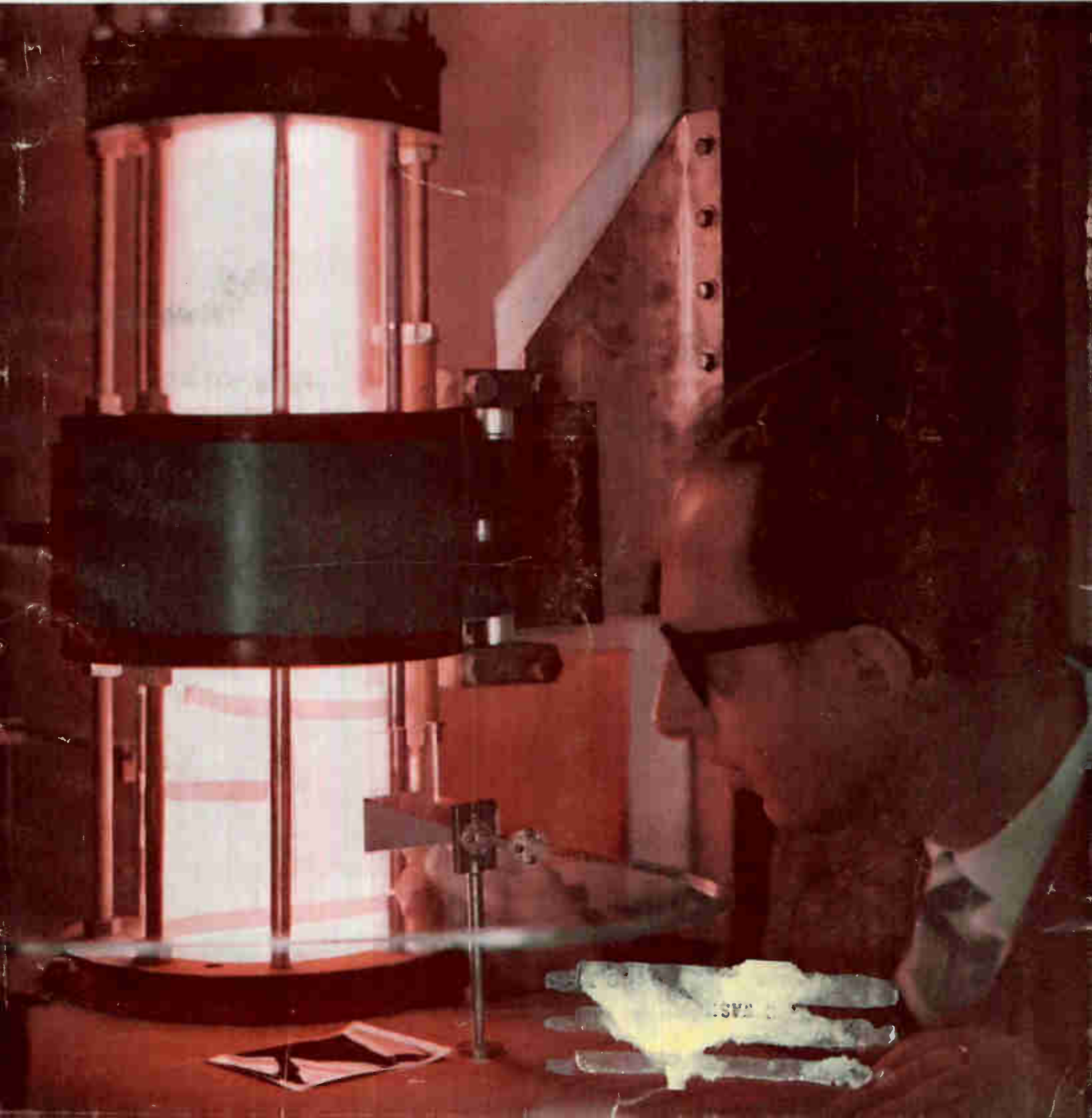
August 5, 1960

electronics

Using 70,000-Mc interferometer to study plasma produced by discharge of 100,000-joule capacitor bank described on p 59

Designing circuits for silicon-controlled rectifiers. See p 53

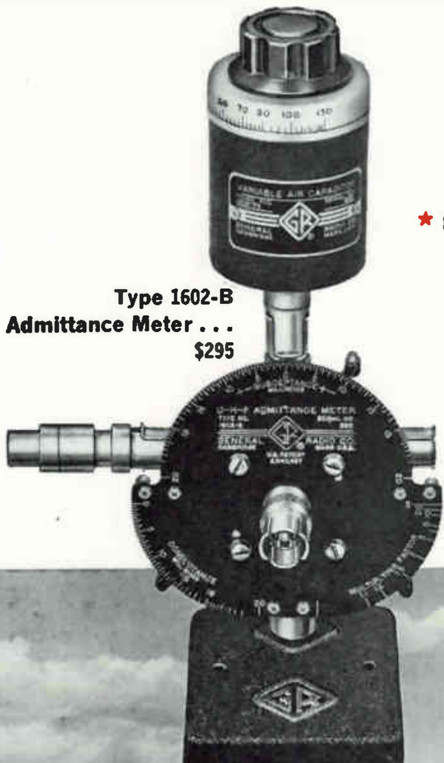
A McGraw-Hill Publication 75 Cents



Uncomplicate your VHF-UHF Impedance Measurements

Nothing approaches the G-R Admittance Meter in simplicity, ease of use, versatility, and accuracy for admittance, impedance, and VSWR measurements at frequencies from 20 to 1500 Mc.

Its design is basic . . . three coaxial lines, one containing a conductance standard, one a susceptance standard, and one for connection to the unknown, are fed from a voltage source at a common junction point. Each of the lines contains an adjustable loop which samples the field within the line. In making measurements, these loops are adjusted for a null with the aid of an appropriate null detector. (G-R Type DNT Detector recommended.) At null, the settings of the conductance and susceptance loops times a multiplying factor established by a third loop gives the value of the unknown.



Type 1602-B Admittance Meter . . . $295

★ **WIDE FREQUENCY RANGE . . .** 20-1500 Mc; direct reading from 41-1500 Mc; useful for matching to 2000 Mc.

★ **DIRECT READING RANGES** that are independent of frequency
- **Conductance:** 0.2 to 1000 millimhos
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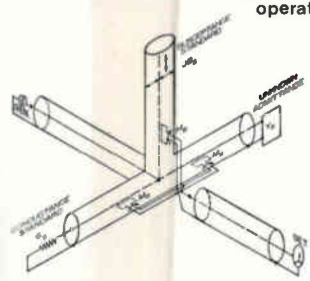
With ¼-wavelength line between unknown and Meter, scales become direct reading in **Resistance** from 1 to 5000Ω, and **Reactance** from ±1 to ±5000Ω.

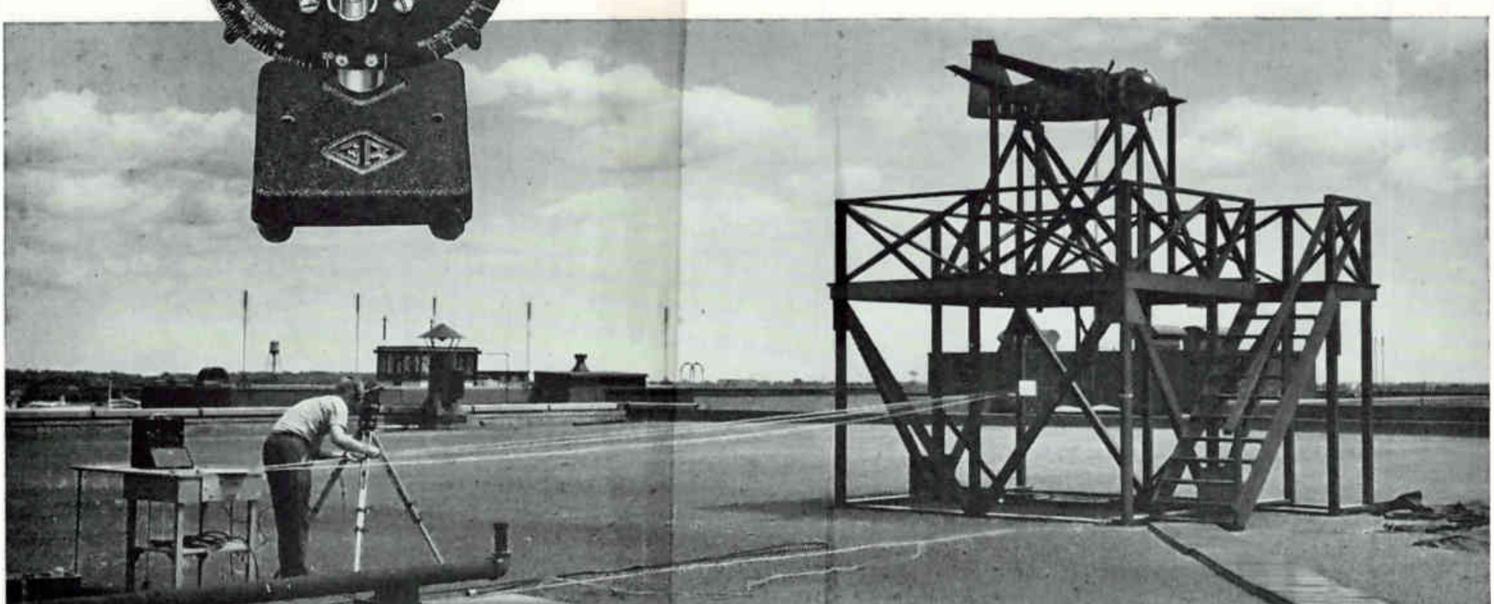
★ **EASY TO USE . . .** no sliding balances to chase . . . only three levers to adjust

★ **UNCOMPLICATED CONSTRUCTION** guarantees long, reliable operation and insures that basic ±3% accuracy will be held indefinitely.



★ **SMALL, LIGHTWEIGHT, PORTABLE . . .** ideal for antenna measurements

★ **A WIDE VARIETY OF ACCESSORIES** available to extend versatility:
- Balun for measurements on balanced lines and circuits.
- Component Mount for measuring circuit elements.
- Terminations for measuring reflection coefficient.
- Adaptors ranging from BNC to 3⅛-inch rigid line for measurements with any connector system.
- Oscillators and detector systems for complete frequency coverage.



A tribute to the Admittance Meter's versatility is its use at Grumman Aircraft, Bethpage, Long Island. Grumman engineers were faced with the problem of making accurate measurements on developmental aircraft antennas without influencing, by their physical presence, the antenna's radiation pattern or impedance characteristics. As a solution, they mounted an Admittance Meter, a G-R Unit Oscillator, and DNT Detector System inside an aircraft model. Pull cords connected to the Admittance Meter's controls were run out to a remote point where the operator could make his measurements without disturbing the setup. By adjusting the cords and using a surveyor's transit to read the instrument scales, accurate measurements could readily be made.

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August 5, 1960

electronics

A McGraw-Hill Publication 75 Cents

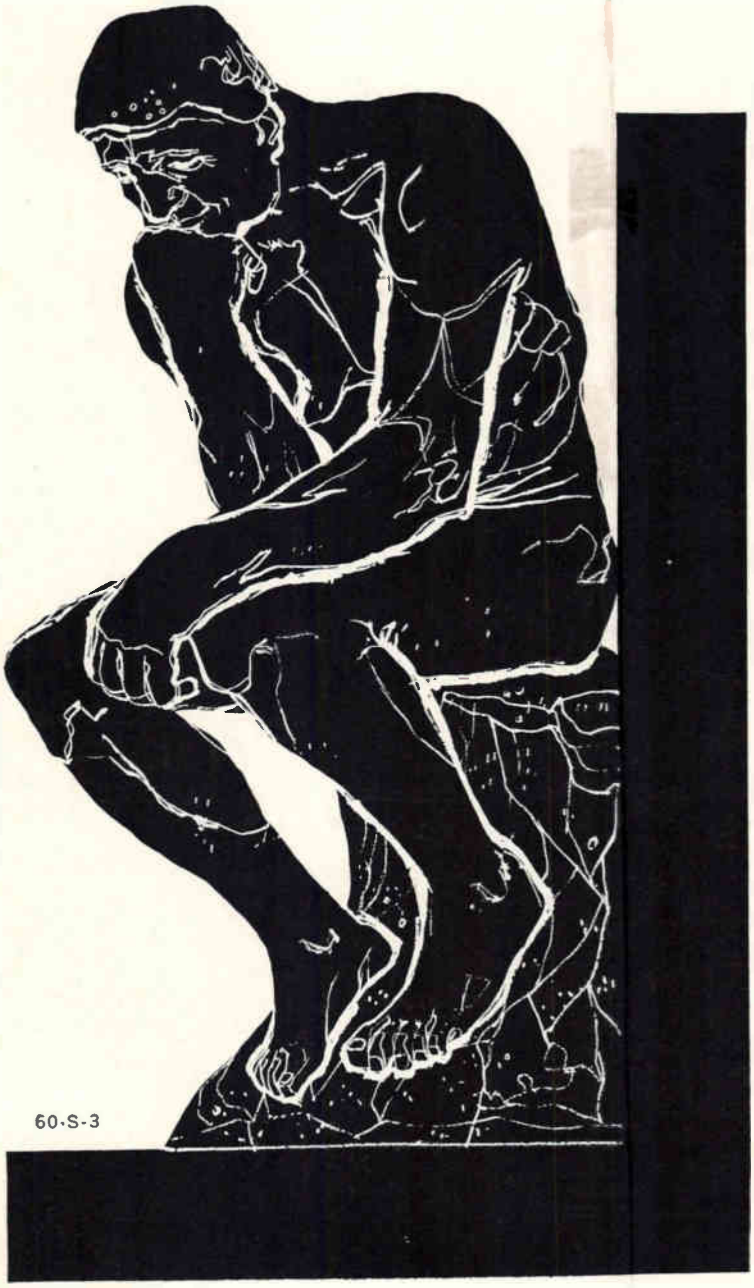
W. W. MacDONALD, Editor

BUSINESS

ENGINEERING

DEPARTMENTS

North Electric opens a whole new chapter in control switching for communications



DATELINE 1960
new north solid state switching technique chosen for 412L air weapons control system

In awarding the contract for the design and manufacture of fixed and mobile electronic communications and switching centers for the U.S. Air Force, General Electric, prime contractor for the "412-L" project, selected North Electric Company, recognizing that a major technological breakthrough in electronic switching has been achieved by North with the development of a unique "Resonant Transfer" technique for generating or detecting pulses in Time Division Multiplex Solid State Switching!

The adoption of this North concept opens a whole new era in communications, a whole new chapter in the history of electronic switching!

It is highly significant that with this development the switching art has reached the state of sophistication demanded by new weapons capabilities. It is equally significant that this development should come from the Company whose history, over better than three-quarters of a century, has been one of continuous progress and development in this field!

As future progress is made—as man reaches further and further into the unknown reaches of the universe—leadership in the highly demanding field of communications and control will continue to come from

ELECTRONETICS DIVISION

NORTH ELECTRIC COMPANY

647 S. MARKET ST. GALION, OHIO

electronics

Aug. 5, 1960 Vol. 33, No. 32

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CROSSTALK

NEW ON THE MARKET. Important characteristic of the electronics industry is the stream of new products that flows almost continuously from plants all over the world. When an electronics engineer asks "What's new?" he often means "What can I buy to solve my most recent design problem?"

Our *New on the Market* department is very popular with readers. The lead items in particular are carefully selected by the editors from the 200 or more we hear about every week. Few of them are more than a day or two old at press time; for example: as we write this, new products descriptions for this issue have not yet been written.

It will pay to watch the *New On the Market* department closely.

PLASMA RESEARCH. A capacitor bank is one of the main components needed to produce a plasma with the necessary confinement fields for experimental studies. The 100,000-joule capacitor bank described in this issue by R. Buser and P. Wolfert of U. S. Army Signal Research and Development Laboratory is being used at the S plasma facility of USASRDL's Exploratory Research Division. Design and construction of the capacitor bank were aimed at obtaining wide applicability, maximum safety and reliable components; the bank was to be usuable for producing high magnetic fields and high-temperature plasmas.

ISLAND INDUSTRY. Puerto Rico, long of strategic value to U. S. defense operations, is now becoming increasingly important in the electronics industry. West coast U. S. firms in particular are finding value in making their wares on this Caribbean island and shipping them to east coast markets.

In addition to this, tax benefits, lower overheads and cheap land are helping to spur growth of the island's electronics industry. U. S. firms, with the aid of the Puerto Rican Economic Development Administration, are finding it easy to locate their new plants on the island. Associate Editor Emma has been talking facts and figures with Administration spokesmen. To learn what they told him, see p 32.

Coming In Our August 12 Issue

WESTERN ELECTRONICS. The approach of the Wescon meeting has become a time for reviewing the growth of western electronics industry and looking ahead to future developments. Indications are that this year will show no let-up in the phenomenal growth that has marked the past 11 years.

Next week, Pacific Coast Editor Hood reports the latest sales and employment data for the 11 western states and fills you in on some of the new developments there in electronics. You'll learn, for example, about progress in cryogenic gyroscopes, an X-band ruby maser, a compact ferrite isolator for uhf and advances in hardware for learning machines.

MORE. Other interesting feature material to appear next week includes: a discussion about circuits using cadmium-sulfide field-effect transistors, by R. R. Rockemuehl of General Motors Research; an analog multiplier which uses time as one variable, by T. R. Hoffman of General Electric; a telemetry system for frozen food quality studies, by R. H. Elsken of Western Region Research, and a helical resonator design chart by W. W. Macalpine and R. O. Schildknecht of ITT.

COMMENT

Electronics in Japan

Congratulations on your excellent article "Electronics in Japan," in the May 27 issue of ELECTRONICS (p 53) . . .

HOWARD F. VAN ZANDT
INTERNATIONAL STANDARD ELECTRIC
TOKYO, JAPAN

The special report on Electronics in Japan has roused unusual interest. On p 71 (May 27) is shown a series of automatic machines used to print silver paste on ceramic wafers, in which we were especially interested . . .

V. A. KAMIN
CENTRALAB
MILWAUKEE

Ions and Health

I was most interested in your article "Ions Affect Health, Behavior," which appeared in the Feb. 26 issue, p 45. At this institute we are also conducting several experiments concerning the effects of atmospheric ions on human systems, and we are quite interested in learning of other work being done in this field . . .

JOHN RHEINSTEIN
INSTITUT FUR TECHNISCHE ELEKTRONIK
MUNICH, GERMANY

In view of the interest which your article raised and the comments on it, I am sending you a copy of an article published in the *Boston Globe* July 10 . . .

CHARLES G. HATAY
MANCHESTER-BY-THE-SEA, MASS.

The newspaper article spread across the whole page under the headline "What Radiation Can Do to Your Behavior," and described much of the same subject matter as covered in our February article. Dr. Hatay was quoted in the article as believing—among other things—that negative ionization of the air could cut the divorce rate, improve morale and industrial productivity, increase the willingness of students to learn. Maybe somebody should install a negative-ion source in the halls of the

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FLUSH-MOUNTING

recti/riter® — rectilinear galvanometric recorders

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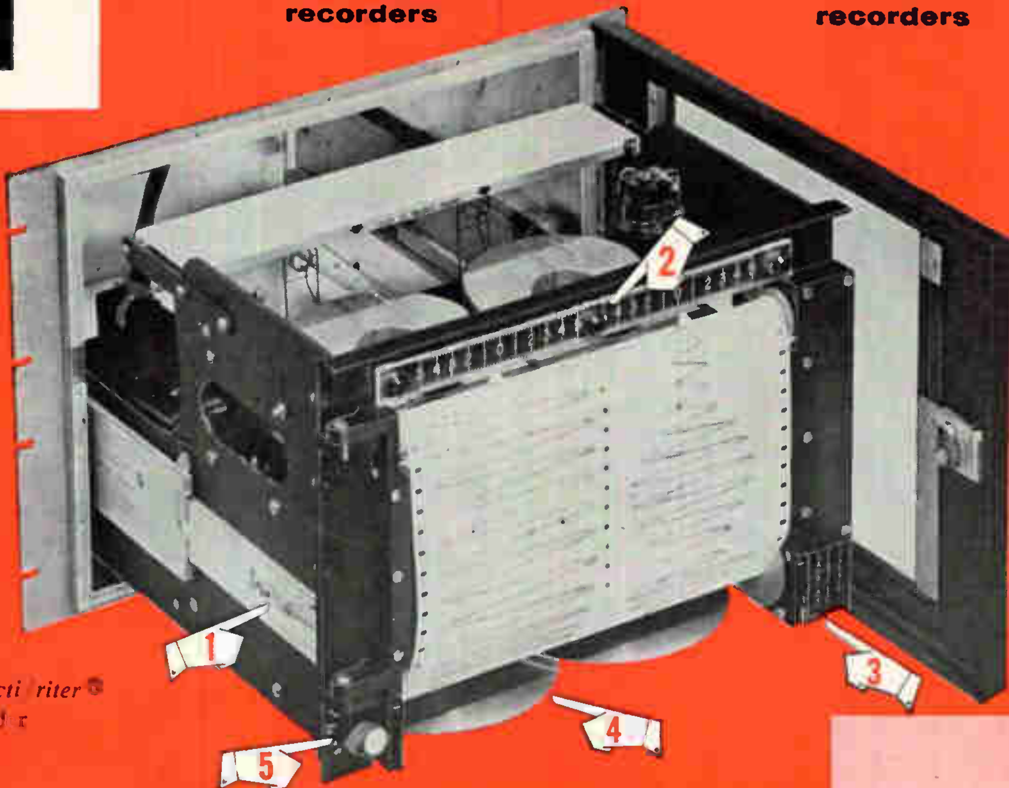

DUAL recti/riter® recorder

Exclusive convenience features are added to industry-proved recording performance

The NEW flush-mounting *recti/riter* and *servo/riter* recorders (single, dual, and wide channel) contain these operating conveniences, while retaining the reliability and performance characteristics of the proved TI portable recorders.

1. Chassis rolls out and quickly disconnects for maximum ease of installation, adjustment or servicing.
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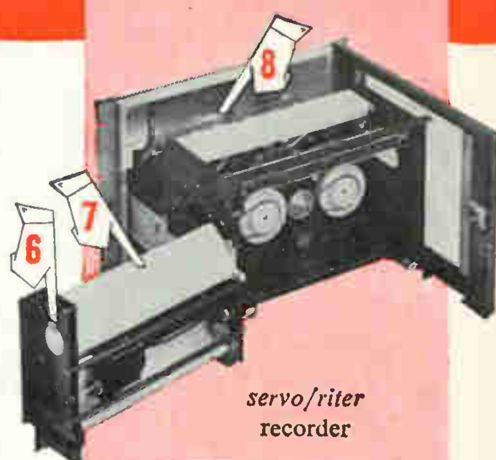
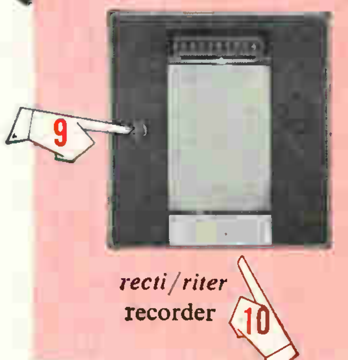
7. Swing-open chart carriage permits easy paper loading and adjustment. Simply lift up to remove carriage. Advanced design eliminates chart drive gear train lash . . . gives better paper position accuracy.
8. Interior design provides flexibility and adequate space to add special functions with ease.
9. Dust tight case has key lock available for limited access. Dimensions: Single recorders—11½″ W., 12⅛″ H., 16″ D.; Dual recorders—16¾″ W., 12⅛″ H., 16″ D.
10. Panel may be easily modified to permit paper feed through bottom of door.



servo/riter recorder



recti/riter recorder

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CIRCLE 7 ON READER SERVICE CARD

UN—in the Capitol building and the Kremlin too, for that matter.

Employ the Handicapped

I am sending you a print of the new "Employ the Handicapped" postage stamp. I believe you can benefit American business and industry by publicizing this stamp, because it has been found that physically handicapped workers can be particularly industrious, faithful and efficient employees, with below-average absenteeism and accident records.

The stamp itself will be blue, will be released on Aug. 28 to coincide with the opening at New York's Waldorf Astoria Hotel of the first world congress ever held in the U. S. by the International Society for the Welfare of Cripples. It will be printed on Cottrell presses in sheets of 50, electric-eye perforated. Its central design shows a man operating a drill press from a wheelchair.

Your readers can place advance orders for the stamp with their local postoffices. This will give the Post Office Department an inkling as to whether or not it needs to print more than the 120 million now planned. . . .

EDWIN D. FOWLE
PRESIDENT'S COMMITTEE ON EMPLOYMENT OF THE PHYSICALLY HANDICAPPED

ELECTRONICS NEWSLETTER

Polaris' Success Sparks More New Contracts

FLUSHED BY SUCCESS of the undersea Polaris shoot, Navy last week let a number of new contracts.

Northrop copped a $28-million order for design and production of electronic gear for Polaris. Included in the work are automatic checkout systems, gyroscope gear, radiometric sextants for the submarine launchers.

Remote-control guidance for Navy's drone antisubmarine helicopter (Dash) program will be built by Babcock Radio Engineering under $2.7-million contract.

Doppler navigation gear for Lockheed P3V-1 antisubmarine aircraft will be built for Navy by Ryan Electronics. The Ryan doppler gear will be tied in with inertial systems being built by Litton Industries.

The other services were active too. Air Force bought two high-speed data-processing systems from Beckman Instruments for $1.1 million, will use them to translate information from various satellites into common machinable language in standard format. Systems will also control data flow.

Autonetics division of North American Aviation has subcontracted $6.7-million worth of R&D incident to the Minuteman ICBM program. General Electric got $1.4 million for development of silicon transistors and $2.4 million for development of solid electrolytic slug capacitors and tantalytic foil capacitors; International Resistance Co. got $1.7 million for development of metal film resistors; and Sprague Electric got $1.3-million to develop solid tantalum electrolytic capacitors.

Microwave May Unlock Vast Oil Reserves

MICROWAVE HEATING system to liquify viscid petroleum trapped in oil-bearing rock is under development at Raytheon. A deep penetrating beam, produced by a microwave generator inserted in the well, will liquify the molasses-like oil and permit it to be pumped to the surface. Geologists claim a 20-deg rise in temperature in a two-foot area around the well bore will be enough to let them pump the oil out.

Government reports estimate that these previously inaccessible oil reserves add up to seven times the world supply considered economically recoverable up to this time. In the U. S. alone there are 182 billion barrels out of the reach of conventional techniques.

A microwave radiator 6 in. in diameter and 20 ft long, powered by a 5-to-10-Kw generator on the surface, will be lowered into a 3,500-ft deep Montana oil well this summer for preliminary field tests.

Court Invalidates Magnetic Patent

MAGNETIC-RECORDING patent governing use of synthetic ferrosoferric oxide and synthetic gamma ferric oxide, and covering certain methods of producing oxides and using them on magnetic tape, has been invalidated by the courts. U. S. Court of Appeals for the Seventh Circuit (Chicago) last month upheld earlier court decisions that patent 2,694,656 is invalid, because the subject matter had previously been disclosed in other patents and publications.

Patent in question had been issued to Marvin Camras and assigned to Armour Research Foundation. ARF had licensed it to Minnesota Mining & Manufacturing, giving MMM exclusive right to grant sublicenses.

Sending Radioteleprinter Signals Through Earth

NEAR CARLSBAD, N. M., last week, a 150-Kc radio transmitter sent 60-wpm teleprinter traffic 4½ miles through a salt substratum 1,000 ft below the surface of the earth. First traffic was a message addressed to President Eisenhower.

The system was operated by Deeco Corp. of Leesburg, Va. The antenna was an electromagnetically coupled loop in an abandoned potash mine. In practice, the antenna would be set in an 8-in. diameter drill hole.

The system is immune to interception and to atmospherics. Experiments with low-, medium- and high-frequency carriers have demonstrated that attenuation increases with frequency. Although traffic can be handled somewhat faster than 60-wpm, the system is described as having a moderate data rate.

Detector to Warn of Nuclear Explosion

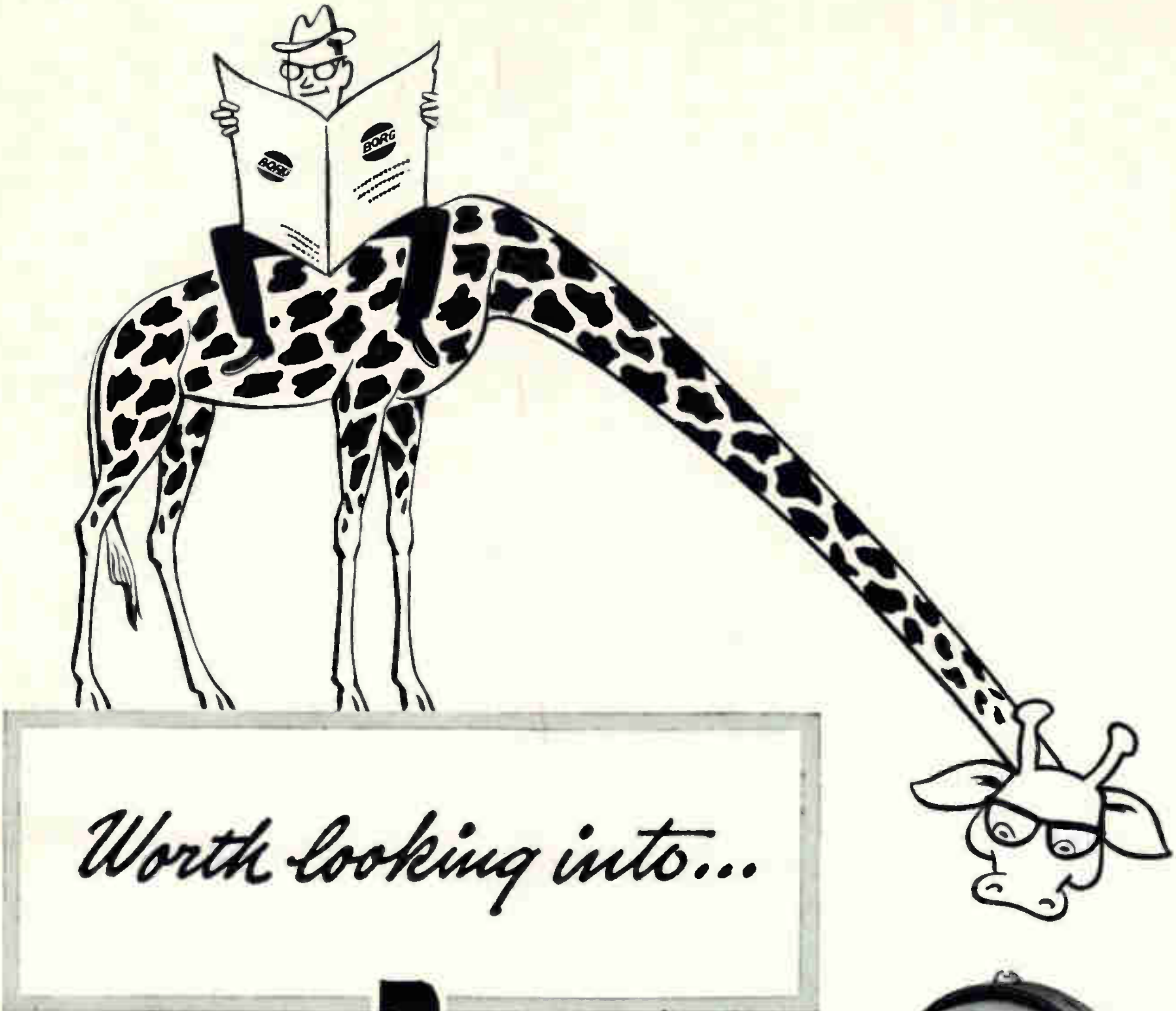
PHOTOELECTRIC DETECTOR that responds to the flash of a nuclear blast will activate emergency devices at ICBM bases in the event of surprise attack. The device, developed by Tecto Electronics, Spokane, Wash., consists of a single monolithic photovoltaic cell, sensitive only to light intensities greater than sunlight.

The device will operate a relay which sends out an alarm, closes blast doors and ventilation system intakes. Similar devices are suggested for civil-defense use to turn off water mains, gas lines, and power distribution facilities.

Thermoelectric Generator To Run Weather Station

AUTOMATIC NUCLEAR - POWERED weather station for use in remote areas will be built by Martin Co. Spokesmen for the Baltimore company say the device will monitor temperature, wind speed and direction, and barometric pressure, will be capable of transmitting data for two years without refueling. Data will be continuously processed, and every three hours a burst of information on local weather conditions will be transmitted to a manned receiving station several hundred miles away.

Electrical energy will be supplied by a small thermoelectric nuclear generator similar to Martin's Snap series (ELECTRONICS, p 11, July 8). System is scheduled for completion in early 1961.



Borg 1300 Series Direct-Reading Microdials *are* worth looking into. Designed for high-speed operation, these turns-counting dials perform at speeds of 6,000 counts per minute. Three, four and five digit models. Indexed accuracy is one part in a thousand. Compact design requires minimum control panel space. Dust sealed . . . meet military specifications. Large, one-piece, sealed window curved to provide wide-angle viewing. Complete data is on catalog sheets BED-A135 and BED-A136. See your Borg technical representative, distributor or write us today. *Borg Equipment Division, Amphenol-Borg Electronics Corporation, Janesville, Wisconsin. Phone Pleasant 4-6616.*

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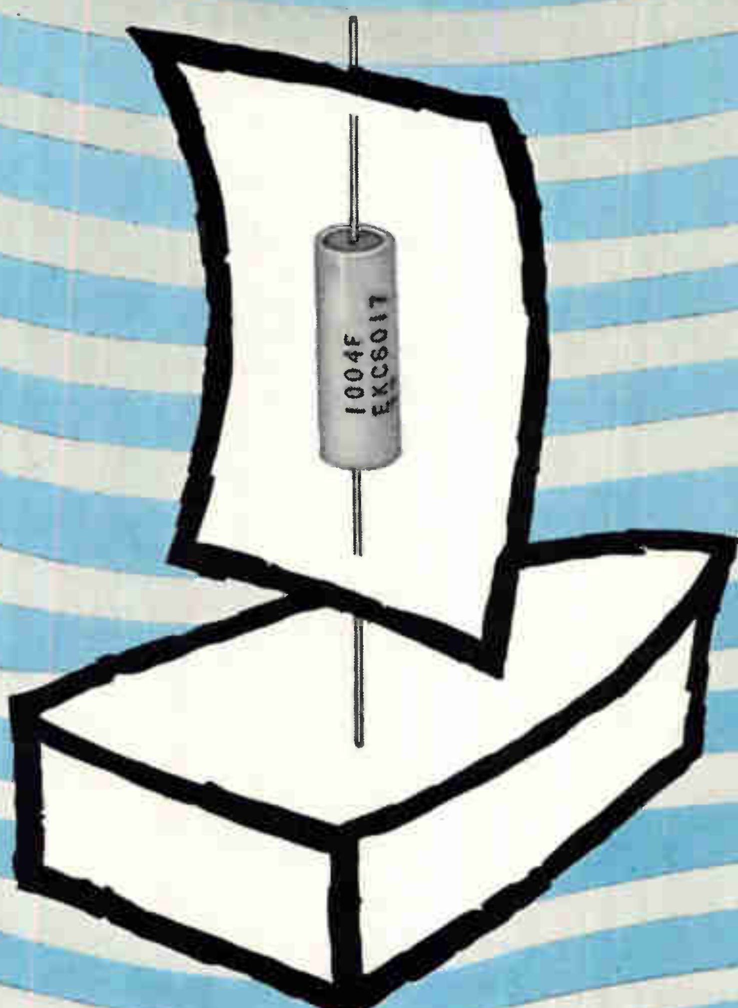
new metal film hermetically sealed resistor that's moisture resistant



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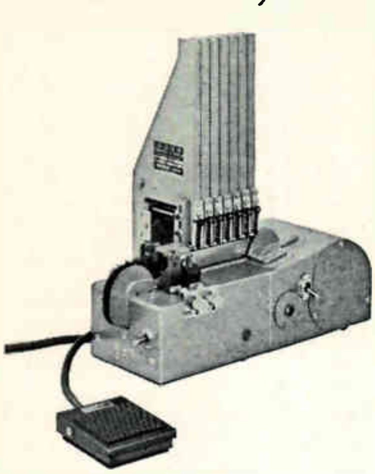

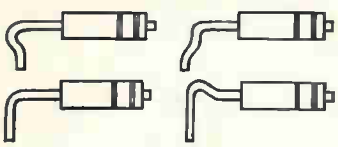

WASHINGTON OUTLOOK

SUBSTANTIAL INCREASE in defense spending seems probable no matter who wins the election in November.

Sen. John F. Kennedy (Mass.), the Democrat presidential nominee, is committed to jacking up military expenditures. One of the major planks in his party's platform deplores alleged inadequacies in U. S. military power and calls for accelerated efforts in just about every important defense program. The Senator has talked about boosting the defense budget by $2.5 billion to $3 billion annually.

Now, Republican standard-bearer Richard Nixon seems also to have embraced the idea that fiscal considerations must not limit the Pentagon's budget, and that there are serious deficits in many key areas of military preparedness. Up to now, Nixon has stood by President Eisenhower's argument that the nation's defense posture is adequate and that large hikes in military spending are dangerous if they threaten the national economy.

Likeliest beneficiaries of any Pentagon budget increase are the ICBM projects; Navy's Polaris program; an airborne bomber alert; antisubmarine warfare; reconnaissance and warning satellites; modernization of Army forces, with stress on ground communications. Clamor of the military professionals has been loudest for extra funds for these programs.

MEANTIME, RIGID RESTRICTIONS are still clamped on the defense budget. The armed services have been instructed to prepare budget requests for fiscal 1962 within current spending levels. As in the past, efforts to hold expenditures at a steady rate in the face of continually rising hardware costs mean that some projects will have to go (as Corvus went last week; see ELECTRONICS, p 14, July 29).

The administration's effort to prepare a budget at this year's rate of spending could be easily undone. In January 1953, for instance, the new Defense Secretary, Charles E. Wilson, lopped $5 billion off the appropriation request drafted by his predecessor just before it went to Congress. A Kennedy administration could just as easily beef up the budget this time.

If elected, Kennedy would be allowed to watch over Eisenhower's shoulder during November and December as the finishing touches are put on the appropriation request. In case of a Republican victory, Nixon would probably present the Eisenhower budget to Congress, then prepare a supplemental request later on.

INSPECTION TEAM from the Air Materiel Command recently visited seven major defense plants to determine how contractors are adhering to recently revised Air Force regulations on cost estimates and pricing techniques. Rules had been tightened up to bar inflated cost estimates and excessive charges disclosed by recent reports of the General Accounting Office.

In four of the plants, the inspectors said, unrealistic overhead costs were being charged to the Air Force. Three plants were charged with making "inflated materiel estimates." Three allegedly had no established estimating system to audit costs submitted by major subcontractors. Two companies, the Air Force says, refused to submit cost breakdowns to justify estimates. Only one firm is said to have submitted price exhibits. None were reported to have considered unit cost reduction benefits from large-scale production runs.

Gen. S. E. Anderson, AMC's commander, reported the findings in a scorching letter sent to Electronic Industries Association and to several large electronic contractors. Anderson complained of "inadequate pricing techniques," urged "more aggressive management".

Approximately actual size

This 3 lbs. of transistorized new AC amplifier gives you 20 or 40 db gain, increases scope or VTVM sensitivity 10 or 100!

This new hp 466A AC Amplifier is just 4″ high, 6″ wide and 6″ deep. Yet it can become one of the most helpful instruments on your bench, or in the field. It is ac or battery powered; battery operation gives you hum-free performance and easy portability. Response is flat within approximately ½ db over the broad range of 10 cps to 1 MC, distortion is less than 1%, and gain is stabilized by substantial negative feedback to virtually eliminate effects of transistor characteristics and environment.

For a demonstration on your laboratory or field application, call your hp representative or write direct.

Specifications

Gain:	20 and 40 db, ±0.2 db at 1000 cps.
Frequency Response:	±0.5 db, 10 cps to 1 MC; ±3 db, 5 cps to 2 MC.
Output Voltage:	1.5 v rms across 1500 ohms.
Noise:	75 μv rms referred to input, 100,000 ohm source.
Input Impedance:	1 megohm shunted by 25 μμf.
Output Impedance:	Approximately 50 ohms.
Distortion:	Less than 1%, 10 to 100,000 cps.
Power:	Ac line power normally supplied, but battery operation available. (12 radio type mercury cells, battery life about 160 hours.) Specify battery operation if desired.
Dimensions:	6¼″ wide, 4″ high, 6¼″ deep. Weight: approx. 3 lbs.
Price:	$150.00 f.o.b. factory. (Either ac or battery operation.)

Data subject to change without notice.

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K-5 Dichroic mirror permits simultaneous recording and parallax-free viewing. Available with Polaroid® Land back for 60 sec. prints. Records up to 10 traces on a single frame. Or can be equipped with either 35mm electrically-pulsed or continuous-motion magazine. f/1.9 standard or flat-field lens.

DIRECT VIEW Provides a direct, binocular view of the CRT while recording. Non-reversed image. Uses Polaroid® Land back. Records up to 10 exposures on 1 frame. Electric shutter actuator optional. Also available in electrically-pulsed or continuous-motion 35mm or 70mm models. Camera swings back, lifts off. f/1.9 standard or flat-field lens.

KD-5 Best for special lab situations requiring simultaneous recording of CRT phenomena and identifying data. Written information, counter and 24 hour clock can all be recorded on same frame. Electric camera with Automatic 35mm pulse or continuous-motion magazine. Dichroic mirror for simultaneous viewing. No parallax.

"POLAROID"® BY POLAROID CORP.

*Trade Mark

When it comes to recording oscilloscope traces, there's only one thing to remember, Beattie Oscillotron. Each of the three models shown here is designed for a special purpose. Each embodies the advanced engineering and precision craftsmanship that have made Beattie the leader in the industry. Which Oscillotron is best for you? Tell us your needs and we'll help you decide. Write or phone today for full information.

BC BEATTIE-COLEMAN inc.

See us at Wescon—Booth 2307

1000 NORTH OLIVE STREET, ANAHEIM, CALIFORNIA • BRANCH: 437 FIFTH AVENUE, NEW YORK, N. Y.

MOST ADVANCED OPERATIONAL ELECTRONIC WARFARE SYSTEM FOR OUR ARMED FORCES

The most potent airborne Countermeasures Equipments yet devised are being produced in quantity by Hallicrafters for our military aircraft. Teamwork with our armed forces continues to pay off for America–in more effective, more economical electronic warfare systems.

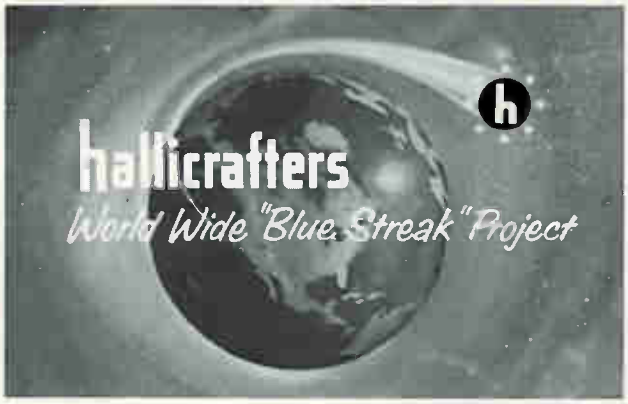
hallicrafters company

Military Electronics Di

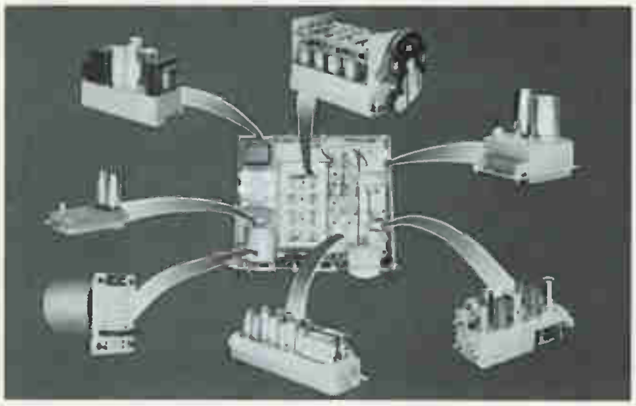
Chicago 24, Illinoi

"There is but one lamp by which our steps are guided—the lamp of experience"
-Patrick Henry

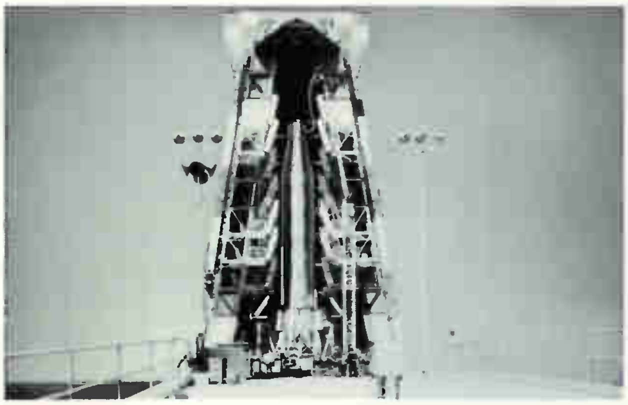
For more than a quarter century, Hallicrafters has worked in close partnership with our armed forces on fast solutions to critical military electronics problems. Out of this priceless experience are emerging startling new ideas and hard-hitting, fast-moving techniques to keep our country one jump ahead in electronic warfare . . .



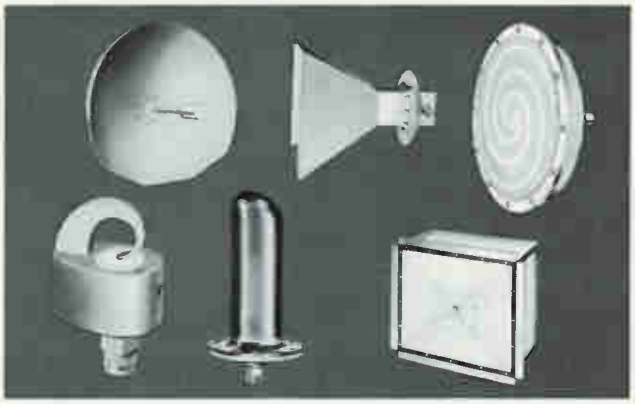
New levels of speed and efficiency are being reached in equipment modernization, retrofit and technical support programs with Hallicrafters' radical new "Blue Streak" project. Specially-trained Maintenance and Technical Support Teams, close-knit and flexible, can be tactically deployed to accomplish maintenance, installation and testing of electronics weapons systems anywhere in the world.



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



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



Airborne antennas and micro-wave components with power capability in excess of 1,000 watts, can be made available to solve tomorrow's very high power handling requirements. Testing of microwave components is possible with special high power generators, designed and built by Hallicrafters.

For further information on Hallicrafters facilities and experience in military electronics research, development and production, please write to:

hallicrafters company

Military Electronics Division, 4401 W. 5th Ave., Chicago 24, Ill.

Looking for a challenging new opportunity? We are interested in qualified engineers at all levels. For full details in confidence, contact William F. Frankart, Director of Engineering.

Gulton Buys L. I. Company

MERGERS AND ACQUISITIONS this quarter are continuing at the same brisk pace that has characterized much of the financial activity of our industry's history. Here are some current examples:

Gulton Industries, Metuchen, N. J., reports acquisition of year-old **Systems Research Group, Inc.,** Mineola, N. Y., for an undisclosed price. The Long Island firm, which specializes in advanced analytical research and problem solution will continue to remain under the direction of its founder, H. N. Shapiro. L. K. Gulton, president of the company bearing his name, says SRG will continue to serve industry and government clients on a fixed time and price basis in data processing, computer programming and research, and will in addition employ its abilities to develop new products and extend applications of existing Gulton equipment.

Avien Inc., Woodside, N. Y., has received the green light from its directors to acquire **Electrol Inc.,** Kingston, N. Y. Leo Weiss, Avien president, says the Electrol transaction, combined with other developments of the past few months, should boost combined company sales over the $10-million mark. For the nine-month period ended Mar. 26, sales were $3,958,000.

Daystrom Inc., Murray Hill, N. J., has acquired the assets of **Wiancko Engineering Co.,** Pasadena, Calif. for an undisclosed amount. The West Coast firm, founded in 1946, makes instrument systems and transducers for measurement and control. Its present sales are running to about $5 million a year. Daystrom sales are reported in excess of $90 million annually.

Martin Company, Baltimore, announces acquisition of a substantial though undisclosed amount of interest in **Nuclear Corporation of America.** George M. Bunker, Martin board chairman, says the companies have a common interest in the nuclear and electronics fields and that a close working relationship betwen the two companies is desirable.

Missile Dynamics Corp., Los Angeles, has been acquired by **Lancer Industries, Inc.,** Mineola, N. Y., by an exchange of stock. The 15-year-old California company will operate as a subsidiary of the Long Island firm, which manufactures fiberglass swimming pools. Lancer's first quarter sales this year were in excess of $1½ million. Missile Dynamics sales for 1959 were $2 million with about 80 percent in government contracts.

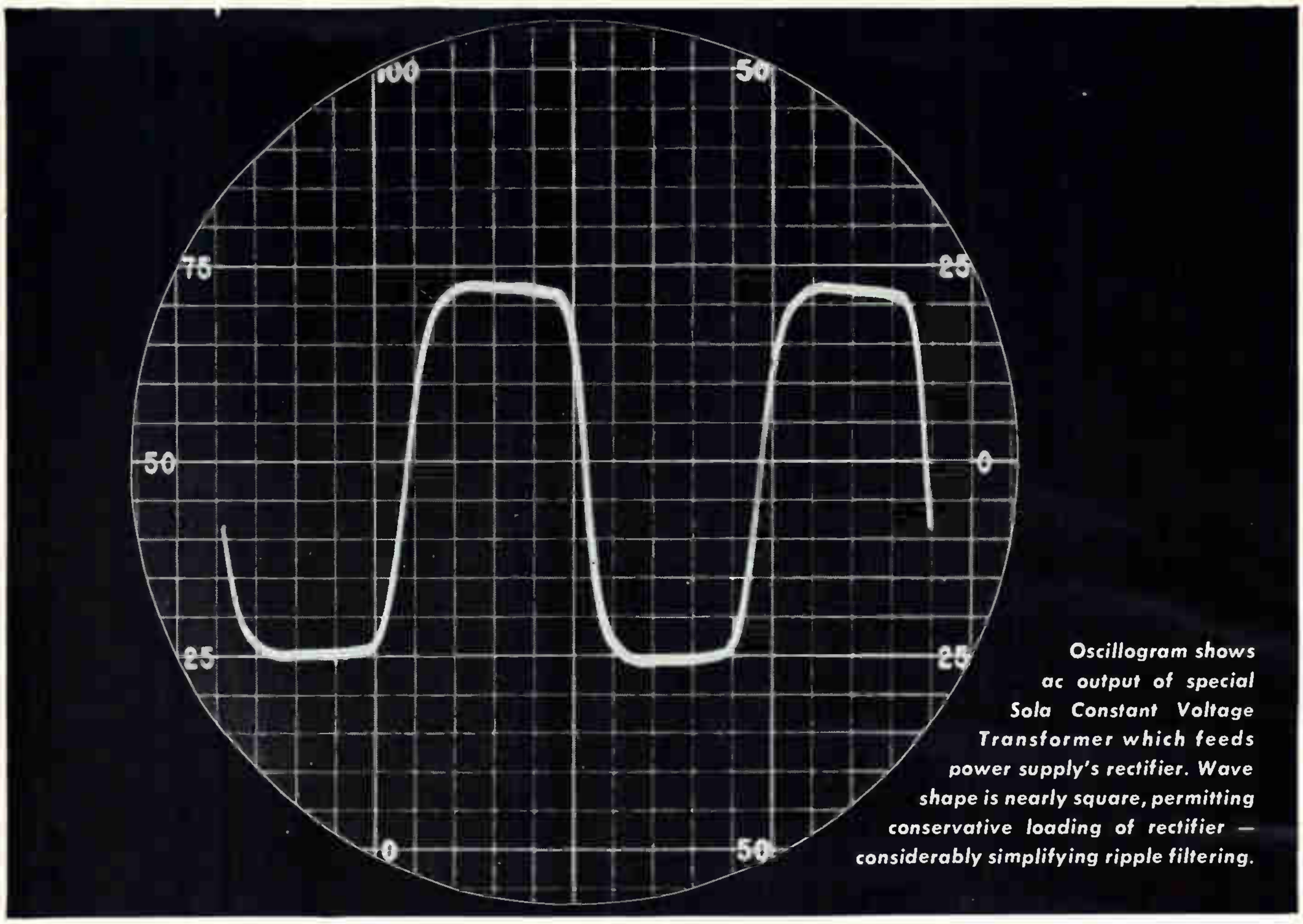
Instruments for Industry, Hicksville, N. Y., manufacturer of countermeasures systems and related components, has purchased the assets of **George Rattray & Co.,** Richmond Hill, N. Y. Equipment has already been moved to Hicksville from Richmond Hill, says IFI president E. H. Swanson. The move is expected to add $750,000 to company volume in the first year. IFI net sales in 1959 were $2,489,320.

25 MOST ACTIVE STOCKS

WEEK ENDING JULY 22, 1960

	SHARES (IN 100's)	HIGH	LOW	CLOSE
Avco Corp	1,589	15⅛	14	14¾
RCA	1,476	65¼	48⅞	60¼
Gen Electric	1,035	89⅝	79	80¾
Ampex	840	36½	33⅝	34
Gen Tel & Elec	832	29⅛	28¼	28½
Sperry Rand	720	23⅝	22½	22⅝
Int'l Tel & Tel	580	40¾	37¾	38
Gen Inst	511	45¾	38¾	39⅜
Westinghouse	501	57½	52⅛	53
Standard Kollsman	451	24⅛	21⅞	23⅛
Collins Radio	422	63¾	58⅝	59½
Philco Corp	420	27⅜	23¾	25
Raytheon	392	41½	38⅜	39½
Victoreen Inst	378	15⅛	13⅝	14½
Litton Ind	369	84⅝	78	80⅜
Fairchild Camera	340	174¾	160½	163¼
Gen Dynamics	317	43¾	41¼	43⅛
Zenith	302	120¼	110½	110¾
Int'l Resistance	298	32⅝	29¾	30¼
Univ Controls	286	16	14⅜	14½
Varian Assoc	285	57⅝	55¼	55⅜
Cohu Electronics	266	10⅞	9½	9¾
Burroughs	257	36½	34⅛	34½
Beckman Inst	253	88¾	81¼	83⅛
Siegler Corp	239	35½	32½	33

The above figures represent sales of electronics stocks on the New York and American Stock Exchanges. Listings are prepared exclusively for ELECTRONICS by Ira Haupt & Co., investment bankers.



Oscillogram shows ac output of special Sola Constant Voltage Transformer which feeds power supply's rectifier. Wave shape is nearly square, permitting conservative loading of rectifier — considerably simplifying ripple filtering.

Square-wave output of special transformer gives high efficiency in Sola's regulated dc power supply

Sola engineers (men with a keen eye for a trim wave shape) designed a special constant voltage transformer having nearly a square-wave output. Then they linked the transformer with two other components to produce a regulated dc power supply which has notable efficiency.

They fed the regulated output of this transformer into a semiconductor rectifier . . . the low-peak characteristic of the square wave results in a conservative loading on the economical rectifier assembly. It can deliver considerable amounts of current as long as you don't over-voltage it—and over-voltaging just doesn't happen when the input to the rectifier is Sola-regulated to within ±1%.

The rectified voltage feeds into the third component in this happy combination—the high-capacitance filter. The capacitor's filtering job is made easier because the rectified square wave contains a comparatively small amount of ripple. Final dc output from the filter has less than 1% rms ripple . . . for many applications there is no need for a voltage-dropping, efficiency-cutting choke coil.

The Sola Constant Voltage DC Power Supply has output in the ampere range, regulates within ±1% even under ±10% line voltage variations, and is suitable for intermittent, variable, and pulse loads. It has low output impedance, is very compact, and provides about all you could ask for in maintenance-free dependability.

Hundreds of ratings of these dc power supplies have been designed and produced to meet widely varying electrical and mechanical requirements of equipment manufacturers. In addition, there are six stock variable-output models and six stock fixed-output models with ratings from 24 volts at six amps to 250 volts at one amp.

For complete data write for Bulletin 7H-DC

SOLA

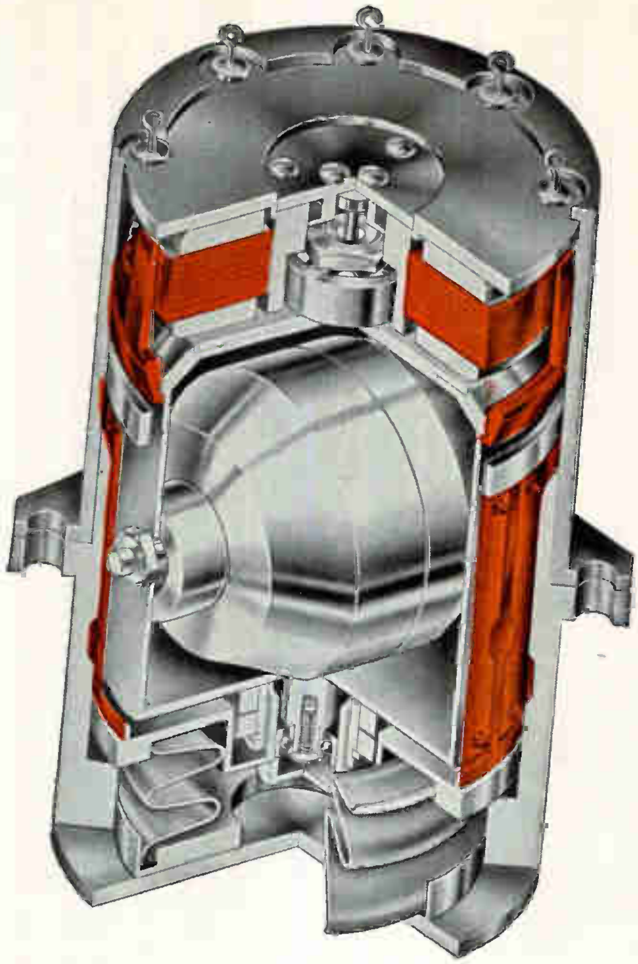
B P C

A DIVISION OF BASIC PRODUCTS CORPORATION

SOLA ELECTRIC CO., Busse Rd. at Lunt, Elk Grove, Illinois, HEmpstead 9-2800 • In Canada, Sola-Basic Products Ltd., 377 Evans Ave., Toronto 18, Ont.

Ketay 2″ floated rate gyro controls damping from −54° to +74° C.

...saves space, weight, wattage and wear



Ketay has been successful in developing a floated rate gyroscope with a unique bellows and spring fingers system which compensates for temperature changes. Fluid viscosity is allowed to change freely, while the damping gap is controlled instead. This ingenious shear damping principle offers true "second order performance." No heating is required from −40° to + 74° C.

THIS UNIQUE KETAY FLOATED DESIGN FOR TELEMETERING AND INSTRUMENTATION OFFERS:

- increased shock (150G) and vibration (25G) resistance.
- gimbal support on precision ball bearings and support independent of torsion bars, permitting gimbal balance to exceptional accuracies.
- DC motor with direct battery operation, resulting in rapid run-up.
- AC motor without brushes, achieving longer life.
- AC or DC pick-offs. AC units give high output: 7½ volts per degree of gimbal deflection.
- 200 turn wire wound potentiometer

TYPICAL RG 20 SPECIFICATIONS

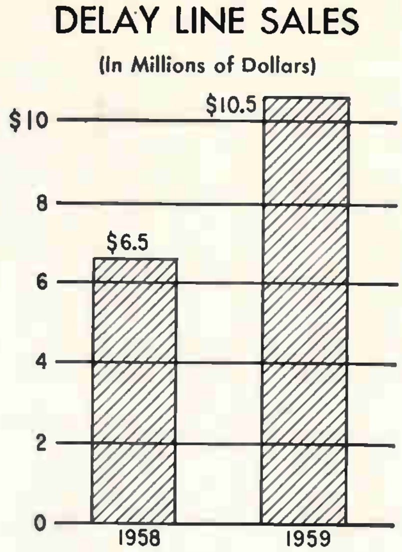
Rate (deg/sec)	±30
Natural Frequency	25 cps (min)
Size	Diameter 2″ Length 2⅞″
Damping (Ratio to Critical) over temperature	.07 ±0.2
Spin Motor	115V Line to Line 3φ 400 cps
Pickoff Type	Inductive
Excitation	26 VRMS 400 cps
Sensitivity (v/deg/sec)	0.2
Threshold (deg/sec)	0.06
Weight	1¼ lbs. (max)

For detailed specifications and drawings write to:

KETAY DEPARTMENT

NORDEN
DIVISION OF UNITED AIRCRAFT CORPORATION
Commack, Long Island, New York

Big Sales Gain for Delay Lines



Source: ELECTRONICS

LAST YEAR was highly successful for delay-line manufacturers. Dollar sales of the average company increased 63 percent over 1958, with a number of firms enjoying twofold or greater sales increases.

Information comes from reports by 17 delay-line manufacturers on their 1959 and 1958 sales. Seventeen out of 34 manufacturers queried by ELECTRONICS supplied total dollar sales and unit sales by types.

The respondent manufacturers reported total sales for all delay lines of $7,912,232 in 1959 as against $4,846,078 in 1958. These returns indicate total industry sales in 1959 amounted to about $10.6-million, 63 percent more than the $6.5 million estimated by industry sources as total delay-line sales for 1958.

Delay lines are extensively used in communications, countermeasures, fire-control, missile guidance and navigation equipment. They are also widely used in research and development and to some extent in data-handling and detection equipment.

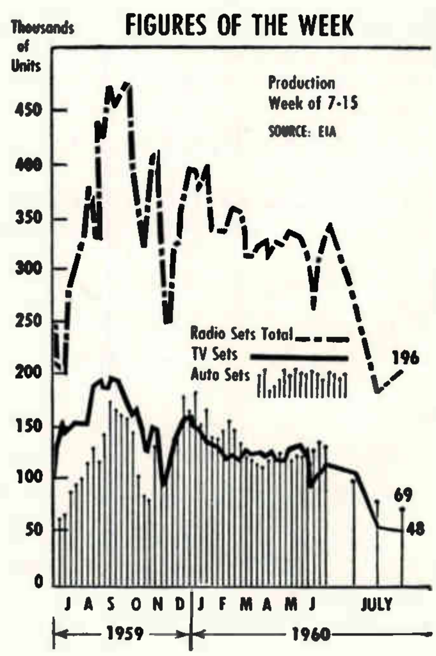
Of the four types of delay lines — distributed-parameter lumped-parameter, acoustic, and magnetostrictive—sales of the distributed type fared best last year.

Nine manufacturers reported sales of 66,296 distributed-parameter units in 1958 and 200,794 units in 1959, a 203-percent increase for the year. Sales of the lumped-parameter type gained 141 percent in 1959, with unit sales of 12 firms moving up from 58,006 in 1958 to 139,613.

In comparison with other types, acoustic delay-line sales increased only moderately. Five firms reported sales of 4,880 units in 1958 and 6,200 in 1959, an increase of 27 percent. It was not possible to measure the sales advances for magnetostrictive delay lines.

Electronics parts distributing industry sales volume hit an all-time high in 1959 of $815 million, 10 percent higher than 1958's $740 million, reports National Credit Office. Distributors told NCO that sales were good in the first five months of 1960, and that they expect continued sales expansion in the remaining months of the year. Constantly growing industrial business, hi-fi and stereo components demand, plus strong service business, have been of particular help in keeping distributor sales high.

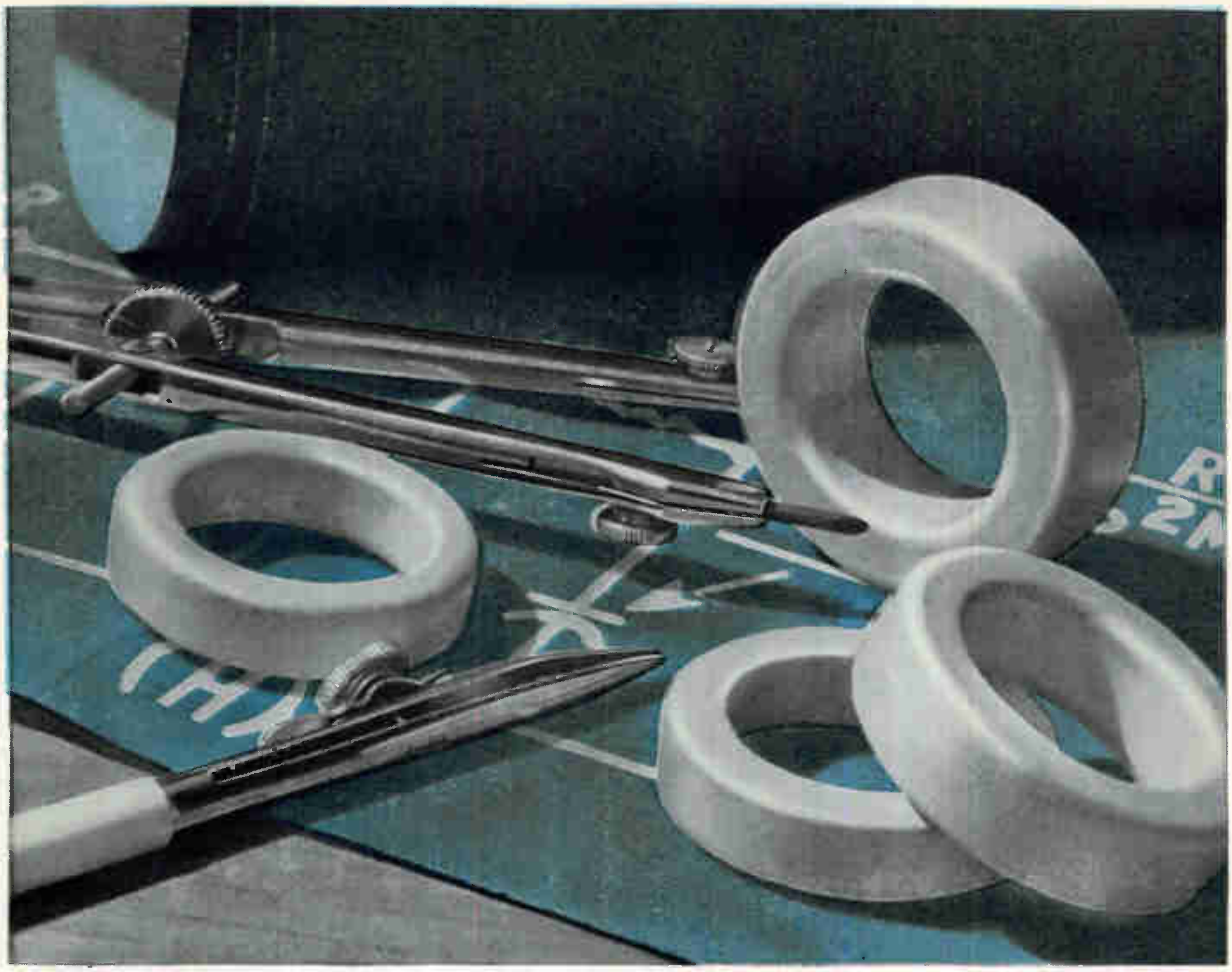
FIGURES OF THE WEEK



LATEST MONTHLY SALES TOTALS

(Source: EIA)
(Add 000)

	May 1960	April 1960	Change From One Year Ago
Rec. Tubes, Value	$25,580	$25,759	− 1.3%
Rec. Tubes. Units	30,354	29,737	− 0.8%
Pic. Tubes. Value	$13,330	$13,783	+ 4.6%
Pic. Tubes, Units	660	707	− 1.0%
Transistors, Value	$24,146	$23,199	+27.0%
Transistors, Units	9,046	9,891	+42.3%



You get an extra measure of design freedom with

... POWDERED PERMALLOY FILTOROID® CORES*

The high permeability and low core loss of powdered permalloy Filtoroid cores can remove design roadblocks for you. You can build extra frequency stability into filter networks with these cores. Their permeability *remains* stable with changes in time and flux levels. Distortion factors are held to a bare minimum. Temperature coefficient of inductance is tightly controlled.

There's extra design flexibility for you, too, in the broad range of Filtoroid cores available. They're made in three standard permeabilities—150, 125 and 60—in sizes up to 1.570" O.D., all carried in stock for immediate shipment.

Our engineers are ready right now to help you select the proper Filtoroid core for your filter circuits. Write or call for a discussion of your needs, or send for Bulletin G-1.

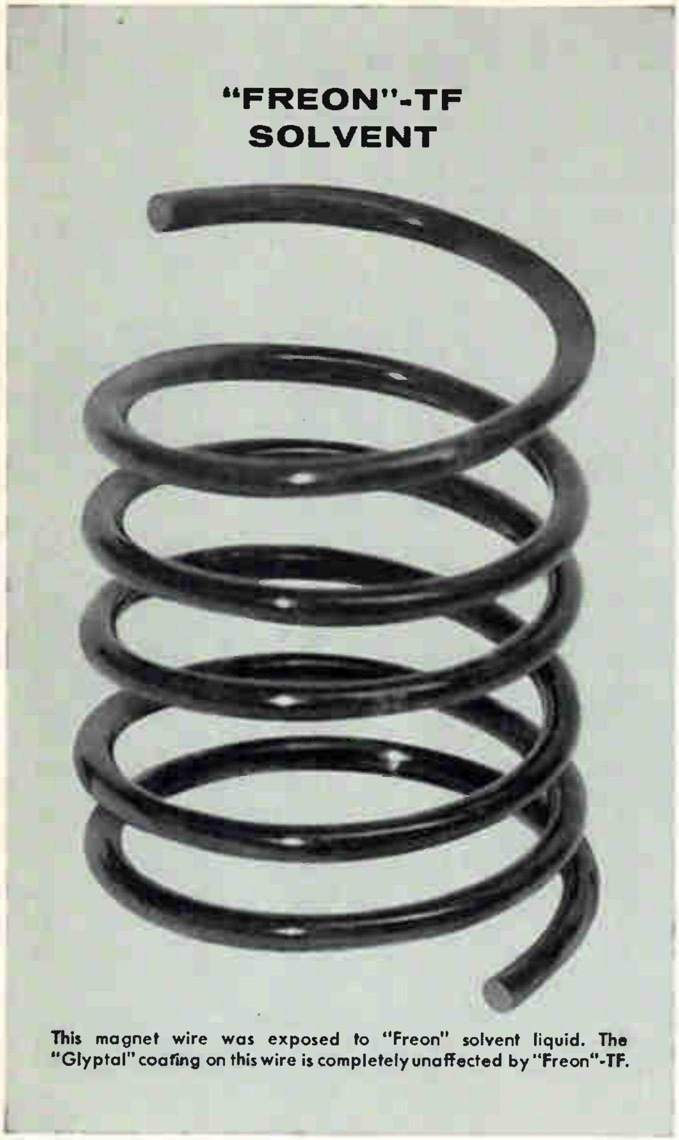
*MADE UNDER A LICENSE AGREEMENT WITH WESTERN ELECTRIC COMPANY

MAGNETIC METALS

transformer laminations • motor laminations • tape-wound cores
powdered molybdenum permalloy cores • electromagnetic shields

MAGNETIC METALS COMPANY • Hayes Avenue at 21st Street, Camden 1, N. J.

CIRCLE 25 ON READER SERVICE CARD



This magnet wire was exposed to "Freon" solvent liquid. The "Glyptal" coating on this wire is completely unaffected by "Freon"-TF.

This "Glyptal"-insulated wire was exposed to ordinary chlorinated solvent for the same length of time as the one on the left. The solvent dissolved the resin binder and softened the alkyd finish.

Comparison with ordinary chlorinated solvent proves:

FREON® solvents won't damage metal, elastomers or plastics . . . are safer for degreasing precision equipment

"Freon" solvents give you an effective and remarkably safe means of cleaning electric motors, ultra-precision mechanical and electronic equipment, and component parts. They minimize swelling of elastomers and plastics . . . will not soften paint, wire coatings or insulators. "Freon" solvents are also non-corrosive to metals without inhibitors. In addition, "Freon" solvents leave no residue when they dry and can be recovered and reused readily.

"Freon" solvents are safe for personnel, too. They are non-explosive and non-flammable. "Freon" is virtually non-toxic. Vapors are odorless and will not cause nausea or headaches.

FREE 12-PAGE BOOKLET explains the unique properties of "Freon" solvents and how they minimize cleaning hazards.

FREON®
solvents

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REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

E. I. du Pont de Nemours & Co. (Inc.)
"Freon" Products Division 528
Wilmington 98, Delaware

Send me your free, 12-page booklet on "Freon" solvents.

Name ____________________

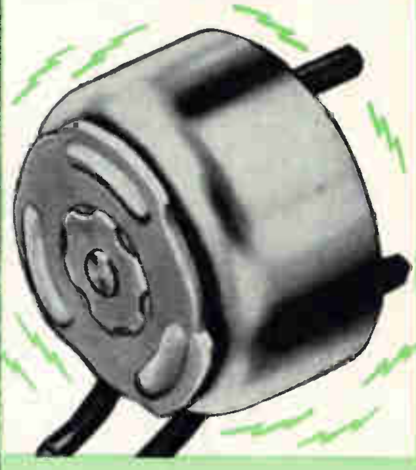
Company ____________________

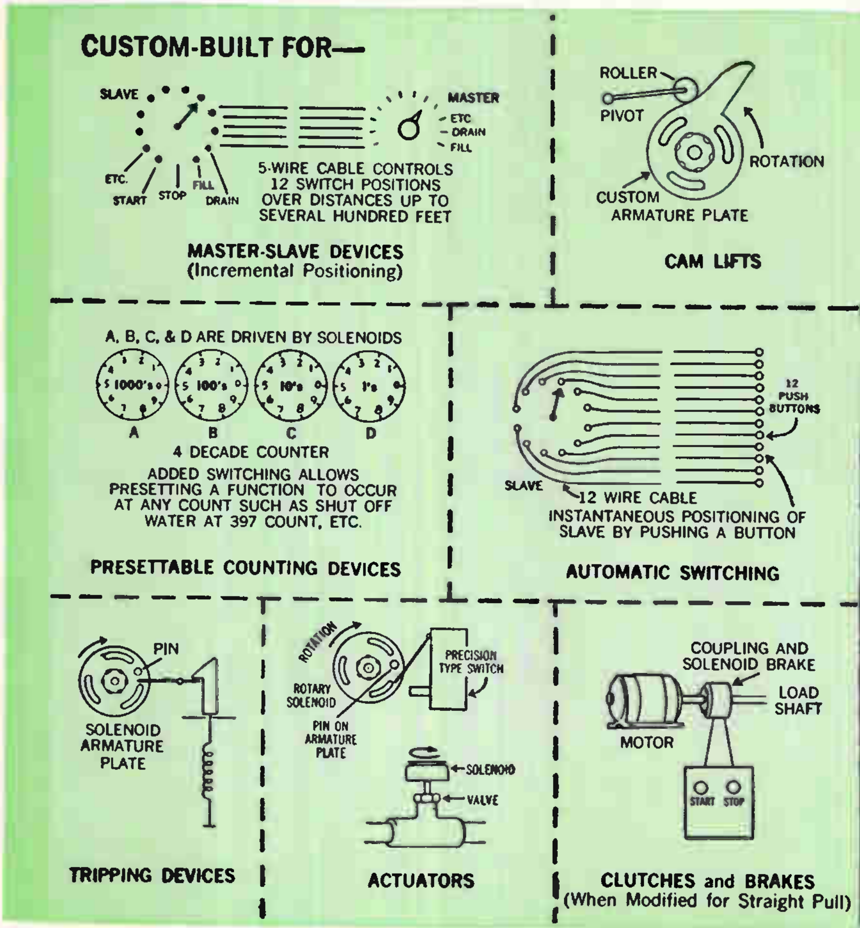
Address ____________________

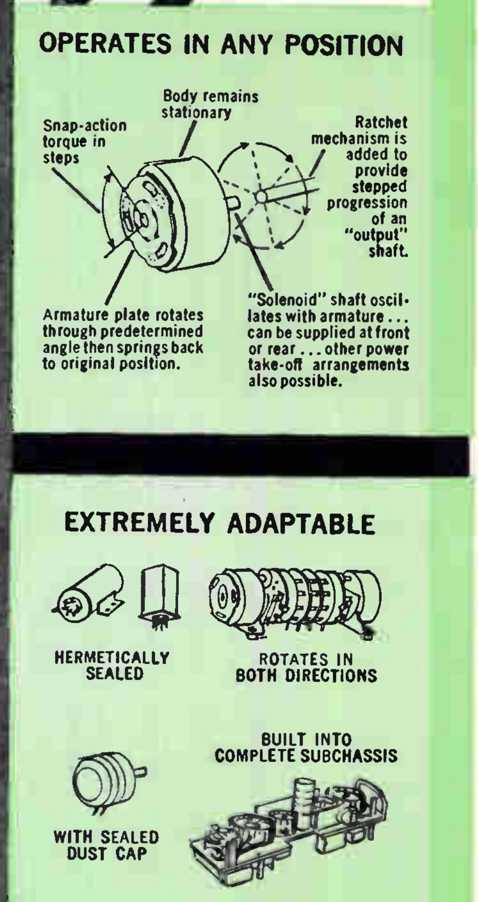
City ____________ *State* ____________

have you checked this Remote Actuator for jobs under Shock and Vibration?

...OAK ROTARY SOLENOIDS







stepping torques from 6.4 to 64 inch-ounces

If you've been searching for an actuator that meets such specs as MIL-S-4040A, and is remarkably small for the amount of work it can do, investigate Oak Rotary Solenoids. They operate on DC and are designed for intermittent service. Standard models give steps of 25°, 35°, 45°, 67.5°, or 95° in either a left or right-hand direction. Self-stepping or externally pulsed units are also built. Oak Rotary Solenoids find wide use in both commercial and military equipment. Why not evaluate their unusual capabilities for your next project. We will be glad to help you engineer the job. Just send us a short description and sketch.

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1260 Clybourn Ave., Dept. G, Chicago 10, Ill.
Phone: MOhawk 4-2222
West Coast Div.: Oak Electronics Corp.
11252 Playa Court, Culver City, Calif.
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SWITCHES • ROTARY SOLENOIDS • CHOPPERS
VIBRATORS • TUNERS
SUBASSEMBLIES

CIRCLE 27 ON READER SERVICE CARD

NEW! 16 LOW COST

all-electronic, totally-transistorized

DIGITAL MULTIMETERS

NOW IN A SINGLE 5¼″ OR 8¾″ x 19″ PANEL Digital Multimeters for measuring any combination of AC/DC volts, AC/DC ratios, and resistance, with pre-amps for higher sensitivities, and optional electrical outputs and print control capabilities!

This new line of all-electronic, solid state instruments meets the growing requirement for precision, multi-purpose measuring instruments. Any combination of AC and DC voltages, AC and DC ratios, resistances . . . every electrical parameter which is of interest to the instrumentation designer . . . can now be measured quickly, accurately, with a single instrument.

Unmatched specifications! These Multimeters are the first to have a combination of high input impedance, 4 digit accuracy, automatic ranging, automatic polarity and high speed in a single instrument!

All electronic, solid state circuitry! Exclusive use of transistors and diodes provides a light, compact instrument possessing exceptionally high reliability and accuracy. The experience of more than 6,000 digital instruments has gone into their design.

Unique reference supply gives unequalled stability! For these new instruments, EI has developed a pre-regulated, twin Zener diode bridge with the Zener diodes in a temperature-stabilized oven. Temperature stability and drift characteristics of this reference are better than .005% and unequalled in the industry.

Easily integrated into semi- or completely automatic systems! These new instruments reflect EI's active-participation in the building of small and medium size digital systems. All necessary control logic is available at rear panel connectors for external control. Every instrument is ideally suited for automatic input signal conditioning or scanning operation. Models with electrical outputs will operate directly in multi-point scanning and print-out data logging systems without any additional circuitry or auxiliary equipment.

Electrical outputs optional! Where "hard copy" of test results is not required, the addition of electrical outputs and print control capabilities is a costly, unnecessary luxury. EI provides these new instruments, in every measuring configuration, either with or without these features.

Sensitivity control eliminates effect of noisy readings! A front panel sensitivity control is provided on each of the instruments to overcome unusual noise conditions and give, as a by-product, a qualitative measurement of the noise present.

FLIP-TOP BOX CONSTRUCTION FOR EASY MAINTENANCE.

Electro Instruments, Inc.

3540 AERO COURT • SAN DIEGO 11, CALIF.

CIRCLE 28 ON READER SERVICE CARD

Now pick the instrument that exactly meets your needs and order by model number!

MODEL 840
DC Volts/DC Ratios

MODEL 841
DC Volts/DC Ratios/Resistance

MODEL 842
DC Volts/DC Ratios/AC Volts

MODEL 843
DC Volts/DC Ratio/AC Volts/Resistance

MODEL 844
DC Volts/Ratio/DC Pre-Amplifier

MODEL 845
DC Volts/Ratio/Resistance/DC Pre-Amplifier

MODEL 846
DC Volts/Ratio/AC Volts/DC Pre-Amplifier

MODEL 847
DC Volts/Ratio/AC Volts/Resistance/Pre-Amplifier

MODEL 848
DC Volts/Ratio With Electrical Outputs

MODEL 849
DC Volts/DC Ratios/Resistance With Electrical Outputs

MODEL 850
DC Volts/DC Ratios/AC Volts With Electrical Outputs

MODEL 851
DC Volts/DC Ratio/AC Volts/Resistance With Electrical Outputs

MODEL 852
DC Volts/Ratio/DC Pre-Amplifier With Electrical Outputs

MODEL 853
DC Volts/Ratio/Resistance/DC Pre-Amplifier With Electrical Output

MODEL 854
DC Volts/Ratio/AC Volts/DC Pre-Amplifier With Electrical Outputs

MODEL 855
DC Volts/Ratio/AC Volts/Resistance Pre-Amplifier With Electrical Outputs

Many variations of these basic models including AC ratiometers, milli-ohmmeters, microvoltmeters and specialized measuring instruments tailored to individual systems requirements are available in the same physical configurations.

Ask your EI sales office or representative for complete information.

Faster conversion times, higher input impedance, greater accuracies, plus all of the other specifications you wanted in a digital multimeter!

DC VOLTAGE SPECIFICATIONS: Apply to all instruments incorporating the pre-amplifier

Range: ±.00001 to .09999; .0001 to .9999; 1.000 to 9.999; 10.00 to 99.99; 100.0 to 999.9 v
Accuracy: 0.02% ±1 digit for 10 microvolt range of .00001 to .09999 v; 0.01% ±1 digit from .0001 to 999.9 v
Input Impedance: 1000 megohms up to 9.999 v; 11 megohms up to 999.9 v
Average Reading Time: 50 milliseconds
Operating Ambient Temperature: 0-50°C
Maximum Source Impedance: 5 K ohms on 10 microvolt range only; noncritical all other
Automatic Features: Ranging, polarity

DC VOLTAGE SPECIFICATIONS: Apply to all instruments except those incorporating the pre-amplifier

Range: ±.0001 to ±.9999; ±1.000 to ±9.999; ±10.00 to ±99.99; ±100.0 to ±999.9 v
Accuracy: 0.01% ±1 digit
Input Impedance: 1000 megohms to ±9.999 v; 11 megohms to ±999.9 v
Average Reading Time: 50 milliseconds
Max. Balance Time: 200 milliseconds
Operating Ambient Temperature: 0-50°C
Automatic Features: Ranging, polarity

DC RATIO SPECIFICATIONS: Apply to all instruments measuring DC ratios

Range: .0000 to .9999*
Accuracy: ±1 digit
Input Impedance: 1000 megohms
Average Reading Time: 50 milliseconds
Max. Balance Time: 100 milliseconds
Reference Voltage: 10 volts ±10% (nominal)
Reference Input Impedance: 1000 megohms
Operating Ambient Temperature: 0-50°C

*With properly chosen reference supply, ratios of up to 100 times unity may be measured.

AC VOLTAGE SPECIFICATIONS: Apply to all instruments measuring AC voltages

Range: .0000 to .9999 VAC; 1.000 to 9.999 VAC; 10.00 to 99.99 VAC; 100.0 to 999.9 VAC
Accuracy: 0.1% and two digits
Frequency Response: 30 cps to 10,000 cps
Input Impedance: 1 megohm shunted by 30 mmfd up to 9.999 VAC; 10 megohms shunted by 30 mmfd up to 999.9 VAC
Average Reading Time: 2 secs. low freq.; ½ sec. high freq. (400 cps and up)
Operating Ambient Temperature: 0-50°C
Automatic Features: Ranging

RESISTANCE SPECIFICATIONS: Apply to all instruments measuring resistances

Range: 000.1 ohms to 999.9 ohms; 1000. ohms to 9999. ohms; 10.00 K ohms to 99.99 K ohms; 100.0 K ohms to 999.9 K ohms
Accuracy: 0.01% ±1 digit to 99.99 K ohms; 0.03% ±1 digit to 999.9 K ohms
Average Balance Time: 200 milliseconds
Operating Ambient Temperature: 0-50°C
Automatic Features: Ranging (decimal point placement)

ELECTRICAL OUTPUT SPECIFICATIONS: Apply to all instruments incorporating electrical outputs

• Both 2-4-2-1 Binary Coded Decimal and 10 Line Coded Decimal are provided

CIRCLE 29 ON READER SERVICE CARD

J. P. Costas and L. C. Widmann, coinventors of GE's new communications system, check transmitter terminal for field test

Broadband Phantom Bypasses Spectrum Crowding

"Military circuits will have to go broadband or die in a battle environment," say inventors of high-security broadband communications system

PROMISING APPROACH to the problem of an increasingly crowded electromagnetic spectrum is broadband transmission, says John P. Costas, consulting engineer for General Electric's heavy military electronics department.

The orthodox approach has been use of narrower and narrower bandwidths to squeeze in more channels. This procedure has merit in commercial applications where strict control over stations is exercised by a central authority, Costas says. "The military communications planner, however, faces an environment so radically different from that found in most commercial practice that a different approach to systems design is called for."

The military user can not save bandwidth with the hope that only friendly users will benefit by his economy. The spectrum belongs just as much to hostile or friendly forces. Continued narrowing of transmission bandwidths will lead to serious system breakdown due to poor reliability resulting from interference. "Military circuits will have to go broadband or die in a battle environment," Costas says.

Though broadband techniques will probably not provide the military with all the volume of traffic they are now demanding, they will offer the circuit reliability the military needs. Following this premise, Costas and his coworkers are completing work on a system which represents "an attempt to take the theory of broadband communications and reduce it to practice in a form suitable for general purpose military field use."

Costas' system, called Phantom L, uses a special double single-sideband transmission resulting in a transmission bandwidth of several hundred kilocycles. This version of Phantom is to be used in long-haul h-f circuits where multipath conditions are encountered.

Because system average power is spread over such a large bandwidth, conventional narrow-band circuits operating within the Phantom passband will normally be unaware of its presence. In normal operation the Phantom signal will appear as random noise to conventional receiving equipments.

The data rate is purposely kept low in relation to transmission bandwidth—from about ten teleprinter channels down to hand-keyed Morse. This high ratio of transmission bandwidth to data rate results in a high degree of immunity to jamming or interference, also allows Phantom I to be operated in heavily congested portions of the h-f spectrum. The system can tolerate the interference caused by other signals and at the same time use these other signals as cover to enhance the transmission security of Phantom.

To receive Phantom transmissions, a receiving station must have not only the gear but also know the operating frequency and signaling waveform used.

Since many hundreds of thousands of signaling waveform selections can be set up in the equipment, this last item is of utmost importance. Furthermore, waveform selections may be changed as often as necessary.

"The designer of a military communications system of this type must not depend upon secrecy for successful operation He must assume that an enemy has possession of his system, complete with instruction manuals. The design must be such that the system can still perform its function."

This is the philosophy Costas adopted in developing Phantom I. "Phantom is much like a combination lock in that detailed knowledge of the lock is of little help to the unauthorized," Costas explains.

Two Phantom systems operating in the same frequency band but using different signaling waveform selections will appear as random noise to each other.

Equipment will be tested on a coast-to-coast circuit after laboratory verification tests are completed. Many different frequencies in the h-f band will be used.

The technique is not restricted as to frequency. Operation at frequencies much lower or higher than h-f poses no severe problems. High-frequency band was chosen for test because of severe multipath and interference conditions encountered in this range. Besides point-to-point communications, Costas foresees use in aircraft and satellite communications systems.

Highlighting Tomorrow's Communications

National symposium emphasizes need for more systems, new methods, longer ranges. Satellites hold the spotlight at this week's Globecom Symposium in Washington

SATELLITE SYSTEMS, tropospheric communications, submarine cables and digital data systems were the main features of the fourth National Global Communications Symposium being held this week in Washington.

Important trend pointed by the meeting is the greater reliance that engineers of tomorrow's communications systems are placing on these new techniques, especially on satellites. This year's experimental work with satellites, and the body of reliable data being accumulated about the skyborne relay systems, will make of them the workhorses of future global and national communications systems.

This week's symposium is under the dual sponsorship of the Professional Group on Communications Systems of the Institute of Radio Engineers and the Army Signal Corps. More than 20 companies are presenting 62 papers which cover virtually all aspects of communications on the global scale.

Satellite systems held the spotlight on Aug. 2, second day of the meeting. One paper, delivered by C. A. Brown of Convair, compared active communications satellites and other long-haul systems. Another speaker, ITT Labs' L. Pollack, presented his company's views on a worldwide system which would use three active satellites in stationary orbits. The system would provide 1,000 channels 50 to 100 Mc wide that would reach about 98 percent of world's population. Passive relay systems were discussed by D. T. Worthington of Rome Air Development Center, and M. G. Chatelaine, Ryan Aeronautical, presented a paper on anisotropic communications satellites.

The first day of the symposium was devoted to propagation, included a paper from Boeing describing experiments in earth communications. The speaker, C. D. Lunden, outlined his company's use of buried antennas to transmit at radio frequencies to points as far away as 100 miles.

Two papers by A. J. Vadasz and J. R. Poppe of General Electric described a thin-route, or digital, troposcatter system. Thin-route tropo reportedly can make point-to-point communications possible at one-third the cost and one-tenth the bandwidth of conventional tropo systems. The GE engineers described a 152-mile hop between Arlington and Lynchburg, Va., using a 4-by-8-ft antenna screen weighing 50 pounds. The transmitter puts out only 170 watts, rather than the multiple kilowatts required by the conventional systems. The speakers indicated that federal agencies and the armed services would probably be first to use the new gear, added that commercial applications would probably follow along soon after.

ATT spokesmen discussed submarine cables. A. C. Duncan told of his company's overseas operations, touched on problems of cable reliability. Bell Labs' E. T. Mottram described the design of a new submarine cable system and coworker A. C. Dickieson closed the session with a discussion of time assignment interpolation.

Confidence in the future of satellite communications for the armed forces is again stressed in a session on the third day wrapping up some technical details of satellite systems. A paper by USAF Captain G. B. Parks and Bendix's J. W. McNabb disclosed technical considerations for Air Force communication satellites. Other Bendix speakers included C. Kent and L. Newland, who gave comparisons of orbit configurations for satellites, and W. N. Mollard who discussed frequency selection for space communications. Role of satellites in ITT's Aircom global system was discussed by E. W. Keller, R. L. Krulee and R. A. Weber.

Other sessions held during the three-day meeting covered such topics as command-control communications, equipment, digital data systems, network control, switching, global trunk systems and interference problems.

Incoming teleprinter communication arriving over new troposcatter system is examined by engineer J. R. Poppe. In background are dual diversity receivers used in the system

How a One-Plant Island Grew Up

Puerto Rico had only one electronics plant in 1948. Today electronics shipments from more than 50 plant sites in the island commonwealth exceed $47 million

ELECTRONIC COMPONENTS by the shipload are now leaving Puerto Rico through channels once sailed by Spanish galleons. Workers who recently knew only how to wield the sugar cane machete are now turning out missile parts, tv tubes and strain gages in modern factories.

From a single plant employing 16 workers in 1948, electronics in the commonwealth now has more than 56 factories employing about 5,000. In the last ten months of 1959, 10 new electronics plants went into operation and are now manufacturing such products as transducers, precision resistors, circuit breakers, switching components, cathode-ray tubes, photoelectric devices and phonograph pickups.

According to Puerto Rico's Economic Development Administration, electronics manufacturers on the island are enjoying record profits exceeding what similar operations would net in stateside factories. In 1958, for example, net profits as a percentage of sales averaged 37.4-percent in Puerto Rico as compared with 7.7 percent before taxes and 3.8 percent after taxes for plants on the mainland. According to a Department of Commerce survey, in 1959 the value of shipments from the island was $47 million, up 39 percent from the year before.

One major reason for the increased profits is the island's unique federal tax position. While enjoying the benefits of American citizenship, currency, federal courts, armed forces and tariff protection, Puerto Rico has always been outside the federal tax structure. In addition, under provisions of the Industrial Incentive Act of 1954, manufacturers of electrical products (including electronics) are in most cases free from commonwealth taxes for their first ten years of operation.

Industrial space, mostly in spread-out one-story buildings, is available throughout the island. Most electronics plants are now located in the suburbs of San Juan (the island's capital), Mayaguez on the west coast and Ponce in the south. The Economic Development Administration of Puerto Rico aids in obtaining sites by lease or purchase. Yearly rentals are as low as 50 cents a square foot.

For labor recruitment, the Puerto Rican Employment Serivce, a commonwealth agency, tests and screens work applicants for electronics as well as other industries. On-the-job training programs are also offered. To provide in-plant training, EDA will send supervisors and managerial trainees to plants on the mainland, or bring technicians to the island to conduct training programs.

Stratham Instruments of Los Angeles, now building one of Puerto Rico's newest electronics plants, will invest $1 million in the island's economy within the next few years. Last month, the company held its third ground-breaking since 1953. According to president R. M. Jones, the transducer manufacturing firm's current move entails a 23,000 square-foot plant costing $350,000.

To date, 75 California companies, many of which are electronics firms, have opened Puerto Rican facilities since 1952. One reason for this amount of interest from West Coast companies is that they can sell and ship to Eastern markets in closer competition with Eastern companies. A West Coast manufacturer can ship an object the size of an electric motor from San Juan to New York for about $1.70 as compared with $3.95 from his home state on a per-pound basis. In addition to ships, five airlines serve the island regularly. Rates to New York range from 10 to 22 cents a pound.

There is a considerable amount of official and quasi-official assistance given to electronics companies scouting the commonwealth for plant sites. Primary source of help is the Economic Development Administration of Puerto Rico. In administering industry growth under the project name Operation Bootstrap the EDA has had to enlarge its facilities. It now has offices in New York, Chicago, Los Angeles, San Francisco and Miami.

Besides EDA, the island's electronics industry is considerably aided by the Puerto Rico Electronics Manufacturers Association whose membership consists of the more than half a hundred mainland firms on the island. Members aid prospective newcomers by arranging plant tours, gathering information and lending a helping hand in other ways.

Almost 5,000 workers like these at Stratham Instruments' Puerto Rico plant have made the transition from farm work to component assembly

Infrared May Detect Extraterrestrial Life

ULTRASONIC INFRARED DETECTION may soon help look for extraterrestrial life, says Paul S. Johnson, project scientist for the physics division of the Air Force Office of Scientific Research (AFOSR).

Use of infrared may become practical for long-range detection because of recent improvements in detecting weak signals in noise background, Johnson says.

Reason for interest is that living organisms radiate infrared energy when they convert sunlight into other forms of energy.

Two aspects of infrared are involved in AFOSR's work. One is the search, at a wavelength of about ten microns, for planetary life near stars beyond our solar system. The other is the more immediate problem of detecting life processes on earth's planetary neighbors through infrared emanations associated with organic transformations.

Stanford University's detection through 44 db of noise of an echo signal bounced off the sun is an example of weak radiation detection under difficult conditions, Johnson says.

More recently, J. Wiesner of MIT and E. Lilley of Harvard teamed up to detect the deuterium line in space. The deuterium line (327 Mc) is extremely weak, only 1/6,700 as strong as the hydrogen line (1,420 Mc). Wiesner feels that his detector and digital correlator will enable him to detect an energy level of the deuterium line which is 1/15,000 as strong as the hydrogen line. Thus he feels he has sensitivity to spare.

In addition to advance in signal processing, AFOSR expects soon to have promising research on coherent infrared oscillators and detectors. The infrared maser, on which research is being conducted by C. H. Townes of Columbia University under AFOSR contract, could well be one such highly sensitive device, Johnson says. The Cerenkov radiator being investigated by P. D. Coleman of Illinois has produced substantial power (0.1 watt) at 3 mm. Its principle may prove useful at the longer infrared wavelengths.

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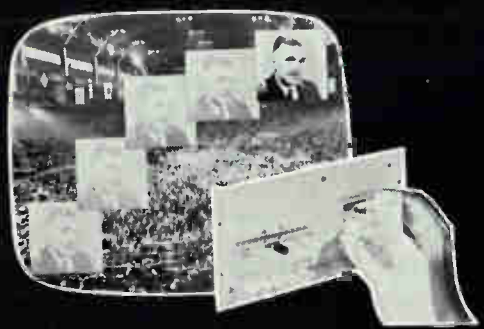
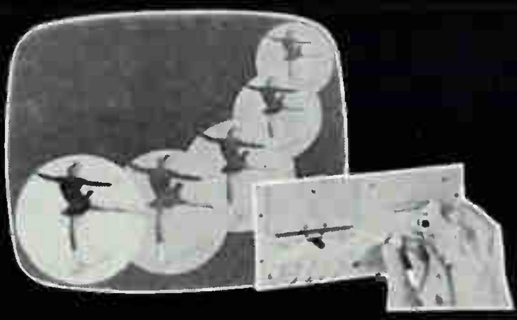
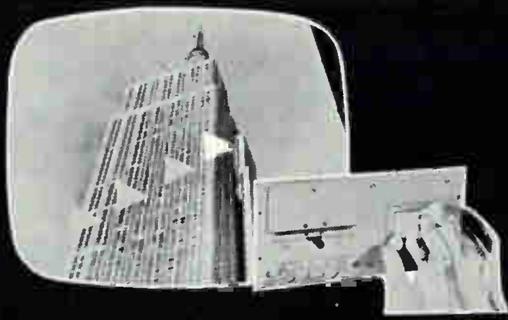


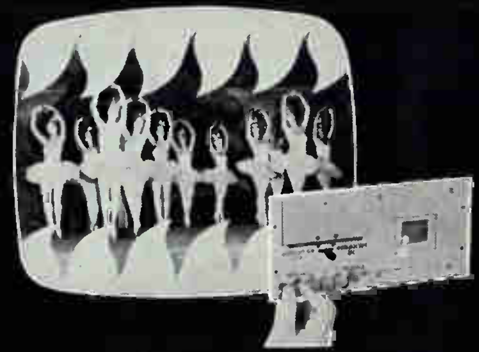
Insert May be Placed at Any Position on Raster



Electronic Spotlight



Electronic Pointer



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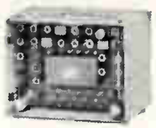
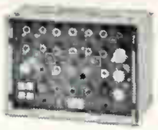


490WA1 Waveform generator. Generates keying signals for the 72 different wipes.



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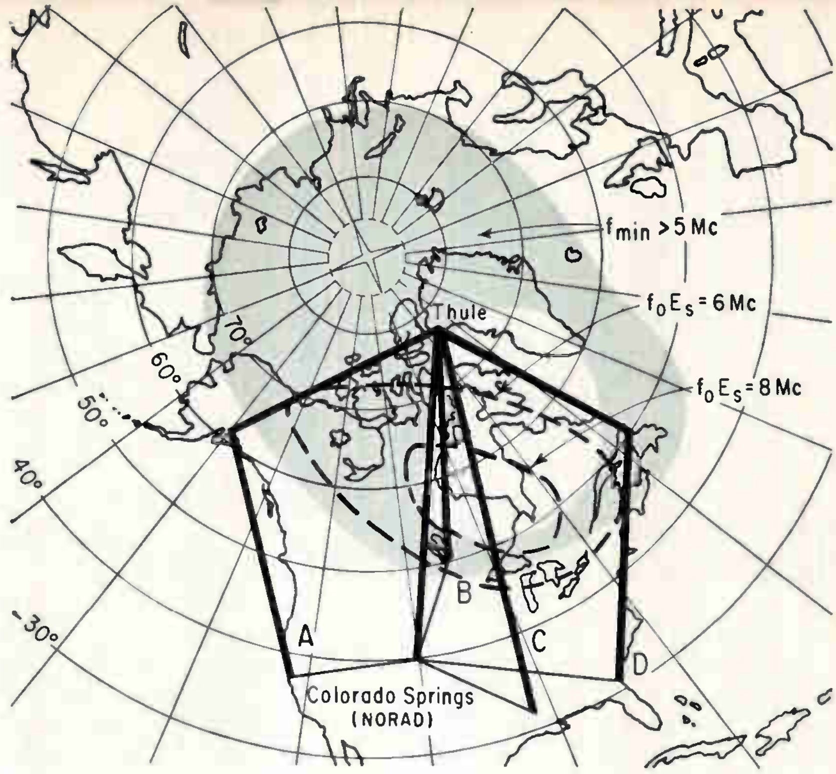
At height of September '57 ionospheric storm, polar blackout (hatched area shows severe absorption) cut direct ties between Thule and Colorado Springs, also eliminated alternate routes A and D. Enhanced sporadic-E (regions in dashed lines) permitted use of two-hop route B at about 20 and 23 Mc, and an M-hop (F to E_s to F to ground) on route C at about 18 and 22 Mc



Sneaking Through Radio Blackouts

By THOMAS MAGUIRE
New England Editor

NEW APPROACH to radio blackouts in northern latitudes looks like a workable solution to Arctic communications problems.

The propagation barrier resulting from ionospheric disturbances could cripple some of the vital components of national defense: command and control communications for the Strategic Air Command; relays handling information obtained from BMEWS and DEW-line radar; missile detection and guidance; fighter control.

The new approach is suggested in a study made by the geophysics section of Avco's research and advanced development division in Wilmington, Mass. The study, sponsored by the propagation sciences laboratory of the USAF Electronics Research Directorate at Hanscom AFB, grew out of a project under which Avco investigated the possibilities of forecasting anomalous refractive, scintillation and absorption effects in northern latitudes (ELECTRONICS, p. 32, Apr. 10, 1959).

Radio blackouts result from either electromagnetic radiation or solar particles emitted from solar storms. A few minutes after a solar flare, a pulse of electromagnetic radiation reaches the ionosphere causing an sid—sudden ionospheric disturbance. Several hours later, solar particles reach the earth's polar ionosphere causing enhanced D-region ionization. About 24 to 36 hours after the flare a geomagnetic disturbance often develops. This disturbance may last up to five days; during this time h-f radio communications with northern installations become ineffective.

Avco's proposal for use of ionospheric disturbances results from a synoptic study of a severe ionospheric storm that occurred in September 1957. The study included a detailed investigation of how the ionosphere behaves and how the disturbance moves. Additional studies are planned under Air Force sponsorship.

Radio blackout involves a decreased reflectivity of the F-layer (200 Km and above) and a vastly enhanced absorption of signals in the D-layer (50-100 Km). The net result is a lowering of the highest frequency receivable between two points (the maximum usable frequency, or muf) and a raising of the lowest usable frequency (luf). When the muf and the luf meet, no signals are receivable and blackout occurs.

The study shows that during ionospheric disturbances there is a great increase in sporadic-E. Intense sporadic-E is an efficient reflector of h-f signals; since it appears to occur systematically during severe ionospheric disturbances when the F-layer can no longer be used, the sporadic-E offers an alternative reflector.

Taking into account existing communication sites, Avco has plotted four possible paths from Thule to the North American Air Defense Command in Colorado Springs to show that if h-f communications cannot be made directly, it is still possible to maintain contact by using alternate routes and modes.

The ultimate system hinted at would include computers—using as input the data on a disturbance as it develops. The computer would automatically switch transmitters to optimum propagation paths and optimum frequencies.

Earlier models, however, would rely on sender's use of a manual of geophysical data that would indicate the paths and frequencies available during a blackout.

Blending Ice Cream Electronically

Computer and rate-of-flow meters adjust recipe under control of graphic program console (left)

BOSTON—AUTOMATED BATCHING of ice cream mix by an electronic control system has helped a Boston plant to increase production capacity by 70 percent.

The system installed at H. P. Hood & Sons includes computer calculation of recipes and instrumented control of blending, pasteurization, homogenizing, cooling and clean-in-place routine for lines, valves and tanks. One person controls the entire operation from a programming console.

Engineered by the Brown Instruments division of Minneapolis-Honeywell, the system incorporates turbine rate-of-flow meters of the Potter Aeronautical Corp.

Mixing dairy ingredients in correct proportions is a complex operation. Different mixes vary in content of butterfat and milk solids. The mix for a given formula must be recalculated daily—based on information from lab analysis—due to fluctuations in the constituents.

In the Hood system an analog computer, separate from the control system, determines by simultaneous equations how much of each ingredient is required for a given formula, and digitally converts this information into pounds for translation by the batch blending system.

The computer uses a group of chopper-stabilized d-c operational amplifiers and switching circuits to set up and monitor the operation. A digital voltmeter translates the analog solution and settings to digital form for readout. Honeywell engineers say the analog approach was adopted because of its operating simplicity and cost.

Once the coefficients are programmed into the computer, the formula expressed in pounds of various ingredients is resolved in 50 milliseconds and coded on a punch card. The punch card, which may be used for inventory and accounting, masterminds the electronic equipment that directs the flow of liquid raw products from storage to blending tanks. The card is inserted in an instrumented console that contains 11 contacts as output controls.

Ingredients are measured into the blending tanks by flow-sensing devices that have turbine-type rotors. As liquids pass through the meters, the rotors intercept fields of associated permanent magnets to produce pulse trains. The pulse trains drives totalizers, recorders and other devices in the control room.

The Potter turbine rate-of-flow meter acts as the signal source for the electronic devices. Using modular units as building blocks, the system contains 3,000 diodes and 2,000 transistors. There are 234 transistor and subassembly boards in the system.

Hungary Pushes Instruments

CURRENT SOVIET ACTIVITY in electronics continues to set the pace for work going on in satellite nations.

Cornerstone of communist economic planning is elimination of superfluous production (Khrushchev laughs at the West's extravagant excess capacity every time he talks about industrial production).

Hungary's electronics industry is a good example of the situation in the satellites.

Hungary is spending more money on R&D in the instrument field than in any other electronic activity. State-owned instrument industry includes 23 facilities which are given prototypes to work from by two state research institutes. The industry has increased its production volume 13.5-fold in the last ten years, now produces 3,700 types of instruments. Current R&D is centered on tv-test gear, nuclear instruments, geophysical and seismic equipment, remote control systems.

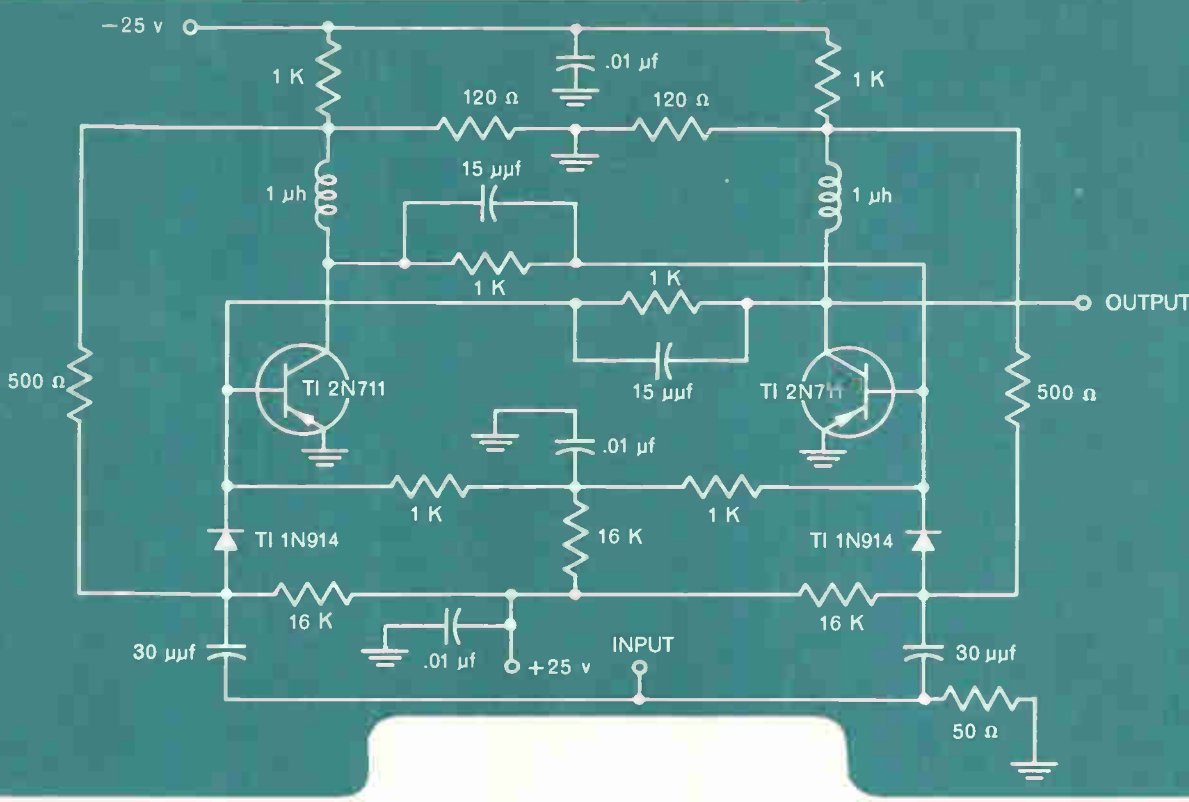
The telecommunications industry has stepped up its output 523 percent since 1950, mostly in tv sets, carrier equipment and tape recorders. Radio set production is off in Hungary this year and last.

Satellite governments, like their Soviet model, love to talk growth in percentages; actual production figures are somewhat more illuminating. Tv set production for 1959 was 42,575, more than double 1958's 16,131 sets. Radio set production dropped from 116,118 sets in 1958 to 78,883 in 1959.

Tape-recorder output was about 5,500 sets.

Much of Hungary's consumer-goods production is aimed at the export market. In 1959, more than half the radios wound up in the Benelux and Scandinavian markets, the Near East, or Latin America. Tv sets were widely sold in other satellite countries and the Near East, with East Germany being the biggest taker.

CIRCLE 37 ON READER SERVICE CARD→



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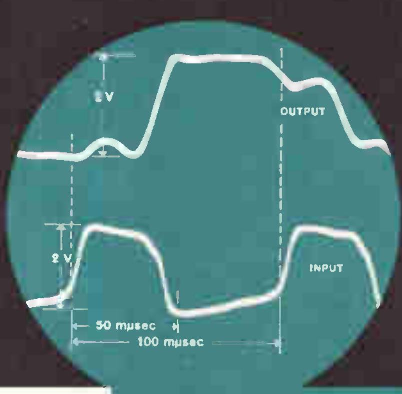

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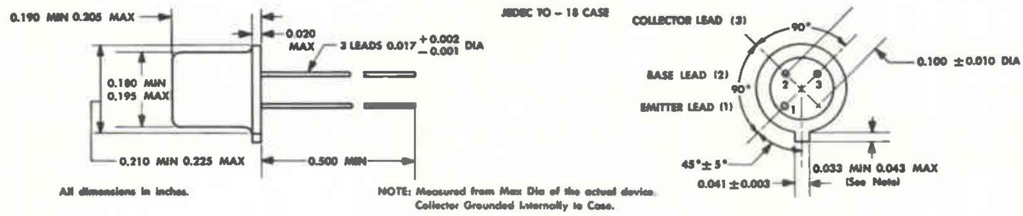
SEE OVERLEAF

TYPES 2N705, 2N710 and 2N711
P-N-P DIFFUSED-BASE MESA GERMANIUM TRANSISTORS

mechanical data: Welded case with glass-to-metal hermetic seal between case and leads. Approximate unit weight is 0.35 gram.



ACTUAL SIZE

absolute maximum ratings at 25°C case temperature (unless otherwise specified)

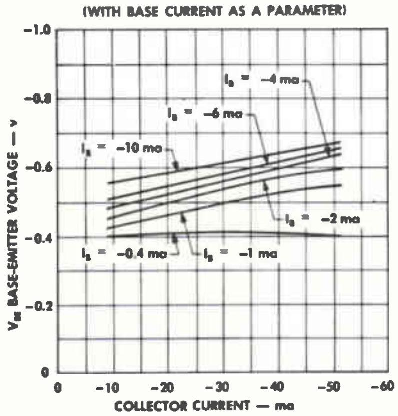
	2N705	2N710	2N711	unit
Collector-Base Voltage	−15	−15	−12	v
Emitter-Base Voltage	−3.5	−2.0	−1.0	v
Emitter Current	−50	−50	−50	ma
Collector Current	−50	−50	−50	ma
Total Device Dissipation	300	300	300	mw*
Collector Junction Temperature	+100	+100	+100	°C
Storage Temperature Range		−65 to +100		°C

*Derate at 4 mw/°C; this is equivalent to a maximum power rating of 300 mw at a case temperature of 25°C. The power rating in free air at 25°C is 150 mw.

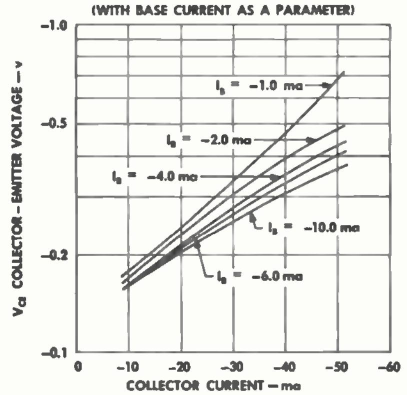
typical design characteristics at 25°C

		2N705			2N710			2N711			unit
symbol	conditions	min	typ	max	min	typ	max	min	typ	max	
I_{CBO}	$V_{CB} = -5v, I_E = 0$		0.3	3		0.3	3		0.3	3	μa
BV_{CBO}	$I_E = 0, I_C = -0.1ma$	−15			−15			−12			v
BV_{EBO}	$I_E = -0.1ma, I_C = 0$	−3.5			−2.0			−1.0			v
h_{FE}	$I_C = -10ma, V_{CE} = -0.3v$	25	40								
	$I_C = -10ma, V_{CE} = -0.5v$				25	40		20	30		
V_{BE}	$I_C = -10ma, I_B = -0.4ma$	−0.34		−0.44	−0.34		−0.50	−0.34		−0.50	v
V_{CE} (Sat.)	$I_C = -10ma, I_B = 0.4ma$		−0.23	−0.30		−0.23	−0.50				v
	$I_C = -10ma, I_B = 0.5ma$								−0.23	−0.50	v
t_d & t_r	$V_{BE(0)} = 0.5v, I_{B(1)} = -1ma$		60	75		60	75		70	100	mμsec
t_s	$V_{CC} = -3.5v, R_C = 300$ ohms		75	100		75	100		100	200	mμsec
t_f	$I_{B(2)} = 0.25$ ma		80	100		80	100		90	150	mμsec

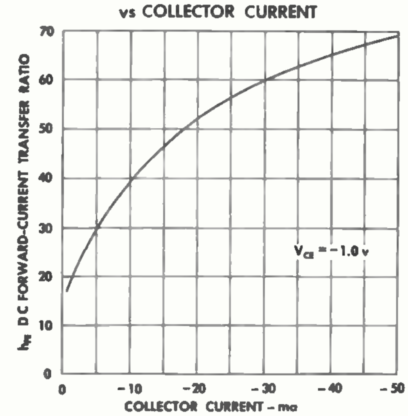
BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT
(WITH BASE CURRENT AS A PARAMETER)



COLLECTOR-EMITTER VOLTAGE vs COLLECTOR CURRENT
(WITH BASE CURRENT AS A PARAMETER)



DC FOWARD—CURRENT TRANSFER RATIO vs COLLECTOR CURRENT



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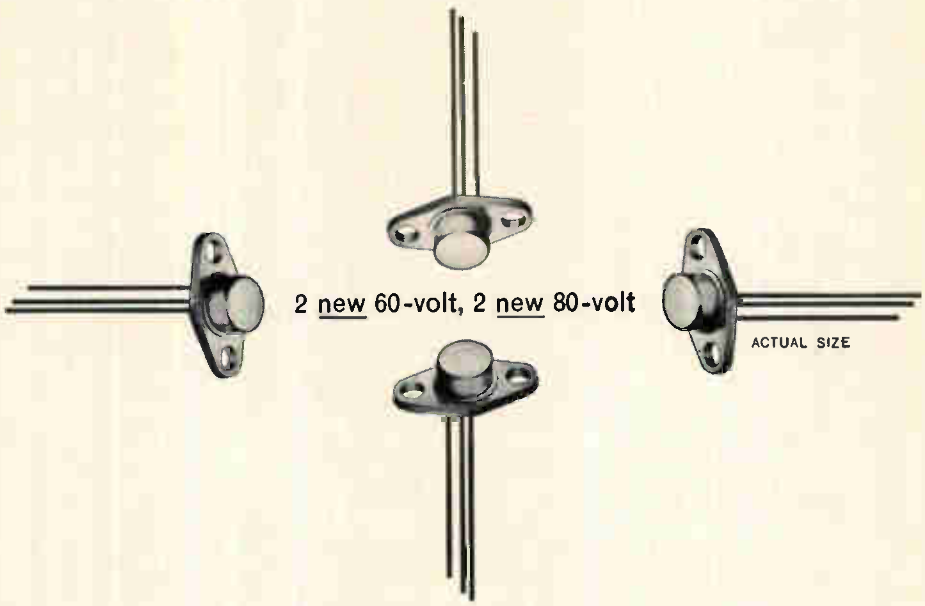
4 new miniature DELCO POWER TRANSISTORS



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V_{EBO}	20	20	20	40	40
V_{CEO}	30	40	40	60	60
I_C	1.5 A	1.5 A	1.5 A	1.5 A	1.5 A
I_{CO}	200 μ a	100 μ a	100 μ a	100 μ a	100 μ a
H_{FE}	30/90	30/75	50/125	30/75	50/125
$V/_{Sat}$	1.0 V	1.0 V	0.6 V	1.0 V	0.6 V

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FCC Hearings Stress

Global communications and frequencies required are under discussion in Washington as industry presents its views

SPACE COMMUNICATIONS proposals are under scrutiny in Washington this week following industry comment on the much-contested hearings above 890 Mc.

The issue is whether or not frequencies should be set aside exclusively for earth-to-satellite communications. On opposite sides are American Telephone & Telegraph Corp. and Electronic Industries Association.

AT&T, in presenting a global communications system proposal, contends that co-channel interference will result between earth-satellite systems and point-to-point microwave links unless special allocations are made.

EIA representatives counter that satellite communication systems (passive and active) will not cause harmful interference with conventional point-to-point ground microwave installations. Oral presentations were made last week by EIA's W. L. Firestone (Motorola) and S. G. Lutz (Hughes Aircraft) before the Commission.

Part of EIA's written testimony stated that satellite communications systems were far enough in the future to allow allocations to be handled by groups of the International Telecommunications Union that are slated to review space communications at an extraordinary Administrative Radio Conference in 1963.

FCC responded by initiating a general inquiry concerning space communications requirements and asked for public comment by March 1961. EIA spokesmen say they plan to comment.

EIA's position is that the U.S. presentation at the Geneva Conference of ITU last December covered frequency demands for today's operations and requirements in space communications, and that subsequent filings should be confined to nongovernment space systems.

Included in the EIA presentation was a study by the Association's microwave section chaired by L. G. Walker (Raytheon). The conclusions of the study group are: Satellite communications using either passive or active repeaters will not cause harmful interference to ground links operating on the same frequencies if reasonable engineering judgment is used; surface point-to-point systems will not

Installations like this Project Echo transmitter and receiver at Bell Labs' Holmdel, N. J. site will figure in future earth to satellite systems

Space Needs

cause harmful interference to satellite systems on the same frequencies if reasonable engineering judgment is used; it is not necessary that special allocations be made; and any nongovernment authorization for satellite communications purposes should be within present allocations for fixed services.

On the other side, AT&T points to the growing need for more global communications facilities and sees satellite systems as an answer. In written and oral testimony before the Commission, Bell Labs president James Fisk and members of his staff asked that specific frequencies above 890 Mc be set aside now as a guarantee against cochannel interference.

To support the testimony, the AT&T men presented a plan to the Commission based on work already done with National Aeronautics and Space Administration and other space research groups.

According to the AT&T testimony, a system of about 50 satellites in random polar orbits about 3,000 miles high could provide worldwide communications with about 26 transmitter-receiver ground terminals.

Such a system could be established for \$115 million (\$65 million for ground stations, \$50 million for satellites). Each pair of ground stations, says AT&T, could provide 600 telephone circuits. For about \$55 million more, the equipment could be further adapted to provide transoceanic television between each pair of stations.

According to testimony, AT&T would expect to use such a satellite system for international communication and, in collaboration with foreign organizations, would share the cost of the satellites.

As part of the AT&T filing, company spokesmen laid particular stress on the growing traffic load in today's communications.

MEETINGS AHEAD

Aug. 8-11: American Astronautical Society, Western National; Olympic Hotel, Seattle, Wash.

Aug. 8-19: Vibration Testing, Sine, Complex and Random Wave, Theory and Practice; Ling Electronics, Anaheim, Calif.

Aug. 9-12: American Institute of Elec. Engrs., Pacific General; San Diego, Calif.

Aug. 15-19: High-Speed Photography, Stroboscopic Light Laboratory; MIT, Cambridge, Mass.

Aug. 18-19: Electronic Circuit Packaging Symp.; Univ. of Colo., Boulder, Colo.

Aug. 22: Scientific Apparatus Makers Assoc., Market Managers, SAMA; Statler Hilton, Los Angeles.

Aug. 22-26: Thermonuclear Plasma Physics, Symposium; Oak Ridge, U. S. Atomic Energy Comm., Gatlinburg, Tenn.

Aug. 23-26: Western Electronic Show and Convention, WESCON; Memorial Sports Arena, Los Angeles.

Aug. 23-26: Association for Computing Machinery, Nat. Conf.; Marquette Univ., Milwaukee.

Aug. 23-Sept. 3: National Radio & TV Exhibition; Earl's Court, London.

Aug. 29-31: Metallurgy of Elemental and Compound Semiconductors AIME; Statler Hotel, Boston.

Sept. 7-8: Value Engineering, EIA; Disneyland Hotel, Anaheim, Calif.

Sept. 7-9: Automatic Control, Joint Conf., ASME, IRE, AIEE, ISA, MIT; Cambridge, Mass.

Sept. 9-10: Communications: Tomorrow's Techniques—A Survey, IRE; Roosevelt Hotel, Cedar Rapids, Ia.

Sept. 13-14: Bionics Symposium, Applying Biological Principles to Engr. Design, ARDC, Wright Air Devel. Div.; Dayton Biltmore Hotel, Dayton, O.

Oct. 10-12: National Electronics Conf., Hotel Sherman, Chicago.

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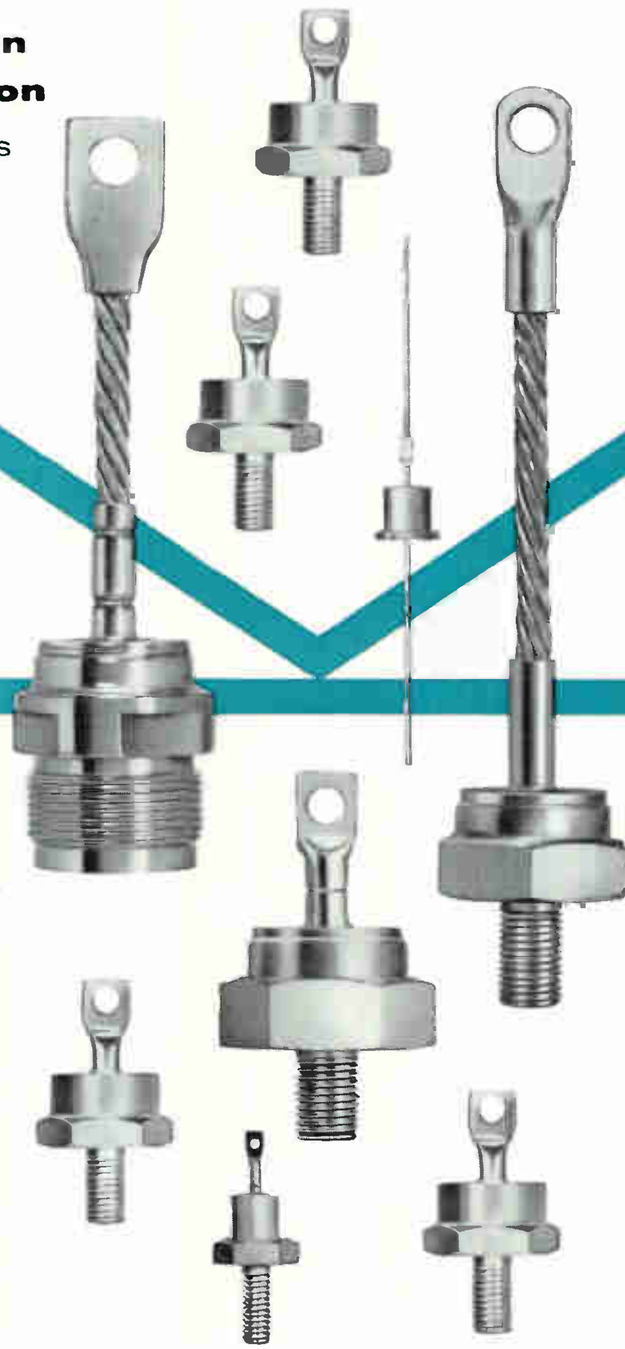

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250- mA 150°C Ambient Temperature	1N538	200	750 mAdc @ 50°C 250 mAdc @ 150°C	250 μAdc	0.5	
	1N540	400	750 mAdc @ 50°C 250 mAdc @ 150°C	250 μAdc	0.5	
	1N547	600	750 mAdc @ 50°C 250 mAdc @ 150°C	250 μAdc	0.5	
1 Amp 150°C Case Temperature	1N253	100	1.0 Adc	100 μAdc	—	
	1N254	200	0.4 Adc	100 μAdc	—	
	1N255	400	0.4 Adc	150 μAdc	1.0 ▲	
	1N256	600	0.2 Adc	250 μAdc	—	
20 Amp 140°C Case Temperature	1N1191	50	20 Adc	5 mAdc	.55	250
	1N1192	100	20 Adc	5 mAdc	.55 Full	250
	1N1193	150	20 Adc	5 mAdc	.55 cycle	250
	1N1194	200	20 Adc	5 mAdc	.55 avg.	250
	1N1195	300	20 Adc	5 mAdc	.55 150°C	250
	1N1196	400	20 Adc	5 mAdc	.55 case	250
	1N1197	500	20 Adc	5 mAdc	.55 temp.	250
	1N1198	600	20 Adc	5 mAdc	.55	250
25 Amp 150°C Case Temperature	CS-120Z	50	25 Adc	5 mAdc	.55 Full	350
	CS-120A	100	25 Adc	5 mAdc	.55 cycle	350
	CS-120B	200	25 Adc	5 mAdc	.55 avg.	350
	CS-120C	300	25 Adc	5 mAdc	.55 @	350
	CS-120D	400	25 Adc	5 mAdc	.55 150°C	350
	CS-120E	500	25 Adc	5 mAdc	.55 case	350
	CS-120F	600	25 Adc	5 mAdc	.55 temp.	350
35 Amp 140°C Case Temperature	1N1183	50	35 Adc	10 mAdc	0.6	500
	1N1184	100	35 Anc	10 mAdc	0.6 full	500
	1N1185	150	35 Adc	10 mAdc	0.6 cycle	500
	1N1186	200	35 Adc	10 mAdc	0.6 avg.	500
	1N1187	300	35 Adc	10 mAdc	0.6 140°C	500
	1N1188	400	35 Adc	10 mAdc	0.6 case	500
	1N1189	500	35 Adc	10 mAdc	0.6 temp.	500
	1N1190	600	35 Adc	10 mAdc	0.6	500

	Type	Peak Reverse Voltage (Volts)	Average Forward Current	Maximum Reverse Current*	Fwd. Voltage Drop** (Volts)	Surge Current† (Amps)
50 Amp 150°C Case Temperature	CH116Z	50	50 Adc	20 mAdc	1.1	500
	CH116A	100	50 Adc	20 mAdc	1.1	500
	CH116B	200	50 Adc	20 mAdc	1.1	500
	CH116D	400	50 Adc	20 mAdc	1.1	500
	CH116F	600	50 Adc	20 mAdc	1.1	500
70 Amp 150°C Case Temperature	1N1396	50	70 Adc	15 mAdc	1.3	1500
	1N1397	100	70 Adc	15 mAdc	1.3	1500
	1N1398	150	70 Adc	15 mAdc	1.3	1500
	1N1399	200	70 Adc	15 mAdc	1.3	1500
	1N1400	300	70 Adc	15 mAdc	1.3	1500
	1N1401	400	70 Adc	15 mAdc	1.3	1500
	1N1402	500	70 Adc	15 mAdc	1.3	1500
70 Amp 150°C Case Temperature	CH109Z	50	70 Adc	30 mAdc	1.3	1500
	CH109A	100	70 Adc	30 mAdc	1.3	1500
	CH109B	200	70 Adc	30 mAdc	1.3	1500
	CH109C	300	70 Adc	30 mAdc	1.3	1500
	CH109D	400	70 Adc	30 mAdc	1.3	1500
	CH109E	500	70 Adc	30 mAdc	1.3	1500
80 Amp 150°C Case Temperature	1N1291	50	80 Adc	30 mAdc	1.3	1500
	1N1292	100	80 Adc	30 mAdc	1.3	1500
	1N1293	200	80 Adc	30 mAdc	1.3	1500
	1N1294	400	80 Adc	30 mAdc	1.3	1500

▲ Max. fwd. voltage drop @ 0.5 amp., 25°C case temperature
* Full cycle average for rectifier operating into inductive or resistive load at rated current and voltage
** 50 amp units @ 100 amps D.C. and 25°C;
70 and 80 amp units @ 150 amps D.C. and 25°C
† Max. half sine wave peak current for one cycle @ 60 cps

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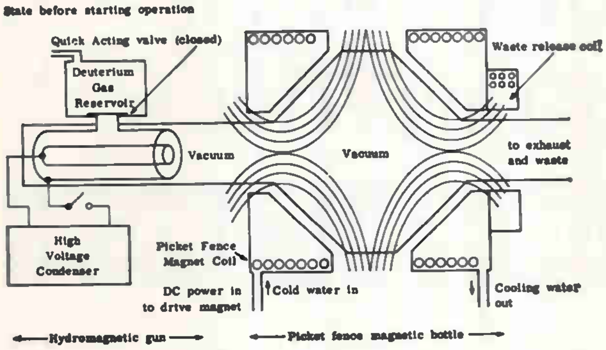
Science non fiction at Los Alamos

Is this the shape of things to come in Sherwood?



The cusped geometry or picket fence was proposed back in 1954 independently by Grad at N.Y.U. and Tuck at Los Alamos, to get around hydromagnetic instability of plasma-magnetic field interfaces. Nobody did much about it at the time. The pinch effect seemed to hold more promise, so why bother about a leaky picket fence? A large magnet to produce a DC picket fence geometry was built but laid aside. For several years the stabilized toroidal pinch (called Perhapsatron at Los Alamos) held the stage. But as our measuring techniques got better, the pinches began to show a most sinister behavior. An apparently stabilized pinch which should have been radiating energy at the rate of several kilowatts, turned out to be losing it at a rate of hundreds of megawatts. As we got the impurities out of the system, the losses seemed to go down. One pinch (Perhapsatron S-5) has seemed so clean we are trying to raise its temperature to thermonuclear levels by pouring in more power.

Then there appeared the spectre of plasma oscillations and their evil effects on magnetic confinement. In principle, plasma oscillations can thrive on the interaction of a fast wind of plasma electrons moving through a slower cloud of plasma ions. This makes things look bad for the pinch effect, because the plasma has to have a large electric current in it, and therefore an electron wind.

The Russians delivered the next blow. Trubnikov and Kondryatsev predicted an enormous cyclotron radiation flux from a plasma containing a magnetic field. This would ruin the chances for DD reactors, and make things tough even for DT reactors. Among other complications, a nearly perfect mirror would have to be placed around the inner wall of the plasma container to reflect the radiation back.

Then Rosenbluth and Drummond argued that when the angular distribution is considered, the radiation isn't really so bad—say 1/50th of what T and K say. Now Trubnikov has come right back with another paper that says it is five times worse than R and D said it was. The above theories are pretty simple—the real problem is exceedingly difficult theoretically. It may be quite a while before there is anything new in this direction.

Anyhow, the point is that DD reactors with magnetized plasmas now seem to be out. But some people, like Tuck, claim that DD reactors are the only ones that make sense, since a DT reactor which must carry on its back a monstrosity of a tritium recovery plant could never compete with fission power anyhow.

This brings us to the point that if we want to have a DD reactor, it has to have no magnetic field in its plasma. So all right, don't put a magnetic field in the plasma. Unfortunately, there aren't any magnetic confinement systems stable enough to hold a pure plasma, except one. You've guessed it—it's the picket fence.

So we went back to the warehouse and dusted off the magnet we built long ago. Already it is going full blast, a second one has been built and a third one is on its way. Of course, we aren't alone any more in this field. Small cusped geometries are being studied at General Atomic, Livermore, Stevens, Harwell, Utrecht and Kharkov. Pretty soon we will have only picket fences and plasma guns at Los Alamos, aside from a few Scyllas to study plasma at thermonuclear temperatures, unless old Perhapsatron S-5 does something pretty spectacular.

The diagram of Picket Fence I (above), run by D. Hagerman and J. Osher, shows how plasma is injected as a slug, strong enough to push through the magnetic field and spread out inside. (This is called entropy trapping, but that's another story). Does it work? Well, that depends. It's a lot more complicated than we thought. At first, we nearly died of joy when the plasma was shot in and seemed to stay around for ages in our time scale (1000 microseconds), emitting light in the process. But when a magnetic probe was inserted, the harsh truth was revealed—the containment lasted only a few microseconds. In other words, the long time period we thought we had observed was merely cold plasma emitting light by recombination.

Just lately, however, Messrs. Hagerman and Osher have cleaned things up to the point that hot plasmas are pushing the field aside strongly and are keeping the inside field pushed aside for very satisfying periods, like 50 microseconds. Also, if we keep the magnetic probe out of the way of the plasma, it stays around longer, which is what it should do. This particular picket fence is a horror to keep a vacuum in, as it is completely overrun with O rings. The next one will be baked. Fun, eh?

What about the leaks in the fence? It is pretty leaky, but we think we have an answer to that too, so watch for the story on the TLC picket fence one of these days.

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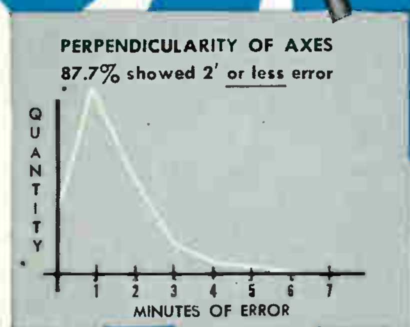

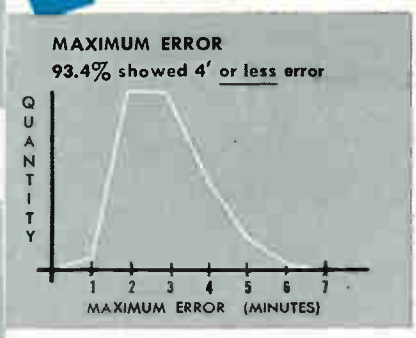

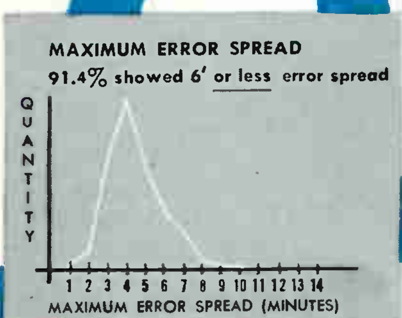

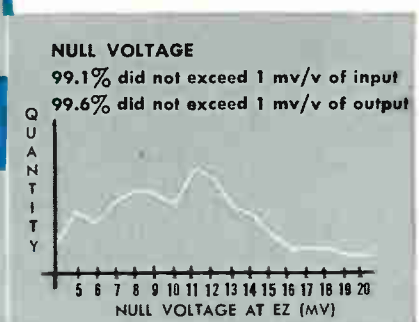

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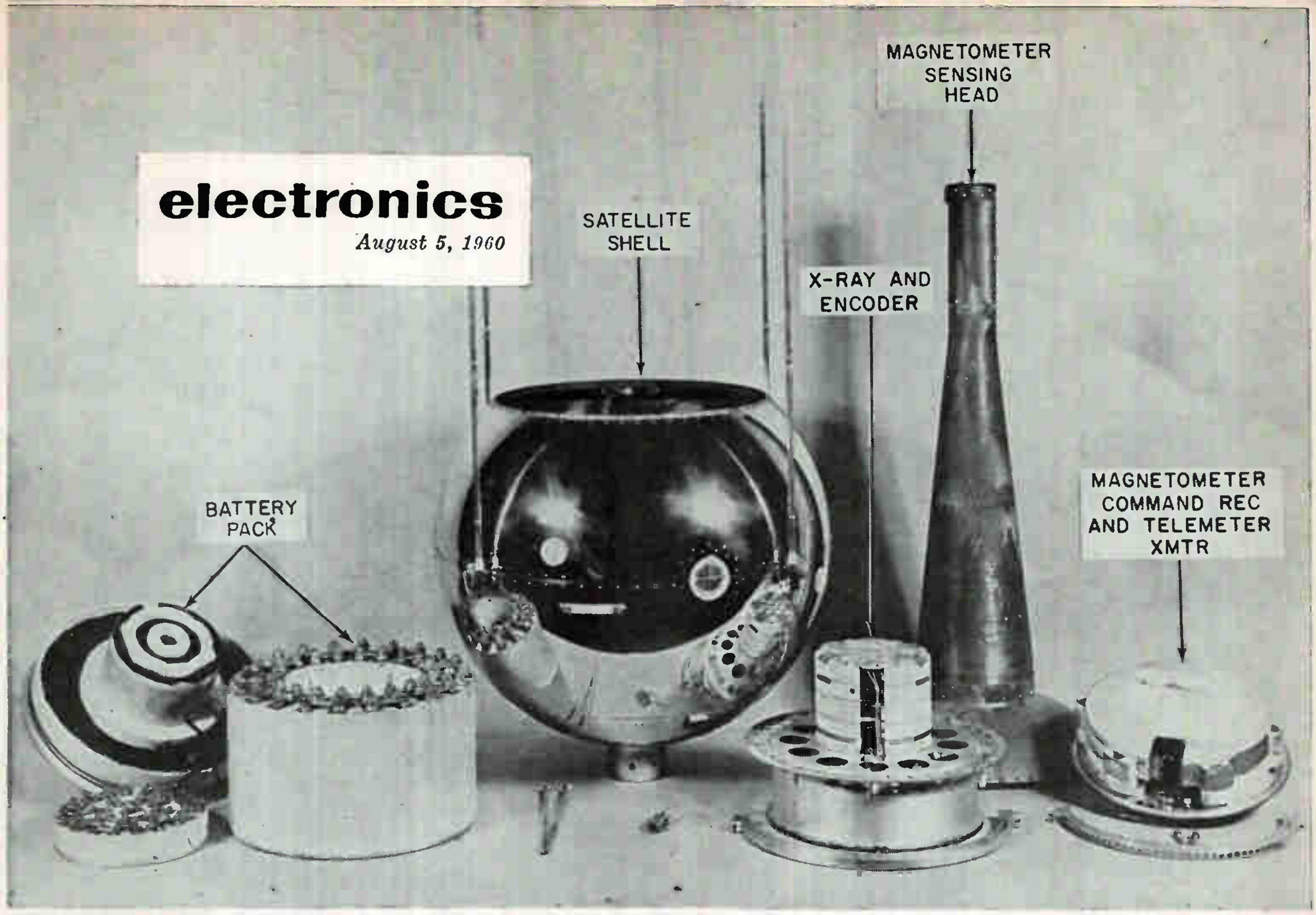


Vanguard III used proton precessional magnetometer to measure fields

Magnetic Measurements in Space

Proton precessional and optically pumped magnetometers can be used to make magnetic measurements in space. Data obtained may prove theories

By DOLAN MANSIR,
Project Engineer, Varian Associates,
Palo Alto, Calif.

THE SCIENTIFIC objectives of sending magnetometers into outer space are of sufficient importance to bear repetition. It is generally agreed that the earth is comparable to a bar magnet, with poles located in the Arctic and Antarctic regions. While the knowledge of the existence of such a magntic field is one of the oldest physical phenomena known to mankind, the origin and exact nature of the earth's field can only be postulated.

There is superimposed on the main magnetic field a daily variation (diurnal variation) which is believed to be caused by electric currents in the ionosphere. Also, magnetic storms are not uncommon. There is some relationship between these magnetic storms and sunspots. The recent discovery of the Van Allen radiation belts has lead to postulations of currents that could cause magnetic variations at the surface of the earth. The true description of the earth's magnetic field is often masked by geological irrgularities in the earth's crust.

For these reasons it is difficult to make an accurate map of the earth's magnetic field. Time-correlated magnetic measurments in space and at the earth's surface may provide some basis for proving old theories or formulating new ones. In addition, it is expected that measurements of the lunar magnetic field and magnetic fields of other planets will contribute greatly to understanding the origin of the earth's magnetic field.

In the Vanguard III satellite, which made measurements at altitudes from 510 to 3,750 km, magnetic field measurements were made by a proton precession magnetometer. Later satellites will use optically pumped alkali vapor magnetometers to make these magnetic measurements.

The proton precession magnetometer was conceived by the late Russell Varian.[1] The nucleus of the hydrogen atom, a proton, is known to have a magnetic moment and spin angular momentum. These two properties determine a physical constant called a gyromagnetic ratio; the equation $w = \gamma_p H$ relates frequency (ω), gyromagnetic ratio (γ_p) and magnetic field intensity (H). This frequency is known as the Larmor, precession or nuclear resonance frequency.

The proton has often been likened to a gyroscope. If a spinning gyroscope is acted upon by an external torque it will start to precess. The proton, when acted upon by a torque $M_e \times H$, produced by the interaction of the magnetic moment of the proton and the environmental magnetic field, will also precess at the Larmor frequency.

The precessing of a single proton is impossible to detect. A number of protons must precess in phase coherence to have a detectable rotating magnetic moment. The method of obtaining phase coherence in the spin systems of the Vanguard III magnetometer is surprisingly simple.

A container of liquid, abundant in hydrogen, is placed in a relatively strong magnetic field (600 or 700 gauss) that has a direction other than the earth's magnetic field. Now if the strong magnetic field is suddenly removed (in a time short compared to one Larmor period) the nuclei will precess about the earth's field at the Larmor frequency. After a short time, approximately three seconds, the phase coherence is lost and it is necessary to start with the aligning process again. If the aligning or polarizing field is normal to the earth's magnetic field a maximum amplitude signal is obtained. Any other orientation results in decreased signal amplitude, but there is no orientation dependence of the precession frequency.

Since the gyromagnetic ratio is known to an accuracy better than one part in 100,000, it is possible to measure absolute values of magnetic field to this accuracy by measuring the frequency of precession. Relative measurements can be even more accurate—accuracy being limited only by the electronics in the system. The earth's field is nominally 0.5 gauss in the United States, and precession frequencies are in the order of 2,000 cycles.

A block diagram of the magnetometer portion of Vanguard III is shown in Fig. 1. Only the command receiver and tracking transmitter were continuously powered during flight. Magnetic measurements were made when the satellite was within command range of a Minitrack tracking station, and a simultaneous measurement was made of the magnetic field at ground level.

Turn-on and turn-off are accomplished as shown in Fig. 2. The ground command causes a momentary relay contact closure in the command receiver. This action turns the magnetometer circuits on. During the 0.1 second command relay K_1 is closed, K_2 is energized through the normally open contacts of K_1 and R_1 through to the battery. The plus battery is connected to the magnetometer ground through the contacts of K_2 allowing emitter current to flow in Q_1 holding K_2 energized.

Turn-off is accomplished after one magnetic measurement by coupling a positive pulse to the base of Q_1, driving it to cutoff and allowing K_2 to drop out.

The second set of contacts on K_2 switch charge capacitors C_1 and C_2 into monostable multivibrator Q_2 and Q_3 (polarize multivibrator, Fig. 1). The capacitors are charged to the battery potential between commands. This stabilizes the multivibrator period. Also, the voltage across the capacitors is such that the multivibrator is forced to trigger to its unstable state immediately upon turn-on.

An additional feature of the turn-on circuit is a safeguard against a temporarily locked-on command receiver relay. From Fig. 1 it is seen that the timing functions of the magnetometer are accomplished by the 2-second polarize multivibrator and the 2-second delay multivibrator. The turn-off pulse is derived by differentiating the negative pulse from the delay multivibrator. If the command receiver relay (K_1 of Fig. 2) failed to open in less than 4 seconds, the turn-off pulse would be ineffective in turning off K_2, and the circuits would remain on. A second trigger pulse, due to the discharge of C_3 through R_2, R_1 and the command relay's normally closed contacts, is coupled to the polarize multivibrator through C_4. So, even if the command relay stayed on several minutes, the magnetometer would merely go through another polarize-measure cycle and then turn off.

The sensing head is simply a solenoid of 600 turns of aluminum wire. When connected to the 14.5 volt battery a current of about 7 amp passed through the coil, resulting in a polarizing field of about 600 gauss. Thus the sensing head or coil furnishes the strong magnetic field for polarizing nuclei and the precessing magnetic moments induce the signal voltage in it. Figure 3 is an oscillograph of a signal from the Vanguard magnetometer while over Australia.

When the 600 gauss field is switched off rapidly, the self-induced voltage across the coil would rise to several hundred volts if nothing were done to prevent it. This could cause insulation breakdown or excessive arcing in the switching relay. The coil is damped by paralleling (see Fig. 2) R_3 and R_4 with C_5. This combination is connected across the coil through silicon diode D_1. The 5 ohms resistance is sufficient to overdamp the coil, and C_5 limits the amplitude of the half-cycle transient. Diode D_1 switches the combination out of the circuit when the voltage across the coil drops to less than 0.3 volt.

The proton supply, normal Hexane, is contained in the core of the coil. Hexane was chosen because of its low freezing temperature and because its relaxation time (the time for phase incoherence to occur) is relatively long even at subzero temperatures.

The signal voltage, V_S, available to the amplifier is given by

$$V_S = M\omega Q_R n A/\sqrt{2}$$

where M is the polarization of the proton supply per unit volume; A, the average area of the coil; ω, the angular precession frequency; n, the number of turns in the receiving coil and Q_R, the effective Q of the coil.

Since M is proportional to the polarizing field in the sensing head, and thus proportional to the polarizing coil current, it is possible to calculate an optimum coil for a given polarizing power and maxi-

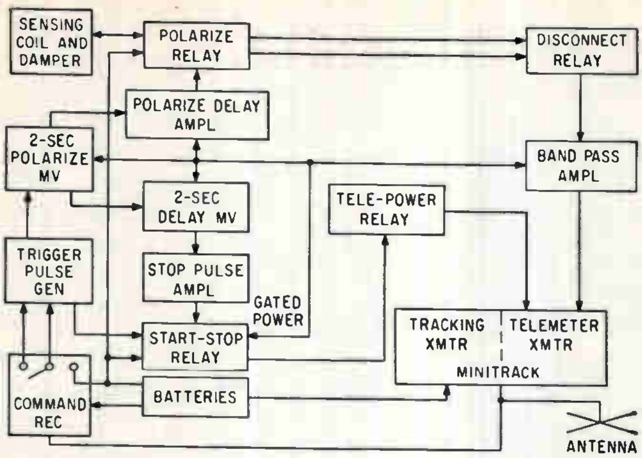
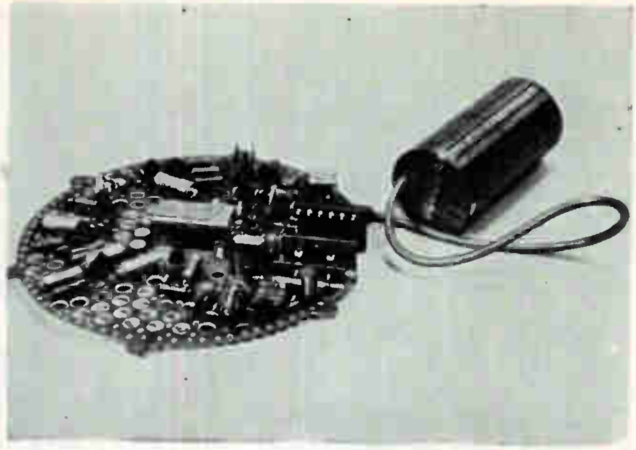


FIG. 1—Band pass amplifier amplitude modulates 80 mw telemeter transmitter



Electronics and sensing head of magnetometer used in Vanguard satellite

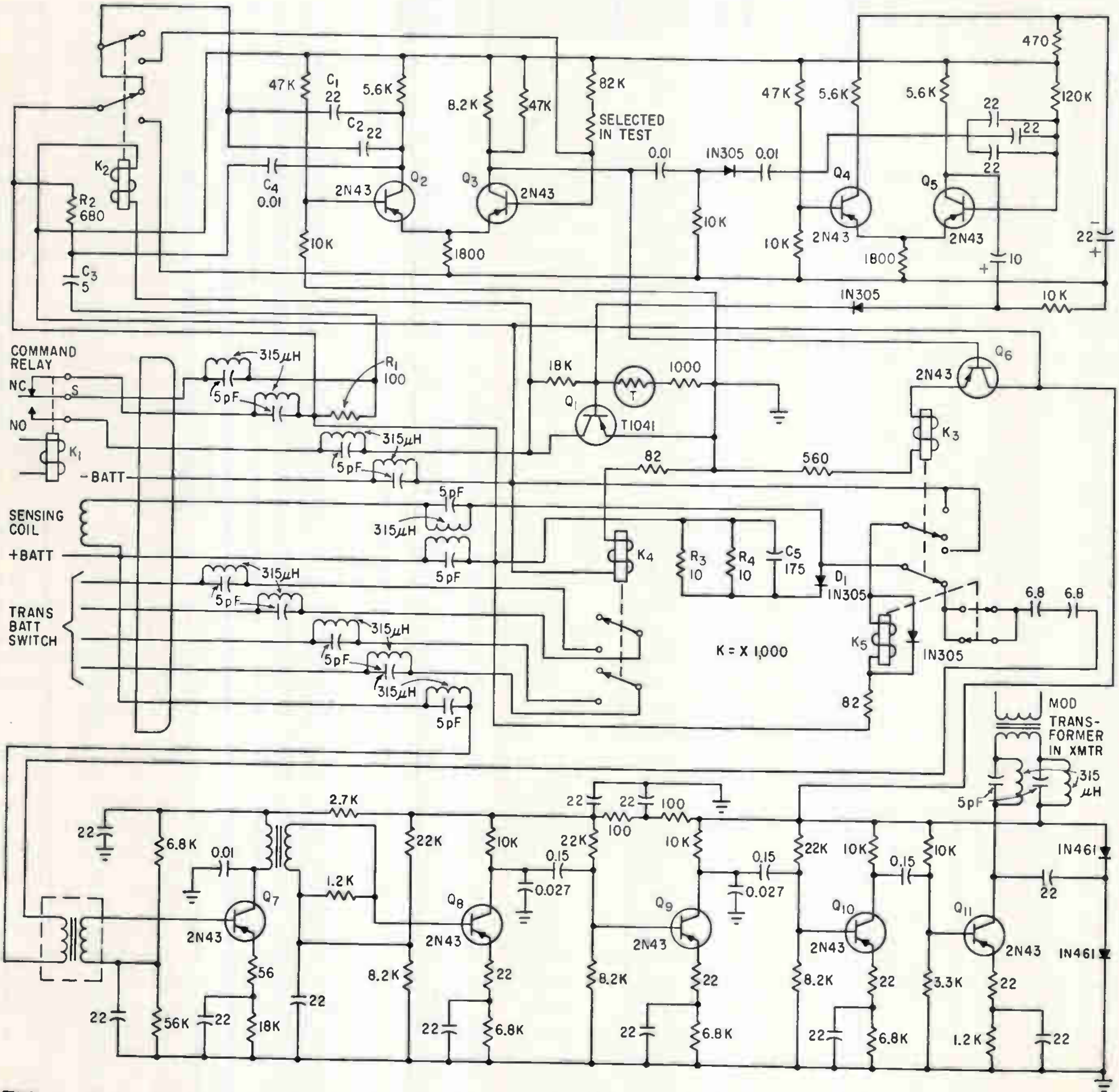


FIG. 2—Complete schematic of magnetometer used in Vanguard shows how control is obtained

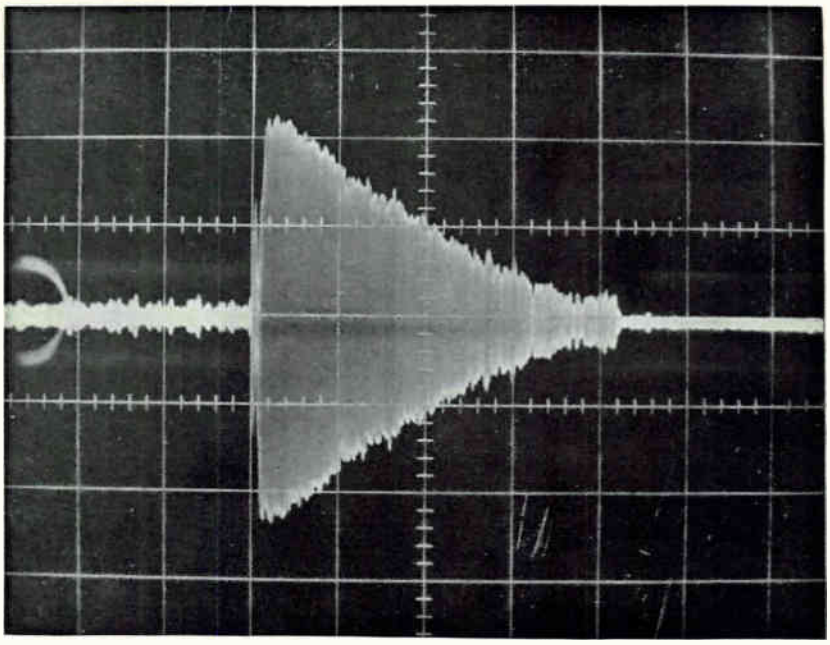


FIG. 3—Trace from outer space

mum weight-size specifications. The factor *M* is also proportional to a parameter, called filling factor, that accounts for the coefficient of coupling between precessing nuclei and the turns in the coil. The filling factor for a solenoid is difficult to calculate; therefore, it was assumed that the proton supply was contained in a sphere in the center of a solenoid. Using this assumption the optimum ratio of coil radius to proton supply radius was calculated. The satellite magnetometer coil is a close approximation to the calculated coil parameters.

The signal voltage available at the coil terminals, at optimum orientation and at a frequency of about 2,000 cycles, was calculated to be in the order of 2 microvolts. Since the signal voltage is frequency dependent, the amplifier bandpass was made to peak near the center of the predicted range of frequencies to be encountered, and to fall off at about 12 db an octave at higher frequencies. The 3-db down points were 600 cycles and 2,200 cycles. The noise figure of the amplifier is sufficiently low to recover signals from the noise at 300 cycles to 2,400 cycles. A good noise figure was obtained by selection of the first amplifier transistor, and matching of the sensing coil to the base of the first amplifier. The 2N43 transistors were less noisy than several other types that were tried.

Care was taken to reduce the number of pieces of magnetic materials used in the construction of the satellite structure and the electronics. Errors due to iron pieces that could not be eliminated were measured to be in the order of 1 gamma (one gamma equals 10^{-5} gauss). The goal at the beginning of the magnetometer satellite program was to have less than 5 gammas error.

The only other source of appreciable error lies in the tumble rate of the satellite. The tumble frequency could add to or subtract from the precession frequency and a one cycle per second tumble could give an error of about 23.5 gammas. The tumble frequency of Vanguard III is about 0.09 cycles per second, equivalent to about 2 gammas. This error can be corrected since the tumble frequency can be obtained from both the agc in the ground receiver and optical aspect in the satellite.

At this time, little more than 10 percent of the data obtained from Vanguard III has been analyzed, so only a few general statements regarding the results can be made. In the absence of magnetic storms the fields in space are exceptionally stable. There is a possibility that a magnetometer altimeter could be useful in space vehicles. In general the magnetic storms in space are negative when they are negative at the earth's surface, indicating the main electric current producing a storm is located at some distance above the inner radiation belt. The data indicate that electric shell currents occur at different distances from the earth for different storms and that the distance may vary with time during a given storm. Measured fields range from 0.07 gauss at apogee over South America to 0.375 gauss at perigee.

Although the Vanguard III magnetometer represents a real advance in space magnetic measuring instruments, it has two disadvantages which practically preclude the possibility of eventual flight in a deep space probe. The instrument requires some 200 watt-sec of power to make a single measurement and the signal amplitude from the device is field dependent. It would not be practical to build an instrument to measure fields weaker than about 5,000 gammas because of increased weight and power requirements. The optically pumped alkali vapor magnetometer overcomes these limitations.

The optical pumping process was invented by A. Kastler.[2] In the magnetometer to be described, the method of observing the pumping process was conceived by H. G. Dehmelt[3] of the University of Washington at Seattle.

Optical pumping consists of raising atoms from a low energy state to a higher energy state. Consider the energy level diagram for rubidium in Fig. 4. This shows the three lowest allowed values of the total energy of the atom. These energy levels can be further broken down into several additional energy levels (shown as dashed lines), but for the present consider only the three.

In the absence of external influences, the electrons of the rubidium atoms will be in the unexcited or ground state. To pump electrons to the *P* or excited state it is necessary to expend energy. Electrons can be excited to the *P* state by bombardment with electron or ion beams, or by irradiation with light of the correct wavelength. Electrons will not remain in the *P* state; they fall back immediately into lower energy states. In so doing they emit electromagnetic radiation which accounts for the energy necessary to raise them to the *P* state. Electrons returning to the ground or *S* state have equal probability of returning to either of the two Zeeman splittings. Those which end up in the higher energy level are trapped. Those which return to the lowest energy level are available to be pumped again. This is the process by which electrons are raised to a higher level.

In practice, rubidium vapor in a sealed glass cell is irradiated with light from a rubidium spectral lamp. As long as the light has enough intensity to pump faster than the electrons can be depumped by thermal agitation, the gas cell will be more transparent to the rubidium light than it would be if no pumping had taken place.

Transitions between energy levels correspond to definite spectral lines in the electromagnetic spectrum. For instance, transitions between the *P* states and *S* states emit visible wavelength in the order of several thousand megacycles (these transitions are not dependent upon the magnetic field and are being used in atomic clock applications). When the rubidium atoms are placed in a magnetic field, the higher energy level of the *S*- state hyperfine splitting further splits into five levels called the *m* levels. Transitions between *m* levels are magnetic-field dependent and therefore can be used in a magnetometer system.

For Rb 87 the transition between *m* levels is at the rate of 699,632 cycles per second in a one-gauss field. To cause transitions between *m* levels the pumped gas cell is irradiated at the Larmor frequency by an electromagnetic field developed in a coil of wire wound around the cell. The transitions cause an intensity modulation of the light beam transmitted through the cell. Modulated light is detected with a mosaic of silicon solar cells and the photoelectric current is amplified. The amplifier drives the field coil at the cell to perpetuate the transition between *m* levels. The result is an apparatus which continuously oscillates at a frequency which is proportional to the earth's magnetic field.

The complete signal producing apparatus is shown in block diagram Fig. 5. The rubidium spectral lamp transmits light through a filter (to remove unwanted spectral lines), collecting lens, circular polarizer, gas cell and focusing lens to the silicon cell mosaic. The mosaic drives the amplifier, which drives the feedback coil and, in the rocket magnetometer, modulates the telemeter transmitter.

To develop high intensity noise-free low-power light sources it was necessary to develop new lamps. Commercially available lamps were bulky, required high power, and, worst of all, were so noisy that they were of little use.

The present lamps are electrodeless, the discharge being produced by an r-f field at 100 Mc. The tank coil of a 100-Mc oscillator is wound around the lamp bulb. The bulb contains rubidium metal and krypton. The electric field first ignites the krypton. When the temperature in the bulb reaches approximately 100 C, the discharge is through the rubidium vapor. Power consumed in the lamp package is approximately 5 watts. This includes heater power for the subminiature 5718 triodes.

The amplifier for this magnetometer presented some unusual engineering problems. The physics of the system require that the feedback field to the cell be 90 degrees leading phase angle with respect to the modulated light. The silicon mosaic appears capacitive between the frequencies of 50 Kc to 300 Kc, which automatically provides for the phase angle for magnetic fields corresponding to this frequency range. For frequencies of 50 Kc down to a few cycles (the ratio is about 7 cycles a gamma) the silicon mosaic can be made to look resistive, or at least to be resistive up to a few kilocycles and contribute a small phase angle over the rest of the band. For this frequency band it will be necessary to make the amplifier phase shift a precise function of frequency to achieve the 90-degree phase. Because of these phase shift characteristics the present models of magnetometers are being built to cover either the range of 0.5 gauss (350 Kc) to 0.07 gauss (49 Kc) or 0.07 guass (49 Kc) to 1 gamma (7 cycles). The latter range is suitable for lunar and interplanetary probes where operation at altitudes less than one earth radius is not essential.

There are a number of advantages of the optical pumped rubidium system over the proton free precession system. These include greater dynamic range, less power consumption and faster data sampling rate. Also, signal amplitude is not a function of frequency and the higher *g* factor possible permits more accurate measurements.

A Thor-Delta vehicle will carry the rubidium magnetometer to outer space. A test flight of the magnetometer in a Javelin rocket is planned for this summer.

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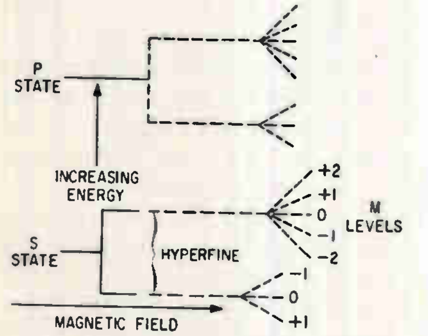

FIG. 4—Atoms are optically pumped between energy levels

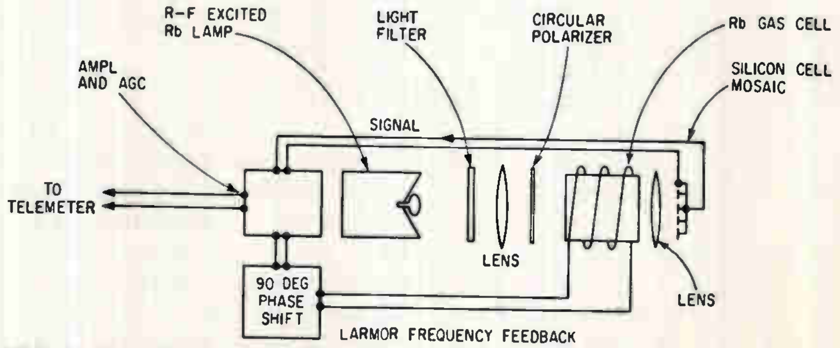

FIG. 5—Rubidium vapor self-oscillating magnetometer requires phase shift in feedback loop

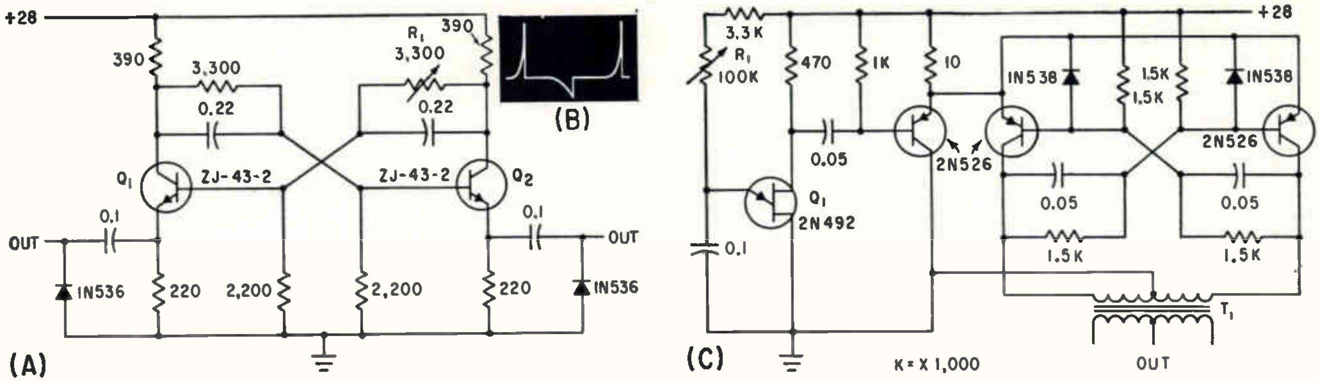

FIG. 1—Trigger circuit for silicon-controlled-rectifier circuits (A) produces output pulses at a 3-Kc rate; one of the two outputs of this circuit is shown in (B). The trigger circuit shown in (C) produces square-wave output pulses at the secondary of transformer T_1

TURN-OFF CIRCUITS FOR

Although applications discussed here involve inverters, circuit design information is applicable to other controlled rectifier applications

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SILICON CONTROLLED RECTIFIERS are useful power-switching devices. At 400 cps, the ratio of the maximum power switched into load to triggering power received is about 5 million, or 67 db. Triggering and turn-off circuits for controlling the rectifiers will be described, with particular emphasis on inverter applications.

The units can be triggered from a d-c or a-c source although a pulse trigger is preferable for most inverter applications. A pulse with steep wavefront assures that rectifiers with different triggering sensitivities will still be turned on at a fixed time. If the rectifier is to remain in conduction, the circuit must allow anode current to build up sufficiently fast to reach a value above the holding-current level before the trigger energy is removed. Thus, the required gate-pulse width may depend on the circuit rise time as well as turn-on time. Turn-on time is about 2 to 4 μsec. For fast turn-on time, it is desirable to exceed the minimum gate energy that is necessary to assure the triggering of any unit under the most adverse conditions. For example, a type C35 would require 3-v, 80 ma at its gate at −65 C junction temperature; 5 w is the maximum peak power that can be applied to gate of any C35.

The unijunction transistor in a simple relaxation oscillator circuit provides a pulse source for many applications. Saturating reactors have also been used as a pulse source for triggering.

One of the important design problems for parallel inverter circuits involves the triggering of one rectifier enough in advance of the second so that the commutating capacitor will have assumed ample charge for commutation by the time the second unit is triggered. A triggering source that applies alternating pulses to each rectifier in an inverter application is desirable. This type of pulse generation is available from the transistor multivibrator circuit of Fig. 1A. The two outputs from the multivibrator give alternating trigger pulses to each rectifier; input to one is shown in Fig. 1B. Resistor R_1 may be adjusted for symmetrical operation. Each 0.1-μf capacitor, in conjunction with the gate impedance of a controlled rectifier, differentiates the square wave at the emitter to give the desired pulse output. The diode at the output prevents negative pulses from reaching the gate.

If the inverter application requires a higher degree of frequency control, then the transistor multivibrator can be controlled by an external source such as the unijunction relaxation oscillator (Q_1) shown in Fig. 1C. The square-wave output delivered by transformer T_1 is required for triggering some special inverter circuits.

Figure 2A shows a parallel inverter. Its two unijunction-oscilla-

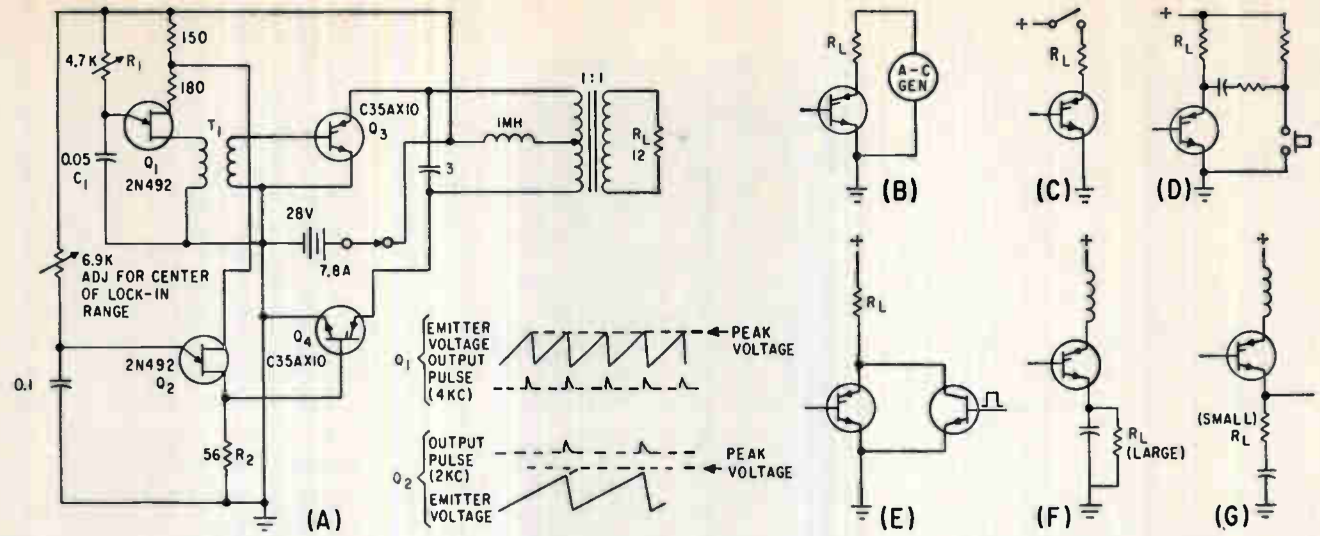

FIG. 2—Circuit and waveshapes for 2-Kc inverter (A). Basic turn-off circuits are: phase commutation with one a-c source (B), line interruption with a reset switch (C), parallel-capacitor commutation (D), shunt-transistor turn-off (E), series capacitor, parallel load (F), and series capacitor, series load (G)

CONTROLLED RECTIFIERS

tors (Q_1 and Q_2) could also trigger series inverters, giving symmetrical operation. This trigger circuit does not have alternating trigger pulses for each controlled rectifier, but it offers an advantage in simplicity, being a source of trigger pulses of good frequency stability despite variations in supply voltage and ambient temperature. Unijunction transistor Q_1 operates at twice the frequency of Q_2. The timing circuit for Q_2 is set for operation at slightly less than one half the frequency of Q_1, but base two of Q_2 (its upper base) receives a sync pulse whenever Q_1 fires. Thus oscillator Q_2 operates at exactly one half the frequency of Q_1. Waveshapes of Fig. 2A show how Q_2 triggers before its emitter reaches its nominal peak voltage.

Pulse transformer T_1 couples the output of Q_1 to Q_3 to help compensate for the loss in energy when using an 0.05-μf capacitor (C_1) at the emitter of Q_1 in place of an 0.1-μf capacitor. The 0.05-μf capacitor is required to operate Q_1 at 4 Kc and keep charging resistor R_1 above 3,000 ohms, making the relaxation-oscillator circuit stable.

The 56-ohm resistor (R_2) at base two of Q_2 is made as large as practical to reduce the shunting of the Q_2 output pulse to the gate of Q_4. The maximum value for R_2 is limited so that the interbase leakage current of Q_2 through this resistor has a drop of less than 0.25 v. Keeping R_2 low prevents the leakage current at extreme temperature from triggering Q_4.

Figures 2B to 2G show basic types of circuits used to turn off controlled rectifiers. Most inverter applications use one of the methods indicated in D, E, F or G. To obtain fast switching times for high-frequency inverters, the series or parallel-capacitor circuit (D or F or G) is used. A rectifier may be turned off by reducing its anode current just below the hold-in value, but the gate will regain control in a shorter time if the unit is reverse biased with a low-impedance external circuit that will permit a reverse current of a few amperes to flow. This action speeds the recovery time of the two end junctions (Fig. 3A). The end junctions will recover in 2 or 3 μsec if a reverse current of equal or greater magnitude than that shown in Fig. 3B were permitted to flow. After recovery of the end junctions, the center junction will recover. After all junctions recover from their saturated condition, which existed during conduction, the controlled rectifier is capable of blocking in the forward direction.

A special inverter-type of rectifier that has controlled turn-off characteristics is available. With this inverter type, the gate will regain control in 12 μsec or less at a junction temperature of 125 C. The operating inverter circuit must permit a reverse current with time that meets the criteria specified in Fig. 3B. If this requirement is realized, positive voltage may be reapplied in 12 μsec, or longer if need be, to confine the reapplied voltage to the designated operating range (Fig. 3C).

Figure 3D shows the variation in turn-off time for the inverter-type rectifiers with different values of forward current at three junction temperatures. The curve indicates the improvement in turn-off time that can be realized by using the most effective heat sink that is practical for a particular application. The typical turn-off time for the C35 series is about twice that of the special inverter unit.

Figure 4A shows a parallel-inverter circuit for measuring turn-off time. The unit under test, Q_1, is triggered by closing S_1 and an anode current of 10 amperes flows. In about 3 seconds, the junction-to-stud temperature drop stabilizes at 20 C. If the stud temperature is maintained at 105 C by an external heat source, the junction temperature will then be at the maximum

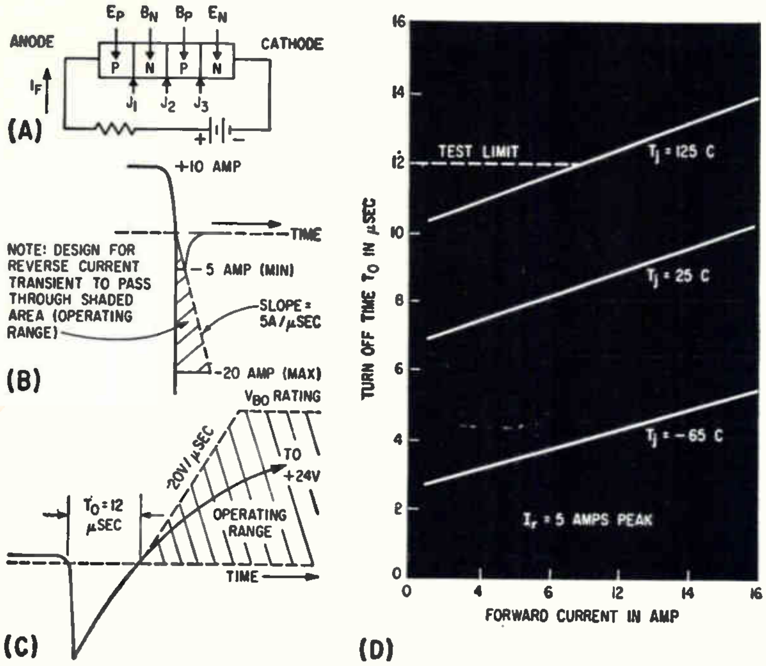

FIG. 3—Rectifier conducting, gate open (A). Typical rectifier current waveform is shown with test limits of amplitude and rise time (B); voltage across rectifier is shown with test limit of reapplied forward voltage (C). Turn-off time of inverter-type unit (D)

rated value of 125 C. During this time, capacitor C_1 charges to about 17 v through R_1. When S_1 is closed, Q_2 turns on and connects the positively charged plate of C_1 to the cathode of Q_1 and causes reverse current to flow. Because of the turn-on time of Q_2, this reversal is not instantaneous. The impedances of Q_1, Q_2, R_2, R_3 and the circuit wiring limit the reverse current in this loop. It may be necessary to adjust R_4 to obtain exactly 5-amperes peak reverse current (see Fig. 3B). After Q_1 is reverse biased for 12 μsec, its anode-to-cathode voltage passes through zero and builds up in the forward direction. If the turn-off time of the rectifier is less than 12 μsec (see Fig. 3C) it will remain turned off and the ammeter reading will return to zero. If not, the rectifier will turn back on and current will continue to flow through it until S_3 is opened. It will generally be necessary to adjust the value of C_1 to obtain a turn-off interval of exactly 12 μsec, as shown in Fig. 3C. The turn-off interval can be measured by observing the anode-to-cathode voltage of Q_1 on an oscilloscope. The time interval between closing S_1 and S_2 should be minimized to prevent overheating of R_2 and R_4. If the test rectifier fails to turn off, S_3 should be opened immediately to prevent overheating.

A noninductive high-frequency shunt must be used as R_2 to secure an accurate reverse-current measurement.

A 15-w current-pulse-viewing probe is satisfactory.[1, 2]

Figure 4B shows an inverter with capacitor turn-off that is isolated from the load. Its turn-off circuit has an advantage in that load-power-factor variations do not affect the turn-off time. The energy stored in commutating capacitor C_1, which is equal to $\frac{1}{2}(CE^2)$, increases as the load current increases because of autotransformer action. This is desirable in that commutating-energy requirements increase for higher currents at time of turn off. This circuit permits a smaller commutating capacitor and

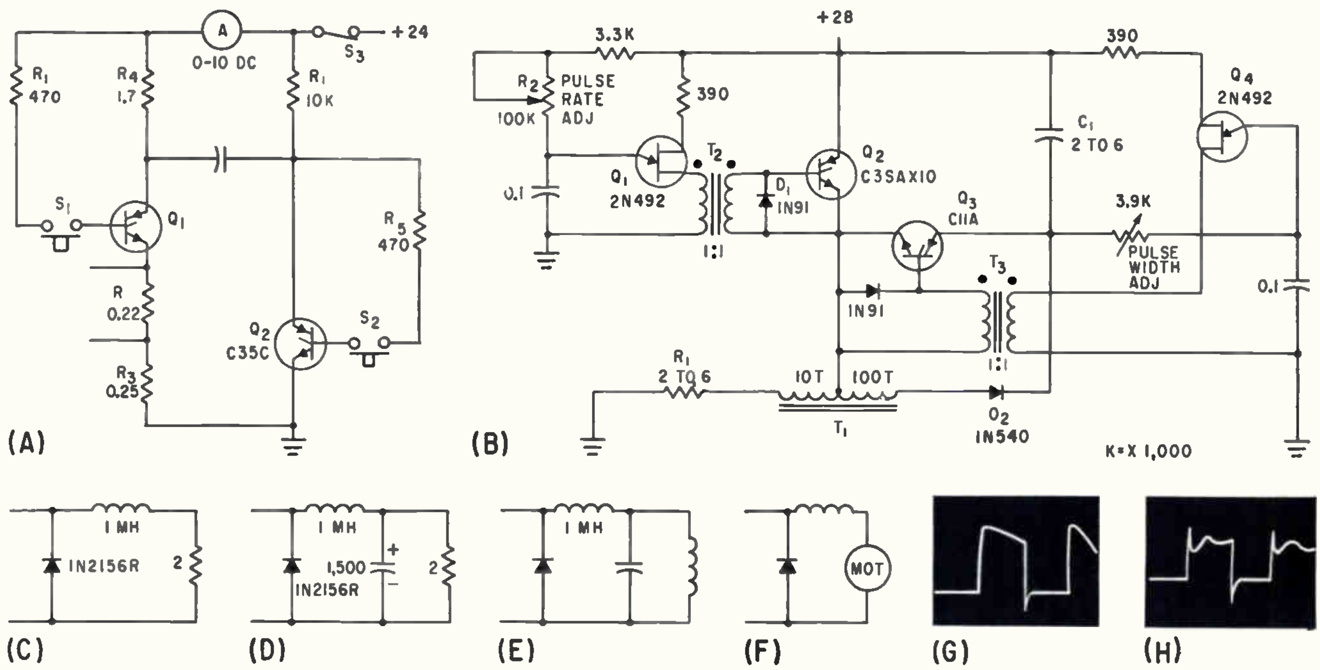

FIG. 4—Circuit for testing turn-off (A). Various loads may be used in inverter that is shown in (B); these include inductive (C), capacitive (D), resonant-tank (E) and d-c motor (F) loads. Waveshapes of (G) and (H) are for a 2-ohm-resistive load and the load of (C), respectively

operates more efficiently with varying load conditions.

When oscillator Q_1 turns on Q_2, current flows through autotransformer T_1 into the load (R_1). The autotransformer action charges C_1 so the voltage at the junction of C_1 and the anode of Q_3 is 6 to 30-volts more positive than the supply voltage, depending on the load current. This voltage on C_1 is the charging source for the relaxation oscillator, (Q_4) that turns on Q_3. When Q_3 goes on, it connects C_1 to the cathode of Q_2, making the cathode voltage of Q_2 more positive than its anode. Effectively, Q_2 is now reverse biased, and turns off. The conduction time of Q_2 can be adjusted by the trigger timing circuit of Q_3. Varying the trigger rate of Q_2 will vary the power delivered to the load. This trigger rate can be adjusted automatically for load regulation.

Using the higher voltage available on C_1 as a charging source permits higher frequency operation of the Q_3 triggering circuit and thus shorter conduction periods for Q_2. The diodes connected from the gate to the cathode of each controlled rectifier prevent negative pulses from reaching base one of the unijunction transistors; a negative pulse could cause a unijunction transistor to fire prematurely. Pulse transformers T_2 and T_3, which have 1:1 turns ratios, enable Q_1 and Q_4 to deliver more trigger power than with direct coupling because of the improved impedance match.

The C35AX10 is an inverter type with a fast turn-off characteristic. The C11A is a lower-current controlled rectifier with characteristics similar to the C35 series.

If a transformer couples the load in the circuit of Fig. 4B, it must be designed to handle a unidirectional current.

With a 2-ohm resistive load, the circuit requires that C_1 be at least 6 μf with an input of 280 w. The capacitor for C_1 must have low high-frequency impedance with a minimum of losses.

Various loads for the inverter of Fig. 4B are shown in Fig. 4C to 4F. The inductive load of Fig. 4C has 8.3 amperes for the controlled rectifier current at commutation time, compared to 11.3 amperes for a 2-ohm resistive load. At 8.3 amperes, a 4-μf capacitor is adequate for C_1. With this inductive load, Q_2 has a conduction time of about 230 μsec and is reverse biased for 14 μsec. The reverse current reaches 4.25 amperes in 0.5 μsec. Figures 4G and 4H show current waveshapes through Q_2 for a 2-ohm resistive load and for the inductive load of Fig. 4C, respectively.

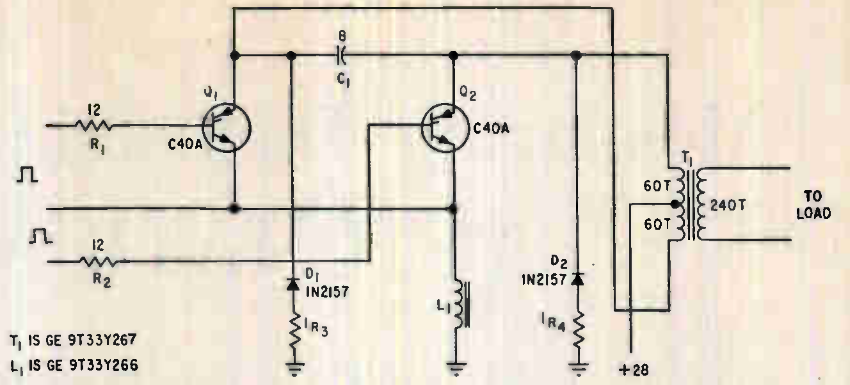

FIG. 5—This parallel inverter is well suited for driving different loads

The rectifier in Fig. 4C is a clamp which prevents the voltage from swinging below ground, thus decreasing the voltage requirements for the controlled rectifiers.

The capacitive load of Fig. 4D uses the series inductance to limit the current and also aids in filtering the d-c output. The forward and reverse currents are similar to that of Fig. 4H, with C_1 still 4 μf. The load of Fig. 4D gives an overall circuit efficiency of 80 to 90 percent. With this load a d-c to d-c converter with a variable output voltage can be varied from 1.5 to 21 v d-c by changing the repetition rate from 125 cps to 2.8 Kc. Spikes on the output have a peak-to-peak amplitude of 1.6 v. It would be easy to decrease ripple at these frequencies with additional filtering.

A regulated output can be achieved by a feedback network to adjust the repetition rate.

A resonant tank load (Fig. 4E) can be pulsed at its resonant frequency or for higher frequencies. For example, if the tank is resonant at 20 Kc, an inverter repetition rate of 2.5 Kc would pulse the tank circuit every eighth cycle.

The load of Fig. 4F would permit R_2 to control the speed of a d-c motor since the conduction time in the duty cycle can be varied from 14 to 85 percent.

Varying load conditions may present a problem for parallel inverter circuits. Since the amount of commutating capacitance is correct for only one load value, during light-load conditions reduced load current makes the waveform depart considerably from a square wave and the peak voltage across the controlled rectifiers can rise to several times the supply voltage. This condition is particularly bad for circuits designed for a lagging, low p-f load when the load p-f increases. Heavy loads could cause loss of commutation voltage and light loads could cause excessive voltage peaks across the controlled rectifiers.

The parallel inverter shown in Fig. 5, which was developed by W. McMurray and B. D. Bedford of the General Electric Engineering Laboratory, is uniquely suited for driving reactive loads. It produces what is essentially a square-wave output under all load conditions and does not create high voltages across the controlled rectifiers under light-load conditions. Feedback diodes D_1 and D_2 prevent the voltage across either half of the primary of T_1 from exceeding the supply voltage. The diodes maintain a square-wave output under all load conditions and permit use of lower-breakover-voltage controlled rectifiers. They also compensate for leading or lagging p-f loads by feeding reactive power back into the supply; thus, the size of commutating capacitor C_1, which depends on the maximum current to be commutated, need not be large.

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Measuring Dielectric Properties AUTOMATICALLY

Capacitance bridge balanced by servos produces continuous curves of dielectric properties as functions of temperature. Instrument eliminates interpolation of manually recorded data and allows higher rates of heating and cooling

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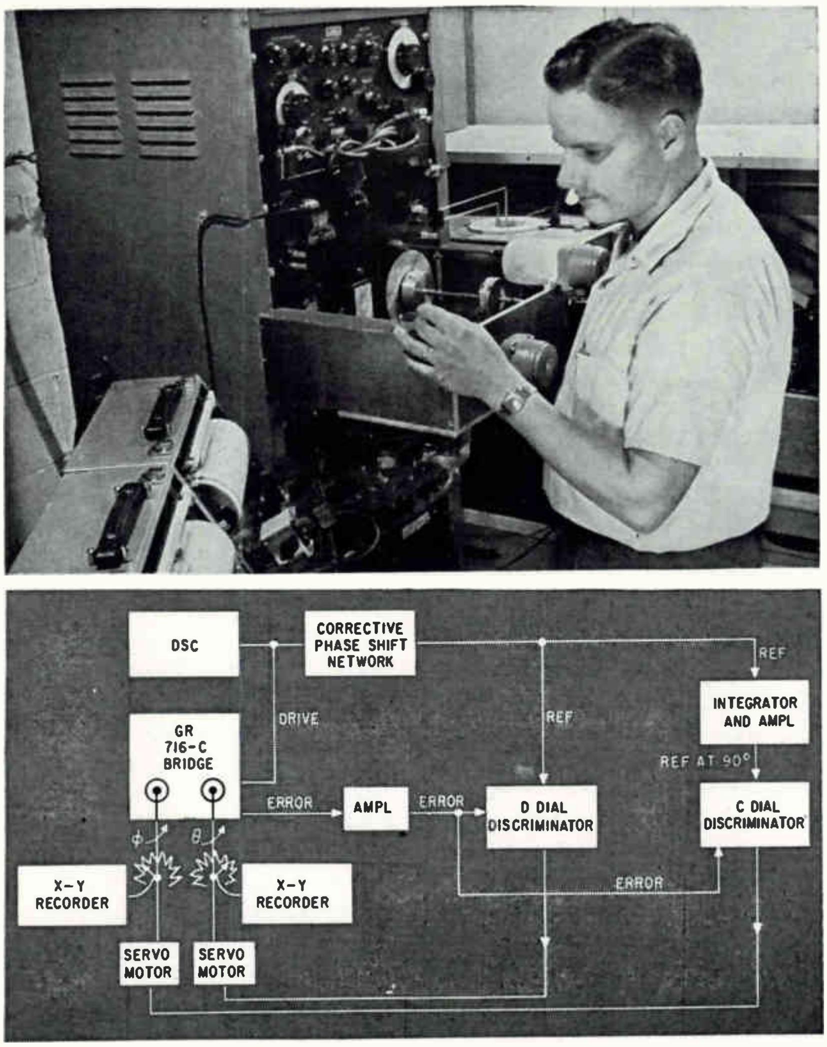


FIG. 1—Operator adjusts automatic balancing modification of capacitance bridge (top); block diagram (bottom) shows balancing servomotors

MANY SYSTEMS are available for measuring dielectric properties as a function of temperature, but the majority of these are manually operated. Continuous measurements at a low heating rate over a wide temperature range are expensive, because an operator must record the values over a period longer than a normal working day. Equally important but more difficult are measurements at high heating rates, especially on materials whose properties change rapidly with temperature. Measurements on materials undergoing thermal cycling are prohibitive for a complicated cycle or a moderate quantity of samples.

To circumvent these difficulties and contribute to the understanding of the physical phenomena associated with electrical behavior of ceramic materials, equipment was designed to automatically measure dielectric constant and dissipation factor with time and temperature as variables. The equipment records dielectric properties as continuous functions of the variables.

The equipment shown in the photo is a General Radio 716-C capacitance bridge with null-seeking servo systems added to keep the bridge in balance. Servomotors drive the balancing dials directly. Also coupled to the servomotor shafts are position-indicating potentiometers which feed an output voltage to X-Y recorders. This voltage is proportional to the positions

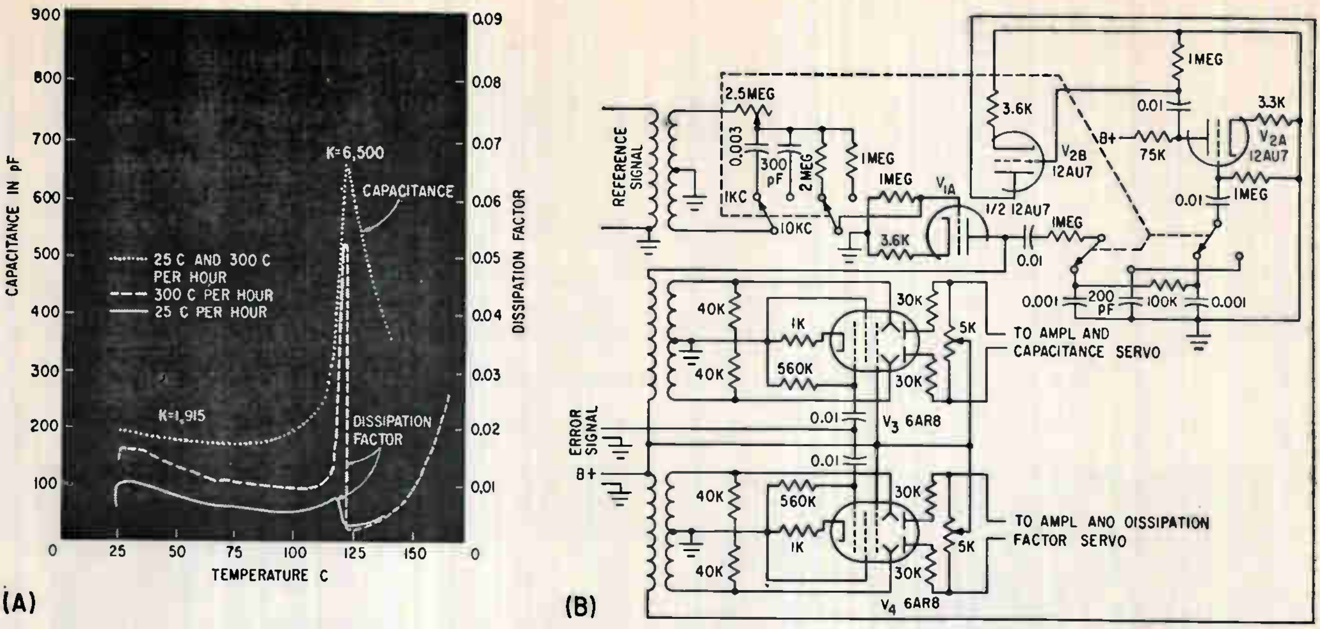


FIG. 2—Curves (A) display dielectric properties of $BaTiO_3$ as a function of temperature and heating rate; schematic (B) shows switches for operation at either 1 Kc or 10 Kc.

of the capacitance dial and the dissipation factor dial. Pressure-sensitive switches, actuated by the dissipation factor dial, advance the adder switch through a stepping relay and drive motor. A thermocouple voltage, or a voltage which is proportional to time, is fed to the other axis on the recorders.

The bridge is driven by the oscillator, and, when unbalanced, produces an error signal which is detected through the amplifier (Fig. 1, bottom). This signal has two quadrature components which may vary in sign depending upon the direction of unbalance of the two dials on the bridge. The dissipation factor discriminator senses the in-phase (or 180 deg out-of-phase) component relative to the reference signal and excites the servomotor to drive the dissipation factor dial until that part of the bridge is again in balance.

The reference signal is also fed to the capacitance discriminator after a 90-deg phase shift. This circuit now responds to the original quadrature components of the error signal from the bridge. Again, the servomotor drives the capacitance dial until the capacitance is balanced and no error signal is detected. The circuits in this particular equipment are designed to operate at 1 Kc and 10 Kc.

The curves in Fig. 2A show the effect of heating rate on the properties of barium titanate. The data for the curve taken at 25 C per hour would require six man-hours as opposed to less than one-half man-hour when automatic equipment is used. The data for the 300 C per hour curve are extremely difficult to obtain, if at all possible, without automatic equipment. This is a direct result of the difficulty of maintaining balance on manual equipment when properties are changing rapidly.

A researcher will often make measurements, plot the points and draw an average curve. A second-order effect or an effect of a minor constituent may thus be overlooked. A minor deviation detected with a continuous curve is shown in Fig. 2A. This deviation was accentuated by the higher heating rate.

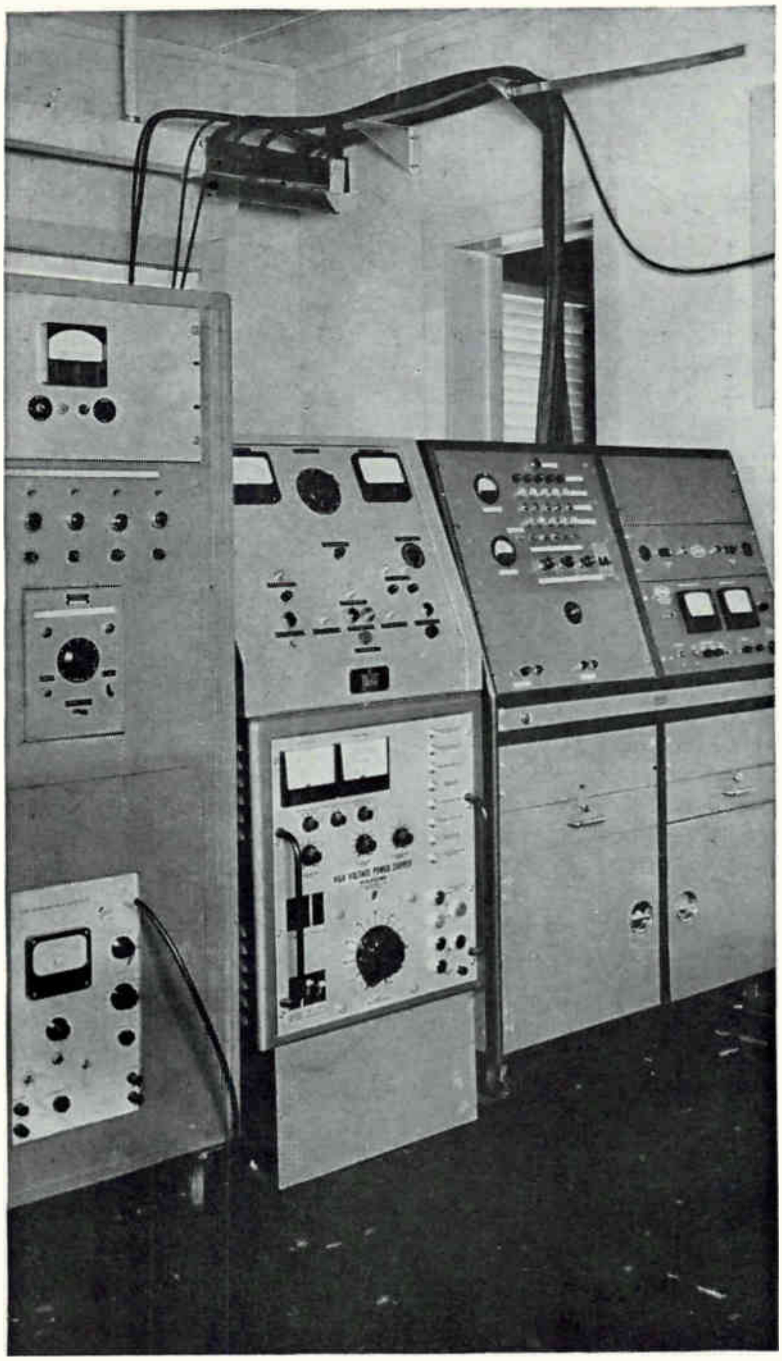
Referring to the schematic diagram of the phase discriminator and servo drive, Fig. 2B, the reference signal is transformer coupled into a phase-shifting circuit to compensate for phase shifts in the bridge and amplifier. The signal is then amplified in V_{1A} and transformer coupled to the deflection plates of V_3. The amplified signal from V_{1A} is also fed through an integrator to obtain a 90-deg phase shift. The phase shifted signal is amplified by V_{2A} and V_{2B} to its original amplitude and transformer coupled to the deflection plates of V_4. This phase shift is necessary for proper discrimination of the bridge error signal components.

Sheet beam tubes V_3 and V_4 are for gating applications. When a signal is applied to the control grid in-phase or 180 deg out-of-phase with the deflector voltage, an average d-c potential difference will develop between the plates of the tube. The polarity reverses when the phase of the control grid signal reverses. There is no potential difference when the control grid signal is in quadrature with the deflector voltage. Since the deflector voltages of V_3 and V_4 are 90 deg out of phase, each 6AR8 will respond to only one component of the bridge error signal, thereby providing the necessary discriminating action. The d-c voltage across the plates of V_3 is amplified and drives the servomotor in a direction corresponding to the polarity of the voltage. The servomotor turns the capacitance dial of the bridge until the bridge is balanced. When balance occurs, there is no longer an error signal of the particular phase to give a d-c voltage across the plates of V_3. Hence the motor stops when the bridge is balanced. The operation of V_4 is identical except that it responds to the resistive component of the signal and therefore rotates the dissipation factor dial to balance. Switches are used to open the servo loop and provide manual motor excitation.

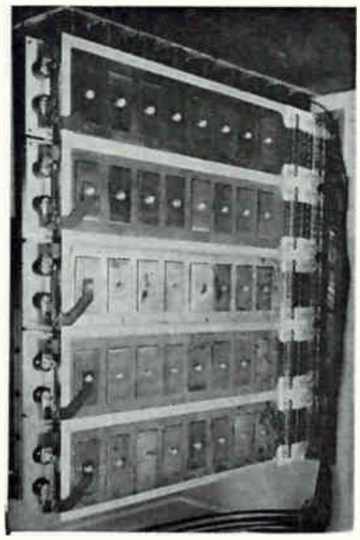
The equipment was developed by R. D. Robinson, B. Erickson, D. A. Felton, T. A. Ross, and the author.

Experimental 100,000 Joule

Capacitor bank, similar to the one described in this article, is one of the main components needed to produce extremely high magnetic fields and high-temperature plasmas. Design of a capacitor bank and some operating details are discussed



The capacitor bank main control removes safety handswitches shorting the bank section, trigger and firing capacitors; controls power to the capacitor bank; engages interlocks; and selects the desired bank section for use



Capacitor bank consists of five sets of eight high-voltage, low-inductance capacitors connected in parallel

A CAPACITOR BANK is a special kind of energy-storage device that is useful in applications where energy must be released in extremely short times[1,2]. The quality of a capacitor bank may be characterized by stored energy, ringing frequency and maximum current.

Stored energy

$$E = CV_o^2/2 = QV_o/_2 [\text{joules}] \qquad (1)$$

Ringing frequency

$$\nu = 1/\tau = 1/[2\pi\sqrt{(1/LC) - (R^2/4L^2)}]$$
$$\approx 1/[2\pi\sqrt{1/LC}] (\text{sec}^{-1}) \qquad (2)$$

Maximum current

$$I_{max} = V_o/\sqrt{R^2 + L/C} \approx V_o\sqrt{C/L} [\text{amp}] \qquad (3)$$

where C = capacitance in farads, V_o = voltage applied to the bank, Q = charge in coulombs, τ = period in seconds, L = inductance in henries, and R = resistance in ohms. The resistance R in Eq. 2 and 3 is given by

$$R = (2L/\tau)[ln(a_n/a_{n+2})] \qquad (4)$$

where a_n and a_{n+2} are two successive

Capacitor Bank for Plasma Research

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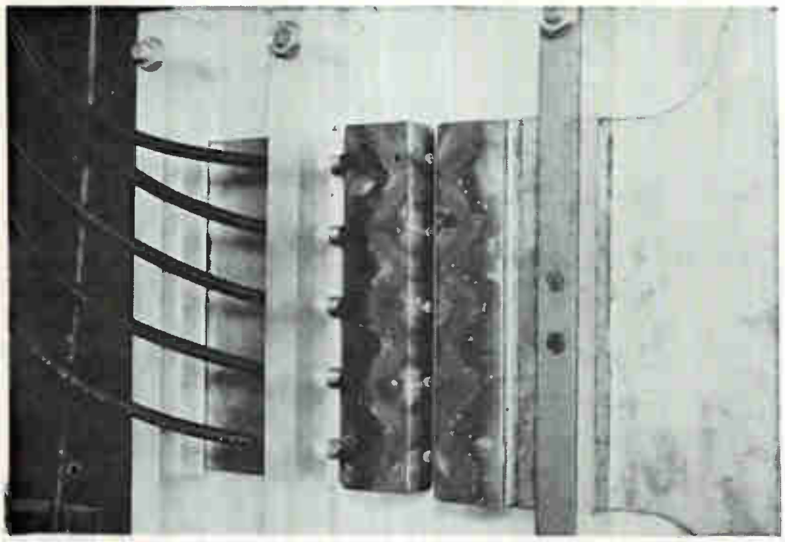

Adjustment of bank airgap switch is very critical as all five pins must fire simultaneously to produce a uniformly distributed plasma. When uniform current distribution exists in the airgap, minimum induction and corrosion exists

Bank airgap switch before firing

Firing of bank airgap switch, bank uncharged

Firing of bank airgap switch, proper adjustment

Firing of bank airgap switch, improper adjustment

current amplitudes having the same sign.

There are two possible arrangements in constructing a fast capacitor bank; a circularly symmetrical arrangement, using coaxial cable connections as shown in Fig. 1A; and a linearly symmetrical arrangement, using transmission-line connections as shown in Fig. 1B. Both capacitor bank arrangements have been built and are being used.

In the circular symmetry arrangement, the inductance equals

$$L_{sum} = (L_1/n) + (L_2/n) + L_s + L_L \quad (5)$$

where L_1 = inductance of one capacitor, L_2 = inductance of one cable, L_S = inductance of one switch, L_L = inductance of the load, and n = number of capacitors.

Inductance L_2 is equal to lL_{20} (where l = the cable length in centimeters, L_{20} is expressed by

$$L_{20} = 10^{-9}[[2\ ln(b/a)] + [1 + (b^2/a^2)]^2 \; ln[1 + (a^2/b^2)] - (b^2/a^2) - 1] \; [\text{henries/cm}] \quad (6)$$

where a = inside radius (Fig. 2A) and b = outside radius.

Inductances L_1, L_2, and L_s are given quantities. The selection of commercial capacitors and cables with low inductance is limited. If the capacitors (having a narrow side A) are placed along the circumference of a circle of radius l, $2\pi l/A = n$ capacitors can be arranged. Then

$$L_{sum} = (L_1/n) + [L_{20}(A/2\pi)] + L_s + L_L \quad (7)$$
$$C_{sum} = nC_1$$

where C_1 = capacitance of one capacitor.

The ringing frequency (no load, terminals shortened) is

$$\nu = (1/2\pi) \sqrt{1/[(L_1C_1) + [nL_{20}(A/2\pi)C_1] + nC_1L_s]} \quad (8)$$

Value ν can be improved (achieve higher frequencies) by using a number of switches in parallel. If m parallel switches, are used, nC_1L_s in Eq. 8 is replaced by nC_1L_s/m.

The disadvantage of this circularly symmetrical arrangement

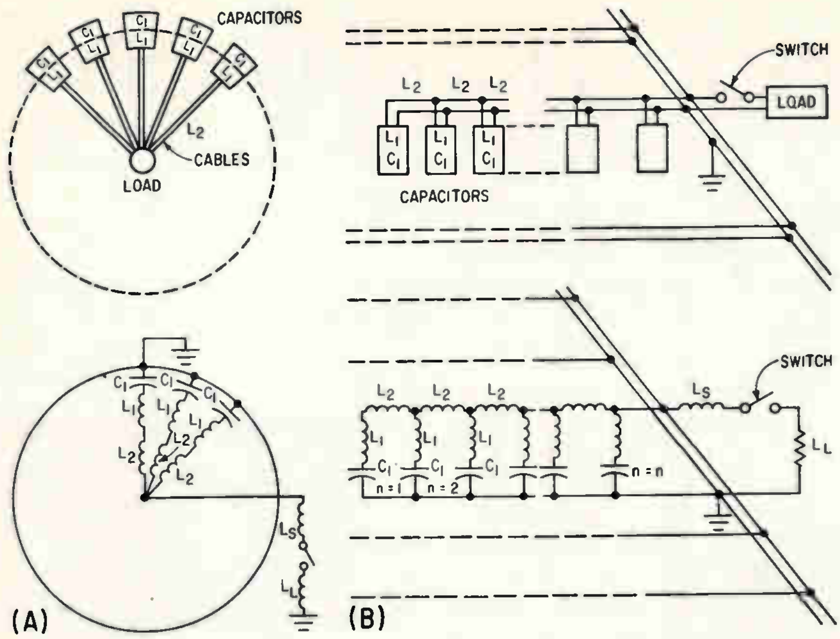

FIG. 1—Circularly symmetrical capacitor bank (A) compared with linearly symmetrical arrangement (B)

is the need for a large space. The most convenient location is a two-story building, wherein the capacitor bank would be on the first floor and the experimental setup on the second.

The linear symmetry arrangement, a linear filter network, is physically more concentrated than the circularly symmetrical arrangement. Calculation of the ringing frequency is more complicated for linear symmetry than for the other type. It starts with the notation L_1, C_1, L_s, and $L_2 = lL_{20}$

$$L_{20} = \mu_o d/w \text{ [henries/cm]} \quad (9)$$

where l = length of the transmission line, d = separation of the plates, w = width of the plates and μ_o is equal to the permeability of the vacuum.

The current carried by section n of the network after the switch is closed consists of current components from all sections. Each section oscillates with a given ringing frequency (so called eigenfrequency). The frequency of section i (not considering L_s, L_L) is

$$\nu_i = \frac{1}{2\pi}\sqrt{\frac{2(1-\cos i\pi/n)}{2L_1C_1(1-\cos i\pi/n)+L_2C_1}} \quad (10)$$

As a lower limit for the ringing frequency, select the minimum frequency of the n sections. For the case $n = 8$

$$\nu_{min} = (1/2\pi)\sqrt{(0.16)/(0.16L_1C_1+L_2C_1)} \quad (11)$$

If $L_2C_1 \ll 0.16L_1C_1$ $\nu = (1/2\pi)\sqrt{1/(L_1C_1)}$

Comparing both types of banks with respect to r-f, there is no essential difference provided low-inductance cables (term L_{20} in Eq. 8) for high voltages and accessories are used for the one type, and a proper transmission line (term L_2 in Eq. 10) is used for the other type. In view of limited room conditions, a combined system as shown in Fig. 1B (several linear systems in parallel) offers the most compact arrangement. Disregarding cables and transmission lines, the switch has the greatest r-f influence.

A number of switches have been designed for fusion research: Scylla switch (Los Alamos)[3], air-gap switch (Kolb)[4] and plasma switch (Bostick)[5]. Every switch adds some inductance to the circuit. The desirable properties of a switch are low corrosion at currents up to 100 kiloamps, rugged construction, exchangeability, low inductance and good reliability.

After deciding in favor of the linearly-symmetrical arrangement, the airgap switch was selected for geometrical reasons. If the arcing across the gap takes place at only one spot, the following expression for inductance is approximately true (Fig. 2B)

$$L_s = 10^{-9}\left[4f\left(ln\frac{d}{c}+\frac{1}{4}\right)\right] \text{[henries]} \quad (12)$$

where f = length of discharge channel, c = diameter of discharge channel and d = distance of the two conducting paths.

If the breakdown within the airgap is started simultaneously at m points

$$L_s^1 = L_s/m \quad (13)$$

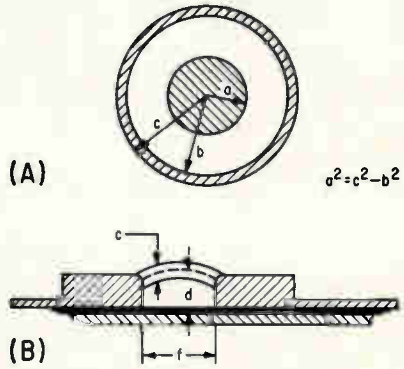

FIG. 2—Cross section of cable (A) and schematic of air gap (B)

Every breakdown process has its characteristic buildup time t as a function of the special discharge mechanism. To avoid statistical fluctuations in time and space, the relation $t << \tau$ is sought. Using Townsend's theory[6]

$$t = 1/v[\alpha - (1/f)[ln\,(1/\gamma) + 1]] \quad (14)$$

where α = first Townsend coefficient, γ = second Townsend coefficient and v = velocity of the electrons [cm/sec].

The complete capacitor bank installation shown in Fig. 3A, consists of two parts: the bank and the

CHARACTERISTICS OF CAPACITOR BANK

	Capacitor (μf)	Ring. Freq. ν (Kc)	Inductivity (μh)	Resistance (ohms)	Max. Current I (amp)
1 Capacitor Unit	12	200 – 10%	≈0.05	....	....
1 Bank Section	8 × 12	≈130	≈0.015	≈10^{-3}	1.6 × 10^6
5 Bank Sections in Parallel	5 × 8 × 12	≈130	≈0.015	≈10^{-3}	8 × 10^6

trigger systems, and the control system. The bank is composed of 40 capacitors, assembled in 5 sections, which can be discharged singly or in parallel. Each section has its own charge relays whereby connections are made to the charge equipment, and its airgap switch that connects the section to the main collector plate. The airgap switches are fired by a special trigger system.

The 5 sections of the bank are identical, each one consisting of 8 high-voltage low-inductance capacitors connected in parallel by a low-inductance transmission line. The sections lead to a common collector plate. The high-voltage end of the conductor is broken by an airgap switch, which is triggered by 5 insulated pins in the load-side part of the switch.

The bank section is charged through a relay and a high-voltage, double-pole single-throw switch that connects the charging equipment to the bank section. The OFF position of the switch grounds the bank through the charge resistors. Four resistors are used; if one fails, the bank is grounded through the other three. Hand switches are used to short circuit the bank when it is not used. As a main safety device, a pressure switch is mounted on the back of each capacitor. If a capacitor failure causes an increase of pressure to 3 atmospheres, the switch closes and actuates a red light on the capacitor and on the control panel of the bank. In addition, the power line of the corresponding relay is opened to prevent charging the bank section. A defective capacitor can be replaced from the rear of the rack after the pressure is released.

Two timing problems had to be solved. First, was firing the bank with an adjustable time delay against a zero pulse (used to trigger oscilloscope displays and the discharge of a second small capacitor bank) and second, to have adjustable delay between the firing of the bank sections to vary the shape of the bank discharge current.

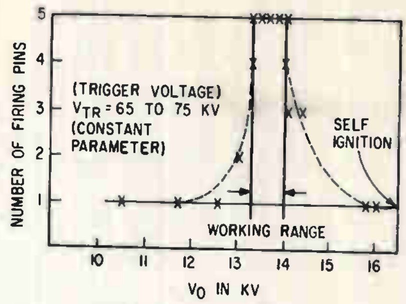

FIG. 4—Typical switch firing characteristics at given airgap and trigger voltage

Figure 3B shows a diagram which is similar to a counter circuit. Two bistable flip-flop circuits in series act as a frequency divider. For trigger action the input is connected to a pulse generator. Three outputs deliver pulses with time distances related to the input frequencies. For adaption to the 60-ohm output cables, every output has a thyratron cathode follower. Only a single pulse goes out after triggering because the time constant of the anode circuit is high. One of the three pulses triggers the bank. For amplification a second thyratron discharges a 20-Kv capacitor through the primary of a pulse transformer. Its secondary voltage triggers the airgap switch of the main trigger capacitor to which the 25 parallel-connected trigger pins of the bank airgap switches are connected. Filter networks in the leads provide the delay between the bank sections.

Figure 4 illustrates the typical firing characteristics of a switch at a given airgap and trigger voltage. The table gives characteristic values of the USASRDL capacitor bank, as calculated from experimental data.

The authors acknowledge the assistance of I. A. Balton and staff.

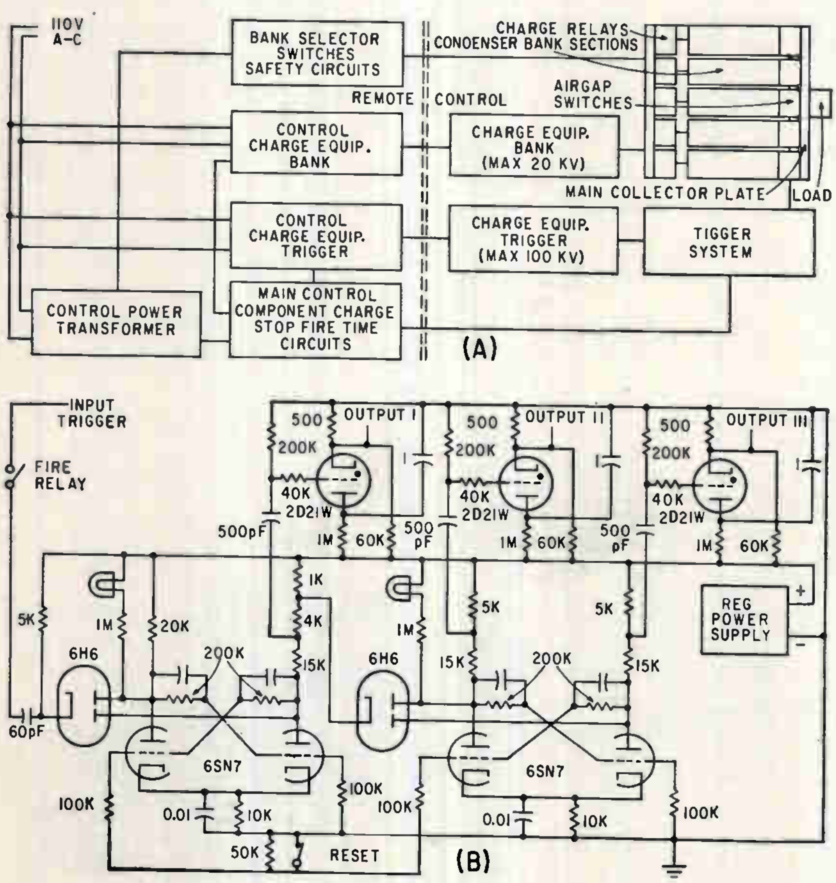

FIG. 3—Capacitor bank (A) consists of bank and trigger systems. Bank trigger (B) uses two flip-flops as frequency divider

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Tracing Tunnel Diode Curves

Diode holder uses germanium blocks for low inductance resistors, allows a curve tracer that will show the characteristic curves of most tunnel diodes

By H. G. DILL,
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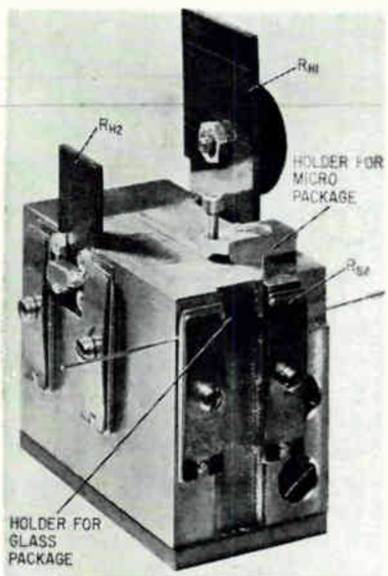


Diode holder uses germanium blocks for resistors to keep inductance low, can be used with both types of diode packages

MAJOR PROBLEMS in tracing the negative resistance region of tunnel diodes are circuit instability and the high admittance of the devices. Attention to the details of the diode holder is necessary if switching and oscillation are to be prevented.

The voltage-current diagram supplies useful information about tunnel diodes and other two terminal devices. Design parameters that can be taken from such curves are current ratings, peak-to-valley ratio and resistance over the whole voltage range including the negative resistance region.

Often it is difficult to trace the negative resistance region because of stability problems. Included in Fig. 1A is the equivalent circuit of a tunnel diode; its impedance is given by

$$Z = \omega L_S + R_S + 1/(j\omega C_T - g_T)$$
$$= R + jX$$
$$R = R_S - g_T/(g_T^2 + \omega^2 C_T^2)$$
$$X = \omega[L_S - C_T/(g_T^2 + \omega^2 C_T^2)]$$

The solutions in ω for the real part R and the imaginary part X are

$$\omega_R = \frac{g_T}{C_T}\sqrt{\frac{1}{R_S g_T} - 1}$$

$$\omega_X = \frac{1}{C_T}\sqrt{\frac{C_T}{L_S} - g_T^2}$$

The frequency where the real part of Z disappears is ω_R. For ω smaller than ω_R, the input resistance is negative

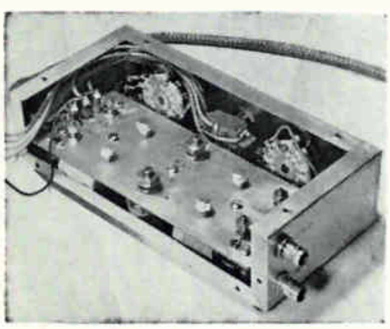
$$Z = -R + jX$$

For ω greater than ω_R, the input resistance is positive

$$Z = +R + jX$$

Resonant frequency of the equivalent circuit is ω_X. All possible modes of operation are shown in Fig. 1A, which also indicates the two conditions necessary for stable operation. The d-c stability condition is obtained for R_S less than $1/g_T$. If this condition is not fulfilled the tunnel diode behaves as a switch and cannot be biased in the negative resistance region. If the second condition, R_S greater than $L_S\, g_T/C_T$, is not fulfilled the tunnel diode circuit will oscillate in the negative resistance region.

The stability considerations derived from Fig. 1A are valid only as long as ω_X is a real solution. The region of stable operation disappears for $C_T/L_S \leqq g_T^2$. This leads to the basic condition for stable operation, $L_S < L_{Smax}$, where $L_{Smax} = C_T/g_T^2$. This requirement can be fulfilled with present tunnel diodes in a curve tracer cir-



Horizontal and vertical amplifier chassis

Diode holder and amplifiers are separated from power supply and sweep generator

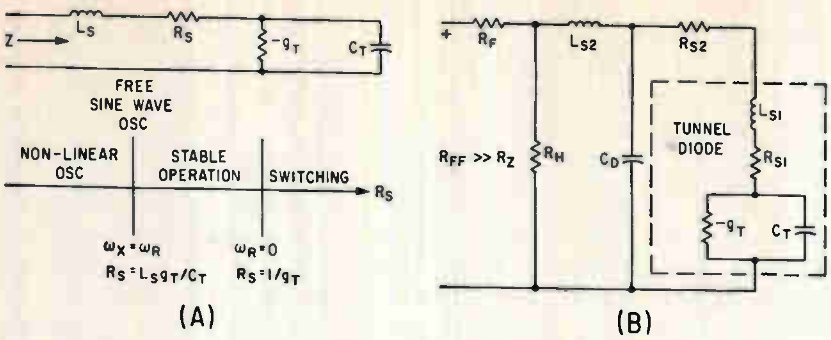


FIG. 1—Tunnel diode equivalent circuit and diode stability conditions (A); diode measuring circuit (B)

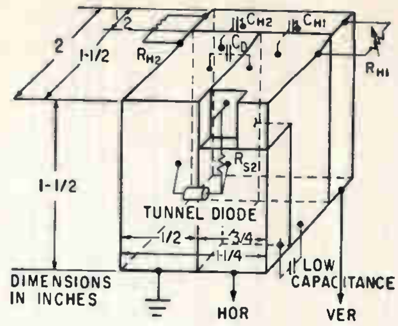


FIG. 2—Holder for the glass package can be used with TO 18 package

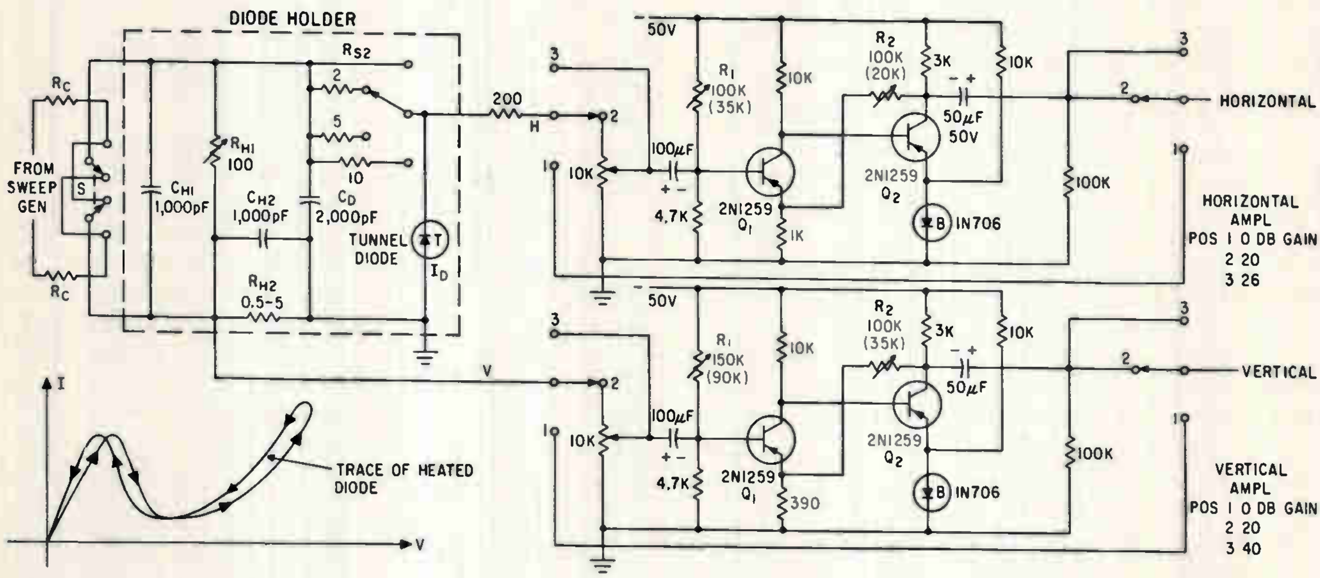


FIG. 3—Diode holder circuit and amplifier circuits. Diode heating causes a shift in characteristic as shown in inset

cuit. Figure 1B shows a tunnel diode in a test circuit which allows stable biasing in the negative resistance region.

If capacitor C_D of Fig. 1B is removed, the condition for stability is

$$L_S g_T / C_T < R_S + R_H < 1/g_T$$

where $R_S = R_{S1} + R_{S2}$ and $L_S = L_{S1} + L_{S2}$. The d-c condition $R_S + R_H < 1/g_T$ is easy to fulfill if the tunnel diode does not have an extremely high g_T. The a-c condition $L_S\, g_T/C_T < R_S + R_H$ may introduce a problem if L_S is too high.

But there are drawbacks to the arrangement produced by removing C_D. Resistor R_H must be mounted close to the tunnel diode to keep L_{S2} low. This is not desirable if the tunnel diode is tested at different ambient temperatures. Changes in R_H from temperature variations may cause instability. The resistor R_H itself may have an undesirable inductive effect. In addition, for each tunnel diode the a-c and d-c stability conditions have to be adjusted.

A capacitor across the tunnel diode allows the a-c and d-c stability conditions to be treated separately. If C_D is big enough to provide a short in the oscillatory range, L_{S2} can be neglected and R_H can be located in a convenient place.

If the a-c stability criterion $R_{S1} > L_{S1}\, g_T/C_T$ is not fulfilled, R_{S1} is increased by a small resistor R_{S2}. To keep the inductance L_{S1} low, a germanium block is used for R_{S2}.

The diode holder produces output signals proportional to the voltage and current of the test diodes, and stabilizes the diode in the negative resistance region.

A diagram of the diode holder is shown in Fig. 2 and the circuit diagram of the holder is shown in Fig. 3. Resistor R_{H2} produces a voltage drop proportional to the diode current I_D. The diode holder is grounded so that no measurement error is introduced by R_{H2}. The d-c stability can be adjusted with R_{H1} alone if R_{H1} is much greater than R_{H2}. This arrangement has the advantage of using the lowest amount of sweep power.

The photograph and the diagram (Fig. 2) of the diode holder show how the capacitor C_D and germanium resistor R_{S2} are arranged to keep the loop inductance as low as possible. Capacitor C_{H1} and C_{H2} are not absolutely necessary but increase the stability of the jig against undesired oscillation.

Capacitors C_D, C_{H1} and C_{H2} are produced by a thin layer of mica between brass blocks. Practical design was complicated by two problems. The 0.5 mil mica between the brass blocks usually produced a short circuit as soon as pressure was applied. Hard dust particles and an uneven surface cause high specific pressure in certain areas and puncture the insulation. The air space between the uneven brass surfaces reduces the capacitance considerably, since the dielectric constant for mica is approximately seven times as large as for air.

Both problems were solved by applying a thin film of silicone oil between the mica and brass surfaces; since the liquid distributes the pressure equally over the whole surface the short circuits were eliminated and the capacitance increased considerably.

For diodes in micro packages the holder has such a low inductance that most diodes are stable without additional resistance R_{B2}. For diodes in glass or TO 18 packages, a pressure holder with interchangeable germanium resistors R_{B2} is used. No detectable phase shift of the sweep voltage is introduced by C_D, C_{B1} or C_{B2}.

With a stabilized tunnel diode and a d-c power supply, it is possible to plot the static V-I diagram. The same diagram can be displayed on an oscilloscope if a sweep voltage with the proper repetition rate drives the diode. The waveform need not be linear if horizontal and vertical deflection are taken from the same source. The sweep generator produces a shunt-rectified sine wave as shown in Fig. 4A.

Heating effects in some diodes may cause a double trace as shown in the inset of Fig. 3. Reducing the power dissipation in the diode reduces the heating and can be done by using just the shaded portion of the wave in Fig. 4B.

Figure 4C indicates how the fast rising part of a sine wave is produced. A power transistor in series with a sine wave generator is switched on only during the fast rising part of the sine wave. A Schmitt trigger produces the square waves to drive the power switch. Switching time is adjusted by a phase-shift network and the variable width pulse from the Schmitt trigger. The power transistor is back biased to insure a low leakage current. Figure 4D shows the circuit of the complete sweep generator.

If $2R_C$ (Fig. 4D) is much greater than R_{B1} (Fig. 3) the sweep generator does not affect the stability of the diode holder. Maximum peak currents of 0.6 amp are sufficient for most tunnel diodes. The polarity switch in Fig. 3 allows the diode to be swept in the reverse or forward direction.

The condition $R_{B2} << R_{B1}$ (Fig. 3) can be satisfied for a wide current range if R_{B2} is chosen small enough (about 1 ohm). The low signal across R_{B2} can be boosted with a vertical amplifier, with the ultimate limitation being hum and noise. The horizontal output uses an amplifier to overcome the low horizontal sensitivity of some oscilloscopes.

Horizontal deflection is proportioned to the voltage across the tunnel diode and can be measured with a calibrated oscilloscope. Vertical deflection is proportional to the current I_D (Fig. 3): for a known R_{B2}, I_D can be calculated.

Figure 1B shows how capacitor C_D produces a short across the tunnel diode in the oscillatory range. This allows R_B to be located away from the diode where temperature variations are negligible.

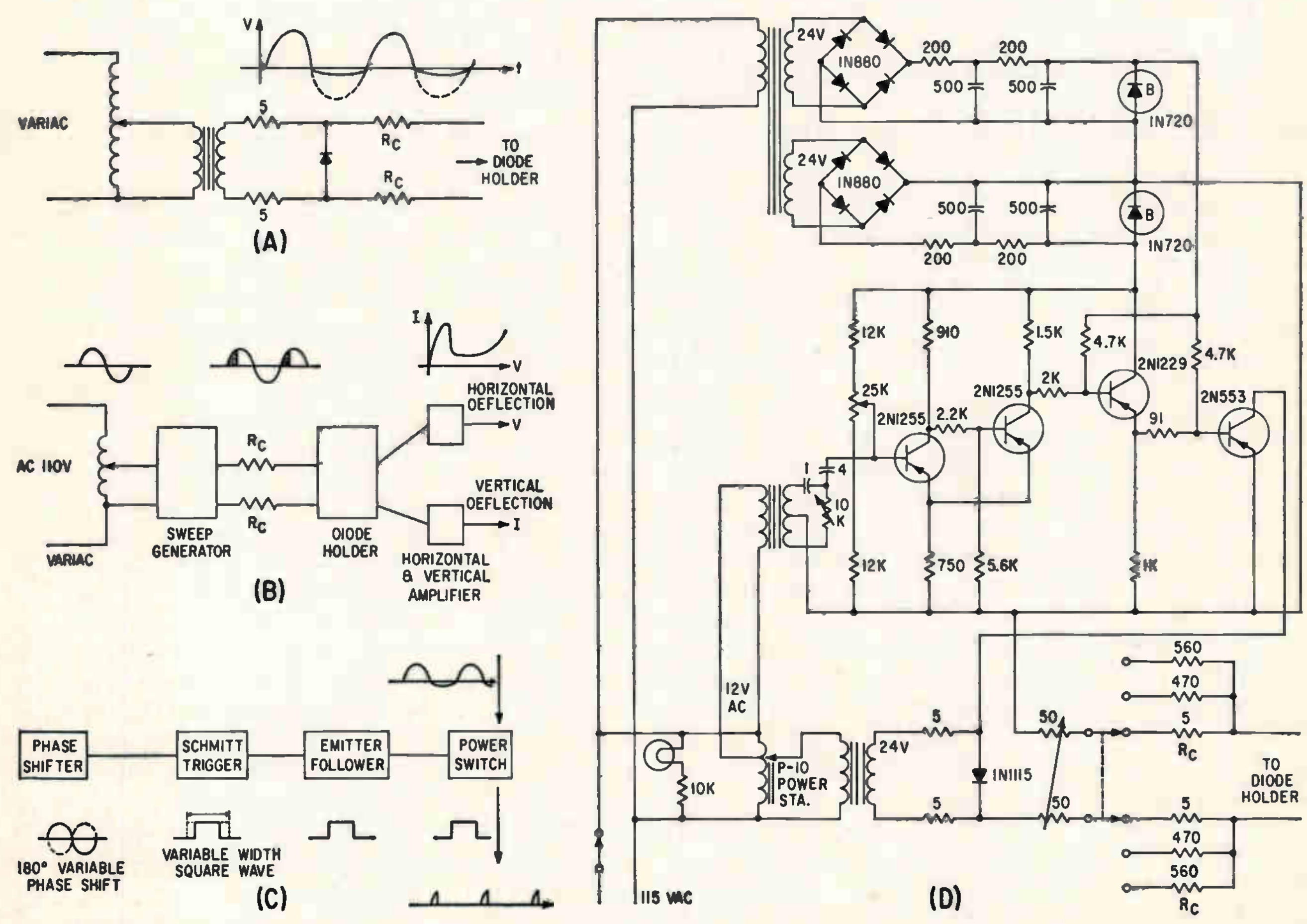


FIG. 4—Shunt rectifier of the sweep generator is shown in (A). Only cross-hatched portion of the waveform (B used. In (C) pulse from the Schmitt trigger controls the sweep waveform. Complete sweep circuit (D)

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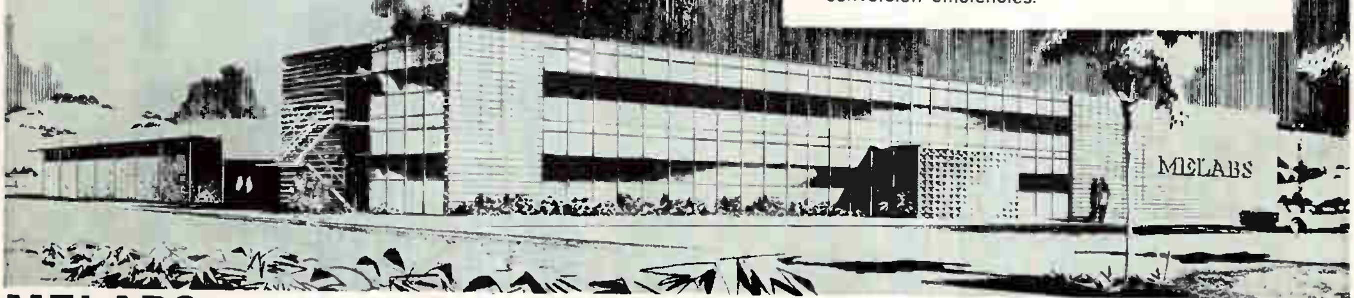

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Calculations are simplified if radiation cooling alone is considered; the problem is then solved by using a flat plate as the heat sink for all transistors

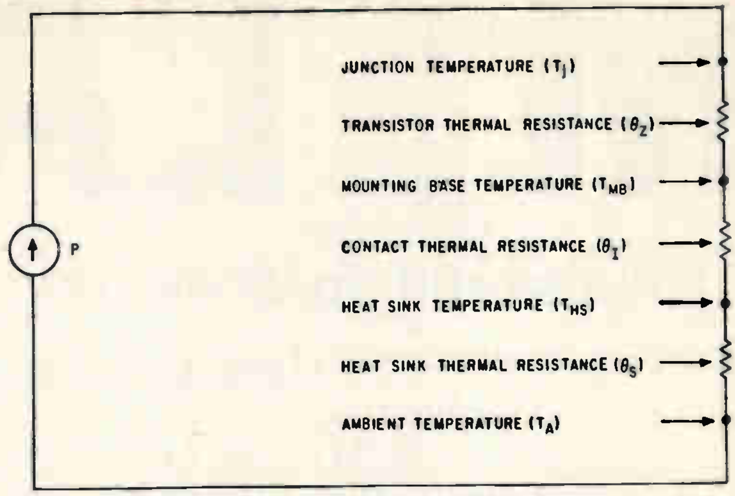

FIG. 1—Equivalent circuit of transitor heat-transfer path

Transistor Heat Sink Calculations

By MYRON GREENBAUM,
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Long Island City, N. Y.

CIRCUIT DESIGN engineers are often called upon to calculate the heat-sink area required to cool power transistors. The problem can be complex if radiation, convection, and conduction of heat are taken into account[1]. Usually the problem is simplified by considering only radiation, and the heat sink is then designed on the basis of a flat plate. Various techniques have been developed using this method[2], but the method is simple only if the heat sink is to dissipate the heat developed by one transistor. Often, a heat sink is required to dissipate the heat of several transistors, each dissipating different amounts of power.

The electric analog of the thermal problem will be considered. Power P will be considered as a constant current generator, temperature T as a voltage, and thermal resistance θ as an electrical resistance. The transistor mounted on a heat sink can therefore be studied as an equivalent circuit, see Fig. 1. Thermal potential (temperature difference) across the current generator is then

$$T_j - T_a = P\,(\theta_z + \theta_I + \theta_s) \qquad (1)$$

Junction temperature T_j, is a function of the power dissipated by the transistor. The maximum power that can be developed by the transistor is limited by the maximum junction temperature, $T_{j\,max}$.

The transistor thermal resistance, θ_z, is expressed in dimensions of degrees centigrade temperature rise per watt of dissipated power. It is a function of the transistor construction, and is specified by the transistor manufacturer.

The contact thermal resistance, θ_I, is a function of the type of contact between the transistor mounting base and the heat sink, for example, a dry metal-to-metal contact gives $\theta_I = 0.5$ degree centigrade per watt and when lubricated with Dow Corning No. 4 Silicone Compound it becomes $\theta_I = 0.3$ degrees C/watt.

The thermal resistance, θ_s, between the heat sink and its environment involves the finish, shape, color and area of the material. Curves relating θ_s and heat sink area for ⅛-inch thick, bright and black anodized aluminum are shown in Fig. 3. These curves were obtained from experimental test data.

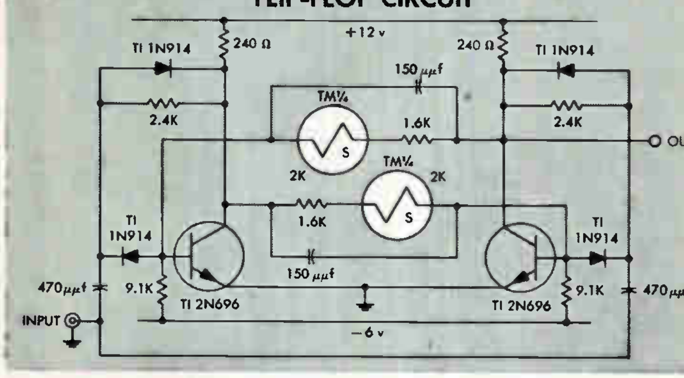
Hence when maximum values of T_j, T_a, P, θ_z and θ_I are known, substitution in Eq. 1 gives the value of θ_s. By consulting curves of θ_s versus heat-sink area, the appropriate radiating area can be found. The inverse problem can also be solved, that is, the value of T_j when the heat sink area or θ_s is known.

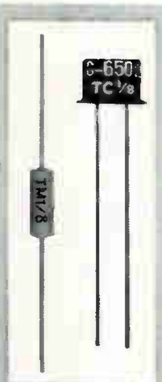
When several transistors are to be mounted on one heat sink, a new equivalent circuit must be considered. Assume each transistor is mounted on a separate heat sink and power is applied to each transistor, as in Fig. 2A. The areas of the individual heat sinks are then varied until all the heat-sink temperatures (T_{hs}) are the same. The individual heat sinks can then be connected, and for material having perfect thermal conductivity, the entire heat sink will have the same equilibrium temperature, T_{hs}. Using this analysis all T_{hs} points of the individual equivalent circuits can be connected. See Fig. 2B.

The thermal drop across θ_s

How to compensate for temperature variation in a transistorized flip-flop

FLIP-FLOP CIRCUIT





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Type No.	Wattage Rating	Body Dimensions	
	W	Length	Diameter
TM ¼	¼	0.585"	0.200"
TM ⅛	⅛	0.406"	0.140"
TC ⅛	⅛	TO—5 Transistor Package	
P-100†	—	0.500"	0.078"

† Hermetically sealed glass package for instrumentation and temperature control available in resistances of 100 ohms, 500 ohms and 1000 ohms ±10% measured at 25°C

This flip-flop circuit, designed by Texas Instruments, uses *sensistor*® silicon resistors in the cross-coupling network to compensate for increases in h_{FE} with temperature. At 125°C, it resolves 100 mμsec input pulses arriving at a 5 mc rate whereas a fixed resistor version was limited to 3.6 mc. In addition, at +125°C the circuit will operate at a resolution rate greater than 5 mc if the input pulse can be greater than 10 volts when the pulse width is decreased from 100 mμsec.

Another advantage of *sensistor* silicon resistors in a flip-flop using high h_{FE} transistors is the reduction in input voltage required to trigger at high temperatures. For instance, the *sensistor* silicon resistor circuit requires only 10 volts to trigger whereas the fixed resistor circuit required 14 volts.

Sensistor silicon resistors are temperature-sensitive devices that feature a positive temperature coefficient of +0.7% per °C. This predictable rate of resistance change makes *sensistor* resistors ideal for temperature compensation from —50°C to +200°C at frequencies up to 20 Kmc.

The *sensistor* silicon resistor, developed by TI, provides circuit design engineers with a lightweight temperature compensating and sensing device. Commercially available for over two years, the devices have been used successfully for bias stabilization in a-c coupled stages and in the first stages of d-c amplifiers; and have found wide application in amplifiers, power supplies, servos, telemetry, magnetic amplifiers, computer switching, and thermometry.

In addition, specify from this complete line of TI precision film resistors.

MOLDED

±1% tol

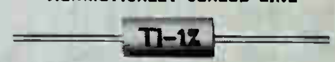
TI type number	wattage rating watts	MIL desig-nation	standard resistance ranges	max. recom-mended voltage volts
CDM⅛	⅛	RN60B	10 Ohm-1 Meg	350
CDM¼	¼	RN65B	10 Ohm-1 Meg	500
CDM½	½	RN70B	10 Ohm-5 Meg	750
CDM 1	1	RN75B	10 Ohm-10 Meg	1000
CDM 2	2	RN80B	50 Ohm-50 Meg	2000

MIL-LINE

±1% tol

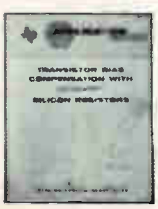
TI type number	wattage rating watts	MIL desig-nation	standard resistance ranges	max. recom-mended voltage volts
CD⅛R	⅛	—	10 Ohm-1 Meg	350
CD¼R	¼	RN10X	10 Ohm-1 Meg	500
CD½PR	½	RN15X	10 Ohm-3 Meg	650
CD½MR	½	RN20X	10 Ohm-5 Meg	750
CD½SR	½	—	50 Ohm-10 Meg	850
CD1R	1	RN25X	10 Ohm-10 Meg	1000
CD2R	2	RN30X	50 Ohm-50 Meg	2000

HERMETICALLY SEALED LINE



±1% tol

TI type number	wattage rating watts	MIL desig-nation	standard resistance ranges	max. recom-mended voltage volts
CDH⅛M	⅛	—	10 Ohm-500K	250
CDH⅛	⅛	RN60B	10 Ohm-1 Meg	350
CDH¼	¼	RN65B	10 Ohm-1 Meg	500
CDH½P	½	—	10 Ohm-3 Meg	650
CDH½A	½	RN65B	10 Ohm-3 Meg	650
CDH½M	½	RN70B	10 Ohm-5 Meg	750
CDH½S	½	—	50 Ohm-10 Meg	850
CDH 1	1	RN75B	10 Ohm-10 Meg	1000
CDH 2	2	RN80B	50 Ohm-50 Meg	2000



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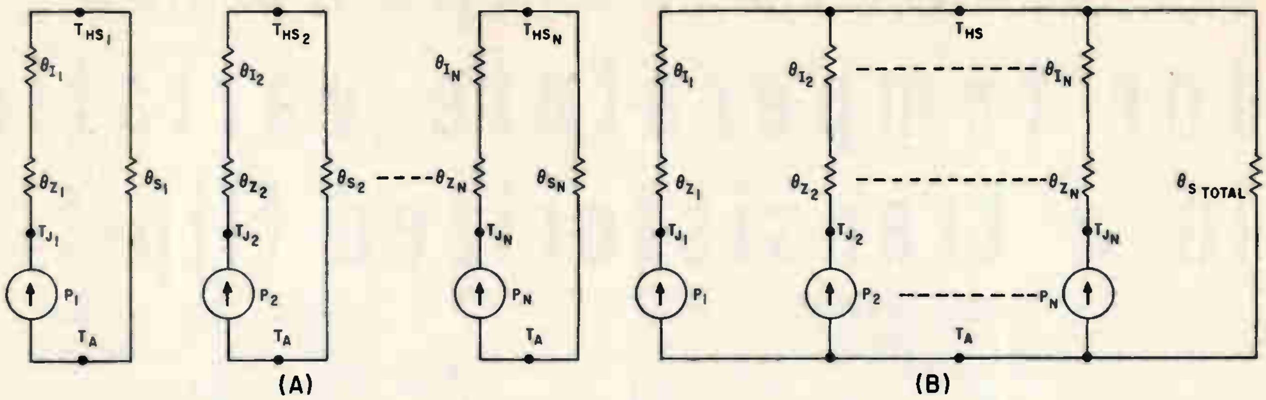

FIG. 2—Equivalent circuit analogue is extended to severaltransistors (A); parameters adjusted for mounting all transistors on common heat-sink (B)

total is

$$T_{hs} - T_a = (P_1 + P_2 + \cdots + P_n)(\theta_s \text{ total})$$

$$T_{hs} - T_a = \theta_s \text{ total} \sum_{k=1}^{n} P_k \qquad (2)$$

Knowing P, θ_z and θ_I for all transistors, and selecting a safe value for T_j, the overall heat sink temperature T_{HS} can be found. The required value of T_{HS} for any transistor is then given by

$$T_{HS} = T_j - P(\theta_z + \theta_I) \qquad (3)$$

The lowest value of the calculated heat sink temperatures is then used as the overall heat sink temperature for all transistors on the common radiator.

The foregoing analysis shows that some of the transistors will be operated well below their maximum permissible values, and not, therefore, at their full capability. Thus, if several transistors, each dissipating different amounts of power are to be mounted on thermal radiators, it is advantageous to mount those dissipating least power on a separate sink.

A heat sink calculation will now be considered. Three transistors dissipating 12 watts each, and two transistors at 6 watts are all to be mounted on a black anodized aluminum heat sink. The maximum junction temperature of all transistors is 85 degrees C and the ambient temperature 55 degrees C, while θ_z and θ_I and 1 and 0.42 respectively for all transistors. Using Eq. (3)

$$T_{HS\,1-3} = 85 - 12\,(1 + 0.42) = 85 - 17 = 68 \text{ degrees C.}$$

$$T_{HS\,4-5} = 85 - 6\,(1 + 0.42) = 85 - 8.5 = 76.5 \text{ degrees C}$$

Hence, temperature at which radiator will run is lowest of these two = 68 C. The thermal resistance θ_s total will be found by using Eq. (3)

$$T_{hs} - T_A = \theta_s \text{ total} \sum_{k=1}^{n} P_k$$

$$68\,C - 55\,C = \theta_s \text{ total } [3 \times 12 + 2 \times 6] \text{ whence } \theta_s \text{ total} = 0.272$$

Now entering the accompanying graph with θ_s total, the required area of black anodized aluminum is found to be 1,000 square inches. Hence, using both sides of the radiator, a plate of 500 square inches is needed.

The author would like to thank Alex Goldberger, Engineer and Jordan Kass, Senior Project Engineer, Polarad Electronics for their help in the completion of this article.

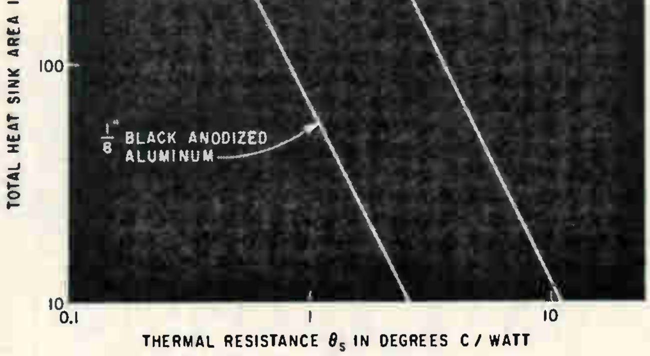

FIG. 3—Graph relates the radiating area to the thermal resistance; both sides of the heat sink are included

BIBLIOGRAPHY

(1) General Electric; Silicon Control Rectifier Handbook
(2) Motorola; Silicon Zener Diode Handbook

Plasma Studies May Aid Space Communications

By H. HODARA, Head of Space Communications, Research & Development Div., The Hallicrafters Co., Chicago, Ill.

COMMUNICATIONS between the earth and space vehicles is significantly affected by ionized regions in the transmission path. Detailed investigations indicate the possibility of using static magnetic fields to allow propagation of radio waves through these ionized media.[1] Further study may also permit communications between distant points on the earth along the lines of its magnetic field.

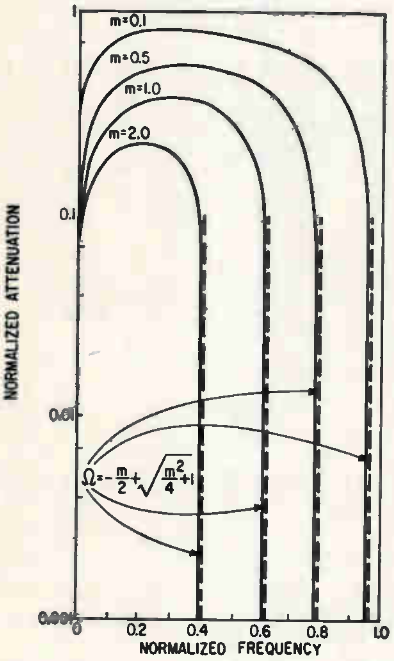

FIG. 1—Propagation of LH wave at frequencies below ω_p is limited by m in longitudinal magnetic field with no collisions

Results of the studies described in this article will also be presented in a more detailed paper at the coming 11th International Astronautical Congress in Stockholm, Sweden, between August 15 and 20.

The ionosphere, consisting of ions, free electrons and neutral molecules, is one such ionized region. It causes Doppler shift in communications with artificial satellites, introducing errors in orbital measurements. A re-entering space vehicle generates an ion sheath about as thick as its diameter that attenuates radio transmission through it. A communications blackout can result over a wide range of frequencies for several seconds, depending on vehicle course and velocity. Telemetry signals can be lost, and, in a manned space vehicle, the blackout could cause loss of two-way communications vital to proper maneuvering.

Free electrons in an ionized medium can oscillate at plasma frequency ω_p, which varies directly as the square root of electron density. Thus, $\omega_p = \sqrt{(Q^2/M)\ (N/\epsilon_o)}$, where Q, M and N are electron charge, mass and density, respectively and ϵ_o is dielectric constant of free space (all in MKS). Cutoff frequency in a waveguide is analogous to ω_p, with propagation impossible for signal frequency ω below plasma resonant frequency.

The frequency with which electrons collide with ions and molecules is represented by ν. Transfer of energy at collision causes the observed attenuation. In a static magnetic field, B_o, a free electron describes a circle perpendicular to the field lines. Gyrofrequency ω_b at which the electron revolves increases directly with field strength and is $\omega_b = (Q/M)B_o$. The magnetic field alters electron motion and introduces new propagation modes.

Propagation characteristics have been derived for a simple model of an ionized medium.[1] Thermodynamic equilibrium is assumed, and

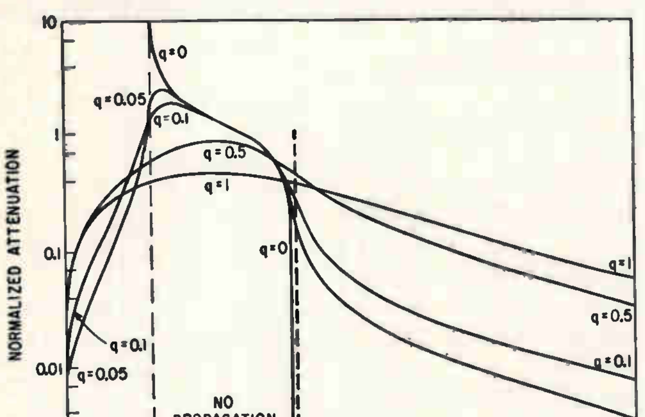

FIG. 2—Attenuation of RH wave depends on q with an applied longitudinal magnetic field and with m equal to 0.5

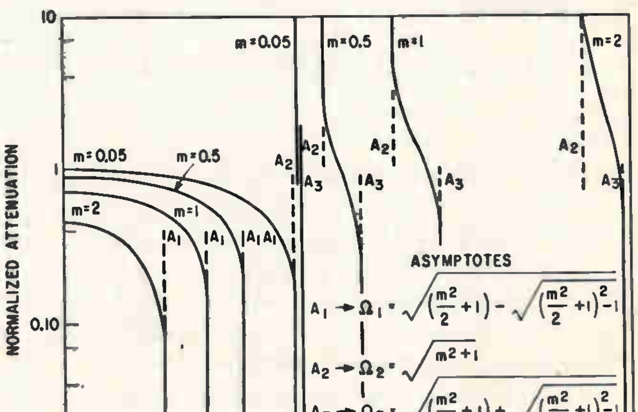

FIG. 3—Transverse magnetic field seems to offer no advantages in propagating LH wave with no collisions

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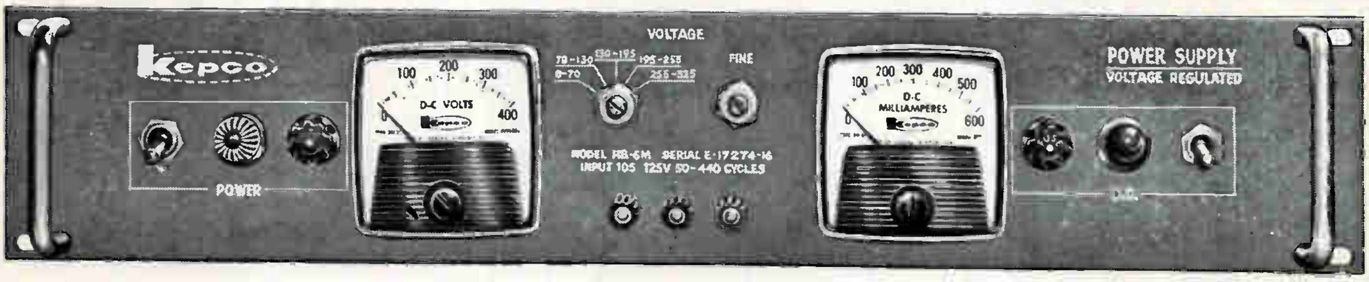

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HB-4	0–325	0–0.4	<0.1	0.2	<0.1	3 Mv.	2.0	2.0	19"	3½"	14⅜"	$320.00
HB-6	0–325	0–0.6	<0.1	0.2	<0.1	3 Mv.	1.0	1.0	19"	3½"	14⅜"	$365.00
HB-20	0–325	0–0.2	<0.01	0.02	<0.01	1 Mv.	0.4	0.4	19"	3½"	14⅜"	$465.00
HB-40	0–325	0–0.4	<0.01	0.02	<0.01	1 Mv.	0.2	0.2	19"	3½"	14⅜"	$520.00
HB-60	0–325	0–0.6	<0.01	0.02	<0.01	1 Mv.	0.1	0.1	19"	3½"	14⅜"	$565.00

STABILITY: (for 8 hours) 0.2% or 0.2 volts, whichever is greater, after 1 hour warmup. *Depth behind panel.
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electron pressure and ion motion are neglected. Propagation characteristics are expressed in terms of only three parameter: ω_p, ν and ω_b. Because transmission must often be analyzed under the worst possible conditions, at maximum ω_p, the parameters are normalized in Fig. 1-4 with respect to ω_p. Thus $\Omega = \omega/\omega_p$, $m = \omega_b/\omega_p$ and $q = \nu/\omega_p$. Attenuation is plotted against frequency for various values of the normalized parameters. Normalized attenuation in db/meter is $[8.7(\omega_p/c_v)^{-1}]\alpha$, where $c_v = 10^8$ meters/sec, the speed of light in a vacuum.

The plots show that in ionized media with a steady applied longitudinal magnetic field, both right-handed (RH) and left-handed (LH) circularly polarized waves are possible. An LH wave (Fig. 1) can be transmitted free of attenuation below plasma resonance but only over a limited frequency range. With no collisions ($q = 0$), to transmit at 0.4 Ω, m must be 2. If ω_p is 3 Gc (electron density 10^{12} electrons/cm^3), required magnetic field is about 2,000 gauss. Generating such large fields in a space vehicle is now only remotely possible.

To transmit an RH wave, however, magnetic field strength need not be so large; a low-frequency window exists (Fig. 4). With $q = 0$, an RH wave can propagate with no attenuation if $\Omega < m$. With a magnetic field of 100 gauss, transmission up to 300 Mc is possible with little or no attenuation, independently of electron density. Generating such a field is difficult but by no means impossible; it is only concentrated around the antenna and need not extend beyond a fraction of an inch into the shock wave boundary layer where electron density is greatest. The field might be generated by magnetizing the space vehicle shell[2] or by creating large circulating currents on its skin with arrays of thermocouples.[3] Solving this problem can eliminate the communications blackout at reentry.

When collisions are considered, there are no sharp frequency boundaries between regions of propagation and of absorption. Theoretically, all frequencies can propagate with different attenua-

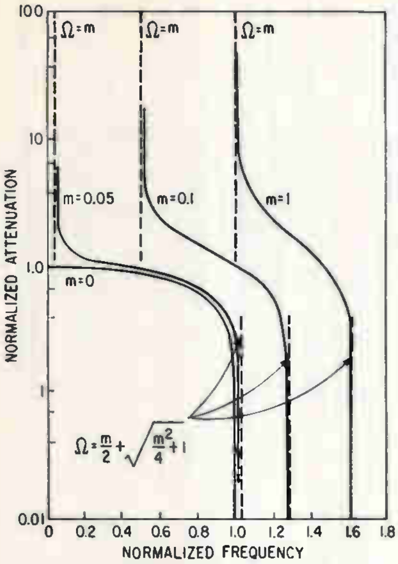

FIG. 4—With applied longitudinal magnetic field and no collisions, RH wave can propagate at frequencies determined by m

tions, depending on ν, which agrees with published data.[4] For example, with ω_p of 1 Gc, an applied magnetic field of 100 gauss (0.5 m) and $\nu = 0$, transmission is impossible between 0.5 and 1.3 Gc (Fig. 2). However, if electron collisions occur at a frequency of 1 Gc (q = 1) under the same conditions, total attenuation never exceeds 5 db for a 50-cm ion sheath.

In the earth's magnetic field, ω_b is a few megacycles at the surface. At higher altitudes, ω_b falls in the vlf range. The low-frequency windows ($\Omega < m$) in Fig. 2 suggest the possibility of transmitting vlf signals along the lines of the earth's magnetic field. At vlf, interaction between waves and ions as well as electrons must be considered.

As further investigation and experimentation proceeds in this area, communications into and from space and between distant points on the earth along the lines of its magnetic field may become a reality.

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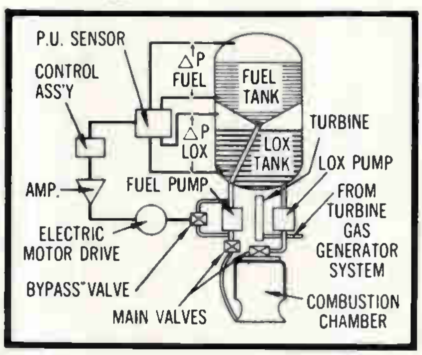
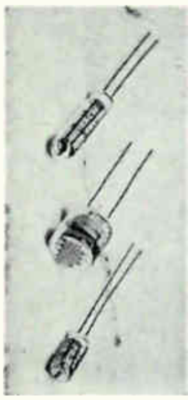
(3) T. Dialewsky, Private Communication, Cook Research Lab., Morton Grove, Ill., January 1960.
(4) K. M. Baldwin, O. E. Basset and E. I. Hawthorne, Avco Research & Advanced Development Div., Telecommunications during Re-entry, Symposium on the Plasma Sheath, December 7-9, 1959.



Photocells Open Up New Applications

POLYCRYSTALLINE photoconductive cells are small, non-linear circuit elements, that behave as light controlled variable resistances. By replacing a critical resistance in a conventional circuit, a photoconductive cell can transform operation of the circuit into a direct function of ambient light intensity. Several recent control and instrumentation circuits using the variable resistance characteristic in novel ways, demonstrate the still untapped versatility of the cells.


The light touch

Early applications of photoconductive cells were based on direct replacement of photoemissive tubes for reasons of economy, ruggedness, and miniaturization. The cells are many times smaller than the equivalent photoemissive tubes, and associated circuitry, that they replace.

One manufacturer, Clairex Corp., New York City, claims photoconductive cells are one million times more sensitive to light changes than ordinary photoemissive tubes, and require a lower operating potential.

Clairex produces a series of cadmium sulfide and cadmium selenide cells. The devices are composed of a small chunk of photosensitive material mounted on a small ceramic wafer $\frac{3}{16}$ in. in diameter, and $\frac{1}{16}$ in. thick. Indium electrodes symmetrically cover part of the surface, leaving a photosensitive rectangle about $\frac{3}{16}$ in. long and $\frac{3}{64}$ in. wide, with the electrodes paralleling the long edge.

Depending on application the complete assembly may be either hermetically sealed in a thin glass envelope, or housed in a polyester-plastic case having a small transparent window.

Spectral response of the cells depends upon the type of photosensitive material used, and the cell geometry. Peak response points of the Clairex units range from 5150 A to 6900 A. Most cells are sensitive to a wide band of light frequencies, including those extending past the visible spectrum limit, enabling their use in "invisible" light applications.

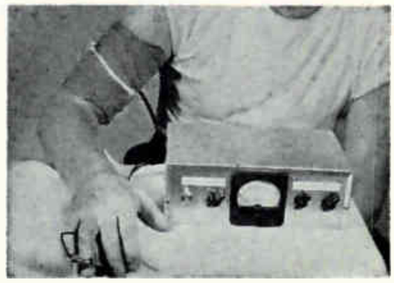
Certain units will differentiate between visible colors, and can be used where several interfering light sources are present, but only one, monochromatic, source is of controlling interest.

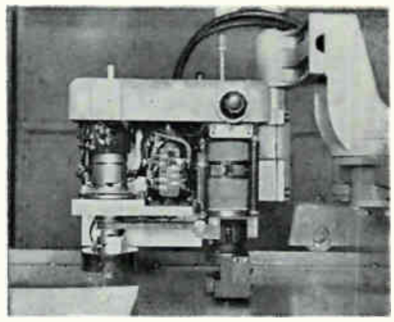
Light to dark current ratios of typical cells, measured after 5 seconds in the dark following exposure to a 2 ft-candle intensity light, vary from about 100 to over 10,000, depending on the photosensitive material used. The cells have an operating temperature range of −50 C to 75 C.

Control and instrumentation devices using photoconductive cells usually shield them from extraneous light, with an enclosure, and use some type of controlled light source for excitation. Very small fluctuations in light intensity reaching the cell can be monitored. These fluctuations may be caused by a changing semi-transparent medium between the cell and the source, or by a varying light beam modulated by an element sensitive to some physical phenomenon.

Indirect blood pressure measurements are made, by a new photosphygmometer, by monitoring the changes in transmittance, of a light beam, through a blood vessel network. During each cardiac cycle, the volume of blood in the network changes, altering the light transmittance. The device, developed at the Dept. of Anesthesiology, University of Va. Hospital, can be used on any mass of tissue that has a vascular supply, and through which light can be transmitted. The nail bed is ideally suited for this purpose, being highly vascular, and semi-transparent.

Variations in transmittance are monitored with a transistorized unit in which the signal is amplified and indicated by deflections on a ballistic V. U. meter or oscillograph, or by the presence of an audio tone.


Photocell and lamp assembly clipped to patient's finger in blood pressure measurement


Tracing mechanism for gas cutter uses photoconductive cells

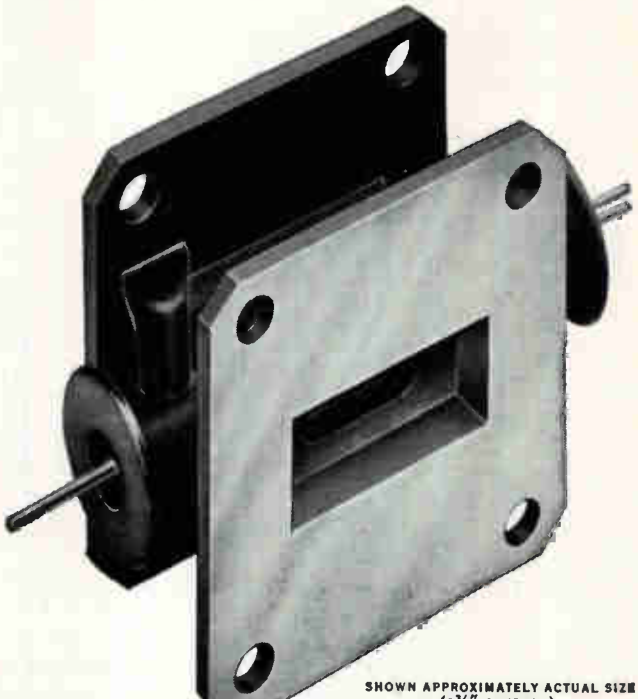
In use, the photocell assembly, and a small low-intensity light source, are clipped to the patients finger, and light intensity and amplifier gain are adjusted until fluctuations are observed. A conventional blood pressure cuff is placed on the arm and inflated until the fluctuations disappear. Pressure is slowly reduced until fluctuations are observed; at this point cuff pressure will closely approximate systolic pressure in the area of the cuff.

The system reportedly has high sensitivity and a good signal to noise ratio, and can be used where conventional methods are not applicable, such as on infants, and in detection of hypertension.

Photoconductive cells are also used as sensing elements in a photoelectric wind speed anemometer developed by Wong Laboratories, Cincinnati, Ohio. A circular array of ten cells surrounds a central light source that is covered by a small domed shell having a small axial

Microwave Component News from SYLVANIA

New broad-band high-speed microwave switch



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slit on its side. The shell is supported by low-friction jeweled bearings and is mechanically connected to an assembly of light plastic wind cups. As the wind cups rotate in a breeze, the shell revolves, illuminating each of the photocells in a circular sequence. The number of pulses per unit time is a measure of wind velocity. An external pulse shaping and sizing unit prepares the pulses for counting, and conversion into an analog form for direct indication of wind speed.

An automatic control and pattern tracer for gas cutting machines uses photoconductive cells in an industrial control application. The device was developed at Canadian Westinghouse for use with conventional gas cutting machines in operation throughout the plant.

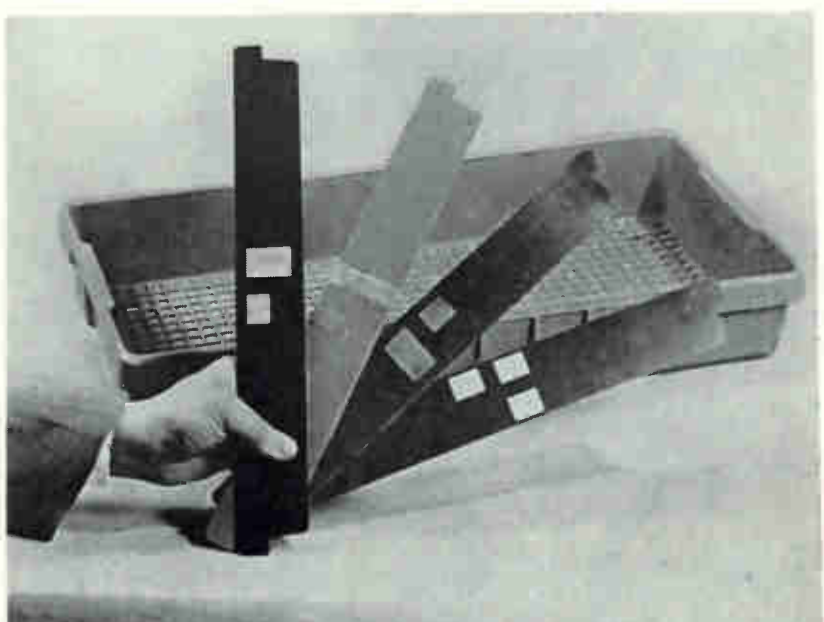
The pattern tracer will follow a pencil line, and is accurate to 1/100 in., making it possible to prepare patterns for automatic cutting operations at low cost.

The tracer consists of a line scanner, using a photocell, and associated servo mechanisms and control equipment. A housing, containing the cell and a light source, are positioned above the line to be followed. The cell, mounted on a torsion spring, vibrates above the pattern line in synchronism with the 60 cps mains supply. Servo motors keep the photocell directly over the pattern line and the gas cutters on the right cutting path, as a drive wheel moves the entire device along the pattern. The tracer will follow most patterns at speeds up to 30 in. per minute, but sharp corners, down to radii of 1/32 in., are taken at a slow speed of 1/10 in. per minute.

Automatic shutdown devices stop forward motion and turn off the cutting gas if the tracer looses the pattern line. An operator initially guides the tracer onto the pattern using manual controls, and then switches the machine to automatic operation. The gas cutter shuts down automatically when the cut is completed.

Another commercial application of the cells is in a photoelectric contact printer built by Morse Instrument Company, Hudson, O. A photocell, housed in a special hood, integrates the light and dark areas of a photographic negative to determine correct exposure time in producing contact prints. A "dodging" feature enables the machine to skip over pre-determined areas on a negative.

New Code Readers Sort Mail



In the tray code readers, above, the metal-composite laminates are attached to the sides of mail-bearing trays in automated post offices, where they signal electrically-activated mechanisms when to shunt a tray to the branch conveyer for a given geographical area

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In the face of this growing teacher shortage, college applications are expected to *double* within ten years.

At the rate we are going, we will soon have a very real crisis on our hands.

We *must* reverse this disastrous trend. You can help. Support the college of your choice today. Help it to expand its facilities and to pay teachers the salaries they deserve. Our whole future as a nation may depend on it.

It's important for you to know more about what the impending college crisis means to you. Write for a free booklet to: HIGHER EDUCATION, Box 36, Times Square Station, New York 36, N.Y.

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HIGHER EDUCATION
KEEP IT BRIGHT

Programmed Metallizer Produces Microcircuits

By I. L. BRANDT, CBS Electronics Div., Columbia Broadcasting System, Inc., Danvers, Mass.

MICROELECTRONIC CIRCUITS are manufactured in volume by this division, using a specially designed vacuum metallizer. In a 90-minute cycle, it will produce on appropriate subtrates 88 inch-square circuits or 352 half-inch-square circuits. Sequential evaporation of many materials, ranging from copper and gold for conductors to chrome and Nichrome for resistors, is possible.

A cutaway view of the fixturing is given in Fig. 1A. Substrates, ground optically smooth, are loaded into the removable, anodized aluminum cage. As the bell jar is pumped down in 7 minutes to a working pressure of 2×10^{-6} mm, the substrates are heated to 500 C.

Then a gas such as argon is injected through a preset variable leak at a pressure of 50 microns. A 5 Kv, 250 ma glow discharge is actuated. Ionic bombardment[1] removes all impurities from the substrate and readies the surface. Bombardment time can be varied between 30 seconds and 10 minutes. The substrate fixture revolves through a standard rotating vacuum seal and is driven externally. Rotation speed is programmable between 10 and 120 rpm.

Located in a 9-inch radius from the axis of the cage are 12 250-amp filament terminals which can be programmed for series or parallel evaporation. A 12-position, remotely-controlled shutter starts and stops each evaporation. The materials are evaporated from either heated boats, crucibles or filaments designed to approximate a point-source.

The evaporation process is completed by high-temperature aging to assist proper crystal formation and nucleation of the evaporated films. After aging, a 4-micron layer of SiO may be programmed for evaporation as a protective coating over the completed microcircuit. Fig. 1B shows the arrangement of power, control and monitoring equipment.

Operator loads holder. Heater is at left

Film thickness is optically monitored (Fig. 1C). The proper arrangement of a light source and a multiple, remote test glass holder allows measurement of light transmission. A second unit automatically compares reflection measurements. When the density reaches its predetermined value, a sequence relay terminates the evaporation cycle. Calibrated meters allow the operator to observe density continually.

In multifilm evaporation, direct electrical resistance monitoring is necessary. Insulated tracks are installed in the bell jar and signals are transmitted through rotating brushes to the monitoring buttons (Fig. 1A). Resistance of the deposited films is monitored by sweeping at 60 cps. When preset values are reached, evaporation is terminated. The amplifier and sensor are designed for simultaneous control of up to 6 evaporations.

At present, the evaporator simultaneously deposits conductors and resistors while capacitors and active elements such as transistors are mounted separately. However, the system is flexible. As microcircuit development becomes more

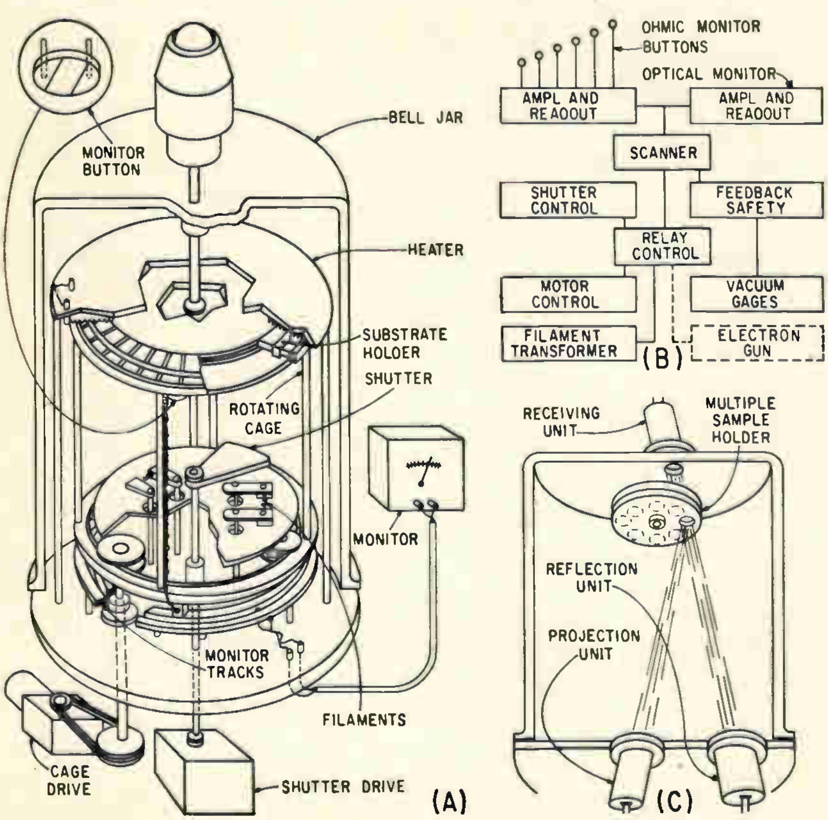


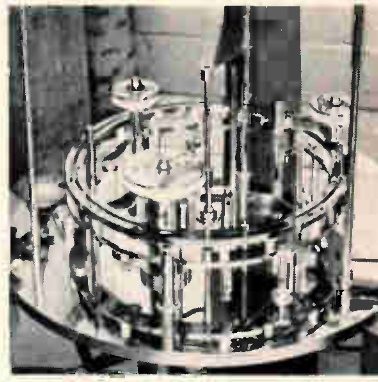
FIG. 1—Fixturing and resistance monitoring setup in bell jar (A), power and control diagram (B) and optical monitoring arrangement (C)

complex, units can be added for additional functions.

The design permits inclusion of induction melting of evaporants using levitation. This will become increasingly important as methods for epitaxial growth of semiconductor materials are perfected. The bell jar can be isolated from the diffusion pump and Vac-Ion and cryogenic pumps mounted to its adaptor flanges to make vacuums of 10^{-10} mm possible. Two electron guns may be mounted on bell jar inlets to evaporate difficult refractories or insulator materials. The gas injection system is designed for sputtering operations and the ionic power supply capacity is adequate for the conversion.

All bell jar parts are bright nickel plated and polished to speed pump-down. Gage and substrate heater is adjustable between 9 and 24 inches from the base plate. Vacuum inlets accommodate rotating seals or high- and low-voltage terminals. The mechanical pump is gas ballast, 2-stage, 30 cfm; the diffusion pump is a 12-inch, 4,000 liter per second fractionating type. Leak rate is less than 25 micron an hour and ultimate vacuum is 1.3×10^{-7}. High vacuum valves are electrically controlled, pneumatic high-transconductance types. The bell jar is provided with 2 visual observation ports and 3 optical monitoring ports. Terminals include 12 250-amp low voltage terminals, 4 30 Kv terminals, 16 5-amp terminals and 2 high-voltage water-cooled induction terminals.

Author looks through bell jar port. Programming consoles are at left and diffusion pump at right



Closeup of filaments, shutter mechanism and monitor tracks

REFERENCE

(1) L. Holland, The Cleaning of Glass in a Glow Discharge, *Brit J Appl Phys*, Oct., 1958.

Audio-Visual System Guides Assembly

AUDIO-VISUAL assembly instruction and training system is being offered by Applied Communications Systems, Culver City, Calif. The system is built around a unit containing a colored slide projector and a magnetic tape playback unit.

Assembly instructions and tone signals to actuate the slide changer are recorded tape. The tape is cartridge-loaded. Background music, automatically hushed when a signal from the tape is present, can be fed into the unit. The assembler listens with earphones.

The audio-visual unit is installed in a work station which can be modified to suit job and personnel requirements. Slides and tapes are prepared on portable or fixed mastering equipment. According to the firm, the system eliminates the need for blueprints, assembly drawings and schematics on the assembly line, decreases training time and defect rates, and steps up production rates by as much as 40 percent.

Slides and recorded instructions detail assembly methods

NOTE: If your copy of "POCKET GUIDE TO THE PROPER SELECTION OF DIGITAL MEASURING INSTRUMENTS" has already been torn out, circle 241 on the reader service card.

TEAR ALONG THIS LINE

POCKET GUIDE

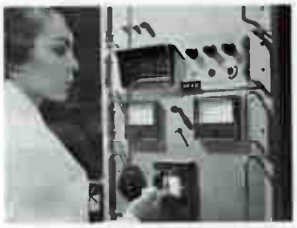
TO THE PROPER SELECTION OF

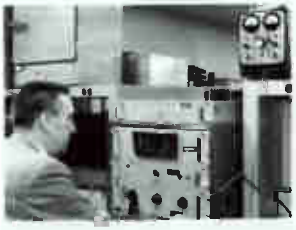
DIGITAL MEASURING INSTRUMENTS

TEAR ALONG THIS LINE

What are the practical applications of digital measuring instruments?

Five years ago — few. Today — a host of industrial and military applications, matching the growth and importance of electronics. DC digital voltmeter uses include automatic missile checkout, production line inspection, readout and printout for computers, instrument calibration, laboratory testing, receiving inspection. Likewise, other digital instruments have become invaluable measuring tools — DC digital ratiometers and ohmmeters; AC voltmeters and AC ratiometers. Consider a digital measuring instrument if you have any of these needs: more productive use of unskilled employees, high speed measuring, better than 0.1% accuracy, precision uneffected by rugged operating conditions, automatic measuring or data logging, exceptional reliability, fast measurement of any parameter convertible to voltage (pressure, speed, temperature, flow, liquid level, weight, light, etc.)





What is the best digital voltmeter available today?

There is no such animal as "best" for all applications. All DVMs are, in a sense, a compromise of accuracy, speed, reliability, stability, and, of course, price. Like your selection of a car, boat or camera — choice of a digital voltmeter is dependent on your

INDUSTRIAL VOLTMETER — This 4-digit instrument is an outstanding value for applications requiring ±0.01% accuracy at lowest cost . . . designed for visual readout only, does not contain printout connections or oil bath switches . . . features simple, time-proved 7-tube circuit . . . measures DC from ± 0.001 to ± 999.9 — AC and low-level DC with accessories . . . for applications requiring 0.01% accuracy without printout—production testing, instrument calibration, laboratory testing, receiving inspection.

Circle 248 on Reader Service Card **COMPLETE $1,425**

INDUSTRIAL VOLTMETER — Lowest cost 4-digit instrument available anywhere with printer connection and print control for automatic data logging systems using plug-in accessories — input scanners, data printers, etc. . . . output operates an H-P 561 type digital data printer without modification . . . also features plug-in stepping switches for ease of servicing . . . other than printout and plug-in switches, 484 has same basic features and specifications as the time-proved 481 . . . measures DC from ± 0.001 to ± 999.9 — AC and low-level DC with accessories . . . for applications requiring ± 0.01% accuracy and printout at low cost.

Circle 249 on Reader Service Card **COMPLETE $2,150**

INDUSTRIAL OHMMETER — Companion to the 481, this 4-digit ohmmeter equals the performance of other units costing twice as much . . . measures 0.1 ohm to 10 megohms . . . accuracy of ±0.05% +1 digit, ±0.1% of reading above 5 megohms . . . 20 times faster than using a Wheatstone bridge . . . completely automatic . . . used for fast, easy resistance measurements not requiring printout, such as receiving inspection, production, quality control, laboratory testing.

Circle 250 on Reader Service Card **COMPLETE $1,425**

LOW-COST VOLTMETER — Only full 4-digit voltmeter in the price range of 3-digit meters and laboratory quality pointer meters . . . measures DC voltage from ± 0.001 to ± 499.9 with accuracy of ± 0.02% + 1 digit . . . AC and low-level DC with accessories . . . features quality NLS construction, design simplicity, time-proved circuitry . . . designed for measuring applications that require the speed, ease, and accuracy of a digital voltmeter without the need for printout or automatic range-polarity selection . . . applications include transducer and test equipment calibration, quality control, production line and receiving inspection, laboratory uses.

Circle 251 on Reader Service Card **COMPLETE $985**

VOLTAGE COMPARATOR—This transistorized go/no-go voltage comparator provides a precise, fast, reliable means to determine if a voltage is within prescribed limits — and to transmit go/no-go commands to electrical recording, control and warning systems . . . signals voltage tolerance by colored bulbs and contact closures within 90 milliseconds . . . manual limit settings from ± 0.001 to ± 999.9 volts — in .01% steps.

Circle 252 on Reader Service Card **COMPLETE $1,775**

COMPARISON AMPLIFIER — Automatic comparator model for applications where limits are already available in analog voltage form from fixed or automatically programmed voltage dividers . . . voltage range from —50 volts to +50 volts with a limit sensitivity of 500 microvolts.

Circle 253 on Reader Service Card **COMPLETE $950**

HUNDREDS OF COMBINATIONS

A wide range of accessories are available from NLS for easy, plug-in combination with the basic units pictured. This provides you with several hundred combinations from which to select the grouping which best answers your measuring and data logging problems.

• AC/DC Converters with or without automatic ranging • AC Reference Voltage Converter for AC ratio measurement • Remote Readouts • Preamplifiers for low-level DC • Transistorized Input Scanners • Data Printers • Transistorized Serial Converters • Flexowriter Systems • Electric Typewriter Systems • Tape Punches • Output to operate almost any device requiring contact closures in parallel decimal form.

Originator of the Digital Voltmeter

non-linear systems, inc.

DEL MAR (SAN DIEGO), CALIFORNIA

subject to change without notice.

individual needs. If you require the most favorable combination of reliability, speed, accuracy and versatility for critical data logging and measuring applications, a multi-purpose instrument with transistorized circuitry and mercury-wetted relays is the answer . . . maximum measuring speed — an all-electronic model . . . greatest accuracy — a DVM with full 5-digit resolution . . . maximum stability in the medium priced range — a transistorized instrument with plug-in oil-bath stepping switches . . . low-cost measuring — a meter with dry stepping switches and vacuum tubes.

What factors should be weighed in purchasing a DVM?

REQUIREMENTS OF APPLICATION.

Don't overbuy. Many times a less expensive instrument can be as effective for limited needs. Be sure you actually need printout connections, or 1000 readings per second, or four or five measuring functions. On the other side of the coin, money is well spent for a higher-priced instrument with mercury-wetted relays if your requirements are of a critical nature, such as missile checkout. On versatility — many times it is wise to purchase the basic DVM now and add accessories later for AC, low-level DC, and data logging. This practice can save you money when your future needs are not now crystallized because simple plug-in accessories can be added at any time to form hundreds of combinations.

RELIABILITY.

Reliability cannot always be judged on the basis of price. Rather, look closely at the type of construction and the more subtle clues, quality of components and simplicity of circuitry. For example, does that stepping switch meter have stock telephone switches or the type specially designed for digital voltmeter use . . . do switches have phenolic insulation or diallyl phthalate which protects the instrument's accuracy against the effects of moisture . . . are there excessive solder joints and cable connections? Often it's wise to check with present users on reliability they've experienced with the instrument.

ACCURACY.

Obviously, the manufacturer's statement of accuracy is not enough. Basic questions include: How often must you correct for long term drift? When subjected to sharply varying inputs or signal input noise, will the instrument display a value the input signal actually had during the balancing cycle? Does the instrument have a great number of pots that must be trimmed frequently? Some do — some don't.

SPEED.

Of course, all DVMs are extremely fast as compared to pointer meters and other measuring devices. But they vary widely among the basic types, ranging in balancing time from about 2 seconds to 50 microseconds. Consider carefully if you require exceptional speed — relatively few applications do. Do you have a high-speed, high-cost printer capable of handling 500 to 1,000 readings per second? Are you willing to pay for higher measuring speed, both in terms of initial cost and more complex circuitry that can lessen reliability and stability? In most cases, speed is less important than other considerations.

VERSATILITY.

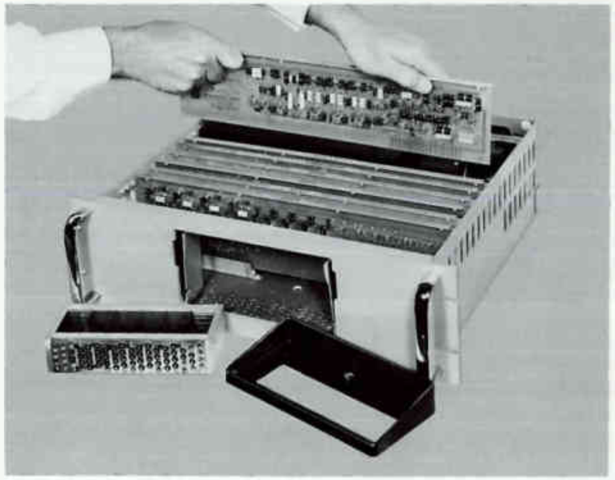
If you require several measuring functions, a multi-purpose instrument with built-in multi-functional circuitry can save you money. A suggestion: many times measurements of voltage ratio can be much more useful and more accurate over the long haul than measurements of absolute voltage.

EASE OF OPERATION.

This is an inherent advantage of DVMs but some are easier to operate than others. For example, some instruments do not require desensitizing — their logic always produces a reading as accurate as the voltage is stable.

EASE OF SERVICING.

This often overlooked factor deserves major consideration.
How long does it take to replace a stepping switch?
How much of the unit's construction is plug-in?
How fast can a readout bulb be replaced?



How important is servicing in selecting a DVM?

An engineer who has had a critical project held up by a DVM failure will answer this one in a hurry. It is vital in two ways — first, in the design and construction of the instrument itself . . . second, in the service provided by the manufacturer. Check both the manufacturer's reputation for servicing and the instrument. What per cent of the components are mounted on plug-in boards? Can malfunctions be found and corrected in minutes, hours or days?

Are digital voltmeters high priced?

You might be surprised by the price tag of some of the lower-cost DVMs. High-volume production techniques and simplied design have put a full 4-digit DVM without printout within the price range of a high-quality pointer meter. Even the premium DVMs are high priced only in the same way that an automatic washing machine is more costly than a scrub board. If a DVM allows you to make more productive use of unskilled personnel, to increase production, or to simplify quality control, its initial cost can be many times less than the resultant savings. Please see the other side of this pocket guide for a complete range of digital instruments . . . by price . . . by application.

MAKE YOUR SELECTION

FROM THE MOST COMPLETE

LINE OF DIGITAL

MEASURING INSTRUMENTS

...BY PURPOSE

...BY PRICE

For your convenience, NLS offers highlights on basic digital measuring instruments in its line. Notice the reader service card number listed with each. For additional information . . . please circle the appropriate number on the reader service card in the back of the magazine, or write NLS for complete brochure on specific instruments of interest to you.

A WORD ON NLS . . .

Non-Linear Systems, Inc., produced the world's first digital voltmeter in 1952. Today the company is the established leader in the field. Fast, friendly service is available everywhere through factory-trained representatives and NLS engineers.

NLS M24 **MULTI-PURPOSE INSTRUMENT** — Measures DC voltage from ± .0001 to ± 999.9 with ± 0.01% accuracy, DC voltage ratio to ± .9999 with ± 0.01% accuracy, resistance from 0.1 ohm to 1 megohm with accuracy of ± 0.05% of reading + 1 digit . . . 1/3 second balancing time . . . with accessories, measures AC voltage or AC ratio, low-level DC . . . completely automatic . . . output for data logging . . . transistorized circuitry, mercury-wetted relays . . . recommended for measuring and data logging demanding best combination of reliability, accuracy, speed and versatility—missile systems checkout, industrial electronic systems, unattended data logging, quality control, laboratory uses.

Circle 242 on Reader Service Card **COMPLETE $5,650**

NLS V24 **VOLTMETER-RATIOMETER** — Same basic features, specifications and applications as the M24 except it does not measure resistance.

Circle 243 on Reader Service Card **COMPLETE $4,950**

NLS R24 **RATIOMETER** — Measures DC ratio with ranges of ± .9999/9.999 . . . same basic features and applications as M24 and V24.

Circle 244 on Reader Service Card **COMPLETE $4,650**

NLS V35 **TRANSISTORIZED VOLTMETER-RATIOMETER**—This all-transistorized instrument is the first true 5-digit voltmeter with the **Factual Fifth Figure**, full 5-digit resolution of 0.001% . . . measures DC voltage from ± 0.0001 to ± 999.99 with ± 0.01% accuracy, DC voltage ratio from ±00.001% to ±99.999% with accuracy of ±0.005% of reading or ±1 digit . . . with accessories, measures AC voltage, low-level DC . . . completely automatic . . . features **No-Needless-Nines** logic, plug-in oil-bathed stepping switches . . . output for data logging . . . fastest stepping switch instrument . . . recommended for uses requiring maximum accuracy such as automatic missile checkout; production line inspection of transistors, resistors, diodes; readout and printout for computers.

Circle 245 on Reader Service Card **COMPLETE $3,750**

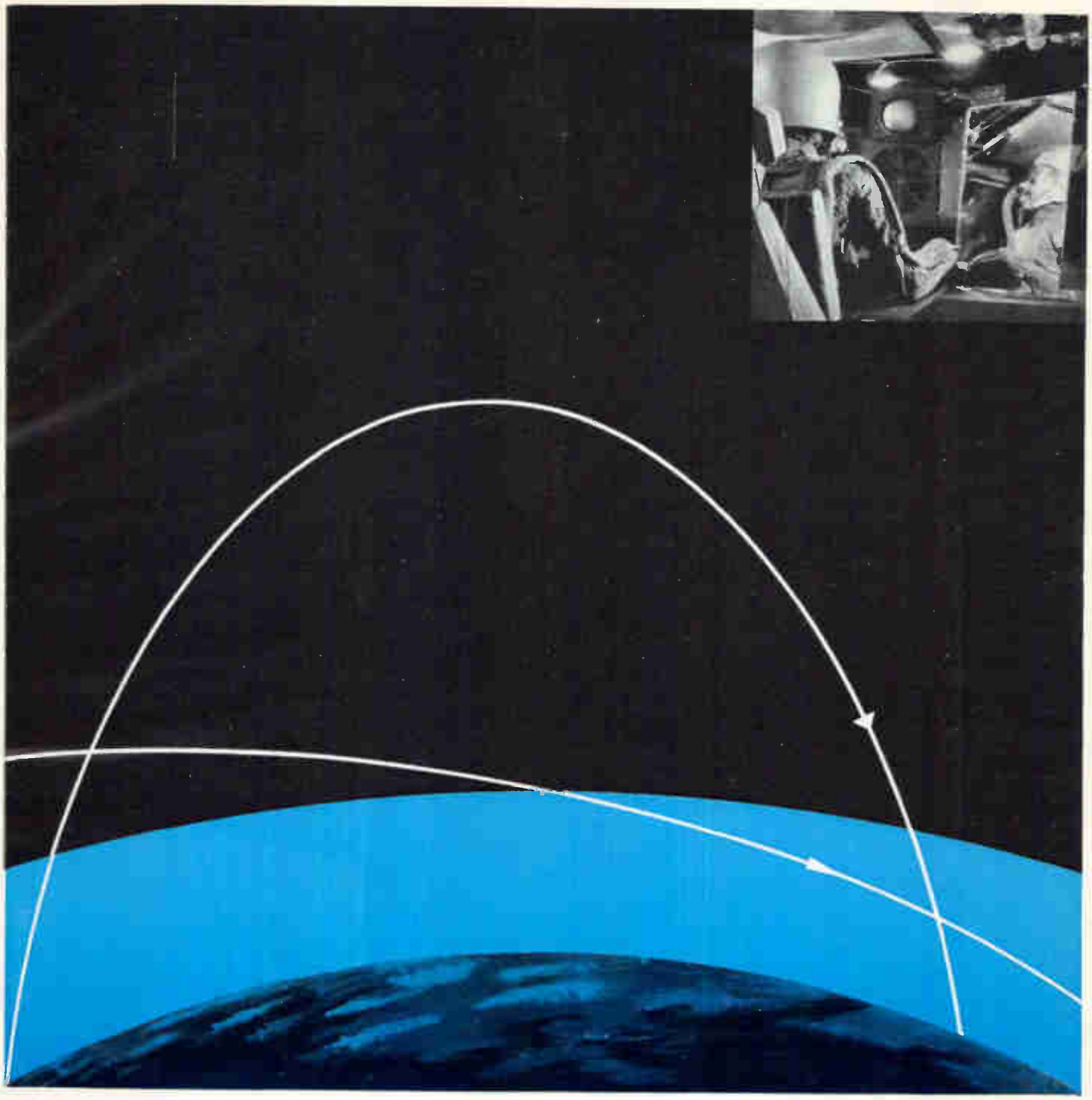
NLS V34 **TRANSISTORIZED VOLTMETER-RATIOMETER** — 4-digit quality and performance companion to V35 — with **No-Needless-Nines** logic, plug-in oil-bathed stepping switches and full transistorization . . . measures DC voltage from ± .0001 to ± 999.9 with ± 0.01% accuracy, DC voltage ratio from ± 00.01% to ± 99.99% with ± 0.01% accuracy . . . with accessories, measures AC voltage, low-level DC . . . output for data logging . . . fastest stepping switch instrument . . . designed for uses requiring Series 30 reliability without the need for 5-digit resolution.

Circle 246 on Reader Service Card **COMPLETE $3,150**

NLS V44 **ALL-ELECTRONIC DIGITAL VOLTMETER** — 200 readings per second . . . measures DC voltage from ±0.001 to ±999.9 with ±0.01% accuracy . . . completely automatic . . . output for data logging . . . recommended for applications in which exceptionally high speed is essential.

Circle 247 on Reader Service Card **COMPLETE $6,150**

Specifications and prices are



Ballistic and boost-glide flight paths

These flight paths, arcing through space and re-entering the atmosphere, are characteristic of the paths of a ballistic missile and a boost-glide vehicle. In both areas. Boeing holds major contract responsibilities. Boeing is weapon system integrator for the solid-fuel ICBM, Minuteman, and as part of a USAF-NASA research program. is developing Dyna-Soar to study the problems of manned space flight. The Dyna-Soar vehicle will be capable of re-entering the atmosphere and making a normal controlled landing.

Boeing scientists and engineers, in addition, are advancing the state of the art in many areas: advanced military and commercial aircraft, hypersonic flight, space crew environments. vertical and short take-off and landing aircraft, gas turbine engines, anti-submarine warfare systems, among others.

Professional-Level Openings

These and other future-oriented programs at Boeing offer outstanding career openings to professional specialists in the scientific and engineering disciplines, as well as in a broad spectrum of company activities in other-than-engineering areas. You'll find at Boeing a professional environment conducive to deeply rewarding achievement. Drop a note, now, to Mr. John C. Sanders, Professional Personnel Administrator, Dept. ENG. Boeing Airplane Company, P. O. Box 3822, Seattle 24, Wash.

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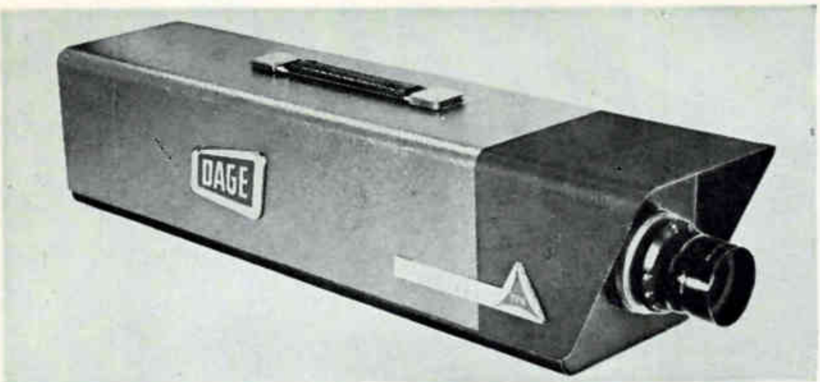
New On The Market



Lightweight Tv Camera

800-LINE RESOLUTION

USING AN image orthicon camera tube and completely transistorized, the model 81 industrial i-o tv camera is a lightweight, portable device designed for industrial use at low light levels. The camera is made by Dage Television Div., Thompson Ramo Wooldridge Inc., Michigan City, Indiana.

A transistorized preamp is mounted within the camera, the output of which is used to drive a low-impedance coax cable. The camera control provides either industrial or EIA sync, with remote operation possible.

The camera control is of modular construction to provide ease of servicing and maintenance. Each module provides a logical division of the functions of the system.

Camera adjustment controls for beam, target potential, and electrical focus appear on the front panel assembly, as do function controls for remote controlled accessories. Adjustment of set up or black level is also provided. Connectors for the camera cable are grouped on the rear panel.

CIRCLE 301 ON READER SERVICE CARD

Coaxial Isolators

ARE MINIATURIZED

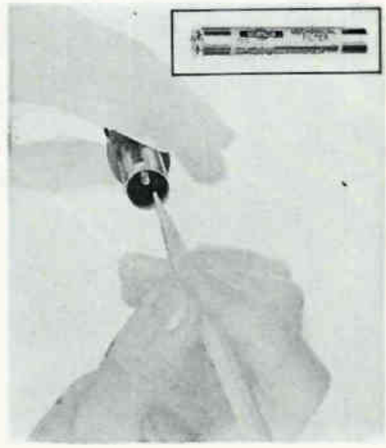
MINIATURIZED COAXIAL line isolators that can be used in missile and aircraft equipment, telemetry, radar and communication systems have been developed by Sperry Microwave Electronics Co., Clearwater, Florida. The complete line of units, which can operate from uhf to X-band regions, have no external permanent magnets.

Three basic units that operate at C, S, and L-band, designated D44C7, D44S7, and D44L7, respectively, operate over 10-percent bandwidths and provide more than 15-db isolation and less than 0.9-db insertion loss. The respective bandwidths covered by the isolators are 5.4 to 5.9, 2.7 to 3.1, and 1.25 to 1.35 GC. The isolators measure ¾ inch in diameter; lengths vary from 4¼ inches for the C-band unit to 6⅝ for the L-band unit. Respective weights are 4, 5, and 6 oz each.

The units have almost 100 percent magnetic shielding. Application of external magnetic fields of several hundred oersteds exhibit negligible effect on the electrical performance.

The three basic models are available for delivery from stock in small quantities, or in production quantities with delivery beginning 30 to 60 days after order. They are also available in other frequency bands on special order. Prices of these models are $225, $225, and $235 respectively.

CIRCLE 302 ON READER SERVICE CARD



Magnetostrictive Ferrites

IN MECHANICAL FILTERS

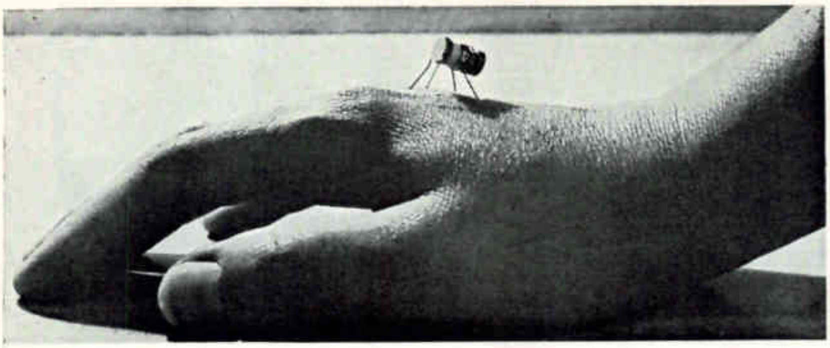
MECHANICAL FILTERS using ferrite material are now being manufactured by the Western Division of Collins Radio Company, 2700 West Olive, Burbank, Calif. Based on a new design development using magnetostrictive ferrite material, the filters have greatly improved performance. Combining the mechanical filter's advantages of selectivity, simplicity, compactness and reliability with added strength allows operation under the shock and vibration of missile launching and other severe environmental conditions. Other advantages of the ferrite filters include flatter pass-band response and lower transmission loss.

The ferrite material replaces the usual nickel-alloy rods used as transducers. The transducer rods convert electrical energy to mechanical energy. This energy is then transmitted through resonant mechanical elements of the filter to an identical transducer where it is converted back to electrical energy.

This development allows designing and producing mechanical filters meeting specifications previously considered difficult or impractical. Filters with various

center frequencies and bandwidths for use in missile guidance and telemetering systems are available.

CIRCLE 303 ON READER SERVICE CARD



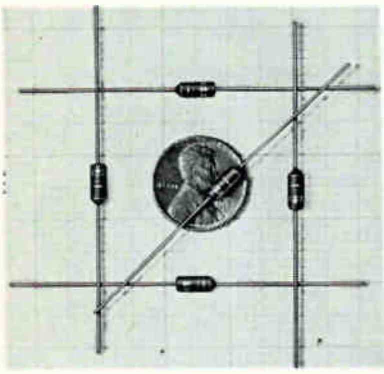
Miniature Capacitors

WITH FINE TUNING

MINIATURE PRECISION air capacitors now being produced by Johanson Manufacturing Corporation, Boonton, N. J., have internal spring fingers with a Teflon disk-lock to guarantee that settings are held under shock and vibration. Despite their small size—less than ½ in. long by barely more than ¼ in. o-d—these tubular capacitors are fully adjustable from 0.8 to 10 pf.

More than ten turns are required to cover the complete range which varies linearly. These high-Q capacitors use air as the dielectric. In construction, several thin wall sections of silver and gold-plated Invar tubing are alternately mounted on the rotor and stator sections. A cap with a silicone rubber washer permits positive sealing, eliminating changes with atmospheric conditions. Leads of the capacitors are gold plated.

CIRCLE 304 ON READER SERVICE CARD



Silicon Rectifiers

SUBMINIATURE SEALED

A SERIES of low-cost subminiature silicon rectifiers, using a Tri-Seal construction assuring high reliability in environmental extremes, has been announced by International Rectifier Corp., 1521 E. Grand Ave., El Segundo, California. The units combine a high forward current rating of 400 ma with small size—200 units occupy one cubic inch.

Electrical specifications include reverse leakages of only 1 μa at rated prv at 25 deg C, maximum voltage drop of 1 volt at rated current, and surge current capabilities of 3 amperes over the operating temperature range from minus 65 deg C to plus 130 deg C.

Designated Types X4M2 through X4M6, the series provides a peak reverse voltage range from 225 to 600 volts, and are capable of high temperature operation (150 ma current output at 100 deg C). Each rectifier junction is environment protected by a 3-barrier Tri-Seal process completely enclosing the assembly in a ruggedized case resistant to moisture and contaminants.

Price is $0.75 to $1.75 in quantities of 1-99. Production quantities are readily available.

CIRCLE 305 ON READER SERVICE CARD

Engineering Design Kits

OFFER CHOICE

ENGINEERING DESIGN kits containing standardized electronic hardware for prototype or breadboard buildup now are offered by the U. S. Engineering Co., a division of Litton Industries, 13536 Saticoy St., Van Nuys, Calif.

Available kits contain either an assortment of interchangeable grommets, terminals and a swaging tool for component evaluation or laboratory use; stand-off terminals

of various insulating materials and mounting configurations; subminiature printed circuit terminals, including a special soldering tool, or a complete line of solder terminals.

Tools and components are in individual compartments in a plastic case.

CIRCLE 306 ON READER SERVICE CARD

Digital X-Y Plotter

MAGNETIC TAPE INPUT

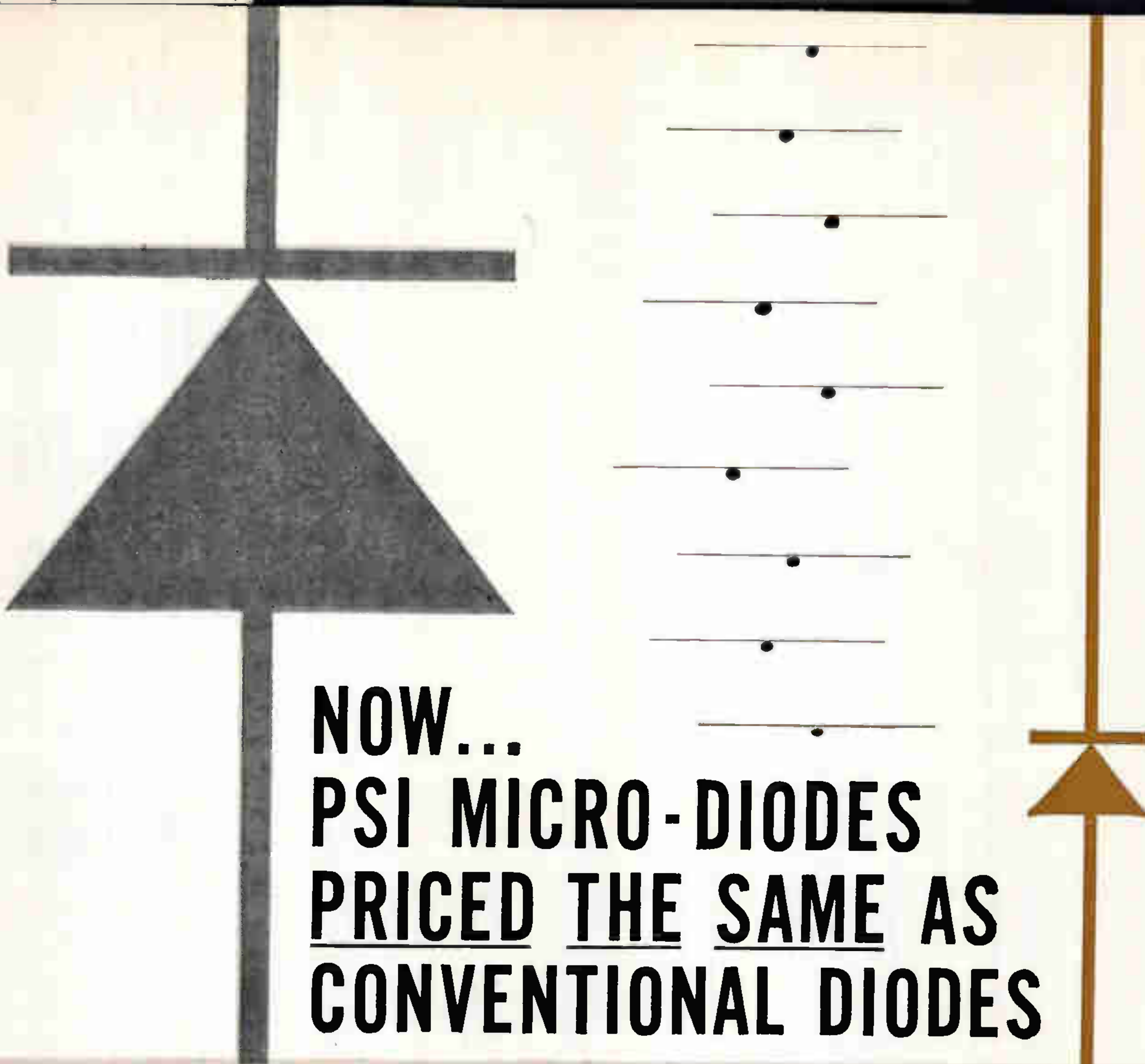
A DIGITAL *X-Y* Plotter, the Dataplotter 3400 Magnetic Tape Input, is being introduced by Electronics Associates, Inc., Long Branch, New Jersey. The unit, including an EAI 30 inches by 30 inches *X-Y* plotting board, can be used for rapid and accurate reduction of digital data recorded on magnetic tape into inked plots on conventional cartesian-coordinate graph paper. The device has high reading and plotting speeds, with accuracies of 0.021 inch at full scale. Since it reads directly from magnetic tape, the digital plotter eliminates the time-consuming step of first preparing magnetic tape from punched cards or paper tape.

CIRCLE 307 ON READER SERVICE CARD

Decade Resistance Standard

NO ZERO CORRECTION

AN ULTRA-HIGH performance decade resistance standard, covering a resistance range from 10 milliohms to 1.2 megohms continuously, has



NOW...
PSI MICRO-DIODES
PRICED THE SAME AS
CONVENTIONAL DIODES

Silicon Micro-Diodes (1/50 the size of conventional diodes) are now available at the same price as their larger counterparts. They include the electrical equivalents of several widely used types:

HIGH SPEED MESA COMPUTER DIODES—1N904 • 1N914. GENERAL PURPOSE COMPUTER DIODES—1N643 • 1N658 • 1N663. LOW LEAKAGE SILICON DIODES—1N457 • 1N458 • 1N459...and a new high voltage series to 1.2 kilovolts.

Additionally, Pacific Semiconductors, Inc. has recently introduced a series of Micro-Transistors designed as companion components. These include electrical equivalents of transistor types 2N696 and 2N697.

RELIABILITY ≥ CONVENTIONAL DIODES

These Micro-Diode types meet or exceed all environmental requirements of MIL-S-19500B.

1. MOISTURE RESISTANCE: MIL-STD-202A, method 106A.
2. TEMPERATURE CYCLING: Ten 15-minute cycles—65°C to 200°C.
3. THERMAL SHOCK: MIL-STD-202A, method 107, test condition C (—65°C to 200°C).
4. CONSTANT ACCELERATION: More than 20,000 G.

For details on life testing and reliability curves, write today for "Micro-Diode Reliability Study."

Pacific Semiconductors, Inc.

PSI

A SUBSIDIARY OF THOMPSON RAMO WOOLDRIDGE, INC.
12955 Chadron Avenue, Hawthorne, California

Sales Offices in: NEWARK · BOSTON · DE WITT, N.Y. · OTTAWA · BALTIMORE · CHICAGO (Oak Park) PHILADELPHIA (Rockledge) · ST. PETERSBURG · DALLAS · DETROIT · LOS ANGELES · PALO ALTO
DISTRIBUTORS IN MAJOR ELECTRONIC CENTERS COAST-TO-COAST.

CIRCLE 97 ON READER SERVICE CARD

been announced by Electro Scientific Industries, Inc., (formerly Electro Measurements, Inc.), 7524 S. W. Macadam Ave., Portland, Oregon. The last dial controls a 105-division slide wire rheostat with a resistance of 100 microhms per dial division.

To eliminate the necessity of a zero correction, the 10 milliohm per step decade stops at a minimum setting of 10 milliohms. Lead and contact resistance make up part of this 10 milliohm resistor; the rest of it is a resistor set to give the total value of 10 milliohms. To avoid problems of lead and contact resistance variations, provision has been made for making four terminal measurements. Dimensions: 7 inches high; 19 inches long; 7 inches deep.

Price: $1,200, fob Portland, Oregon. Availability, 60 days.

CIRCLE 308 ON READER SERVICE CARD

Exciter/Driver System

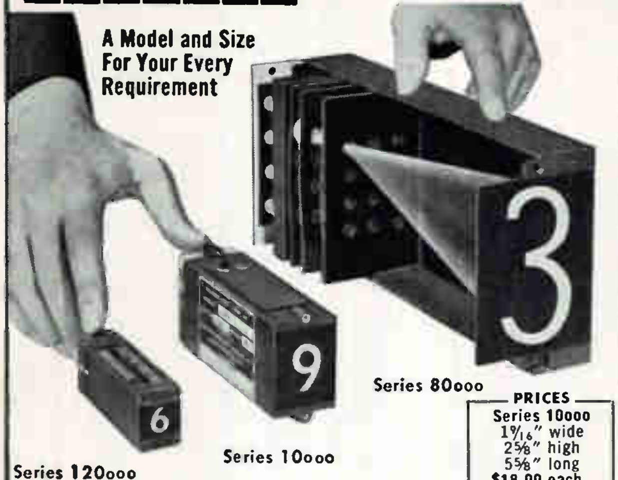
SINGLE-SIDEBAND

KAHN RESEARCH LABORATORIES, INC., 81 S. Bergen Place, Freeport, N. Y., has developed exciter/driver systems which are achieving peak envelope powers of 10 Kw to 4 megawatts, with undesired sideband rejection of 35 to 40 db. Model SSB-58-1A system used with new a-m transmitters reduces overall ssb system costs 50 percent or more. Even greater savings can be realized by converting existing a-m or c-w transmitters to ssb operation. Doppler-free, multichannel FSK teletypewriter, data, voice and facsimile are transmitted on either single or two independent 6 Kc sidebands, over the 1 to 30 Mc range.

CIRCLE 309 ON READER SERVICE CARD

PROVEN, DEPENDABLE . . . REAR-PROJECTION TYPE

IN-LINE DIGITAL DISPLAYS



PRICES

Series 10ooo
1 9/16" wide
2 5/8" high
5 5/8" long
$18.00 each

Series 80ooo
3 1/4" wide
5 1/4" high
11 15/16" long
$33.00 each

Series 120ooo
1" wide
1 5/16" high
3 7/8" long
$35.00 each

Quantity Prices
On Request

OUTSTANDING FEATURES

- All digits displayed on front viewing screen
- All digits uniform in size and intensity
- High-contrast viewing screen
- Digit style of your choice
- Colored digits of your choice
- Individual units may be group assembled for panel mounting

WRITE TODAY FOR COMPLETE DETAILED SPECIFICATIONS

Representatives in principal cities

INDUSTRIAL ELECTRONIC ENGINEERS, INC.
5528 Vineland Avenue, North Hollywood, California

CIRCLE 204 ON READER SERVICE CARD

ELECTRONIC AND LOGICAL DESIGNERS FOR POLARIS PROJECT

and proprietary projects

TO WORK in solid state electronics design and digital circuits . . . with America's fastest growing computer firm, located in America's fastest expanding electronic community.

FOR YOU if you want to contribute to America's number one missile project . . . and if you are anxious to advance the overall state of the art. These are career growth positions . . . with good salaries to match your talents and the importance of the work you will be doing. Fine company benefits, pleasant surroundings . . . top level professional environment.

ELECTRONIC DESIGNERS

RESPONSIBILITIES—Transistorized circuit design to be used as building blocks in computing systems and peripheral units.

EDUCATIONAL REQUIREMENTS—Must have B.S. or M.S. in Electrical Engineering.

EXPERIENCE—At least 4 years applicable experience in solid state work, preferably computer.

LOGICAL DESIGNERS

RESPONSIBILITIES—Participation in design of general purpose computer. Also to design special purpose peripheral units to be used in conjunction with general purpose computers.

EDUCATIONAL REQUIREMENTS—Must have B.S. in Electrical Engineering or in Math.

EXPERIENCE—At least 4 years applicable experience, preferably computer work.

ARE YOU LOOKING for work with plenty of challenge . . . for a career offering both intellectual and financial growth . . . for an organization not tied-down to yesterday's systems? If you are, perhaps you are the person we are looking for and Control Data is the company for which you are looking. You'll also like this area—a wonderful, refreshing place in which to live and bring up your family.

CONTACT
Richard O. Klune

CONTROL DATA CORP.
501 Park Ave., Minneapolis 15, Minn.
FEderal 9-0411

CIRCLE 378 ON READER SERVICE CARD

NOW . . .

Miniature RF Connectors Match Electrical Specs . . . of Standards!

NEW GREMAR *Red Line* CONNECTORS BRING RELIABLE MINIATURIZATION TO COAXIAL CABLE ASSEMBLIES!

REPLACE STANDARDS WITH MINIATURES! Now, because of GREMAR CONNECTRONICS (T), it is possible to miniaturize your RF cable assemblies and still maintain rigid electrical specs.

Red Line Miniatures, identified by their red Teflon insulation, are half the size and weight of the reliability-proved GREMAR TNC Connectors.

DESIGNED FOR USE WITH MIL-TYPE SUBMINIATURE COAXIAL CABLES, Red Line Miniature Connectors and adapters feature:

- A new patented metal-to-metal cable clamping method which saves up to 80% of your cable assembly time while assuring a lower, more constant VSWR.
- Nominal 50 ohm characteristic impedance, 500 volts rms peak and 10,000 megacycles practical frequency limit.
- Operating temperature range: −65F to +350F.
- Meets or exceeds all applicable requirements of MIL-STD-202A and MIL-E-5272B.
- Configurations for all typical applications including adapters to BNC and TNC connectors.
- Metal parts are heavily silver plated for maximum corrosion-resistance . . . protected with Iridite to retard tarnishing. All contacts are gold-plated.
- Standard *Red Line* adapters and connectors are stocked for *immediate* delivery.

WRITE FOR BULLETIN 9 containing complete data on Gremar *Red Line* Miniatures. Literature on all other RF connectors is available for the asking.

GREMAR MANUFACTURING COMPANY, INC.
RELIABILITY THROUGH QUALITY CONTROL
Dept. A Wakefield, Mass., CRystal 9-4580

CIRCLE 99 ON READER SERVICE CARD

Literature of

PRECISION ELECTRICAL INSTRUMENTS Muirhead & Co., Ltd., Beckenham, Kent, England, has published the 1960 edition of its abridged (8-page) catalog containing brief details and summary specifications of its entire range of products including precision electronic instruments, components, synchros and servomotors, servo equipment, and facsimile equipment.

CIRCLE 350 ON READER SERVICE CARD

TRANSISTOR DIGITAL CIRCUITS Epsco Inc., 275 Massachusetts Ave., Cambridge, Mass., has issued a new brochure, "Transistor Digital Circuits", describing its complete line of advanced solid state transistor and magnetic components.

CIRCLE 351 ON READER SERVICE CARD

INDUSTRIAL TELEMETERING Electro-Mechanical Research, Inc., ASCOP Division, Princeton, N. J. An 8-page brochure gives features of the ASCOP telemetry system, shows typical line costs and line capacities; describes how the telemetering system works in simple terms; and outlines typical systems.

CIRCLE 352 ON READER SERVICE CARD

CIRCUIT BREAKER Airpax Electronics Inc., Cambridge Division, Cambridge, Md. New circuit breaker specification AM513 tabulates and illustrates standard current ratings, release coil impedances, typical time delay curves, mounting and outline dimensions.

CIRCLE 353 ON READER SERVICE CARD

APPLICATION NOTE INDEX Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif., has prepared a complete index of some 40 *Application Notes* issued by the company over the past several months. The index presents a useful abstract of each of the notes which cover a variety of subjects of interest to users of electronic measuring instruments.

CIRCLE 354 ON READER SERVICE CARD

CONTACTS AND STRIP Texas Instruments Incorporated, Metals & Controls division, 34 Forest St., Attleboro, Mass. How to redesign

staked, brazed or welded electrical contact assemblies to permit simplified manufacture, increased strength and accurate dimensional control by means of top-lay contacts or clad strip material is described in a new 4-page brochure.
CIRCLE 355 ON READER SERVICE CARD

RECORDING OSCILLOGRAPH Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. An eight-page bulletin illustrates and describes a new type 5-123 recording oscillograph designed for maximum reliability, flexibility, ease of installation, operation and maintenance.
CIRCLE 356 ON READER SERVICE CARD

MOBILE TRACKING ANTENNA D. S. Kennedy & Co., Cohasset, Mass. Specifications and detailed information, including antenna pattern data, are reported in a two-page bulletin which describes the recently announced mobile tracking antenna system, model 1092.
CIRCLE 357 ON READER SERVICE CARD

SELENIUM RECTIFIERS Radio Receptor Co., Inc., subsidiary of General Instrument Corp., 240 Wythe Ave., Brooklyn 11, N.Y., has released 8-page catalog EL-316 covering all product lines of selenium diodes and rectifiers designed to meet applications in the electronics, entertainment and special products fields.
CIRCLE 358 ON READER SERVICE CARD

RELAY SOCKET ASSEMBLIES Augat Bros., Inc., 33 Perry Ave., Attleboro, Mass. Catalog No. RS-160 illustrates and describes a line of microminiature relay socket assemblies featuring precision turned screw machine contacts with silver and gold plating.
CIRCLE 359 ON READER SERVICE CARD

POWER SIGNAL GENERATOR Rohde & Schwarz, 111 Lexington Ave., Passaic, N. J. Data sheet 410040 describes type SLRD uhf power signal generator with a frequency range from 275-2,750 Mc, maximum output power of 20 w and high frequency and amplitude stability.
CIRCLE 360 ON READER SERVICE CARD

CIRCLE 101 ON READERS SERVICE CARD→

Vitro Opens West Coast Facility

VITRO CORPORATION OF AMERICA recently announced the opening of a West Coast facility in Los Angeles to serve the electronics, space, weapons, chemical and nuclear industries.

Frank B. Jewett, Jr., Vitro president, said the new facility includes an electronic marketing, maintenance and service operation, product showrooms and administrative offices.

Sales engineers and other technical personnel have been assigned to the unit to provide technical aid, closer coordination and faster service for customers in a wide range of processing and space-age technologies. Electronic equipments and spare parts are being stocked to expedite product service and delivery.

Vitro has obtained a five-year lease on the property, a new two-story building with space for growth.

Among divisions currently represented at the West Coast facility are Nems-Clarke Co., Vitro Engineering Co. and Vitro Laboratories.

Nems-Clarke, producer and designer of communications equipment for defense and industry, is supplying equipment of its own design for a number of space and missile projects.

Vitro Laboratories is engaged in systems engineering coordination of Terrier, Tartar, Talos and Polaris missiles for the Navy Bureau of Weapons' missile-ship program.

It is also active in the field of underwater ordnance development, electronics research, development and engineering, and operation of missile and armament test facilities.

The division's representation at the West Coast facility is in addition to the Vitro field engineers assigned to missile manufacturing operations at Convair in Pomona and Lockheed Missile Systems division in Sunnyvale, Calif., the Bremerton Navy Yard and Bethlehem Steel in San Francisco.

Vitro Engineering Co. provides design, engineering and construction management services for industrial and defense facilities. It has designed more than 25 nuclear research and test facilities, including radiological laboratories, nuclear reactors and nuclear power plants.

The company also designs space-environmental and major-weapons test facilities.

Geotech Elects Executive V-P

THE BOARD of directors of the Geotechnical Corporation, Garland, Texas, recently announced the election of William B. Heroy, Jr., to the office of executive vice president. He joined Geotech in 1945 and was subsequently appointed a vice president and member of the board of directors.

In his new position, Heroy will direct and coordinate the operations of the company. The 230-man company recently moved into its new 40,000 sq ft plant. The modern plant has complete facilities for R&D, machine and sheet metal fabrication, assembly testing of electronic and electromechanical equipment.

Geotech, formerly known for its geophysical R&D and exploration, has diversified and expanded its activities in recent years. It now develops and manufactures instruments and systems for data telemetry, timing and recording, data reduction and seismology. The company is also known for its research and consultation in geology and geophysics.

Austin Marx Takes Sales Manager Post

COMPUTER-MEASUREMENTS CO., Sylmar, Calif., recently appointed Austin F. Marx sales manager.

Prior to joining Computer-Measurements, he was eastern regional manager for the EASE computer group of Beckman Instruments.

Wilcox Forms New Division

THE WILCOX ELECTRIC COMPANY of Kansas City, Mo., has announced the recent formation of the Wilcox Magnetics Division. The new division is staffed and fully equipped to design and manufacture a wide

For these applications too...

- BROADCAST
- INDUSTRIAL CONTROL
- MEDICAL ELECTRONICS
- NUCLEAR ELECTRONICS
- COMMERCIAL SOUND

USE CBS INSTRUMENT TUBES

CBS Instrument Tubes are designed, manufactured and tested for critical instrumentation use. But their advantages of extreme stability without need for expensive screening and "burning-in" by you . . . their 10,000-hour guaranteed life . . . tight characteristics . . . and premium construction . . . also result in the finest tubes ever produced for most other applications. You profit also from important savings in tube costs made possible by elimination of shock and vibration controls not required.

See what these CBS Instrument Tubes can do for you. Check the many types available. Order them from your local sales office. Test them in your designs.

SELECT FROM 11 NEW TYPES DESIGNED BY CBS ELECTRONICS

CBS 7548	Practical secondary-emission pulse amplifier with 4 ns rise time at 1 amp.
CBS 7721	Frame-grid, wide-band pentode with gain-bandwidth product of 465, Gm of 35,000, and I_B of 22 ma.
CBS 7728	Stable medium-mu twin triode replacing 12AT7.
CBS 7729	Stable high-mu twin triode replacing 12AX7.
CBS 7730	Stable medium-mu twin triode replacing 12AU7.
CBS 7731	Stable vhf triode-pentode replacing 6U8.
CBS 7732	Stable high-gain r-f pentode replacing 6CB6.
CBS 7733	Stable high-perveance video pentode replacing 12BY7A.
CBS ECC88/6DJ8	High-gain, low-noise, frame-grid twin triode.
CBS E88CC/6922	Ruggedized version of ECC88/6DJ8.
CBS E280F/7722	Frame-grid, wide-band pentode with gain-bandwidth product of 362, Gm of 26,000, and I_B of 20 ma.

Watch for more "new-concept" Instrument Tubes by their originator . . . CBS Electronics.

UNIQUE FEATURES

Only in CBS Instrument Tube versions of standard receiving tubes, will you find all these advantages:

- Stable characteristics
- Tight test limits
- Extensive life tests*
- Coil heaters
- Gold-plated base pins
- Maximum value and performance per dollar for critical sockets

10,000-HOUR WARRANTY

*Include unique 100-hour life assurance tests . . . comprehensive 1000-hour life tests . . . 5000-hour informational life tests.

CBS instrument tubes®

GOLD-PLATED BASE PINS

The high-conductivity gold-plated base pins used on all CBS Instrument Tubes typify their built-in premium quality.

CBS ELECTRONICS A Division of Columbia Broadcasting System, Inc.

Sales Offices: *Danvers, Mass.*, 100 Endicott St., SPring 4-2360 • *Newark, N. J.*, 231 Johnson Ave., TAlbot 4-2450 • *Melrose Park, Ill.*, 1990 N. Mannheim Rd., EStebrook 9-2100 • *Los Angeles, Calif.*, 2120 S. Garfield Ave., RAymond 3-9081 • *Atlanta, Ga.*, Cary Chapman & Co., 672 Whitehall St., S.W., JAckson 4-7388 • *Minneapolis, Minn.*, The Heimann Co., 1711 Hawthorne Ave., FEderal 2-5457.

range of magnetic components, according to James E. Gardner, executive vice president of Wilcox Electric.

The division's complete environmental test facilities allow development and qualification of transformers and specialty items to all requirements of MIL-T-27A, Gardner said.

Duncan Joins Gorham As Staff Scientist

APPOINTMENT of Kenneth Duncan as staff scientist of the Gorham Electronics Laboratory has been announced by Gorham Mfg. Co., Providence, R. I.

Duncan comes to Gorham from the Raytheon Co., Maynard, Mass., where he was section head of engineering and antenna design and analysis department. Previously, he was with Gabriel Electronics Division as chief electronic engineer. He had earlier been a design and development engineer for the General Electric Company.

Amperex Announces Four Promotions

FOUR senior applications engineers have been promoted to the position of section head in the applications engineering department of Amperex Electronic Corp., Hicksville, N. Y.

The promotions are of Bertram Green, to head, industrial tube applications; Wallace Hickman, to head, microwave tube applications; Albert H. Katz, to head, transmitting and communication tube applications; and Kevin Redmond, to head, semiconductor applications. All four men report to Selig Gertzis, chief applications engineer.

Green joined Amperex in 1948 as

equipment engineer, in charge of designing, building and maintaining plant electronic equipment. In 1955 he became a senior applications engineer.

Hickman has been with Amperex since 1954 in the microwave tube development group and the microwave tube applications group.

Katz came to Amperex in 1954 as an applications engineer concentrating on mobile radio.

Redmond joined Amperex in 1957 as applications engineer, special purpose tubes and semiconductors.

Richard Cook Joins TIC Staff

RECENT ADDITION to the engineering staff of Technology Instrument Corp. of California is Richard Cook. Previously associated with Valor Instruments, Cook Instruments, Dix Engineering, Allied Research & Development, and Raytheon, he joins TIC as an electronic component engineer.

Cook will direct the company's product expansion into lumped constant delay lines featuring a very high delay time to rise time ratio per cu in. Company expects to be in full scale production by September 1st.

Announce New Company

PITTSBURGH ELECTRONICS CORPORATION has been organized in Pittsburgh, Pa., to engage in the manufacture and sale of pulse transformers and other electronic parts, components and assemblies.

P. J. Gentile is president; John M. Heim and Harry Eyberger, vice presidents; and Robert C. Downie, secretary and treasurer.

OPPORTUNITIES TO GROW with Kollsman

AIR DATA INSTRUMENTS & SYSTEMS

Senior Project Engineers, EE & ME. For aircraft and missile instrumentation. 5 to 10 years' project experience in precision electromechanical devices, pressure transducers.

AUTOMATIC ASTRO TRACKING SYSTEMS

Project Engineers, EE. For automatic astro tracking systems. Up to 5 years' related experience.

STAFF ENGINEERS & SPECIALISTS

a) Experience in the research and development of transistors in servo, digital and instrumentation application. Minimum 3 years' experience desired in transistor circuit design for military applications.

b) Experienced with IR to UV radiation properties and applications, noise theory and detectors.

c) Optics—IR through visual optical design, lens design, materials.

d) Digital computers—logic or packaging experience.

e) Theoretical mechanics—inertial and trajectory studies.

Kollsman's leadership and continuing growth in the field of automatic navigation and flight instrumentation for aircraft, missiles and other space vehicles assures excellent opportunities for qualified men. Please send resume to T. A. DeLuca.

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SUBSIDIARY OF STANDARD KOLLSMAN INDUSTRIES, INC.
80-08 45th AVENUE, ELMHURST, NEW YORK

CIRCLE 379 ON READER SERVICE CARD

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(Classified Advertising)

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The advertising rate is $24.75 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request. AN ADVERTISING INCH is measured ⅞ inch vertically on one column, 3 columns—30 inches—to a page. EQUIPMENT WANTED or FOR SALE ADVERTISEMENTS acceptable only in Displayed Style.

UNDISPLAYED RATE

$2.40 a line, minimum 3 lines. To figure advance payment count 5 average words as a line.
PROPOSALS, $2.40 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).

SPECIALS IN • KLYSTRONS •

2K25	$13.50
2K26	33.50
2K28	27.00
2K29	27.50
2K33A	144.00
2K42	170.00
2K43	144.00
2K44	126.00
2K45	35.00
2K50	72.00
2K56	50.00
X12	475.00

Many other types

See pages 622, 23 & 24 of the 1959 Electronics Buyers' Guide for a more complete listing.

Phone: WAlker 5-6000
Cables: TELSERSUP

LIBERTY ELECTRONICS, INC.
582 BROADWAY
New York 12, N. Y.

CIRCLE 460 ON READER SERVICE CARD

SINGER

More than a Century of Engineering Tradition

The connecting factor between bobbins and broadband preamplifiers is the engineering tradition that brought them to fruition. Since 1850, the Singer Manufacturing Company has evolved a habit of alert engineering skill and steady business growth. These inherent factors for your professional success are now a part of the new Military Product Division at Singer-Bridgeport.

Openings exist for:

- **ELECTRONIC ENGINEERS**
- **ELECTRICAL ENGINEERS**
- **MECHANICAL ENGINEERS**

Singer-Bridgeport assures you the rare combination of security and genuine ground-floor opportunity that is vital to your professional growth. Your projects receive strong support from Singer-Bridgeport's integrated organization which has the advantages of development, production, assembly and environmental test facilities.

Send your resume in strict confidence to Mr. Fred Corbett, Supervisor of Employment

SINGER-BRIDGEPORT
A DIVISION OF THE SINGER MANUFACTURING COMPANY
915 Pembroke Street Bridgeport 8, Conn

CIRCLE 380 ON READER SERVICE CARD

DISENCHANTED ENGINEERS

If your present employer has failed to utilize your full potential, why not permit us to explore the parameters for your personal qualifications with the many dynamic young companies in aviation, electronics, missiles and rockets. We now have in excess of 4,000 openings in the $8,000 to $40,000 bracket, all of which are fee paid. Why wait? Send resume in duplicate at once indicating geographical preferences and salary requirements.

FIDELITY PERSONNEL
1530 Chestnut Street, Philadelphia 2, Pa.
Established 1943

CIRCLE 381 ON READER SERVICE CARD

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Expanding Electronics division of Engineering Service Corp. requires Sales Representatives for its new digital products & design and fabrication services. Many territories open. Inquire immediately to:

MODERN DESIGN
Vestal Parkway Vestal, N. Y.

CIRCLE 382 ON READER SERVICE CARD

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POSITION WANTED

Electrical Engineer (German) seeks connection with American firm with subsidiary in Germany or wishing to establish production facilities. Knowledge of American and German production methods, personnel procedures. Experienced in automatic machinery, communication circuits and electrical test equipment in U. S. and abroad. PW-4939, Electronics.

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NO COST OR OBLIGATION

This service is aimed at helping you, the reader of "SEARCHLIGHT", to locate Surplus new and used electronic equipment and components *not currently advertised.* (This service is for USER-BUYERS only).

How to use: Check the dealer ads to see if what you want is not currently advertised. If not, send us the specifications of the equipment wanted on the coupon below, or on your own company letterhead to:

Searchlight Equipment Locating Service
c/o ELECTRONICS
P. O. Box 12, N. Y. 36, N. Y.

Your requirements will be brought promptly to the attention of the equipment dealers advertising in this section. You will receive replies directly from them.

Searchlight Equipment Locating Service
c/o ELECTRONICS
P. O. Box 12, N. Y. 36, N. Y.
Please help us locate the following equipment components.

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NAME ....
TITLE ....
COMPANY ....
STREET ....
CITY 8/5/60

INDEX TO ADVERTISERS

Audited Paid Circulation

*See Advertisement in the July 20, 1960 issue of Electronics Buyers' Guide for complete line of products or services.

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

ADVERTISERS INDEX

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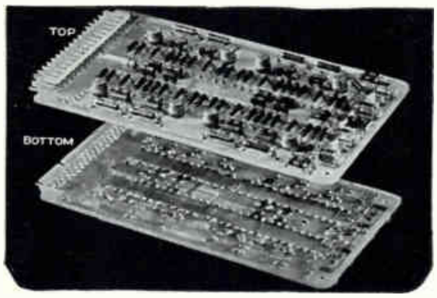

Engineers and Scientists

With the advent of solid state technology and a mounting recognition that environmental and hence materials considerations hold many of the clues to future advances in outer space apparatus, the scientist has come to the fore in our industry. This is as it should be, yet we detect murmurings that the scientist will somehow or other replace the engineer. This is not as it should be. In fact it's impossible.

Scientists—good ones—will be needed in ever increasing number, it is true. But without engineers—plenty of engineers and good engineers—the findings of our scientists will never be translated into the fabulous products we've been promised tomorrow. Without engineers, good engineers, superior and reliable military weapons cannot be had. In fact the key to this crucial problem of reliability is largely in the hands of engineers.

There has been some concern approaching hysteria regarding scientific education. Educators urge science on our youth. We hear less and less about engineering. Educators, clamoring to fall in line with popular thinking, extol the teaching of engineering in a scientific frame of reference. Engineering courses are scientifically oriented. Engineering courses and curriculi this fall will have been altered to achieve these distinctions.

This is not good. An engineer is an engineer, with reason to be proud of it if he's a good one. And it's difficult enough in four short years to absorb the engineering knowledge necessary to become a good engineer without diluting the curriculum with a scientific flavor. Where will a half-engineer half-scientist fit into industry? No deprecation of science or scientists is implied or intended, but let us have our engineers trained in an engineering frame of reference.

James Girdwood

PUBLISHER

V-BAND MAGNETRONS

Life — over 700 hours reported
Peak power available — more than 10 kw. (More power than you can get from any other device at this frequency)
Duty cycle — up to 0.001. (For the BL-221, it is 0.00055)
Vibration — will survive 10 g's
Shock — 50 g's at 4 millisec
Lightweight — 7.25 lbs
Mounting — mates to modified standard flange
Ruggedized — Ceramic and metal construction
Fixed tuned

Band	Tube Type	Frequency Range (MC)	Minimum Peak Power (KW)	Output Mates with
V	BL-235	51,000–54,000	10	UG385/U
V	BL-236	54,000–57,000	10	UG385/U
V	BL-237	57,000–60,000	10	UG385/U
V	BL-221	69,000–70,500	10	UG385/U

VISIT US AT THE WESCON SHOW—BOOTH #612-613

New product catalog available. Send for your copy today.

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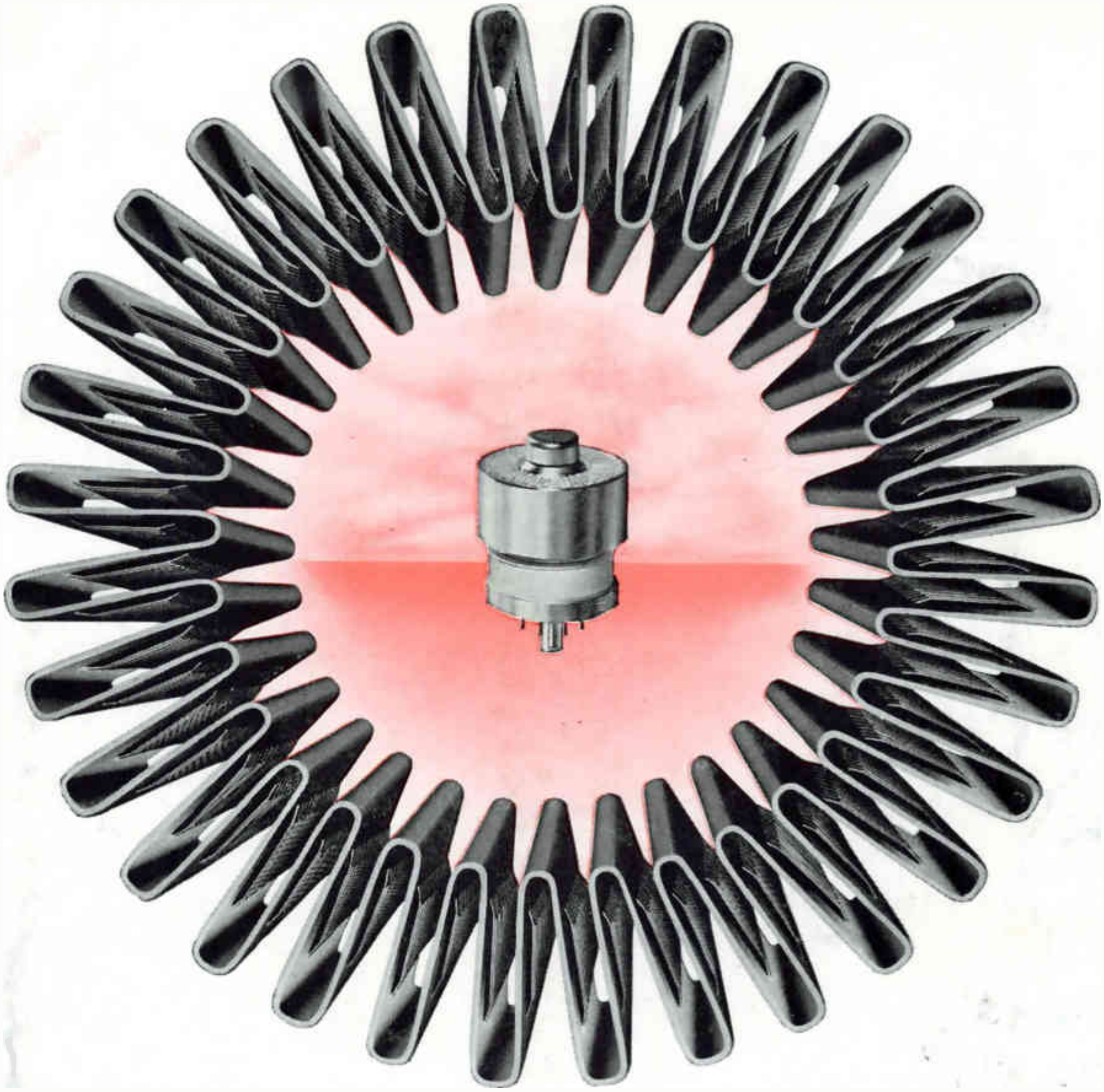
Offices in major cities — A subsidiary of Varian Associates.

Leaders in the design, development and manufacture of TR, ATR, Pre-TR tubes; shutters; reference cavities; crystal protectors; silicon diodes; magnetrons; klystrons; duplexers; pressurizing windows; noise source tubes; high frequency triode oscillators; surge protectors.



RCA radiator efficiency allows you to cut blower horsepower in half

Resulting space and weight savings permit more compact packaging, greater design versatility

Recently a leading manufacturer of communications equipment ran a comprehensive series of tests comparing the heat dissipating capabilities of RCA-7203/4CX-250B, with integral radiator, to a standard JAN/4X-250B. The results: the JAN/4X-250B required twice as much blower horsepower.

The integral radiator on RCA-7203 is an exclusive RCA development. It is used on many types of RCA tubes for air-cooled operation. Its remarkably efficient louvered construction is a logical development in radiator design . . . but only RCA has mastered the complex manufacturing problems involved.

This high-efficiency integral radiator is one of the things that makes RCA power tubes so popular in designs where space and weight are critical considerations. For further information about this and other pace-setting features of RCA power tubes, including the new Cermolox* line, write:

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