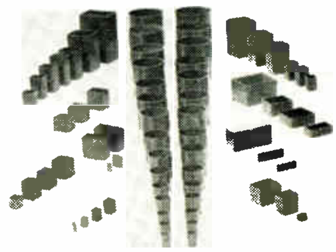
NASSAU LABORATORIES, 29 Haven Ave., Port Washington, N. Y. Model SF-1, switcher-fader is capable of continuous, heavy broadcasting operation. In application, it permits the director to change the transmitted picture from one camera to another in a smooth fade or lap-dissolve without interference, without picture interruption and with full control of picture level. All fades go to black when no picture is present. Unit contains illuminated push buttons for selection of the cameras to be switched.

**CIRCLE 329 ON READER SERVICE CARD**

## Pressure Controller

MICRO GEE PRODUCTS, INC., 6319 W. Slauson Ave., Culver City, Calif. Model 57Q is an all solid-state pressure controller that combines both electronic and pneumatic servo loops into a compact control instrument.

**CIRCLE 330 ON READER SERVICE CARD**

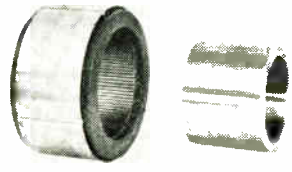


## Plastic Cups

### FOR ENCAPSULATION

ELECTRONIC PRODUCTION & DEVELOPMENT, INC., 501 N. Prairie Ave., Hawthorne, Calif., offers a line of EC high temperature resistant plastic cups. All are compression molded using flameproof glass-fiber filled diallyl-phthalate material approved under MIL-M-19833-GDI-30F.

**CIRCLE 331 ON READER SERVICE CARD**

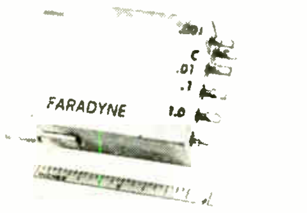


## Torque Motor

### THREE PHASE

CURVIN DEVELOPMENT CO., 13735 Saticoy St., Van Nuys, Calif. Model 120, a 60 cycle 3 phase torque motor, produces stall torque in excess of 10 lb ft. It is 7½ in. in diameter by 4½ in. long and has a 4 in. diameter hole through the rotor. It is a 32 pole induction motor with a no load speed of approximately 225 rpm.

CIRCLE 332 ON READER SERVICE CARD




## Multiple Capacitor

HERMETICALLY SEALED

GULTON INDUSTRIES, INC., 212 Durham Ave., Metuchen, N. J., announces a Faradyne Mylar capacitor with values of 1 $\mu$f, 0.1 $\mu$f, 0.01 $\mu$f and 0.001 $\mu$f within a single unit. Tolerance on these values within one unit is $\pm$0.25 percent. Use of the Faradyne unit in oscilloscopes and other instruments can eliminate the need for employing potentiometers, which are usually required to adjust to the desired RC constant.

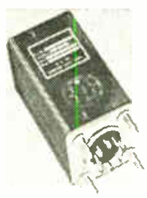
CIRCLE 333 ON READER SERVICE CARD

## Coil Winder

FULLY AUTOMATED

GEO. STEVENS MFG. CO., INC., Pulaski Rd. at Peterson, Chicago 46, Ill. Model 518-RW, a 6 station indexing machine, winds multilayer coils as well as single layer coils, close, space wound, linear or non-linear coils.

CIRCLE 334 ON READER SERVICE CARD



## Voltage Sensor

STUD MOUNTED

HI-G, INC., Bradley Field, Windsor Locks, Conn. Standard line of voltage sensors will accommodate a voltage to be sensed of 17 v d-c to

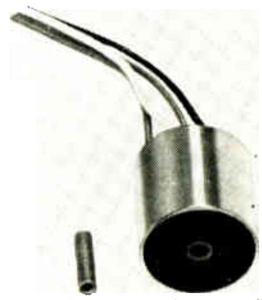
33 v d-c, accuracy ± 2½ percent of specified value over temperature range, drop-out or release voltage within ½ v of actual pull-in, operate and release time 10 millisec over temperature range. Temperature range −65 to +125 deg operating, to +150 deg storage; vibration 20 g to 2,000 cps; shock 50 g for 11 ± 1 millisec; insulation resistance 1,000 megohms.

**CIRCLE 335 ON READER SERVICE CARD**

## Voltage Regulators

THE SUPERIOR ELECTRIC CO., Bristol, Conn. The EMS series Stabiline automatic voltage regulators are available for single or three phase duty with ratings from 25 to 275 Kva.

**CIRCLE 336 ON READER SERVICE CARD**



## Transformer

### DIFFERENTIAL TYPE

SANBORN CO., 175 Wyman St., Waltham 54, Mass. Series of linear displacement transducers, with infinite resolution, high accuracy and sensitivity, includes a built-in carrier system. Model 7 DCDT-050, first in the series, has a rated displacement range of ±0.050 in. Entire unit weighs approximately 0.8 oz, occupies less than ½ cu in. and is hermetically sealed. D-C output is 1.6 v max. Price is $99.

**CIRCLE 337 ON READER SERVICE CARD**

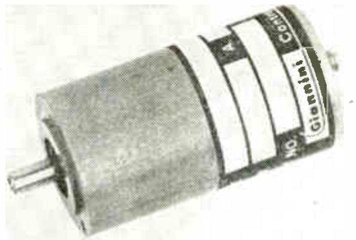
## Coil Forms

### FOR PRINTED CIRCUITS

CAMBRIDGE THERMIONIC CORP., 445 Concord Ave., Cambridge 38, Mass., has three new horizontal coil forms for i-f and r-f printed circuits. Designated parts 2533,-4 and -5, these internally threaded, grade L-5 silicone-impregnated, ceramic coil forms are designed with

mounting pins to fit 0.040 in. diameter holes.

**CIRCLE 338 ON READER SERVICE CARD**




## D-C Servo Motor

MINIATURIZED

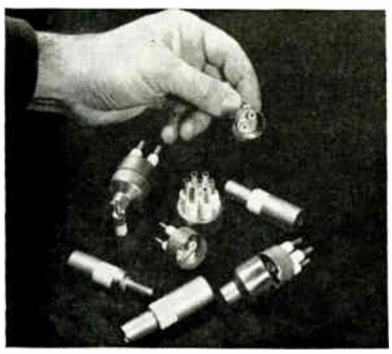
GIANNINI CONTROLS CORP., 1600 S. Mountain Ave., Duarte, Calif. Miniature d-c servo motor is designed for applications ranging from timing devices to the motor portion of an integrating accelerometer used in missile programs. O-d measurement is 3/4 in. and length is 1 3/8 in. Unit develops 1 oz-in. of stall torque and a no-load speed of 22,000 rpm. Insulation system is rated at 155 C and a minimum life of 500 hr is normal.

**CIRCLE 339 ON READER SERVICE CARD**

## Ultrasonic Welder

SONOBOND CORP., subsidiary of Aeroprojects Inc., West Chester, Pa. New version of the Sonoweld model W-600-TSR ultrasonic welder is utilized to weld closures of electronic packages in a totally controlled atmosphere. A solid state joining process is used.

**CIRCLE 340 ON READER SERVICE CARD**

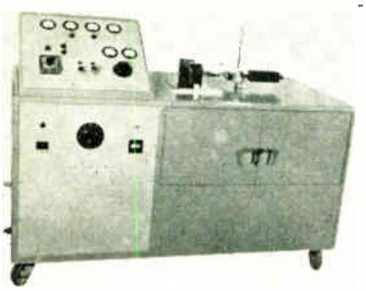


## Cable End Seals

CERAMIC-TO-METAL

ADVANCED VACUUM PRODUCTS, INC., 440 Fairfield Ave., Stamford, Conn., offers a line of ceramic-to-metal cable end seals for use with mineral-insulated cable. Because of special processing techniques and use of high-purity alumina, the seals can withstand temperatures to 1,500 F, and pressures as high as 5,000 psi. All seals are subjected to rigorous testing with a mass spectrometer for a maximum permissible leak rate of $10^{-8}$ cc of helium per sec. They are rated at 1,000 to 2,500 v, 20 to 60 amp, with terminal torque ratings of 15 to 35 in.-lb.

**CIRCLE 341 ON READER SERVICE CARD**

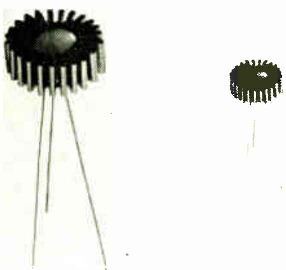


## Pulse Modulator

HEAVY-DUTY

BURMAC ELECTRONICS CO., INC., 142 South Long Beach Road, Rockville Centre, L. I., N. Y. Model 504 pulse modulator will pulse various types of transmitting tubes to 2½ megawatts peak drive power. Unit has an output of 0-35 Kv peak at up to 70 amp peak with provision to match load impedances of 500 to 1,000 ohms. Pulse widths are 0.5, 1 and 3 $\mu$sec.

**CIRCLE 342 ON READER SERVICE CARD**



## Transistor Cooler

ONE SIZE FITS ALL

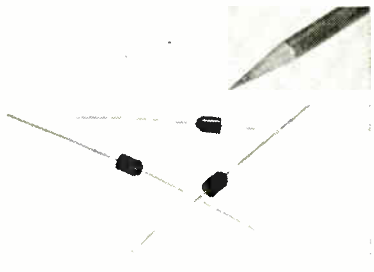
INLAND CERTIFIED ELECTRONICS, 323 W. Washington Blvd., Pasadena, Calif., announces a transistor cooler that fits all TO size transistors from 0.335 in. to 0.400 in. Sixty-three different sizes of coolers were formerly required. Designed for p-c board mounting, the 4 sq in. of cooling area not only provides greater cooling efficiency, but also serves as a transistor retaining device.

**CIRCLE 343 ON READER SERVICE CARD**

## Snap-Action Switch

CONTROL PRODUCTS, INC., 280 Ridgedale Ave., East Hanover, N.J., offers a snap-action switch for use in precision pressure switches in aricraft, missiles and similar applications requiring temperature range of −80 F to 180 F.

**CIRCLE 344 ON READER SERVICE CARD**

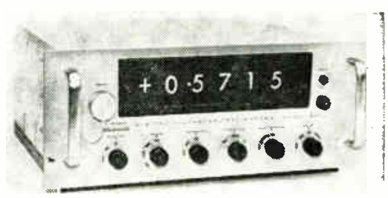


## Silicon Rectifiers

EPOXY-ENCAPSULATED

COMPUTER DIODE CORP., 250 Garibaldi Ave., Lodi, N. J. Eleven new low-leakage, high-current, epoxy-encapsulated silicon rectifiers include three EIA types and eight CODI specials. All are double sealed, of an all-welded construction, and are polarized for automatic insertion.

**CIRCLE 345 ON READER SERVICE CARD**




## Digital Voltmeter

AND RATIOMETER

COHU ELECTRONICS, INC., Kin Tel Div., 5725 Kearny Villa Road, San Diego 12, Calif. Model 551, which uses mercury-wetted relays, measures d-c between 0.0000 and ±999.99 v, ratios between ±0.00001 and 999.99 v. D-C measurements are made in less than 0.3 sec and displayed on a built-in projection readout. Printer drive circuit ac-

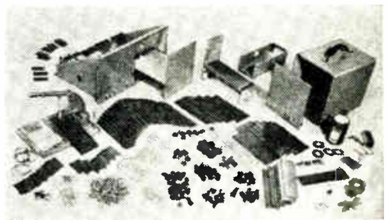
cessories permit recording all measurements on an external digital printer. Price is $4,150.

**CIRCLE 346 ON READER SERVICE CARD**

## Gearhead Motor

GLOBE INDUSTRIES, INC., 1784 Stanley Ave., Dayton 4, O. Type CLC gearhead motors are 2.88 in. in diameter, produce 1/40 h-p output, with typical max output 120 in. lb torque at 15 rpm synchronous speed.

**CIRCLE 347 ON READER SERVICE CARD**



## Construction Kit

FOR PROTOTYPE WORK

ALDEN PRODUCTS CO., 117 N. Main St., Brockton, Mass. Kit No. 37 includes all the circuitry mounting and packaging components needed to assemble various combinations of a functionally subdivided rack module and a rugged, quick access, portable instrument. It utilizes the best Alden circuit mounting techniques and an introduction to the plug-in unit construction system.

**CIRCLE 348 ON READER SERVICE CARD**

## Synchros

HIGH PRECISION

REEVES INSTRUMENT CORP., Garden City, N. Y. Thirty-second accuracy Size 23 synchros conform to MIL-S20708A. Series includes both transmitters and control transformers; and can be supplied for either a 60- or 400-cycle input. The transmitters have an extremely low output impedance, thus enabling one transmitter to drive a number of control transformers without degrading system performance.

**CIRCLE 349 ON READER SERVICE CARD**

## PRODUCT BRIEFS

SILICON CONTROLLED RECTIFIER rated at 3 and 5 amp d-c. Sarkes Tarzian, Inc., 415 N. College Ave., Bloomington, Ind. (350)

WIREWOUND POTENTIOMETER high-power, small size. Bourns, Inc., 1200 Columbia Ave., Riverside, Calif. (351)

MICRO ZENER DIODES 2.7 to 18 v. TRW Electronics/Pacific Semiconductors, Inc., 12955 Chadron Ave., Hawthorne, Calif. (352)

REGULATED POWER SUPPLY 300-5,000 v d-c. Kilovolt Corp., 238 High St., Hackensack, N. J. (353)

GLASS EPOXY LAMINATE for p-c applications. Formica Corp., 4614 Spring Grove Ave., Cincinnati 32, Ohio. (354)

TRANSISTOR OSCILLATOR low profile. Monitor Products Co., Inc., 815 Fremont Ave., South Pasadena, Calif. (355)

MAGNETOSTRICTIVE DELAY LINE operates at 4 Mc. Computer Control Co., Inc., 983 Concord St., Framingham, Mass. (356)

CONDUCTOR PAINT silver-filled. Epoxy Products Div., Joseph Waldman & Sons, 137 Coit St., Irvington 11, N. J. (357)

VERSATILE TEST STAND designed for printed circuits. Circuit Structures Lab, P.O. Box 36, Laguna Beach, Calif. (358)

CERAMIC COMPOSITION features a low loss tangent. Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J. (359)

COMMUNICATIONS SWITCH space-saving, 24-position. Chicago Dynamic Industries, Inc., 1725 Diversey Blvd., Chicago, Ill. (360)

INSTRUMENT COUNTER rated at 3,000 rpm intermittent. Durant Mfg. Co., 1912-A N. Buffum St., Milwaukee 1, Wis. (361)

TRIMMER RESISTOR infinite resolution. Weston Instruments Div., Daystrom, Inc., 614 Frelinghuysen Ave., Newark 14, N. J. (362)

GERMANIUM TRANSISTORS 15 amp collector current. Tung-Sol Electric Inc., 1 Summer Ave., Newark 4, N. J. (363)

# Literature of

TRANSFER MOLDING Hull Corp., Hatboro, Pa., has available a technical paper entitled "Transfer Molding—past, Present and Future." **(364)**

CONTROL KNOBS National Radio Co., Melrose 76, Mass. Data sheet CO-9 covers a wide variety of commercial knobs. **(365)**

F-M TAPE SYSTEM Sanborn Co., 175 Wyman St., Waltham 54, Mass. A single-page bulletin describes a 7-channel f-m tape system. **(366)**

DIGITAL LOGIC MODULES Scientific Data Systems, 1542 Fifteenth St., Santa Monica, Calif., has published a brochure on an integrated line of all-silicon semiconductor digital logic modules. **(367)**

ACCELERATORS High Voltage Engineering Corp., Burlington, Mass., offers a booklet on Tandem Van de Graaff accelerators. Request copy on organization letterhead.

RECTIFIER POWER UNITS Syntron Co., 241 Lexington Ave., Homer City, Pa. An 8-page bulletin outlines a line of selenium and silicon rectifier power units. **(368)**

P-C CONNECTORS Continental Connector Corp., 34-63 56th St., Woodside 77, N. Y., offers a printed circuit connector catalog covering its entire line. **(369)**

POWER TRANSFORMERS Tektran Inc., 2905 N. Leithgow St., Philadelphia 33, Pa. Two recent bulletins describe silicon rectifier power transformers. **(370)**

CAPACITOR TEST REPORT Vitramon, Inc., P. O. Box 544, Bridgeport, Conn. Brochure of 16 pages contains summary test data on porcelain capacitors to high reliability specification S-1002. **(371)**

TEFLON Tri-Point Industries, Inc., 175 I. U. Willets Rd., Albertson, L. I., N. Y., has issued a 24-page technical manual-catalog on Teflon forms and products. **(372)**

COOLING DEVICE Dynacool Mfg. Co., P. O. Box 132, West Hurley, N. Y. Bulletin contains illustration, specifications and prices for the Power 500S series cooling device. **(373)**

SIGNAL ANALYZER Raydata Corp., 1078 E. Granville Rd., Columbus

# the Week

24, O. Bulletin describes model 41 signal analyzer for industrial and laboratory measurements. (374)

PRESSURE MONITOR Datametrics Inc., 87 Beaver St., Waltham 54, Mass. A bulletin covers the type 25 pressure monitor. (375)

HIGH VOLTAGE CHOPPER Solid State Electronics Co., 15321 Rayen St., Sepulveda, Calif., has issued a data sheet on the model 150 silicon transistor electronic chopper. (376)

DIGITAL MODULES Computer Control Co., Inc., 983 Concord St., Framingham, Mass., has published 28-page S-PAC digital module catalog S-1. (377)

MATERIALS EVALUATION Materials Testing Laboratories Div., Magnaflux Corp., 7300 W. Lawrence, Chicago 31, Ill. Bulletin outlines the materials evaluation services available from MTL's nationwide network of 15 laboratories. (378)

POWER TRANSISTORS Kearfott Div., General Precision, Inc., Little Falls, N. J. Three catalog sheets cover 7 types of *pnp* germanium alloy junction power transistors. (379)

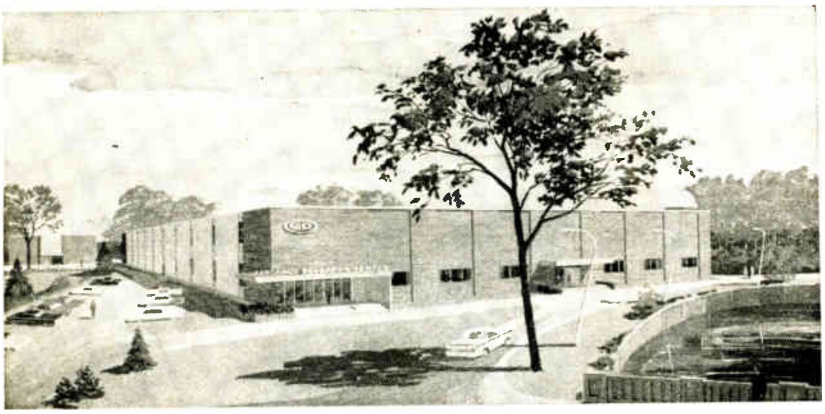
ELECTROMAGNETIC RELAYS Potter & Brumfield, Princeton, Ind. A catalog features a complete line of electromagnetic relays. (380)

PCM GROUND STATION Epsco, Inc., 275 Massachusetts Ave., Cambridge 39, Mass., offers a 28-page brochure on its universal pcm ground station, model PCG-UN1. (381)

COMPUTER POWER SUPPLIES Kearfott Div., General Precision, Inc., Little Falls, N. J. A 2-page catalog sheet contains application data for computer power supplies. (382)

TRIMMING POTENTIOMETERS Daystrom, Inc., Potentiometer Division, Archbald, Pa., offers a technical data sheet on the 200 series Squaretrim subminiature trimming potentiometers. (383)

SOUND MEASUREMENT H. H. Scott Instrument Division, 111 Powder Mill Rd., Maynard, Mass., has available an 8-page brochure on sound measuring and analyzing instruments. (384)



# GPE To Open Research Center

A RESEARCH CENTER for aerospace sciences will be opened this year as part of the advanced research program of General Precision Equipment Corp., Tarrytown, N. Y. The 80,000 sq ft center is under construction at Kearfott Division, Little Falls, N. J. Its purpose is to centralize research activities of the division.

The 1962 completion date was announced by J. W. Murray, chairman of the board, and D. W. Smith, president, in the annual report to stockholders. "Current backlog and new business booked after the close of the year indicate increased sales for 1962," they said. "We expect 1962 net profits to show improvement over those of 1961."

Reporting that investment in research and development had continued at a high level in 1961, the corporation said that past research in navigational aids and precision components alone had resulted in more than $500 million sales in the past few years.

The new center will be devoted in part to basic materials research that can result in new products. Overall, the corporation expects its research programs to yield many developments that will contribute to future growth.

These programs include projects in stellar navigation, space-vehicle computers and instrumentation, miniaturization, optical masers and electronic flight simulation. Others are specialized radar devices, infrared systems, explosive ordnance and propellants, bionics and microcircuitry.

## Aerospace Research Hires Schissler

L. ROBERT SCHISSLER has been appointed to the staff of Aerospace Research, Inc., Newton, Mass. He will be primarily involved in the design and fabrication of rocket receivers at very low frequencies for use in probing the ionosphere.

Schissler was formerly with Simplex Wire and Cable as a research scientist.

## Stern Accepts Executive Post

MARVIN STERN, 39-year old deputy director of defense research and engineering, Department of Defense, in charge of weapon systems, is resigning to become corporate vice president for research for North American Aviation, Inc., Los Angeles, Cal. A mechanical engineer with a doctorate in mathematics, Stern has been at the Pentagon since August 1960, was previously General Dynamics' corporate staff executive for research and development.

## Tamar Electronics Appoints Whiteside

GEORGE A. WHITESIDE has been appointed vice president and general manager of Wiancko Engineering, a division of Tamar Electronics, Inc., Anaheim, Calif.

Prior to his new post at Tamar, Whiteside was the assistant to the vice president of the Armament and Flight Control Division of Autonetics.

## Electra Mfg. Co. Names Butler

GEORGE D. BUTLER, formerly vice president of marketing for International Resistance Co., has become president of Electra Manufacturing Co., Kansas City, Mo. Electra, which employs approximately 850

people, produces electronic components for industrial computers and control equipment for military electronics and for the aerospace industry.

Butler is director of the Precision Potentiometer Manufacturer's Association.

## Eveleth Assumes New Position

JASON F. EVELETH has been appointed chief engineer of the Ultra-Sonic Delay Line division of Andersen Laboratories, Inc., West Hartford, Conn. Andersen Laboratories manufactures components and systems used by 3D radar, man-in-space, DEW line, computer and nuclear activities.

For the past five years Eveleth has been associated with the Corning Glass Works.

## Acton Laboratories Names MacMullen

ALEXANDER MACMULLEN has been named manager of instrumentation engineering at Acton Laboratories, Inc., Acton, Mass., subsidiary of Bowmar Instrument Corp., Fort Wayne, Ind. He will be responsible for design and development of the company's line of instruments for measurement of voltage, impedance, phase and delay, as well as special components for space and industrial applications.

MacMullen formerly was a manager of the communications design section at Raytheon Co. and a project engineer with Radio Free Europe.

## Rudenberg Joins Arthur D. Little

H. GUNTHER RUDENBERG has joined Arthur D. Little, Inc., Cambridge, Mass., as a member of the senior staff of the research and development division. In this post he will be concerned with the development of the new generation semiconductor devices, and related research and engineering problems.

Previously Rudenberg was director of research at Transitron Electronic Corp., a post he held since the founding of the firm in 1952.

## Connor Accepts Additional Post

PHILLIP R. CONNOR, JR., president of Space-Tone Electronics Corp., Washington, D. C., has been elected board chairman of Solar Systems, Inc., North Hollywood, Calif. Space-Tone recently took over active management of Solar Systems, Inc.

Solar Systems is engaged in research and development work on solar cells and solar equipment, electronic systems and solid propellant cooling systems for missiles.

## Autometric Names Abraham Mann

APPOINTMENT of Abraham Mann as head of the electronics department of Autometric Corp., New York City, has been announced.

Mann is concurrently a member of the staff of the Polytechnic Institute of Brooklyn, where he teaches graduate courses in electrical engineering. He was formerly manager of the electronics department, system development section, Bulova Research and Development Laboratories.

## PEOPLE IN BRIEF

**Peter L. Fetterolf** leaves Minneapolis Honeywell to join Potter Instrument Co., Inc., as assistant to the manufacturing mgr. **Ralph L. McCreary**, formerly with Collins Radio Co., named mgr. of the Motorola Inc. Systems Research Laboratory. He succeeds **John F. Byrne** who has been appointed mgr. of advanced technical plans for the company's Military Electronics div. **Grant D. Christensen**, previously with General Dynamics Corp., now mgr. of engineering services of McDonnell Aircraft Corp. **L. J. Bonis** moves up from executive v-p to president of Ilikon Corp. **Robert H. Borders**, ex-Hallicrafters Co., named executive v-p and elected to board of directors of Schaevitz Engineering. **John F. Jewett** promoted to assistant director of engineering of the eastern operation of Sylvania Electronic Systems. **Richard C. Hahn**, formerly with The Victoreen Instrument Co., joins CBS Laboratories as mgr., program development., Acoustics and Magnetics Branch. **Thomas R. Bristol** advances to assistant to the mgr., display devices dept., for Litton Industries' Electron Tube Div. **John M. Klaarenbeek**, ex-Hurletron, Inc., appointed quality assurance mgr. of Babcock Relays. **Irving J. Gabelman** elevated to director of advanced studies of Rome Air Development Center. **Roy E. Wendahl** advances to executive v-p of Hughes Aircraft Co.

# electronics

## WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

### ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

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

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

### STRICTLY CONFIDENTIAL

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

### WHAT TO DO

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

| COMPANY | SEE PAGE | KEY # |
|---|---|---|
| ALLSTATES DESIGN & DEVELOPMENT CO., INC. New York, New York | 100* | 1 |
| ATOMIC PERSONNEL, INC. Philadelphia, Pennsylvania | 126 | 2 |
| BOEING COMPANY Seattle, Washington | 93 | 3 |
| DELCO RADIO Div. of General Motors Corp. Kokomo, Indiana | 24* | 4 |
| EITEL-McCULLOUGH INC. San Carlos, California | 71* | 5 |
| ESQUIRE PERSONNEL SERVICE INC. Chicago, Illinois | 126 | 6 |
| FAIRCHILD STRATOS Aircraft & Missiles Div. Hagerstown, Maryland | 80, 81* | 7 |
| GENERAL ELECTRIC COMPANY Light Military Electronics Dept. Utica, New York | 126 | 8 |
| INTERNATIONAL BUSINESS MACHINES CORP. Poughkeepsie, New York | 127 | 9 |
| LOCKHEED CALIFORNIA CO Div. of Lockheed Aircraft Co. Burbank, California | 74, 75* | 10 |
| LOCKHEED-GEORGIA CO. Div. of Lockheed Aircraft Co. Atlanta, Georgia | 20* | 11 |
| MARTIN COMPANY Orlando Div. Orlando, Florida | 100* | 12 |
| MICROWAVE SERVICES INTERNATIONAL, INC. Denville, New Jersey | 100* | 13 |
| MOTOROLA, INC. Chicago, Illinois | 101* | 14 |
| NATIONAL CASH REGISTER CO. Dayton, Ohio | 124, 127 | 15 |
| NATIONAL CASH REGISTER CO. Electronics Division Hawthorne, California | 91 | 16 |

CONTINUED ON PAGE 126

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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)

41362

| | | |
|---|---|---|
| ☐ 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 | ☐ .................. |

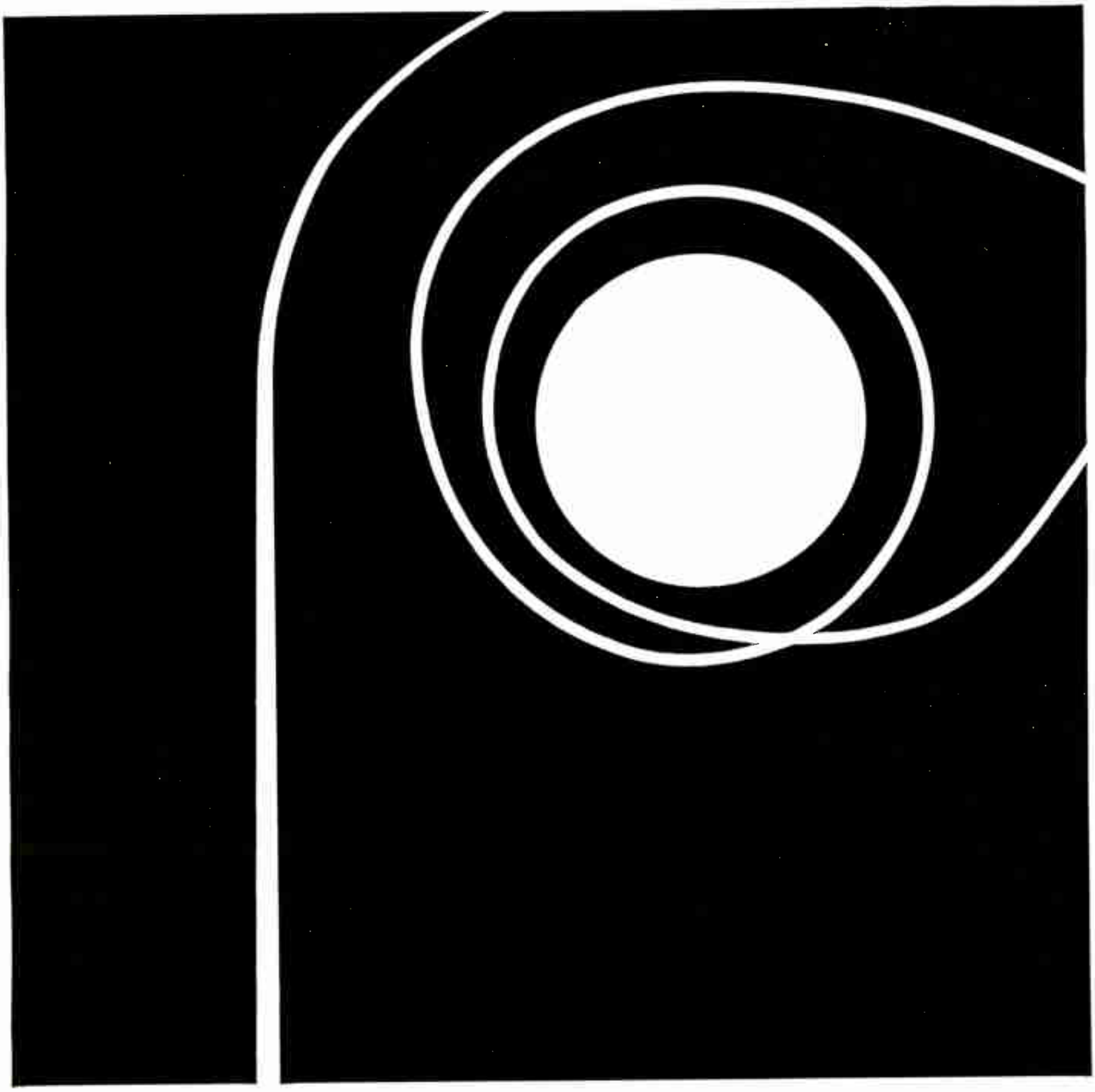
### CATEGORY OF SPECIALIZATION

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



ENGINEERS, EE:

# Looking for more responsibility immediately... and a starting salary that reflects it?

General Electric's Light Military Electronics Department is seeking highly competent engineers to fill immediate technical leadership and consulting openings in the following program areas:

- Space Vehicle Guidance Systems
- Missile & Satellite Computers
- Microelectronics
- Space Detection & Surveillance
- Navigation & Communication Systems
- Silicon Crystal Circuit Development
- Command Guidance & Instrumentation
- A.E.W. & Control
- Electronic Countermeasures
- Space Communications & Telemetry
- Undersea Warfare Systems
- Thin Films
- Automated Test Equipment

LMED

LIGHT MILITARY ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

## THESE ARE SAMPLES OF THE IMMEDIATE OPENINGS:

**▶ TRANSISTOR CIRCUIT DESIGN**
...on computers utilized in airborne early warning system.

**▶ LEAD EE**
...to integrate logic and circuit design efforts on space vehicle guidance equipment.

**▶ CIRCUIT DEVELOPMENT AND APPLICATION ENGINEER**
...should be capable of doing work in the following areas: a) Paper design & synthesis of complex circuitry such as is found in airborne electronics; b) Analysis of complete systems to determine and design those portions capable of being microminiaturized; c) Advise and consult with product line electronic design engineers; d) Prepare proposals.

**▶ DATA PROCESSING CONSULTING ENGINEER**
...involves computer design, including logic and logic organization, basic computer circuit design, memory storage circuits and devices, overall computer systems synthesis. Also includes direct leadership of D/A projects for advance design techniques, consultation with design engineers on product line design problems, assistance in preparation of technical proposals, participation as panel member in design reviews, leadership of technical symposia in your design field.

**▶ SYSTEMS ANALYST**
...includes missile flight test and analysis regarding guidance systems and computation; orbital trajectory analyses; overall system, sub-system and error analysis.

**▶ COMMUNICATION ENGINEER**
...for design studies and analyses regarding command control systems for space applications.

**▶ SPACE NAVIGATION OR GUIDANCE ENGINEER**
...to conduct systems studies regarding integrating hardware, e.g., developing stellar, radio or inertial navigation or guidance systems to perform specific missile function.

**▶ MICROWAVE ENGINEER**
with 3 to 5 years' antenna and microwave design experience to design radar and missile antennas, and microwave components.

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

*An Equal Opportunity Employer*

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with

**The Bristol Company**

Leading manufacturer of automation equipment and control systems requires men, preferably 25 to 35 years old, to sell high quality, nationally accepted products to wide variety of industrial markets.

Openings in various areas of the country. Successful applicants take comprehensive three-months course at headquarters. Salary and expenses

All replies confidential; every inquiry answered.

Write: Charles F. Johnson, Mgr. of Sales Training

**The Bristol Company**

Waterbury 20, Conn.

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**COMPUTER APPLICATIONS SPECIALIST**

$12,000 Per Year

Will investigate application for special purpose analog and digital computers and data processing equipment. Analyze requirements and prepare proposals and estimates. Staff opportunity. Company client assumes all expenses.

ESQUIRE PERSONNEL

202 South State St. Chicago 4, Ill.

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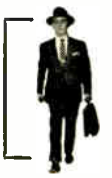

***MANUFACTURERS' REPRESENTATIVES***

IN THE ELECTRONIC INDUSTRY

**SAMUEL K. MACDONALD, INC.**

*manufacturers representatives over 25 years*

**1531 SPRUCE STREET, PHILA. 2, PA.**

*Territory:*
Pennsylvania • New Jersey
Delaware • Maryland
Virginia • West Virginia
District of Columbia

*Other Offices:*
Pittsburgh
Baltimore
Washington, D.C.

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For professional, individualized fee-paid service write for confidential application.

A national employment agency for the Nuclear & Scientific Fields.

ATOMIC PERSONNEL, INC.

Suite 1207L, 1518 Walnut St., Phila. 2, Pa.

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*ADDRESS BOX NO. REPLIES TO: Box No. Classified Adv. Div. of this publication. Send to office nearest you. NEW YORK 36: P. O. Box 12 CHICAGO 11: 645 N. Michigan Ave. SAN FRANCISCO 11: 255 California St.*

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***SELLING OPPORTUNITY WANTED***

**Sales Representation—Competent Staff of** Professional Engineers available to represent aircraft & equipment manufacturers in Texas, Oklahoma, Kansas and Missouri. Facilities resume upon request. RA-8515, Electronics.

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## EMPLOYMENT OPPORTUNITIES

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

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

### — RATES —

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

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

Subject to Agency Commission.

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

**Box numbers**—count as 1 line.

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

Not subject to Agency Commission.

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# electronics

## WEEKLY QUALIFICATIONS FORM FOR POSITIONS AVAILABLE

(Continued from page 123)

| COMPANY | SEE PAGE | KEY # |
|---|---|---|
| PHILCO WESTERN DEVELOPMENT LABS. Palo Alto, California | 125 | 17 |
| SCOPE PROFESSIONAL PLACEMENT CENTER Waltham, Massachusetts | 100* | 18 |
| SIMMONDS PRECISION PRODUCTS INC. Tarrytown, New York | 100* | 19 |
| SNELLING & SNELLING Boston, Massachusetts | 100* | 20 |
| SYLVANIA MOUNTAIN VIEW OPERATIONS Mountain View, California | 124 | 21 |

* These advertisements appeared in the 4/6/62 issue.

# SPECIAL PURPOSE TUBES

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| OA2 | .80 | 4-65A | 10.00 | 25Z6WGT | 1.50 | 725A | 10.00 | 5751WA | 2.00 |
| OA2WA | 2.00 | 4-125A | 20.00 | 26Z5W | 1.50 | 726A | 5.00 | 5763 | 1.75 |
| OA3 | .85 | 4-250A | 32.50 | FG-27A | 20.00 | 726B | 5.00 | 5777 | 150.00 |
| OB2 | .60 | 4-400A | 30.00 | 28D7W | 3.50 | 726C | 8.50 | 5778 | 150.00 |
| OB2WA | 2.00 | 4-1000A | 85.00 | FG-32 | 6.50 | 802 | 5.00 | 5783 | 2.25 |
| OB3 | .70 | 4AP10 | 10.00 | 35T | 10.00 | 803 | 3.50 | 5787 | 2.50 |
| OC3 | .50 | 4B31 | 12.50 | 35TG | 1.50 | 804 | 15.00 | 5796 | 8.00 |
| OD3 | .30 | 4C35 | 15.00 | FP-54 | 100.00 | 805 | 7.50 | 5800/VX-41 | 7.50 |
| C1A | 7.50 | 4CX250B | 30.00 | FG-57 | 6.00 | 807 | 1.35 | 5803/VX-55 | 5.00 |
| 1AD4 | 1.50 | 4D32 | 15.00 | RK-60/1641 | 1.50 | 807W | 1.75 | 5814A | 1.35 |
| 1B24A | 12.50 | 4E27 | 10.00 | HY-69 | 3.00 | 808 | 2.50 | 5829 | 1.00 |
| 1B35A | 3.00 | 4J32 | 100.00 | BL-75 | 3.00 | 809 | 5.00 | 5830/FG41 | 100.00 |
| 1B63A | 10.00 | 4J34 | 100.00 | TG-77 | 7.50 | 810 | 15.00 | 5836 | 50.00 |
| 1C/3B22 | 5.00 | 4J50 | 100.00 | HF-100 | 10.00 | 811 | 2.50 | 5837 | 50.00 |
| C1K | 7.50 | 4J52 | 35.00 | 100TH | 12.00 | 811A | 4.00 | 5840 | 2.50 |
| 1P21 | 32.50 | 4PR60A | 50.00 | 100TL | 12.00 | 812A | 4.75 | 5845 | 6.00 |
| 1P22 | 8.00 | 4X150A | 15.00 | FG-105 | 25.00 | 813 | 12.50 | 5852 | 5.00 |
| 1P25 | 10.00 | 4X150D | 15.00 | F-123A | 5.00 | 814 | 3.50 | 5876 | 8.50 |
| 1P28 | 15.00 | 4X150G | 25.00 | FG-172 | 25.00 | 815 | 2.50 | 5879 | 1.25 |
| 1Z2 | 1.50 | 4X250B | 25.00 | 211 | 2.50 | 816 | 2.25 | 5881/6L6WGB | 2.50 |
| 2-01C | 12.50 | 4X250F | 30.00 | 212E | 25.00 | 826 | 3.50 | 5886 | 4.00 |
| 2AP1A | 7.50 | 5BP1A | 9.50 | FG-235 | 40.00 | 828 | 12.50 | 5894 | 18.85 |
| 2B23 | 20.00 | 5C22 | 17.50 | 242C | 10.00 | 829B | 9.50 | 5915 | 1.00 |
| 2BP1 | 8.50 | 5CP1A | 9.50 | 244A | 3.50 | 832 | 2.50 | 5931/5U4WG | 4.00 |
| 2C36 | 22.50 | 5CP7A | 9.50 | 245A | 3.50 | 832A | 7.50 | 5933/807W | 2.50 |
| 2C39A | 9.75 | 5D21 | 7.50 | 249B | 10.00 | 833A | 37.50 | 5948/1754 | 100.00 |
| 2C39B | 15.00 | 5J26 | 50.00 | 249C | 5.00 | 834 | 7.50 | 5949/1907 | 50.00 |
| 2C40 | 7.50 | 5JP1 | 7.50 | 250R | 10.00 | 836 | 2.50 | 5963 | 1.10 |
| 2C42 | 3.00 | 5LP1 | 7.50 | 250TH | 25.00 | 837 | 1.00 | 5964 | .85 |
| 2C43 | 7.50 | 5R4GY | 1.10 | 251A | 50.00 | 838 | 1.00 | 5965 | .85 |
| 2C46 | 5.00 | 5R4WGA | 5.00 | 254A | 3.50 | 842 | 7.50 | 5976 | 50.00 |
| 2C50 | 4.00 | 5R4WGB | 6.00 | FG-258A | 75.00 | 845 | 7.50 | 5992 | 5.00 |
| 2C51 | 1.50 | 5R4WGY | 2.75 | 259A | 3.50 | 849 | 75.00 | 5993 | 5.00 |
| 2C52 | 1.50 | 5RP1A | 9.50 | 262B | 3.50 | 851 | 35.00 | 6002/QK221 | 250.00 |
| 2C53 | 7.50 | 5Y3WGT | 1.25 | 267B | 5.00 | 866A | 1.90 | 6005/6AQ5W | 1.50 |
| 2D21 | .50 | 5Y3WGTB | 3.00 | 271A | 12.50 | 869B | 50.00 | 6012 | 4.00 |
| 2D21W | 1.00 | 6AC7W | .50 | 274A | 3.50 | 872A | 5.00 | 6021A | 2.00 |
| 2E22 | 2.50 | 6AC7WA | 2.00 | 283A | 3.50 | 874 | .75 | 6027/2J42A | 100.00 |
| 2E24 | 2.25 | 6AG5WA | 1.50 | 287A | 3.50 | 884 | 1.25 | 6032 | 10.00 |
| 2E26 | 2.50 | 6AG7Y | 1.00 | QK-288 | 250.00 | 885 | .85 | 6037/QK243 | 50.00 |
| 2J42 | 75.00 | 6AK5W | 1.25 | HF-300 | 35.00 | 889RA | 150.00 | 6045 | 1.15 |
| 2J51 | 50.00 | 6AK5 (WE) | .75 | 300B | 5.00 | 891R | 200.00 | 6072 | 1.50 |
| 2J55 | 90.00 | 6AL5W | .60 | 304TH | 35.00 | 913 | 9.50 | 6073 | 1.50 |
| 2K22 | 25.00 | 6AN5 | 1.75 | 304TL | 35.00 | 920 | 2.50 | 6074 | 1.75 |
| 2K25 | 8.50 | 6AN5WA | 3.50 | 307A | .50 | 927 | 1.50 | 6080 | 3.35 |
| 2K26 | 35.00 | 6AQ5W | 1.00 | 310A | 3.50 | 931A | 3.50 | 6080WA | 5.00 |
| 2K28 | 30.00 | 6AR6 | .75 | 311A | 3.50 | 1000T | 80.00 | 6080WB | 12.50 |
| 2K29 | 25.00 | 6AS6 | .85 | 313C | 1.50 | R1130B | 10.00 | 6082 | 2.50 |
| 2K30 | 50.00 | 6AS6W | 1.00 | 323A | 6.00 | 1500T | 150.00 | 6087/5Y3WGTB | 3.00 |
| 2K33A | 200.00 | 6AS7G | 2.50 | 328A | 3.50 | 1611 | 2.00 | 6101/6J6WA | 1.50 |
| 2K34 | 75.00 | 6AU6WA | 1.25 | 329A | 4.50 | 1614 | 2.75 | 6106 | 1.50 |
| 2K35 | 200.00 | 6B4G | 3.35 | 336A | 2.50 | 1616 | 1.00 | 6115/QK351 | 50.00 |
| 2K39 | 150.00 | 6BA6W | .75 | 337A | 3.50 | 1620 | 4.00 | 6130/3C45 | 6.50 |
| 2K41 | 50.00 | 6BE6W | 1.50 | 347A | 1.00 | 1624 | 1.00 | 6136/6AU6WA | 1.25 |
| 2K42 | 125.00 | 6BH6W | 2.75 | 348A | 4.50 | 1625 | .50 | 6146 | 3.00 |
| 2K43 | 175.00 | 6BL6 | 20.00 | 349A | 3.50 | 1635 | 2.00 | 6159 | 3.50 |
| 2K44 | 125.00 | 6BM6 | 25.00 | 350A | 3.50 | 1846 | 50.00 | 6161 | 35.00 |
| 2K45 | 20.00 | 6BM6A | 30.00 | 350B | 2.50 | 1855 | 250.00 | 6186/6AG5WA | 1.50 |
| 2K47 | 150.00 | 6C4W | 2.50 | 352A | 8.50 | 2050 | 1.25 | 6189/12AU7WA | 1.50 |
| 2K48 | 50.00 | 6C4WA | 1.00 | 354A | 12.50 | ZB-3200 | 100.00 | 6197 | 1.75 |
| 2K50 | 100.00 | 6C21 | 17.50 | 355A | 12.50 | 5528/C6L | 3.50 | 6201/12AT7WA | 1.85 |
| 2K54 | 10.00 | 6D4 | 1.50 | 371B | 2.50 | 5545 | 20.00 | 6202/6X4WA | 1.50 |
| 2K55 | 15.00 | 6F4 | 3.50 | 388A | 2.00 | 5550 | 30.00 | 6211 | .75 |
| 2K56 | 50.00 | C6J | 10.00 | 393A | 5.00 | 5552/FG235 | 50.00 | 6216 | 3.00 |
| 2P21 | 40.00 | C6J/A | 15.00 | 394A | 3.00 | 5553/FG258 | 75.00 | 6233 | 100.00 |
| 2X2A | 1.00 | C6J/K | 20.00 | 395A | 2.25 | 5557/FG17 | 5.00 | 6236 | 125.00 |
| 3A5 | .75 | 6J4 | 1.50 | 396A/2C51 | 1.50 | 5558/FG32 | 6.50 | 6248 | 500.00 |
| 3AP1 | 3.50 | 6J4WA | 2.50 | 398A/5603 | 3.00 | 5559/FG57 | 6.00 | 6263 | 9.00 |
| 3B24W | 3.00 | 6J6W | .60 | 401A/5590 | 1.00 | 5560/FG95 | 20.00 | 6264 | 9.00 |
| 3B24WA | 5.00 | 6J6WA | 1.00 | 403B/5591 | 3.00 | 5561/FG104 | 40.00 | 6265/6BH6W | 2.75 |
| 3B25 | 2.50 | 6K4 | 2.00 | 404A/5847 | 7.50 | 5586 | 150.00 | 6299 | 37.50 |
| 3B26 | 2.25 | 6L6GAY | .75 | 407A | 3.75 | 5636 | 2.25 | 6316/BL800A | 100.00 |
| 3B28 | 3.00 | 6L6WGA | 1.50 | 408A/6028 | 3.25 | 5642 | 2.00 | 6322/BL25 | 15.00 |
| 3B29 | 5.00 | 6L6WGB | 2.50 | 409A/6AS6 | 1.00 | 5643 | 3.00 | 6336 | 8.75 |
| 3BP1A | 5.00 | 6Q5G | 2.50 | 410R | 75.00 | 5647 | 3.50 | 6336A | 12.75 |
| 3C/4B24 | 4.00 | 6SJ7WGT | 1.25 | 416B/6280 | 30.00 | 5651 | .75 | 6344/QK235 | 500.00 |
| 3C22 | 25.00 | 6SK7W | .75 | 417A/5842 | 9.50 | 5654/6AK5W | 1.50 | 6352 | 7.50 |
| 3C23 | 4.00 | 6SK7WA | 2.00 | 418A | 9.50 | 5656 | 5.00 | 6385 | 6.00 |
| 3C24/24G | 7.50 | 6SL7WGT | 1.00 | 420A/5755 | 5.00 | 5663 | 1.00 | 6390 | 125.00 |
| 3C33 | 7.50 | 6SN7W | .50 | 421A/5998 | 7.50 | 5665/C16J | 35.00 | 6394 | 10.00 |
| 3C45 | 3.50 | 6SN7WGT | 1.00 | 429A | 6.50 | 5667 | 125.00 | 6438 | 5.00 |
| 3CX100A5 | 17.50 | 6SN7WGTA | 2.50 | GL-434A | 7.50 | 5670 | 1.00 | 6463 | 1.00 |
| 3D21A | 2.50 | 6SU7GTY | .85 | 450TH | 40.00 | 5672 | 1.35 | 6485 | 1.50 |
| 3D22 | 8.00 | 6V6GTY | 1.00 | 450TL | 40.00 | 5675 | 8.50 | 6517/QK358 | 500.00 |
| 3DP1A | 5.00 | 6X4W | .75 | 575A | 15.00 | 5678 | 1.25 | 6533 | 5.00 |
| 3E29 | 7.50 | 6X4WA | 1.50 | 578 | 5.00 | 5686 | 2.25 | 6542 | 5.75 |
| 3GP1 | 1.50 | 6X5WGT | 1.00 | KU-610 | 5.00 | 5687 | 1.50 | 6550 | 3.00 |
| C3J | 7.50 | 5RL7F | 100.00 | NL-623 | 8.50 | 5691 | 5.00 | 6807 | 20.00 |
| C3J/A | 9.50 | 5RL7H | 100.00 | 631-P1 | 5.00 | 5692 | 2.50 | 7034/4X150A | 15.00 |
| 3J21 | 35.00 | 7AK7 | 2.50 | 673 | 15.00 | 5693 | 3.50 | 7044 | 1.50 |
| 3J31 | 50.00 | 7MP7 | 22.50 | 676 | 30.00 | 5696 | .75 | 7580 | 35.00 |
| 3JP1 | 5.00 | 10KP7 | 15.00 | 677 | 40.00 | 5720/FG33 | 17.50 | 8002R | 25.00 |
| 3K21 | 125.00 | 12AT7WA | 1.50 | 701A | 5.00 | 5721 | 110.00 | 8005 | 7.50 |
| 3K22 | 125.00 | 12AU7WA | 1.50 | 703A | 1.50 | 5725/6AS6W | 1.50 | 8008 | 7.75 |
| 3K23 | 200.00 | 12AX7W | 1.35 | 707B | 2.50 | 5726/6AL5W | .75 | 8013A | 5.00 |
| 3K27 | 150.00 | 12AY7 | 1.00 | NL-710 | 9.75 | 5727/2D21W | 1.25 | 8014A | 30.00 |
| 3K30 | 100.00 | C16J | 25.00 | 715C | 15.00 | 5728/FG67 | 10.00 | 8020 | 4.50 |
| 3KP1 | 9.75 | FG-17 | 5.00 | 719A | 12.50 | 5749/6BA6W | .75 | 8025A | 7.50 |
| 3RP1 | 7.50 | HK-24 | 5.00 | 721B | 5.00 | 5750/6BE6W | 1.50 | 9003 | 2.00 |
| 3WP1 | 12.50 | 25T | 10.00 | 723A/B | 3.50 | 5751/12AX7W | 1.35 | 9005 | 3.00 |

*ALL TUBES ARE NEW, INDIVIDUALLY CARTONED, FULLY GUARANTEED*

*Prices are FOB shipping point*

## western engineers

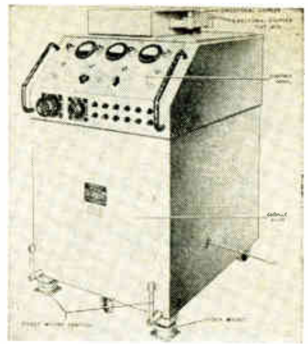
*Orders for less than $10 cannot be processed*

ELK GROVE, CALIFORNIA

*SUPPLIERS OF ELECTRON TUBES SINCE 1932*

**CIRCLE 460 ON READER SERVICE CARD**

## • MAGNETRON PULSER •



Made special to test, pulse and age magnetrons type 4J50, 4J78 and similar. Can be easily modified to test any magnetron up to 500 KW input. Variable repetition rates and power output. Power input 115V, 50-1000 cycles. Unit size: 30" x 48" x 28"—mounted on casters. Packed in new original factory cases.

**SPECIAL PRICE. . $1,950.00**

*only a fraction of manufacturers cost*

Of interest to manufacturers and users of magnetrons . . . laboratories . . . and airlines.

**LIBERTY ELECTRONICS, INC.**

582 Broadway New York 12, N. Y.
Phone: WAlker 5-6000 Cables: TELSERSUP

**CIRCLE 461 ON READER SERVICE CARD**

## CAPACITORS

| MFD | VOLTS | PRICE | MFD | VOLTS | PRICE |
|---|---|---|---|---|---|
| .001 | 75KV | 80.00 | † 2 | 6000V | 24.50 |
| *.025 | 50KV | 29.50 | 3 | 20KV | 125.00 |
| *†.2 | 50KV | 64.50 | 4 | 10KV | 67.50 |
| †.25 | 15KV | 15.95 | 5 | 10KV | 70.50 |
| †.25 | 20KV | 22.50 | 9 | 10KV | 115.00 |
| †.25 | 32.5KV | 44.50 | † 10 | 5000V | 45.00 |
| †.5 | 25KV | 29.50 | † 15 | 5000V | 48.00 |
| †* 1 | 7500V | 8.00 | 75 | 6000 | 59.50 |
| | | | 120 | 3000 | 55.50 |

— SPECIAL —

32 mfd—600 V. . . . . . . . . . . . . . . . $3.50
Comprising four 8 mfd sections. 5 solder lug terms. Dims. 4¾x3¾x3¼. Large qua. available.
* Case Common.
† Large qua. available.

*Write for complete listing*

**MONMOUTH RADIO LABS.**

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CAPITOL 2-0121 ART HANKINS, *Prop.*

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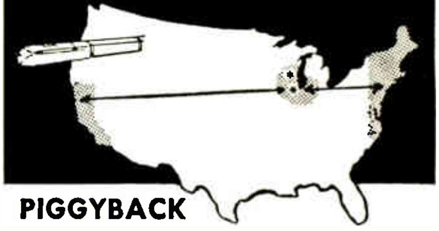
## LIFSCHULTZ
**FAST FREIGHT**



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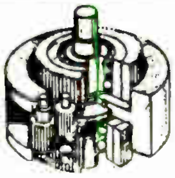
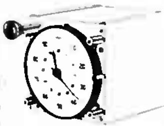
## SIMPLE DIFFERENTIAL WITH BALL-BEARING SUN GEARS



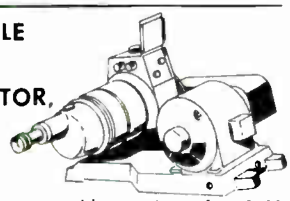
The 1:1 reverse ratio spur gears are 48-tooth, 32 pitch brass with 3/16" available face. On one side, the shaft is 23.64" dia. for 11/16" and has a pin hole, then increases in dia. to .377" for the remaining 3/16" of length On the other side, the shaft is .377 dia. ¼" lg 2-13/16" dia. is required to clear the body.
Stock no A6-115 ........ each $15.00

## 1/100 SECOND TIMER, INTERVAL, 115 VAC, 60 CYCLE



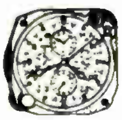
mfgd. by Standard Electric Time Co. accuracy ± .005 sec w/DC clutch first hand speed —1 RPS—totalizes 60 seconds short hand smallest graduations .01 sec. 115 VAC, 60 ohms, brake solenoid 27.5 VDC dial—white background w black characters clock motor to close set of contacts at one second intervals contact rating 1 amp. 28 VDC. non-inductive. Manual reset. outside dim. 3¾ sq. in.
PRICE ........ $25.00 EACH

## 400-CYCLE MOTOR GENERATOR, PU-20



The generator assembly consists of a 1400-watt, 120-volt, 400-cycle inductor-alternator and a 400-watt, 27-volt D.C. generator. The alternator rotor and the D.C. generator armature are mounted on a common shaft, which is dual-belt-driven by a 3-H.P., 1750-R.P.M., 115/230-volt, single-phase 60-cycle electric motor. Weatherproof output box is mounted on top of the stator shell. It contains a rheostat, adjustable resistor, two pin jacks for plugging in an A.C. voltmeter. Size: 28" W., 33" L., 18" H. Weight, approx. 250 lbs.
Price $175.00

## 8-DAY ELAPSED-TIME SURPLUS AIRCRAFT CLOCK



Here's an accurate time control center that'll help you win your next rallye. It not only tells you the date and time of day right to the second, it's a stop watch that gives you elapsed time in seconds, minutes, and hours! The 24-hour clock simplifies adding and subtracting elapsed time for your navigator. Manufactured by Elgin Watch Co. to exacting military specifications, it will remain accurate in spite of road bumps and vibrations. Uses no electrical connections. Does the job of high-cost equipment. Jeweled/Sweep Second Hand/Luminous Hands and Numerals/25-Hour Dial/Black Face and Plastic Case/3⅛" Mounting.
Cost the Government $185.00
Only $39.95 Postpaid

## SPERRY VERTICAL GYRO

Part #673073, Motor 115 volts, 3 phase, 400 cycle, 8 watts, 20,000 RPM. 3-minute runup, synchro pickoffs, roll 360°, pitch 85°. Synchro excitation 26 volts, 400 cycle, 150 m.a. Vertical accuracy ±½°. Weight 3½ lbs. Approx. dim. 5¾" L., 4½" W., 4½" H.
Price $35.00

## VARIABLE SPEED BALL DISC INTEGRATORS

(All Shafts Ball Bearing Supported)

No. 145 Forward & Reverse 2¼"-0-2¼". Input shaft spline gear 12 teeth 9/32" dia. ⅜" long. Output shaft 15/64" dia. x 15/32" long. Control shaft 11/32" x ⅜" long. Cost aluminum construction. Approx. size 3" x 3" x 2¾" ........ $17.50

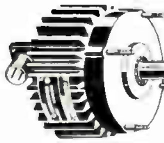
No. 146 Forward & Reverse 4-0-4. Input shaft 5/16" dia. x ¾" long. Output shaft 15/64" dia x 9/16" long. Control shaft 11/64" dia. x 11/16" long. Cost aluminum construction. Approx. size 4½" x 4½" x 4". **$18.50 ea.**

## SMALL DC MOTORS

(approx. size over 3¾" x 1¼" dia.:

- 5067043 Delco 12 VDC PM 1" x 1" x 2", 10,000 rpm. $7.50
- 5067126 Delco PM, 27 VDC, 125 RPM, Governor Controlled 15.00 ea.
- 5069600 Delco PM 27.5 VDC 250 rpm 12.50
- #5069625 120 rpm, mfr. Delco, 27 VDC governor controlled ........ $15.00
- 5069230 Delco PM 27.5 VDC 145 rpm 15.00
- 5068750 Delco 27.5 VDC 160 rpm w. brake 6.50
- 5068571 Delco PM 27.5 VDC 10,000 rpm (1x1x2") 5.00
- 5069790 Delco PM, 27 VDC, 100 RPM, Governor Controlled 15.00 ea
- #5069800 575 rpm, mfr. Delco, 27 VDC, PM reversible governor controlled, equipped with 27 VDC clutch ........ $17.50
- 5072735 Delco 27 VDC 200 rpm governor controlled. 15.00
- 5BA10A118 GE 24 VDC 110 rpm 10.00
- 5BA10AJ37 GE 27 VDC 250 rpm reversible 10.00
- 5BA10AJ52 27 VDC 145 rpm reversible 12.50
- 5BA10AJ50, G.E., 12 VDC, 140 rpm 15.00
- 5BA10FJ401B, G.E. 28 VDC, 215 rpm, 10 oz. in., 7 amp. contains brake 15.00
- 5BA10FJ421, G.E. 26 VDC, 4 rpm, reversible, 6 oz. in., .65 amp 15.00

## 400 CYCLE PM GENERATOR



115/200 volts A.C. 1- or 3-phase, 200 watts 4,000 r.p.m. Approx. dimensions: 4¾" dia.; 3" long; ½" shaft, AN connector. $75.00

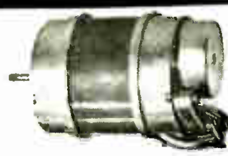
## DIRECTIONAL INDICATOR, TYPE C5C

Mfgr. Summers Gyroscope Company. 115 volt A.C., 400 cycle, 3 phase. Contains direct reading gyro with caging mechanism and power failure indicator. Hermetically sealed case. 5" dial, 0 to 360°
PRICE ........ $22.50

## MINNEAPOLIS-HONEYWELL RATE GYRO (Control Flight)

Part no. JG7005A, 115 volts A.C., 400 cycle single phase potentiometer take off resistance 530 ohms. Speed 21,000 r.p.m. Angular momentum 2½ million, CM²/sec. Weight 2 lbs. Dimensions 4-7/32 x 3-29/32 x 3-31/64.
Price $22.50

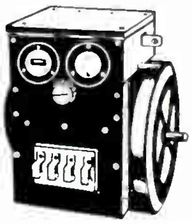
## SELSYNS-SYNCHROS



| | |
|---|---|
| 1CT cont. Trans 90/55V 60 cy. | $27.50 |
| 1DG Diff. Gen. 90/90V 60 cy. | 34.50 |
| 1F Syn. Mtr. 115/90V 60 cy. | 34.50 |
| 1G Gen. 115V 60 cy. | 34.50 |
| 1HDG | 37.50 |
| 1HCT | 37.50 |
| 1SF Syn. Mtr. 115/90V 400 cy. | 12.50 |
| 23TR4 torque receiver | 34.50 |
| 23TR6 torque receiver | 37.50 |
| 23CT6 control transformer | 37.50 |
| 23CX6 control transmitter | 37.50 |
| 23TX6 torque transmitter | 37.50 |
| 7DG differential generator | 37.50 |
| 2J1F1 Gen. 115/57.5V 400 cy. | 7.50 |
| 2J1F3 Gen. 115/57.5V 400 cy. | 10.00 |
| 2J1FA1 Gen. 115/57.5V 400 cy. | 7.50 |
| 2J1G1 57.5/57.5V 400 cy. | 5.00 |
| 2J1H1 Diff. Gen. 57.5V 400 cy. | 7.50 |
| 2J5D1 Cont. Trans. 105/55V 60 cy. | 17.50 |
| 2J5F1 Cont. Trans. 105/55V 60 cy | 17.50 |
| 2J5H1 Gen. 115/105V 60 cy. | 17.50 |
| 2J15M1 Gen. 115/57.5V 400 cy. | 17.50 |
| 5CT Cont. Trans. 90/55V 60 cy. | 34.50 |
| 5D Diff. Mtr. 90/90V 60 cy. | 34.50 |
| 5DG Diff. Gen. 90/90V 60 cy. | 34.50 |
| 5F Syn. Mtr. 115/90 VAC 60 cy. | 34.50 |
| 5G Syn. Gen. 115/90VAC 60 cy. | 34.50 |
| 5HCT Cont. Trans. 90/55V 60 cy. | 37.50 |
| 5SDG Diff. Gen. 90/90V 400 cy. | 12.50 |
| 6DG Diff. Gen. 90/90V 60 cy. | 25.00 |
| 6G Syn. Gen. 115/90VAC 60 cy. | 34.50 |
| 7G Syn. Gen. 115/90VAC 60 cy. | 42.50 |
| C56701 Type 11-4 Rep. 115V 60 cy. | 20.00 |
| C69405-2 Type 1-1 Transm. 115V 60 cy. | 20.00 |
| C69406 Syn. Transm. 115V 60 cy. | 20.00 |
| C69406-1 Type 11-2 Rep. 115V 60 cy. | 20.00 |
| C78248 Syn. Transm. 115V 60 cy. | 12.50 |
| C78410 Repeater 115V 60 cy. | 20.00 |
| FPE 49-7 Diehl servo motor, 115 volts, 60 cycle, 10 watts | 30.00 |

## 400 CYCLE, 3 PHASE GENERATOR

BY MASTER ELECTRIC



Type AG, frame 364Y, 7.5 kw, 3428 rpm, pf .95 Star connected 120/208 3 phase, 22 amps. Delta connected 120 volt single phase 6 amps. Self excited. Complete with control box, voltage regulator, AC voltmeter and frequency meter. Shaft 1" dia., 2" long; overall dim. of unit: 21"x18"x20".
Price $395.00 each

## SENSITIVE INTEGRATING GYROS

This is the famous HIG Gyro which is being used in missile guidance systems, radar stabilization and fine control systems. Government cost approximately $1500.
PRICE $50.00

## 400 CYCLE PM GENERATOR

Mfgd. by T K M Electric Corp.
Model #A-12
120/208 volts, 400 cycle, 1 or 3 phase, 1 kva, pf 0.8, rpm 8,000. Approx. dim. 6" x 5½". Internal spline drive. Price $100.00

## HONEYWELL VERTICAL GYRO MODEL AG7044A17

115 volts, 400 cycles, single phase, 35 watts. Pitch and roll potentiometer pickoffs 890 ohms, 40 volts max. AC or DC. Speed 20,000 rpm, ang. momentum 12,500,000 gm-cm 2/sec. Erection system 27 VAC, 400 cycles, time 5 min. to ½°; caging mechanism operates on 24 VDC.
$49.50

## DIRECTIONAL GYRO

Mfg. Sperry Part #656519
115 VAC 400 N 3 phase
$35.00 ea.

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SPECIALIZING **R & D** RESEARCH & DEVELOPMENT EQUIPMENT

## MICROWAVE ANTENNAS

**3 CM ANTENNA ASSEMBLY:** Uses 17" paraboloid dish, operating from 24 vdc motor. Beam pattern: 5 deg. in both Azimuth and elevation. Sector Scan: over 160 deg. at 35 scans per minute. Elevation Scan, over 2 deg. Tilt. Over 24 deg. .......... $27.50
**3 cm. Horn.** 1"x½", with twist and 180 deg. bend. With dielectric window .......... $7.50
**AT49 APR** Broadband Conical. 300-3300 MC. Type N Feed .......... $5.95
**Discone Antenna.** AS 125 APR. 1000-3200 mc. Stub supported with type "N" Connector .......... $6.95
**AS14A AP.** 10 CM pick up dipole assy, complete w/ length of coax and "N" connectors .......... $4.50
**AS46A APG-4** Yagi Antenna. 5 element array .. $8.95
**30' Parabolic** Reflector Spun Aluminum dish 10½" Focus .......... $4.85
**18" PARABOLIC DISHES**, spun aluminum. Focus approx. 8 inches .......... $3.95
**APS-4**, 3 cm. antenna. Complete. 14½ dish. Cutler feed dipole directional coupler, all standard 1" x ½" waveguide. Drive motor and gear mechanisms for horizontal and vertical scan. complete ... $27.50

## PULSE NETWORKS

**G.E.** #6E3-5-2000-50P2T, 6KV "E" circuit, 3 sections 5 microsecond. 2000 PPS 50 ohms impedance .......... $4.00
**G.E.** #3E (3-84-810) (8-2-24-405) 50 P4T: 3KV "E" CKT Dual Unit: Unit 1, 3 sections, 0.84 Microsec. 810 PPS. 50 ohms imp; Unit 2, 8 sections, 2.24 microsec. 405 PPS. 50 ohms imp. .......... $3.75
**H-616 10 KV.** 2.2 usec., 375 PPS. 50 ohms imp. $8.50
**H-615 10KV.** 0.85 usec. 750 PPS. 50 ohms imp. $8.50
**H-605:** 25KV. "E" CKT. 1.5 usec. 400 PPS. 50 Ohms Impedance. 5 sections .......... $47.50
**7-5E3-1-200-67P**, 7.5 KV "E" Circuit, 1 Microsec. 200 PPS, 67 ohms impedance 3 sections .......... $4.00
**7-5E4-16-60**, 67P, 7.5 KV "E" Circuit, 4 sections 16 microsec. 60 PPS. 67 ohms impedance .......... $6.00
**7-5E3-3-200-67P**, 7.5 KV. "E" Circuit, 3 microsec. 200 PPS. ohms, imp. 3 sections .......... $7.00

## X BAND—1" x ½" WAVEGUIDE

**90 degree elbows.** "E" or "H" Plane 2½" radius $5.50
**ROTARY JOINT** (APS-6) Sperry PT #658275, 180 deg. rotation, choke-to-choke. Has "Built-in" Di-Coupler. 20 DB., with "N" Takeoff .......... $12.50
**PARABOLOID DISH**, 18" diam. Spun Aluminum, 8" Focus. For AN/APS-6 .......... $3.95
**3 CM. DIPOLE** and Feed Assembly. (May be used with above dish) 8 inches long .......... $5.00
**FLEXIBLE SECTIDN** 9 in. long, Cover-to-Cover $4.00
**3 CM. DIPOLE FEED**, 15" L. for APS-15 .......... $8.50
**Cross-Guide Directional Coupler.** UG-40 output flange. Main Guide is 6" Long, with 90 Deg. "E" Plane bend at one end, and is fitted with Std. UG 39/UG 40 flanges. Coupling figure: 20 db Nominal .. $12.50
**Bulkhead Feed-thru Assembly** .......... $9.75
**Pressure Gauge Section** with 15 lb. gauge .......... $7.50
**ADAPTER**, waveguide to type "N", UG 81-U, p/o TS 12, TS-13, Etc. .......... $6.50

**I.F.F.** I KW Pulsed Output Pkg. Tunable 154-186 mc. adj. modulating pulses 4-10 micro sec. comp. 115v 60 cy ac pwr. supply. Video output receiver. New w/tubes .......... $200.00
Dipole Array for above .......... $10.00

## COAXIAL R.F. FILTERS

**F-29/SPR-2.** Hi-Pass., with 1000 mc. Cut-off. Type "N" input and output. 50 Ohms Z .......... $5.00
**F-4/SPR-1.** Hi-Pass. with 300 mc cut-off. Type "N" input and output. 50 Ohms Z .......... $5.00

## ANTENNA PEDESTAL SCR 584

Full azimuth and elevation sweeps 360 degrees in azimuth. 210 degrees in elevation. Accurate to 1 mil. or better over system. Complete for full tracking response. Angle acceleration rate: AZ. 9 degrees per second squared EL. 4 degrees per second squared. Angle slewing rate: AZ 20 degrees per sec. EL. 10 degrees per sec. Can mount up to a 20 ft. dish. Angle tracking rate: 10 degrees per sec. Includes pedestal drives, selsyns, potentiometers, drive motors, control amplidynes. Excellent condition. Ideal for missile & satellite tracking, antenna pattern ranges, radar systems, radio astronomy, any project requiring accurate response in elevation and aimuth. Complete description in McGraw-Hill Radiation Laboratory Series, Volume I, page 284 and page 209, and Volume 26, page 233.
*Price on request.*

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**TS 12.AP** complete with waveguides #1 & #2 units —P.O.R. **CF-2 CARRIER** 6'x2'x18" .......... $75.00
**400 MC RADAR**, complete set w/indicators, control boxes, **XMTR. RCVR**, connectors, less 2 cables .......... $57.50
WE HAVE OVER 100,000 THERMAL RELAYS IN 10 TYPES P.O.R.

## PULSE EQUIPMENT

**MIT. MOD. 3 HARD TUBE PULSER:** Output Pulse Power 144 KW (12 KV at 12 Amp). Duty Ratio: .001 max. Pulse duration: 5, 1.0, 2.0 microsec. Input voltage: 115 v. 400 to 2400 cps. Uses: 1-715, 4-829-B, 3-72's, 1-73. New .... Less Cover—$60.00
**ASD Modulator Units.** mfd. by Sperry. Hard tube pulser delivers Pk. pulse of 144 kw. Similar to Mod. 3 unit. Brand new, less tubes .......... $52.50
**Airborne RF head**, model AIA, delivers 50 Kw peak output at 9000 mc. at .001 duty. Complete with pulser unit and all tubes. Used, excel .......... $85.00

## PULSE TRANSFORMERS

**Westinghouse 4P37:** Primary: 50 ohms imp. 750 v. Sec. 15 kv. 1000 ohms imp. Bifilar filament trans. built in, delivers 12.6 v at 2.5 amp. (pri. 115 v. 400 cy.) .......... $17.50
**RAYTHEON WX 4298E:** Primary 4KV., 1.0 USEC. SEC: 16KV-16 AMP DUTY RATIO: .001 400 CYCLE FIL TRANS. "BUILT-IN" .......... $22.00
**WECO:** KS 9948: Primary 700 ohms; Sec: 50 ohms. Plate Voltage: 18 KV. Part of APQ-13 .......... $7.50
**K-2745** Primary: 3.1/2.8 KV. 50 ohms Z. Secondary: 14/12.6 KV 1025 ohms Z. Pulse Length: 0.25/1.0 usec @ 600/600 PPS. PK. Power 200/150 KW. Bifilar: 1.3 Amp. Has "built-in" magnetron well .......... $15.00
**K-2461-A.** Primary: 3.1/2.6 KV—50 ohms (line). Secondary 14/11.5 KV—1000 ohms Z. Pulse Length: 1 usec @ 600 PPS. Pk. Power Out: 200/130 KW. Bifilar: 1.3 Amp. Fitted with magnetron well $17.50

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**HERSHEL SPECIALS**

**BUTTERFLY CONDENSERS**
**YOUR CHOICE**
**$4.95**

TYPE A 4¼" Dia.
TYPE A—106 330 MC-Antenna Type

TYPE B 4⅜" Dia.
TYPE B—135 485 MC

TYPE C 2½" Dia.
TYPE C—300 1000 MC-Uses 368AS tube

TYPE D 2½" Dia.
TYPE D—300 1000 MC-Clip for Xtal Det.

These units make the finest tuners for Ultra-high frequency transmitters, receivers, frequency meters, and oscillators.

TERMS: Cash with order or 25% DOWN—BALANCE C.O.D.
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## GET IT from GOODHEART!

### MEASURE E, I, R TO 4-FIGURE ACCURACY

and with ZERO current drawn from ckt being measured. Voltage: Direct reading, Potentiometric method. We supply the L & N 3-dial Kelvyn-ckt 2K ohm Voltage Divider, accuracy .01%, plus .01% resistors for Divider connection as Wheatstone Bridge, plus 0-center uAmmeter, plus exact instructions, theory & practical ckts, Divider & Potentiometer. You supply cheap batteries for 3-figure accuracy or standard cell for 4 figures. This is a $1055.00 Test Set!
All for only .......... **$79.50**

West. Elect. KS-10375 Null Voltage Test Set, 0-250 V, made by L & N, is 4-dial 100 K ohm Voltage Divider, accuracy 1 part in 100,000, with sensitive L & N Galvanometer and convenient switching ckts built in, all in portable case .......... **$199.50**

### WESTON STANDARDIZING POTENTIAL XFRMR

Mod. 311 Type 3. Adjust 120 v 50-125 cy to wdg 1 to read 150.0 v on your meter at wdg 3. Get 1½, 3, 7½, 15 & 30 v at wdg 2, accurate 0.1%, to 500 ma. Regular $461.50,
Only .......... **$199.50**

### MIL SPEC SILICON DIODES IN250A

Unused, contract termination. 200 PIV 20A at 150 deg. C. ¼-28 stud, hex base. Max 1½ v drop, 5 ma reverse, 250 A ½-cy surge. Regular $14.00. Buy postpaid at only .......... **$2.50**

### PRECISION PHASE METER AN/URM-67

Phase Monitor ME-63/U in chest w/cords. Inputs 20-20,000 cy 2-30 v peak, reads 0-360 ± 1 deg.. Same as Control Electronics Co. Model 120. Acquis. cost $1420.00. Like new,
only .......... **$275.00**

### HANDY-DANDY 3-PH 400 CY INVERTER

Ideal for labs, instrument checkouts, breadboard assemblies, etc. Eclipse-Pioneer #12142-1-A, In: 27½ v dc 22A. Out: 3 ph 115 v 400 cy 250 VA 1.0 PF. V & freq. regulated. Only 9¼" lg, 6¼" h. Very clean, checked, grtd, w/mating plug.
14 lbs fob San Diego, only .......... **$24.50**

### GRAPHIC RECORDERS AND AMPLIFIERS

Brush BL-262, 2-channel elect. wrtg, rack mtd. sensitivity 1.1 mm/v. 1450 ohms, 16 v rms FS. Switch selects 8 chart speeds from 1 to 250 mm/second. Regularly $1650. Our price, checked OK ... $395.00
Brush BL-202, same penmotors, 2 chan. portable, ink wrtg, gear-shifted 5, 25, 125 mm/sec. Regularly $875.00. Checked, ready to use .......... $250.00
Same for electric wrtg/pwr supply .......... $295.00
Easterline-Angus portable Type AW, spring-wound chart drive, 2½-0-2½ ma dc, checked OK ... $175.00
Est.-Angus ditto 1 ma dc full scale, new ... $250.00
Est.-Angus ditto except 20 pens record 24 v dc events with 400 ohm actuators, new, only .......... $150.00
Gen. Radio #715AM DC Amplifier, new, only .. $97.50
Sanborn #154-100B rack-mtg 4-chan. recorder, elect. wrtg. plus time marker. Multiple chart-speed choice. Checked and certified 100% OK .......... $450.00
Sanborn #150-2900V. 2-chan. DC amplifier .. $175.00
Penmotors only, similar in shape to Brush BL-902A, less penholders, unknown make, appear exc ... $49.50

### NEW COMPLETE MAGNETOMETER AN/ASQ-3

Osc. O-3 & Converter CV-1 in Case CY-4; Head (with orienters) DT-2; Dynamotor Assbly DY-6; Control C-8; Indicator ID-5 (is a ½-0-½ ma dc meter, may be parallelled by a recorder if desired); set of plugs; and 160-page Handbook. Input 28 v dc 10A, starting surge 70A. At max. sensitivity, 5 gammas produce ½ ma dc. In Mfr's packing, clean and fresh as day it left the factory. Shpg wt 250 lbs.
fob Phila., Pa .......... **$349.50**

Add for Recorder RD-4/ASQ. new .......... $200.000

### RADIO RECEIVER AND/OR SPECTRUM ANALYZER

AN/APR-4 rcvr is the 11-tube 30 mc IF etc. for its plug-in tuning units; has S-meter, 60 cy pwr sply, Pan., Video & Audio outputs. AM. Checked, aligned. with heads for 38-1000 mc,
pwr plug & Handbook, fob Los Ang .... **$164.00**

Add $59.50 for 1-2.2 kmc; and $175.00 for 2.2-4 kmc; add $150.00 for 30 mc Panadapter RDP; add $79.50 for Test Oscillator TS-47/APR (40-3000 mc ± 1%. CW, AM, Pulsed, w/built-in 60 cy sply).

### 0.1% SORENSEN LINE VOLTAGE REGULATOR

#50005 holds setting 110-120 v to 0.1% despite line changes 95-130 v 1 ph 50/60 cy & load changes 0-5 kva. Max. harmonics 3%. Recovery 0.15 seconds. Regular $695 less spares. New ..........
w/spares, 285 lbs fob Utica, N.Y. **$349.50**

### 2 KVA SOLA CONSTANT-VOLTAGE XFRMR

Input 95-125/190-250 v 50 60 cy 1ϕ. Sec. 115.0 v ± 1%, 0-17.4 A. New. 260 lbs
fob Harrisburg, Pa. only **$89.50**
Convert above output to 230.0 v ± 1% with Westinghouse 5 kva autotransformer, new,
fob Los Angeles, add only .......... **$45.00**

### STODDART NOISE/FIELD STRENGTH METER

NMA-5A(TS-587/U)complete, certified OK, w/Handbook, uncalibrated, fob Los Angeles **$499.50**

### TRIM ANTENNAS TO EXACT IMPEDANCE

Navy OCK rf bridge is same electrically as Gen. Radio's $620.00 #916AL, has all accessories. Aer-O-Com's $425.00 Artificial Antenna DA-200 cranks up to exact L, C & R, 2-22 mc to trim xmtrs up to 200 W Po. Combination OCK & DA-200, both like new, $1045.00 value,
fob Los Angeles for only .......... **$370.00**

### STANDARD SIGNAL GENERATOR BARGAIN

Navy LAE-2 new or like new, 520-1300 mc ± 1%, AM, CW, Pulse, calibrated Vo 1 uv to .1 v ± 1 db & 1%. Pulse delay 3-300 usec, duration 2-30 usec, rate 60-2500 pps.
FOB San Diego, only .......... **$89.50**

### BECKMAN/BERKELEY COUNTERS, ½ PRICE

#554-F1, 5 rows, 0-100,000. Time base .1, 1, 10 sec. Schmidt triggering. Exc.
cond., fob Los Angeles only .......... **$325.00**
#7360 Universal EPUT Time Interval, 6 rows, 0-1 mc. Time 1 usec to 10 million sec. Trigger slope selection. Exc. cond.,
ready to use, fob Los Angeles only ..... **$625.00**

**R. E. GOODHEART CO.**
P. O. Box 1220-E Beverly Hills, Calif.

## ANTENNA PEDESTAL SCR 584-MP 61B

Full azimuth and elevation sweeps 360 degrees in azimuth. 210 degrees in elevation. Accurate to 1 mil. or better over system. Complete for full tracking response. Angle acceleration rate: AZ, 9 degrees per second squared EL, 4 degrees per second squared. Angle slewing rate: AZ 20 degrees per sec. EL. 10 degrees per sec. Can mount up to a 20 ft. dish. Angle tracking rate: 10 degrees per sec. Includes pedestal drives, selsyns, potentiometers, drive motors, control ampildynes. Excellent condition. Quantity in stock for immediate shipment. Ideal for missile & satellite tracking, antenna pattern ranges, radar system, radio astronomy, any project requiring accurate response in elevation and azimuth.
Complete description in McGraw-Hill Radiation Laboratory Series, Volume 1, page 284 and page 209, and Volume 26, page 233.

### SCR 584 RADARS AUTOMATIC TRACKING

3 CM & 10 CM. Our 584s in like new condition, ready to go, and in stock for immediate delivery. Ideal for telemetry, research and development, missile tracking, satellite tracking, balloon tracking, weather forecasting, antiaircraft defense tractical air support used on Atlantic Missile Range, Pacific Missile Range, NASA Wallops Island, A.B.M.A. Write us. Fully Desc. MIT Rad. Lab. Series, Vol. 1, pps 207-210, 228, 284-286.

### AN/TPS—1D RADAR

500 kw. 1220-1359 mcs. 160 nautical mile search range P.P.I. and A. Scopes, MTI. thratron mod. 5J26 magnetron. Complete system.

### AN/TPS 10D HEIGHT FINDER

250 KW X-Band. 60 & 120 mile ranges to 60,000 feet. Complete.

### AN/APS—15B 3 CM RADAR

Airborne radar. 50uw output using 725A magnetron. Model 3 pulser. 30 in. parabola stabilized antenna. PPI and "A" scope. Complete system. $1200 each. New.

### 10KW 3 CM. X BAND RADAR

Complete RF head including transmitter, receiver, modulator. Uses 2J42 magnetron. Fully described in MIT Rad. Lab. Series Vol. 1, pps. 616-625 and Vol. II, pps. 171-185 $375. Complete Radar System $750.

### 10 CM. WEATHER RADAR SYSTEM

Raytheon, 275 KW output S band. Rotating yoke P.P.I. Weather Band. 4, 20 and 80 mile range. Price $975. complete. Has picked up clouds at 50 miles. Weight 488 lbs.

### CARCINOTRON

Type CM 706A Freq. 3000 to 4000 mcs. CW. Output 200 Watts minimum. New, with full guarantee.

### VA-800 KLYSTRON

1.7 to 2.4 KMC. (continuously turnable). 10 KW. CW. 50 db Gain output UG-435 A/U Flange $975 each.

### 2 MEGAWATT PULSERS

(A) 31 KV at 60 amps .002 Duty Cycle Ideal for 5J26 at 500KW 5C22 Thyr. $950
(B) 30 KV at 70 amps .001 Duty Cycle 5C22 Thyr. $1250 w/pulse trans.

### MIT MODEL 9 PULSER 1 MEGAWATT—HARD TUBE

Output pulse power 25 KV at 40 amp. Max. duty ratio: 002. Uses 6C21 pulse tube. Pulse duration .25 to 2 microsec. Input 115 volts 60 cycles AC. Includes power supply in separate cabinet and driver. Fully guaranteed as new condition. Full Desc. MIT. Rad. Lab. Series "Pulse Generators."

### 500 KW PULSER

5C22 Hyd Thyr Modulator. 22KV at 28 Amps. W/HV & Fil Supplies. 3 pulse length rep rates: 2.25 usec 300 pps. 1.75 usec 550 pps. .4 usec 2500 pps. 115V 60 cy. Will deliver nominal 225 KW X Band using 4J50 magnetron.

### MIT MODEL 3 PULSER

Output: 144kw (12kv at 12amp.). Duty ratio: 001 max. Pulse duration: .5 1 and 2 micro sec. Input: 115v 400 to 2000 cps $325 ea. Full desc. Vol. 5 MIT Rad. Lab. series pg 140.

### L BAND RF PKG.

20KW peak 990 to 1040MC. Pulse width .7 to 1.2 micro sec. Rep rate 180 to 420 pps. Input 115 vac. Incl. Receiver $1200.

**RADIO RESEARCH INSTRUMENT CO.**
**550 FIFTH AVE., NEW YORK**
**JUDSON 6-4691**

CIRCLE 470 ON READER SERVICE CARD

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# SEARCHLIGHT SECTION

## RATES

### DISPLAYED

The advertising rate is $27.25 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request. AN ADVERTISING INCH is measured 7/8 inch vertically on one column, 3 columns—30 inches—to a page. EQUIPMENT WANTED or FOR SALE ADVERTISEMENTS acceptable only in Displayed Style.

### UNDISPLAYED

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

PROPOSALS, $2.70 a line an insertion. BOX NUMBERS count as one line additional in undisplayed ads.

DISCOUNT OF 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

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### SMALL AD but BIG STOCK

**of choice test equipment and surplus electronics**

Higher Quality—Lower Costs
Get our advice on your problem

**ENGINEERING ASSOCIATES**
434 Patterson Road — Dayton 19, Ohio

CIRCLE 471 ON READER SERVICE CARD

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### MICROWAVE ANTENNAS

6' Spun aluminum dish. Parabolic, Andrews #2006 W/T4 Mounting brackets, de-icer and dipole radiator. New crated for export. $100.00 complete. One hundred available. Also Rigid Line, Hangers & Fittings.

**SIERRA WESTERN ELECTRIC**
1401 Middle Harbor Road Oakland 20, Calif.
TE-2-3527

CIRCLE 472 ON READER SERVICE CARD

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**TUBE & COMPONENT**
# FREE...CATALOG
## BARRY ELECTRONICS

512 BROADWAY NEW YORK 12, N.Y.
WAlker 5-7000 TWX: NY 1-3731

CIRCLE 473 ON READER SERVICE CARD

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*Your Inquiries to Advertisers Will Have Special Value . . .*

—for you—the advertiser—and the publisher, if you mention this publication. Advertisers value highly this evidence of the publication you read. Satisfied advertisers enable the publishers to secure more advertisers and—more advertisers mean more information on more products or better service—more value—to YOU.

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*Advertisement*

# INTERESTING TO NOTE . . .

NEW YORK, N. Y. Feb. 1962:—

Universal Relay Corp., 42 White St., New York 13, N. Y. announces the publication of their 52 page Spring 1962 catalog. With publication of the catalog, they inform their customers that "normal inventory includes over 1,500,000 relays in approximately 30,000 types. In most cases stock is sufficient to give immediate delivery of production quantities.

This catalog is, therefore, not just a listing of items available 'on order' but, by and large, it is an indication of in-stock items (either as complete units or as ready to assembly components).

The average shipment is made within 48 hours. Where coils and frames require assembly, or relays require special testing or adjustment, shipments are made within one week to ten days.

Universal is completely equipped to assemble, adjust and thoroughly test any type of relay. Assembly and test facilities have been imitated by some relay manufacturers.

A personal interest is taken in every order. This interest is maintained as the order is processed. And, it continues even after the customer receives the merchandise until he makes sure that it satisfies his needs.

All merchandise is guaranteed, subject to customers' inspection and approval, and may be returned within 30 days for replacement or credit.

The catalog is full of items to fill everyday relay requirements".

**Catalog E-162 may be obtained by writing directly to:**

## UNIVERSAL RELAY CORP.

42 White Street, New York 13, N. Y.
WAlker 5-6900

CIRCLE 474 ON READER SERVICE CARD

# INDEX TO ADVERTISERS

Audited Paid Circulation



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

■

MANUFACTURERS' REPRESENTATIVES



CLASSIFIED ADVERTISING

F. J. Eberle, Business Mgr.



INDEX TO CLASSIFIED ADVERTISERS



■

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

This Index and our Reader Service Numbers are published as a service. Every precaution is taken to make them accurate, but ELECTRONICS assumes no responsibilities for errors or omissions.

*Notice to subscribers . . .*

**RECENT INQUIRY DELAYS DUE TO CHANGE OVER TO SPEEDY, SAME-DAY SERVICE**

Processing of **electronics** reader inquiry cards has been transferred recently to high-speed computers at a new location.

During the transfer, some delays occurred, and your cards did not reach the advertisers with our usual promptness.

Should you experience a delayed response to recent inquiries, it was occasioned by the change over process, and is in no manner the fault of the advertiser.

We are back on schedule, servicing all cards on a current daily basis.


# electronics

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Associated Business Publications

Audited Paid Circulation

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The Vaughn Bldg., 1712 Commerce St.
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85 Westendstrasse

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*"Headquarters for Business Information"*

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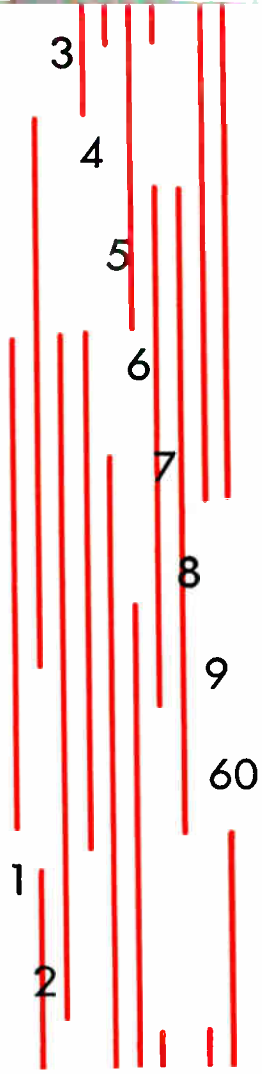
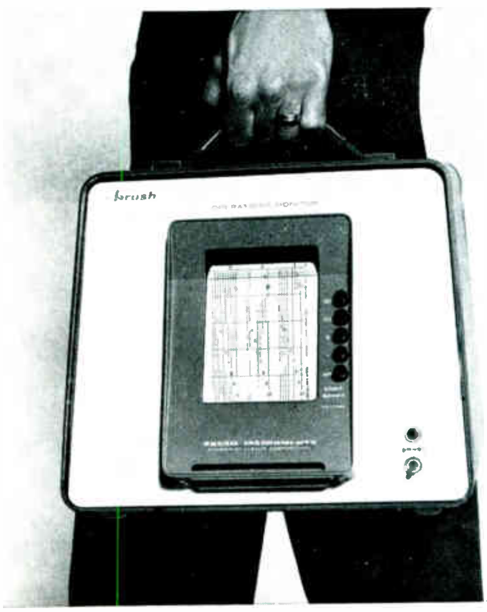
Available by subscription only — to qualified persons actively engaged in the field of the publication. For subscription rates and information describing the editorial coverage of any of the above publications, write to: *Subscription Manager, Circulation Department, McGraw-Hill Publishing Company, 330 West 42nd Street, New York 36, N. Y.*

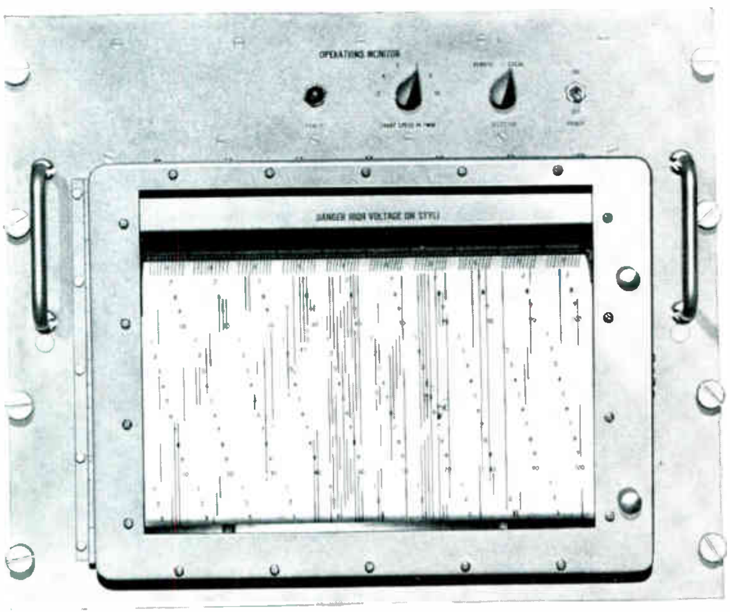
# verify events permanently in milliseconds



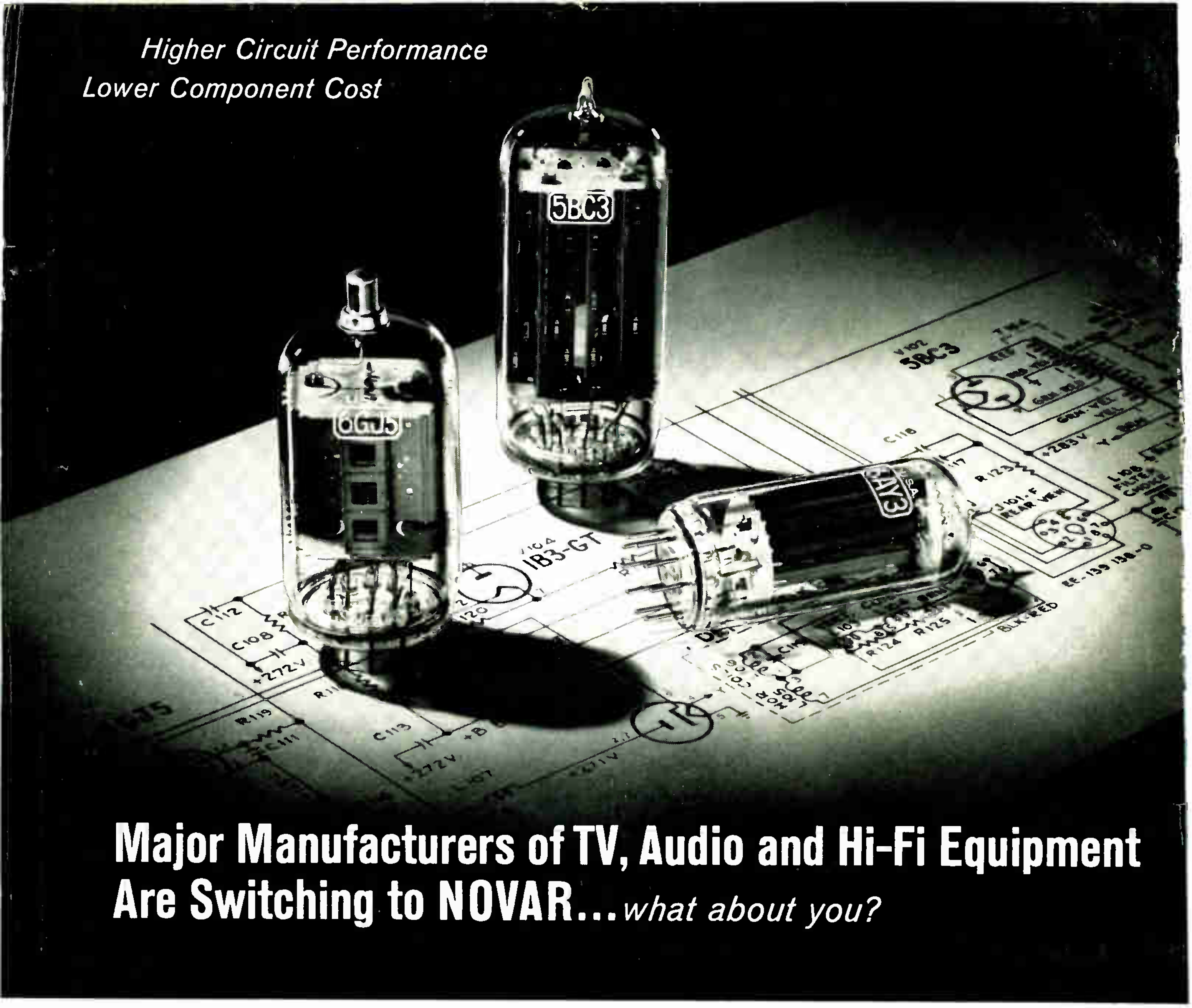

**Brush Operations Monitors'** response to signals is virtually instantaneous—less than 4 milliseconds. Multiple high-speed events are clearly defined from start to stop, on a common time base—and at rates up to 500 per second. Portable 30 channel or rack-mounting 100 channel models record sharp reproducible traces with fixed-stylus electric writing that provides the utmost in reliability. "Built-in" transistor switching to eliminate relays is optional. No direct writing recording system can match the capabilities of Brush Operations Monitors for industrial and military analysis and control. Write for complete specifications and application data.

**brush INSTRUMENTS**
DIVISION OF
37TH AND PERKINS **CLEVITE** CORPORATION CLEVELAND 14, OHIO



CIRCLE 256 ON READER SERVICE CARD




**8** LEADING MANUFACTURERS HAVE ALREADY USED HALF A MILLION NOVAR TUBES IN TV, AUDIO AND HIGH-FIDELITY EQUIPMENT

**14** MORE LEADING MANUFACTURERS WILL USE NOVAR TUBES IN THEIR NEW SET MODELS

Why? Because the 9-pin, integral-base novar design offers *better performance at lower cost* than comparable tubes, regardless of base configuration, previously manufactured with octal base and T-9 or T-12 envelopes. With so many important manufacturers swinging over to low-cost, high-performance novar, you won't want to miss out on the unique advantages of novar design, namely:

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

**Wider spacing between pins (0.172")**—minimizes the possibility of voltage breakdown; hence greater reliability.

**Pin length of 0.335"**—assures firm retention of tube in socket.

**Pin circle diameter of 0.687"**—large enough to permit use of both T-9 and T-12 envelopes.

**RCA "Dark Heater"**—operating about 350°K below the temperature of conventional heaters, "Dark Heater" assures longer tube life and improved stability and reliability.

These novar tube types are commercially available:

**For TV damper service:** RCA-6AY3, 12AY3, 17AY3; RCA-6BH3, 17BH3, and 22BH3; RCA-6DW4 (color and black-and-white).

**For TV horizontal-deflection amplifier service:** RCA-6GT5, 12GT5 and 17GT5; RCA-6GJ5, 12GJ5 and 17GJ5.

**For use in hi-fi amplifiers:** RCA-7868.

**For rectifier use in TV sets, hi-fi audio equipment and radio power supplies:** RCA-5BC3.

For additional information on any novar tube type, call your RCA Field Representative or write Commercial Engineering, RCA Electron Tube Division, Section D-19-DE-3, Harrison, N.J.

RCA® The Most Trusted Name in Electronics

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