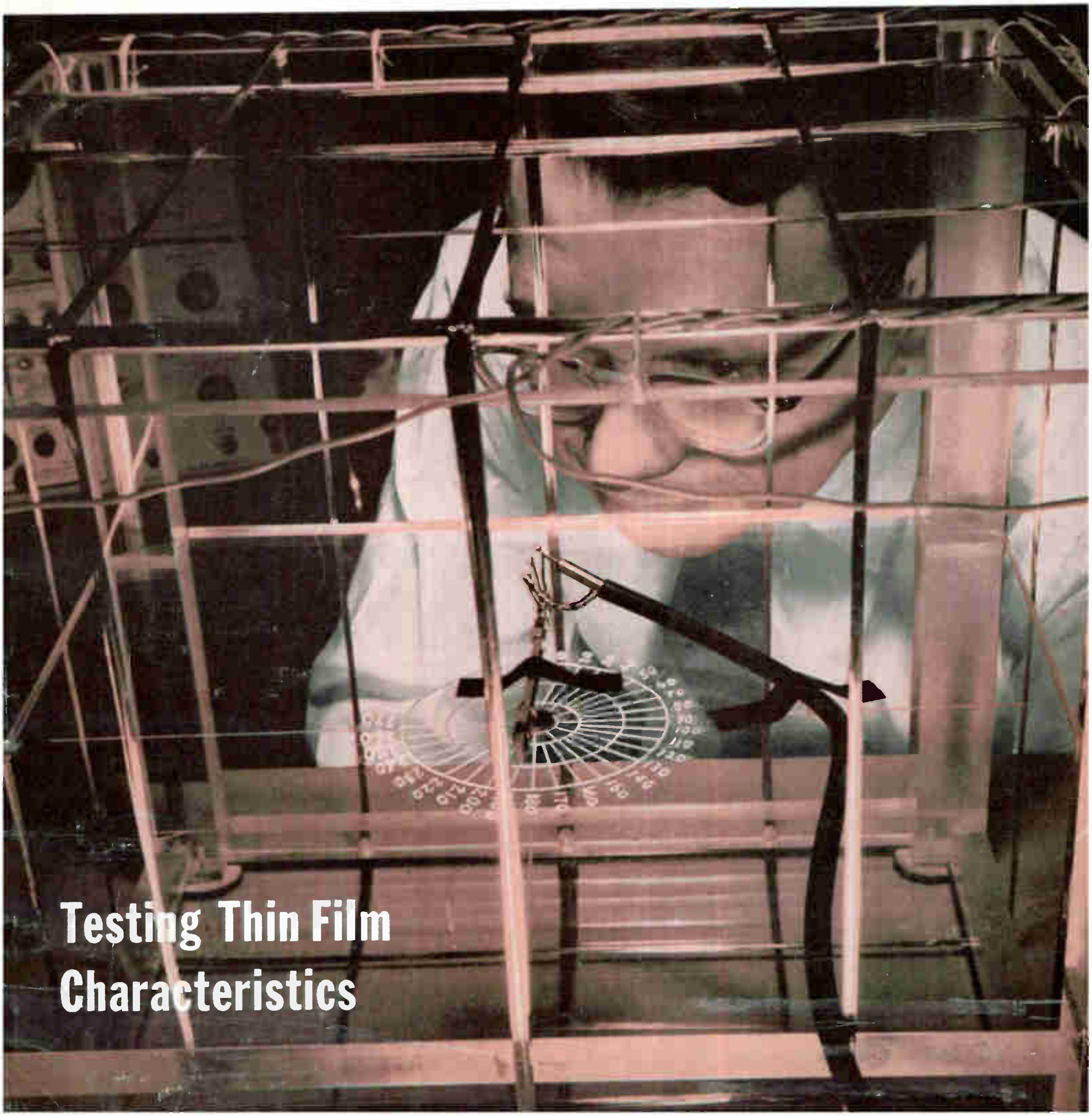
Defense Debate: Orders or Cuts?

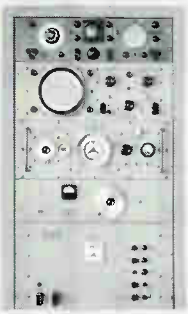
page 26

electronics

A McGRAW-HILL PUBLICATION MARCH 4, 1960 PRICE SEVENTY-FIVE CENTS



FREQUENCY MEASURING EQUIPMENT



hp Primary Frequency/Time Standard System

New compact, easy-to-operate primary frequency and time standard. Consists of the following four basic instruments (plus WWV receiver not supplied).

hp 113AR Frequency Divider and Clock permits adjustment of system for maximum absolute accuracy, simplifies obtaining detailed records of drift rates or time/frequency differences. Precise time comparisons between the 103AR Frequency Standard and WWV (or other) standard time signals serve to average out errors due to propagation path variations. $2,500.00.

hp 103AR Frequency Standard is a completely transistorized oscillator which achieves stability of 5 parts in 10^{10} per day. Provides 1 MC and 100 KC sine output. Price on request.

hp 724AR Standby Power Supply powers the 103AR and 113AR. Standby battery "floats" across regulated power supply, instantly assumes load, continues system operation in case of ac power failure. Built-in alarm circuits. 26 v dc output, 1.5 amp maximum current. Price on request.

hp 120AR Oscilloscope. 200 KC triggered oscilloscope used as indicator. $435.00.

hp 570/571B Digital Clocks

New 570A/571B Digital Clocks (installed in left side of hp Digital Recorder cabinet) add time-of-day information to other recorded data. Clocks can also control rate at which measurements are made. In-line, 6-place numeric readout; maximum 23 hours, 59 minutes, 59 seconds. Operates with internal or external time base. hp 570A (fits 560A) $1,050.00; hp 571B (fits 561B) $950.00.

hp 560A/561B Digital Recorders

hp 560A, 561B Digital Recorders provide continuous, permanent printed record of test data. Analog output of Model 560A makes possible graphic recording with extreme accuracy. Records five 11-digit lines/second; secondary and coding data may be entered simultaneously. hp 560A (6 digits) $1,265.00; hp 561B (for hp Electronic Counters with in-line display and 405AR Digital Voltmeter use) $1,065.00.

hp 100E Precision Frequency Standard

Model 100E is a new precision standard with $5/10^8$ per week stability, the versatility of a wide variety of outputs, and compact size—just 8¾" high. Outputs include 1 MC and 100 KC sine waves from 50 ohm source, plus sine and pulse outputs at 10 KC, 1 KC, 100 cps, 10 cps. A timing comb is provided for calibrating or measurement of sweeps and time intervals. The instrument includes an oscilloscope for calibrating external equipment with Lissajous figures or checking internal frequency division of the Standard. $900.00.

WIN THESE hp INSTRUMENTS!

1ST PRIZE hp 120A 200 KC OSCILLOSCOPE

2ND PRIZE hp 403A TRANSISTORIZED AC VOLTMETER

Guess the engineering man-hours invested in the development of new instruments offered by hp and its subsidiaries, on display at the I. R. E. Show

If your guess is closest to the actual number of man-hours, you win a brand-new hp 120A laboratory oscilloscope. If your guess is second most accurate, you win a compact, multi-purpose new hp 403A Transistorized AC Voltmeter!

Nothing to write, nothing to buy! Just drop by the I.R.E. Show exhibits of hp and its subsidiaries—Dymec, Boonton Radio and Moseley Autograf Recorders. Evaluate the new instruments on display, and record your estimate of development man-hours on an entry blank.

Contest closes at 9 p.m., Thursday, March 24. Winners will be notified later. In case of tie, Hewlett-Packard will award duplicate prizes.

hp AT I. R. E. SHOW
3rd FLOOR
Between Elevators and Escalators on Aisle 300

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are you properly instrumented for the increasingly complex measurements of the demanding new decade— the ELECTRONIC 60's? *Do you have the tools you need to progress, to succeed?*

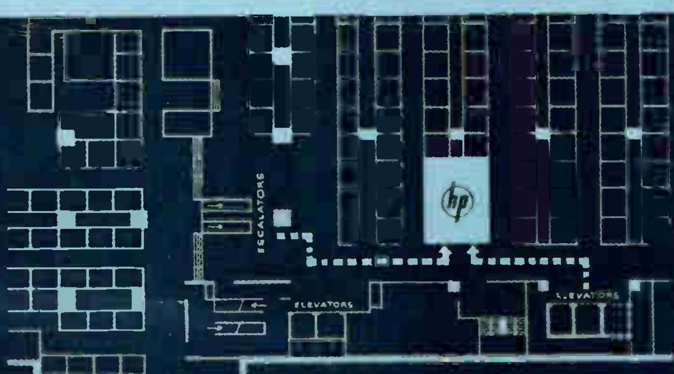
RRRReady?

SEE hp

providing the instruments you need to keep pace now, and promising to provide those you will need to move ahead tomorrow!

HERE ARE THE FIRST OF THE NEW DECADE'S IMPORTANT NEW INSTRUMENTS FROM hp

to save your engineering time, to give you swift, sure answers to the difficult measuring problems ahead



hp NOW ON 3rd FLOOR AT I.R.E. SHOW! BETWEEN ESCALATORS AND ELEVATORS ON AISLE 300

Our new exhibit, between the escalators and elevators, presents 14 new instruments, plus a host of associated and recently introduced equipment. Don't miss it!

OSCILLOSCOPES

hp 185A 500 MC Oscilloscope
hp 187A Dual Trace Amplifier

Versatile sampling oscilloscope permits viewing of repetitive millimicrosecond pulses with conventional scope convenience. Rise time is less than 0.7 millimicroseconds. Full 10 centimeter vertical display and high vertical amplifier sensitivity permit pulse analysis in greater detail than ever before possible. Built-in time and amplitude calibrators provide convenient verification of sweep and amplitude calibrations.

187A Dual Trace Amplifier allows simultaneous viewing of two phenomena and accurate time comparisons. Wide dynamic range, calibrated vertical attenuators, sensitivity 10 mv/cm to 200 mv/cm, ± 5% accuracy. Sweep times range from 10 mμsec/cm to 100 mμsec/cm; magnifier increases fastest sweep to 0.1 mμsec/cm. Other features: new-design high impedance probes, X-Y recorder output, sweep delay control, beam finder. hp 185A, $2,000.00; hp 187A, $1,000.00.

hp 160B 15 MC Militarized Oscilloscope

Model 160B is a reliable, extra rugged, general purpose oscilloscope built to MIL standards. In addition to vertical amplifier plug-ins, a second series of plug-ins, including Model 166C Display Scanner and others provide a high degree of flexibility, eliminate possibility of obsolescence.

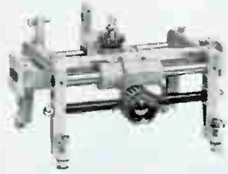
With 162A Dual Trace Amplifier plug-in, maximum sensitivity is 20 mv/cm; amplifier features differential input, 1 MC chopping. High stability is achieved by tube-transistor circuitry and regulated DC filament voltages throughout. 24 calibrated sweep times are provided, 0.1 μsec/cm to 5 sec/cm, ± 3% accuracy. Seven range magnifier increases fastest sweep to 0.02 μsec/cm. Sweep delay plug-in available. Horizontal sensitivity 0.1 v/cm to 10 v/cm. hp 162A, $350.00; hp 160B, $1800.00.

hp 166C Display Scanner

Truly a significant advance in measuring convenience and accuracy. This plug-in unit for the 160B Oscilloscope provides outputs to duplicate a CRT trace with an X-Y recorder such as the Moseley Model 2A; permits permanent, large scale, high resolution record of repetitive waveforms displayed on CRT. Ultimate resolution is higher than either scope CRT or photograph. You can observe scope trace while records are being made.

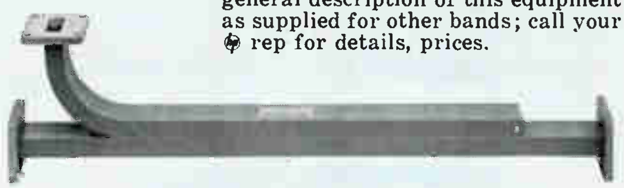
Scanning speed is arranged to keep Y output within bandwidth of conventional recorders. Unique pen speed stabilizer automatically slows X axis drive when fast Y signals occur. At other times permits rapid scanning to allow faithful reproduction of square waves and sharp pulses with reduced scan time. Outputs: Y-axis approximately 1 v full scale; X-axis +50 to —50 v approximately. Sweep range from fastest scope speed to 5 ms/cm (signal rep rate greater than 20 cps). hp 166C, $300.00.

MICROWAVE EQUIPMENT

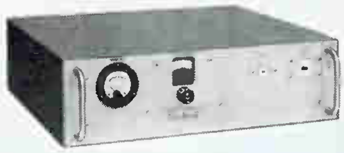


WR75 Components— 10 to 15 KMC!

Tool now for swift, sure measurement in the newly-significant microwave communications band (WR75). New hp microwave equipment includes many popular hp waveguide units—specifically engineered for precise work between 10 and 15 KMC. Check this list: M375A Variable Attenuator, M382A Precision Variable Attenuator, M421A Crystal Detector Mount, M487B Thermistor Mount, M532A Direct Reading Wavemeter, M752 Directional Couplers (3, 10 and 20 db models), M810B Slotted Line, M870A Slide Screw Tuner, M914B Moving Load, M920B Adjustable Short. All fitted with flat cover flanges for WR-75 waveguide. See your hp Catalog for general description of this equipment as supplied for other bands; call your hp rep for details, prices.



hp 938A/940A Frequency Doubler Sets— to 40 KMC



Now have convenient, inexpensive signal generation capability to 40.0 KMC! Operating on harmonic generation principle, new hp 938A provides 18 to 26.5 KMC output; new hp 940A covers 26.5 to 40 KMC. Can be driven from hp 626A and 628A Signal Generators or electronic sweep oscillators. Conversion efficiency less than 18 db at 10 mw input. Output power 0.5 to 1 mw approx. with hp 626A or 628A. Input power 10 mw (required), 500 mw (maximum). Output monitor accuracy ± 1 to ± 2 db depending on model and frequency; output attenuator accuracy ± 2% of reading or 0.2 db (whichever is greater). Attenuator range 100 db; output SWR approx. 2:1 at full output. Size 5" high, 19" wide, 18" deep, weight 20 lbs. hp 938A, $1,500.00; hp 940A, $1,500.00.

hp 344A Noise Figure Meter

Specifically designed to quickly, accurately measure noise figure of operating radar sets. Automatic operation; simple front panel calibration. Militarized, transistorized, for reliability in extreme environments, and minimum size and weight. Gives continuous noise figure presentation on most radar receivers. Extremely high sensitivity permits decoupling noise source up to 20 db from main transmitter line to minimize system degradation. Provision for automatic alarm; special output permits monitoring noise figure with remote meter. Noise source modulator may be installed remotely. Several meter scale/excess noise options; 30 MC input frequency, 1 MC bandwidth, 75 ohms input impedance. Approx. price $1,600.00 (depending on options and modifications selected).

VERSATILE TEST INSTRUMENTS

411A 1 KMC Voltmeter

Perhaps the most widely useful new voltmeter of a decade! A practical, accurate VTVM with frequency response to 1 KMC—measuring ac voltage to 1 millivolt, with high accuracy! Precision linear scale you read instantly, unmistakably, directly! This is the new 411A, latest in broad array of precision voltmeters—standard of the industry!

Overall frequency range 5 KC to 1 KMC; voltage range 1 millivolt to 10 v; 10 millivolts full scale sensitivity. Covered in 7 ranges. Accuracy is ± 3% of full scale, 10 KC to 50 MC; ± 6% of full scale, 50 MC to 150 MC; ± 1 db, 5 KC to 1 KMC. Large linear meter scale. 115/230 v line power. $450.00.

456A AC Current Probe

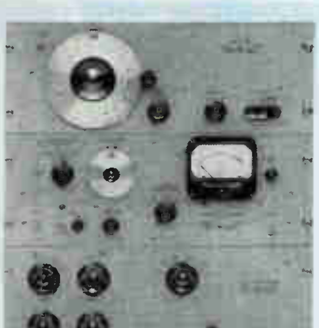
Permits your conventional ac voltmeter or oscilloscope to measure current quickly and accurately—without direct connection to the circuit under test or appreciable loading of the circuit. Unique new probe just *clamps around* the current-carrying wire, providing a voltage output you read on a VTVM or scope. Sensitivity (out/input) is 1 mv/ma; thus, readings are direct in ma. Measures ac in logic circuits, transistors, vacuum tubes; makes possible scope viewing of complex current waveforms with rise times to 0.08 μsec, currents from 1 ma to 1 amp rms. $190.00.

466A AC Amplifier

Highly stable, low distortion, wide range transistorized amplifier offering 20 or 40 db gain to increase scope or voltmeter sensitivity by 10 or 100. Flat response within ± 0.5 db 10 cps to 1 MC renders the instrument appropriate for audio, supersonic or low rf measurements. Powered by ac line voltage or batteries offering approximately 150 hours of hum-free service. Weighs just 3 lbs.; ideal for field measuring. $150.00.

14 NEW INSTRUMENTS and SYSTEMS

to save your time and simplify your job!

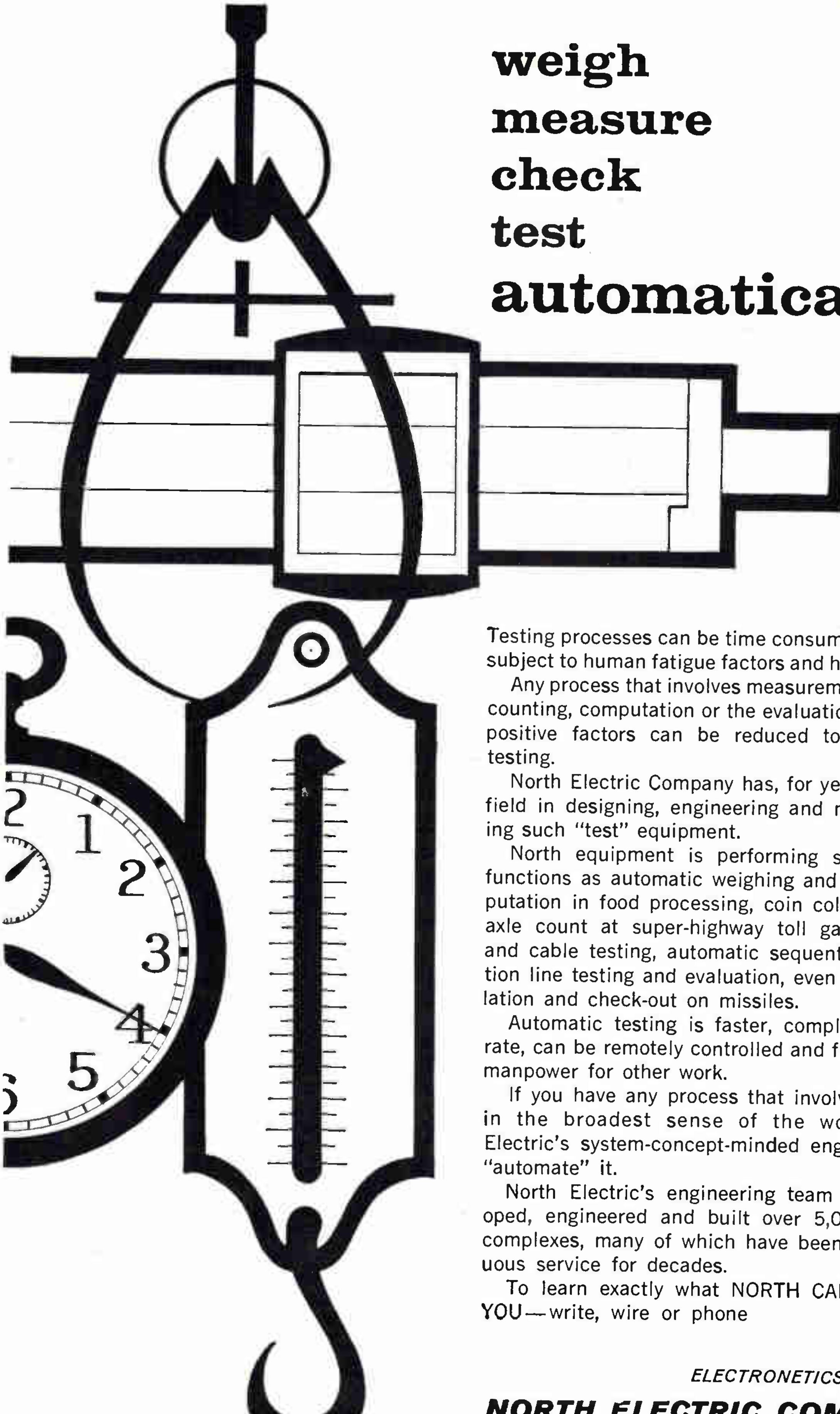


Voltmeter-Oscilloscope Calibration System

Complete calibration of VTVM's or Oscilloscopes involves measurement of both frequency response and voltage accuracy. New calibration system performs these tasks quickly, accurately. System includes: 738AR Voltmeter Calibrator (top), highly stable voltage source providing accurate dc and 400 cps ac levels from 300 μv to 300 v with negligible drift and hum. $875.00.

739AR Frequency Response Test Set (middle) provides a constant amplitude reference voltage of at least 3 v into 50 ohms at frequencies from 300 KC to 10 MC. In connection with 200SR (see below) frequency range extends to 5 cps on low side. $450.00.

200SR Oscillator (bottom) is a special 5 cps to 600 KC oscillator designed for use with Model 739AR. Waveform distortion and output impedance are low to insure reliable measurements. $180.00.



weigh measure check test automatically

Testing processes can be time consuming and are subject to human fatigue factors and human error.

Any process that involves measurement, weight, counting, computation or the evaluation of known positive factors can be reduced to automatic testing.

North Electric Company has, for years, led the field in designing, engineering and manufacturing such "test" equipment.

North equipment is performing such varied functions as automatic weighing and price computation in food processing, coin collection and axle count at super-highway toll gates, circuit and cable testing, automatic sequential production line testing and evaluation, even fault simulation and check-out on missiles.

Automatic testing is faster, completely accurate, can be remotely controlled and frees skilled manpower for other work.

If you have any process that involves testing, in the broadest sense of the word, North Electric's system-concept-minded engineers can "automate" it.

North Electric's engineering team has developed, engineered and built over 5,000 system complexes, many of which have been in continuous service for decades.

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electronics

MARCH 4, 1960

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Vol. 33 No. 10

Issue at a Glance

Business

Engineering

Departments

electronics

March 4, 1960 Vol. 33, No. 10

Member ABP and ABC

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CROSSTALK . . .

THE LARGE AND THE SMALL. Scientific man finds himself ever more deeply involved in reaching for extremes. In this technology, our engineers push the need for precise measurement to limits that we ourselves would not have grasped two decades ago. And so we constantly face the need for bigger numbers and smaller numbers to describe what we see.

For ten years or so we have limped along with double prefixes on our metric units—kilomegacycles, millimicroseconds, and so forth. Indeed, the problem is even older, for the micromicrofarad has been with us almost from the outset.

The metric system was set up with the idea of having a unique prefix for each order of magnitude. That idea does not today seem feasible, but each of the major orders should have its distinctive prefix in order to avoid impossibly long circumlocutions.

In 1958, the International Committee on Weights and Measures adopted four new prefixes for denoting the positive and negative ninth and twelfth orders of magnitude. National Bureau of Standards last year began using the new prefixes. One national committee on electrical standards has adopted one of the prefixes which it needs most.

This magazine will henceforth follow suit. The need to abandon millimicros and kilomegas has pressed us hard, and we gratefully yield to the pressure. Here are the prefixes and abbreviations that will be found in these pages from now on with the various orders of magnitude:

10^{12}	tera-	T	10^{-12}	pico-	p
10^{9}	giga-	G	10^{-9}	nano-	n
10^{6}	mega-	M	10^{-6}	micro-	μ
10^{3}	kilo-	K	10^{-3}	milli-	m
10^{2}	hecto-	H	10^{-2}	centi-	c
10^{1}	deka-	D	10^{-1}	deci-	d

The old ways die hard. Although we'll try to be as consistent as we can, we hope you'll forgive an occasional relapse.

Coming In Our March 11 Special Issue . . .

LOOKING AHEAD. The approach of the International IRE show is traditionally a time for looking ahead to future developments in our industry. Research now underway on new concepts, components and materials will bring significant results in many areas of electronics within the next two years.

In our next issue, a special, you'll read about trends and developments expected for 1961-62 in computers, communications systems, microelectronics, energy converters and other areas. To bring you this informative roundup, Associate Editor Emma and Assistant Editor Wolff have just visited research laboratories and interviewed specialists in a dozen different fields.

To learn the directions that learning-machine research is taking, the outlook for optical masers, the predicted efficiencies for different energy conversion techniques, the latest trends in ultrasonics watch for ELECTRONICS, March 11.

SOLAR CELLS. Because of weight limitations in space vehicles, devices which convert solar radiation directly into electrical power are highly desirable. Next week, R. M. Acker, R. P. Lipkis, R. S. Miller and P. C. Robinson of Space Technology Labs describe the basic design considerations and applications of silicon solar cells in the three space vehicles for the NASA Able-3 and -4 programs.

RAYTHEON METAL ENVELOPE 16″ RADAR DISPLAY TUBES

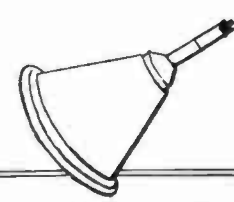
meet your design needs better . . . and faster

- ★ **AVAILABLE immediately in production quantities**
- ★ **AVAILABLE with aluminized faceplates**
- ★ **AVAILABLE with all standard radar phosphors**
- ★ **AVAILABLE with special infrared-stimulable storage phosphors (for true-motion trail indication)**

Every design advantage of metal-envelope CRT's is yours with Raytheon radar display tubes. You get more usable cabinet space and can cluster more components behind the tube. And Raytheon metal-envelope tubes are lighter, too — weigh five pounds less than equivalent 16″ glass envelope CRT's. The rugged metal envelopes withstand plenty of rough handling and vibration, and provide a solid rim around the faceplate that simplifies mounting assembly design.

The faceplate of a Raytheon metal-envelope CRT is precision-curved plate glass, carefully controlled in production to assure absolute uniform thickness — more accurate for optical reflection plotting.

Choose from stock tubes listed below — *available with all standard radar phosphors and special infrared-stimulable storage phosphors* — or let Raytheon's custom engineering service assist you in developing or adapting a tube to meet specific new applications. Write direct to Dept. 2527.



TYPICAL CHARACTERISTICS

Type	Focusing Method	Deflection Method	Deflection Angle	Collector Voltage	Grid #2 Voltage	Grid #1 Voltage	Focus Current (JETEC Coil #109)	Overall Length	Overall Diameter	Screen Diameter
16ADP	magnetic									
CK1352	high-voltage (3300 to 4300 Vdc)	magnetic	53°	12,000 Vdc	300 Vdc	−33 to −77 Vdc	95 ma.	21½″	15⅞″	14⅛″
CK1353	low-voltage (−135 to +400 Vdc)									

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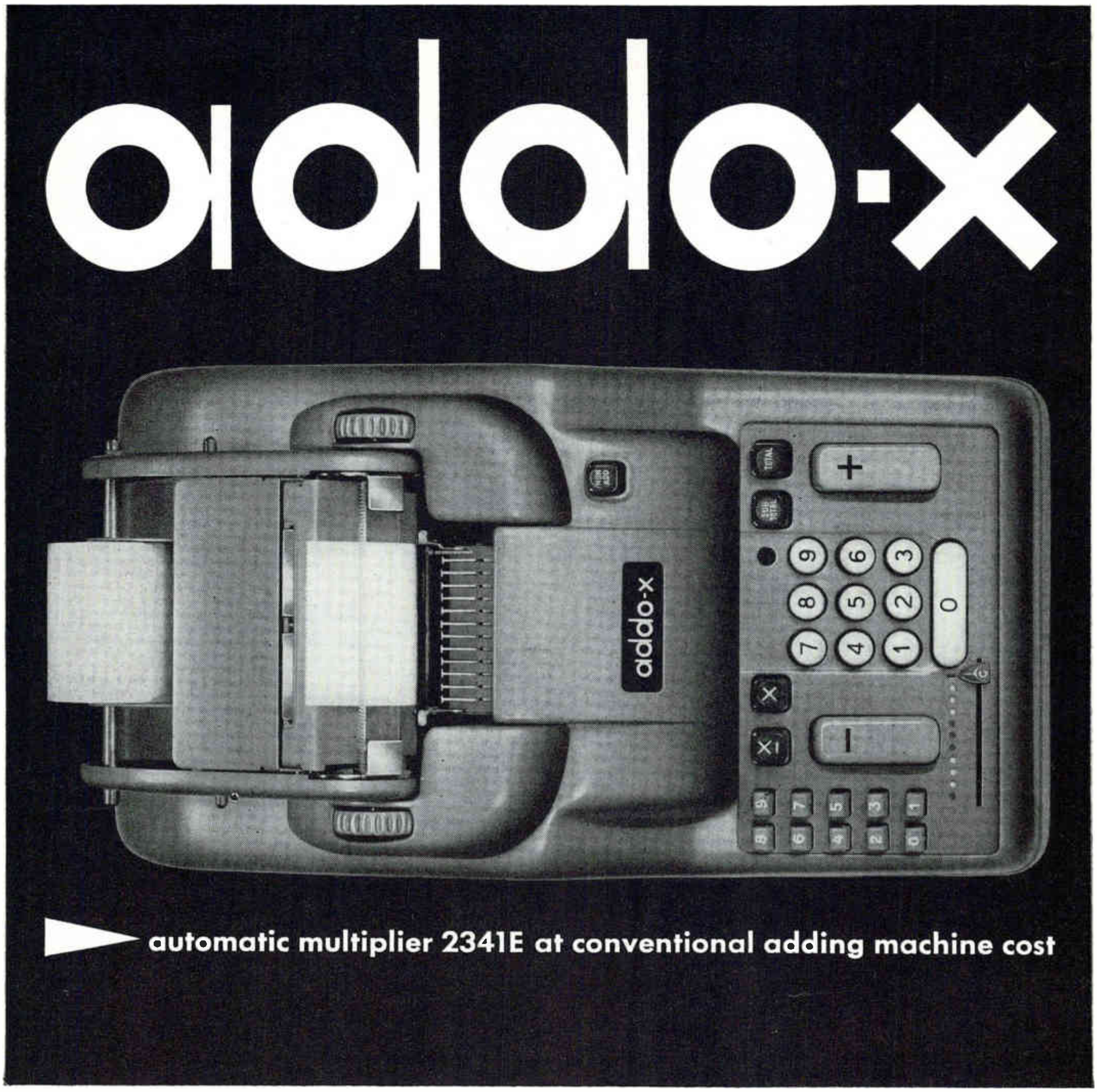


a versatile, double keyboard machine——provides essentially calculator performance and speeds up all percentage, invoice, job cost and payroll computations——has completely automatic multiplication feature——no stroke counting is required——saves time and increases reliability

"addo-x" stands for a family of versatile, time-proven adding and calculating machines backed by nation-wide service facilities——with lifetime guarantee repair parts availability see your dealer for on-your-job proof or write: "addo-x" 300 Park Avenue, New York 22, NY

EXCLU-SIVELY FROM CANNON

A MINIATURE GENERAL PURPOSE PLUG FEATURING ONE RECEPTACLE TO ACCEPT EITHER BALL OR BAYONET LOCK PLUG... WITH HIGH ALTITUDE PERFORMANCE—Now you can get true high-altitude performance in a miniature general purpose plug! Plus, Cannon's KQ/KR *exclusively* provides one receptacle to accept either ball or bayonet lock coupling device. The KQ/KR is the latest Cannon contribution in miniature plugs... crimp-type snap-in contacts... probe-proof socket contacts... moisture sealing grommet... field service with a simple hand tool! The KQ/KR is another reason why you should consult the first name in plugs—why you should always consult Cannon for *all* your plug requirements. Write for further information on the KQ/KR, or any Cannon product.

SEE THE KQ/KR AT
BOOTHS [illegible], IRE SHOW

CANNON PLUGS

CANNON ELECTRIC COMPANY, 3208 Humboldt St., Los Angeles 31, Calif.

CIRCLE 7 ON READER SERVICE CARD

Switch capsule of the new Clareed Sealed Contact Reed Relay consists of a pair of magnetically operated contacts, hermetically sealed in a glass capsule, in an atmosphere of inert gas.

SPECIFICATIONS

Contact Arrangement: Normally form A, form B, in combination form C

Overall length: 3-¼ in. max.

Outside diameter: 0.215 in. max.

Contact material: Gold

Contact rating: 15 volt-amperes max., non-inductive: 1 amp. max.; 250 volts max.

Contact resistance: 25-40 milliohms.

Life expectancy: At 14 volt-amperes (½ ampere, 28 volts dc), 20,000,000 operations.
At 7 volt-amperes (¼ ampere, 28 volts dc), 100,000,000 operations.

Minimum breakdown voltage: (60 cps) 500 volts rms.

Insulation resistance: 500 k megohms min.

Low level load test: 8 microamps, 800 ohms, 250 millivolts, open circuit operated at 3 ips, 100 million operations with no failures.

Switches per Coil	Watts to Just Operate Typical Coils	Milliseconds (including bounce) Operate Excess NI over P.U. 100	200	Release
1	0.25	1	0.8	0.25
2	0.30	1.5	0.9	0.25
3	0.35	2.2	1.5	0.25
4	0.42	3.2	2.2	0.25
5	0.52	3.5	2.5	0.25
6	0.8	5	3.5	0.50
12	1.5	6	5	0.50
20	3.5	8	6	0.50

CONTACT BOUNCE		
	At "just operate"	0.3 ms max.
	At 200 excess NI	0.5 ms max.
	At 400 excess NI	0.8 ms max.
	No bounce on release.	

CIRCLE 8 ON READER SERVICE CARD

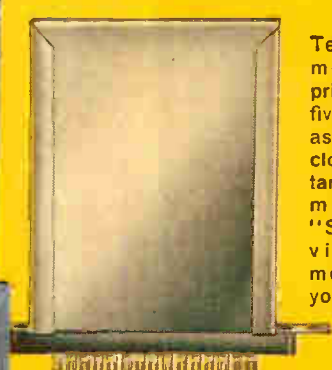
...CLAREED®

a New Concept in Relay Design

The new CLAREED Sealed Contact Reed Relay effectively eliminates contact contamination. With its contacts hermetically sealed in contaminant-free inert gas, this new design assures millions of perfect operations. Hundreds of millions are possible when operated at up to ½ rated contact load.

CLAREED relays are ideal components for transistor drive applications and for use in computers and data processing equipment. Their low inductance and the low inductance change in the operating coil at each operation limits the transients produced. Submit your packaging problem for recommendations.

• PACKAGED TO MEET *your* REQUIREMENTS



Ten CLAREED switches, mounted in line on a printed circuit board with five magnetic coils. This assembly can then be enclosed in the flat, rectangular container or it may be coated with "Skin-Pack," a tough vinyl plastic, and mounted directly into your equipment.

Six CLAREED switches clustered for mounting in a single tube container.

Important features of CLAREED relays are their simplicity and flexibility. They may be mounted to meet the requirements of almost any application and environmental condition, even on your own printed circuit board—to comply with your mechanical design configurations.

CLAREED relays are as flexible as your application requires. Consultation with your nearby CLARE sales engineer is invited. Additional information may be obtained from C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Limited, Box 134, Downsview, Ontario. Cable Address: CLARELAY. *Send for Bulletin CPC 5.*

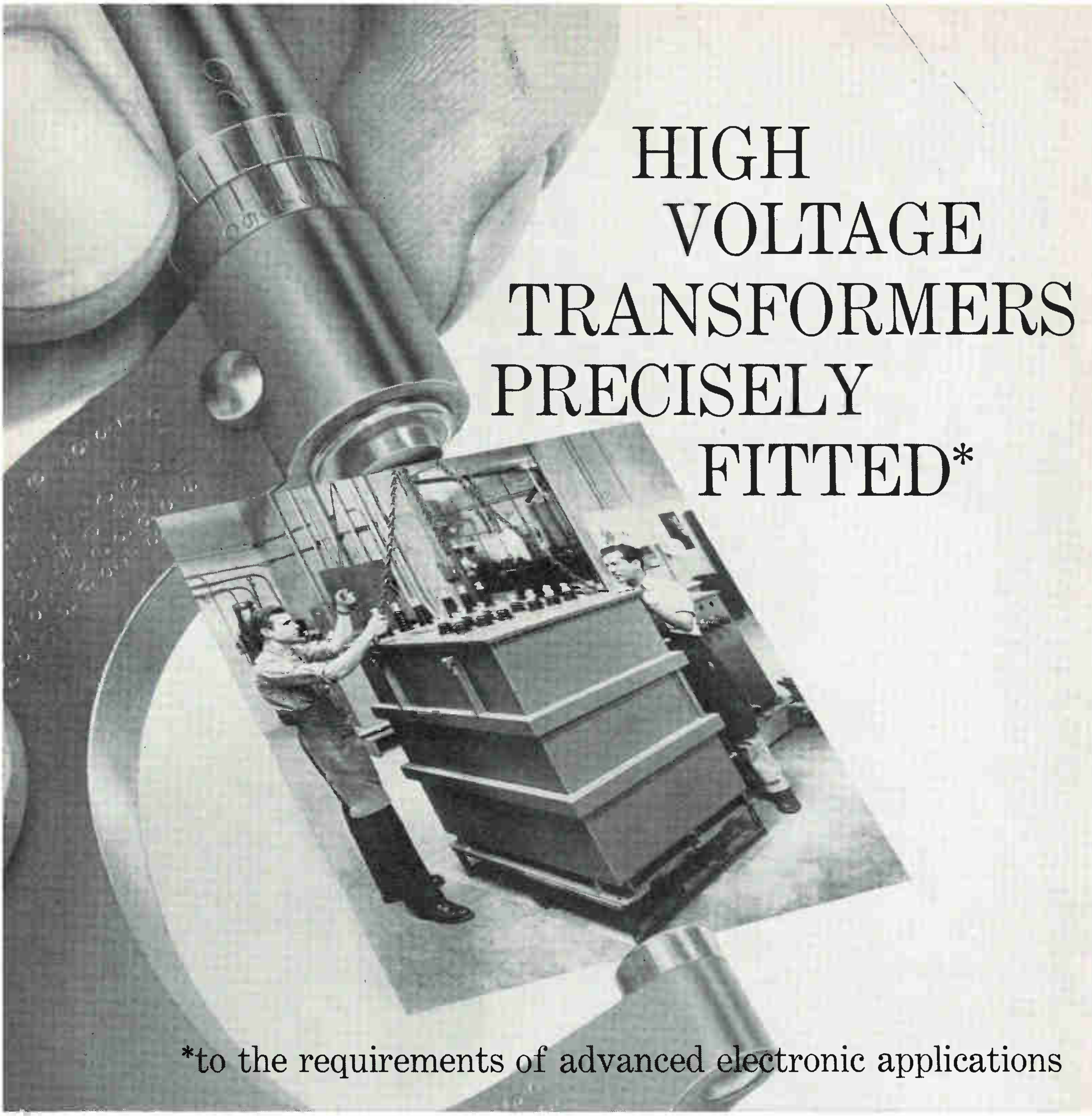
SEE IT AT THE IRE SHOW

New York Coliseum
March 21-24

BOOTH NOS. 2218 & 2220

CLARE FIRST in the industrial field

CIRCLE 9 ON READER SERVICE CARD



Designers of high power transmitters, amplifiers, particle accelerators and other advanced electronic equipment often encounter a problem in finding the **right resource** to meet their exacting specifications for high voltage transformers. The reason: most giant firms don't have the flexibility to fully accommodate the customer on custom engineered units; while many smaller companies simply don't have the technical depth and production capability. **Electro** has all of these qualifications: **unique experience** in custom designing high voltage transformers for advanced electronic applications; the **production capability** to build them; and the **flexibility** to do the job quickly and economically. Electro units are now being used by electronic systems and equipment manufacturers across the nation—in ground radar, scatter communications, missile support equipment, sonic vibration testing equipment, accelerators. If **your** requirement for a high voltage transformer is a little more sophisticated, a bit more demanding and exacting than the average ... then get the complete Electro story.

ELECTRO

high reliability transformers

ELECTRO ENGINEERING WORKS / 401 PREDA STREET, SAN LEANDRO, CALIFORNIA

BUSINESS THIS WEEK

Communications System Within Earth's Crust Is Getting Feasibility Study for Air Force

Studies and experiments in subsurface propagation of electromagnetic waves will be carried out under a $116,000 Air Force contract by Space Electronics Corp., Glendale, Calif. **Rome Air Development Center wants the company to determine if it is feasible to bury the components of a communications systems deep within the earth's crust.**

The California firm says it has already conducted considerable study and experimentation under a previous contract and with its own funds. The company claims that substantial verification of theory for short-range underground communications has been obtained from its experimental underground station.

"Earth crust communication techniques that connect buried sites offer excellent survival potential against natural and artificial hazards," declares Space Electronics. Security of such a system suggests its possible use as a communications network for underground ICBM launching sites. In case of an enemy missile attack, instant massive retaliation would require communications links to U. S. ICBM bases that would not be disrupted by the attack.

Titan Flight Test Program Will Use Pulse-Code-Modulation Telemetry System

Titan ICBM, being pushed rapidly towards operational status, will soon enter a new flight test phase requiring the acquisition of more airborne data. The Air Force has selected pulse-code-modulation telemetry to handle the expanded volume of flight data, ELECTRONICS learns.

PCM, which intersperses analog and digital data on one multiplexed channel, will be used for the first time in a liquid-propelled ICBM. PCM telemetry has already been slated for tests of the more advanced Minuteman solid-fueled ICBM. **The Titan PCM system will transmit digital data on the AC Spark Plug inertial guidance system.** (First operational Titans will use the Bell Telephone Laboratories radio-command guidance system, while later ones will use the AC Spark Plug inertial guidance system).

Radiation, Inc., Melbourne, Fla., is carrying out the PCM telemetry work under a $2,320,000 subcontract. The contract calls for fabrication, testing and delivery of a Titan airborne PCM telemetry system, plus checkout equipment.

Plasma Circuit Used As An Oscillator To Generate Microwave Energy of 2,000 Mc

Beam-generated plasma has been used as an electronic circuit capable of conveying radar energy for practical purposes. **Sperry Gyroscope scientists C. C. Wang, L. P. Levine and J. E. Hopson last week reported that they have used a gyroelectric plasma circuit as a velocity-modulated oscillator to generate microwave energy.** "Gyroelectric" refers to the fact that the charged particles move in a rotary manner similar to a gyroscope's spin.

"As we learn more about the character of the electric circuits formed by plasma," they said, "it is conceivable that they may be used to replace or enhance operation of electronic devices that now use wires, capacitors or other conventional circuit elements."

What the Sperry scientists did was to aim a 500 v beam of electrons through rarefied hydrogen gas contained in an electromagnetic envelope. This created hydrogen ions which behaved like an ordinary feedback circuit. **The ions and electrons coupled into the electron beam. The beam then served as an antenna to convey radar energy of 2,000 Mc out of the plasma circuit.** Sperry scientists expect to reach 70,000 Mc, predict eventual circuits operating at 300,000 Mc.

ELECTRONICS NEWSLETTER

Biocurrents in human cells are being studied by Soviet scientist Platon Kostjuk, Tass reports. He has devised a microelectrode with a tip measuring 0.2 micron in diameter which is inserted into a cell, normally up to 100 microns in size. The biocurrents are transmitted through the electrode to an oscillograph. Readings are then filmed.

Announcement that French instrument companies will hold a 10-day exhibition in Moscow in April rounds out the triumvirate of European countries invited to display their wares in Moscow's Polytechnic Museum. First held was the German instrument exhibition last November. After the French comes the British scheduled for June 16-26. The Soviets have been careful to avoid specifying any area of interest. The British Scientific Instrument Manufacturers Association plans a broad-scope exhibition that omits specialized equipment embargoed for export to Communist countries.

Magnetohydrodynamics symposium held last month at the University of Pennsylvania under the sponsorship of the basic sciences committee of the American Institute of Electrical Engineers points up the fast-growing industry interest in the field. Some 300 scientists heard 37 papers over two days on basic research, communication through plasma, power conversion, fusion and flight applications. Observed one top industry scientist: "Any company interested in missiles and space not now in this field can't afford not to get in it pretty fast."

Tunnel triode, a transistor-like device in which the emitter-base junction is an Esaki tunnel diode and the collector-base junction is a conventional diode, is being investigated at MIT's Lincoln Laboratory as a potentially useful computer element. More details will be given in ELECTRONICS next week in a report entitled "Future Developments in Engineering."

Paragon-Revolute *introduces a great new concept in reduced size reproduction . . .*

RETRIEVABLE MINIATURIZATION

The Paragon-Revolute Continuous Reducing Printer is the heart of Retrievable Miniaturization. Really a giant movie camera, it takes pictures of drawings while they move through the machine at speeds variable from 3 fpm. to 30 fpm. It takes drawings up to 42″ wide, offers reductions of 1/2, 1/3, 1/4, 1/5, 1/6, 1/7, 1/8 size. If desired, one of two ratios supplied may be 1:1 for originals up to a maximum of 21″ wide by any length. Camera feeds the same as blueprint and whiteprint machines.

A.

B.

Lockheed engineers and Paragon-Revolute representatives compare half-size print with full-size drawing at Lockheed Aircraft Corporation, Missiles and Space Division, Sunnyvale, California. Lockheed officials report that Retrievable Miniaturization has given them the economies and advantages possible from reduced print size without sacrifice of valuable information on engineering drawings.

Andrew T. Johnson, (right) and Robert Johnson, owners of their own reproduction and blueprinting service firm in Boston, were the first to install Retrievable Miniaturization as a commercial service. They state: "Retrievable Miniaturization makes real sense to us—and to an increasing number of our customers. Incidentally, our Revolute Processor is doing a fine job in processing direct positive papers.

THE IDEA. Retrievable Miniaturization is a new ingenious method for reducing the size of prints yet keeping them large enough to be completely readable and usable. Developed by Paragon-Revolute, this method is acknowledged as one of the significant advancements in reproduction.

HOW IT WORKS. In Paragon-Revolute's unique Continuous Reducing Printer and Processor, reduced-size transparencies are made directly from original drawings for immediate reproduction in blueprint or diazoprint equipment. Reductions can be made as positives or negatives on paper or film. The Printer takes drawings up to 42″ wide by any length at speeds up to 30 fpm.

THE ADVANTAGES. Retrievable Miniaturization fits in with existing facilities, calls for no drastic changes in present drafting standards or print-making systems. It enables savings in materials up to 300% . . . increases capacity of blueprint or diazotype equipment up to 4 times . . . slashes print handling time, filing space, and mailing costs. Most importantly, it provides readable, usable reduced-size prints without the problems and high cost of blowback systems.

You owe it to yourself and your company to investigate the advantages and savings offered by this great new concept in reproduction by mailing the coupon below.

Reduced-size prints are simple and fast to make. A. Original drawings are fed into B. Revolute Continuous Reducing Printer where they are photographed and reduced on paper or film transparencies. C. Revolute Continuous Processor develops, fixes, washes, and dries transparencies for immediate reproduction in D. Blueprint equipment or E. Diazotype reproduction machines.

C.

E.

D.

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WASHINGTON OUTLOOK

THE AIR FORCE is still fighting to build a new manned bomber, despite the administration decision to hold back development of the 2,000-mph B-70 and a nuclear-propelled aircraft.

Air Force planners now regard a secret study project, Dromedary, as a potential bomber of the future. The project is under the direction of the Rand Corp., and reports say Boeing and Northrop are in on the work.

As presently conceived, the Dromedary would not require the most advanced electronic equipment. The plane would be a relatively slow-flying plane powered by a conventional jet engine. Its virtue would be endurance. It would stay aloft for upwards of 10 days and would be capable of launching air-to-ground ballistic missiles at enemy targets. Because of its airborne endurance, the plane would be less vulnerable to an enemy blow at our fixed bases. Flight endurance would stem from a perforated "laminar-flow" wing designed to reduce drag and therefore fuel requirements.

In effect, the Air Force would be using a low-performance aircraft as a missile platform. While the B-70 and nuclear powered planes would be high-cost aircraft based on breakthroughs in technology and would require new electronic systems, the Dromedary would be a relatively cheap plane which could be built out of current knowhow.

Top Air Force brass are said to be eagerly awaiting the outcome of the study project. They believe they can sell a production program for this type of plane more easily than one for the B-70 or a nuclear-powered plane.

- **The Pentagon** has officially given the green light to serious development of the Air Force's Sky Bolt air-launched ballistic missile. Until now the project had been strictly in the design study stage.

  Nortronics division of Northrop Corp. is guidance system subcontractor to Douglas Aircraft, the weapon system prime. Nortronics has designed an inertial system for the new missile—an outgrowth of Northrop's Mark 1 system for the Snark guided intercontinental missile. The air-launched ballistic missile was primarily conceived for the B-70 and nuclear bombers.

  It's now planned to put the new missile into the B-52 bomber. Only slight modification of the aircraft would be needed, the Air Force claims. The Dromedary aircraft, with its tremendous flight endurance, might also be an ideal platform for the missile.

- **The Air Force** is now plugging for a Pentagon decision for a crash program to develop an operational Midas (Missile Identification Detection and Alarm System) satellite.

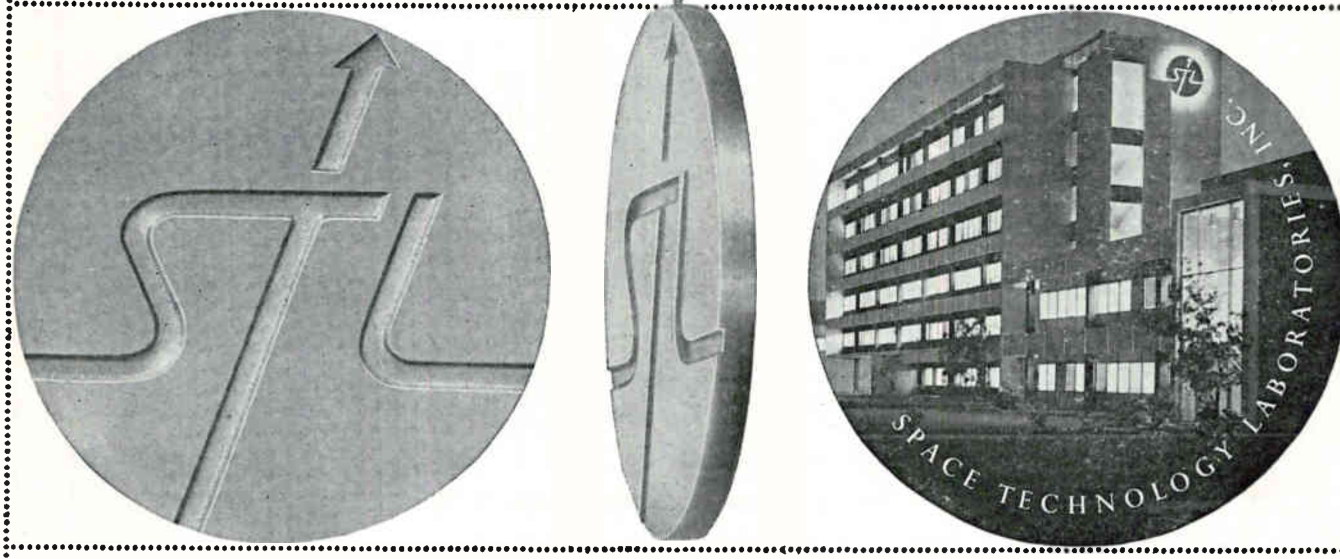
  The satellite would use infrared sensors to detect the heat radiation emitted by enemy ballistic missiles. Lockheed is prime contractor.

  Current Midas development budget runs to $59.7 million, and an increase to $102 million is currently scheduled for fiscal 1961. The Air Force, pushing for greatly increased funds, argues that development has advanced far enough to justify the start of fabrication of operational-type satellites.

  Meanwhile, the Air Force is ready to divert R&D funds originally earmarked for other projects this year to Midas. This is being done in advance of the Defense Department decision now pending.

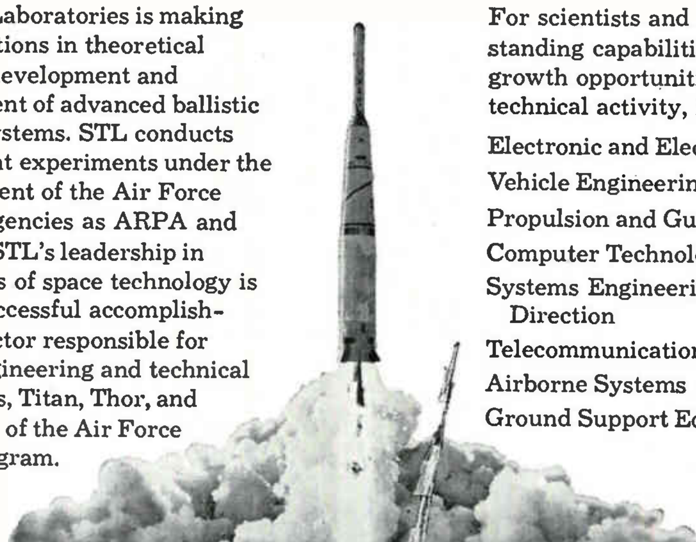
  A major factor in the Pentagon's deliberations is how long the Midas would remain in orbit. The objective is a year-long orbit for the early-warning satellite. The Air Force is confident that the first test satellite, to be launched this year, could be placed in orbit for from one week to a month.

SCIENTISTS AND ENGINEERS: **There are two sides to the STL coin...**



What STL does:

Space Technology Laboratories is making significant contributions in theoretical analysis, research, development and technical management of advanced ballistic missile and space systems. STL conducts advanced space flight experiments under the executive management of the Air Force on behalf of such agencies as ARPA and NASA. In addition STL's leadership in military applications of space technology is illustrated by its successful accomplishments as the contractor responsible for over-all systems engineering and technical direction of the Atlas, Titan, Thor, and Minuteman portions of the Air Force Ballistic Missile Program.



What STL offers:

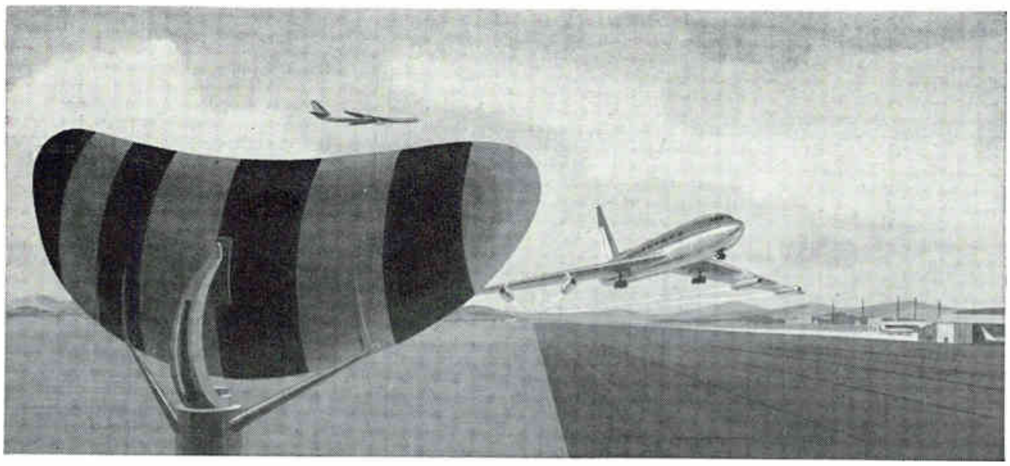
For scientists and engineers with outstanding capabilities, STL offers unusual growth opportunities in many areas of technical activity, including:

Electronic and Electromechanical Systems
Vehicle Engineering and Development
Propulsion and Guidance Systems
Computer Technology
Systems Engineering and Technical Direction
Telecommunications
Airborne Systems
Ground Support Equipment

NEW YORK INTERVIEWS FOR MEMBERS OF IRE

For the convenience of those attending the Institute of Radio Engineers meeting, members of STL's Technical Staff will conduct personal interviews in New York, March 21-24. For an appointment, please telephone Mr. Robert Galbraith at STL's IRE suite, or send a complete resume to *Space Technology Laboratories, Inc., P.O. Box 95004, Los Angeles 45, California*

SPACE TECHNOLOGY LABORATORIES, INC.



Firm price and delivery on low noise parametric amplifiers

Firm price and delivery schedules are available for negative resistance, cavity type amplifiers in the L, S, C, and Lower X-Bands. You can choose from either development models for evaluation in your system, or custom designed, fully qualified units in production quantities. The table at right shows typical amplifier characteristics now being obtained in development models.

With noise figures as low as 2 db, these amplifiers are ideally suited to radar acquisition and tracking systems, tropo-scatter communications, telemetering, satellite tracking, and microwave relay links.

They recover from overload in milliseconds—are resistant to deterioration and failure from high power. Phase jitter and gain stability characteristics are excellent, and with the associated ferrite circulator, the amplifier is fail-safe in case of pump or diode failure.

Small in size and weight, the amplifier can easily be retrofitted to many existing systems.

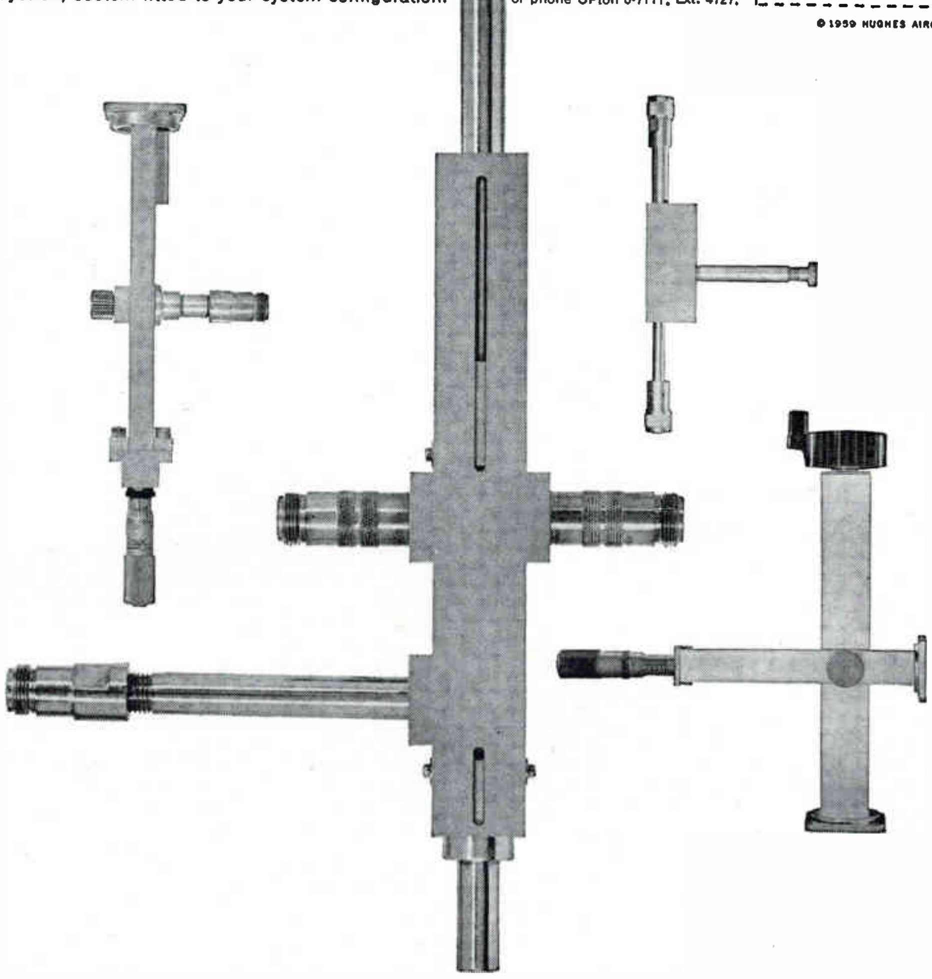
Hughes Microwave Products can provide complete retrofit kits, including ferrite circulator, amplifier, pump circuitry, and pump klystron, custom fitted to your system configuration.

HUGHES PARAMETRIC AMPLIFIERS—Typical Characteristics

	L Band	S Band	C Band	X Band
Pump	50 mw at S or C Band	100 mw at X Band	100 mw at X or K_u Band	150 mw at K_u Band
Gain	15 to 20 db	15 to 25 db	15 to 25 db	15 to 20 db
Bandwidth	2 to 10 mc	Up to 25 mc	Up to 25 mc	2 to 8 mc
Noise Figure	2 to 4 db	2 to 4 db	2 to 4 db	6 db
Remarks	Non-degenerate	Non-degenerate	Non-degenerate	Quasi-degenerate

For information on price and delivery dates, or for further technical data, write Microwave Products, Advanced Program Development, Hughes Aircraft Company, Culver City 3, Calif., or phone UPton 0-7111, Ext. 4727.

HUGHES



HERE'S WHY CENTRICORES ARE PROBABLY THE MOST CONSISTENTLY UNIFORM CORES YOU CAN BUY:

The exceptional uniformity you get in tape-wound Centricores is not easy to come by. It's the result of painstaking precision at every stage of the manufacturing process —and, in fact, *before* manufacturing. Three principal factors help produce Centricore uniformity:

Careful classification of materials—Raw alloys are first "pedigreed"—meticulously selected, then tested for some 14 parameters, and classified by magnetic properties. We're the largest buyer of nickel alloy magnetic materials in the world . . . which permits us to choose material for Centricores from an unusually wide distribution of magnetic properties.

Special winding machines—We build our own machines, to die-making tolerances, for winding magnetic alloy tape into cores. We also build our own machines for applying insulating coating to the tape. These machines give us far greater uniformity in dimensions, insulation and ultimate performance of Centricores.

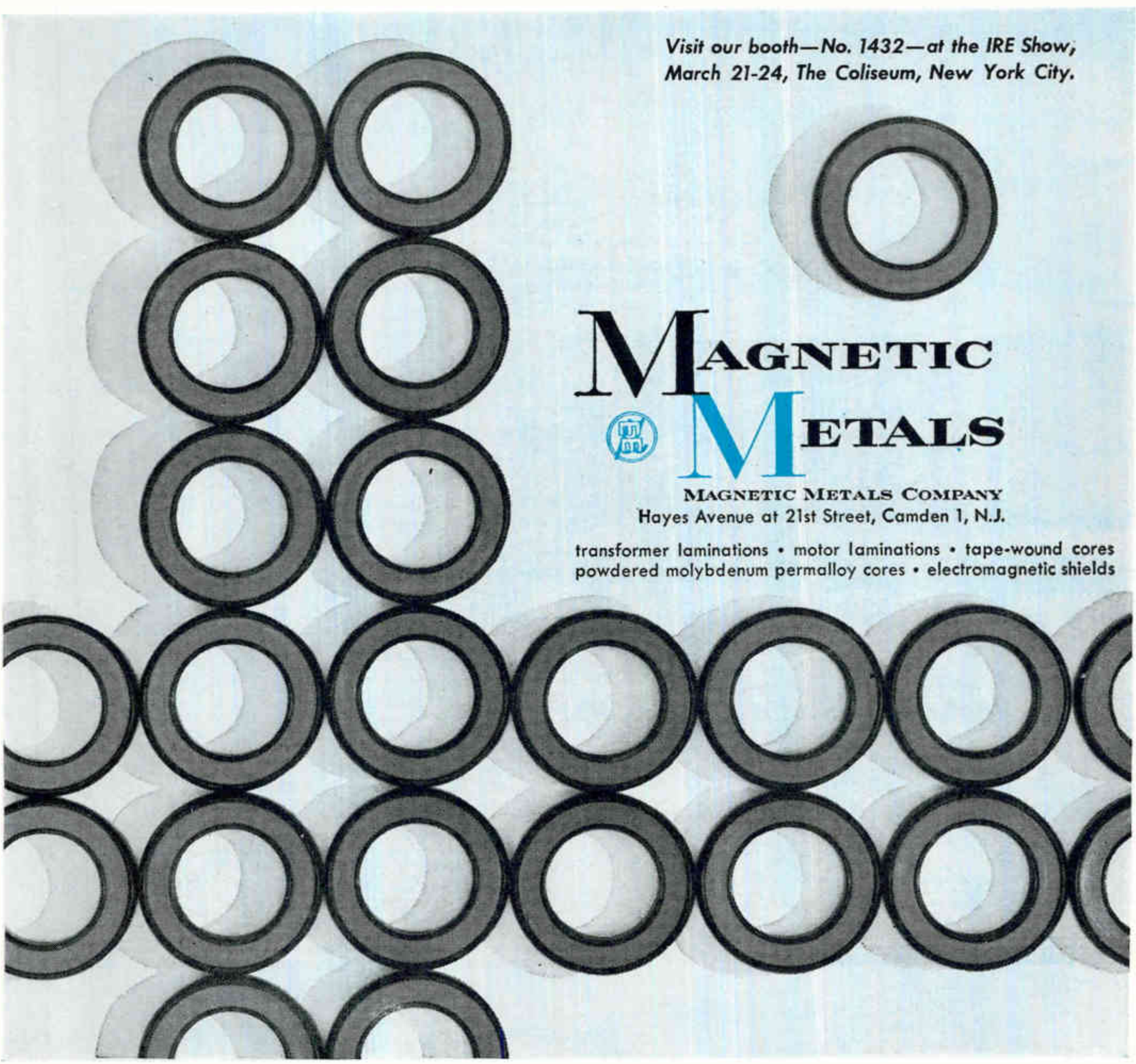
Closely-controlled annealing—Annealing—perhaps the most critical phase of the core-making process—is done under precisely regulated atmospheric and temperature stabilized conditions to hold Centricore magnetic performance to uniformly high levels.

Exceptional uniformity from core to core and lot to lot is further assured with Super Squaremu "79", a new high-performance alloy we've developed. It has outstanding magnetic qualities and is remarkably uniform in squareness, thermal stability and gain. Super Squaremu "79" offers an effective solution to problems of variation in magnetic performance.

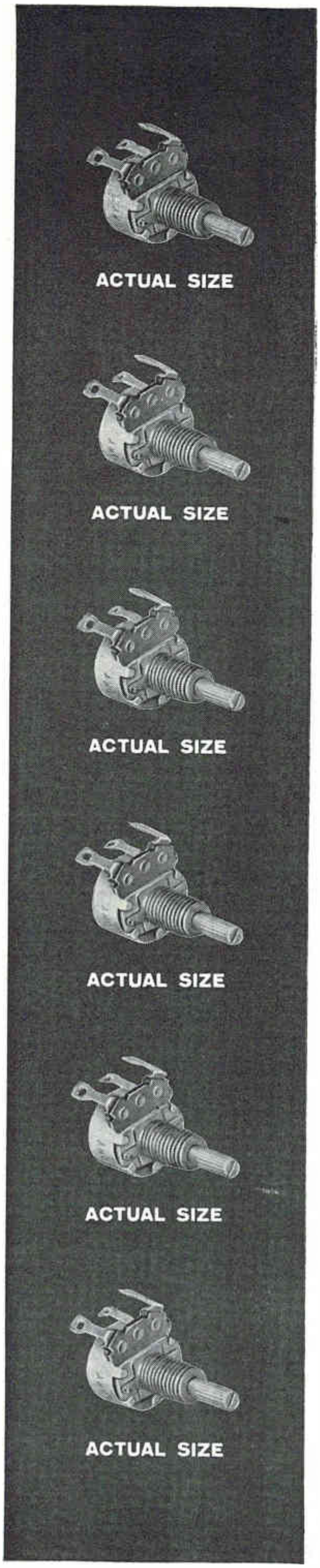
WRITE FOR BULLETIN C-3

SIZE	MATERIAL	THICKNESS
1	HIGH NICKEL Hymu 80 Squaremu 79 Super Squaremu 79	.001"*
THRU	LOW NICKEL Squaremu 49 Carpenter 49	THRU
225	GRAIN-ORIENTED SILICON Crystaligned Microsil	.004*

**Special sizes, shapes and thicknesses quoted on request.*



CIRCLE 17 ON READER SERVICE CARD



NEW ½" CARBON CONTROL

another Mallory "first" in miniaturization

Only ½-inch in diameter, the new Mallory carbon control is the world's smallest conventional-type control for commercial applications. It takes less cabinet space, less panel space, weighs but a fraction as much as the conventional ¹⁵⁄₁₆" controls. It's especially adaptable to miniature, table and clock radios; portable dictating equipment; portable television receivers; test instruments; and hi-fi amplifiers and pre-amps for small cabinets.

The tiny half-inch control retains the quality features that have gained the larger Mallory controls their reputation for outstanding performance: the same high-density, mirror-surface element for long, quiet service; the same ring-type, snap-action switch—simple in design and operation, with high, constant contact pressure, positive contact alignment and continually changing "floating" contact surface.

Available with or without rotary switch, nylon or steel shaft. Rotation: 290° without switch, 320° with switch. Linear taper: 100 ohms to 10 megohms; audio taper: 500 ohms to 5 megohms. Can be applied with element having low end resistance, for use in transistor circuits.

For further information, write to J. R. Woods, Dept. H, Mallory Controls Company, Frankfort, Indiana.

Mallory Controls Company, Frankfort, Indiana

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P. R. MALLORY & CO. Inc.
MALLORY

See the new Mallory half-inch control at Booth 1410 IRE Show

Earnings Rise to New Levels

PROFITS AND EARNINGS reports show a continued brisk pace as 1960 moves to the end of its first quarter. Here are some examples:

• **Litton Industries,** Beverly Hills, Calif., reports six-month sales of $77,400,000, for the period ended Jan. 31, this year. This is a 36-percent increase over the same period a year ago. Before-tax earnings for this year's period totaled $6,020,000, with net earnings after provision for federal and foreign taxes coming to $3,248,000, a 40-percent rise over the like period a year ago. In part, the rise was attributed to the purchase of rights to the Griffith Teleprinter line, the Sweda line of cash registers and point-of-sale recording equipment, and by the introduction of the Printapix direct writing cathode ray tube.

• **Amphenol-Borg Electronics Corp.,** Broadview, Ill., announces net sales of $56,541,533 for 1959 in its report presented recently to stockholders. An increase of 21.6 percent is reported over 1958, which saw net sales of $46,430,851. On the basis of 1,172,044 shares now outstanding, 1959 earnings per share were $2.50, compared with $1.96 in the preceding year. Net income for the 1959 period was $2,926,605, a rise of 28.4 percent over the net income of $2,279,434 in 1958. The 1959 profit was the second largest in company history, the largest being 1957's.

• **Hewlett-Packard,** Palo Alto, Calif., reports net earnings of $1,145,621 for the first quarter of the company's 1960 fiscal year. The quarter ended Jan. 31, 1960. Earnings for the period rose 77.8 percent over the $644,360 figure for the same period a year ago. Per-share earnings during the 1960 first quarter were 36 cents, compared with 20 cents in the 1959 first quarter.

• **The Gabriel Company,** Cleveland, announces combined sales in 1959 of $28,836,253, compared with $22,825,684 in 1958. Total net earnings amounted to $532,906, equivalent to 77 cents a share as compared with $545,066, or 80 cents a share, a year ago. J. H. Briggs, president of Gabriel, points out that although net earnings dipped, operating income rose 21 percent.

• **American Telephone and Telegraph** announces earnings of more than $1 billion in 1959 for the first time in company history. Bell System earnings rose to $1,148,769,000 last year, as compared with $981,463,000 in 1958. This is equal to $5.22 a share, compared to $4.67 in 1958. This record makes AT&T the second U. S. company to reach the billion-dollar profit mark. The first was General Motors, which earned $1,189,477,000 in 1955. Another new record mentioned in the AT&T report cites a gain of 3,298,000 telephones during 1959, bringing to nearly 58 million the number of Bell-operated telephones, more than 80 percent of the national total.

25 MOST ACTIVE STOCKS

WEEK ENDING FEBRUARY 19

	SHARES (IN 100's)	HIGH	LOW	CLOSE
RCA	937	64¾	61	64½
Beckman Inst	859	76¼	67⅛	74½
Univ Controls	848	15½	13⅝	15¼
Gen Electric	830	90¾	85½	89⅝
Dynamics Corp Amer	824	12⅞	10⅞	12⅞
*Int'l Tel & Tel	800	35¼	32	35
Westinghouse	777	50½	45½	50½
Avco	730	13⅜	12¼	13⅜
Sperry Rand	694	23½	22½	23¼
Varian Assoc	608	47⅜	42⅞	47
Collins Radio	577	56⅜	48	56⅛
Philco Corp	531	30⅝	26⅜	30⅜
Gen Tel & Elec	529	77¼	75	77
Ampex	444	36⅞	32¾	36⅞
Litton Ind	412	65¼	59⅝	64½
Reeves Sndcrft	393	10⅞	9⅛	10⅞
Raytheon	387	47½	45⅛	46
Zenith	378	99½	89½	99½
Texas Inst	359	174½	162	174½
Lear Inc	340	17¾	15⅛	17¾
Int'l Resistance	310	23⅞	21⅛	23⅝
Waltham Precision	307	3⅛	2¾	3
Gen Dynamics	303	48⅜	45⅛	48⅜
Loral Electrncs	296	45⅛	38⅛	42¼
Int'l Bus Mach	285	424½	416	422½

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.

New Tube Shipment Figures

PRELIMINARY summary statistics from the 1958 Census of Manufactures, recently issued by the Census Bureau, show value of electronic tube shipments increased 145 percent between 1954 and 1958—from \$451 million to \$1.1 billion.

Census is not yet able to determine the value of shipments for the radio and related products group, which includes the bulk of electronics industry products. It hopes to unscramble the statistics within the next few months.

However, the agency reports that value added by manufacture for this group was \$2.66 billion in 1958, a 28-percent increase over the \$2.08 billion reported for 1954. (Value added is equivalent to shipment value less components, materials, supplies and contract work.)

Soon-to-be issued reports from the 1958 Census on individual products will contain considerable data of use to electronics industry market planners. Order forms which list reports available may be obtained from Commerce Department field offices and from Bureau of the Census in Washington, D. C.

• **Semiconductor** high-power field may grow to major dimensions, said Dr. Guy Suits, GE vice president and director of research, at the 1960 Solid-State Circuits Conference. Two very important power capabilities have recently come into practical use—silicon power rectifiers and silicon controlled power rectifiers. They are adding new dimensions to industrial power technology, he claims. A sizeable market for semiconductor thermojunctions for power generation and for refrigeration is more distant, he says, but shows significant promise.

• **Electronic Industries Association** reports 1959 production and sales totals on tv and radio sets, phonographs, picture tubes and receiving tubes. Gains over 1958 levels were registered by all product groups except monaural phonos. Tv sets, total radio, auto radio and stereo phonos made the biggest gains, all over 20 percent.

Figures issued by EIA for 1959 and 1958, with percentage gains for last year, are shown below:

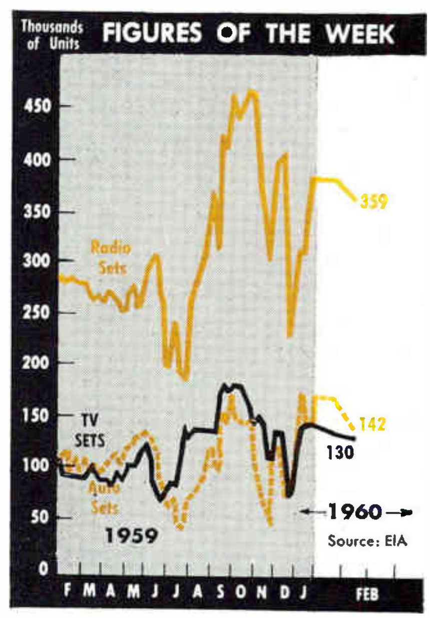
	1958	*1959*	*% Gain*
	(in millions)		
Tv Sets			
Units produced	4.9	6.3	29.0
Retail unit sales	5.1	5.7	11.8
Total Radios			
Units produced	12.6	15.7	24.5
Auto Radios			
Units produced	3.7	5.5	49.5
Home Radios			
Units produced	8.9	10.1	14.1
Retail unit sales	8.63	8.90	3.0
Monaural Phonos			
Factory unit sales	2.9	1.3	—55.8
Retail unit sales	N.A.	1.7	.....
Stereo Phonos			
Factory unit sales	1.1	3.0	174.8
Retail unit sales	N.A.	2.7	.....
Tv Picture Tubes			
Units produced	8.3	9.5	15.4
Production value	\$163.5	\$183.8	12.4
Receiving Tubes			
Units produced	397.4	432.9	9.0
Production value	\$341.9	\$368.9	7.9

N.A.—Not Available

LATEST MONTHLY SALES TOTALS

(Source: EIA)
(Add 000)

	Dec. 1959	Nov. 1959	Change From One Year Ago
Rec. Tubes, Value	\$32,401	\$31,600	+29.0%
Rec. Tubes, Units	37,248	37,211	+30.7%
Pic. Tubes, Value	\$15,941	\$16,059	+26.1%
Pic. Tubes, Units	817	841	+25.9%
Transistors, Value	\$22,820	\$22,743	+37.5%
Transistors, Units	7,826	7,847	+39.1%



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Ever see a
NEW STRIP-CHART RECORDER
that offered you all this:

- 6 push-button variable chart speeds
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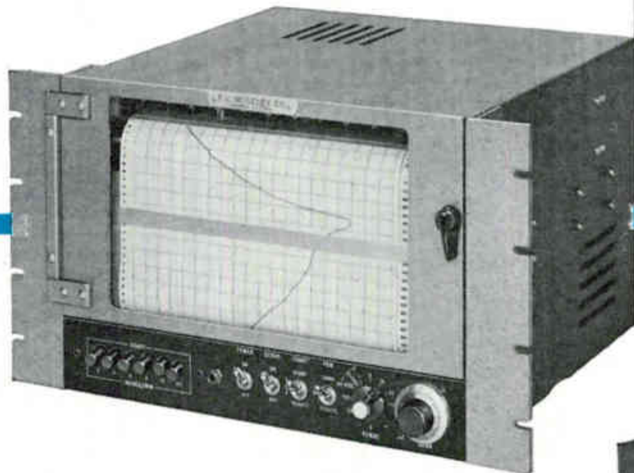

The all-new Moseley Model 80A Strip-Chart Recorder is a precision instrument providing greater versatility and convenience than any commercial strip-chart recorder previously available.

Model 80A gives you instant selection — through transistor switching — of 6 chart speeds. All other function controls are grouped in a newly convenient array on one front panel. The input range of 5 mv to 100 v is covered in 10 steps, or by vernier for completely continuous span voltage control. Input resistance is 200,000 ohms/v through 10 v, 2 megohms on higher ranges. Full range zero set, pen speeds to 0.25 sec full scale, chopper amplifier, standard 120′ rolls. For 19″ relay rack. $1,750.00.

Glass door protects chart; ball-bearing carriage rolls out for easy chart or circuit access

Six chart speeds, 2, 4, 6, 8, 15 and 60 in/min selected instantly by front panel push buttons.

NEW! TYPE F-2 LONG-STRIP CURVE FOLLOWER

New-concept curve follower tracks, converts ordinary recorded trace to electrical energy; requires no metallic inks or re-drawing. Employs unique photoelectric-oscillating mirror principle; permits digital output for tapes, cards, etc.

SEE YOUR MOSELEY REPRESENTATIVE OR WRITE DIRECT FOR DETAILS

Pioneer and leader in X-Y and Strip-Chart Recorders

AUTOGRAF *recorders*

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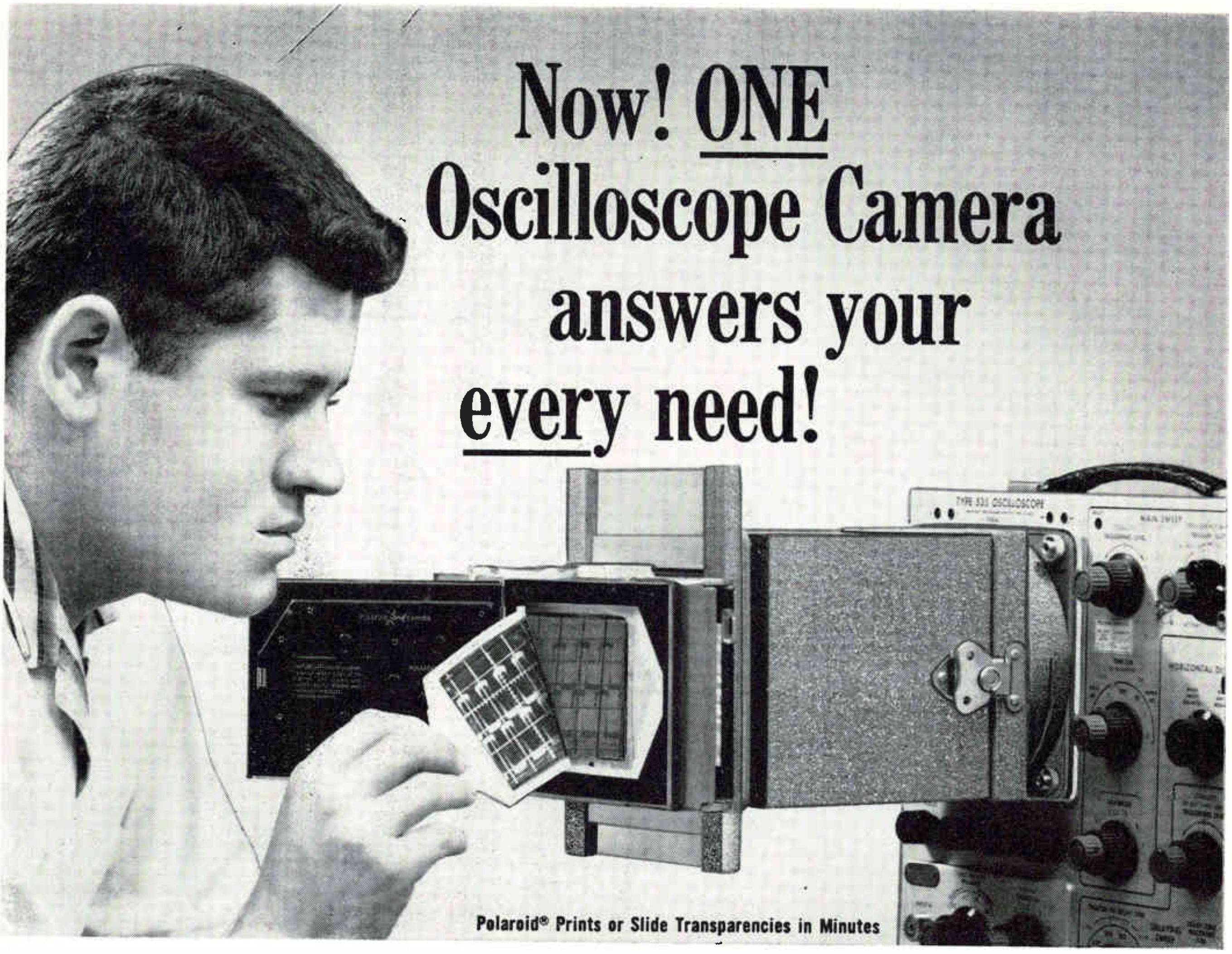

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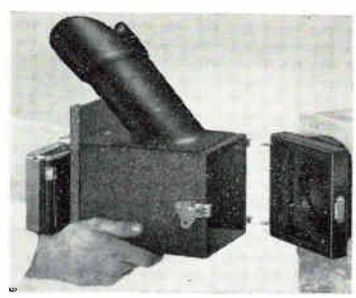
75mm f/2.8 Wollensak lens in Alphax #2 shutter. Precise, split-second focusing. Modular design permits instant conversion for a wide range of instrumentation photography. A truly fine camera at a remarkably low price. Write for complete information.



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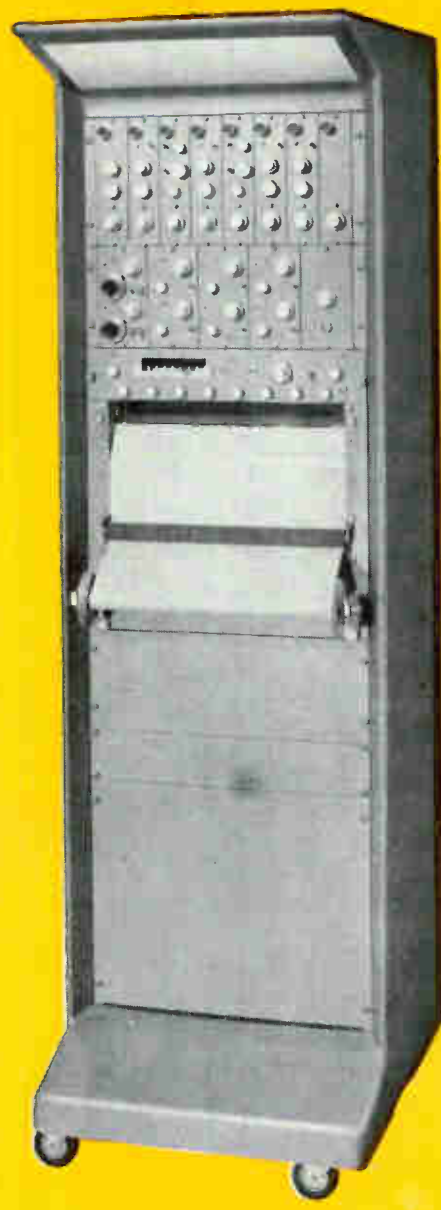

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The Offner Type R Dynograph Assembly is unmatched for sensitivity, accuracy, versatility—we invite you to compare it with any other high speed direct writing oscillograph.

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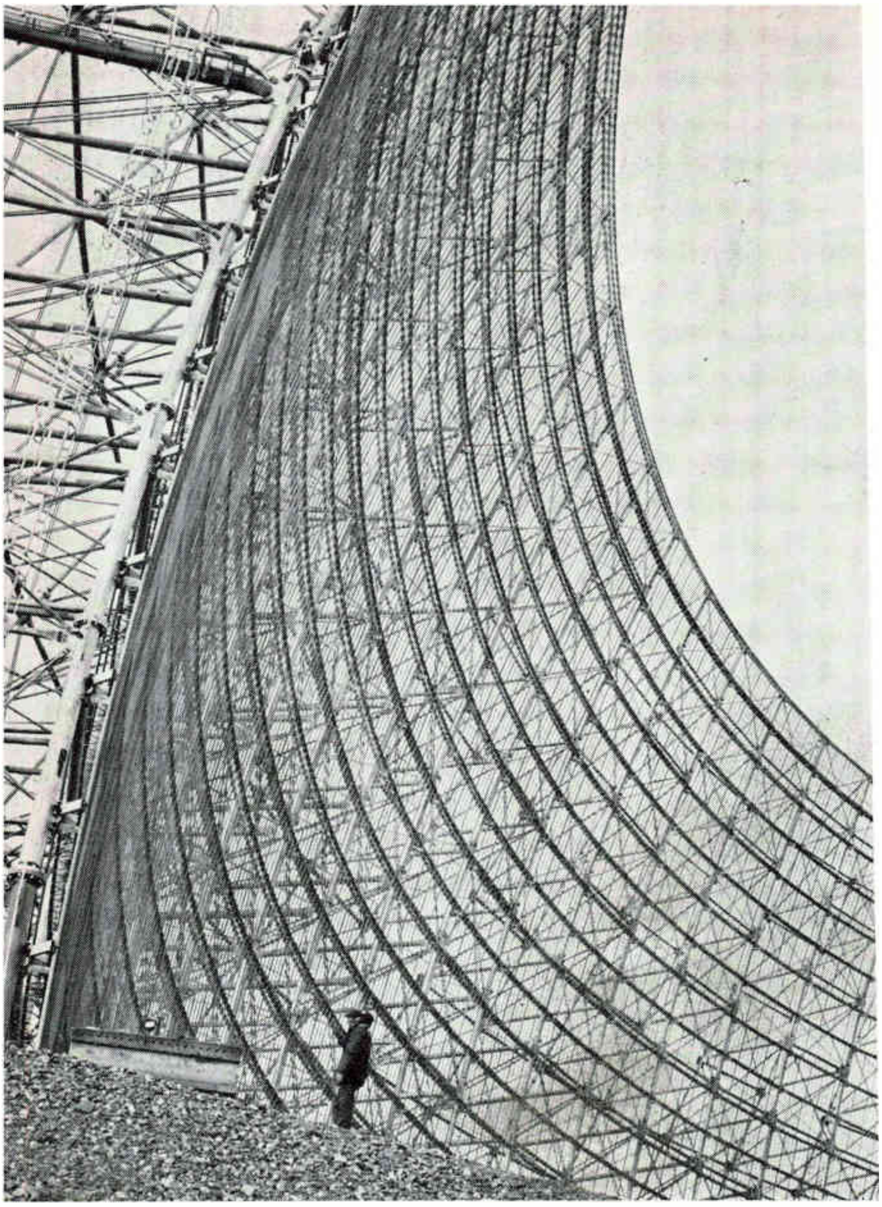


Giant antenna reflector built by D. S. Kennedy is part of GE's surveillance radar system watching Arctic skies from BMEWS sites in Greenland and Alaska

Debate: Defense Orders . . Or Cuts?

Here's where the military controversy stands this week — and what it means to us

WASHINGTON—The great national debate over military policy, though limited to the political arena, has important overtones for the electronics industry.

As a \$6-billion-a-year supplier to the Pentagon, the industry holds a key position in arms production. And as the transition from conventional weapons to space age armament systems speeds up, the electronics role in weaponry grows ever more dominant.

Every twist and turn in the defense debate, therefore, could be translated into terms of new orders —or, conversely, cuts — for electronics producers.

The Eisenhower Administration argues that the U. S. defense posture is adequate. The critics—Congressional Democrats, military professionals, and other experts—say. no, that the U. S. is losing military supremacy to Russia.

Critics base their argument on the so-called "missile gap," a period during the next few years when the Russians **will** have so many more ICBMs that they could theoretically wipe out, instantaneously, most if not all sources of U. S. retaliatory striking power—missile and bomber bases here and abroad.

The administration concedes there will be a missile gap over the next three years at least.

As schedules now shape up for production of "first-generation" Atlas and Titan liquid-fueled ICBMs, the U. S. will have some 60 in mid-1961, compared to roughly 150 for the Soviet Union; about 180 in mid-1962 compared to 350-400 for Russia; and 200-250 in mid-1963, compared to 400-500 for Russia.

In 1964, all the 27 scheduled Atlas and Titan squadrons will be operationally deployed — comprising an arsenal of 270 missiles. By this time, the Russians are expected to have at least double that number of ICBMs.

The Administration's policy is to offset the Soviet quantitative missile lead with a diversified U. S. arsenal of nuclear strike forces. This is centered on manned bomber forces.

We have some 500 B-52 long-range jet bombers (almost 200 more will be built) and about 1,200 B-47 medium-range planes.

Against this air armada the Soviets can probably stack up no more than 250 intercontinental bombers and not many more than 500 medium-range jets.

We also have roughly 600 Navy attack planes on carriers prowling the seas within range of Soviet targets and at least 700 Air Force light bombers or fighter-bombers poised close to the Iron Curtain.

The Pentagon's objective is to lengthen the operational life of manned bombers with stand-off air-to-ground missiles—first the jet-powered Hound Dog, later the Sky Bolt ballistic rocket.

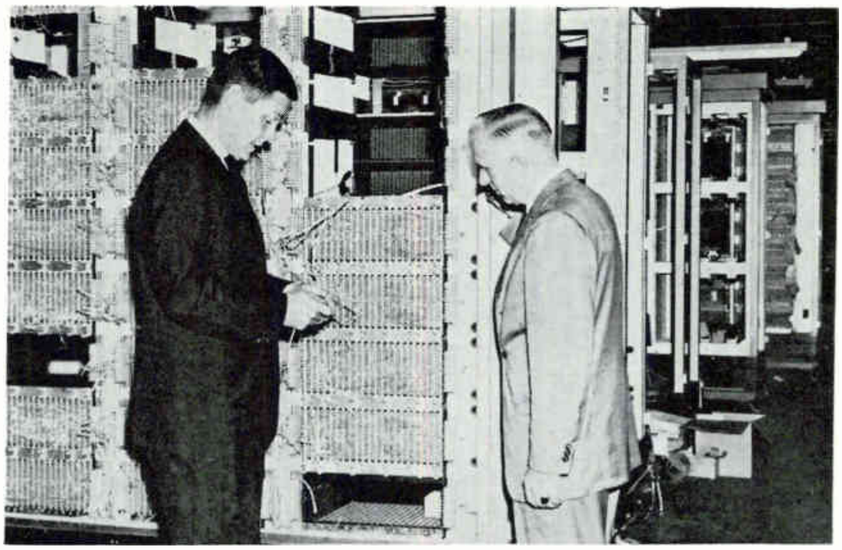
Other key elements of the U. S. deterrent:

- 105 Thor and Jupiter IRBMs already operational or to be deployed shortly in Great Britain, Italy and Turkey.
- The Polaris missile-submarine fleet—to grow from two operational vessels later this year to 15 within the next four years and eventually (the Navy hopes) to 45 vessels.

No possible Soviet surprise attack, say administration leaders, could wipe out this tremendous retaliatory force in one blow. An attack on us would mean nuclear devastation of Russia.

The U. S. deterrent will become bolstered in 1963 when the first solid-fueled Minuteman ICBMs reach the operation stage. These missiles will be set up in underground launchers and on mobile rail cars to make them less vulnerable to attack.

There's another element in the Administration's calm acceptance of quantitative ICBM inferiority: Our strategy is geared to deterrence through the threat of retaliation. The Russians need greater numbers of missiles to clobber most if not all our warmaking facilities to destroy or at least soften our retaliatory capability.



BMEWS computer complex (Sylvania) analyzes radar echoes to separate random noise from enemy missiles

U. S. deterrence can be maintained, Administration spokesmen will tell you, with smaller numbers of nuclear weapons—just enough to retaliate primarily against Russian centers of populations, not necessarily against the growing number of Soviet missile bases, submarine pens, and other strategic sites.

Critics see two glaring deficiencies in this confident appraisal.

First, they believe the Russians could conceivably wipe out instantaneously the bulk of our retaliatory power. Gen. Thomas Power, Strategic Air commander, warns that 150 Russian ICBMs and 150 IRBMs could knock out in one blow the 100 or so fixed U. S. bases here and abroad from which we can launch nuclear retaliation.

Critics believe Russia might be tempted to grimly accept a limited retaliatory blow from surviving U. S. striking forces in return for total devastation of the continental U. S.

A second factor which disturbs critics is this: That while the Administration lays great stress on reliance on manned bombers, it has virtually gutted development of the B-70 successor to the B-52, trimmed output of the B-58 successor to the B-47, and dragged its feet on the question of a continuous airborne bomber alert.

Many experts—such as Gen. Power—see the bomber alert (some 100 aircraft always aloft) as one of the most effective means of insuring invulnerability of our retaliatory strength.

The key to the U. S. deterrent is warning — U. S. nuclear strike forces must be assured of adequate alert time to launch a retaliatory blow. Critics argue that insufficient funds are earmarked for development and production of warning systems.

Many critics are also dissatisfied with U. S. efforts on the active defense side—the development of an anti-ICBM system. The controversy rages, notably, over whether or not the Army's Nike-Zeus is a suitable enough system to justify production. The verdict seems to be no.

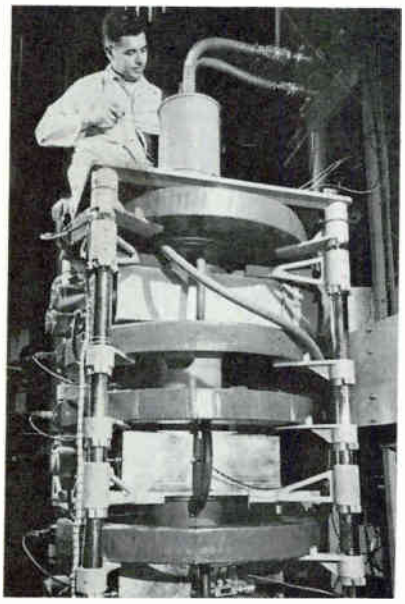
There is great disagreement over the Administration's sense of urgency in the race for space. Indeed, the president refuses to accept the concept of a "race". He has meticulously separated astronautic projects into neatly classified military and civilian types and has clamped severe monetary controls over both.

Critics—and these include top officials within the Administration —are infuriated over the president's approach.

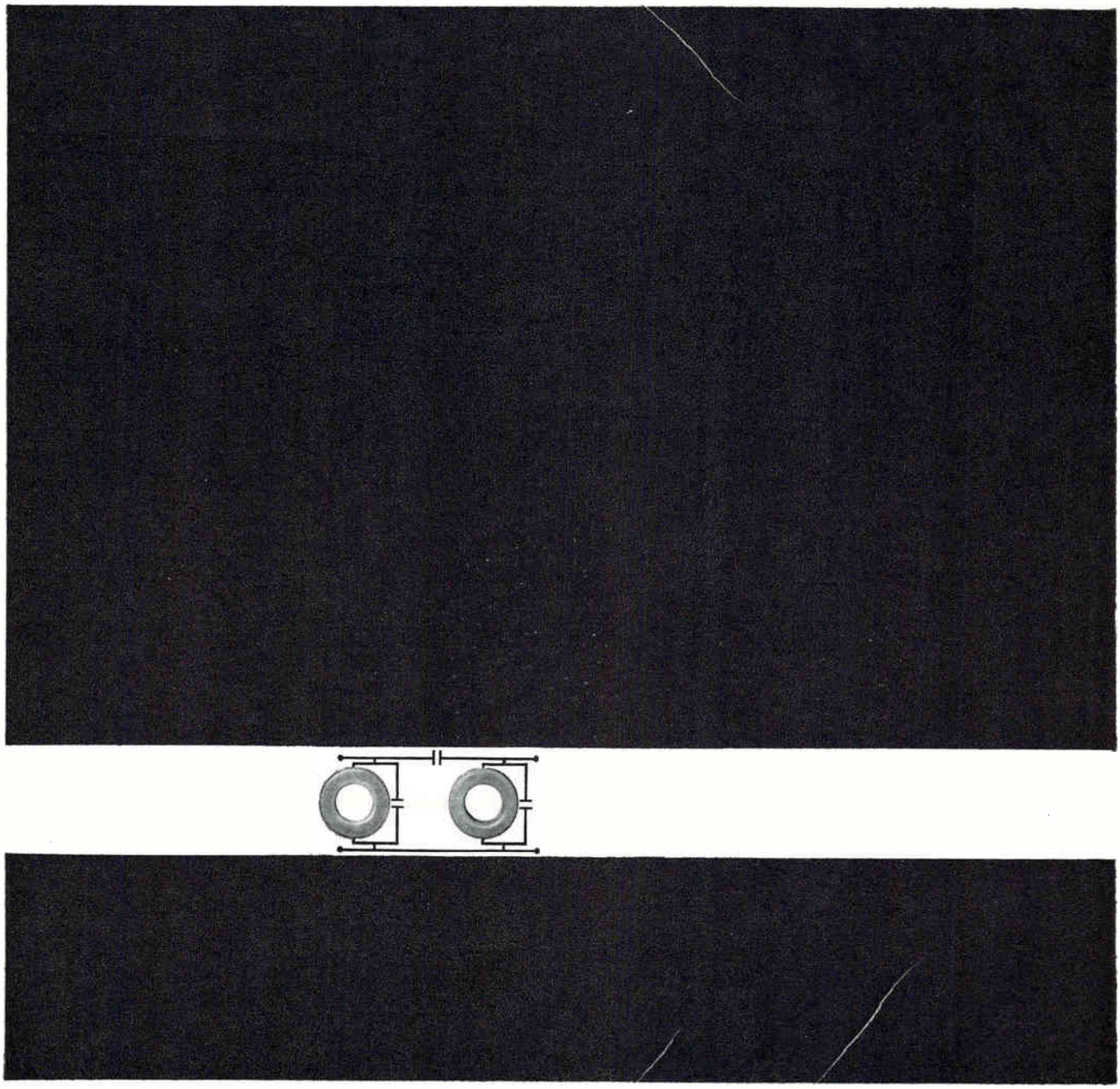
There is serious disagreement over the Eisenhower Administration's emphasis on budgetary considerations in the formulation of defense policy.

Critics keep ticking off what they see as gaps in the defense program: not enough ICBM production and development, not enough Polaris missile subs, etc.

The debate continues.



Nine-foot Klystron tubes (made by Eitel-McCullough and Varian) are used in BMEWS surveillance radar system



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Filter designers! First 160-mu moly-permalloy powder cores pack high performance into smaller space

Filter and inductor designers specify our 160-mu moly-permalloy powder cores for low frequency applications. Where space is precious, such as in carrier equipment and telemetering filters, the high permeability of these 160-mu cores eases the squeeze.

In many cases, 160-mu cores offer designers the choice of a smaller core. In others, because inductance is 28 percent higher than that of 125-mu cores, at least 10 percent fewer turns are needed to yield a given inductance.

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Oscilloscopes Go Digital

Direct readout of amplitude and duration of pulse signals reduces operator errors, cuts measurement time

RECENTLY INTRODUCED oscilloscope now makes possible direct digital readout of amplitude and duration factors.

Interpretation of scope presentations has been an engineering time-stealer since the cathode-ray oscilloscope was invented. Increasing use of test instruments by less skilled operators has put pressure on cro designers to make readout foolproof. DuMont's type 425 oscilloscope (ELECTRONICS, p 11, Feb. 5) presents amplitude and duration data in digital form, reducing both data-taking time and the chance for error.

The DuMont development, and related work in other laboratories, fits into the general trend toward digital test equipment.

Reduction of errors arising from interpolation—or interpretation—is the principal advantage of digital presentation. It also eliminates the parallax problem, improving the accuracy and the repeatability of readings.

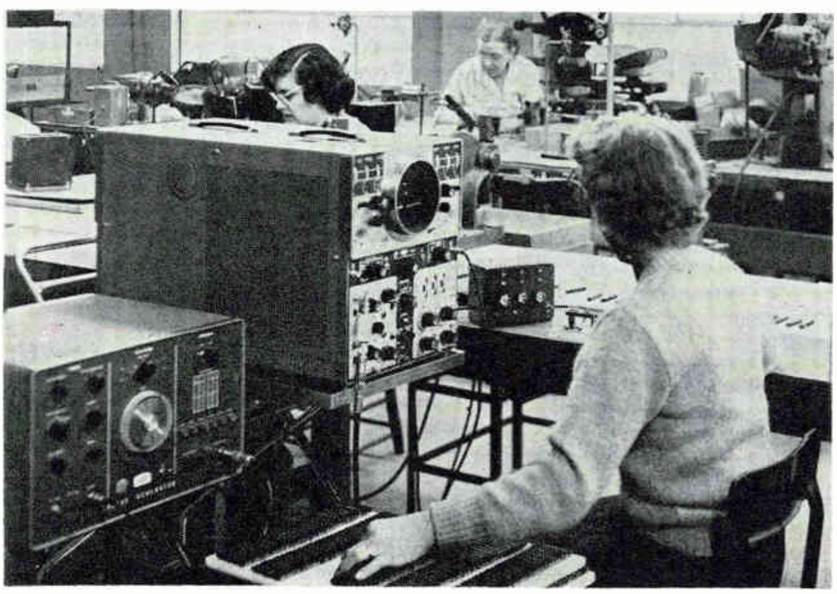
Operation

Two dots which appear on the scope with the signal to be tested are positioned over the signal to derive measurements (see 1-col photo). A joystick-type positioning control is used to move both dots until the index dot (at left in the picture) is positioned over the desired reference point on the signal.

Then two sets of three 10-position thumbswitches, one for controlling vertical movement and one for horizontal, are used to place the right-hand scaling dot at the other measurement point. Vertical displacement between index and scaling dots is read out as amplitude in millivolts or volts; horizontal displacement is interpreted as duration in microseconds, milliseconds or seconds.

Each decimal place of the three-place readout is controlled by one thumbswitch control. Each thumbswitch operates a precision-resistor decade in a passive attenuator circuit. Manipulating the controls turns associated digit-wheel displays, which provide the digital data. The waveform undergoing measurement can be moved by means of another joystick-type control.

After original setup by an engineer, semiskilled production workers can operate the scope, since they need to perform only simple manipulations of relatively few controls, and to take readings directly from digital dials.



At Essex Electronics, Berkeley Heights, N. J., production-checking of delay time, rise time and attenuation of distributed-constant delay lines is speeded

Dot Circuits

The two dots are positioned by square waves which are time-shared into the X and Y axes alternately between sweeps. Blanking circuits are used to eliminate rise and fall transients.

Heart of the circuit is a stable d-c supply whose output is chopped into square waves of 383 cps and modulated 30 cps by a multivibrator. Top of the square wave is held within 0.1-percent tilt. The result is two stable square waves, 110 v in amplitude and of opposite phase, one for horizontal position, the other for vertical.

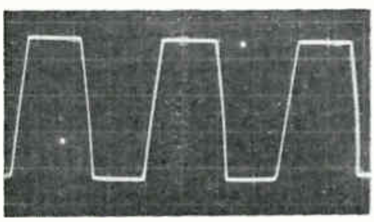
The two square waves are then attenuated under the control of the thumbswitches. The passive attenuator is designed to present a constant impedance to the source. From the attenuator, the two signals go to the X and Y amplifiers. Accuracy of dot positioning depends only on the stability of the d-c supply.

The deflection potential which provides the baseline from which the square-wave signals operate is controlled by the indexing joystick-type control. This control consists of a ball-joint mounted rod which makes contact with forked arms connected to two potentiometers. The potentiometers adjust the baseline deflection potential; thus, vertical or horizontal movement of the joystick causes vertical or horizontal movement of both dots, and intercoordinate movement of the joystick produces corresponding dot movement.

Rise and Fall Times

A further sophistication permits the automatic measurement of rise and fall times. A pushbutton on the panel face inserts a resistor in series with the thumbswitch circuit which results in a 20-percent reduction in peak-to-peak amplitude of the vertical square wave. This reduced signal is fed through a cathode follower to a peak detector, which produces a signal proportional to the square-wave peak value.

The original vertical square-wave from the attenuator, and the signal proportional to the peak value of the reduced square-wave, are applied to a Y amplifier with a double-ended input and added together. The resulting deflection signal positions the dots precisely 10 percent below and above the maximum and minimum points of the trace. The pattern-control joystick is used to position the rise- or fall-time line over the index dot; then the thumbswitches are adjusted to position the scaling dot over the line and



Index dot, left, and scaling dot, right, when positioned on waveform, measure voltage amplitude, signal duration

the time is read out directly to three-place accuracy.

New Cathode-Ray Tube

DuMont's electron-tube division produced a new type of crt for the scope. The tube presents a 5 x 10 cm display; because of higher-than-usual phosphor sensitivity, a 12,000-v acceleration potential permits film oscillographs equivalent to those which are obtained with 24,000-v systems.

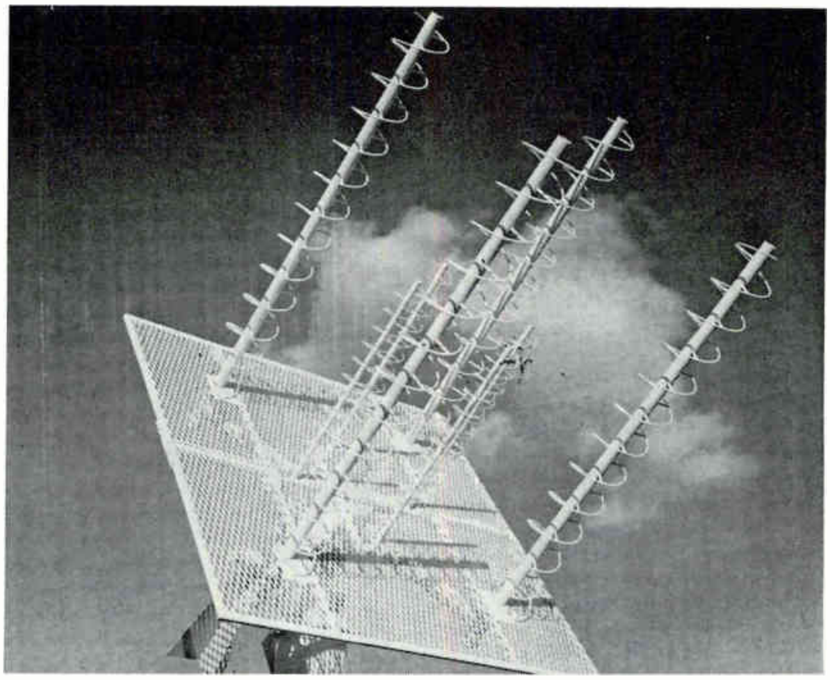
Modular units used in manufacturing the 425 can be interchanged with corresponding modules on other scopes of the same type. Two plug-in cavities permit insertion of various types of X and Y circuits for multiple functions and increased versatility.

Electron tubes used throughout have a mean-time-to-failure rating of 10,000 hours.

Readout accuracy of the instrument is two percent. Operating range is from d-c to 60 Mc, down 3 db at 35 Mc.

50 Antennas to Track Astronaut

First Project Mercury antennas slated for mid-year tests



Quad-helix antennas like this will be used in tracking and communicating with U. S. man in space

FIRST ANTENNAS for Project Mercury's tracking and telemetry systems are tentatively scheduled for mid-year delivery and tests at Wallops Island, Va.—well in advance of the September 1960 to December 1961 target period for launching the first Mercury man-in-space capsule.

Underwood Corporation's Canoga subsidiary, in Van Nuys, Calif., reports it has received a $1-million-plus contract for the design and manufacture of all ground-based telemetry, communications and command control antennas for Mercury. Canoga expects that most of its work will be completed by the end of this year.

At the same time it was reported that the San Diego facility of Stromberg-Carlson, the Rochester, N. Y.-headquartered division of General Dynamics, will design, build and install Mercury's monitor and control display system at Cape Canaveral, Fla. S-C is working under subcontract to Bell Telephone Laboratories. Western Electric heads the team responsible for the global instrumentation and communications network.

How Antennas Work

Some 50 antenna systems are called for in the program, including 13 automatic tracking quad-helix antennas to be used for acquisition aid tracking of vhf telemetry signals.

Tracking stations will be situated at Bermuda, Australia, Hawaii, White Sands, N. M., a West Coast location, Cape Canaveral and Eglin AFB, Fla., among others.

Here's how the antenna systems will work:

Tracking antennas will feed angle data to slaved radars, communications and command antennas, and computers whose function will be to provide down-range orbital extrapolations and predict subsequent orbits.

Tracking radars and associated steerable antenna systems along the astronaut's expected orbit will be positioned by means of the computer output until such time as the acquisition aid antennas are tracking. The company says the antennas will use a phase-comparison simultaneous-lobing technique.

When not tracking, the acquisition aid antennas will be slaved to tracking radars and used only to receive telemetry signals.

Scientists at Boulder Laboratories, National Bureau of Standards, Boulder, Colo., will be responsible for recommending the most reliable radio paths to relay vital tracking data on the capsule back to computers.

Quad-helices will be used for receiving both voice and telemetry signals. Another antenna group is part of the command control and voice transmitting system; four outboard helices will operate in the 200-300-Mc range for voice transmission and four inboard helices in the 400-Mc range will be used for command control transmission.

Control Display System

Flight information from the tracking and telemetry stations and computers will be monitored and displayed in a 40-ft by 60-ft room. A wall map at one end will show the astronaut's orbital flight paths; it will also indicate the ground stations and the ranges of their tracking radars and communications with the capsule. A communications failure at any station will appear on the display.

Special consoles for the chief flight surgeon, capsule communicator and others will operate in front of the wall map, providing them with the displays and controls for their assigned tasks. A flight director at a master console will coordinate all operators, with NASA, Air Force and Navy officials as observers. Smaller displays will be provided for other operational personnel.

New Center Tags

USAF-operated facility coordinates space surveillance, catalogs everything in orbit

Worldwide communications net and two computers coordinate Defense Department's Spacewatch programs

BEDFORD, MASS.—KEEPING TABS on all the satellites in the sky is the job of the National Space Surveillance Control Center, which was dedicated recently at nearby Hanscom AFB.

The new facility, key coordinating point for the joint Army-Navy-Air Force space surveillance program, uses two general-purpose computers and a complex communications web to support the Defense Department's space-watch.

Two days after the dedication, Washington announced the existence of a "mystery" satellite that is orbiting the earth in a polar orbit. The Center here has been keeping track of it, but would not reveal at this time when first it was picked up.

Speaking at the dedication, Lt. Gen. Bernard A. Schreiver, chief of the Air Research & Development Command, stressed the nation's need to know at all times what objects are in the sky. As satellites are launched with military value for surveillance, warning, communications, navigation and meteorology, he said, "it will be even more urgent to know exactly what they are and where they are."

Eventually, Schreiver suggested, the Center here will be tied in with the operational aspects of satellites and space vehicles. Automatic input to the computers from observation stations will ultimately permit orbital computations in real time, with the further possibility of computing control data for powered vehicles.

Sole Responsible Agency

The Center will be sole U. S. agency responsible for keeping track of artificial orbital bodies—including rockets, boosters, and anything else that goes into orbit—from the time of launch until decay or landing. "We never abandon a satellite," says an officer of the Center. "The only way you can tell when there's a new one is to keep track of all the old ones."

Information comes into the Center via commercial telegraph and teletypewriter services, military AirComNet, and direct private-line network to seventeen major satellite observation points, including Cape Canaveral, the Millstone Hill radar, National Aeronautics & Space Administration's space operations control center in Washington, and the Smithsonian Astrophysical Observatory in Cambridge, Mass.

On the first floor of the Center, an IBM 709 system, aided by a smaller IBM 610 computer, figures out orbits, corrects and updates orbital predictions with new data, and estimates future satellite posi-

Satellites

tions and lifetimes.

Twice a month the Center prepares and issues satellite situation reports which are distributed all over the world. Bulletins to the observation stations provide time-of-passage estimates; for those observation points using equipment with limited field of view, the Center also provides look angles.

The Center and directly affected stations can set up a conference hookup during countdown, launch, postlaunch or decay phases of any satellite lifetime where necessary. One near-future addition to the $500,000 Center, besides the on-line automatic input equipment, will be a cryptographic center for the handling of classified information.

Army Operating New Relay Link

MID-CONTINENT link in Army's worldwide communications network is now operational at Fort Leavenworth, Kansas.

Capable of handling 200,000 messages a day, the Midwest Relay Station is the second and largest built of three scheduled to go into service in the U.S., Army says. The first, at Camp Davis, Calif., began operation in 1956 and the third is being completed at Fort Detrick, Md.

The new $10-million station uses completely automatic message switching instead of the manual tape relay method. This permits receiving, processing, and retransmitting messages through the station without human intervention.

Principal developers and suppliers of communications and electronic equipment for the station, according to Army, are Kleinschmidt div. of Smith-Corona for teletypewriter equipment, and Automatic Electric for automatic switching and routing gear.

The station is operated by the U. S. Army Communications Agency and serves as an economical focal point through which domestic government installations can conduct routine business.

MEETINGS AHEAD

Mar. 8-11: Audio Engineering, Western Conv., Audio Eng. Soc., Alexandria Hotel, Los Angeles.

Mar. 17-18: Synchro Design and Testing Symposium, Bureau of Naval Weapons, Dept. of Navy, Dept. of Commerce Auditorium, Wash., D. C.

Mar. 21-24: Institute of Radio Engineers, International Convention, Coliseum & Waldorf-Astoria Hotel, N. Y. C.

Mar. 24-25: Human Factors in Electronics, PGHF of IRE, Bell Labs Auditorium, N. Y. C.

Apr. 3-7: National Assoc. of Broadcasters, Engineering Conf. Committee, NAB, Conrad Hilton Hotel, Chicago.

Apr. 3-8: Nuclear Congress, EJC, PGNS of IRE, New York Coliseum, New York City.

Apr. 11-14: Weather Radar Conference, American Meteorological Society and Stanford Research Institute, San Francisco.

Apr. 12-13: Protective Relay Engineers, Annual, A&M College of Texas, College Station, Texas.

Apr. 12-13: Static Relay Symposium, USA Signal R&D Lab, Hexagon Auditorium, Ft. Monmouth, N. J.

Apr. 12-13: Electronic Data Processing, ARS, Hotel Alms, Cincinnati, O.

Apr. 18-19: Automatic Techniques, Annual Conf., ASME, IRE, AIEE, Cleveland-Sheraton Hotel, Cleveland.

Apr. 19-21: Active Networks & Feedback Systems, International Symposium, Department of Defense Research Agencies, IRE, Engineering Societies Bldg., N. Y. C.

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

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

There's more news in ON the MARKET, PLANTS and PEOPLE and other departments beginning on p 74.

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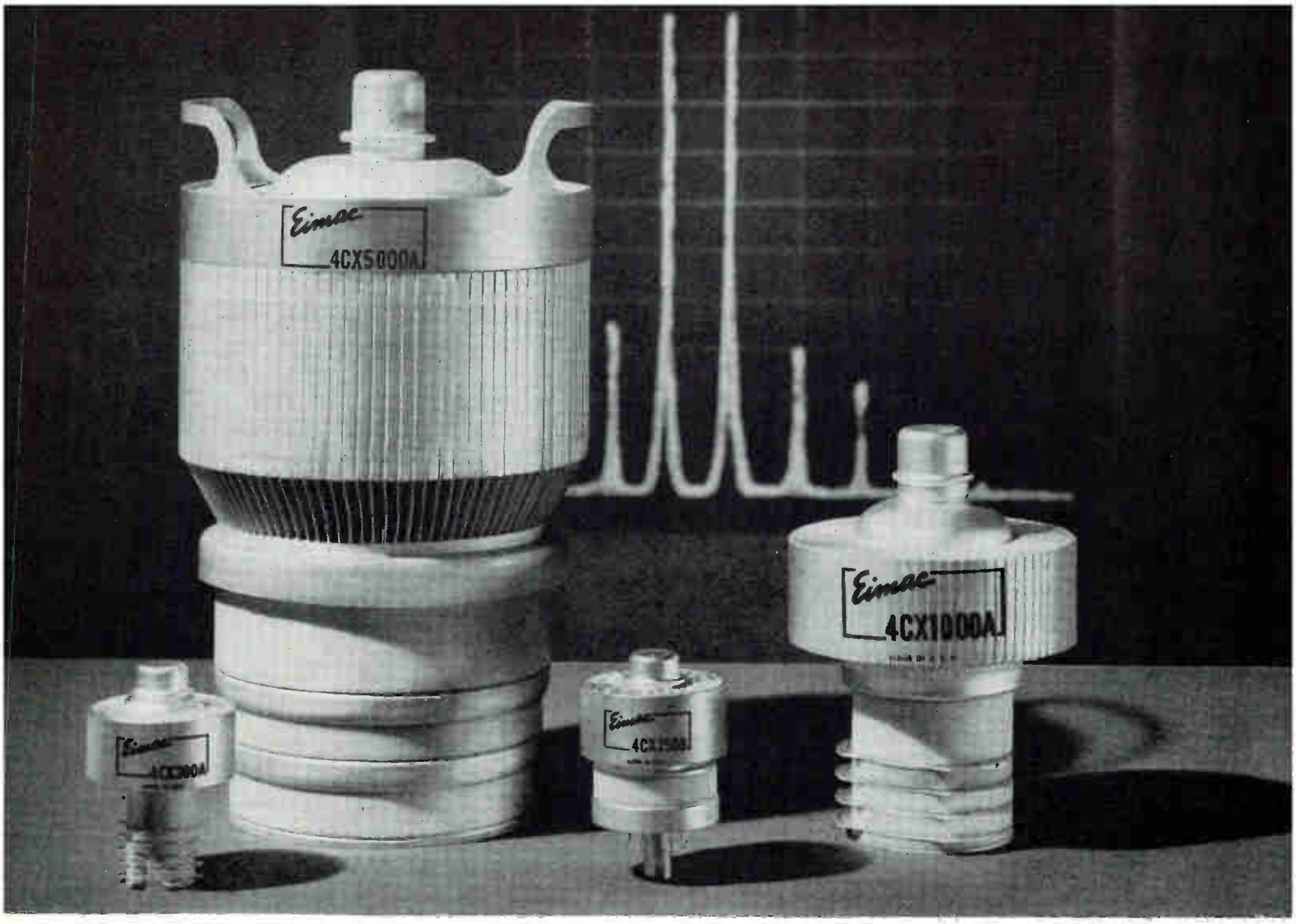
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Eimac
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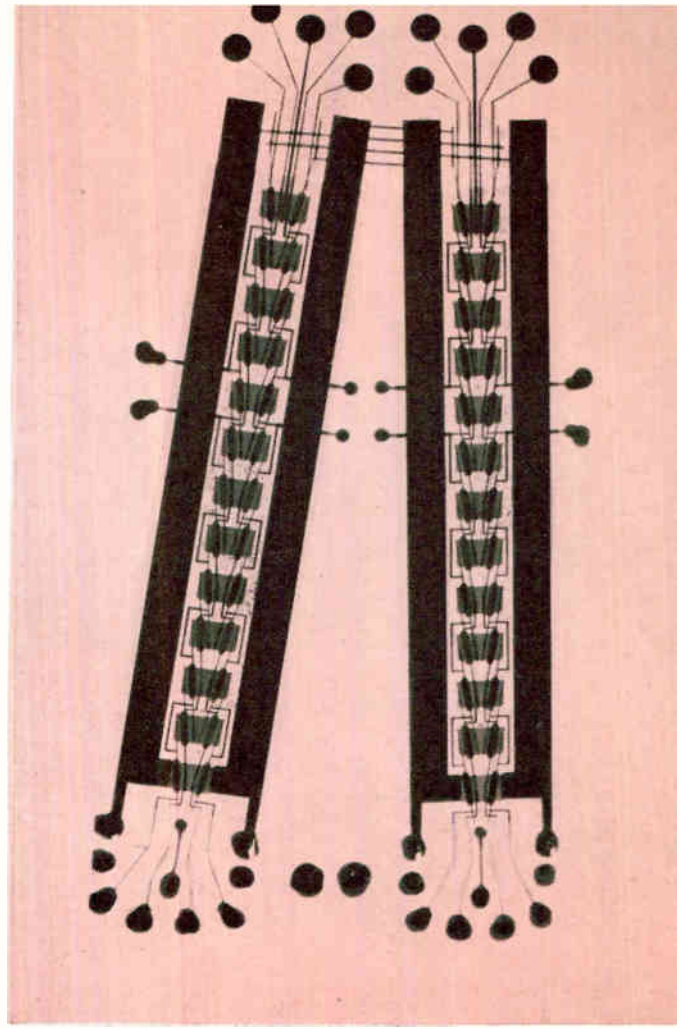
electronics
MARCH 4, 1960

Recent Progress in Solid State Technology

By M. M. PERUGINI, Associate Editor, and NILO LINDGREN, Assistant Editor



Thirteen-stage evaporated-film cryotron shift register. Exploded view, Fig. 6, shows details

Growing complexity of systems is intensifying demands for size reduction, better reliability and lower cost. Concentrated development work on solid-state devices and circuits is bringing system microminiaturization closer

A WELL-ACCEPTED feeling among solid-state engineers is that electronics is entering a new phase and that the problems now being confronted are radically different from those of lumped-parameter days.

At the 1960 Solid-State Circuits Conference in Philadelphia, there was much discussion about the emerging solid-state discipline, and about the place of tunnel diodes, thin magnetic films and cryogenic devices in future systems. There was also lively dispute on the aims of microminiaturization, a field which some observers feel has been overly publicized.

Leaders in the solid-state field are quick to assert that aims have not essentially changed—greater reliability, greater capacity, greater speed and, especially, smaller total cost (including throw-away cost) in electronic systems—and it is likely that in order to achieve these aims in highly-complex systems we are obliged to go to microminiaturization.

The ranging pro- and con arguments on microminiaturization, many of which were well-put, are important, however, for they are symptomatic of the problems and confusions besetting engineers working in the micro-domain. As various devices are scaled down, their behavior varies in often unpredictable fashion, and the electronics designer and applications engineer finds that his old intuition will no longer serve him reliably.

Charting a course for the developing of the new

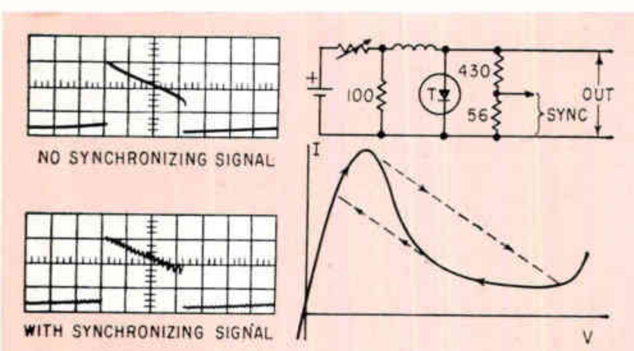


FIG. 1—In this tunnel-diode frequency divider, a relaxation oscillator is synchronized by a weak signal at a higher frequency. Rapid switching occurs when the tunnel-diode operating point moves slightly into the negative-resistance region

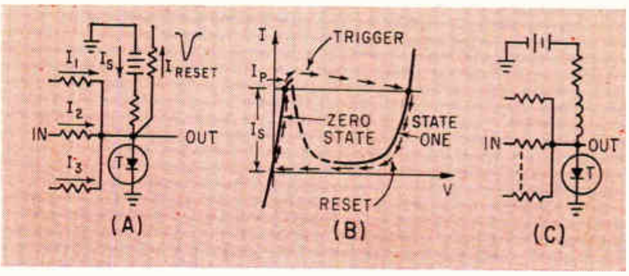


FIG. 2—A three-input threshold gate in the d-c powered bistable mode with unconditional reset (A); trigger action and reset action (B); and d-c powered monostable mode (C)

intuition was the paper "Microelectronics and the Art of Similitude" presented by Douglas Englebart of the Stanford Research Institute.[1] Similitude theory, which is well-developed, considers the comparative behavior of systems, and develops techniques for accurately predicting results on one system from observation on another. It is specially important in new solid-state work, for it provides a methodical way of determining which electronic-device techniques will be usable on a given miniaturization scale.

SOLID-STATE DEVICE DEVELOPMENTS—Because of its smallness, potential low cost, radiation resistance and relatively simple associated circuitry, the tunnel diode has been turned to many applications. It has great potential as a basic building block in future microminiaturization. Despite recent progress, however, there are many problems which must be solved before the tunnel diode's potential can be fully exploited. Among these problems are the need for reliability and reproducibility in manufacture; need to counter high internal capacitance effects at high frequency; need to isolate the tunnel diode from active elements in succeeding stages. The loss of memory in the tunnel diode when current is switched off will limit its applicability in storage systems. Speed of circuitry associated with the tunnel diode is also a problem—device speed now far exceeds circuitry speed.

Another important solid-state development reported at the conference is the recent progress in thin magnetic films for logic and memory circuits. Magnetic films have been formed into nondestructive storage elements, and shift registers operating above one Mc have been produced. The biggest problem in thin films is producing uniformity in film materials. Obtaining uniformity of films in cryotrons is not as difficult. Here, the problem is refrigeration.

All the advances cited can be regarded as advances in miniaturizing. But before micronminiaturization of complex systems can become a practical reality, certain basic problems must be solved: power sources and small inductances are required (promising work on an inductance diode is being pursued at Tohoku University in Japan by J. Nishizawa and Y. Watanabe); at high operating speeds. Not least of the problems is reliability coupled with low cost.

TUNNEL-DIODE APPLICATIONS—Two general types of operation are possible with tunnel (Esaki) diodes: small-signal operation around a bias point in the negative resistance range, which makes possible oscillators and amplifiers; and large-signal switching between two stable points separated by a region of instability, which makes possible basic logic functions required in high-speed digital systems. These and other possibilities inherent in the properties of tunnel diodes have excited concentrated interest in applying them to various circuits and systems. Many notable papers were presented on the application of tunnel diodes to both small- and large-signal functions.

One of the most promising features of the tunnel diode is that its negative resistance remains constant up to extremely high frequencies. The small-signal equivalent circuit, which consists of the negative resistance shunted by the barrier capacitance of the diode, and a series resistance and inductance associated with leads to the diode, has been checked up to frequencies of about 700 Mc it agrees qualitatively with the behavior of tunnel-diode oscillators operating up to a few thousand megacycles.[2]

Because of its flat frequency response, the same diode can be made to provide several different functions at different frequencies.[2] Negative conductance of the diode can be used as an amplifier at any frequency which is low compared with oscillator frequency; an intersection occurs between the two frequencies. When the diode frequency is comparatively low, the device can be thought of as a nonlinear element whose parameters vary slowly in time. Thus, the gain at the higher frequency, or the conversion gain between two higher frequencies will be subject to cyclic variations (see Fig. 1).

In this frequency divider, as the diode operating point moves into the negative-resistance region, high-frequency power is amplified. The signal builds up until it completely dominates the switching characteristics of the relaxation oscillator. Only small signal power is required to lock the relaxation oscilla-

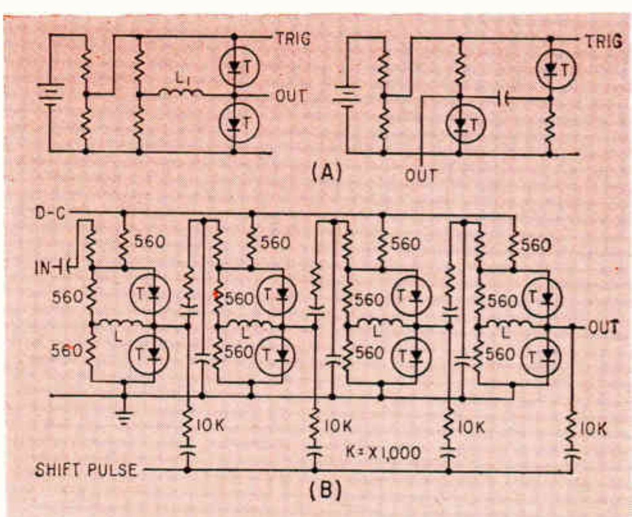


FIG. 3—Two tunnel-diode flip-flops, one inductively and the other capacitively coupled (A); and a shift register using the inductively coupled flip-flop as a building block (B)

tions because of the regenerative effect and because of the stability of the diode. Frequency divisions of 100:1 with power ratios above 40 db have been achieved.

TUNNEL-DIODE LOGIC CIRCUITS—Application of tunnel diodes to circuits for carrying out all basic logic functions has been found feasible[2]. Several modes have been studied. In the d-c powered bistable mode with unconditional reset (Fig. 2A) gain is obtained only when an input current greater than $I_p - I_v$ (Fig. 2B) triggers the diode from a low-voltage or ZERO state to a high voltage or ONE state. An output current is then available to drive other stages. An unconditional reset comes in the form of a power-supply interruption or a negative reset pulse. In this mode, either synthesized three-terminal networks with unilateral properties or unilateral coupling elements such as tunnel rectifiers provide directivity of information flow. Linear summation and threshold detection provide AND and OR operations. Other synthesized networks can provide inversion.

In the d-c-powered monostable mode (Fig. 2C), the basic circuit resets itself after delivering a ONE signal. AND and OR are obtained as in the bistable

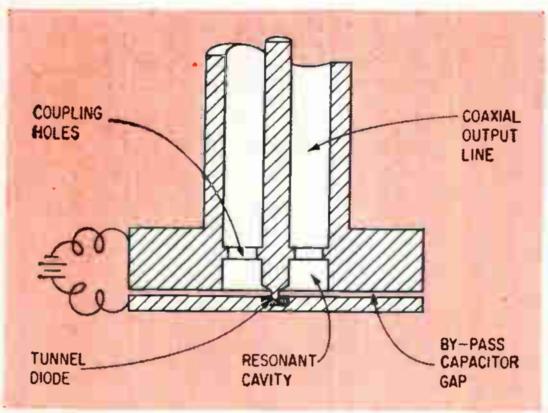
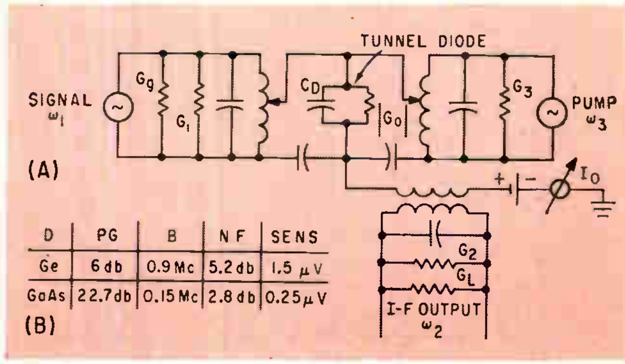


FIG. 4—Microwave oscillator or amplifier circuit. Maximum frequency of 4,000 Mc has been obtained in a demountable circuit of this type using an encapsulated general-purpose diode

mode. Polarity of the output pulse is reversed with a transformer to provide inhibition. Diode coupling provides unilateralization. This circuit requires only a simple d-c power supply; however, to insure coincidence of input pulses to a given stage, clock synchronization is needed.

A third mode of obtaining logic functions, the clock pulse or a-c-powered locking operation,[3] uses a pair of matched tunnel diodes powered by a balanced pulse-voltage source of amplitude sufficient to maintain only one of the diodes in the high state. The circuit is receptive to an input only during the short time when the power-supply pulses are building up, after which it locks into one of its two states. This is essentially a majority-logic type device.

Other applications of tunnel diodes to digital circuits are shown in Fig. 3. These flip-flops use only tunnel diodes and common passive circuit elements.[4]



D	PG	B	NF	SENS
Ge	6 db	0.9 Mc	5.2 db	1.5 μV
GaAs	22.7db	0.15 Mc	2.8 db	0.25 μV

FIG. 5—for this experimental converter (A), signal, local oscillator and difference frequencies are 210 Mc, 240 Mc and 30 Mc respectively. Measured values (B) agree with calculated values

Operation of the inductively coupled flip-flop is as follows. Magnitude of the d-c supply is set so that only one diode can be ON. Necessarily the other diode is OFF. The difference between two diode currents flows through L_1 to ground.

Under steady-state conditions no voltage exists across L_1. When an input triggers the off-diode ON, the voltage induced across L_1 resets the other diode from ON to OFF. Thus, the circuit acts as a center-triggered transistor flip-flop with each pair of positive input pulses completing a switching cycle. Differentiating the output gives a count-by-two scaler.

Figure 3B shows how these inductively coupled flip-flop can be used as building blocks for a shift register. Both the signal and shift pulses are positive. The basic circuit described operates reliably with variations of ±5 percent in tunnel-diode peak current and in resistor values, ±12 percent in d-c supply, and −20 percent to several hundred percent in input-pulse amplitude. Circuits which operate with higher tolerances are being developed.

TUNNEL-DIODE AMPLIFIERS—A tunnel-diode circuit suitable as a microwave amplifier or oscillator is shown in Fig. 4.[5] With weak coupling (small coupling holes to the coaxial line) oscillations will occur at the resonant frequency of the cavity. For amplification, large coupling is needed to prevent oscillation. In such a setup, input signal on the coaxial line reflects back down the line with a gain which will be very high if coupling is just sufficient to prevent oscillation. A circulator may be used to separate input wave and output wave. Maximum frequency oscillations of 4,000 Mc have been achieved. A properly-designed device of this type might provide oscillations up to 10,000 Mc.

Power achievable with single-spot diodes at microwave frequencies is very small because of low current due to its small size, and because of the low voltage. For greater power output, a number of interesting idealized schemes for distributed diode circuits have been presented.[5]

Construction of several tunnel-diode r-f amplifiers was reported.[6] Though such amplifiers show promise of very high gains, high gain-bandwidth product, low noise factor (better than 4 db), and probably low

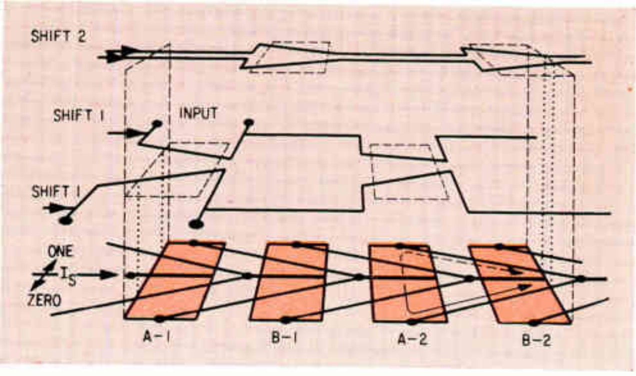


FIG. 6—Exploded view of register shows construction details. Layers are insulated from each other with silicon monoxide

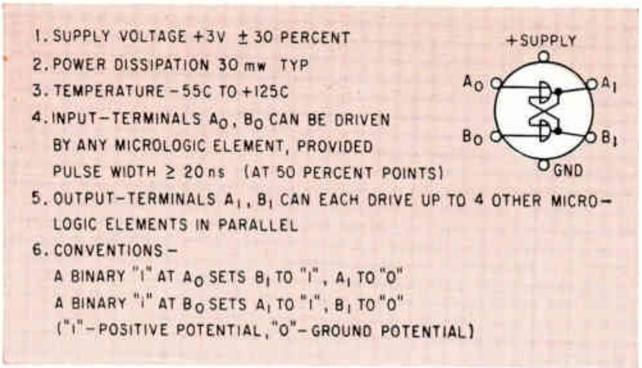


FIG. 7—Preliminary specifications for flip-flop. Future specifications will include delay information

cost, they present a serious problem when they are cascaded. Since the tunnel diode is a two-terminal device, some means of isolating it from following active elements is needed.

A number of interesting storage schemes using tunnel diodes were presented.[7] Cycle time for tunnel-diode memory is less than 100 Manoseconds. Major drawback with tunnel-diode storage is that the memory will be lost when current is turned off.

Another application of the negative-resistance characteristic of the tunnel diode was a down-converter which exhibits low noise, high gain and large band-width.[8] The experimental converter circuit, which can be used in the uhf range, consists of three tank circuits coupled together by a tunnel diode (Fig. 5A). Experimental results using both germanium and gallium-arsenide diodes appear in Fig. 5B. It may be possible to extend operating frequencies into the microwave region, though diode capacitance will undoubtedly present a major problem.

CRYOTRON SHIFT REGISTER—Recent progress in evaporating techniques allows construction of a 13-stage film cryotron shift register (see photo).[9] The register is a double-rank system where the even-numbered stages are the *A* register and the odd-numbered stages the *B* register. Details are indicated in Fig. 6.

If a half supply current is flowing in the solid arrow path and a half current pulse is applied to the shift-1 control, gate *A*-2-ZERO will be resistive and the supply current will take the path indicated by the dotted arrow. Bit 2 of register *A* has now accepted information in the form of a half current in the direction shown by the dotted arrow. By adding a half-current pulse on the shift-2 controls, this information is shifted to bit 2 of register *B*.

Output of the last stage can be connected to the first stage input to circulate the stored information, and a serial output can be obtained inductively across one of the pair of gates in the chain.

Also described was a vacuum-evaporated thin magnetic-film shift register operated at frequencies in excess of 1 Mc.[10]

COMPUTER MINIATURIZATION—The first step in one approach to low cost computers is the development of a family of high-speed, low-power devices which compatibly perform logic functions.[11] These devices, called micrologic elements, will enable computer manufacturers to assemble computers by simply interconnecting the elements. As a result, assembly cost is reduced while a smaller and more reliable computer is obtained. It is expected that the cost of the element will be appreciably less than the cost of the component parts which, when assembled, would perform the same function.

Included in the family of elements are: flip-flop, half adder, half shift register, gate and buffer. Presently packaged in the JEDEC TO-5 case, plans call for also packaging the elements in a TO-18 case. A specification sheet for a flip-flop is given in Fig. 7.

The techniques which have made possible construction of these logic elements on a single silicon die lend themselves well to constructing multiple elements on a single silicon substrate. These elements can then be interconnected so that the substrate is capable of performing a complex logical system or sub-system function. The potential of this extension of current techniques is such that it becomes possible to talk of packaging the entire logic section of a real time computer (equivalent of 2,000 transistors) in 0.15 cc.

This extension is based on the belief that the cost of fabricating a computer this way will be much less. It is felt that the cost of the logic section of a digital computer must be decreased by an order of magnitude using this approach in order to make a serious effort in this direction practical.

There is not much sense in constructing a pea-sized computer to be used with a barrel-sized memory. A great deal of work remains to be done in the reduction of memory size. Integrating micrologic with the more promising memory techniques may yield a computer of minimum total size.

SELF-ORGANIZING SYSTEM—The block diagram of an artificial neuron or information processing cell designed as a component for experimental studies of self-organizing systems is shown in Fig. 8.[12]

Each of the ten exciting and ten inhibiting inputs has a separate weight associated with it. Operation of the cell depends upon the differences between the weighted sum of the exciting and inhibiting signals. Included in the cell is an adaption feature and an absolute inhibit. The externally applied inhibit pulse produces a short state during which the cell is insensitive to all inputs.

Whenever the integral of the output is larger than a specified value, adaption is initiated within the cell. Adaption produces a short state in which the rate at which the cell can be fired by exciting inputs is reduced. The monostable multivibrator used as the threshold circuit produces a pulse whenever the output of the summing amplifier exceeds the threshold level. This pulse serves to increase the gain of the exciting channels which fired the cell. The trailing edge of the pulse is used to generate the positive and negative output pulses.

With minor additions the cell described can be used for perceptron-type experiments.

ADAPTIVE LOGIC—Systems with self-repair capabilities can be obtained by using a photoconductor control matrix.[13] A pattern generator, which can be a random-access film library with a suitable projection system, controls the matrix by projecting various patterns of light on the photoconductors. With the output of the matrix monitored by an error detecting stage, it is possible to step the pattern generator to start the self-repair cycle when a circuit failure occurs. This cycle will continue until the faulty block is detected and removed from the circuit.

PHOTORECTIFIER—An unusual photorectifier based on a combination of a photoconductor and an electret was described in a paper by G. Diemer of Philips in the Netherlands.[14] The rectifier consists of photoconductive cadmium sulfide powder activated with copper and gallium in combination with a glass enamel as a binder.

When a photoconductor powder is combined with an organic or glass binder, the resulting photoconductor shows a strong superlinear dependence of the photocurrent on operating voltage. Current through such a powder layer is limited by the contacts between grains. Thus, the voltage-current characteristic can be explained by assuming that the electron current from one grain to another is governed by a tunnelling process through a voltage barrier. By building in a polarization field between the grains, the magnitude of the field strength in the barrier depends upon the polarity of the supply voltage, and rectification occurs.

Figure 9 shows the structure of the cross section of a developed array of cadmium sulfide photorectifiers between crossbar electrodes. Surface is grooved to reduce forward resistance. With a rectification ratio of 10^4, the forward resistance is still, however, of the order of 100 Kilohms per mm^2. This system is attractive for application in cases where a high-

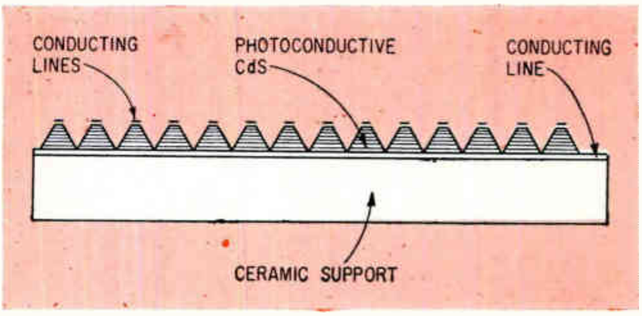


FIG. 9—Cross-sectional view of array of photorectifiers between cross-bar electrodes. There are roughly 25 grooves to the inch in this array

voltage output from a large number of photorectifiers is needed and the high forward resistance can be tolerated, such as in matrices for optical reading and switching. Optical input is obtained by placing a punched card in front of the photorectifying array. Readout is obtained by applying a voltage between a chosen horizontal and a chosen vertical conducting line.

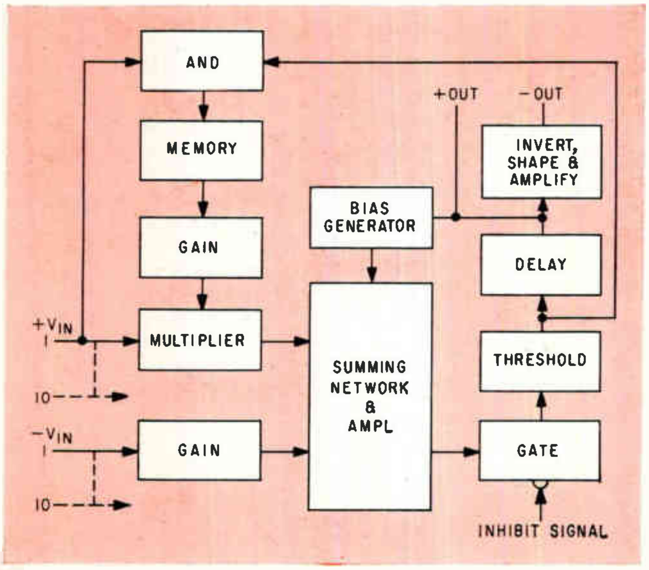


FIG. 8—Overall diagram of neuron shows how inhibiting and adaption are provided

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Computer Switching With

How to select the right power transistor and switching circuit to obtain required switching speed, gain and current-carrying capacity

By **JAMES S. RONNE,** Military Systems Studies Dept., Bell Telephone Laboratories, Whippany, New Jersey

HIGH-SPEED COMPUTERS utilize power transistors in increasing numbers. In selecting one of these units for a particular switching application, it is necessary to consider three requirements: switching speed, pulse gain, and current-carrying capacity. Unfortunately, these parameters are strongly dependent upon circuits and operating conditions. Furthermore, it is difficult to specify standards of comparison which would be appropriate for all types of transistors. As a result, these data are not directly available from published specifications.

It is not difficult, however, to determine the approximate capabilities of a power transistor on the basis of the published data sheet. The method by which a transistor can be evaluated relative to switching speed, pulse gain and current will be discussed. In addition, the considerations involved in realizing the full capabilities of a transistor in a practical circuit will be examined and a design example will be given.

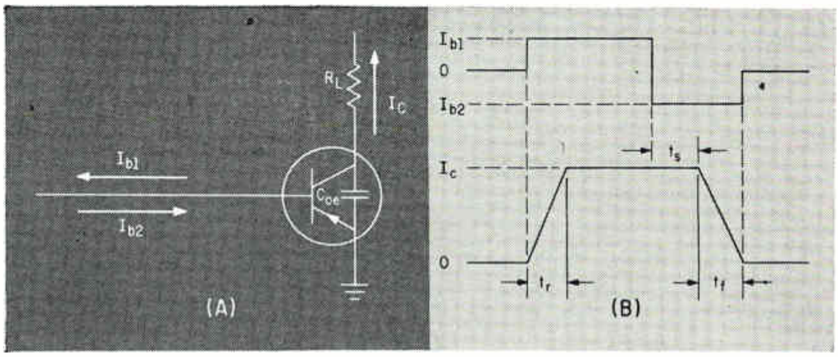

FIG. 1—Transistor capacitance C_{oe} (A) is one of parameters affecting rise time of I_c (B)

Switching Speed

Pulse rise time, t_r, of a transistor is closely associated with frequency cut-off and collector capacitance[1, 2, 3]. The expression for rise time with the emitter grounded is approximately given by[1, 2, 3] (see Fig. 1 and Table I):

$$t_r = t_k \ln [1/(1 - 0.9A/h_{FE})]$$

Typically the rise time will lie in the range, $0.1\ t_k < t_r < 3\ t_k$, depending upon the circuit gain.

Turn-off time is given approximately by:

$$t_f = t_k \ln [1/(0.1 + 0.9h_{FE}/(h_{FE} + A_R)]$$

The fall time will be similarly found to lie in the range:

$$0.1\, t_k < t_f < 2\, t_k$$

depending upon the magnitude of the reverse base current, I_{b2}.

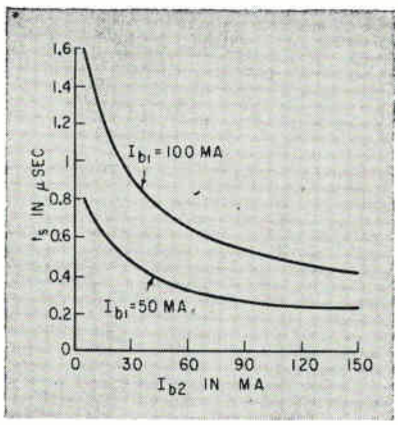

FIG. 2—Storage time (t_s) of GA-53242 transistor is function of I_{b1} and I_{b2}

Unfortunately, storage time (t_s) cannot be calculated from normally available small signal parameters. A typical curve illustrating the dependence of storage time on base current is given in Fig. 2. Current I_{b1} refers to the base current which flows during saturation and current I_{b2} refers to the reverse base current which flows during the storage and turn-off times. It should be emphasized that to pull a transistor out of saturation quickly, a reverse base current must flow which is in a direction opposite to that of the turn-on current. This reverse current can be obtained in several ways.

A simple scheme is to ground the base as shown in Fig. 3A. The base-emitter junction of the transistor resembles a battery of voltage V_j throughout the storage time. The reverse base current is

$$I_{b2} = V_j\,(R_2 + r_b)$$

where V_j and r_b are the junction voltage and base resistance, respectively, during saturation. The junction voltage can be found from the knee of an I_{b1}, V_b curve or from the expression $V_j = V_b - I_{b1}r_b$ where V_b is the d-c base-to-emitter voltage during saturation. In Fig. 3B the equivalent-circuit switch and limiting resistor have been replaced by transistor Q_2. The storage time can be reduced by selecting a transistor for Q_2 which has an effective series resistance (R_2) that is as small as possible. Other methods of reducing storage time will be discussed when the circuit design example is considered.

The maximum available pulse gain is determined by the large-

High-Power Transistors

signal gain of the device. However, the circuit gain is determined by the degree of saturation required. Reducing the circuit gain substantially below the large-signal gain by overdriving will reduce rise time, but unfortunately this method has the adverse effect of increasing the storage time. Furthermore, since some power transistors have low gain at high currents, use of excessive overdrive would sacrifice too much gain. In general, a circuit is designed to have the maximum possible pulse gain consistent with the required switching speed.

Current-Carrying Capacity

Data sheets for switching transistors normally list maximum power dissipation, maximum collector current, and collector saturation resistance (or voltage). However, it is not immediately obvious what the current-carrying capacity of the unit is for a particular switching application. Furthermore, it is difficult to compare the capabilities of transistors on the basis of these specifications.

To evaluate transistors, using their published specifications, a simple expression will be derived which relates pulse width to maximum collector current for various repetition rates. Consider a pulse train (Fig. 4) at the collector with repetition rate, f (in Mc), switching time, t ($t_r + t_f$ in μsec), pulse width t_p (in μsec), with amplitudes E_c and I_c (in volts and amperes). The total average collector dissipation, P_c, is equal to the sum of the average power dissipated during current saturation (P_1), the average power dissipated during switching (P_2), and the average power dissipated during voltage saturation (P_3).

Table I—Parameters

t_r = rise time (0 to 90 percent)
$t_k = 1/\omega a_e + R_L C_{oe}$
$A = I_c/I_{b1}$ = circuit forward gain
$A = I_c/I_{b2}$ = circuit reverse gain,
ωl_e = cutoff frequency, common emitter
h_{FE} = d-c current gain, common emitter
C_{ob} = collector-to-base capacitance
$C_{oe} = h_{FE} C_{ob}$ = collector-to-emitter capacitance

$$P_1 = I_c^2 r_{ce} t_p f$$
$$P_2 = (I_c E_c/4) t f$$
$$P_3 = E_c h_{FE} I_{CBR} t_o f$$

where the product, $h_{FE} I_{CBR}$, represents the maximum collector current during voltage saturation under conditions of maximum junction temperature and r_{ce} is the collector saturation resistance. Power term P_3 becomes important only at high ambient temperature or when the transistor is operated near the maximum power capabilities.

The average total power dissipation is:

$$P_c = P_1 + P_2, \qquad \text{if } P_3 \ll P_c$$
$$P_c = (I_c)^2 r_{ce} t_p f + 0.25\, I_c E_c t f$$

Solving for the pulse width, we get:

$$t_p = \frac{P_T - 0.25 I_c E_c f t}{(I_c)^2 r_{ce} f}, \text{ with } t_p \leq \frac{1}{f} - t$$

and where P_c has been replaced with P_T, the maximum power the transistor is capable of handling. In this way the capabilities of the transistor can be determined for various combinations of t_p, f, and I_c.

The values for switching time (t), collector voltage (E_c), and saturation resistance (r_{ce}) are obtained from transistor specifications and circuit conditions. The maximum power-handling capabilities (P_T) of the transistor in a particular application are not immediately obvious from most published data sheets. The collector current should never be allowed to exceed the maximum value recommended by the manufacturer. The equation for t_p does not take into account this important rating.

Transistor Power Rating

No industry-wide standard has been adopted for transistor power-dissipation rating. Some published ratings are contingent upon maintaining the entire transistor case at room temperature while others represent average values for specified operating conditions. Since the actual power-handling ability of a transistor is strongly dependent upon application and environment, a better scheme would be to provide sufficient engineering data to permit the calculation of the power-handling capability for individual circumstances. These data would include the maximum allowable collector-junction temperature (T_C), the thermal resistance from collector junction to free-air ambient with no external heat sink, (θ_{C-A}) and the thermal resistance from collector junction to mounting surface (θ_{C-C}).

Temperature drop from the col-

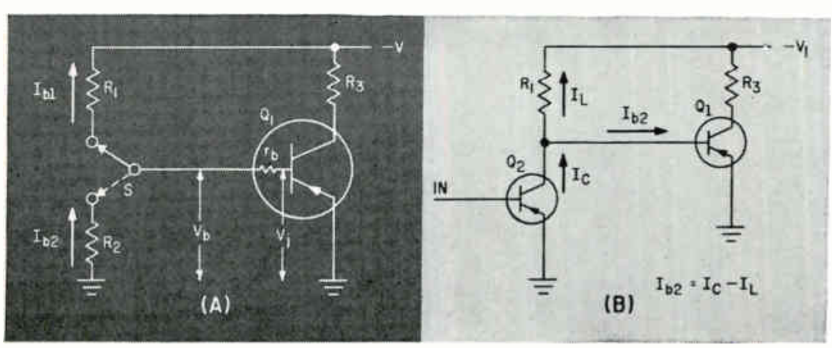

FIG. 3—Switch S is circuit equivalent for transistor Q_2 (B)

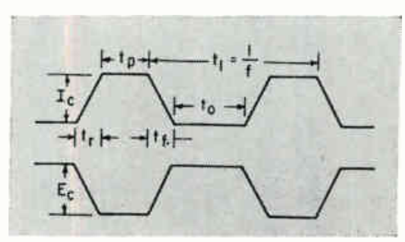

FIG. 4—Waveforms of I_c and E_c

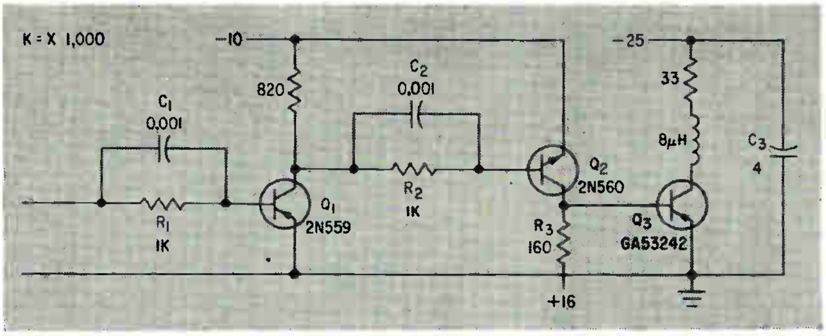

FIG. 5—All transistors of this driver amplifier are initially off

lector junction to the surrounding air is analogous to the voltage drop between two potentials. The thermal resistance from collector junction to mounting surface, $\theta_{C\text{-}C}$, is in series with the thermal resistance of the heat sink, θ_{hs}. Thermal resistance θ_{hs} includes the thermal resistance of the transistor case in parallel with that of any external heat sink. Increasing the size of the external heat sink reduces θ_{hs}, thus allowing a greater temperature drop within the transistor and permitting more power to be dissipated. Thermal resistance has the dimensions of deg C/watt.

An external heat sink can be designed based on the rule-of-thumb thermal resistance figure of (125 C/w)/A for surface areas greater than 5 in.², where A is the total exposed area of the heat sink in in.². This area includes both sides of a flat plate but only the outside surface of a transistor case. For small heat sinks (less than 5 in.²) the value (62 C/w)/A should be used. These values are determined from power dissipation based on heat transfer as a result of radiation and convection from a shiny surface. A properly blackened heat sink can reduce the thermal resistance by as much as 25 percent. Simply painting the area is not recommended, however, since the insulating properties of the paint may increase the thermal resistance.

Obviously, mounting arrangements and the degree of confinement can alter these values considerably in actual circumstances. For this reason, the thermal resistance values given here can be considered to be within a factor of two of the true value. Based on these numbers, however, a quick calculation will determine the approximate capabilities and/or requirements for a given application.

Table II—Typical Characteristics of W E GA-53242

I_c	≤ 3 a
$BV_{CBO,\ EBO,\ CEO}$	≥ 40 v
r_{ce}	0.5 ohm
I_{CBO} (25C, $V_{CB} = -40$v)	5μa
h_{FE} (I_c = 800 ma)	60
C_{ob} (V_c = − 4.5v)	≤ 50 pf
f_{α_e}	100 Kc
θ_{C-C} (int. thermal resistance)	24C/w
T_j (max. junction temp.)	85C

Commonly, only one of the two thermal resistance figures is specified in the published transistor data sheets. Given one, a simple approximation will allow the calculation of the other. This procedure entails a guess as to the effective heat dissipating area of the transistor cases.

As an example, consider the WE 2N560. This transistor has a $\theta_{C\text{-}A}$ of 250 C/w and a maximum junction temperature (T_c) of 150 C.

The internal thermal resistance, $\theta_{C\text{-}C}$, is found from $\theta_{C\text{-}C} = \theta_{C\text{-}A} - \theta_{hs}$. The external area of the case (built-in heat sink) is 0.56 in.²

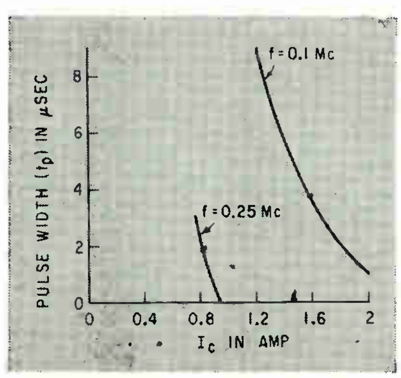

FIG. 6—Current-handling capability of the GA 53242

Thus, internal temperature rise is

$$\theta_{C\text{-}C} = 250 \text{ C/w} - 62 \text{ C}/0.56\text{w} = 140 \text{ C/w}$$

Similarly, given $\theta_{C\text{-}C}$ we can find $\theta_{C\text{-}A}$. The addition of a 3½ x 3½ in. heat sink will reduce θ_{hs} to:

$$\theta_h \text{is} = \frac{125 \text{ C/w}}{2 \times (3\tfrac{1}{2})^2} = \frac{5 \text{ C}}{\text{w}}$$

The 2 in the denominator takes into account both sides of the heat sink. The area of the transistor case is now insignificant and need not be included. The thermal resistance of transistor plus heat sink, θ_f, is $\theta_{C\text{-}C} + \theta_{hs}$, or 145 C/w. (The specification sheet gives the figure as 150 C/w.)

These values can now be combined with the maximum junction temperature to get the maximum power dissipation. For example the 2N560 operating with a 3½ x 3½ in. heat sink in 75 C free-air ambient (T_A) can dissipate $P_T = (T_C - T_A)/\theta_f$. Thus

$$p_T = (150 - 75)/(150/\text{w}) = 0.5 \text{ w}$$

Circuit-Design Example

An experimental solid-state memory requires a drive amplifier which will supply an 8-μh load with a current pulse (I_c) of 750 ma, t_p = 1 μsec, and ($t + t_p$) equal to or less than 2 μsec. (See Fig. 1B.) Repetition rate, f, is 0.25 Mc.

Consider the transistor characteristics listed in Table II. This transistor exhibits low saturation resistance (0.5 ohm) and high gain (60 at 800 ma).

Based upon these data

$$t_k = \frac{10^{-6}}{(0.1)(2\pi)} + (33)(50 \times 10^{-12})(60)$$
$$= 1.7 \ \mu\text{sec}$$

for a load resistance (R_L) of 33 ohms (Fig. 5).

If we design the circuit to have a rise time (t_r) not greater than 0.3 μsec,

$$t_r = 0.3\mu\text{sec} = 1.7 \ln[1/(1 - 0.9A/60)]$$

Solving for A we see that A must be less than 11. The base drive (I_{b1}) required must therefore be greater than I_c/A = 750 ma/11 = 68 ma. The addition of an 8-μh inductance in the collector circuit will add approximately 0.3 μsec to the rise time.

Similarly, a fall time (t_f) not greater than 0.3 μsec is calculated from

$$t_f = 1.7 \ln\{1/[0.1 + 0.9 \times 60/(60 + A_R)]\}$$

Solving for A_B we get $A_B < 13.1$; thus $I_{b2} > 57$ ma. Referring to Fig. 2, we see that a reverse base current of perhaps 100 ma would be desirable to reduce storage time. In the absence of storage-time information, use as large a reverse base current as can be conveniently supplied, in turning off high-speed high-current pulse amplifiers.

A 2 x 2 in. heat sink has a thermal resistance of 16 C/w. The thermal resistance of heat sink plus transistor become θ_t = 16 C/w + 24 C/w = 40 C/w. The maximum power-handling capability of the device at an ambient temperature of 30 C is

$$P_T = (85C - 30C)/(40C/w) = 1.4w$$

The current-handling capability of the unit is

$$I_p = (2.8 - 12 I_c f)/(I_c^2) f$$

where switching time t is 1 μsec and E_c is 25 v (Fig. 4).

This expression is plotted in Fig. 6 for f = 0.25 Mc and f = 0.1 Mc. As indicated, the power requirements are within the capabilities of the transistor. However, the curves of Fig. 6 represent an absolute maximum. Operating a transistor at this value is inviting trouble, since a slight increase in supply voltage or ambient temperature could permanently damage the transistor. Furthermore, the power dissipation term, P_3, would no longer be insignificant. In most instances the safety margin of a border-line transistor can be increased by reducing the supply voltage or increasing the area of the heat sink or doing both.

To obtain the high reverse base current (I_{b2}) required to cancel storage time and turn the transistor off quickly, a special circuit is required. The objective is to establish the maximum possible I_{b2} that is consistent with the circuit and the safe operating margins of the transistor. Some of the coupling schemes which could be used to establish a reverse base current are shown in Fig. 7.

In Fig. 7A, a negative pulse to Q_1 switches it on, grounding the base of Q_2 through R_1, which has a small resistance. In Fig. 7B, a negative pulse switches on Q_1, causing L_1 to impress a turn-off voltage on the base of Q_2.

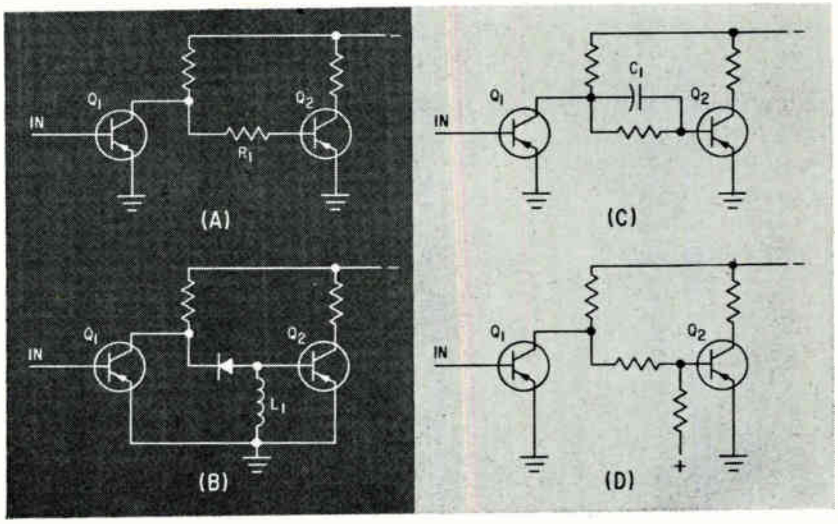

FIG. 7—Coupling circuits which can be used for establishing reverse base current

In Fig. 7C, a negative pulse switches on Q_1, causing C_1 to apply a turn-off voltage to the base of Q_2.

A variation of the method illustrated in Figure 7D is used to turn off transistor Q_3 of Fig. 5. In Fig. 7D, the reverse voltage is applied by means of a voltage-divider network. The resulting coupling network introduces a substantial loss in power. In Fig. 5, a positive turn-off voltage is automatically applied with no added loss in gain or power. This is accomplished by driving *pnp* transistor Q_3 with an *npn* type Q_2. Transistor Q_1 is a 150-mw diffused-base germanium transistor which allows the amplifier to operate from direct-coupled low-level circuits. Switching time in the stages Q_1 and Q_2 of the amplifier is reduced by incorporating the coupling scheme shown in Fig. 7C.

It will be noted that there is no phase reversal between transistors (they are all on or off at the same time). This condition has the effect of reducing the demands placed on Q_2 since it will have the same duty cycle as Q_3. Under no circumstances would transistor Q_2 be subjected to long periods of "soaking", which tends to increase storage time and power dissipation. However, the condition of having all transistors on at the same time increases the demands placed on the power supply. It was found necessary to by-pass the power-supply leads with capacitor C_3 to reduce the ripple to a tolerable level.

In operation, turning transistor Q_1 on causes the negative 10-v supply to apply a turn-on current to transistor Q_2. Coupling resistor R_1 is by-passed with a capacitor C_1 to speed up switching. Turning on transistor Q_2 effectively connects the base of transistor Q_3 to the negative 10-v supply, which applies a 100-ma turn-on current. As a result, approximately 750 ma will flow in the 8-μh load. The 100-ma base current of Q_3 is determined primarily by the series resistance of the emitter-base junctions of the transistors Q_2 and Q_3. Other transistors may have a lower input impedance and therefore require a lower negative-supply voltage or a series current-limiting resistor or both.

Turning transistor Q_1 off removes the forward base bias of Q_2 thus turning it off. Turning off Q_2 effectively connects the base of Q_3 to the positive 16-v supply, through load resistor R_3. As a result, approximately 100 ma of reverse base current flows, which sweeps the minority carriers from the base region and turns transistor Q_3 off quickly.

The amplifier produces 0.75-amp 1.9-μsec. pulses at a 250-Kc repetition rate in the 8-μh load with a 0.25-ma, 1-μsec. input. Transistor Q_3 remains saturated for approximately 1 μsec.

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Transfluxor Oscillator

Magnetic-electronic oscillator retains last frequency setting for many hours after removal of control signal

By RICHARD J. SHERIN, Product Development Laboratory, IBM Corp., Poughkeepsie, N. Y.

DEMAND by industry for a simple device to replace the servomotor-controlled oscillator has existed for some time, particularly among manufacturers of military communications equipment, automobile radio receivers and frequency standards.

Previous continuously-variable voltage-controlled oscillators all drift cumulatively off frequency when the controlling voltage is removed. Although it is possible to approximate this type of oscillator to any desired degree of accuracy by using a digital register, such a system is not simple.

Basis of the transfluxor oscillator described is the circuit shown in Fig. 1. The small aperture of a transfluxor[1] is used as the magnetic core member in a Royer converter circuit[2]. A square-wave output is obtained having a period which is a linear function of the time integral of the voltage induced in the large aperture by the control signal.

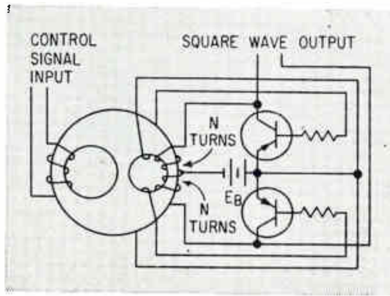

FIG. 1—Basic transfluxor oscillator circuit is essentially magnetic multivibrator with electronic frequency control

Transfluxor Operation

To simplify the discussion, assume that the cross-sectional areas of transfluxor legs 2 and 3 are equal and that of leg 1 is twice this value as shown in Fig. 2A. Also, assume the material used in the transfluxor has a nearly rectangular hysteresis loop. Using the sign convention established in Fig. 2B, it is apparent that: $-2\phi_s \leqq \phi_1 \leqq 2\phi_s$; $-\phi_s \leqq \phi_2 = \phi_3 - \phi_1 \leqq \phi_s$; and $-\phi_s \leqq \phi_3 = \phi_1 + \phi_2 \leqq \phi_s$ where ϕ_s is the saturation flux for leg 2 and for leg 3.

Consider the magnetization of the small aperture when $\phi_1 \geqq 0$. When the direction of magnetization is counterclockwise, leg 2 saturates at $\phi_2 = -\phi_s$ with leg 3 still unsaturated and $\phi_3 = \phi_1 + \phi_2 = \phi_1 - \phi_s$. When the direction of magnetization is clockwise, leg 3 saturates at $\phi_3 = \phi_s$ with leg 2 still unsaturated. Hence, the flux change, $\Delta\phi_3$, in leg 3 during clockwise magnetization starting with leg 2 saturated and ending with leg 3 saturated is given by $\Delta\phi_3 = 2\phi_s - \phi_1$. Similarly, for $\phi_1 \leqq 0$, $\Delta\phi_3 = 2\phi_s + \phi_1$ and in either case $\Delta\phi_3 = 2\phi_s - |\phi_1|$.

Switching Ring C_1

Referring to Fig. 2C, when legs 2 and 3 are both unsaturated, the magnetomotive force (mmf) which must be applied to leg 3 to change ϕ_3 is at most equal to that value which will switch flux in the ring C_1 when it is unsaturated. In operation, when a sufficient mmf is applied to the small aperture, the flux density vector field pattern will be changed in such a way that the shortest closed path enclosing the small aperture and having no saturated segment is affected first. Paths of greater length are affected as the material closest in to the small aperture becomes saturated.

The change in the flux density field pattern proceeds from the inside to the outside until some path is reached which has sufficient length so that the applied mmf is less than the threshold mmf for this path. When the mmf is sufficient to overcome the threshold mmf for this path, it is great enough to saturate all the material inside the circle C_1 and, therefore, is an upper bound on the mmf re-

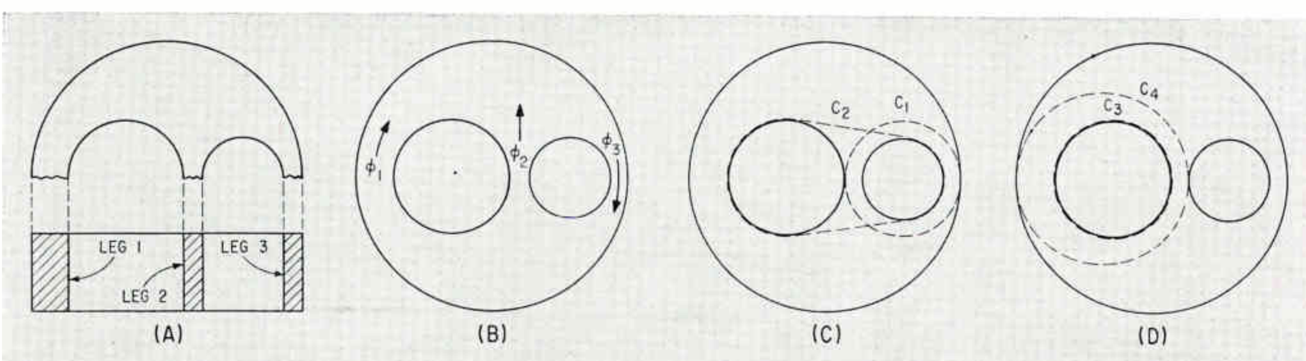

FIG. 2—Transfluxor construction and magnetization. Cross-sectional area of transfluxor legs (A); definition of fluxes used in description of transfluxer operation (B); paths determining the range of mmf which can be applied to leg 3 (C); and paths determining a maximum range for the mmf threshold presented to the control signal (D)

Gives Drift-Free Output

quired to switch the flux in a closed path through legs 2 and 3.

Switching Ring C_2

When leg 3 reaches saturation in the downward direction, an arbitrarily large downward mmf will cause no further flux change in the transfluxor. When leg 2 reaches saturation in the downward direction, a sufficiently large upward mmf on leg 3 can cause counterclockwise magnetization of a path which encloses both the small and large aperture thereby altering ϕ_1. However, if the counterclockwise mmf is limited to a value below that which will switch flux in the path C_2, then it is insured that the upward mmf on leg 3 will cause no further flux change after leg 2 has become saturated in the downward direction.

Circuit Parameters

The circuit of Fig. 1 is so designed that either transistor once ON is held in the saturated ON state for any collector current up to some maximum value I_m. Circuit parameters are chosen so that I_m is greater than that value which would just magnetize an unsaturated path C_1 but smaller than that value which would magnetize an unsaturated path C_2. Thus, the mmf is just greater than the threshold mmf for the length of the path referred to and will therefore alter the flux density direction along the path if the path is not already saturated in the direction of the mmf. These limit values are separated by a factor of two or more in a typical transfluxor, hence the adjustment is not at all critical.

Each time collector current I_m is reached in the ON transistor, the fed back voltage to the ON transistor decreases causing a corresponding decrease in the collector current. Because of the presence of a small amount of elastic flux excursion, this decrease in current causes the voltage to reverse across all the windings on the small aperture, the formerly ON and OFF transistors interchange states and the flux in leg 3 is then driven back toward the opposite saturation condition. The flux changed in leg 3 between the two saturation conditions is $|\Delta\phi_3| = 2\phi_s - |\phi_1|$, and the period of the oscillator is directly proportional to this value.

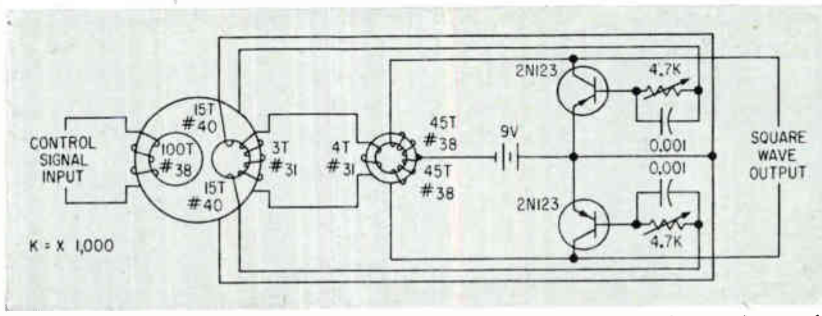

FIG. 3—Experimental transfluxer oscillator operates between 100 Kc and 1 Mc. In practical applications, a larger transfluxer would be used and the extra transformer eliminated

OSCILLATION TIME CALCULATIONS

Time in μsec for a half cycle of oscillation is that time required to switch the flux $\Delta\phi_3$ and is given by:

$$T = \frac{N}{E_B - \Delta E}\Delta\phi_3 = \frac{N}{E_B - \Delta E}(2\phi_s - |\phi_1|)$$

where all fluxes are measured in volt-μsec/turn and ΔE accounts for the sum of the voltage drop across an ON transistor and the IR loss in the conducting N turn winding. The relation between a corresponding flux and voltage is given by:

$$\phi_1(t) = \int_0^t \frac{e_c(t)}{N_c}\,dt$$

where e_c is the voltage induced in an open circuited winding of N_c turns on leg 1 and t is measured in μsec. Thus:

$$T = \frac{N}{E_B - \Delta E}\left(2\phi_s - \left|\int_0^t \frac{e_c(t)}{N_c}\,dt\right|\right).$$

Letting A be the cross-sectional area in cm^2 of leg 3 and B_s the saturation flux density in gauss for the core material, $\phi_s = B_sA/100$ volt-μsec/turn. The threshold mmf, F_c, in ampere-turns for the control signal falls in the range $H_TL_3/0.4\pi \leq F_c \leq H_TL_4/0.4\pi$ and the range of satisfactory adjustment for I_o is determined by $H_TL_1/0.4\pi < NI_m < H_TL_2/0.4\pi$, where H_T is the threshold mmf in oersteds for the core material and L_1, L_2, L_3 and L_4 are the lengths in cm of paths C_1, C_2, C_3 and C_4, respectively.

Frequency Control

When the transfluxor oscillator parameters are properly chosen, ϕ_1 is unaffected by the mmfs applied to the small aperture. Only when the mmf produced in leg 1 by the control signal exceeds a certain threshold will ϕ_1 begin to change. After this threshold is exceeded, the rate of change of ϕ_1 will be proportional to the voltage induced in an open circuited winding on leg 1, that is, the control voltage is a driving voltage minus an IR drop in the control winding.

This threshold mmf falls in the range bounded by the mmf values required to magnetize unsaturated paths C_3 and C_4 as shown in Fig. 2D, and corresponds to the static friction in the servomotor of a servomotor-controlled oscillator. It is the threshold effect which stabilizes the oscillator frequency against cumulative drift resulting from noise current in the control winding of the transfluxor oscillator in one case and from noise current in the servomotor drive voltage in the other case. The experimental oscillator (Fig. 3), uses an RCA XF3006 transfluxor.

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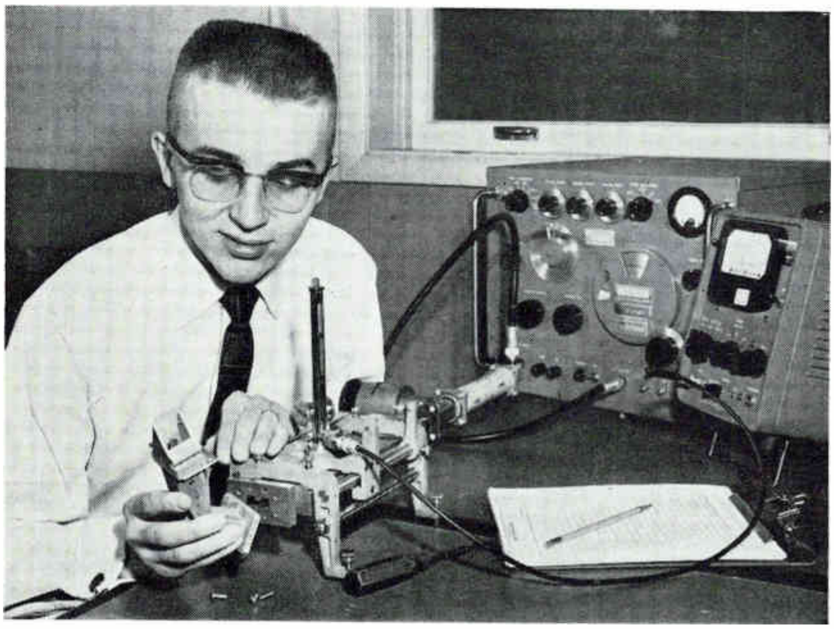


Antenna is mounted on ridged waveguide slotted line prior to measuring vswr

Table I—Antenna Characteristics

Frequency Band	7–11 Gc
Max vswr	1.5
Max On-Axis Axial Ratio (E_{max}/E_{min})	2
Min 3 db E_ϕ Beamwidth in $\theta=0$ plane	100 deg
Min 6 db E_ϕ Beamwidth in $\theta=0$ plane	140 deg
Min 3 db E_θ Beamwidth in $\theta=0$ plane	140 deg
Min 3 db E_θ Beamwidth in $\phi=0$ plane	52 deg
Min 3 db E_ϕ Beamwidth in $\phi=0$ plane	78 deg
Average Power Tested	200 w
Approx Min On-Axis Gain Relative to Isotropic Radiator	3

X-Band Horn Antenna

Elliptically-polarized antenna has 3-db and 6-db beamwidths of 140 degrees. Applications are in countermeasure, telemeter and beacon systems

By **RAYMOND E. METTER,** Aero-Space Division, Boeing Airplane Co., Seattle, Washington

An X-band horn antenna has been developed that can be used whenever there is a broad beamwidth requirement with either horizontal, vertical or elliptical polarization. These applications are found in electronic countermeasure, telemeter and beacon systems.

The antenna to be described is elliptically polarized and has the unique feature of a wide beamwidth in two polarizations. In the plane corresponding to the H-plane of the waveguide feed, the antenna has a minimum 3-db beamwidth of 140 deg for the polarization perpendicular to the H-plane of the waveguide feed and a minimum 6-db beamwidth of 140 deg for the orthogonal polarization over the 7-11 Gc band.

Basically, the antenna is a modified open-ended waveguide. It consists of a linear taper transition from standard waveguide to square waveguide, a Rexolite dielectric phase shifter and a V-shaped aperture. (See Fig. 1.) The antenna characteristics are summarized in Table I.

Design Considerations

For discussion purposes the antenna is located at the center of the spherical coordinate system shown in Fig. 2. The H-plane of the waveguide feed is parallel to the $\theta = 0$ plane and the antenna axis is coincident with the intersection of the $\theta = 0$ and $\phi = 0$ planes. The $\theta = 0$ and $\phi = 0$ planes are the horizontal and vertical planes, respectively; E_θ and E_ϕ represent the vertical and horizontal polarizations, respectively.

With a standard open-ended waveguide that is linearly polarized, E-plane 3-db beamwidths of greater than 120 deg can be obtained. It is not simple, however, to obtain broad H-plane patterns. If elliptical polarization is required, it is not possible with open-ended waveguide to obtain broad patterns in any plane since the narrow dimension of the rectangular waveguide must be increased so that the elliptically polarized mode can be supported.

In the $\theta = 0$ plane, an elliptically polarized 0.9-inch square open-ended waveguide in free space will theoretically have an E_ϕ 3-db beamwidth variation of 85 deg to 60 deg and an E_θ beamwidth variation of 85 deg to 73 deg over the 7-11 Gc band.[1] To achieve a broad pattern, two antennas can be combined with a waveguide tee and oriented so that each antenna covers adjacent 60-deg regions.

The main disadvantage of this configuration is interference in the

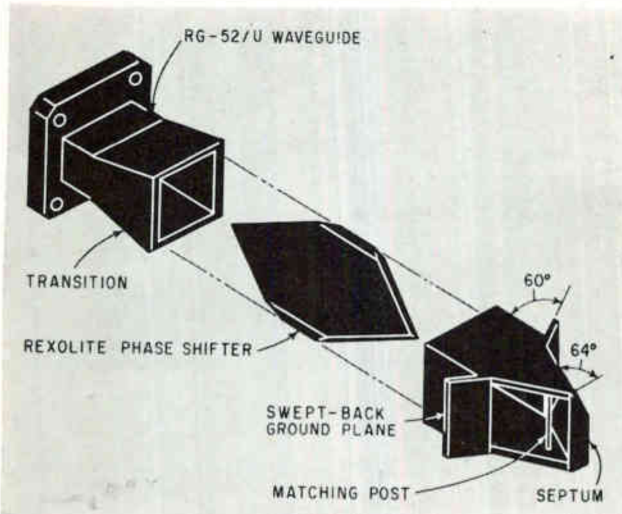


FIG. 1—Prototype antenna is 4.125 inches from beginning of flare on transition piece to edge of septum

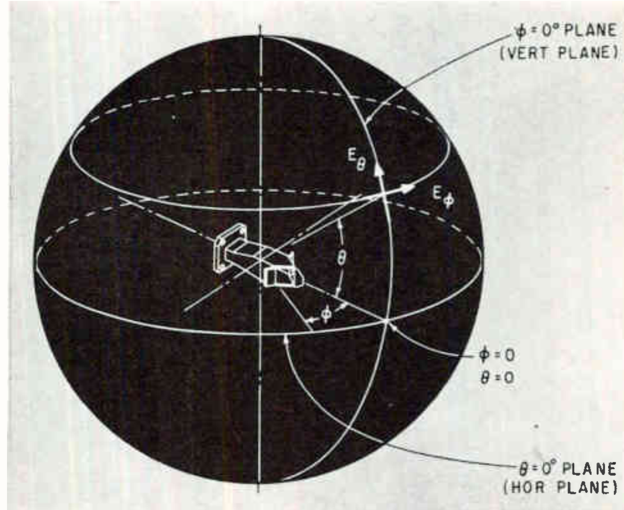


FIG. 2—Spherical coordinate system defines waveguide feed planes, and vertical and horizontal polarizations

Has Broad Beamwidth

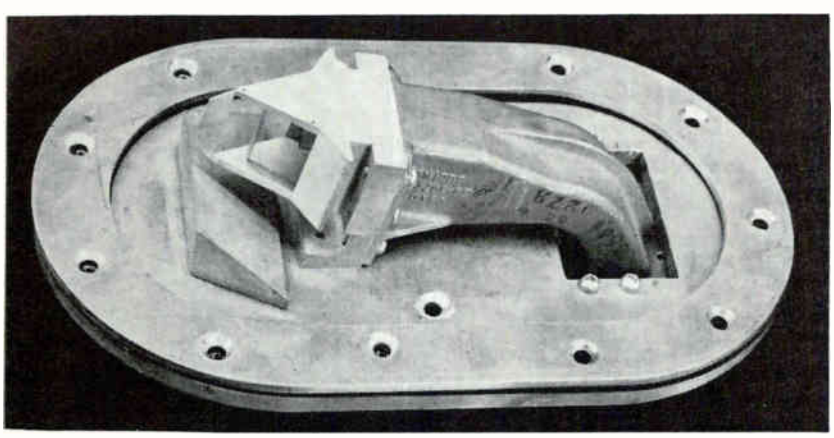
pattern and complexity of the feed. As the two antennas are moved closer together, the number of nulls decreases while the width of the nulls increases. When the effective phase centers of the two antennas are less than $\lambda/2$ apart, the nulls will be eliminated; however, this configuration is physically unrealizable with two separate horn antennas. This leads to the possibility of modifying one antenna so that it "looks" like two antennas whose effective phase centers are less than $\lambda/2$ apart. The antenna discussed below falls into this class. Basically, it is an open-ended square waveguide with a V-shaped aperture divided by a septum.

Elliptical Polarization

One way to produce circular polarization is to convert a linearly polarized wave into two equal-magnitude orthogonal waves 90 deg out of time phase. One common method is to feed a partially dielectric-filled square waveguide from a twisted feed.[2] An improved design was developed by W. D. Hodge,[3] where it is not necessary to twist the feed. This design consists of feeding a linearly polarized wave (TE_{10}) into a square waveguide which contains a Rexolite dielectric slab placed diagonally.

In square waveguide, the TE_{10} wave may be thought of as two equal-magnitude orthogonal modes whose transverse E fields are 45 deg from the incident E field.[4] The polarization of one mode is perpendicular to the dielectric and the polarization of the other mode is parallel to the dielectric. As they propagate through the dielectric, each mode is retarded in phase with the wave parallel to the dielectric lagging the wave perpendicular to the dielectric since most of the parallel wave travels in the dielectric. By choosing the proper length dielectric, a 90-deg phase shift is obtained which produces a circularly polarized output wave.

A rigorous solution of the fields in the loaded dielectric square waveguide would result in the propagation constants for both modes so that the phase shifter design could


Possible antenna installation could be used on airplanes or missiles by placing mounting plate flush with vehicle's skin. Tapered block is required for null filling

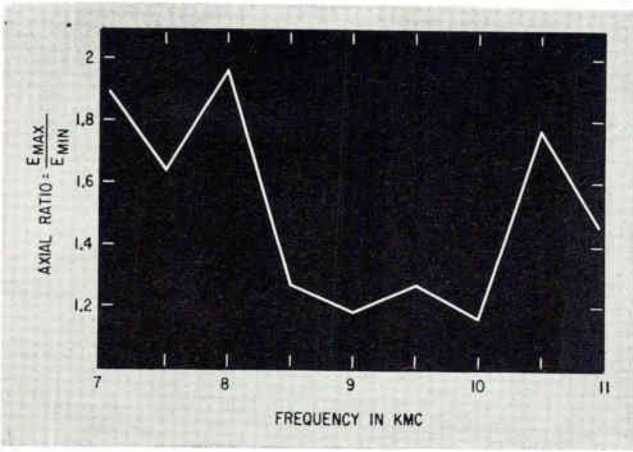


FIG. 3—On-axis axial ratio of prototype antenna

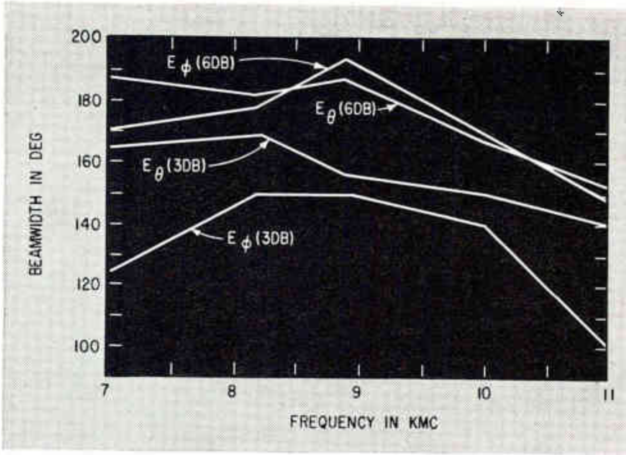


FIG. 4—Beamwidth in $\theta = 0$ deg plane of prototype antenna

be optimized. A rigorous solution could parallel the work of W. Ayres[5]; however, the mathematics become extremely complex when the phase shifter is oriented diagonally. Thus, the phase shifter size was determined experimentally.

The transition from the RG-52/U waveguide feed to the square waveguide is a linear taper one inch long. Although there are many sophisticated methods for a low vswr transition, it has been demonstrated that a linear taper design is a very good approximation to the optimum design.[6] From a manufacturing standpoint, the linear taper is, of course, superior.

Phase-Shifter Placement

In the development of the transition and phase shifter, it was found that the composite vswr was reduced considerably and the ellipticity improved when the phase shifter was placed in the transition region. The reduction in vswr is probably due to the shorter wavelength in the dielectric region which makes the transition longer in terms of wavelengths. Also, the reflections from the dielectric cancel the reflections from the transition.

When radiating into free space, the overall configuration resulted in a compact mode transducer from linear to elliptical polarization which had a vswr of less than 1.4 and an on-axis axial ratio of less than 1.41 over the 7-11 Gc band. After the aperture was modified, as will be described, the on-axis axial ratio was less than 2 (see Fig. 3). An axial ratio of 1 indicates circular polarization.

As previously noted, one way to obtain broad patterns is to orient two apertures so that their respective radiation patterns cover adjacent regions in space. To approximate this concept, a 0.9-inch square waveguide may be cut in a V shape with a pin placed at the apex.

Silver[7] indicates that in the $\theta = 0$ plane the E_θ pattern has 10-db beamwidths of greater than 180 deg at some frequencies. Using the previously developed elliptically polarized square waveguide feed, an extensive set of patterns was taken of pinned horns with different angled V-shaped apertures. The resulting E_θ 3-db beamwidths were more than 140 deg over the 7-10 Gc band. Above 10 Gc, the beamwidth narrowed to 100 deg at 11 Gc. In order to maintain broad patterns across the frequency band, it seemed logical to try to separate the two apertures. This was accomplished by replacing the pin with a septum. It was found that a one-fourth-inch septum on a 64-deg horn gave E_θ patterns in the $\theta = 0$ plane of 140 deg or more over the 7-11 Gc frequency band. (See Fig. 4.)

During the E_θ investigation, E_ϕ patterns in the $\theta = 0$ plane were also obtained. The 3-db beamwidths were of the order of 70 deg and were affected in a second-order manner with the previous parameter variations. It is logical to assume that the aperture distribution which controls the E_ϕ pattern is essentially unaffected by changes of septum size or apex angle since the E_ϕ vector is perpendicular to the septum. That is, to a first approximation, the E_ϕ vector does not see the septum.

It is well known that the E-plane beamwidth of a linearly polarized antenna can be increased considerably if the antenna aperture is flush with a ground plane. Although the intended use of the antenna dictated that it would be mounted in a free-space environment, it was still possible to exploit a small ground plane. In developing a broadbeam linearly polarized antenna, it has been found that the E-plane pattern of an open-ended rectangular waveguide could be broadened with the use of a small swept-back ground plane.[8] The same attack was used on the V-shaped horn. A series of patterns were run with ground planes of different lengths and at different angles. It was found that one-half-inch ground plane at 60 deg was optimum. This configuration resulted in E_ϕ 3-db beamwidths greater than 140 deg over half of the frequency band. The 6-db horizontal E_ϕ beamwidths are more than 140 deg over the 7-11 Gc band. (See Fig. 4.) The swept-back ground planes do not affect the E_θ pattern in the $\theta = 0$ plans as $E_\theta = 0$ at the sides of the waveguide aperture. Thus, to a first approximation, the patterns of the two polarizations in the $\theta = 0$ plane can be controlled independently.

Impedance Matching

Without any impedance compensation, the antenna had a maximum vswr of 3:1. Since the transition and phase shifter are relatively well matched, the primary reflections arise from the aperture. In particular, it is clear that the septum is the main cause of mismatch and it was found that the matching problem consisted of eliminating the effect of the septum on the E_θ polarization.

Impedance measurements indicated a shunt inductance in the vicinity of the aperture would be beneficial. Consequently, a 0.05-inch diameter post was tried in the open V-shaped region. A location for the pin was found where the vswr of the E_θ polarization was reduced to less than 1.6:1.

Since the post improved the vswr of the E_θ polarization considerably, the antenna was assembled, and the optimum post location was obtained. This location was slightly different since the post is now matching out the complete antenna. In conjunction with the post location variation, the distance between waveguide transition and aperture was also varied so advantage could be taken of the cancelling of net reflections from the two main mismatch regions.

It was found that the best results were obtained when the point of the phase shifter is flush with the square opening. As a fine tuning adjustment, the corners of the septum were mitered. The result was a vswr of less than 1.5 over the 7-11 Gc band.

Applications

The antenna was originally designed for an airborne application. It, of course, may be used whenever there is a broad beamwidth requirement with either horizontal, vertical or elliptical polarization.

For a linearly polarized application, a broad E_θ pattern in the $\phi = 0$ plane can be obtained by removing the phase shifter. If a broad E_ϕ pattern is desired, it is necessary to remove the phase shifter and rotate the transition 90 deg about the waveguide axis. The V-shaped aperture can be used to broaden the beams of other basic antennas. For example, a V-shaped configuration can be placed on the aperture of a cavity-mounted elliptically polarized helix and affect a broadening of the patterns.

Instead of mounting the antenna in an essentially free-space location, the situation may occur where the antenna is protruding from a ground plane. It has been found that the one-half-inch swept-back ground planes have little effect on the broad E_ϕ patterns when the back edge of the ground plane is resting on the large ground. Thus, the swept-back ground planes can be removed.

Effect of Ground Plane

Although a large ground plane (at least 10 λ) generally broadens the E_θ pattern, the resulting E_ϕ patterns were not as broad as were obtained in free space with the small swept-back ground planes. Thus, when the environment is a large ground plane, the broad E_ϕ pattern is narrowed. The broad E_θ pattern is essentially unaffected by changes in ground planes. For a narrow band application, there is the possibility of using chokes in the ground plane which will curtail the excitation of current along the conductor. The chokes will tend to prevent E_ϕ pattern degradation caused by the ground plane.

This principle was used in the models shown in Fig. 5. In order to use available feeds and to facilitate assembly, it was necessary to construct the antenna with a flange directly behind the swept-back ground planes. To prevent broad E_ϕ pattern degradation, chokes were cut behind the small ground planes. The electrical characteristics of the antennas in Fig. 5 are the same as the prototype antenna except that the 3-db beamwidth of the E_ϕ pattern in the $\theta = 0$ plane narrows to 100 deg at 7 Gc.

Some of the ideas used in this development may be useful in developing a broadbeam elliptically polarized antenna in both planes. For example, a crossed septum and four swept-back ground planes might possibly be used.

The author is indebted to W. D. Hodge and J. C. McInturff, whose previous antenna developmental results were used extensively and to C. H. Vandermeer who constructed and tested the experimental models.

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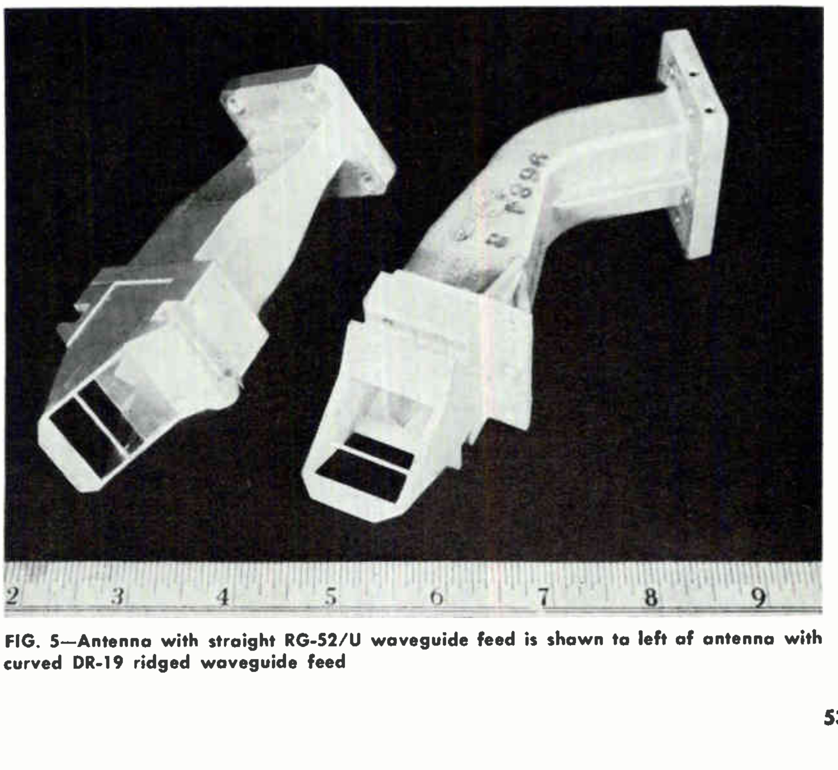


FIG. 5—Antenna with straight RG-52/U waveguide feed is shown to left of antenna with curved DR-19 ridged waveguide feed

Precision Phasemeter for

Operating in the band from 100 to 520 Mc, system measures phase differences between two signals within 0.2 degrees. Frequency of operation can be extended up to X-band and down to 20 Mc

By ROGER T. STEVENS, Electronics Systems, Inc., Boston, Massachusetts

PHASE MEASUREMENTS in the uhf region have typically been laborious and inaccurate. But certain electronic applications require very accurate measurements, one example being a phased antenna array. Accurate determination of antenna patterns of phased arrays requires the precise determination of the phase characteristics of each element of the r-f system.

A new phasemeter, operating in the band from 100 to 500 Mc, will measure the phase between two signals to within 0.2 degree for c-w signals and to within 0.5 degree for pulsed r-f in the same frequency range. By changing the i-f frequency, the same method can be used down to 20 Mc; with suitable preamplifying equipment, operation up to X-band is possible. An important advantage of the new instrument is that no manual adjustments are required after the initial calibration. This is true even if the phase difference varies over the full 360 degree operating range. The output is in digital form, giving the phase difference directly in degrees.

Basic Circuit

The basic approach to phase measurement is shown in Fig. 1. The two input signals, f_1 and $(f_1 + \phi)$, determine the phase between two 90-Mc signals, which in turn determine the phase between two audio signals. The audio frequency used is approximately 2.78 Kc, selected because one cycle of this frequency equals 3,600 cycles of the 10-Mc clock source. Thus one pulse of the 10-Mc clock becomes equivalent to 0.1 degree. The phase relationship of the two input signals, f_1 and $(f_1 + \phi)$, is maintained throughout the heterodyning process and the two audio signals differ in phase by the same amount as the signals being measured. Controlled by zero-crossings of the audio signals, pulses from the 10-Mc clock are counted by the readout circuits, giving the phase angle directly in degrees and tenths of a degree. Thus, for an angle of 45.4 degrees, for example, 454 pulses would be counted during the time between successive positive-going zero-crossings of the 2.78-Kc audio signals.

The operation of the uhf phasemeter is complicated by the necessity for measuring phase differences of pulsed signals. If such pulses were converted directly to audio, only segments of each audio cycle would be present, and such segments might or might not include the required zero crossings. This makes it necessary to measure the zero crossings of the audio sig-

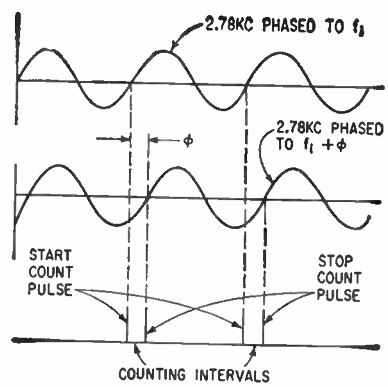


FIG. 1—Phase angle, ϕ, between signals being measured is maintained throughout the heterodyning process. A 10-Mc counter operates during the counting intervals

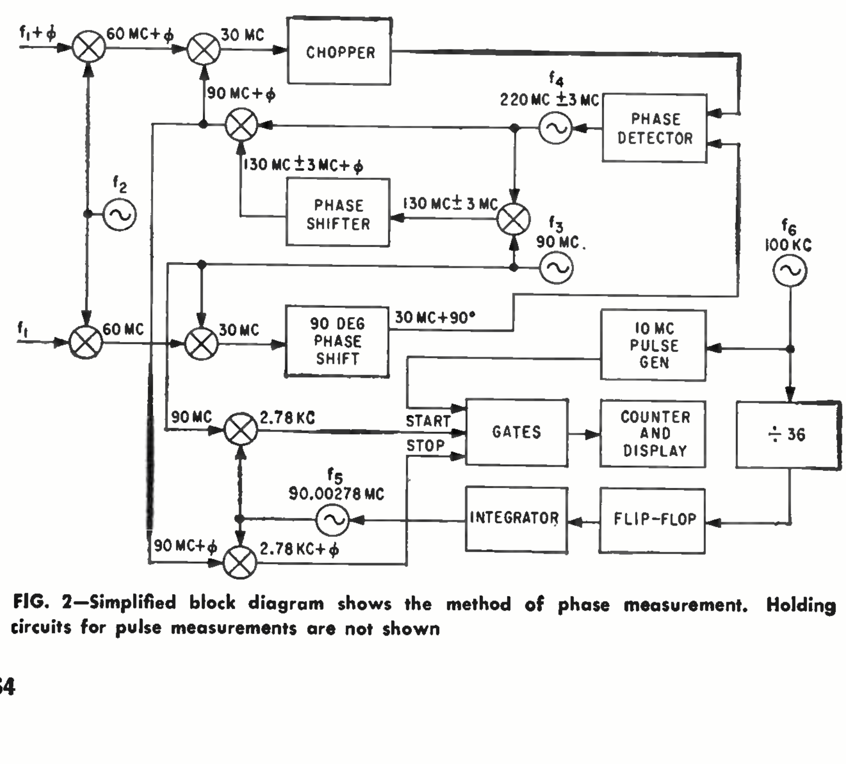
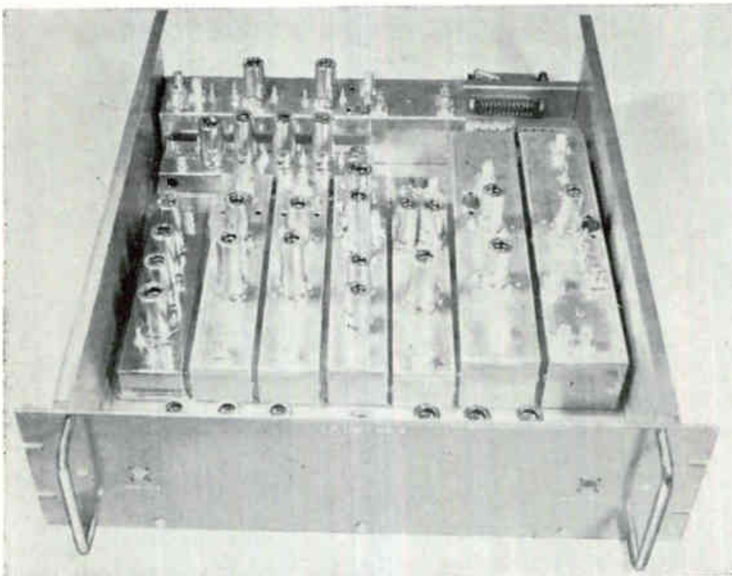
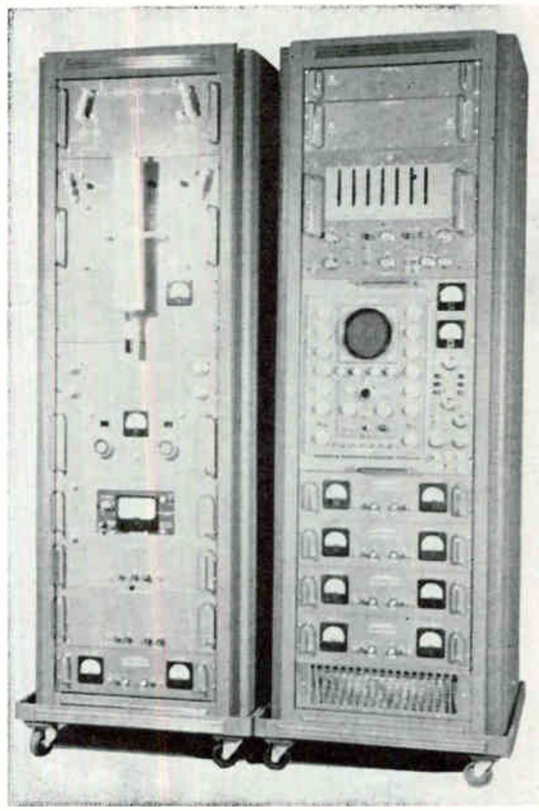


FIG. 2—Simplified block diagram shows the method of phase measurement. Holding circuits for pulse measurements are not shown

CW or Pulsed UHF



Subassemblies are built on separate chassis, with plug-in construction. One of the i-f units is shown above



Phasemeter mounts in two relay racks, measures c-w or pulsed r-f from 100 to 520 Mc

nals resulting from two internally generated, phase-controlled c-w signals rather than those from the input signals themselves.

The simplified block diagram of the system, shown in Fig. 2, does not show amplifiers, attenuators, etc., but does show all the operational steps. Since standing waves can change the phase relationship of the signals to be measured, the input signals f_1 and $(f_1 + \phi)$ are first fed to precision 50-ohm matching devices which minimize the vswr. Next, each input is fed to a variable attenuator where the signal level is set to the proper amplitude for input to the preamplifiers. These attenuators make it possible to handle signals at levels from -80 to $+40$ dbm. There is one restriction, however: the difference in amplitude between the two signals must be limited to 30 db. This limitation occurs because one of the two input signals must be used for calibration. After calibration, amplitude changes of greater than 30 db between the calibrating and actual signals cause phase shifts in the preamplifiers. The signals are then amplified sufficiently to establish a low noise figure for the system. They are then heterodyned with a stable local oscillator, f_2, to produce 60-Mc i-f signals. The oscillator f_2 is adjusted manually until the desired 60-Mc beat is obtained.

Phase Difference

The two 60-Mc signals are amplified and then used to establish the phase difference between two 90-Mc signals. One 90-Mc signal is obtained from a crystal oscillator, f_3. This same signal from f_3 is mixed with a variable 220-Mc $\pm$ 3 Mc oscillator f_4, to produce a 130-Mc $\pm$ 3 Mc signal. This signal is passed through a phase shifting network. The amount of phase shift produced by this network depends upon frequency, the difference between the phase shift for 127 Mc and 133 Mc being slightly greater than 360 degrees. The output of the phase shifter is mixed with the same 220 $\pm$ 3-Mc oscillator to yield the same 90-Mc signal but differing in phase by the amount inserted by the phase shifting network. It is the same 90-Mc signal since f_4 has been added and subtracted. By controlling the frequency of the 220-Mc oscillator, the phase difference between the two 90-Mc signals may be made to be anything between 0 and 360 degrees. The phase relationships are made clear in Fig. 2.

When these 90-Mc signals are beat against the 60-Mc i-f signals, the result is two identically phased 30-Mc outputs. Each of these 30-Mc outputs receives additional i-f amplification. One 30-Mc signal is passed through a chopper, while the other is given a 90-degree phase shift. The two signals are then fed to a phase detector. Regardless of signal polarity from the chopper, the phase difference between the two signals normally is 90 degrees and the output of the phase detector

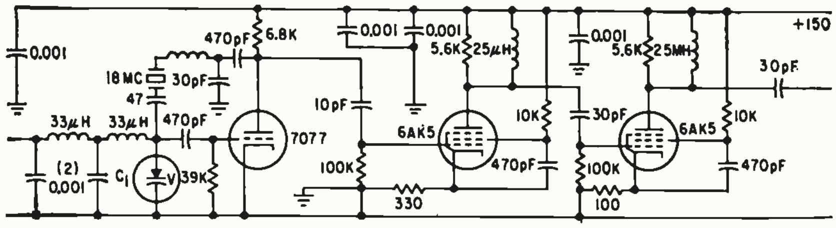


FIG. 3—Voltage-variable capacitor C_1 controls the 18-Mc oscillator over 2-Kc range

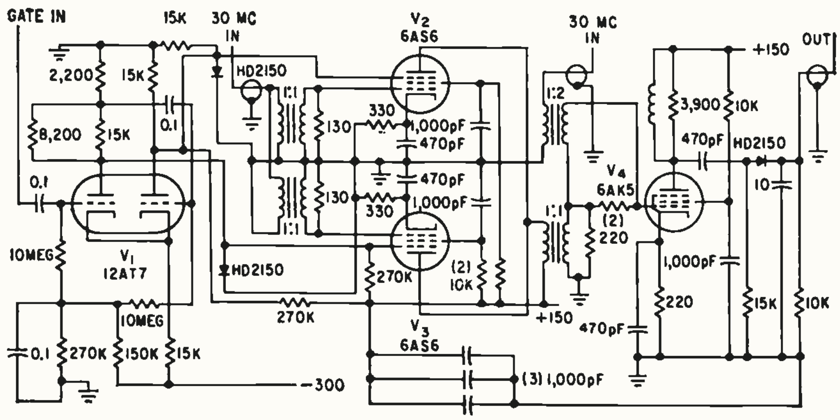


FIG. 4—Chopper and phase detector develop voltage to control f_4

is zero. Should the phase correction be incomplete, the phase difference will be more than 90 degrees (resulting in a positive voltage from the phase detector) in one chopper position and less than 90 (resulting in a negative phase detector output) in the other chopper position. Thus the phase detector puts out a square wave for c-w input signals or a series of alternately positive and negative pulses for pulsed r-f input signals, at the frequency of chopper operation.

Error Correction

The phase detector output is applied to a boxcar detector which is gated at the prf for pulsed r-f inputs or left on continuously for c-w input signals. In both cases the output of the boxcar is a square wave. When the boxcar is gated, the gating is controlled by a flip-flop which is triggered by the delayed detected envelope of the r-f pulse. The amount of delay is variable to permit the boxcar to sample the phase detector output at any point in the r-f pulse. The error voltage thus developed operates on f_4 such that the phase difference between the two 30-Mc signals is always held at 90 degrees.

Two important features of this phase control system should be noted. First, because of the action of the chopper, the phase detector output is a-c so that d-c drift is not a factor in determining accuracy. Second, the loop always corrects until the phase difference returns to 90 degrees so that accuracy of the phase detector is only required at this point and non-linearities in the phase detector curve are unimportant.

Assuming that the phase correcting loop is functioning properly, two 90-Mc c-w signals are available which differ in phase by exactly the phase difference of the input signals. These two signals are heterodyned with the output of a variable oscillator, f_5, which is controlled so that the resulting audio signals have a period corresponding to the time of 3,600 cycles from a 10-Mc oscillator—or approximately 2.78 Kc.

Pulses from the positive-going zero-crossings of the audio signal and timing pulses alternately trigger a flip-flop which produces a symmetrical square wave if the audio frequency is correct. If the audio frequency is incorrect, one half cycle of the square wave is longer than the other. This square wave is integrated, giving a d-c control voltage which shifts the variable oscillator until the audio frequency is correct.

The two audio signals are fed to identical squaring amplifiers (not shown in the block diagram), each of which consists of a number of cascaded differential amplifiers followed by a differentiator and pulse former. Each squaring amplifier puts out a set of *A* pulses corresponding to the positive-going zero-crossings of the audio signal and a set of *B* pulses corresponding to the negative-going zero-crossings. These pulses are fed to gates which alternately permit first the *A* pulses and then the *B* pulses to operate the counter control gate. The control gate permits the counter to count 10-Mc pulses between the arrival of the start and stop pulses. After counting between five sets of *A* pulses and five sets of *B* pulses the lock-out gate operates, stopping the counting and permitting display of the result.

It is possible for the squaring amplifiers to be biased so that the output pulses do not correspond exactly to the zero-crossing of the audio signals. In this case, for example, the spacing between *A* pulses might be too great and that between *B* pulses too little. These errors are equal and opposite, however, so that by counting between equal number of *A* and *B* pulses the bias errors are cancelled and the resulting count is correct.

The bias correcting technique used in the counting circuit may fail when the phase difference is close to 0 or 360 degrees. The correcting technique depends upon averaging the count that is too small with the one that is too large to obtain the correct result. Near 360 degrees the too small count is slightly less than 360, for example 350 degrees. The too-large count, however, being more than 360, has recycled and is reading say 10 degrees. Averaging these gives an incorrect result of 180. To provide for this contingency, an ambiguity resolution circuit is included. This circuit senses when the above situation might occur and causes the short counts to be increased from 10 to 370 so that summing results in a correct 360 (or 0) total.

The phasemeter also includes a laboratory type oscilloscope which permits examination of the two 2.78 Kc audio signals for detection of phase jitter in the original signals. The oscilloscope is also used for checking waveforms throughout the system.

Variable 90-Mc Oscillator

Figure 3 is a schematic diagram of the variable 90-Mc oscillator—f_5 of Fig. 2. This oscillator requires a high degree of short-term stability while at the same time the frequency must be capable of being controlled by a d-c voltage. To satisfy the stability requirement, a General Electric type 7077 ceramic triode is used in a crystal oscillator circuit, at a fundamental frequency of 18-Mc. The interelectrode capacitance and internal inductances of this tube are stable so that frequency changes due to drifts, etc., within the tube are minimized.

The crystal can be pulled about 2 Kc, which represents a 10-Kc variation in the 90-Mc output frequency. Since this oscillator operates approximately 2.78 Kc away from the fixed 90-Mc oscillator, the range of variation is sufficient. It was found that conventional frequency control by a reactance tube was not satisfactory since the reactance tube contributed variations which changed the frequency independently of the control voltage. Frequency control is therefore achieved by varying the d-c voltage on a voltage-variable capacitor C_1 in the crystal resonant circuit.

The fifth harmonic of the basic oscillator frequency is the desired 90-Mc signal which receives amplification and buffering by two additional stages before being fed to the mixers. The 90-Mc fixed oscillator f_3 is of similar construction except for the elimination of the frequency control circuit. The 220-Mc oscillator f_1 is similar except that a Clapp circuit is used instead of the crystal, permitting greater frequency swing at the expense of less stability, which is not of prime importance in this oscillator.

Chopper and Phase Detector

The chopper and phase detector unit appears in the schematic of Fig. 4. The gate operates a Schmitt trigger circuit, V_1, which alternately cuts off V_2 or V_3 by putting a large negative voltage on the appropriate suppressor grid. The inputs to the control grids of the two 6AS6's are the normal 30-Mc signal and its inverted image. It was found impractical to wind center-tapped transformers with characteristics of the push-pull output sufficiently alike to produce identical but oppositely phased signals. This goal was achieved, however, by using two identical transformers wound on ferrite cores.

The phase detector output must be the same for a null (90 degrees phase shift between signals) as when one or both signals are absent to avoid confusing the phase control loop when pulsed r-f inputs are being compared. This precludes the use of a 6BN6 phase detector. It was also found that diode phase detectors, balanced or unbalanced, could not be made sufficiently accurate. The most satisfactory technique was vectorially adding the two signals by series transformers and then amplifying and detecting the resultant signal.

The ambiguity resolution circuit is shown in Fig. 5B and the associated timing diagrams in Fig. 5A. The offsets of the STOP A and STOP B pulses from their 360-μsec positions are caused by bias in the squaring amplifiers. It can be seen that for this particular situation (phase difference near 0 or 360) half the counts will be 350 degrees and half 10 degrees, giving an incorrect average of 180 degrees. To prevent this, first the bias is deliberately altered so that the long count always occurs between A pulses. The START A pulse fires a one-shot multivibrator which produces a 200-μsec gate. This gate passes through a cathode follower and diode D_2 and raises the potential of the junction of D_2D_3 and the two resistors and capacitor sufficiently so that the STOP A pulse-triggers cannot pass through D_3. This simple method of inhibiting is also used in many of the other control circuits associated with the counter.

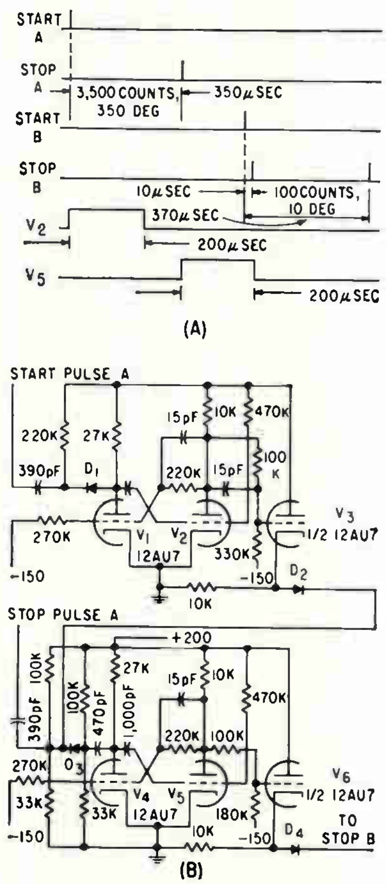


FIG. 5—Ambiguity resolution circuits prevent counting error when phase shift is close to 0 or 360 degrees. Timing is shown in (A); circuit in (B)

If the STOP A pulse occurs within 200 μsecs of the START A pulse, no ambiguity problem exists. In this case the STOP A pulse is inhibited and no further action is taken by the ambiguity resolution circuit. If the situation is similar to that shown in the timing diagram, the STOP A pulse is not inhibited and triggers another one-shot multivibrator, which also produces a 200-μsec gate. Since the next STOP B pulse is approximately 180 μsecs from the STOP A pulse, it will be inhibited by this gate. Thus the first STOP B pulse shown in the timing diagram does not occur and the counter continues until the next STOP B pulse arrives 360 μsecs after the inhibited one. Thus five counts of 350 degrees are summed with five counts of 370, yielding a correct 360 reading.

The complete phasemeter, mounted in two relay racks, is shown in one of the photographs; beside it is one of the i-f decks.

Design of the uhf phasemeter was under the direction of W. Talley, assisted by K. Shen and the author.

The entire development program was performed under contract to Sylvania Electric Products, Inc. and appreciation is expressed for the interest and support given to this program by members of Sylvania's technical staff.

Measuring Total Circuit Inductance

By SAUL RITTERMAN, Electronic Scientist, Picatinny Arsenal, Dover, New Jersey

THERE are applications in circuit breadboarding where it is necessary to know the value of the lumped circuit inductance. Resistance and capacitance can be readily measured, but measuring lumped circuit inductance, especially at higher frequencies, presents some difficulty. A method is described whereby the overall circuit inductance may be measured quite simply and reasonably accurately; the only equipment necessary is an oscilloscope with calibrated sweep velocities.

Method

The circuit under investigation is considered as a series circuit incorporating switch S as in Fig. 1A. The capacitor C is charged to V_o volts and the switch closed. Depending upon the relationship between the values of resistance, capacitance and inductance in the circuit, the resulting current flow will range from an overdamped through critically damped to an oscillatory discharge. The three possibilites are as follows:

Overdamped condition when $(R/2L)^2 > 1/LC$

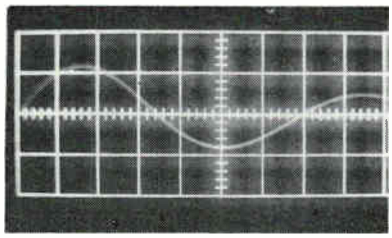
Current $i\ (t) = V_o/L[(R/2L)^2 - 1/LC]^{\frac{1}{2}} \times \sinh\ [(R/2L)^2 - 1/LC]^{\frac{1}{2}}\ t \times \epsilon^{-Rt/2L}$ (1)

Critically damped when $(R/2L)^2 = 1/LC$

Current $i\ (t) = V_o t/L \times exp\ [-t/(LC)^{\frac{1}{2}}]$ (2)

Oscillatory condition when $(R/2L)^2 < 1/LC$

Current $i\ (t) = V_o/L\ [1/LC - (R/2L)^2]^{\frac{1}{2}} \times \sin\ [1/LC - (R/2L)^2]^{\frac{1}{2}}\ t \times \epsilon^{-Rt/2L}$ (3)



Oscilloscope waveform shows ratio of successive maximum as 6 to 2.5

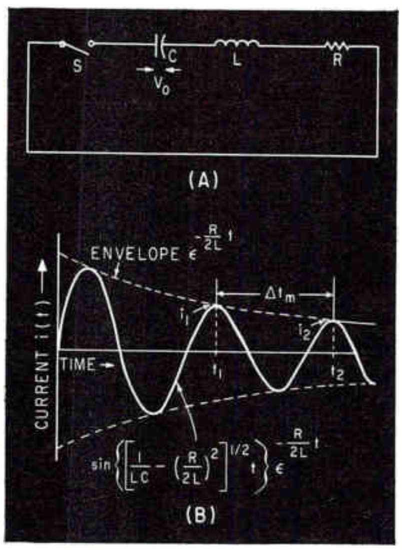


FIG. 1—Diagram (A) represents equivalent lumped-circuit inductance as L. Waveform (B) indicates ratio i_1/i_2 to be measured

The oscillatory condition is of greatest interest. If $1/LC >> (R/2L)^2$ an accurate value of the inductance may be obtained by measuring the time for one cycle of oscillation. (By an oscilloscope, for example). Take $T = 2\pi\ (LC)^{\frac{1}{2}}$ where T is the time of one cycle. Since T and C are known, or can easily be determined, the inductance is given by $L = (T/2\pi)^2/C$.

If the factor $(R/2L)^2$ is appreciable compared to $1/LC$, then in solving for L this factor cannot be omitted. Thus the simple method just outlined is not valid for this case. However, the numerical value of the inductance can be derived by a less direct method involving measurements of successive maxima, and the time interval between.

The general equation (3) defines the damped sinusoid and Fig. 1B represents such a waveform. For each successive maxima, $\sin\ [1/LC - (R/2L)^2]^{\frac{1}{2}}\ t = 1$ and the equation may be rewritten for these maxima as $i\ (t) = K exp\ (-Rt_1/2L)$, where $K = V_o/L\ [1/LC - (R/2L)^2]^{\frac{1}{2}}$.

Evaluating the last equation in terms of the successive maxima gives $i_1 = K exp\ (-Rt_1/2L)$, and $i_2 = K exp\ (-Rt_2/2L)$. Dividing these two equations: $i_1/i_2 = exp\ [-R(t_2 - t_1)/2L]$ or $\ln\ (i_1/i_2) = R \Delta t_m/2L$ where $\Delta t_m = t_2 - t_1$. Thus, $L = R\ \Delta t_m/2 \ln\ (i_1/i_2)$.

The inductance value may now be found since R is known, and i_1/i_2 as well as t_m may be obtained from an oscillograph trace. Figure 2 is a graph of L and Δt_m for a range of values of a, where $a = R/2\ \ln\ (i_1/i_2)$.

The oscillograph trace shows the current in a series circuit where the total resistance R was 0.8 ohms and the sweep speed of the oscilloscope trace 20×10^{-6} sec/cm. From the graph and the formula $a = R/2\ \ln\ (i_1/i_2) =$

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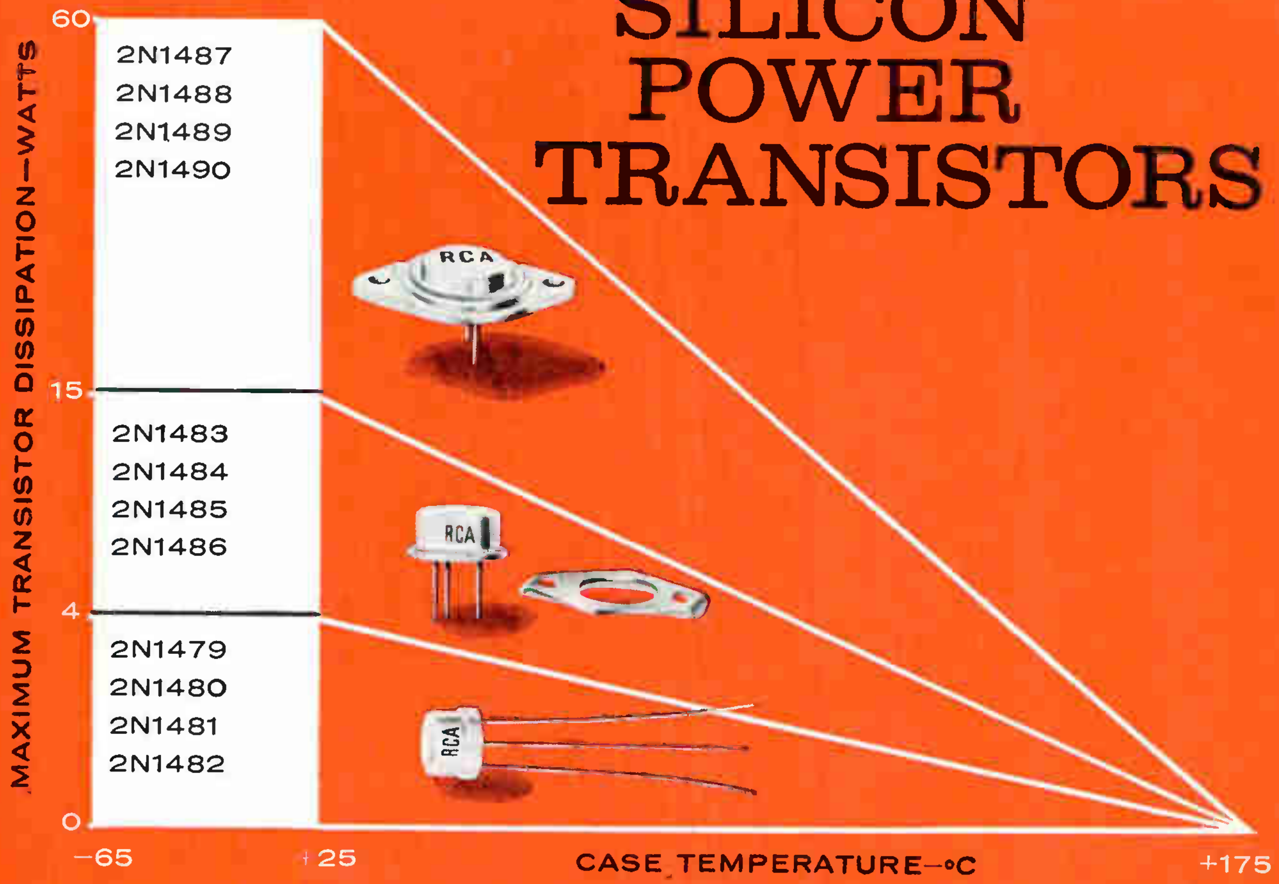

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				V_{CB} = 30v	I_C = 0.2 amp	I_C = 0.2 amp
2N1479	60	40	1.5	10	7	15-75
2N1480	100	55	1.5	10	7	15-75
2N1481	60	40	1.5	10	7	35-100
2N1482	100	55	1.5	10	7	35-100
				V_{CB} = 30v	I_C = 0.75 amp	I_C = 0.75 amp
2N1483	60	40	3	15	2.67	15-75
2N1484	100	55	3	15	2.67	15-75
2N1485	60	40	3	15	1.00	35-100
2N1486	100	55	3	15	1.00	35-100
				V_{CB} = 30v	I_C = 1.5 amp	I_C = 1.5 amp
2N1487	60	40	6	25	2.00	10-50
2N1488	100	55	6	25	2.00	10-50
2N1489	60	40	6	25	0.67	25-75
2N1490	100	55	6	25	0.67	25-75

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0.8/2 ln (6/2.5) = 0.46.

Also from the graph, Δt_m = 140 × 10^{-6} sec.

Extrapolating from Fig. 2, the value of L is given as 65 × 10^{-6} henry. The actual value of L was known to be 73 × 10^{-6} henry, the error is attributed to inaccuracy in measuring (i_1/i_2). Nevertheless, the error is fairly small and the method is sufficiently accurate for breadboard work.

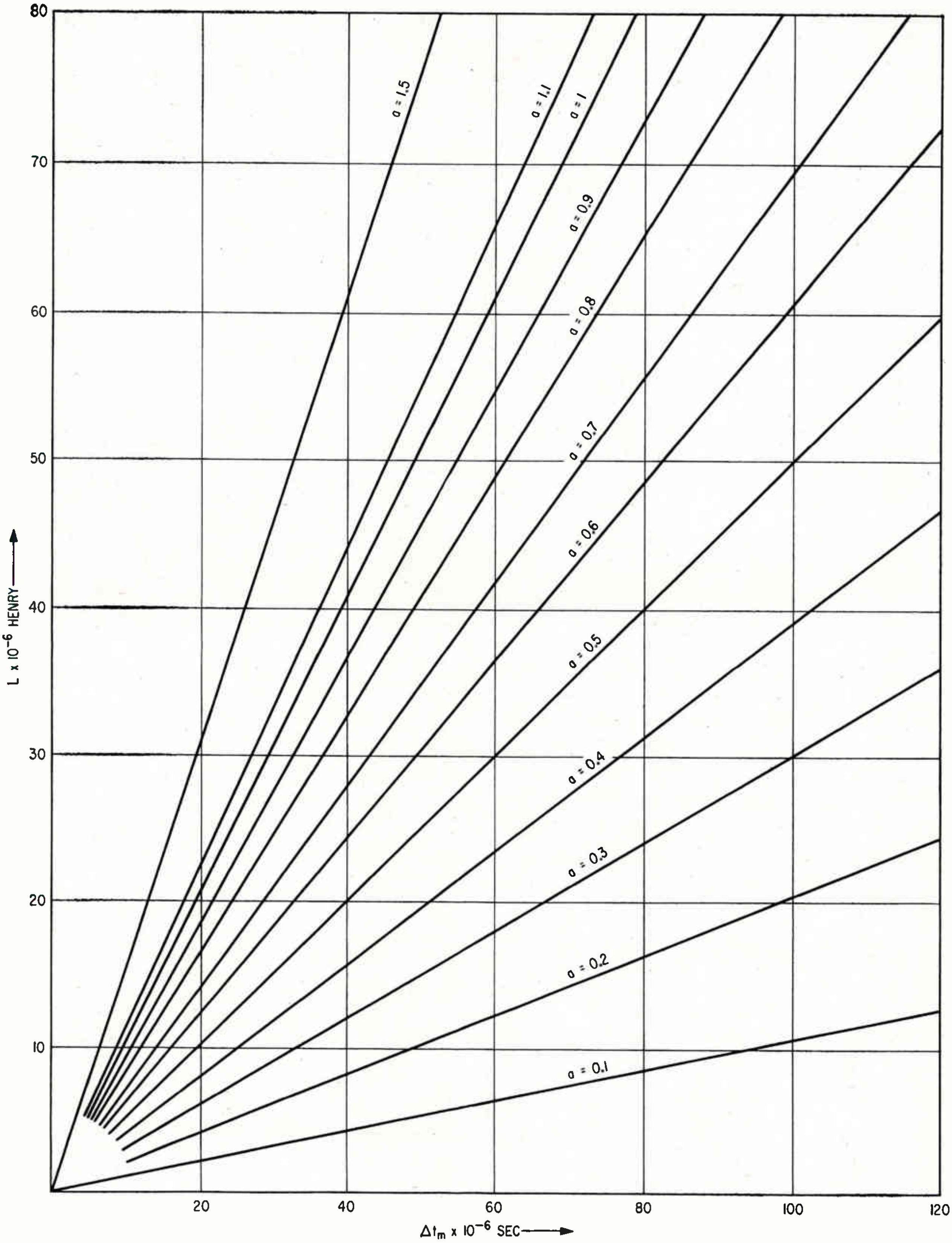

FIG. 2—Inductance values are provided by interpolation or extrapolation

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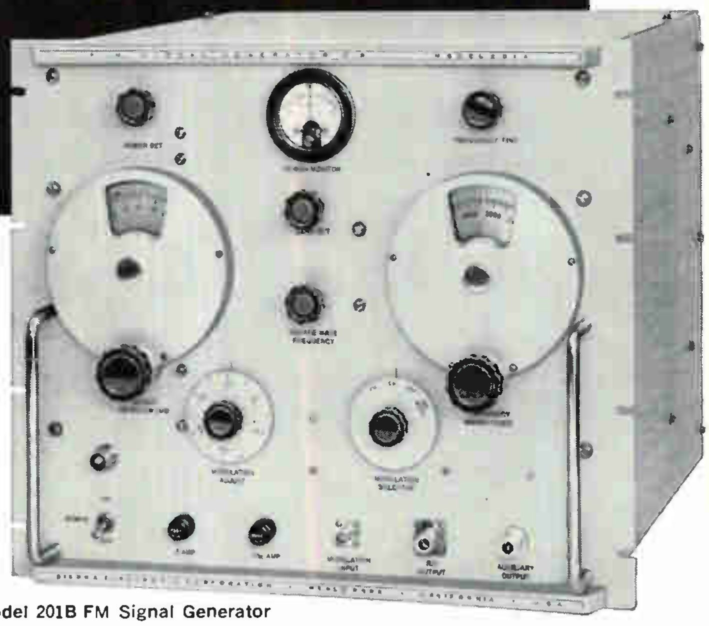
Superior FM characteristics, 1% deviation linearity. Precisely calibrated output continuously variable 0 dbm to —110 dbm. External modulation (to 500 kc) or CW output. Wide tuning range, vernier, direct reading.

Above are principal features of the new Sierra 201B UHF FM Signal Generator, specifically designed for telemetry and data transmission applications in the 1.3 to 2.5 kmc range.

Brief specifications here give more details; for full information and demonstration call your Sierra representative or write direct.



Sierra Model 201B FM Signal Generator

SPECIFICATIONS

Frequency	
Range:	1300 mc to 2500 mc in one band.
Tuning:	Separate vernier control for small changes in frequency.
Stability:	Drift not over 5 kc per minute.
Dial Accuracy	1%
R.F. Output—Calibrated	
Level:	Continuously variable 0 dbm to −110 dbm.
Output Accuracy:	Within ± 3 db from 0 dbm to −20 dbm, ± 1.5 db from −20 dbm to −60 dbm, ± 1 db from −60 dbm to −90 dbm and ± 3 db from −90 dbm to −110 dbm.
Source Impedance:	50 ohms, VSWR less than 1.6.
R.F. Output—Auxiliary	
Level:	Non-adjustable, 0 dbm to −5 dbm.
Isolation:	Exceeds 30 db.
Source Impedance:	50 ohms, VSWR less than 1.3.
Modulation	
Internal Squarewave AM:	100% AM modulated by internally generated 800-1200 cps squarewave.
External Frequency Modulation:	Deviation linear within 1% to 2 mc, within 2% to 3 mc. Response within 0 to −3 db, 100 cps to 500 kc.
CW:	CW signals have spurious FM hum and noise of less than 10 kc peak to peak.
AC Power Requirement	117 volts ± 10%, 50-60 cps, 200 watts.
Dimensions	Height: 15¾ in., Width: 19 in., Depth: 16 in.

Sierra

SIERRA ELECTRONIC CORPORATION

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CIRCLE 61 ON READER SERVICE CARD

Sun Sensor Orients Space Craft

STATIONARY sun-position sensor could establish one axis of a coordinate reference system on a space vehicle. The system was described by G. C. Anthony, IBM Airborne Computer Laboratory, and F. A. Boyer, Instrumentation Div., I T & T., at the 1960 Winter Convention on Military Electronics.

The sensor consists of two cubes, each having five faces covered with a light-sensitive material. It generates a signal proprotional to the amount of light energy striking the face. The sensor establishes light-source position relative to the space craft by establishing a relationship between illumination on three faces and the vehicle position vector relative to the sun.

The sensor could also provide information for ground computation of vehicle attitude relative to the sun and for stabilizing solar cells and scientific sun-sensing instruments.

Requirements

Reliability will be a major factor in interplanetary missions because they will last a year or more. It would be desirable to turn off navigation equipment during most of the trip using it only occasionally to check position.

Since the vehicle will be injected into an elliptical heliocentric orbit with limitations on injection parameters, approximate location in the solar system can be calculated at any instant. In the heliocentric orbit in Fig. A, nominal vehicle positions have been computed for

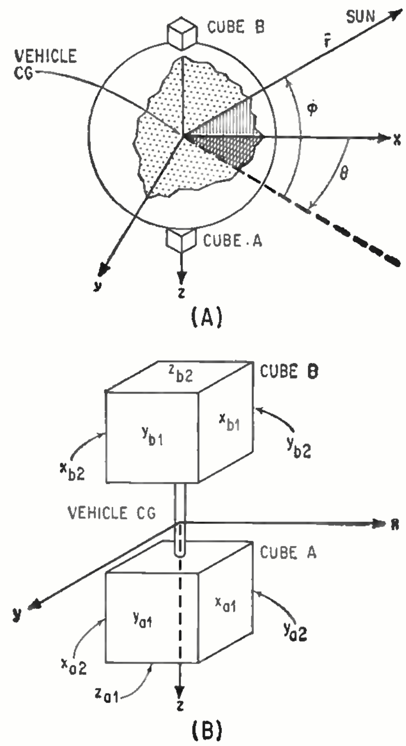


FIG. 2—Spherical coordinate system (A) is fixed with respect to vehicle with sensor surfaces (B) established relative to the x, y and z axes

times t_1 and t_2. The navigation system verifies these positions by celestial observations.

Conventional attitude - sensing systems establish reference coordinates by setting up initial conditions and continuously monitoring changes. They provide no useful attitude or position information after periods of inoperation without a search for reference objects.

By identifying an object of first order brightness (the sun) and knowing approximate vehicle position in the solar system, one axis of a reference coordinate system is established. Conical angle Δ in Fig. 1B between the line of sight to the sun and a planet or star can be determined from a celestial map. A second axis of reference can be identified by inaugurating a conical scan to locate the second celestial landmark.

Line of sight to the sun can be established with the sun-position sensor. To prevent vehicle shadows from falling on sensor surfaces, a cubic sensor is used on each side of the vehicle. The sensor without prior search identifies the position of a light source relative to sensor position in space. It gives instantaneous position identification of the sun by complete coverage of the entire celestial sphere and has no moving parts to affect dynamics of the vehicle. Power consumption is less than an inertial platform. Because of its simplicity and intermittent operation, it is inherently reliable. The axis reference requires no previous attitude information.

Analysis

Relative position of the sun with respect to the vehicle axes is obtained by relating light energy falling on each face of the cubic sensor to spherical coordinates of the sun position vector r. Azimuth and elevation angles are θ and ϕ, respectively. Rate information is obtained by measuring instantaneous angular velocity of azimuth and elevation servos or by noting angular deviations between two successive fixes in a given time.

The sensor in Fig. 2A is mounted on the yaw axis with one cube on each side. The spherical coordinate system is fixed with respect to the vehicle. Sun rays are assumed parallel because over-all length of the sensor is small compared to radial distance from the sun. Vector r describes range to the sun, with direction defined by asimuth θ and elevation ϕ angles. Angular polarity is chosen by the right-hand rule.

Cubes A and B are in the posi-

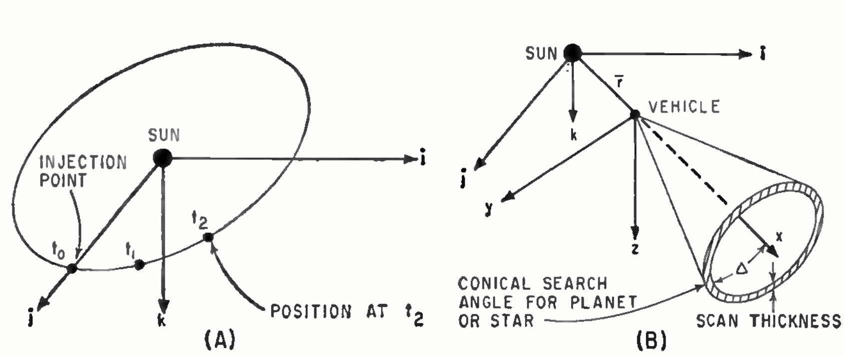
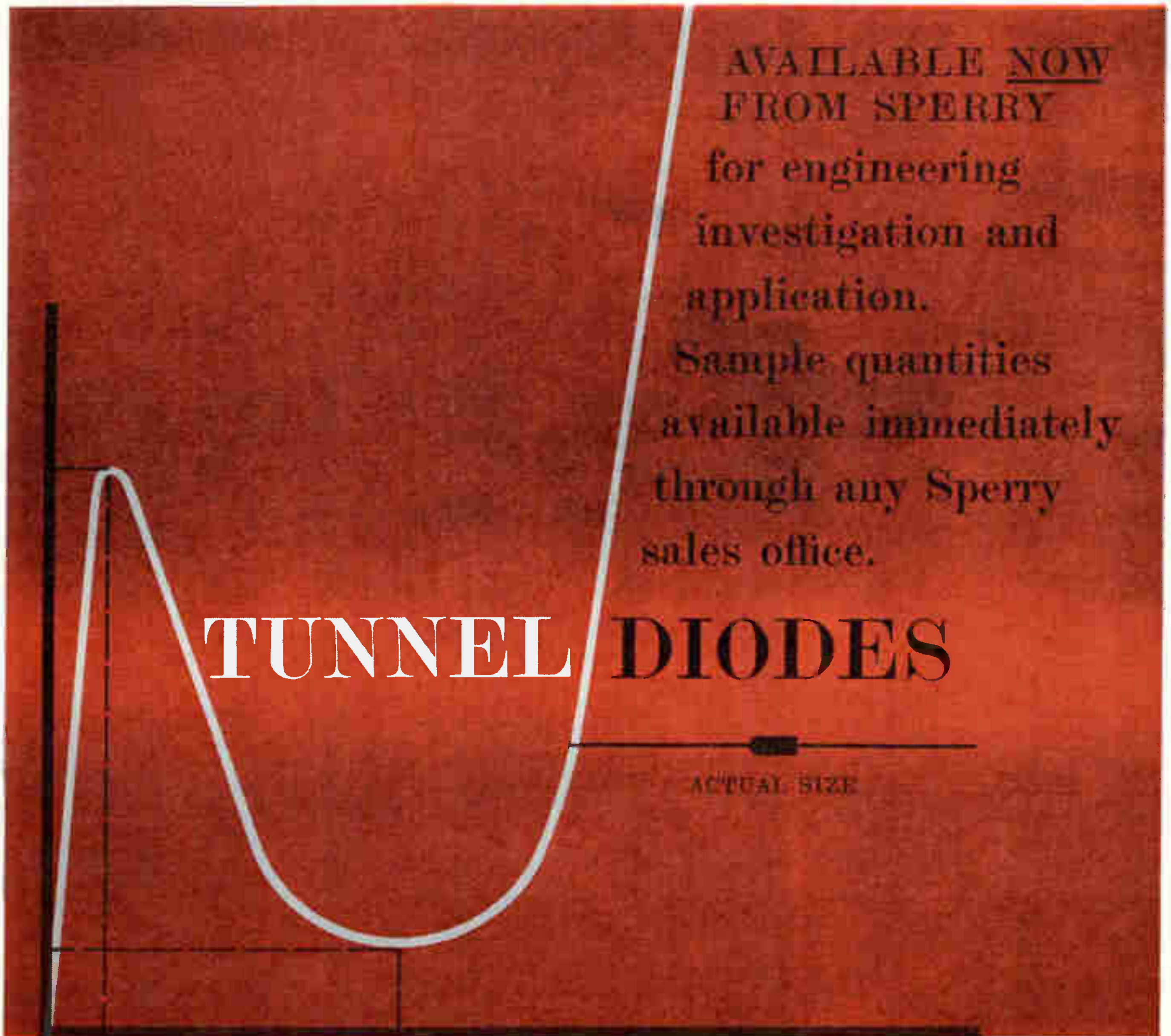


FIG. 1—Heliocentric orbit (A) shows how positions can be determined at times t_1 and t_2. Conical search pattern (B) locates second celestial landmark



TENTATIVE SPECIFICATIONS

Type	I_{peak}(ma)	I_p/I_v(min)	V_{peak}(mv)	V_{valley}(mv)	T
	(TYPICAL VALUES)				
T101	0.8	4.5	55	300	−55 to 100°C.
T102	1.5	4.5	55	300	−55 to 100°C.
T103	3.5	4.5	55	300	−55 to 100°C.
T104	7.0	4.5	55	300	−55 to 100°C.

SPECIAL SAMPLE OFFER

Order 5 tunnel diodes (T101 or T102) for $150, or request price on other types from the nearest Sperry sales office listed below.

SPERRY

See us at IRE booth 2434

SPERRY SEMICONDUCTOR DIVISION, SPERRY RAND CORPORATION, SOUTH NORWALK, CONNECTICUT
Call or write: Sperry Semiconductor, Wilson Avenue, SOUTH NORWALK, Conn., VOlunteer 6-1641; in NEW YORK PLaza 2-0885; 3555 W. Peterson Ave., CHICAGO 45, Ill., KEystone 9-1776; 2200 East Imperial Highway, EL SEGUNDO, Calif., ORegon 8-6226.

tive and negative directions, respectively, on the z axis. In Fig. 2B, letter subscripts identify the sensors, and surfaces normal to x, y and z axes have number subscripts 1 and 2 to identify faces normal to positive or negative axes, respectively. Luminous flux from the sun in the small solid angle subtended by one face in Fig. 3 is $F = I\,A \cos \gamma / r^2$ in lumens, where I is luminous intensity of the sun, A is face area and γ is angle between the normal to the face and the line between the vehicle and the sun.

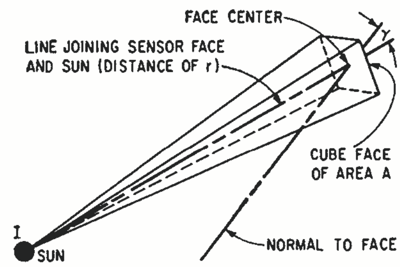


FIG. 3—Diagram shows amount of luminous flux intercepted by sensor face

Illumination E of the sensor face is equal to the luminous flux incident per unit area; hence, $E = F/A = I \cos \gamma / r^2$ lumens/meter^2.

Having identified each face with respect to body axes and having defined spherical coordinates of the sun with respect to these axes, the system must then determine the angle of incidence of the sun's rays on each face. Angles between the sun-position vector and the x, y and z axes are related mathematically to the spherical coordinate angles θ and ϕ.

Intermittent Recorder For Distant Sferics

RECORDING system simultaneously photographs randomly occurring events displayed on an oscilloscope screen and the precise time of each event. The camera was developed by the National Bureau of Standards to record electromagnetic radiation from lightning (sferics) propagated over long distances.

Because a picture is taken only when the camera is triggered by the event to be photographed, film consumption is reduced considerably. Station WWV synchronizes the system with accuracy dependent only on propagation variables of the time signal. A complete cycle takes 7 millisec.

Operation

The rapid frame rate of the camera is obtained with a high-speed clutch between the film drive and a continuously revolving flywheel. Clutch actuation mechanism is similar to a large electrodynamic speaker. A pulse triggered by the signal is applied to the clutch part corresponding to the voice coil. A cone is driven into engagement with the flywheel and rotates a small drum in contact with the film. Pulse length is such that rotation of the drum pulls exactly one frame of film past the lens opening.

Peak power to the voice coil is about 35 kw. Power surges of this magnitude may be repeated at intervals of only a few milliseconds by using two capacitors and two thyratrons in a series arrangement. An 88-μf capacitor is discharged through the voice coil by one thyratron. After a short delay, it is recharged from a 1,600-μf capacitor by the other thyratron. Thus power required to operate the system need only provide average current sufficient to maintain the charge on the large capacitor at maximum duty cycle.

Time Display

Event time is displayed by an array of small neon bulbs that indicate, in binary fashion, numbers corresponding to hour and date. The bulbs are illuminated by a 100-μsec pulse. The timing circuit consists of conventional decimal-counting units arranged to count from 10 μsec to 31 days with the count controlled by a precision 100-kc standard.

Each decimal-counting unit has a binary output that is read out by the same pulse that triggers the camera. To prevent ambiguity in readout if the binary output is changing state, readout time is controlled by the timer. The readout is made by the first 100-μsec pulse following the event to be recorded. Shorter times are resolved by time markers on an oscilloscope trace separated from the signal display trace.

CIRCLE 65 ON READER SERVICE CARD→

Designing With Rotary Solenoids

By LEO ORLANDO, Field Engineer, G. H. Leland, Inc., Dayton, Ohio

WITH SPACE and weight savings becoming increasingly important, rotary solenoids are achieving impressively greater application in the design of automation, communication and electronic equipment.

Essentially, solenoids convert electrical pulses into mechanical motion. Their principal parts are the coil-core, or stator, which creates an electromagnetic field, and the armature, which is drawn to close the field. The movement of the armature produces work.

The space between the armature and the core is the air gap. The greater the gap, the lesser the effect of the magnetic field on the armature and, therefore, the lesser the force of the armature toward the stator. By the same token, the smaller the air gap, the greater the effect of the magnetic field on the armature and therefore the greater the force.

For this reason, in most solenoids there is less pull-force created at the beginning of the armature's movement, when the air gap is at its widest, than when the armature moves further into the magnetic field and greater pull-force develops. Generally, most solenoids have less work potential, by far, at the beginning of the stroke than toward the end of the stroke, when the air gap becomes smaller.

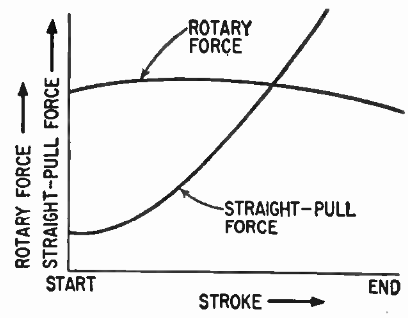


FIG. 1—Helical-type rotary solenoids have a force that is practically uniform during the stroke. In straight-pull solenoids, pivotal, or pure rotary types, that force is low at the beginning of the stroke, but rises sharply towards completion of the stroke

Almost solid steel and copper, this ball-race, helical-type rotary solenoid has a precision-wound coil that puts the maximum amount of copper into the allowable space. This results in maximum power output with minimum size and weight

The rotary solenoids like this one are used in missiles, aircraft and satellites, and much of today's electronic, automation and communication equipment.

Helical Rotary

A notable exception is the highly-efficient ball-race rotary solenoid developed by G. H. Leland Inc., Dayton, Ohio. Basically a straight-pull unit with a very short air gap, it has an armature supported by three precision ball bearings in ball races. When the solenoid is energized, the armature is pulled into the coil. However, as the ball bearings move down the compound incline of the ball races, the armature follows the direction of the ball bearings and moves in a rotary motion.

In this conversion the incline of the ball races is steep at the beginning of the rotary stroke, when the gap is widest, then gradually levels off as the balls approach the deep end of the ball races. This transfers torque to the start of the stroke, where it is usually needed, and gives a virtually flat torque-versus-stroke curve, (see Fig. 1). In precision applications, such as computers, commercial tape recorders, vending machines, waveguide switches and aircraft communications equipment, where reliability is essential, d-c solenoids are employed almost exclusively.

The ball-race rotary solenoid gives maximum power output with minimum size and weight. The coil is wound by a special precision process that puts the maximum amount of copper into the allowable space and results in each Ledex solenoid developing tremendous force for its size and power input—up to four times as much as ordinary solenoids. Yet a relatively uniform torque curve is maintained across the stroke.

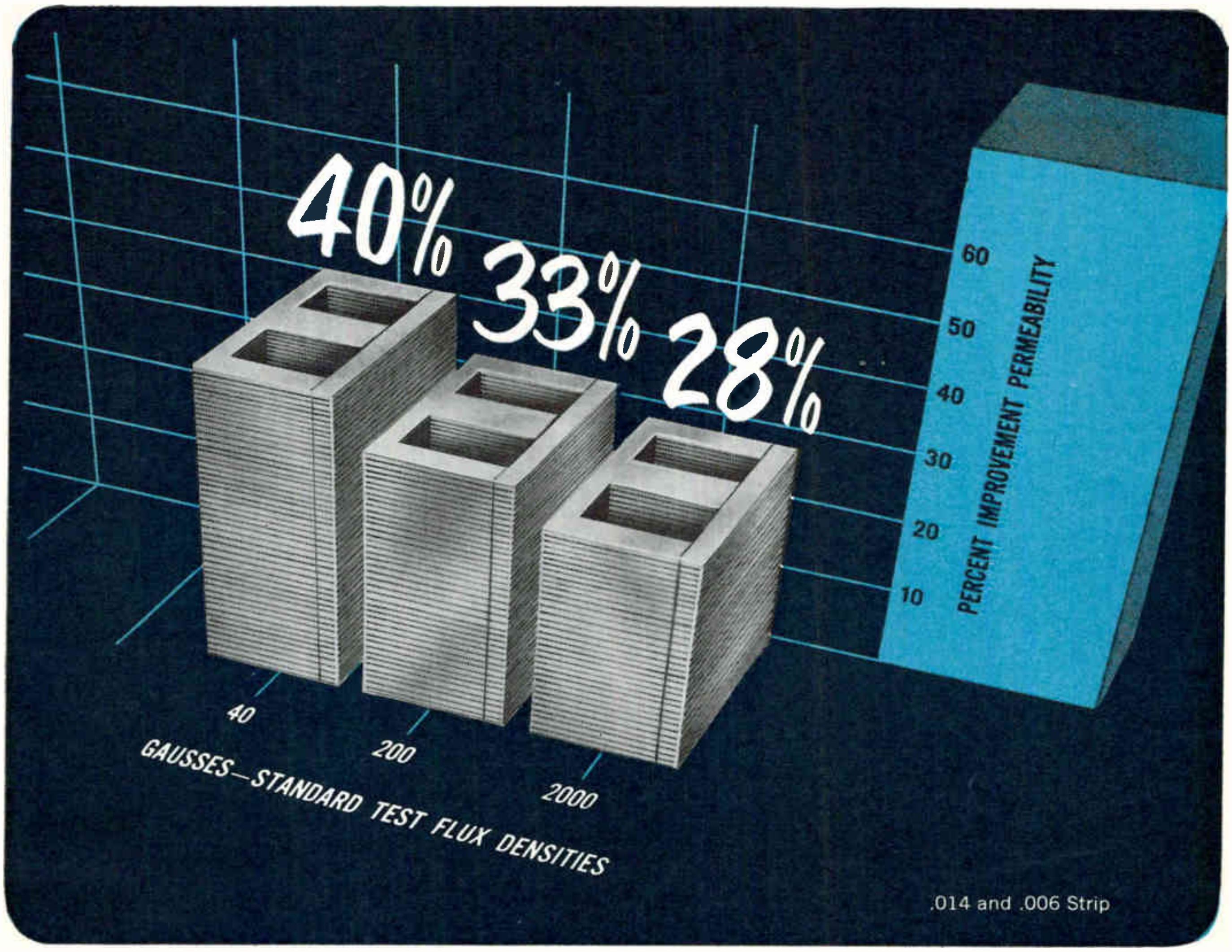
This uniform curve is due to a ball-race method that transfers torque to the beginning of the stroke, where it is usually required. Virtually all the energy from the motion of the armature is turned into rotary energy.

The roller-cam rotary solenoid also takes advantage of a complete magnetic circuit with a single moving air gap.

In this case, when the coil is energized, the armature is prevented from rotating by member or members. It travels in a straight line into the coil and, as the air gap is closed, axial forces are exerted upon shaft rollers by the cams. Since radial thrust bearings restrict the shaft from axial movement, the axial force is converted to torsional force.

The ball-race solenoid requires fewer parts than the more-expensive roller-cam type, which may account for its considerably longer life and probably greater reliability. In general, however, compared to other solenoids both produce the

Experience—the added alloy in A-L Electrical Steels



Higher permeability values now guaranteed for Allegheny Ludlum's Moly Permalloy

Means new, consistent and predictable magnetic core performance

Molybdenum Permalloy nickel-iron strip is now available from Allegheny Ludlum, with higher guaranteed permeability values than former typical values. For the buyer, this new high quality means greater uniformity . . . more consistent and predictable magnetic core performance.

This higher permeability is the result of Allegheny Ludlum's intensive research on nickel-bearing electrical alloys. A similar improvement has been made in AL-4750 strip steel. A-L continues its research on silicon steels, including Silectron, well-known grain-oriented silicon steel, and other magnetic alloys.

Complete facilities for the fabrication and heat treatment of laminations are available from Allegheny Ludlum. In addition, you can be assured of close gage tolerance, uniformity of gage throughout the coil, and minimum spread of gage across the coil-width.

If you have a problem relating to electrical steels, laminations or magnetic materials, call A-L. Prompt technical assistance will be yours. And write for more information on Moly Permalloy. *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.* Address Dept. E-27.

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highest torque-for-given-size and perform more work in ratio to the wattage input.

Depending on the type and size of solenoid, the actuation speed will run from one to 100 milliseconds. Naturally, the time will be affected by the load and the power input. The greater the load of a given unit, the slower the actuation within the range of limitations. By the same token, the smaller the unit, the faster the actuation. Depending on coil, wire size, number of windings, size of unit, and so forth, operation of rotary solenoids can be from two to 400 volts. The type of coil to be used is determined by the power source available, the duty cycle, the torque requirements, and the operating conditions.

Torque Requirements

Since virtually any wire size can be used to wind the coil, there are no problems in meeting these demands. Torque requirements are equally simple to meet, since the range of torque available goes from less than one gram-centimeter up to 100 pound-inches.

Current requirements are approximately proportional to the torque needed. For instance, if a unit that is no larger in diameter than 3½ in. and no greater in depth than 2½ in. is to achieve 100 pound-inches of torque with reliability, it will require considerable current.

Solenoids can be made to meet varied temperature specifications. Basically, however, most solenoids will withstand coil temperatures up to 120 C, although 90 C is usually considered safer. Some solenoids feature a coil option that permits coil temperatures up to 175 C. It is very probable that the development of new high-temperature-resistant materials will result in even higher temperature limits.

Solenoids can also be made to cover a wide range of operation, from highly-intermittent duty to continuous duty. However, as a solenoid progresses from intermittent to continuous duty, a decrease in torque can be expected. There are some stalled-motor types of rotary solenoids designed specifically for continuous duty, but they rarely achieve a torque as high as that available from such solenoids as the ball-race type.

In addition, as the temperature increases internally, due to the power input, and environmentally, there is also a decrease in torque.

All these factors should be considered at the outset—in the design stage. To avoid possible complications, the solenoid manufacturer should always be consulted before a production design requiring his unit is finalized.

Take-Offs

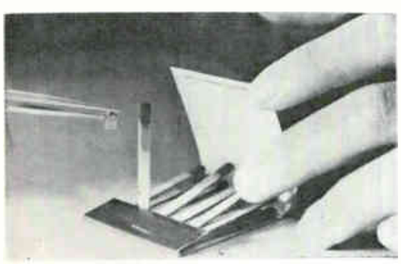
Strokes of practically any degree of rotation are available within a 95 deg. arc. In general, the shorter the stroke, the shorter the air gap and the greater the torque.

The power in solenoids can be harnessed in many ways. Most common is the extension of a shaft from either end, or both. The shaft has a rotary motion, and a load can be directly affixed, or a lever or pin connected—either to the shaft or to the load.

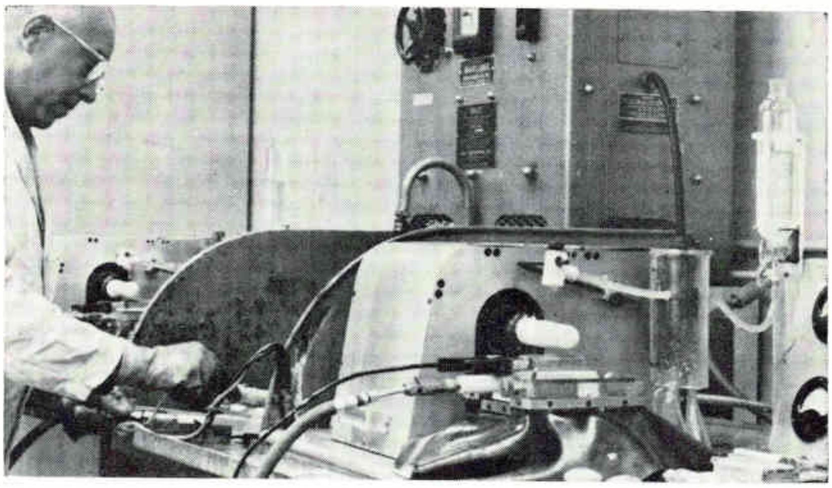
A load can be connected directly to the armature of solenoids with armature plates by using pins or tapped holes. Floating-type ratchets can be had also, resulting in an indexing motor when both ratchet and detent mechanism are used.

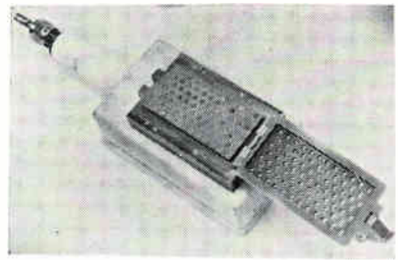
A natural outcome of a rotary solenoid with ratchet drive mechanism and detent is the rotary selector switch—many types of which are manufactured, all actuated by a rotary solenoid and with varying degrees of power-carrying potential and versatility.

Tunnel Diode Sample



No bigger than the head of a match, and holding great promise for applications in missiles, satellites and ultra-high-speed data-processing systems, this RCA germanium tunnel diode is among many now being offered to the electronics industry for experimental purposes on a commercial sampling basis. The diodes can operate as amplifiers, mixers, or detectors





Jig holds 81 tab rings. Air pressure restricts solution to tab area

Solder plating setup. Plating solution drips onto anode swab, which applies solution to jig

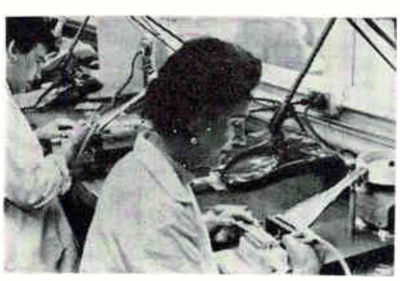
Brush Plating, Jig Speed Soldering

PRECISION SOLDER plating of transistor tabs at high production rates is accomplished at International Business Machines Corporation's Poughkeepsie, N. Y., plant with a brush plating method and an air-operated masking jig. Plating is applied to areas as small as 0.001 square inch with a thickness tolerance of ± 20 millionths.

Alloys of tin, lead, bismuth, gallium or indium are applied to selected areas of a ring $\frac{3}{16}$ inch in diameter, to which a semiconductor wafer is subsequently fused in an automatic furnace operation. Solder was formerly applied by hand with a fine soldering iron tip. The work was tedious and quality control difficult. The solder must not contaminate the ring's center hole.

Plating Process

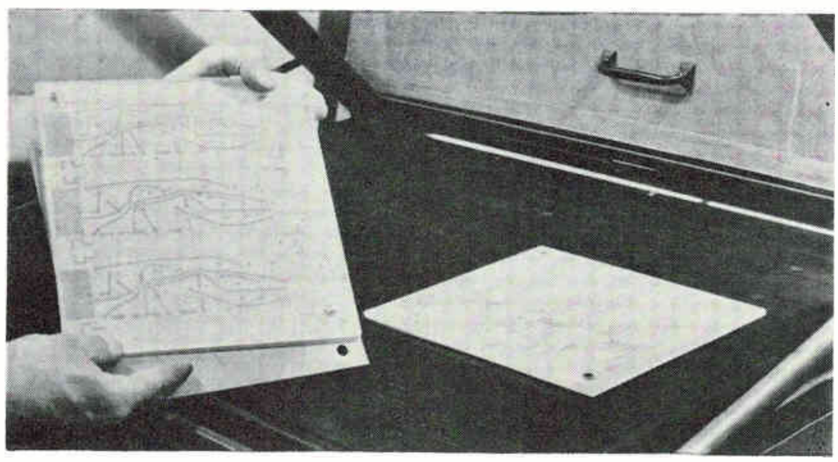
Parts are electroetched to ensure chemical cleanliness. Before plating, parts and jigs are rinsed in running water. Jigs hold 81 parts and are loaded with the aid of a vacuum probe and magnifying glass.



Jigs are loaded with aid of vacuum probe

The jigs are designed to expose only the tab area of the rings to the plating solution. Air pressure is used to push a series of pins up through the center holes of the rings, masking the holes. The air pressure also prevents the plating

Paper Patterns Print P-C Boards

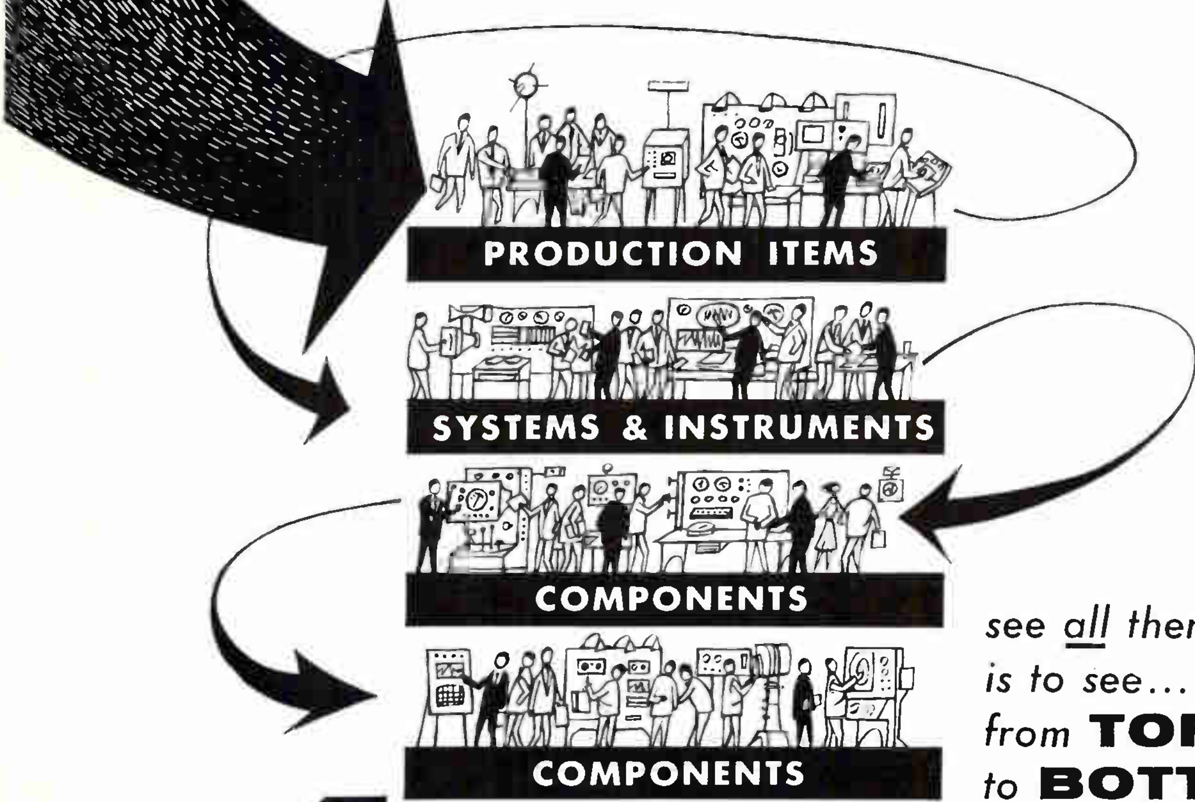


Pins align paper negative of computer circuit with copper-clad laminate

PLASTIC-BACKED paper negatives are used to transfer etched circuit wiring patterns onto copper-clad epoxy glass laminates, at Librascope, Inc., Glendale, Calif. The process reduces alignment and damage problems and insures dimensional stability of the negative. Film negatives can be stretched or shrunken by changes in temperature and humidity, and must be carefully handled to prevent scratches and abrasions.

Librascope transfers the reversed image of the circuit onto a thin, translucent paper stock and bonds it to a rigid plastic sheet. Use of the plastic backing also permits another innovation, alignment pins. All circuit board laminates are jig-drilled with alignment holes at the corners, before being sent to the printing lab. Pins inserted in the corners of the negative support correspond with the holes in the board. The pins hold the board firmly in alignment during printing.

4 BIG FLOORS...



see all there is to see... from **TOP** *to* **BOTTOM**

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at the IRE NATIONAL CONVENTION *and* RADIO-ENGINEERING SHOW!

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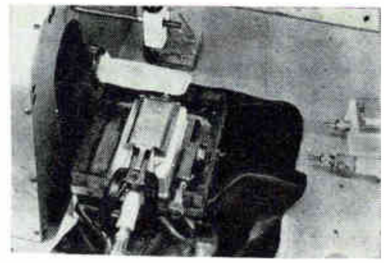


Jig in position on oscillating platen

solution from seeping down between the parts and the jig, completing the masking operation.

The Dalic electrodeposition process, of Sifco Metachemical, Inc., Cleveland, Ohio, is used. This process employs a carbon anode, wrapped with a cotton swab saturated with the appropriate metallic plating solution, as a stylus. The stylus is normally rubbed over the surface to be plated.

Drip-fed Swab

IBM places the loaded jigs on an oscillating platen under the stylus. The platen moves the jig back and forth and from side to side. The stylus is rotated by an electric motor which indexes it about a quarter turn every few seconds to equalize wear on the cotton swab. A drip feed supplies solution to the stylus. Excess solution is channeled into a container for analysis and possible reuse.

The amount of metal deposited is regulated by measuring the current density through the associated Dalic rectifier unit. Its ampere-hour meter, graduated in 0.01 ampere-hour increments, is set to zero before plating begins. When the indicator reaches a predetermined figure, the desired thickness has been reached.

After plating, the fixture is removed from the platen and rinsed under water. Each tab is inspected through a microscope for proper plating. Defective parts are removed from the fixture with tweezers. The process can also be used to apply other metallic platings, including noble metals, zinc and iron.

Coding Teflon Wire

SPECIAL COLOR codes can be applied to polyvinyl chloride-coated, Teflon-insulated wires with ink containing a rapidly evaporating solvent. Freon-MF (Du Pont) is used to prevent color migration and softening of the pvc. Colors are applied by low-cost applicators manufactured by Spectra-Strip Wire & Cable Corp., Garden Grove, Calif. Wire is immersed in a dye container and rewound, for solid colors. Two-color stripes are obtained by applying ink from two containers and then twisting the wire.

Toggle Clamp Makes Portable Punch Press

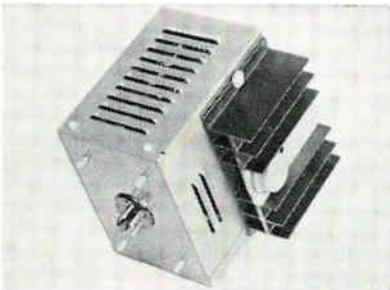
HAND PRESS made from a toggle clamp is used at B/W Controller Corp., Birmingham, Mich., to punch mounting holes in 16-gage steel relay cases. Holes are punched after the case is coated, since hole sizes and locations vary.

A heavy duty plunger-type toggle clamp (Model 650, Detroit Stamping Co., Detroit, Mich.) has a handle extension and support braces welded to the handle. The clamp is mounted on a steel block supported by short columns. A punch is screwed on the plunger. A die button is placed in a locator block that also serves as a platen to support the case. A heavy-duty spring slipped over the punch keeps the handle in a raised position when the press is not in use.

Welded handle extension gives punching leverage

The press can be bolted to a portable table or bench and is light enough to carry. Piercing force generated exceeds 5,000 pounds. Production speed is reported to be about 100 cases an hour, due to elimination of burrs and coating chipping.

On The Market



D-C Power Supplies
solid state

DELTRON INC., 2905 N. Leithgow St., Philadelphia 33, Pa. The PI series are miniaturized all solid state power supplies ideal for built-in applications requiring reliable sources of regulated power in a small convenient package. Models PI82, PI241 and PI50.5 cover every voltage in the range of from 1 to 50 v, adjustable over a 1 v band. Current ranges up to 2 amperes are available from these units. Other PI models cover voltage ranges up to 100 v, some with limited adjustment, others with wide range adjustment.

CIRCLE 301 ON READER SERVICE CARD

Magnetic Shield
for resolution

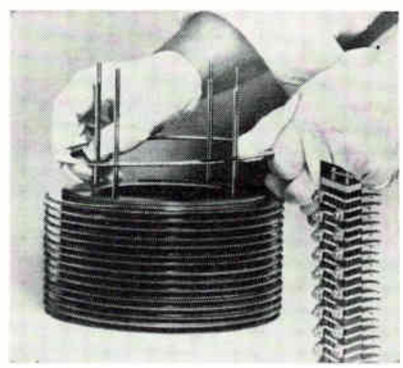
MAGNETIC-SHIELD, division Perfection Mica Co., 1322 N. Elston Ave., Chicago 22, Ill. NeticCo-Netic magnetic shield assures maximum resolution for Hughes H-1010AP20 Tonotron storage tubes and beam display tubes. Shield is nonshock sensitive, nonretentive and does not require periodic annealing. Tubes may be potted and located to other black-box gear for miniaturization. Potting allows tube operation at altitude to 70,000 ft. Prices range from $85.00 to $120.00 per unit.

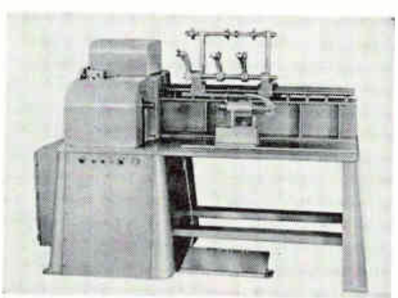
CIRCLE 302 ON READER SERVICE CARD

Slip Ring Assemblies
expanded line

BREEZE CORPORATIONS, INC., 700 Liberty Ave., Union, N. J., has expanded its line of standard slip ring assemblies which now includes seven sizes of flat ring assemblies with ring enevlope diameters ranging from 1 in. through 10½ in. Assemblies are of fabricated construction to provide the maximum resistance to shock, vibration and environmental conditions and to permit the addition of rings when required. Rings are hard silver and brushes are silver graphite. The flat, stacked assembly with rings mounted above and below each barrier provides the maximum number of rings in the shortest axial length for rated capacities. Assemblies can be stacked to produce a multiple unit.

CIRCLE 303 ON READER SERVICE CARD





Coil Winder
controlled unit

GEO. STEVENS MFG. CO., INC., Pulaski Rd. at Peterson, Chicago 46, Ill. New medium-range winder for multiple-winding heavy-duty transformer, bobbin and field coils. Model 650-AM has selective stopping for transformer winding, emergency stop for use if wire supply is exhausted or if wire breaks, instant spiral/rapid traverse, heavy-duty positive locking tailstock, positive stopping magnetic brake, instant reset counter. Drive is 3 h-p 220/440 3-phase motor. Fixed winding speed is 150 rpm with acceleration clutch controlled.

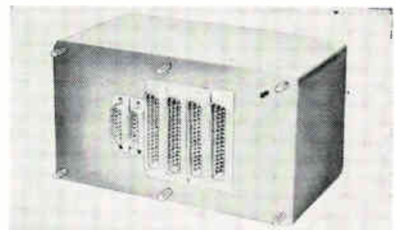
CIRCLE 304 ON READER SERVICE CARD

Acceleration Switch
multilevel device

INSTRUMENTS DIVISION, The W. L. Maxson Corp., 475 Tenth Ave., New York, N. Y. Model 200 unidirectional, single-axis switch is capable of successively closing four independent electric circuits with a common point, in response to preset acceleration levels. Small size and weight make it particularly suitable for use in aircraft and missile control, measuring and indicating devices. Unit consists of a gas damped seismic system with a range of 1

to 10 g, an accuracy of ±0.1 g, repeatability of within 0.1 g, a damping ratio of 0.8 of critical and temperature range of −60 to +250 F. Switch is normally open single pole, four steps, with contact ratings of 100 ma each.

CIRCLE 305 ON READER SERVICE CARD



Multicoders
silicon solid state

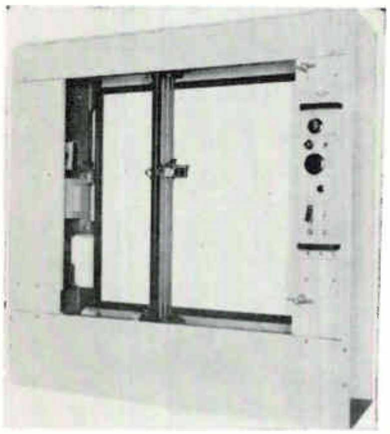
General Devices, Inc., Princeton, N. J. The SL series multicoders for airborne, missile and space vehicle applications can sample up to 88 low level differential data inputs. It is available in single speed or multiple speed models capable of providing all standard IRIG signals pam, pdm and record in 30 to 90 channel formats at speeds 112½ to 900 samples per sec. selectable by inserting the appropriately wired mating connectors. Separate outputs are provided for standard pam signal with master pulse, standard pdm, and differentiated pdm (record) output. Accuracy of ½ percent is claimed for signals of 10 mv amplitude full scale.

CIRCLE 306 ON READER SERVICE CARD

Delay Line
ultraminiature

Control Electronics Co., Inc., 10 Stepar Place, Huntington Station, L. I., N. Y., announces a new magnetostrictive delay line that enables range markers to be generated in the video section of the radar for calibration purposes. Model FM-1080 provides the first video pulse output at precisely 3.050 μsec followed by 6.10 μsec echoes. First marker output level is 25 mv. It has a 1 db pulse decay and input/output impedance of 1K ohm. Weighing only $\frac{1}{4}$ oz, it has a diameter of 0.25 in. and is only 1.2 in. long.

CIRCLE 307 ON READER SERVICE CARD



Plotting System displays, records

WALDORF ELECTRONICS, 360 Wolf Hill Road, Huntington Station, New York. New plotting system displays and permanently records target movement information derived from an AN/MPQ-29 radar set. System is comprised of two vertical plotting boards, a computer console, and a coordinate converter. Radar shaft inputs of slant range, elevation angle and azimuth angle are converted into ground range coordinates in X and Y and fed into the computer console. The computer channels the ground range signals to the plotting boards. Each board displays the ground track of the target on a 30 by 30 in. plotting surface.

CIRCLE 308 ON READER SERVICE CARD

Pulse Generator simple circuitry

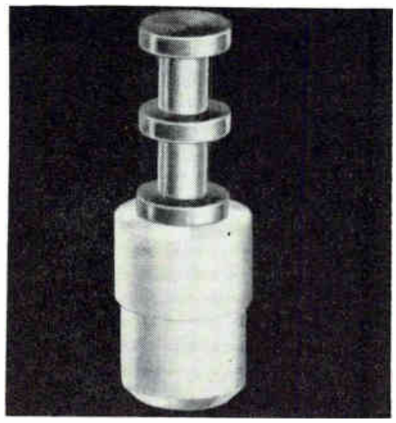
ELECTRO-PULSE, INC., 11861 Teale St., Culver City, Calif. Model 4120B pulse generator is a compact source of medium power, fast rise time, single or recurrent pulses. Instrument features variable control of repetition rate (500 Kc to 0.5 cps), rise time (0.03 to 0.5 μsec), main pulse delay (0.05 to 10,000 μsec) and main pulse width (0.1 to 10,000 μsec). Output amplitude is at least ±35 v into 100 ohm load (50 v positive—90 v negative open circuit), stabilized against line voltage change by use of regulated power in output stage. Overshoot and top slope optimizing adjustments also provided.

CIRCLE 360 ON READER SERVICE CARD

Latching Relay long life

BABCOCK RELAYS, INC., 1640 Monrovia Ave., Costa Mesa, Calif. Performance characteristics of the BR-7A electrical latching relay include shock to 50 g, 11 millisec. Life is said to be capable of over 200,000 operations at the extremes of contact load (10 amperes) and temperature (125 C) with over 350,000 operations under full load at room temperature.

CIRCLE 361 ON READER SERVICE CARD



Teflon Terminal high-torque

SEALECTRO CORP., 610 Fayette Ave., Mamaroneck, N. Y. Type ST-250L4 high-torque Press-Fit terminal is of the dual-turret design permitting two termination positions with holding collars. It is especially applicable in installations requiring beyond-the-usual ruggedness in both assembly procedure and under operational conditions. It is designed for a maximum chassis thickness of 0.110 in. A mounting hole of 0.158 in. ±0.002 in. is required. Terminal height above chassis is 0.406 in. Terminal soldering lug is 0.062 in. in diameter with holding collars measuring 0.125 in. diameter. Turret heights for wire terminations are 0.093 in.

CIRCLE 362 ON READER SERVICE CARD

SSB Converter self-contained

THE HAMMARLUND MFG. CO., INC., 460 W. 34th St., New York 1, N. Y. SPC-10 converter, when used with any standard communications receiver, provides complete ssb reception, or AM/MCW. It connects electrically into any communications receiver having an i-f frequency between 450 Kc and 500 Kc. The connection is made from the converter to the i-f amplifier of the receiver. SPC-10 provides all types of modern tuning modes. All frequency controls are calibrated in Kc from the center of the passband. Seven selectivity positions permit slicing of exact portion of the passband desired from 0.5 to 6 Kc.

CIRCLE 363 ON READER SERVICE CARD

Round Drawn Cases
to house components

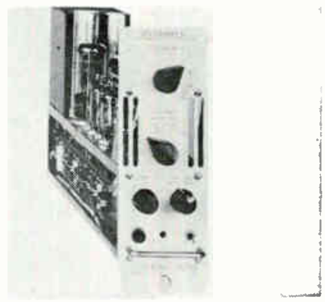
OLYMPIC PRODUCTS CO., INC., Alpha, N. J., has introduced more than 200 new standard sizes of round drawn cases made from aluminum, copper, steel, brass, and mu metal. Especially designed to house electronic components, they range in size from $\frac{1}{2}$ in. to 3 in. in diameter and lengths up to 4 in.

CIRCLE 364 ON READER SERVICE CARD

Full Wave Bridge
silicon rectifier

GATES ELECTRONIC CO., 1705 Taylor Ave., Bronx, N. Y. Model G6S6 is a $1\frac{3}{8}$ in. by $1\frac{3}{8}$ in. by $\frac{1}{8}$ in. silicon rectifier full wave bridge weighing 1 oz which exhibits the following characteristics: maximum piv 600 v, supply voltage with resistive or inductive load 420 v, capacitive load 210 v. Rectified forward current for a resistive load 1.5 amperes maximum, and for a capacitive load 1 ampere maximum.

CIRCLE 365 ON READER SERVICE CARD



Electronic Filter
linear phase shift

DYNAMICS INSTRUMENTATION CO., 1118 S. Mission St., South Pasadena, Calif. Linear phase shift (constant time delay), 36 db per octave terminal slope, and cut-off frequency selectable in tenth-decade steps from 10 cps to 80 Kc are features in the model 1660 electronic filter. Unit is ideally suited for filtering random signals with the least information distortion in the allowed bandwidth. Instrument has 100 K input impedance, 1 ohm output impedance, and the filter characteristics do not change with loading (either high-pass or low-pass operation). Each filter has an individual fully-isolated power supply, voltage steps from 0.1 to 1.0, and 0.1 percent linearity.

CIRCLE 366 ON READER SERVICE CARD

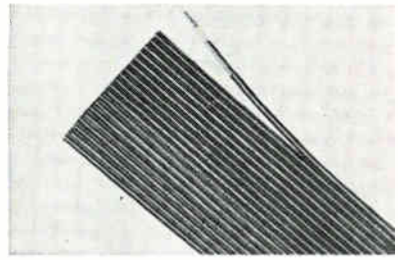
Ku-band Diodes
low noise figure

SYLVANIA ELECTRIC PRODUCTS CO., INC., Woburn, Mass. Matched-pair Ku-band silicon microwave diodes, types 1N78D and 1N78DR, make possible low over-all noise figure in mixer applications such as radar and missile systems. Available in both forward and reverse polarities, when used in matched pairs local-oscillator noise is practically eliminated and a receiver system with

CIRCLE 79 ON READER SERVICE CARD

7.5-db over-all noise figure is realized at 16,000 Mc. The devices have a maximum operating temperature of 150 C and a complete hermetic seal for protection under severe environmental conditions.

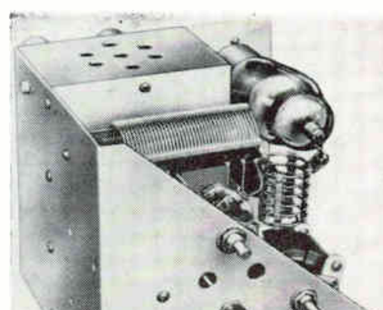
CIRCLE 315 ON READER SERVICE CARD



Ribbon Coax Cable saves space

TIMES WIRE AND CABLE CO., INC., Wallingford, Conn. Ribbon multi-coaxial cables save space in duct and trough installations over the usual round, multiconductor cables. It is ideal for use in modular and p-c applications. Faster access to individual cables permits easier, neater terminal connections. The ribbon design also lends itself to roll-out chassis construction in which the cable connections are made through "window-shade type" roller techniques. Present facilities accommodate up to 25 conductors in a single cable.

CIRCLE 316 ON READER SERVICE CARD



Frequency Multiplier multiband

BARKER & WILLIAMSON, INC., Bristol, Pa., makes a compact frequency multiplier with bandswitching for the 80-40-20-15 and 10 meter bands. Unit operates on a 6 to 10 v r-f supply within the fre-

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rustrak® MAC*

miniaturized — automatic

CHART RECORDER

DIMENSIONS:
3⅝" w x 5⅝" h
x 4⅛" d

Send today for complete specification sheet and prices.

*Miniaturized Automatic Chart Recorder
ONLY $79.50

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industrial co., inc.
130 SILVER STREET
MANCHESTER, N. H.

Jim Leeds wanted to check for electrical interruptions in equipment. A twenty-four hour vigilance on each unit was impractical — required increased manpower and expenditures. Upon extensive investigation, Jim found most automatic checking equipment cumbersome and expensive. What was the answer?

Jim found it in the amazing new palm-sized Rustrak® MAC,* the Miniature Automatic Chart Recorder. With an accuracy of 2%, it compared favorably with units costing 5 times its price. It recorded all interruptions with a continuous, distortion free line on a smudge-proof chart giving him an accurate, continuous record of any intermittence.

The new Rustrak® MAC,* Miniature Automatic Chart Recorder is solving hundreds of recording problems accurately and inexpensively.

It can do the same for you.

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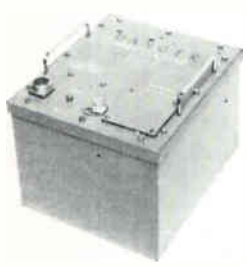
60,000

VOLTS, DC

5 Milliamperes

- ELECTROSTATIC SPRAYING or FLOCKING
- CABLE and DIALECTRIC TESTING
- PARTICLE SEPARATION or DEPOSITION
- ELECTRON MICROSCOPY
- CRT DEVELOPMENT and OPERATION



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Fully instrumented power supply, designed for maximum personnel and equipment protection.

Selenium rectification insures long reliable operation.

High voltage components are oil-immersed for minimum corona generation and compact construction.

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1 KV to 250 KV

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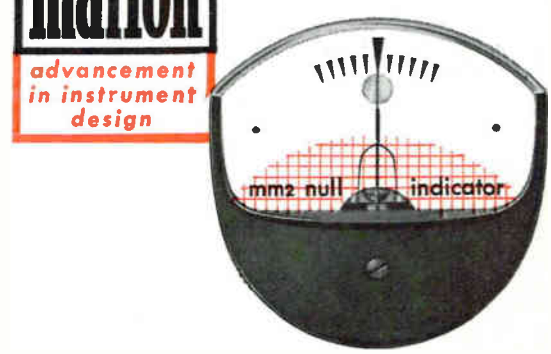
CIRCLE 216 ON READER SERVICE CARD

marion

advancement in instrument design



MEDALIST* null indicators

READABLE . . . WIDE RANGE SENSITIVITY

Modern MEDALIST design provides far greater readability and modern styling in minimum space. Unique core and magnet structure provides ½ ua/mm sensitivity at null point with sharp square law attenuation to 100 ua at end of scale in Type A. Internal resistance is 2000 ohms. Other sensitivities available. ASA/MIL 2½" mounting. Standard and special colors. Bulletin on request. Marion Instrument Division, Minneapolis-Honeywell Regulator Co., Manchester, N.H., U.S.A. *In Canada, Honeywell Controls Limited, Toronto 17, Ontario.*

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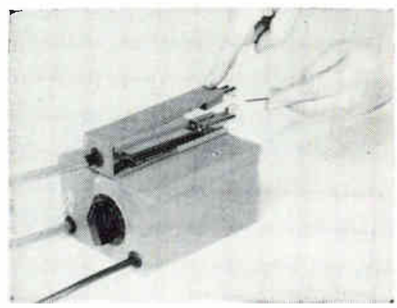
CIRCLE 81 ON READER SERVICE CARD

quency range of 3,350 to 4,000 Kc to produce desired fundamental on 80-40-20-15-10 meter amateur bands. Input to the first multiplier stage may be from an external crystal controlled oscillator or suitable vfo. Model 504 C may be used as a driver for high powered class C or linear amplifiers and as a low power transmitter on either phone or c-w when equipped with suitable power supplies, modulator and excitation.

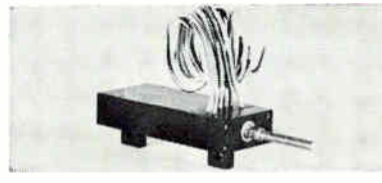
CIRCLE 317 ON READER SERVICE CARD



Wire Stripper thermal type

WESTERN ELECTRONIC PRODUCTS Co., 655 Colman St., Altadena, Calif. Model G thermal wire stripper features a continuously variable heat control for precise temperature adjustment required in stripping virtually any size or type of plastic-insulated wire. Designed for production-line operation, it can be used either as a bench-operated tool or held in the hand for use in inaccessible locations. Stripper uses two parallel heating elements to quickly sever plastic insulation and provides a pincers action to remove it with a slight pull. Since no sharp cutting edges are used, there is complete freedom from cut or nickel wires. Price is $69.50.

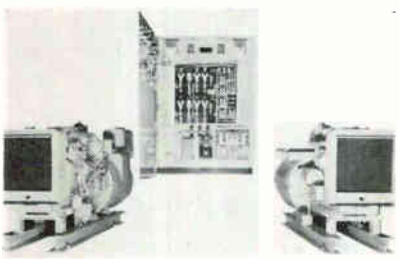
CIRCLE 318 ON READER SERVICE CARD



Linear Motion Pot ½ by 1⅛ in. overall

COMPUTER INSTRUMENTS CORP., 92 Madison Ave., Hempstead, L. I., N. Y., announces a new addition to its line of linear motion pots. Length of the unit is 1 in. greater than the stroke desired. Strokes are available from ¼ in. to 3 in. Model 112 contains two completely independent elements, either or both of which may be linear or conform to a desired function. Where taps are desired, as many as 4 per in. per element may be supplied. Linearity is 0.2 percent of length of stroke; resistance range, 250 ohms to 125 K ohms per in. of stroke; virtual resolution, 1/35,000 per in. of stroke; wattage, 1 w per in. of stroke; temperature range, −55 C to +150 C. Life rating is up to 30 million strokes depending on circuitry.

CIRCLE 319 ON READER SERVICE CARD



Generating Set
no-break

R. H. SHEPPARD CO., INC., Hanover, Pa. When city power frequency drops to 97 per cent of normal value, or voltage to 98 percent, a new no-break generating set automatically takes over with no break in power. It will find many applications in the electronic and communication fields where even momentary power interruptions can damage costly equipment or interrupt vital services. The no-break generating set consists of the Sheppard Diesel engine, a generator and a flywheel, mounted on a common I beam base with generator located between engine and flywheel.

CIRCLE 320 ON READER SERVICE CARD

High Power Sources
ultra-stable

LABORATORY FOR ELECTRONICS, INC., 1079 Commonwealth Ave., Boston 15, Mass., has added three high power sources to its line of ultra-stable microwave oscillators. Model 814-S-31 covers a frequency range of 3,700 to 4,300 Mc and delivers

1 w. The 814-C-31 and 814-C-32 are tunable over a range of 5,900 to 6,400 Mc and 5,400 to 5,900 Mc respectively and deliver an output power of 1 and 1.5 w. All three units have an incidental f-m of less than 5 parts in 10^8 and long term stabilities of better than 1 part in 10^6 over a one-hr period

CIRCLE 321 ON READER SERVICE CARD

Recording System
impact & temperature

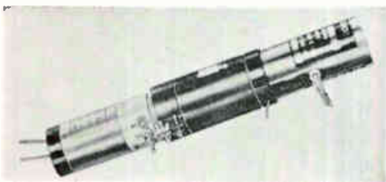
SANTA BARBARA INSTRUMENTATION CORP., 411 State St., Santa Barbara, Calif., announces model ES-101 environmental recording system, designed to measure and monitor the impacts and temperature variations encountered by delicate equipment being transported or stored. A model ER-125 event recorder provides 25 inkless channels of discrete recording and may be used unattended for 30 days. A recording rate of up to 20 events per sec is possible. Data reduction is simplified by the recording presentation and provision for electromechanical counters for quick-access data information.

CIRCLE 322 ON READER SERVICE CARD

Digital Printer
all solid-state

EPSCO, INC., Equipment Division, 275 Massachusetts Ave., Cambridge, Mass. Model DP-834 digital printer complies with MIL-E-4158B and is completely automatic in operation. Featuring a capacity of 11 columns, it prints at speeds to 5 lines per sec. It accepts decimal data for 6 columns from measuring instruments, prints function and polarity as well as decimal point location, and provides 3 columns of test number identification. Individual tests can be selected by switching to aid in system calibration or trouble-shooting. Unit can be connected to the outputs of a-d converters, dvom's, dvm's, mobile data acquisition systems, automatic checkout and monitoring systems, and digital data logging systems.

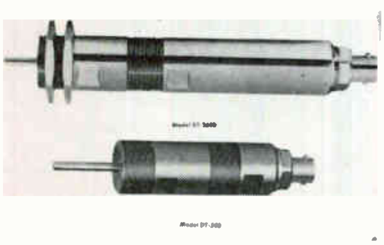
CIRCLE 323 ON READER SERVICE CARD



Modular Assembly
size 8 components

JOHN OSTER MFG. CO., Avionic Division, 1 Main St., Racine, Wisc., offers a time-saving prepackaged size 8 modular assembly consisting of motor generator, gear train, synchro and potentiometer for servo aircraft applications. Type E-108A's components are accurately aligned and calibrated with each other, saving valuable time and assuring maximum performance. Motor generator is rated for 26 v per phase or with 36 v center tap control phase; gear train can be furnished in any ratio up to 6,000:1, synchro has 7 minute accuracy and potentiometer is available in any resistance up to 100K.

CIRCLE 324 ON READER SERVICE CARD



Transducers
displacement type

PHOTOCON RESEARCH PRODUCTS, 421 N. Altadena Drive, Pasadena, Calif. Displacement transducers models DT500 and DT2000 were developed for measuring linear displacement between 0.500 in. and +2.000 in. with a frequency response from 0 to

10,000 cps dependent on the Dynagage measuring system.
CIRCLE 325 ON READER SERVICE CARD

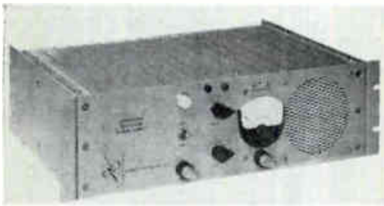
Surge Test Adaptor weighs 25 lb

WALLSON ASSOCIATES, INC., 912 Westfield Ave., Elizabeth, N. J. Model 142 surge test adapter is available for use as an accessory with either the type 138A or 141A silicon rectifier test sets. It may also be used alone, and a permanent cabinet is provided for positioning when desired. Type 142 supplies single ½-wave sinusoidal surge currents, adjustable between 5 and 75 amperes at a maximum repetition rate of 4 per minute. Provisions are made to monitor the output through a 50 mv shunt with an oscilloscope using the sync signal provided. Price is $700 rack mounting, $725 complete in self contained cabinet.
CIRCLE 326 ON READER SERVICE CARD

Frequency Counter easy-to-use

HEWLETT-PACKARD CO., 275 Page Mill Road, Palo Alto, Calif. Model 521G automatically measures frequency and random events per unit of time or with the manual gate feature totalizes electrical events. With transducers, it also provides convenient measurements of such mechanical quantities as speed, rpm, rps, weight, pressure, temperature and acceleration. Frequency range is 1 cps to 1.2 Mc. Unit has an accuracy of ±1 count ± the accuracy of power line frequency — usually ±0.1 percent (±0.01 percent with optional crystal time base installed.) Counter provides a five-place registration. Price is $650.

CIRCLE 327 ON READER SERVICE CARD



D-C Power Supply heavy-duty

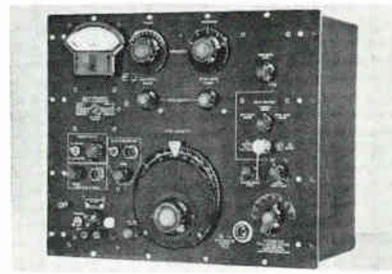
POWER SOURCES, INC., Burlington, Mass. PS4019 is a heavy duty unit designed as a general purpose source of 25-32 v d-c. It provides load current up to 1.5 amperes. Output voltage is selectable by a front panel control. Input voltage in the range 105-125 v a-c may also be selected by front panel switch. Ripple and noise level at the output is less than 2 mv. Regulation is provided to maintain the output voltage within 0.2 v for load changes from 0-1.5 amperes with the line constant. Output impedance is less than 0.2 ohm from d-c to 100 kc.

CIRCLE 328 ON READER SERVICE CARD

Magnetic Amplifier long life unit

ACROMAG, INC., 22519 Telegraph Rd., Southfield, Mich. Model 615 magnetic instrumentation amplifier is especially designed to give power gains of up to 20,000 in a single stage, and is well suited for amplifying low-level d-c signals from thermistors, resistance thermometers, null detectors, and other similar low-level d-c transducers. For industrial process controls, it is easy to produce lead-lag networks, proportional plus reset, signal mixing, and similar operational functions by using one of the model 15's with external resistance capacitance shaping networks.

CIRCLE 329 ON READER SERVICE CARD



Video Generator beat-frequency

GENERAL RADIO CO., West Concord, Mass. Type 1300-A can be used as a source for acoustic and ultrasonic tests, and testing of video systems, amplifiers, discriminators, networks and both wide and narrow-band video filters. Ranges are 20 cps to 20 Kc (sine or square wave) for audio, 20 Kc to 12 Mc (sine) and 20 Kc to 2 Mc (square wave) for video signal and video sweep, with the latter at a 60-cps sinusoidal sweep rate. All signals are monitored by an output voltmeter and are available from an output attenuator. Outputs of a h-f variable oscillator (30 to 42 Mc) and sweep oscillator are also available at jacks at the rear of the instrument.

CIRCLE 330 ON READER SERVICE CARD

Mixer-Preamplifier for X-band

LEL, INC., 380 Oak St., Copiague, L. I., N. Y. Operating over the 10,500-12,400 Mc spectrum, the MMX-3 matched mixer-preamplifier assembly is gain stabilized, has a 20 Mc i-f bandpass centered at 60 Mc, 25 db minimum overall gain, and a 9 db maximum noise figure. It provides a 50 ohm output impedance making it suitable for gain and noise figure measurements on masers and parametric up-converters in addition to its use as standard subassembly for incorporation into a radar or missile receiving system.

CIRCLE 331 ON READER SERVICE CARD

Laboratory Recorder
general purpose

THE SIPPICAN CORP., Box 537, Marion, Mass., announces a general purpose laboratory recorder for use with up to six resistance-type sensing elements or transducers. Six self-contained temperature-controlled bridge circuits are designed for sensor resistances of 85-350 ohms. It records output of the sensors every 5 to 30 sec. Unit features full scale range continuously variable from 0.6 ohm to 60 ohms with an accuracy of $\pm\frac{1}{2}$ percent full scale reading. In typical applications, using chemically pure nickel sensors, temperature changes of 0.01F in range of 100 F to 160 F are continuously monitored and recorded.

CIRCLE 332 ON READER SERVICE CARD

Miniature Relay
5-mw type

BABCOCK RELAYS, INC., 1640 Monrovia Ave., Costa Mesa, Calif. Only 5 mw of power is required to operate the BR-1SZ miniature relay. The hermetically sealed $1\frac{1}{4}$ oz. relay was developed for airborne and ground applications where requirements include very critical pull-in to drop-out ratios, long life and temperatures ranging from -65 C to ± 125 C. New BR-1S series meets MIL-R-5757C, 6106C and 25018, and is available in a variety of mounting and header configurations.

CIRCLE 333 ON READER SERVICE CARD

CIRCLE 91 ON READER SERVICE CARD

Literature of the Week

MISSILE BATTERIES. Yardney Electric Corp., 40 Leonard St., New York, N. Y., has issued bulletin Z-101 containing technical data on three new Silvercel batteries for the missile field.

CIRCLE 380 ON READER SERVICE CARD

ANALOG COMPUTER CONTROL. Controls Division, Hagan Chemicals & Controls, Inc., Hagan Building, Pittsburgh 30, Pa. Complete details on PowrMag solid state analog computer control systems are presented in a recent bulletin.

CIRCLE 381 ON READER SERVICE CARD

PRESSURE CUTOFF. Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif. Bulletin 103 covers the PE-103 pressure cutoff which is specifically engineered for the simultaneous control of pressure data from a multiplicity of pressure channels.

CIRCLE 382 ON READER SERVICE CARD

WAVEGUIDE WINDOWS. Sylvania Electric Products Inc., 1100 Main St., Buffalo, N. Y. A catalog sheet contains electrical and mechanical data for five types of ceramic, glass, or mica waveguide windows.

CIRCLE 383 ON READER SERVICE CARD

AUTOMATIC CHECKOUT. Epsco, Inc., 275 Massachusetts Ave., Cambridge 39, Mass. A 4-page brochure describes new automatic checkout equipment—an rms to d-c converter, a voltage-to-digital converter, a timer-counter and a digital printer.

CIRCLE 384 ON READER SERVICE CARD

SPECTROGRAPH. Kay Electric Co., Maple Ave., Pine Brook, N. J. A recent mailing piece illustrates and describes the Missilyzer, an audio and subaudio spectrograph for missile data reduction.

CIRCLE 385 ON READER SERVICE CARD

NOISE FACTOR IMPROVEMENT. Resdel Engineering Corp., 330 S. Fair Oaks Ave., Pasadena, Calif. Bulletin TF165 describes the development of a vhf-uhf re-

ceiver input system providing a passband of 200 mc without tuning, for governmental and commercial installations, to improve noise factor in receiver installations.
CIRCLE 386 ON READER SERVICE CARD

BASE TAB STAMPINGS. Accurate Specialties Co., Inc., 37-11 57th St., Woodside 77, N. Y. Bulletin Z-102 describes solder clad base tab stampings used in making ohmic junctions to germanium or silicon junction transistors.
CIRCLE 387 ON READER SERVICE CARD

VECTOR ANALYZER. Ad-Yu Electronics Lab., Inc., 249 Terhune Ave., Passaic, N. J. Description, specifications and suggested applications for type 2 Vectorlyzer are contained in a single sheet bulletin.
CIRCLE 388 ON READER SERVICE CARD

POWER CONNECTORS. A.P.M. Corp., 252 Hawthorne Ave., Yonkers, N. Y. Bulletin PL-2 illustrates and describes Part No. N-UP 121M, a flat, armored power connector with a pivotally-mounted grounding blade which provides automatic ground connection when plugged into either 2 or 3-pole receptacles.
CIRCLE 389 ON READER SERVICE CARD

TECHNICAL JOURNAL. Airpax Electronics Inc., Seminole Division, Fort Lauderdale, Fla. Vol. 1, No. 1 of the *Technical Journal*, a periodical devoted to the study and theory of electronic components and systems, is now available.
CIRCLE 390 ON READER SERVICE CARD

X-Y RECORDER. Houston Instrument Corp., P. O. Box 22234, Houston 27, Texas. Bulletin 794-1 gives complete data on a new large scale (24 in. by 36 in.) X-Y recorder offering direct differential transformer or a-c transducer input.
CIRCLE 391 ON READER SERVICE CARD

TEN-TURN POT. Helipot Division of Beckman Instruments, Inc., 2500 Fullerton Road, Fullerton, Calif., has issued a data sheet describing a new series of $\frac{7}{8}$ in. diameter, ten-turn precision pots for servo mounting.
CIRCLE 392 ON READER SERVICE CARD

Zarem: operates in threes

FOR THREE consecutive years president A. M. Zarem has tripled sales, personnel, and floor space of his Electro-Optical Systems, Inc., in Pasadena, Calif. Last month he began consolidating several scattered groups under one brand new roof covering 50,000 sq ft of floor space, boosting company total to 66,000. Basically a research organization, dedicated to space technology, EOS handfeeds projects from initial concept to prototype, bows out when production starts. All activity is divided into five divisions: Solid State, Advanced Electronics, Energy Research, Fluid Physics, and Space Defense Systems.

Founded in 1956, EOS has one of the few research contracts on ionic propulsion for space flight, is well along on development of electro-optical pulsing methods for long range, low-powered communications and control systems. Recently developed are a nickel-sized solid state optical tracker for the military and industry, and several systems for heat rejection in space.

Born 42 years ago in Chicago, Zarem graduated from Illinois Institute of Technology, got his master's and PhD (Magna Cum Laude) in science from CalTech. During a brief stint with Allis-Chalmers, he was active on an "automatic oscillograph with a memory". He joined the Manhattan District Project in 1945.

Zarem is perhaps best known for an ultra-fast electro-optical camera invented while he was head of NOTS Basic Research Electronics division in Pasadena, after World War II. It has an effective exposure time of one-billionth of a second. In 1948 ETA Kappa Nu tabbed him "The Outstanding Young Electrical Engineer of the U. S.," and two years later he was selected as one of "America's Ten Outstanding Young Men" by the National Junior Chamber of Commerce. He joined Stanford Research Institute in 1948, and before striking out on his own in 1955, headed up its Southern California division.

Bristling with good-humored energy, Abe Zarem "never walks but what he runs." The head of an EOS department recently dubbed him "the hardest working employee we've got" after watching him work straight through 48 hours.

An inveterate ping-pong player, Zarem lives with his wife and three children (ages 8 to 13) in San Marino, likes to read non-scientific best sellers. He unwinds after a grueling day by taking long solitary evening walks, claims there are no problems that don't appear simpler at such times.

Ampex Division Advances Glass

PROMOTION of William Glass to manager of the Dayton, O., district office, has been announced by the Ampex Data Products Co., Redwood City, Calif. A division of Ampex Corp., the company manufactures magnetic tape recorders widely used for the acquisition, storage and processing of business and scientific data. The equipment plays a major part in aircraft and missile testing.

In assuming his new position, Glass will supervise technical sales and customer relations for the area.

Before joining Ampex, he was with the Applied Science Corp. of Princeton (ASCOP). Earlier he did telemetry systems work for RCA's Patrick Air Force Base, Florida installation, and was a research and development engineer for Hughes Aircraft, Culver City, Calif.

Raytheon Names Marketing Mgr.

EDMOND P. DIGIANNANTONIO has been named marketing manager of Submarine Signal Operations of Raytheon Company's Equipment Division.

Formerly manager of product planning for Sub-Sig Operations, Di Giannantonio joined Raytheon in 1956 as a product sales manager for the Equipment Division. He later held posts as divisional planning officer and manager of program planning in corporate govern-

Production Inspection is Faster and Easier with a J&L Optical Comparator

. . . and its extreme versatility enables you to perform inspections that used to be "impossible"!

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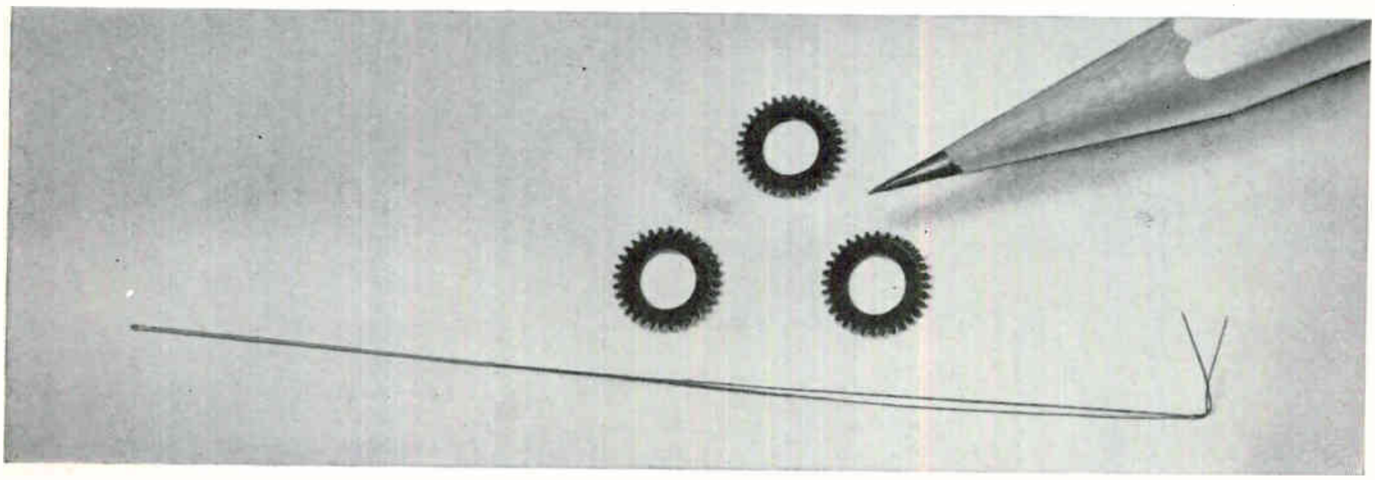
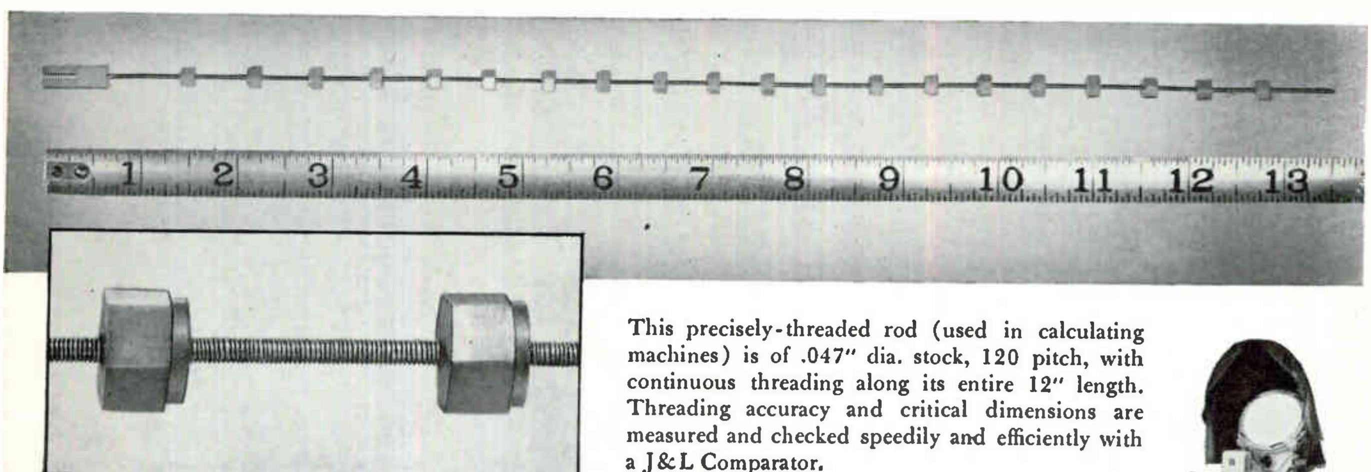


For Instance — A customer writes: "One of our assemblies, containing 32 separate circuits, measures only 5/16" dia. by 1" long. The parts which go into this assembly must have perfect shape and tension, which are impossible to check by mechanical means. Two such parts are these .005" dia. gold wires, and precisely toothed brush spacers. Since using the J&L Optical Comparator in our inspection, assembly failure due to malfunction of either of these two parts has virtually disappeared."



This precisely-threaded rod (used in calculating machines) is of .047" dia. stock, 120 pitch, with continuous threading along its entire 12" length. Threading accuracy and critical dimensions are measured and checked speedily and efficiently with a J&L Comparator.

Model PC-14

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CIRCLE 95 ON READER SERVICE CARD

ment relations.

Prior to joining Raytheon, he was assistant business manager for the Instrumentation Laboratory of MIT.

Sprague Hires McQueeney

APPOINTMENT of William E. McQueeney as a product specialist in the Field Engineering department of the Sprague Electric Co., North Adams, Mass., is announced. His responsibilities will be in the field of electrolytic capacitors.

Prior to joining Sprague, McQueeney was associated with the U.S. Shoe Machinery Co. and, most recently, with the Westinghouse Electric Corp. in Pittsburgh, Pa.

Atlas Engineering Spreads Out

NORMAN SCOTCH, vice president of the Atlas Engineering Co., Inc., Roxbury, Mass., announces the construction of a 15,000 sq ft ultramodern, electronics plant in the Natick, Mass., Industrial Center.

The new plant will house Atlas Controls, Inc., formerly the Power Supply division, a subsidiary of Atlas Engineering Co., Inc.

This development along with the

addition of 10,000 sq ft of new production facilities at the main Atlas Engineering plant are two of the many steps Atlas has taken in its current expansion program. The facilities expansion at Atlas will help expedite many important commodities for the government and civilian market.

News of Reps

Atohm Electronics, Sun Valley, Calif., recently named two new reps:

Ridley Associates of Chicago, covering Illinois and Wisconsin; and **Paul A. Bjork** of San Diego, handling San Diego County.

Brimberg Associates, Inc., of Washington, D. C., has been named engineering sales rep in the Mid-Atlantic states for Pitometer Log Corp. of New York City.

Networks Electronic Corp., Van Nuys, Calif., announces the appointment of three sales reps.

B. B. Taylor Corp., Baldwin, N. Y., will cover the metropolitan New York area, Long Island and northern New Jersey. **Johnson Associates** of Casselberry, Fla., will cover the state of Florida, and the **Emory Design and Equipment Co.** of Birmingham, Ala., will handle Alabama, Georgia and Tennessee.

Land-C-Air Sales of Tuckahoe, N. Y., announce their appointment as sales engineers by El-Rad Mfg. Co. of Chicago, Ill. Territory consists of upstate New York, northern New Jersey, New York City and Long Island.

Henschen, Jensen and Co., manufacturers' rep covering the state of Michigan, recently added to its staff **Ray Van Riper** and **Richard A. "Dick" Albrecht.**

Skysweeper, Inc., McHenry, Ill., has appointed **Mel Foster,** Minneapolis, Minn., as its rep in the Twin Cities area. Skysweeper manufactures transformers, coils, wire harnesses and cable assemblies; also handles a variety of contract assembly work in the electronic field.

BACKTALK

Outstanding vs Authorized

Re: your coverage of United Components' stockholders meeting (p 21, Jan. 29) . . .

It was called to my attention that you referred to the increased capitalization in these terms: ". . . to increase to one million the number of shares *outstanding*." I believe correct wording should have been ". . . to increase to one million the number of shares *authorized*."

There appears to be an important technical difference between the two words *outstanding* and *authorized*. I leave it to your judgment to determine whether a correction is warranted . . .

S. LEIGHTON

DARIUS INC.
NEW YORK CITY

The difference is indeed important: stock authorized by shareholders becomes outstanding only as released by the secretary or treasurer for sale.

Int'l Electrotechnical Committee

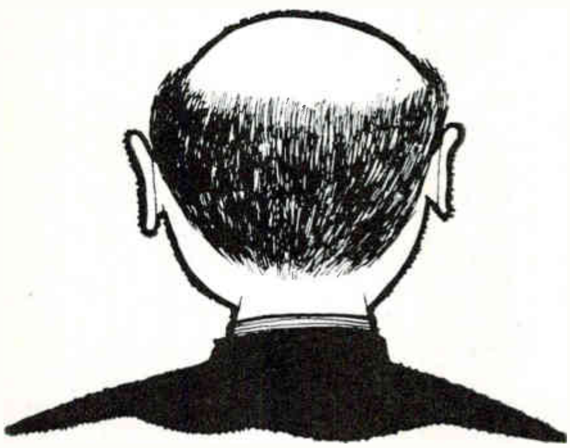
We call your attention to the forthcoming Fall meeting of the International Electrotechnical Committee in New Delhi, India.

The American interests in the work of IEC are represented through the U. S. National Committee of the IEC, which is an integral part of the American Standards Association. The ASA is the coordinating body and clearinghouse for voluntary national standards in the U. S. It is a federation of 120 national trade associations, professional societies and consumer groups, with some 2,000 company members.

ASA is concerned that, because of the distance involved, American representation at New Delhi may be poor. However, it is very much in the American interest to be well represented—for technical, commercial and diplomatic reasons.

Of course, only highly qualified engineers can represent the U. S. at the meeting. Approval of delegates is in the hands of the various technical committees. The problem is that the technical men realize

IT'S WHAT'S IN HERE THAT COUNTS



Do you know, for instance... which electronic stocks are hottest? Who's in the news and why? About "Three Approaches to Microminiaturization"? About the newest product ideas hitting the market? What's up in production? Opportunities overseas? What's going on in Washington?

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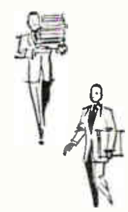

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Cable Address "KYORITSUKEIKI TOKYO"

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the importance of being represented, but that some of the top management people who have to make available the traveling funds may not be fully aware of the importance of the event. I think it is in this area that you can render a valuable service by giving advance news of the meeting and by stressing its significance . . .

SHELDON OSBORNE
KETCHUM, MCLEOD & GROVE
NEW YORK CITY

IEC certainly has performed some important work in the area of standardization, and deserves the cooperation of industry. This technology has been affected before by decisions made without its representation, and we feel that electronics management will adequately support the forthcoming Fall meeting.

Looking to the 60s

I want to extend my compliments to you for the exceptionally fine job you did on the 1960 industry forecast (Special Report "The Electronics Market Looking into the Sixties," p 49, Jan. 1).

In a field where numbers and projections are freely kicked around, it's gratifying to see a report as comprehensive and realistic as yours. You've covered the industry and the related marketing and economic influences in an intelligent manner, providing a good workable research tool. Personally, I expect to utilize the report in both planning future marketing programs and selling management.

Thanks for making my job easier.

EDMUND S. FIELDSTEEL
LORAL ELECTRONICS
NEW YORK CITY

Minification

Re: the argument on the merits of *miniaturize* vs *minify* . . .

Both sides have strong arguments, but in a technical field we can't allow artistic or other nontechnical considerations to have undue influence. The main thing is mutual understanding.

The old word is familiar; I say stick with it.

H. N. STOVER
HADDONFIELD, N. J.

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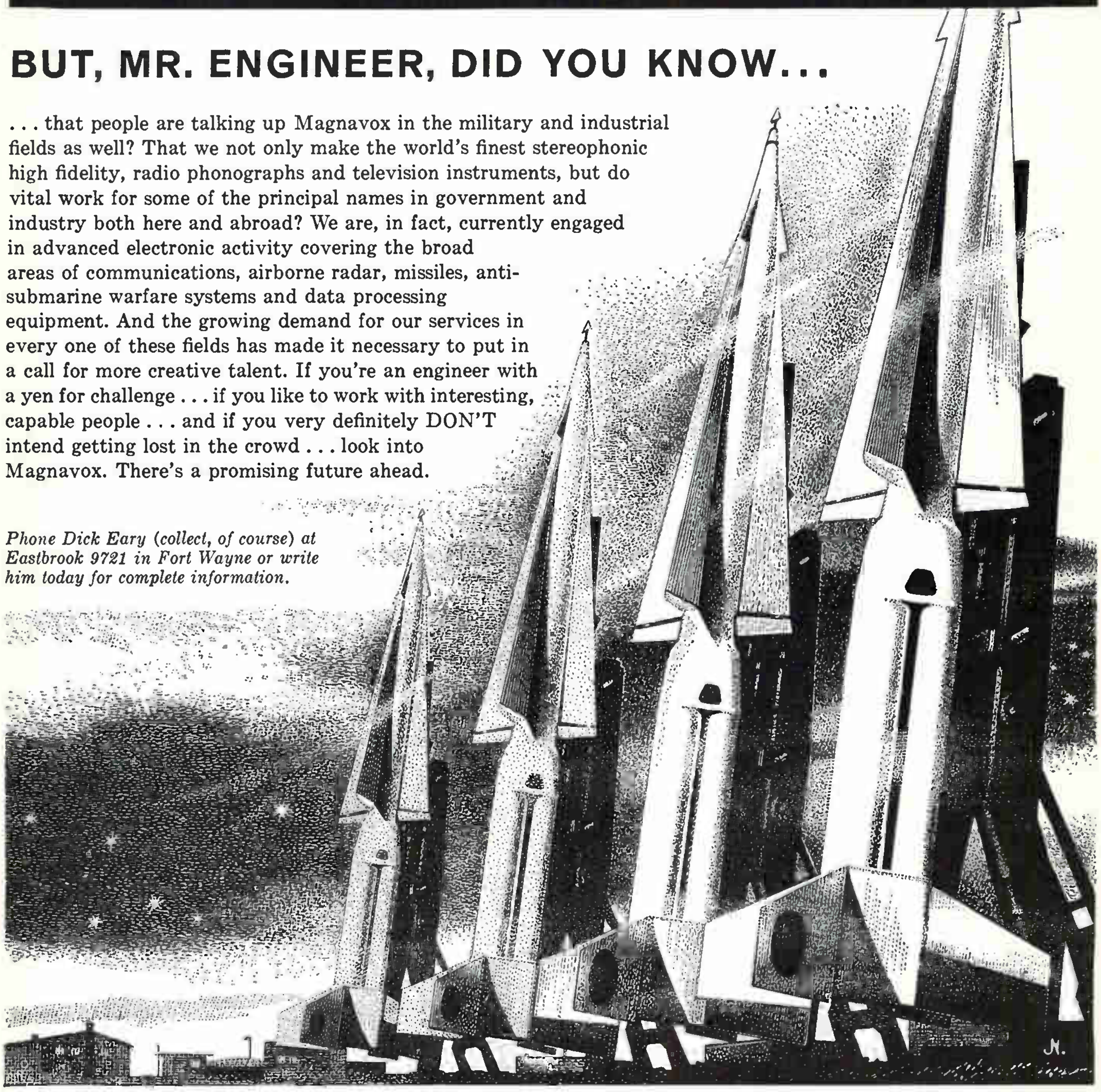

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CIRCLE 462 ON READER SERVICE CARD

INDEX TO ADVERTISERS

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F. J. Eberle, Business Mgr.

ADVERTISERS INDEX

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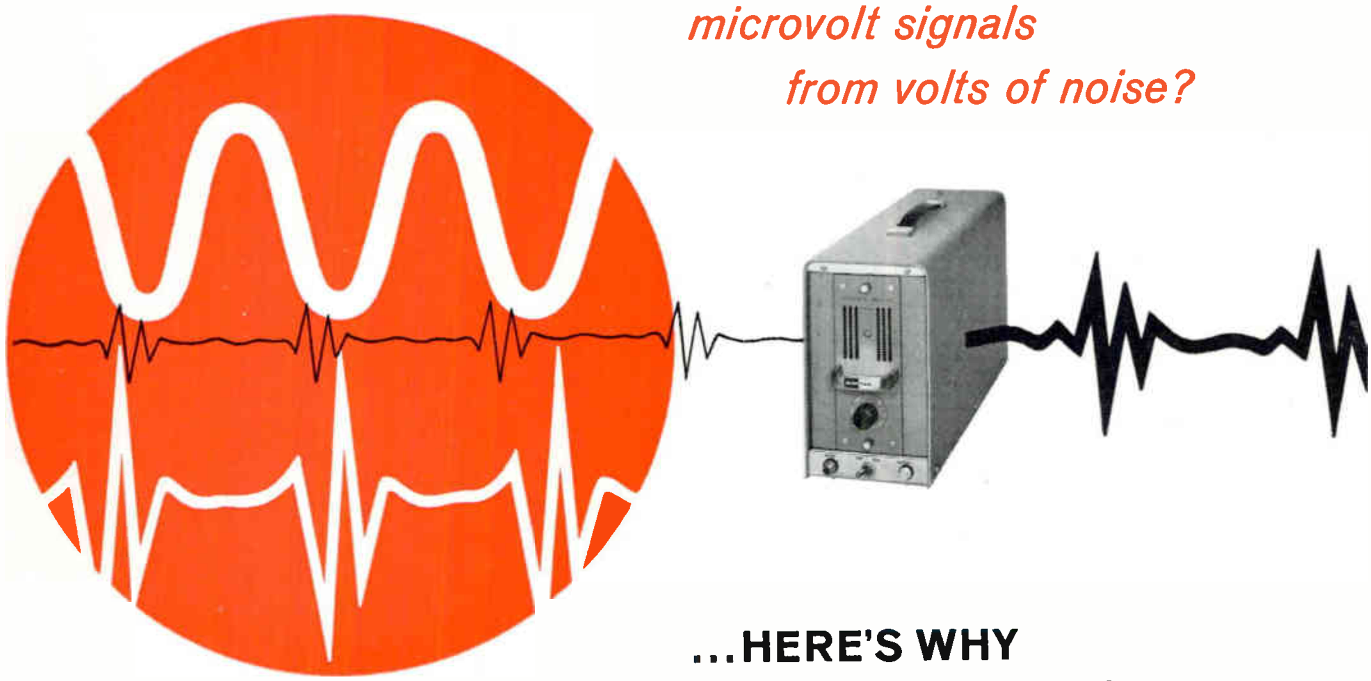

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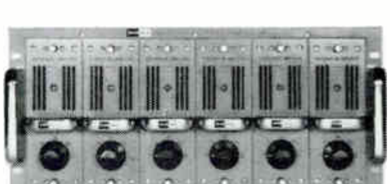

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