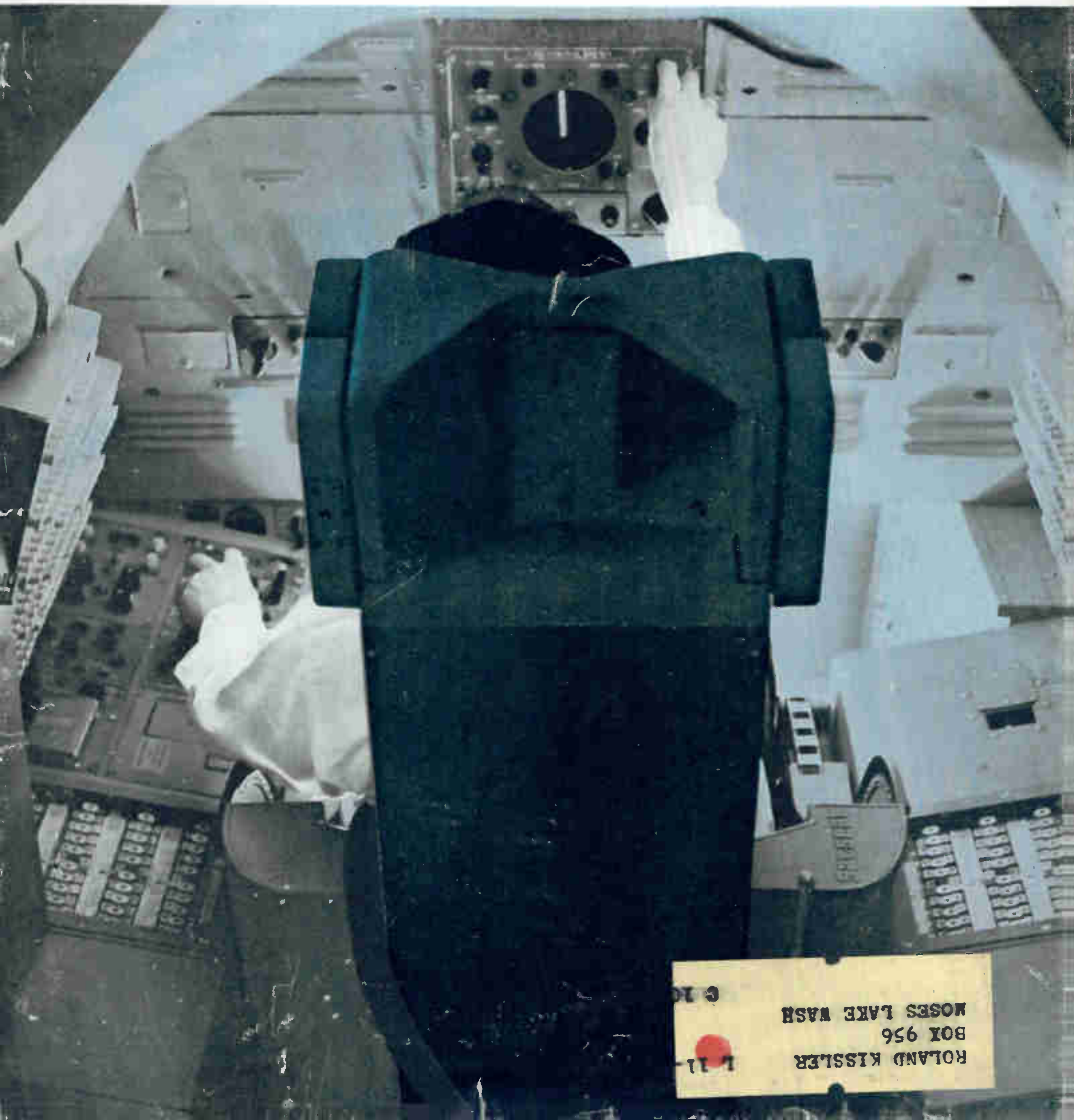
April 7, 1961

electronics

Student, below, is learning how to jam hostile radar using countermeasures and fire-control simulator for B-58 bomber, p 26

Designing switching circuits using avalanche transistors, p 81

A McGraw-Hill Publication 75 Cents



1 µw to 10 mw coverage, in power meter ever produced!

This new ⊕ Power Meter makes continual zero-setting a thing of the past, even on the 10 µw range, with extreme temperature stability and a single zero-set covering all 7 ranges. You get a completely usable 10 db sensitivity premium over previously available equipment.

New, specially designed temperature compensated thermistor mounts are used with the ⊕ 431A. The ⊕478A Coaxial Mount covers 10 MC to 10 GC, and the ⊕ X486A Waveguide Mount covers X-Band.

A dual balanced bridge technique and careful design and construction keep dc power in one bridge equal to the unknown rf power in the other. The dc power is then metered. High heat conductivity materials and matched thermistors in close proximity in the 478A and 486A mounts provide extremely close thermal tracking. Thus ambient temperature effects are automatically balanced out and the meter remains zeroed, even in the presence of thermal shock.

These advantages combine to make the ⊕ 431A unusually useful for instantaneous microwave power measurements. Microwave power standards measurements can be made to a high accuracy and resolution by using the dual bridge of the ⊕ 431A as a transfer device. A dc calibration input jack permits precise dc calibration of the thermistor mount. The grounded output jack will then drive an appropriate digital voltmeter for increased resolution. In addition, the grounded output jack, combined with the nearly drift free operation of the 431A, makes reliable long term recordings of microwave power.

The ⊕ 431A also has an optional rechargeable battery pack which will give up to 24 hours of completely portable operation, as well as regular ac line operation while recharging.

SPECIFICATIONS

Power Range:	10 µw to 10 mw full scale in 7 ranges. Also calibrated from −30 to +10 dbm
Accuracy:	±3% of full scale on all ranges
Overall Thermal Drift:	Less than 2 µw/°C (includes meter and 478A/486A Mounts)
Operating Impedance:	100 or 200 ohms, negative, for operation with above Mounts
Recorder/Voltmeter Output:	Phone jack on rear with 1 ma into 2,000 ohms or less
Calibration Input:	Binding posts on rear for calibrotion of bridge with precise dc standards
Power:	1½ watts, 115/230 v ± 10%, 50-1000 cps
Dimensions:	7½" wide, 6½" high, 12½" deep. Weight 10 lbs.
Price:	$345.00

or perhaps your power measuring requirements can be met by these ⊕ meters

⊕ 430C Microwave Power Meter — 0.02 to 10 mw

This laboratory-proven meter gives instantaneous rf power readings direct in dbm or mw, 10 MC to 40 GC with ⊕ proven bolometer mounts available now. ⊕ 430C operates with any bolometer operating at 100 or 200 ohms, positive or negative temperature coefficient. Fully adjustable biasing current to 16 ma available to bring bolometers to their operating range. Five power ranges are selected with a front-panel control, full scale readings of 0.1, 0.3, 1, 3 and 10 mw. Also continuous readings —20 to +10 dbm. Accuracy is ±5% of full scale reading. Dimensions, (cabinet) 7½" x 11½" x 14"; (rack mount) 19" x 7" x 13½" behind panel. Price, ⊕ 430C $250.00 (cabinet); ⊕ 430CR, $255.00 (rack mount).

⊕ 434A Calorimetric Power Meter — 10 mw to 10 w

Here's the fastest, easiest means yet devised to measure powers accurately from 10 mw to *10 w*, dc to 12.4 GC! No barretter, thermistor, external terminations or plumbing are required. Measurements are as simple as connecting to a 50 ohm type N front panel terminal and reading directly. Only two front panel controls (range and zero); seven meter ranges for full scale readings of 0.01, 0.03, 0.1, 0.3, 1.0, 3.0 and 10 w. Also provides continuous readings —30 to +10 dbw. Accuracy ±5% of full scale (includes dc calibration and rf termination efficiency but not mismatch loss). Greater accuracy can be achieved through appropriate techniques. Dimensions, (cabinet) 20½" x 12½" x 14¾"; (rack mount) 19" x 10½" x 13½". Price, ⊕ 434A, $1600.00 (cabinet); ⊕ 434AR, $1,585.00 (rack mount).

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Unique temperature stability, the most stable microwave

Thermal drift less than 2 μw/°C
±3% accuracy on all ranges

Single setting zeroes all ranges for hours

Easy to operate

Grounded recorder output

Optional portable operation

New hp 431A Power Meter

New hp Thermistor Mounts assure hp 431A Thermal Stability

hp 478A Thermistor Mount

This wide-range, temperature compensated coaxial mount covers 10 MC to 10 GC, with no tuning required. Closely matched thermal environments for the two thermistor pairs for use with the dual bridge hp 431A assure excellent tracking, even under thermal shock. The hp 478A as used with the hp 431A provides high accuracy and virtually drift-free operation.

SPECIFICATIONS

Frequency Range:	10 MC to 10 GC
SWR:	Less than 1.5 (less than 1.3, 50 MC to 7 GC)
Power Range:	1μw to 10 mw (with hp 431A)
Elements:	Four 100-ohm, negative temperature coefficient thermistors permanently installed.
Price:	$145.00

hp 486A Waveguide Thermistor Mount

X-Band Mount, 8.2 to 12.4 GC, provides close temperature tracking with the hp 431A, even in the presence of thermal shocks. No tuning is required. Unusual freedom from drift is assured with extremely close temperature tracking achieved through careful matching of thermal environments for the two thermistors.

SPECIFICATIONS

Frequency Range:	8.2 to 12.4 GC
Power Range:	1μw to 10 mw
SWR:	Less than 1.5
Elements:	Two permanently installed 100-ohm negative coefficient thermistors for each bridge
Waveguide Size:	1" x 1½"
Price:	$145.00

April 7, 1961

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BUSINESS

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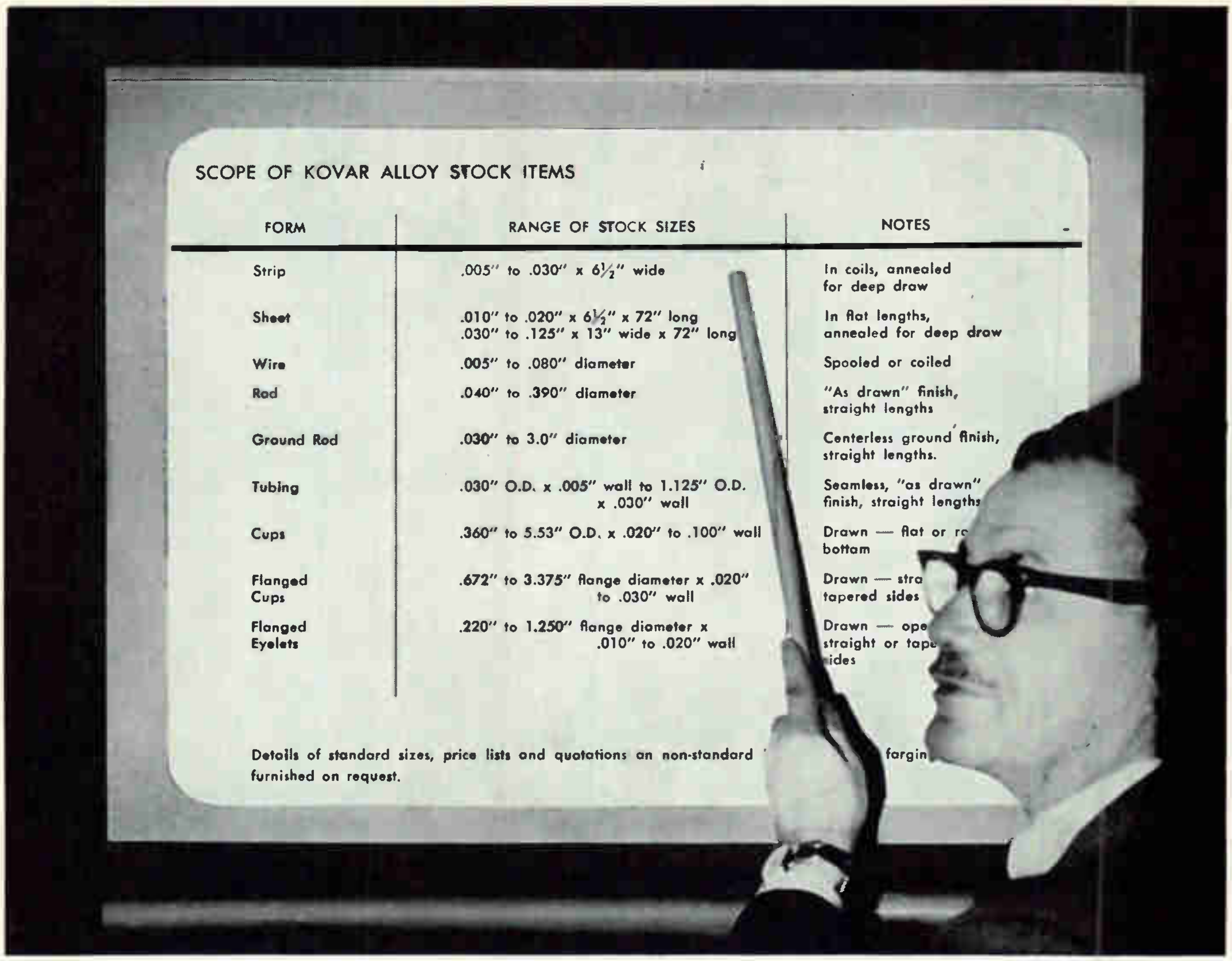

Engineering hints from Carborundum

Check stock forms of KOVAR® Alloy to simplify production problems

KOVAR®, the original iron-nickel-cobalt alloy for making seals with several hard glasses comes in a variety of forms, sizes and parts available as *stock* items for immediate shipment.

The table above summarizes the breadth of these stocks. It does not, of course, cover the wide range of available sizes. For example, over forty sizes of seamless KOVAR alloy tubing are maintained as stock items. Complete, up-to-date data sheets giving specifications, dimensions, surface finishes, tolerances and other details sent on request.

For applications that cannot be served satisfactorily by stock items, specials can be supplied. Complete technical service is offered to help in solving particular processing and application problems. Just write The Carborundum Company, Refractories Division, Dept. E-41 Latrobe Plant, Latrobe, Pa.

FIND OUT ABOUT KOVAR— WHERE IT IS USED AND WHY

Bulletin 5134 gives data on composition, properties and applications of KOVAR alloy. Supplementary technical, dimensional and price data sheets are available to you on specific request.

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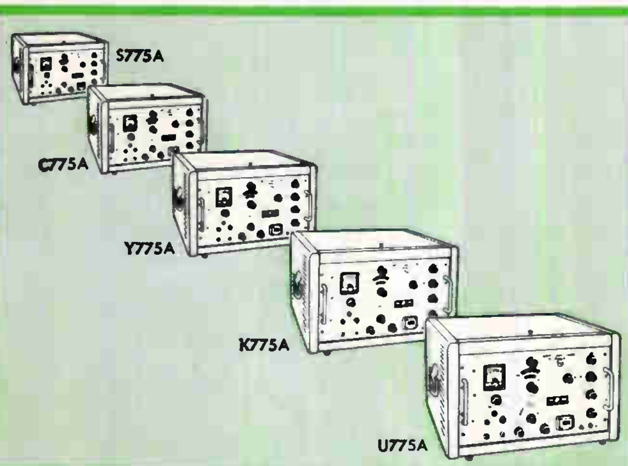
- AGC Provision Eliminates Need for Slow Response Ratiometer Set-ups
- Convenient, Portable, Versatile

for fast, visual reflectometer tests ranges from 2 to 40 KMC

Another breakthrough in measuring convenience has been achieved by the newly expanded FXR family of self-contained, direct reading sweep signal sources. Coverage is now provided as high as 40 KMC. Each unit utilizes a permanent magnet BWO as the tunable RF source.

Output power can be equalized at any detection point relative to the response of the detection element through use of FXR's exclusive built-in AGC circuit. This circuit provides a flat (±0.5 db level) on modulated signal throughout the swept frequency range when used with matched bolometers and directional couplers. This AGC provision eliminates the need for using slow response ratiometers, and allows for visual VSWR or Reflection Coefficient tests.

FXR FAMILY OF ALL ELECTRONIC SWEEP SIGNAL SOURCES



Model Number	Frequency Range (KMC)	Approx. Minimum Power Out.	OUTPUT Waveguide Type	OUTPUT Connector	Price
S775A	2.0-4.0	70 mw	(⅜" Coax Type N)		$2750.
C775A	4.0-8.0	20 mw	(⅜" Coax Type N)		$2800.
X775A	8.2-12.4	20 mw	WR-90	UG-39/U	$2900.
Y775A	12.4-18.0	10 mw	WR-62	UG-419/U	$3300.
K775A	18.0-27.0	5 mw	WR-42	UG-595/U	$3700.
U775A	27.0-40.0	5 mw	WR-28	UG-599/U	$4300.

Characteristics and prices subject to change without notice.

GENERAL SPECIFICATIONS

SWEEP RATE (Resolution): 0.3 to 300 KMC/sec linear with time
SWEEP WIDTH: approximately 200 KC to full frequency range
OUTPUT SIGNAL: CW, square wave (internal 800 to 1200 cps)
FREQUENCY DIAL ACCURACY: ±1% for fixed frequency operation
±2% for sweep frequency operation
POWER REQUIREMENTS: 115/230 v., 50/60 cycles, 200 w.
DIMENSIONS: 12⅞" high x 21¾" wide x 18" deep
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electronics
Apr. 7, 1961 Volume 34 Number 14

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Executive, editorial, circulation and advertising offices McGraw-Hill Building, 330 West 42nd Street, New York 36, N. Y. Telephone Longacre 4-3000. Teletype TWX N.Y. 1-1636. Cable McGrawhill, N.Y. Printed in Albany, N. Y.; second class postage paid.

Subscriptions are solicited only from those actively engaged in the field of the publication. Position and company connection must be indicated on orders. Subscription rates: United States and Possessions, $6.00 one year; $9.00 two years; $12.00 three years. Canada, $10.00 one year. All other countries $20.00 one year. Single Copies, United States and Possessions and Canada 75¢; Buyers' Guide $3.00; Single Copies all other countries $1.50; Buyers' Guide $10.00.

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CROSSTALK

MIDWEST RESEARCH. Our industry, more than any other, knows the value of research. It gave us birth, growth and size. And it gives us an unlimited future. Therefore, this week we report with more than casual interest a development in Ames, Iowa.

A research program into solid-state electronics is being set up there at Iowa State University. The program will be operated with continuing financial support from industrial affiliates throughout the country. Participating companies will get new ideas, information, applications and the talents of 15 to 20 trained graduates as a return on their research investment. For a description of the program's four major areas, and other information, see p 28.

NEW SIMULATOR. The mounting costs of operating complex weapon systems for training personnel continue to create a market for economically-operated simulators. Both variety and complexity of simulators are growing.

A good example of the sophistication now required is the new fire control/electronic countermeasure simulator for the B-58 Mach 2 bomber. Details of this new equipment, now being used at Strategic Air Command bases, are not only revealing from a simulator standpoint but also throw light on the workings of the still highly-classified B-58 ecm system itself. Read our article on p 26.

Coming In Our April 14 Issue

COMMUNICATIONS. Increasing dependence upon radio communication coupled with the crowding of the radio spectrum has resulted in a need for high-performance receivers that can operate with maximum resistance to interference. This need dictates a concomitant requirement for testing specifications, methods and standards by which a given receiver can be graded.

Next week, B. T. Newman of General Electronic Laboratories in Cambridge, Mass., and H. Cahn and R. Keyes of U. S. Army Signal Research and Development Laboratory in Fort Monmouth, N. J. describe methods for testing and objectively grading the performance of voice-communication receivers. Their article presents testing and scoring methods that help the design engineer grade receiver performance by comparing performance with standards based upon an ideal receiver having the most easily definable characteristics.

SWEPT FREQUENCY RECEIVER. An S-Band swept receiver that permits continuous reliable measurement of solar radiation throughout the range of 2,000 to 4,000 Mc is described in our next issue by D. W. Casey II of ITT in Fort Wayne, Ind. Use of a zero frequency i-f improves the noise figure, eliminates images and permits the use of simple video i-f amplifiers.

CIRCLE 5 ON READER SERVICE CARD→

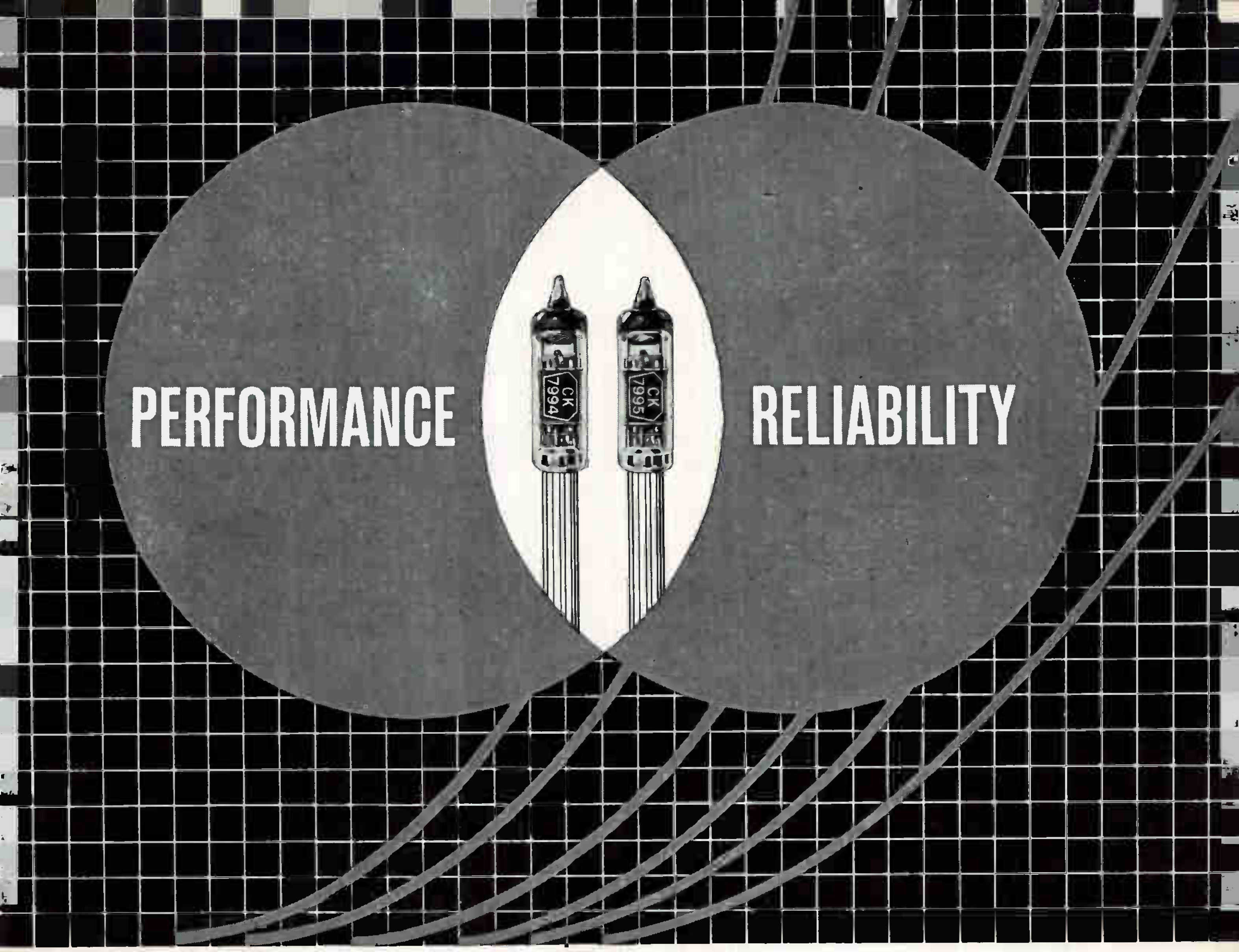

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PLATE VOLTAGE	100 Volts	150 Volts
GRID #2 VOLTAGE	–	150 Volts
CATHODE BIAS RESISTANCE	82 Ohms	160 Ohms
GRID #1 VOLTAGE	0 Volts	0 Volts
PLATE CURRENT	15 mA	8.0 mA
GRID #2 CURRENT	–	2.0 mA
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AMPLIFICATION FACTOR	43	–
Ecl for Ib = 10 A	–6 Volts	–6 Volts

There's no longer any need to sacrifice performance and reliability for small size. Raytheon frame grid subminiatures now fill your design needs with extremely compact tubes of higher gain bandwidth product, lower noise figure, and greatly increased reliability. Two subminiatures with exceptionally high transconductance to plate current ratios are immediately available.

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COMMENT

Arecibo

In response to your article "World's Largest Dish to Aid A-Blast Detection," p 20, Jan. 27, we would like to bring certain facts to your attention.

The facility you describe as the Arecibo Radio Observatory is the Department of Defense ionospheric research facility at Arecibo, Puerto Rico. It is being built for the Advanced Research Projects Agency and is funded by ARPA as part of Project Defender, a program of advanced research in ballistic missile and satellite defense. This program was suggested by and will be supervised through Cornell University under a contract administered for ARPA by the Air Force. Facilities at the site are being planned and constructed by the Army Corps of Engineers.

The instrument you describe as a telescope is in fact primarily a radar which can also be used as a radiotelescope. It will be used principally as a research tool to study the ionosphere, an environment through which satellites and other high-flying objects must pass during their flight. In order to devise proper detection, tracking, and interception techniques for appropriate defense systems, the characteristics of the ionosphere under varying conditions (such as solar activity) and the behavior of objects passing through it must be carefully analyzed. This research will include, for example, the measurement of electron density and the incoherent scattering cross-sections of electrons. It is hoped that the radar to be constructed at Arecibo will provide such fundamental knowledge. It will also be used in the future, as your article suggests, to perform experiments in radioastronomy and the more precise measurement of interplanetary distances.

ELECTRONICS has speculated that the ionospheric research facility is "part of a network for detection of the ionospheric effects of nuclear explosions." We wish to advise you categorically that the facility is not part of a nuclear detection network. It is a scientific laboratory of great potential, and we believe it will enable us to enhance our overall basic knowledge of the ionosphere and space phenomena. ARPA, of course, is studying the scientific and technical aspects of ground-based and space-based detection of nuclear tests in space as part of project Vela, the national program of research and development in nuclear test detection, both underground and at high altitudes. The ionospheric research facility, however, is not part of this test detection research effort.

We are pleased that ELECTRONICS has demonstrated an interest in the ionospheric research facility, but we hope that these comments may be published to clarify the record with respect to its purpose.

J. P. RUINA
ADVANCED RESEARCH PROJECTS AGENCY
WASHINGTON, D. C.

A Department of Defense report on the Arecibo installation says in part: "Among (ionospheric) research projects awaiting completion of the dish (is) . . . detection of natural and manmade disturbances and shocks." The only significant way we know of that man can disturb or shock the ionosphere is by nuclear detonation.

Infrared Transceiver

We would like to rectify a misconception which appears in our article "Solid-State Modulators for Infrared Communications," p 177, Mar. 10. The article describes a prototype infrared transceiver. However, the photographs shown are of Maxsecom (maximum security communications) infrared transceivers developed by Honeywell's aeronautical division in West Los Angeles, based on our prototype.

The performance figures which we quote refer to the prototype rather than to the Maxsecom units, which exhibit superior performance. We would appreciate it if you would point this out to your readers.

PAUL W. KRUSE
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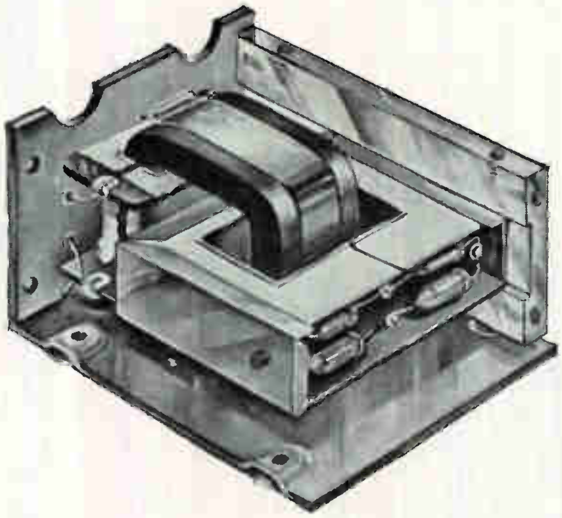

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Significant features of the Isoformer are: (A) Tape-wound magnetic core (B) Shielded primary winding (C) Shielded secondary winding separated from core by air gap.

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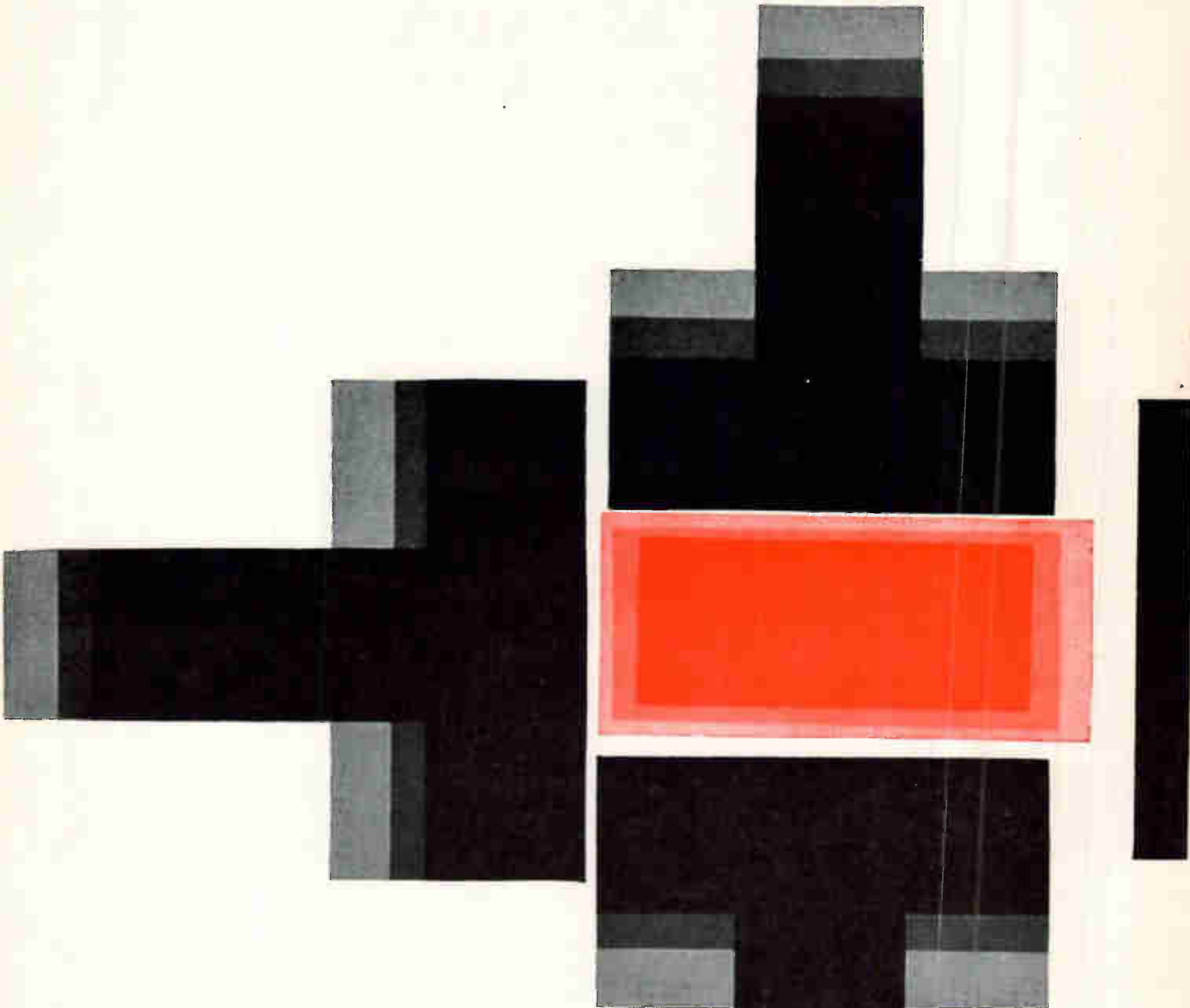
Mallory miniature tantalum capacitors



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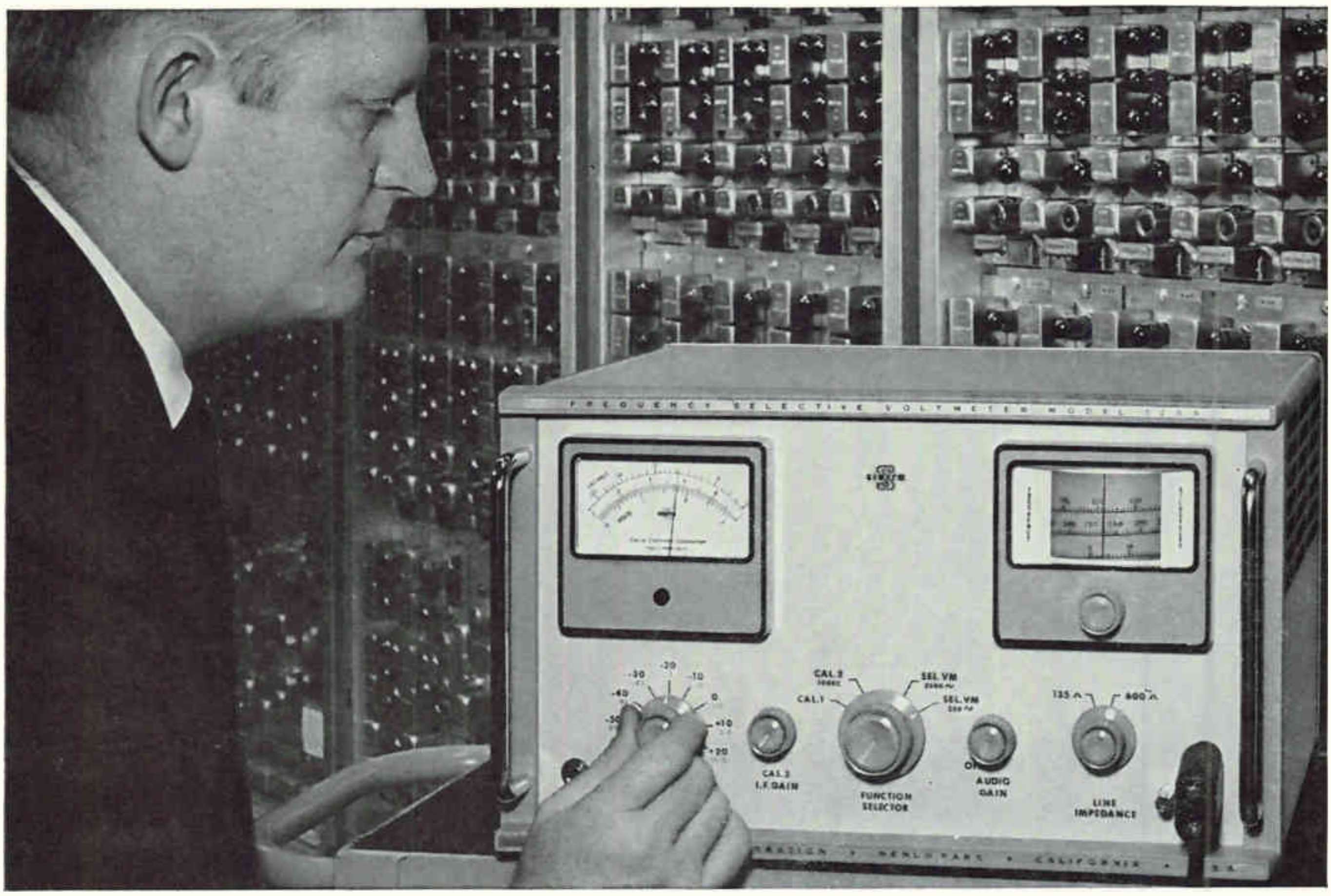

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- Dual selectivity—versatility for communications test, wave analysis, general lab use

SPECIFICATIONS
MODEL 125A

Frequency Range
Tunable Mode: 3 kc to 620 kc
Flat Mode: 1 kc to 620 kc

Measurement Range
Tunable Mode: —90 dbm to +32 dbm
Flat Mode: —30 dbm to +32 dbm

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Narrow: Down 3 db 125 cps off resonance; down 45 db 500 cps off resonance
Wide: Down 3 db 1.25 kc off resonance; down 45 db 5 kc off resonance

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7127

ELECTRONICS NEWSLETTER

Report Navy Is Using New Antisub System

NAVY is reported to be using a submarine-locating device that magnetically attaches itself to the side of a target sub, then broadcasts a beacon on which surface, subsurface ships, planes can home. The parasite transmitter cannot be dislodged by maneuvering, begins transmitting as soon as it makes contact with the sub. If a target submarine should surface to dislodge the instrument, it would give its position away to airborne radars. The device will probably be sown in strategically important channels.

In other antisubmarine defense developments, Huyck Systems was given a $3-million contract for pilot production of AN/ASN-30 tactical ASW display and computer systems. The airborne system is meant for the S2F3 aircraft, a carrier-borne hunter-killer craft. System takes several detector inputs, pinpoints target location, also presents dead-reckoning navigational information for the pilot.

Magnavox received a $10.5-million contract for ASW radars to be mounted aboard the landbased P2V and P3V aircraft. The P3V is the modified Lockheed Electra that is now entering fleet for ASW use.

USAF Asking Bids On Combat Op Center

AIR FORCE announced last week that the 425L system will be open for bids on April 19. The 425L system is designed to be the combat operations center for the North American Air Defense headquarters in El Paso County, Colorado. Construction work will begin before June on the site for the new operations center under Cheyenne Mountain; Defense Department released $8.5 million to begin the work a few weeks ago. The 1962 budget includes an additional $12.4 million for the construction phase of the project.

Total cost of the Cheyenne Mountain facility is expected to be about $66 million. Of this, reliable estimates indicate that about a third will be used up in building the facility. The other $44 million will be spent for equipment, including the high-speed communications systems and electronic computers that will help NORAD officers keep track of the continental defense picture. NORAD officers say that much of the electronic equipment is "only in the R&D stage."

The 425L system is now closer to hardware than two other top-priority L systems. The 465L Strategic Air Command control system is still under development by ITT, and the 473L data-processing and command display system for headquarters USAF is under study by the Air Force and International Business Machines.

Four-MM-Wave Maser Uses Carcinotron Pump

CONTINUOUS-WAVE maser was successfully operated at 4 mm recently by G. S. Heller of MIT's Lincoln Laboratory. Heller used the same crystal type—iron in titanium oxide—as was used in the Lincoln Lab 8-mm maser that is now being readied for use in moon-bounce experiments. Operation at 4 mm was achieved by using a carcinotron to pump the maser. The carcinotron, a backward wave oscillator, was developed for Lincoln Lab by Compagnie de Telegraphie sans Fil of France. It operates on 2 mm, gives out 100 mw at 76 Gc. Gain and bandwidth measurements are now being made on the new maser.

Microwave Radio Systems Employing Transistors

NEW MICROWAVE SYSTEMS entering the market this week feature solid-state construction and increased reliability.

Motorola has developed a transistor microwave package which includes r-f, multiplex, telegraph carrier and alarm equipment. All stages except the r-f transmitter now use transistors; the transmitter contains a long-life reflex klystron. Equipment operates in the 6-Gc region, contains a transmitter automatic frequency control that provides a frequency stability of ±0.005 percent. As many as 600 subcarrier channels of toll-quality voice can be carried on the multiplex equipment. Telegraph carrier provides 18 frequency-shift tone channels over a single voice circuit, and 22 channels that are applied directly on the baseband of a radio communications carrier.

General Electric's microwave system incorporates an error-reducing feedback technique that GE claims can give tenfold increase in power output with 50 percent less power input. Details of the system were not disclosed. The company says that the lowered power drain of the transistor circuits permits operation of the system on battery power; the system is designed for a-c/d-c operation.

Electrochemical Diffusion Makes High-Current Transistor

EXPERIMENTAL TRANSISTOR designed for high-current core driver type applications has been produced by Sprague Electric. The unit is a germanium electrochemical diffused collector transistor, called ECDC for short. It is fabricated by an etching and plating process.

The ECDC is said to have the fast switching characteristics of a microalloy diffused type, can handle larger currents. Collector current rating is 500 ma. Total power dissipation in the device at room-ambients is 200 mw. Sprague plans to try for dissipation levels of 2 and 3 watts using the same construction.

Highway Radiophone Powered by Sun

SUN-POWERED transmiter to allow drivers to call for help along expressways was demonstrated to Chicago and Cook County traffic engineers last week.

System was developed by Hoffman Electronics, is similar to the system used to power orbiting satellites. An experimental adaptation of the satellite system is now in use on the Los Angeles freeway system, provides four pushbuttons to select police, fire, ambulance or mechanical assistance. Hoffman proposed to install the radiophones at half-mile intervals along Lake Shore drive and other Chicago-area expressways, and along all of the 1,500 miles of federal interstate expressway to be built in Illinois.

Cost of regular phone service along tollways is frequently steep; besides, drivers in emergencies don't always have a dime to put in the coinbox. Hoffman spokesmen figure it would cost $20,000 to put in four central receivers at highway police stations, plus $182,000 for 364 call boxes, to serve the Illinois tollways. Maintenance would cost about $48 a box, or $17,472 a year.

Ion Bombardment Used To Dope Semiconductors

MORE INFORMATION about the tightly guarded—and hotly competitive—subject of nuclear bombardment of semiconductors was disclosed last week. High Voltage Engineering Corp. discussed research in the use of positive-ion bombardment to implant controlled amounts of impurities in transistor surfaces.

The company's E. A. Burrill says "heavy ions such as arsenic or antimony can be accelerated to sufficient energies to become imbedded in crystal lattices. Alternatively, neutron bombardment of pure germanium can produce radioactive centers of controlled distribution and concentration in the volume, eventually decaying to stable gallium, an effective impurity for transistors."

Research work may be useful in developing techniques for implanting impurities in tiny areas of a semiconductor surface as part of the molecular engineering technology.

Two Wires Carry 50,000 Bits By Diphase Transmission

NEW TECHNIQUE for handling high-volume digital data was announced last week by RCA. Known as differential diphase transmission, the technique uses two wires, was developed for the Minuteman ICBM program. The two wires provide for data and timing through the use of two-phase transmission, with a simple crystal-controlled clock used to generate timing information. Data rates range from 600 to 2,400 bits per second; RCA claims to have transmitted 50,000 bits per second under laboratory conditions, with higher bit rates possible.

Two-phase technique produces a fair degree of insensitivity to amplitude variations in the line, RCA says, thus making automatic gain controls unnecessary.

Japan Will Produce Own Air-Air Missile

JAPAN's Self-Defense Agency disclosed last week that its 5-ft Mighty Mouse will be produced in quantities of about 10,000 in fiscal 1962. This is the first air-to-air missile developed by the Agency's own laboratory and Japanese industry that will be produced for the defense forces. An antitank missile previously was produced, but the air defense forces had borrowed the U.S. Sidewinder missile, of which Japan has so far bought about 40,000.

Explorer X Finds Strong Magnetic Fields

EXPLORER X, launched from Cape Canaveral on March 25, found magnetic fields far out in space that were stronger than space experts had anticipated. National Aeronautics & Space Administration disclosed last week that data from the 78-lb vehicle indicated fields at 60,000 miles that were "considerably stronger than expected."

The space probe lofted some 112,000 miles from the earth, fell back into the Pacific three days later.

Chicom Telecommunications Copy East German Models

LIMITATIONS of the electronics industry in the Chinese Peoples Republic apparently have hindered the development of modern telecommunications, according to a government analysis. The Chicom Ministry of Posts & Telecommunications has been trying to produce Chinese-character teleprinter equipment since 1953; the equipment now in use to do this job is not of CPR design, but was borrowed from designs produced in the German Democratic Republic (East Germany). Although research and development are being pressed, the government analysis indicates that China's electronics industry still seriously lags that of the West.

Driver Early Warning Spots Radar Traps

RADAR SENTRY that seeks out radar speed traps and alerts the driver by sounding an alarm is being marketed by Radatron Inc., North Tonawanda, N. Y.

Warning device weighs 11 oz, can fit in the palm of the hand, operates from a self-contained battery. It contains a detector sensitive to the spectrum used for police radar; detected output is amplified to power an audible alarm. Range of the device is about a quarter of a mile—1,200 to 1,500 ft—so as not to encourage speeding. When it detects a signal, it puts out a whistle which grows louder as range decreases. Police in several communities have so far not complained about its use.

System Can Control Oil Production Remotely

LOGGING AND TELEMETERING system introduced last week by RCA can keep constant vigil over oil wells and pipelines, relaying instructions to the wellheads and reporting production data. Central control can be placed hundreds of miles from wellheads and pumping stations; orders from the control panel and data for logging and display are exchanged over a telemeter link that can use vhf radio, telephone or telegraph lines, submarine cable (in the case of offshore installations) or microwave. System is dubbed Alert (automatic logging electronic reporting and telemetering), works with RCA's type 130 date-transmission link.

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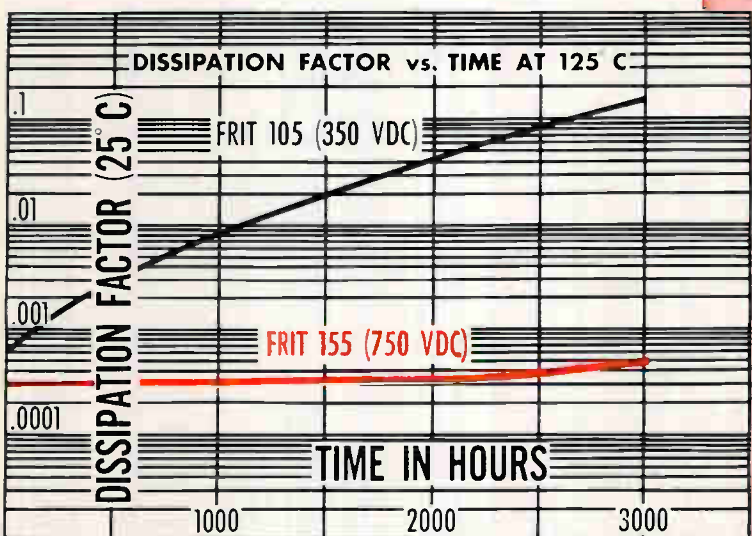

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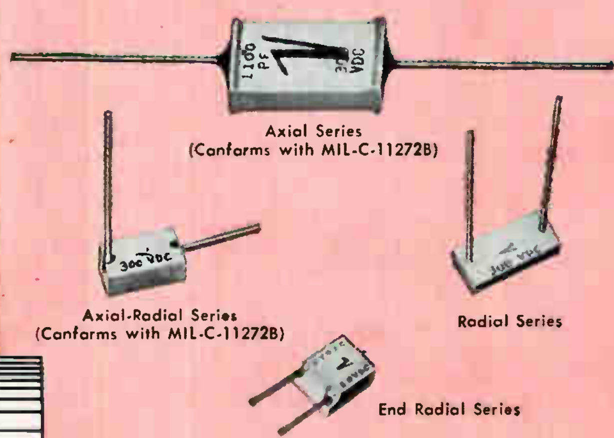

When tested at 125°C with more than twice previous test voltages applied (750 VDC vs 350 VDC and 450 VDC vs 200 VDC) and with the time extended to 2000 hours (more than 10 times as stringent a test) post-test dissipation factor is .002 max. and insulation resistance is greater than 100,000 megohms (10 times better)!

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WASHINGTON OUTLOOK

THE KENNEDY ADMINISTRATION changes in Eisenhower's Pentagon budget for fiscal year 1962, starting July 1, will result in a massive reshuffling of military electronics contracts.

For electronics firms working on the Polaris missile and submarine, Minuteman ICBM, Skybolt missile, Midas, Samos and several other projects, contracting schedules are being substantially boosted. But cutbacks or cancellations are in store for contractors on the Titan II missile, B-70 bomber, Eagle missile and aircraft nuclear propulsion projects.

Effect of the changes is to boost total new procurement and R&D contract awards in the new year roughly $1 billion over Eisenhower's schedules. This figure excludes the five Polaris submarines and extra missiles and the 53 transport planes ordered by Kennedy since his inauguration. Funds for these contracts, however, are sought in the budget revision.

THE POLARIS PROGRAM is being expanded once again by five vessels, which makes the current schedule 29 submarines and at least 464 missiles by the end of 1964. GE, Sperry, NAA-Autonetics, and Minneapolis-Honeywell are among the program's major electronics contractors. The new budget earmarks $1.3 billion extra for the program.

The Air Force's Minuteman schedules are rejuggled. Plans for activating three mobile squadrons, 30 missiles each, on rail cars will be deferred. Instead, an additional fixed base will be built to house three squadrons of 50 missiles apiece. The Pentagon figures installation costs for the mobile units at some 60 percent above fixed-base costs. Production capacity will be doubled, but the new plant will be kept on standby for the time being. NAA-Autonetics is the guidance contractor.

Contracting for the Skybolt air-launched ballistic missile will be doubled. The new budget calls for $100 million for the development project. Nortronics is the guidance contractor.

THE REVISED BUDGET also calls for extra funds to install bomb alarm detectors and signals at key warning and communications points and at all SAC bases; an additional $16.4 million to develop and install improved electronic command and control facilities for strategic forces; substantial acceleration of Midas early-warning satellite development; and an additional $226 million to speed work on the Dyna-Soar, Samos, Advent, Defender and Discoverer military space projects.

TO BEEF UP limited-war forces, the new budget provides for a substantially increased ship rehabilitation and modernization program requiring installation of new ASW and fire control apparatus; expanded research on so-called conventional equipment such as electronic tactical command and control gear for Army field use; development of a new fighter plane for both Air Force and Navy use; and accelerated procurement of various types of battlefield equipment (see p 22).

ON THE OTHER SIDE of the ledger: the revised budget kills plans to set up two Titan II squadrons, 18 missiles in underground launching silos. GM's AC div. is the guidance contractor.

The B-70 cutback will mean cancellation for the second time within two years for projects such as Westinghouse's defensive subsystem, Motorola's mission and traffic control subsystem, NAA-Autonetics' automatic flight control subsystem and Sperry's auxiliary gyro platform. The schedule has been cut from assembly of 12 fully equipped prototype planes to only four stripped-down aircraft with bomb-nav systems.

Bendix's Eagle air-to-air missile is knocked out of the budget. The atomic airplane project is also cancelled. The defense budget turned down the Army's plea to begin production of components of Western Electric's Nike-Zeus antimissile system.

KENNEDY also boosted NASA's budget, earmarking $10 million extra for the communications satellite. Total budget is now $44.6 million.

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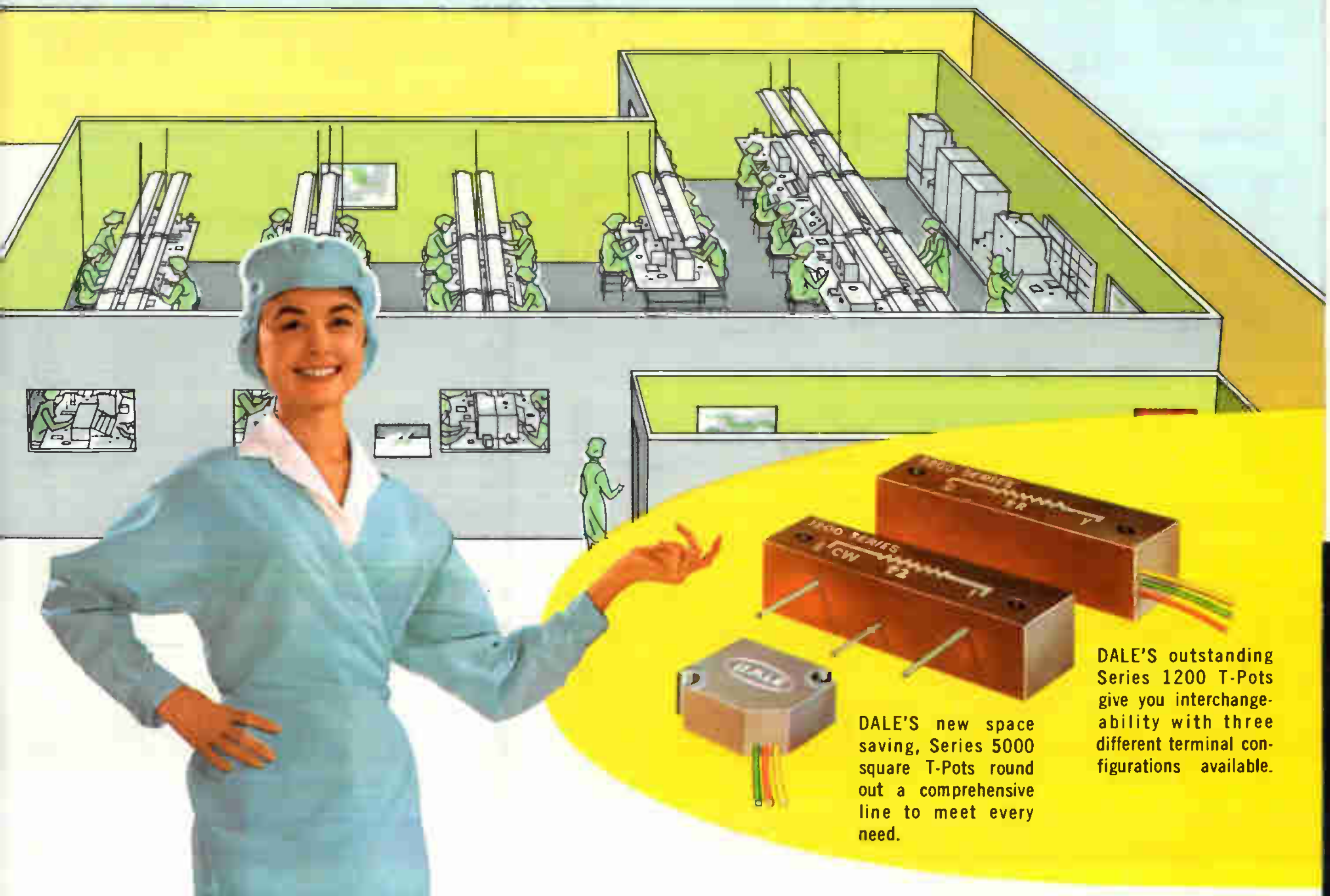

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3. Lightweight precious metal wiper with low weight-pressure ratio provides best performance under vibration and shock
4. "O" ring seal provides protection against humidity, dust and salt spray
5. Thrust spring maintains constant position of lead screw eliminating lead screw backlash
6. Polished stainless steel lead screw is ultrasonically polished for smooth operation and long rotational life
7. Collector provides dual current path for improved reliability and low rotational noise level
8. Wide selection of terminal configurations is available to meet any requirements

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DALE SERIES 1200 WIRE WOUND
A miniature (.280" x .310" x 1.250"), humidity proof, precision T-Pot with welded construction throughout; three different terminal configurations for standard and printed circuit mounting; 10 to 50K ohms; 5% tolerance; 1 watt up to 85° C, derating to 0 at 150° C.

DALE SERIES 900 WIRE WOUND
A sub-miniature (.300" x .180" x 1"), humidity proof, precision T-Pot with welded construction throughout; three different terminal configurations for standard and printed circuit mounting; 10 to 30K ohms; 5% tolerance; 1 watt up to 70° C, derating to 0 at 175° C.

DALE SERIES 600 WIRE WOUND
A sub-miniature (.300" x .180" x 1"), humidity proof, precision T-Pot with welded construction throughout; eight different terminal configurations for standard, panel and printed circuit mounting; 10 to 30K ohms; 5% tolerance; 1 watt up to 70° C, derating to 0 at 175° C.

DALE SERIES 1500 WIRE WOUND
A miniature (.300" x .180" x 1.250"), humidity proof, precision T-Pot with welded construction throughout; nine different terminal configurations for standard, panel and printed circuit mounting; 10 to 50K ohms; 5% tolerance; 1 watt up to 70° C, derating to 0 at 175° C.

DALE SERIES 5000 WIRE WOUND
A new, humidity proof, precision T-Pot with new space saving square configuration (.500" x .190" x .500") and welded construction throughout; 100 to 50K ohms; 5% tolerance; 1 watt up to 70° C, derating to 0 at 150° C.

DALE SERIES 100 WIRE WOUND
A miniature, precision T-Pot, ideal for computers and laboratory type applications; five different terminal configurations for standard mounting; 10 to 50K ohms; 0.8 watt up to 70° C, derating to 0 at 135° C.

DALE SERIES 200 WIRE WOUND
A miniature T-Pot offering dependable performance in normal circuits where economy is important; five different terminal configurations for standard mounting; 10 to 50K ohms; 10% tolerance; 0.5 watt up to 70° C, derating to 0 at 105° C.

DALE SERIES 300 WIRE WOUND
A miniature T-Pot for commercial applications; two different terminal configurations for standard mounting; 100 to 20K ohms; 15% tolerance; 0.25 watt up to 70° C, derating to 0 at 85° C.

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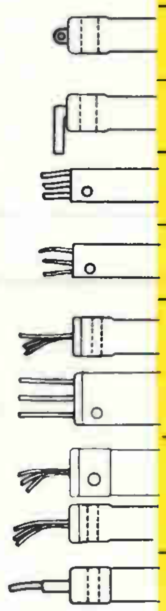
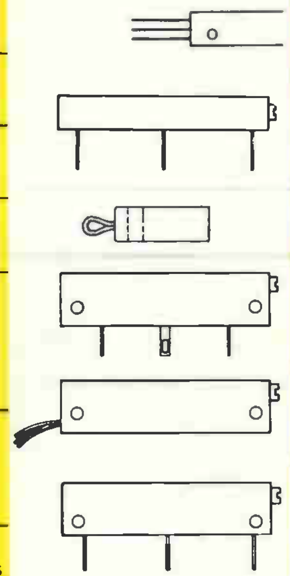
PART NUMBER	TOLERANCE	RESISTANCE RANGE	HUMIDITY PROOF	POWER RATING	RESOLUTION DEPENDING ON VALUE	MAXIMUM OPERATING TEMP (°C.)	CASE DIMENSIONS WIDTH	HEIGHT	LENGTH	MOUNTING HOLE CENTERS	MECHANICAL ADJUSTMENT turns
199 and A10W	± 5%	10 Ohms to 50K Ohms	NO	.8 Watt	.12% to 1.2%	135°	.310	.220	1.250	1.000	25
198 and A10WPC	± 5%	10 Ohms to 50K Ohms		.8 Watt	.12% to 1.2%	135°	.310	.220	1.250	1.000	25
195 and A10WML	± 5%	10 Ohms to 50K Ohms		.8 Watt	.12% to 1.2%	135°	.310	.220	1.320	1.000	25
194 and A10WML-1	± 5%	10 Ohms to 50K Ohms		.8 Watt	.12% to 1.2%	135°	.310	.220	1.320	1.000	25
193 and A10WL	± 5%	10 Ohms to 50K Ohms		.8 Watt	.12% to 1.2%	135°	.310	.220	1.250	1.000	25
299 and B11W	±10%	10 Ohms to 50K Ohms	NO	.5 Watt	.12% to 1.2%	105°	.310	.220	1.250	1.000	25
298 and B11WPC	±10%	10 Ohms to 50K Ohms		.5 Watt	.12% to 1.2%	105°	.310	.220	1.250	1.000	25
295 and B11WML	±10%	10 Ohms to 50K Ohms		.5 Watt	.12% to 1.2%	105°	.310	.220	1.320	1.000	25
294 and B11WML-1	±10%	10 Ohms to 50K Ohms		.5 Watt	.12% to 1.2%	105°	.310	.220	1.320	1.000	25
293 and B11WL	±10%	10 Ohms to 50K Ohms		.5 Watt	.12% to 1.2%	105°	.310	.220	1.250	1.000	25
399 and C12W	±15%	100 Ohms to 20K Ohms	NO	.25 Watt	.6% to 1.2%	85°	.310	.220	1.250	1.000	25
398 and C12WPC	±15%	100 Ohms to 20K Ohms		.25 Watt	.6% to 1.2%	85°	.310	.220	1.250	1.000	25
697 and 750WL-1	± 5%	10 Ohms to 30K Ohms	YES	1 Watt	.23% to 1.82%	175°	.300	.180	1.000	.750	17
692 and 750W	± 5%	10 Ohms to 30K Ohms		1 Watt	.23% to 1.82%	175°	.300	.180	1.000	.750	17
691 and 750WP	± 5%	10 Ohms to 30K Ohms		1 Watt	.23% to 1.82%	175°	.300	.180	1.000	P.C.	17
690 and 750WT	± 5%	10 Ohms to 30K Ohms		1 Watt	.23% to 1.82%	175°	.300	.180	1.000	.750	17
686 and 751WL	± 5%	10 Ohms to 30K Ohms		1 Watt	.23% to 1.82%	175°	.300	.180	1.000	Panel	17
685 and 751W	± 5%	10 Ohms to 30K Ohms		1 Watt	.23% to 1.82%	175°	.300	.180	1.000	Panel	17
684 and 751 WT	± 5%	10 Ohms to 30K Ohms		1 Watt	.23% to 1.82%	175°	.300	.180	1.000	Panel	17
683	± 5%	10 Ohms to 30K Ohms		1 Watt	.23% to 1.82%	175°	.300	.180	1.000	P.C.	17
997	± 5%	10 Ohms to 30K Ohms	YES	1 Watt	.23% to 1.82%	175°	.300	.180	1.000	.750	17
996	± 5%	10 Ohms to 30K Ohms		1 Watt	.23% to 1.82%	175°	.300	.180	1.000	.750	17
983	± 5%	10 Ohms to 30K Ohms		1 Watt	.23% to 1.82%	175°	.300	.180	1.000	P.C.	17
1289	± 5%	10 Ohms to 50K Ohms	YES	1 Watt	.12% to 1.13%	150°	.280	.310	1.250	1.000	25
1288	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to 1.13%	150°	.280	.310	1.250	1.000	25
1287	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to 1.13%	150°	.280	.310	1.250	P.C.	25
1597 and 1000-WL-1	± 5%	10 Ohms to 50K Ohms	YES	1 Watt	.12% to 1.13%	175°	.300	.180	1.250	1.000	25
1592 and 1000W	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to 1.13%	175°	.300	.180	1.250	1.000	25
1591 and 1000WP	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to 1.13%	175°	.300	.180	1.250	P.C.	25
1590 and 1000WT	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to 1.13%	175°	.300	.180	1.250	1.000	25
1586 and 1001WL	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to 1.13%	175°	.300	.180	1.250	Panel	25
1585 and 1001W	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to 1.13%	175°	.300	.180	1.250	Panel	25
1584 and 1001WT	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to 1.13%	175°	.300	.180	1.250	Panel	25
1583	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to 1.13%	175°	.300	.180	1.250	P.C.	25
1580	± 5%	10 Ohms to 50K Ohms		1 Watt	.12% to 1.13%	175°	.300	.180	1.250	P.C.	25
5050	± 5%	100 Ohms to 50K Ohms	YES	1 Watt	.10% to .72%	150°	.500	.190	.500	.520	25

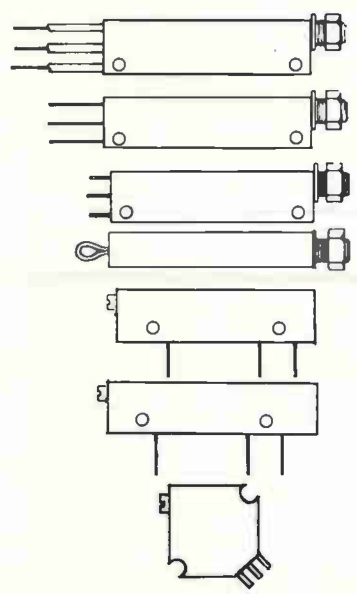
TERMINAL CONFIGURATIONS



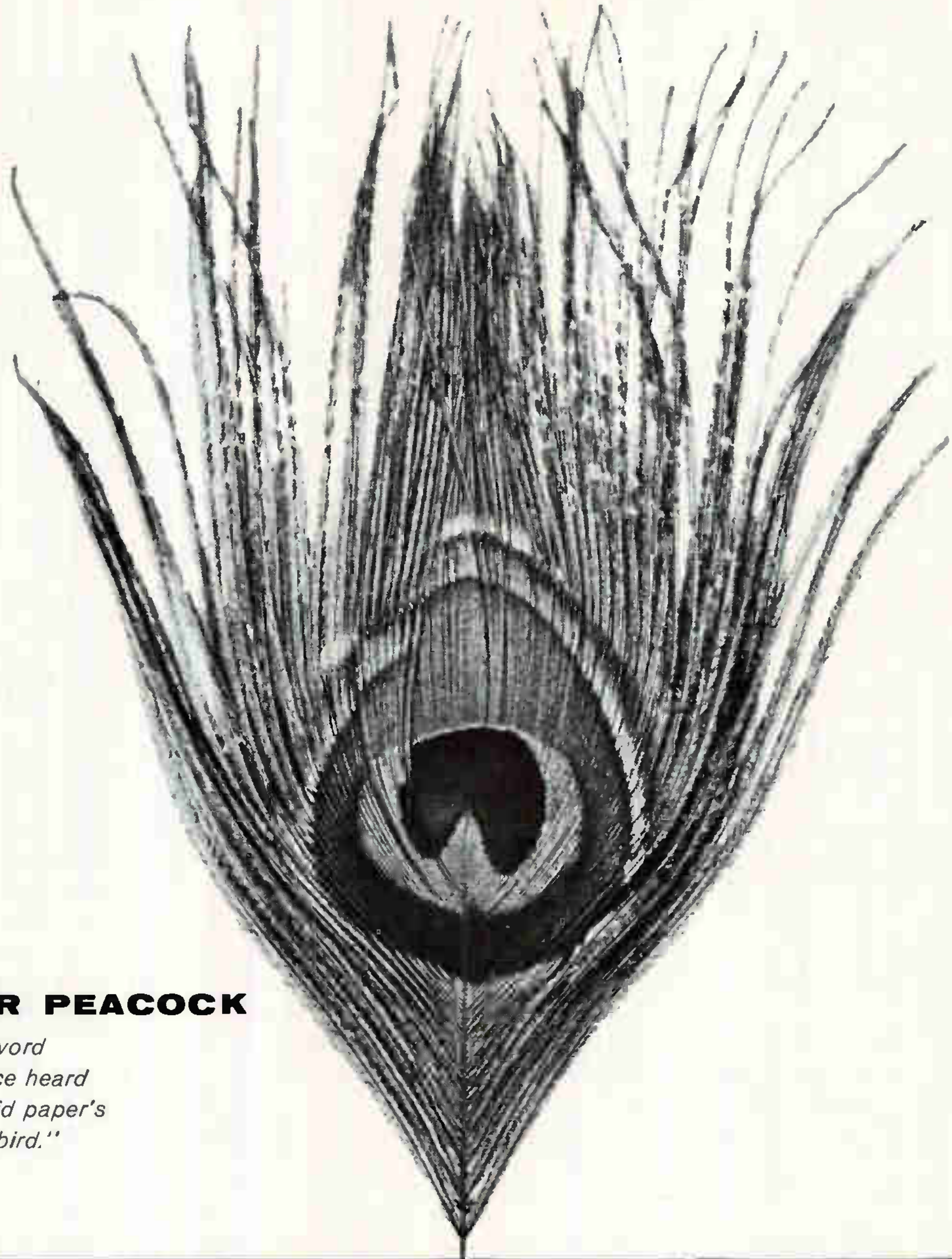
NUMBER	
99	Solder Lug
98	Printed Circuit Solder Lug
97	28 Awg Stranded Teflon Leads
96	30 Awg Stranded Teflon Leads
95	Molded Cap 28 Awg Stranded Vinyl Leads Emerging Separately
94	Molded Cap 28 Awg Stranded Vinyl Leads Emerging as a Group
93	28 Awg Stranded Vinyl Leads Attached to 99 Style Solder Lugs



NUMBER	
92	26 Awg Solid Wire Leads
91	Printed Circuit Pins 22 Awg
90	Hook Type Wire Solder Terminal
89	Solder Lug
88	30 Awg Stranded Teflon Leads
87	Printed Circuit Pins 21 Awg



NUMBER	
86	Panel Mounted Style with 28 Awg Stranded Teflon Leads
85	Panel Mounted Style with 26 Awg Solid Wire Leads
84	Panel Mounted Style with Hook Type Wire Solder Terminal
83	Printed Circuit Pins 22 Awg
80	Printed Circuit Pins 22 Awg
50	30 Awg Stranded Teflon Leads



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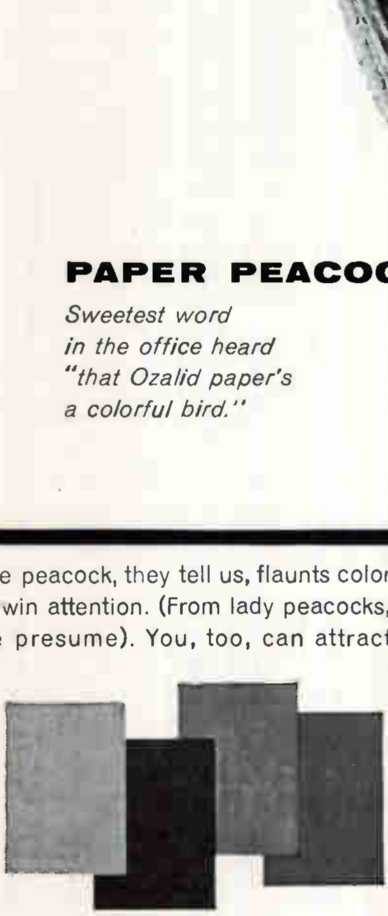

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President Expands Limited War Market

THE PRESIDENT'S decision to beef up capabilities for limited warfare means an expanded market for the special electronic equipment involved.

The services with more money to spend are those with the most responsibility for waging war in limited areas. The Marine Corps expects a budget appropriation increase of from 50 to 75 percent.

The Army and Navy will fare well since—with a few exceptions—almost all weapons used by both are suitable for limited war. Exceptions are systems that imply general war such as Navy's Polaris missile and Army's Nike missiles assigned to the North American Air Defense Command.

The Air Force, whose objectives and weapons are oriented more toward general war, will nevertheless receive some strengthening.

The President's recommendation to Congress last week included a $122-million increase in obligational authority "to speed up current limited warfare R&D programs and to provide for the initiation of entirely new programs"; $172 million to finance the expanded program for long-range airlift aircraft; $40 million for construction of an additional amphibious transport of a new type, increasing both speed and the capability of Marine Corps sealift capacity; $84 million for an increase in the Navy's ship rehabilitation and modernization program; and $230 million for increased procurement of helicopters, rifles, modern nonnuclear weapons, electronics and communications equipment, improved ammunition for artillery and infantry weapons and torpedoes.

For USAF fighter aircraft, $45 million was requested for a new tactical fighter with nonnuclear capabilities and $25 million to modify the F-105.

Some definite uses to which the services will put the new money were outlined by Secretary of the Army Elvis J. Stahr, Jr., top military brass and by representatives from industry at the recent Electronic Industries Association meeting in Washington.

For Next 10 Years . . .

JOHN F. GRECO, Hughes Aircraft, foresees Army's electronics market for limited war over the next ten years at about $5.77 billion. Here's how the market breaks down:

Program	Total *(billion)*	Electronics Dollars *(billion)*
Air Mobility ..	$3.16	$0.350
Missiles & Rockets	$7.29	$2.200
Control	$3.41	$3.070
Non-Mission Oriented Research ...	$1.02	$0.150
	$14.88	$5.770

All four services stressed the need for better communications.

Specific communications needs were pointed out by Army's Director of Combat Developments Brig. Gen. John T. Snodgrass: more range in single channel radio sets; more mobility and ruggedness in multichannel sets; and spectrum saving techniques.

Another area where added research would pay dividends, Snodgrass said, is a small tactical tropospheric scatter system, mobile and rugged enough for use in forward combat areas.

Brig. Gen. R. C. Richardson, chief, Long Range Planning Group, USAF, foresees a need for better command and control communications between tactical air command bases. Also, better communications between farflung bases and headquarters.

Marine Corp Deputy Chief of Staff for R&D, Brig. Gen. B. A. Hochmuth, says the Marines need "an improved integrated family of radios which will provide reliable communications down to the rifle squad level under all conditions of terrain and environment."

Combat surveillance and target location systems were stressed by the Army and Marine Corps.

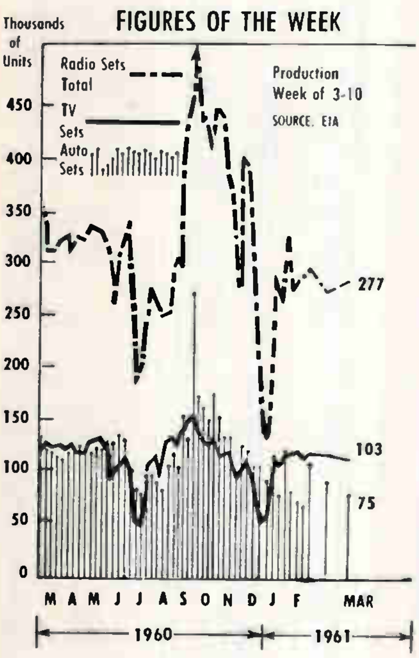
The Marines, Hochmuth said, find the following practical disadvantages in existing target location systems: "They are usually line-of-sight; complicated and difficult to maintain; bulky and relatively heavy; they are dependent on heavy, noisy, external power source (generators) and are primarily defensive in application."

Army would like an effective battlefield identification system to discriminate between friend and foe on the ground and in the air. Also, a rapid warning net to tell combat troops to take cover against a friendly nuclear burst.

The Marines want an integrated comprehensive system that provides all elements of a landing force with position location and navigation data.

Director of Development Programs Rear Adm. J. A. Jaap, described these needs for Navy over the next few years: improved navigation and station-keeping devices, mine detection, ASW, electronic countermeasures and counter-countermeasures. Jaap said there's a "wide open field for new offensive 'dirty work' electronic devices."

Navy also wants revolutionary sources of power and a shipboard missile launcher for inexpensive space probes for weather reconnaissance, sea surveillance, upper air soundings and one-time communications.



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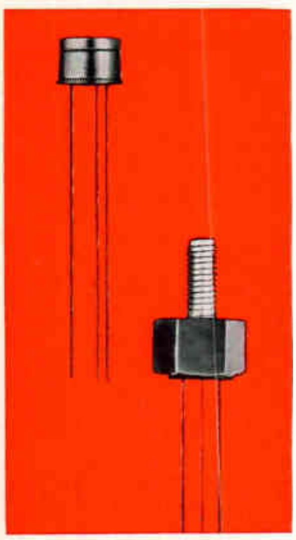

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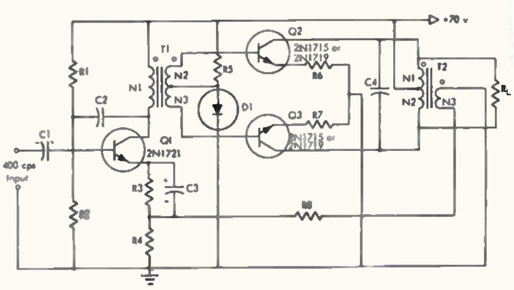

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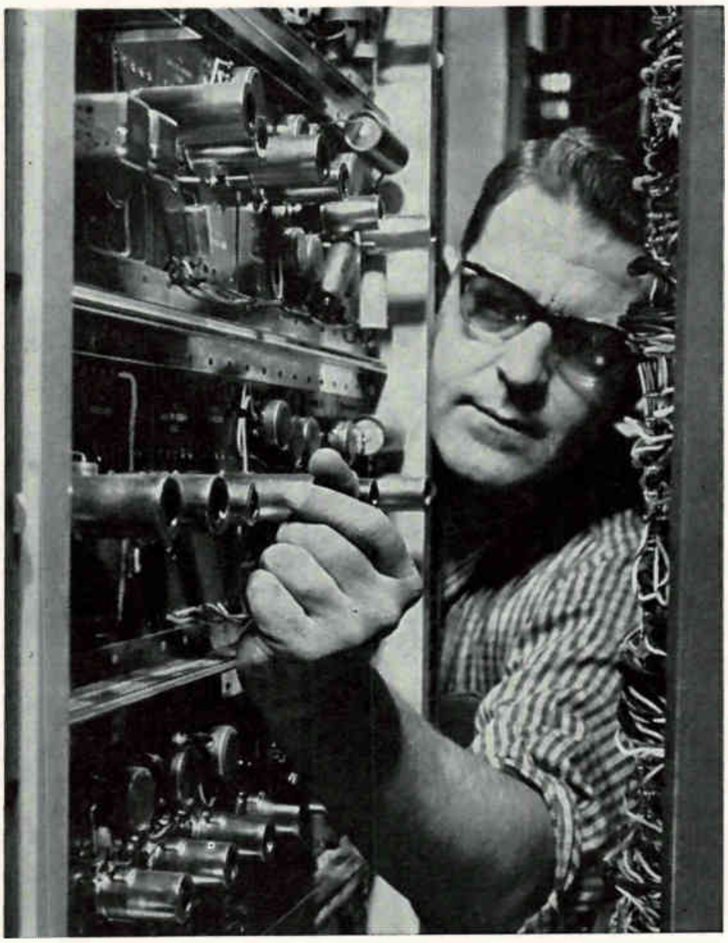
Instructor orients B-58 Defense System Operator in ecm simulator used at SAC bases

Computer system uses upright slide-out racks



B-58 GETS

OPERATORS OF THE still highly classified electronic defense system for the Convair B-58 are "flying" missions this week in a simulator, an exact replica of the Mach 2 bomber's Defense System Operator (DSO) battle station, at the Strategic Air Command's Carswell AFB, Fort Worth, Texas. Three more trainers are scheduled for installation at other SAC bases.

The ecm simulator, designated AN/ASQ-T1, was designed, and developed and built by Reflectone Electronics, Inc., under contract with B-58 prime contractor Convair div. of General Dynamics.

The simulator can be operated independently or interconnected with the navigator and pilot trainers to provide integrated air crew training. Initial cost of one DSO trainer is approximately 1/100 of one B-58 aircraft.

The system consists of a trainee station—a duplicate of the third crew station of the B-58—an instructor's station, recording equipment and instrumentation.

The trainer simulates two ground-based radars and three radar-equipped airborne targets (some of which may be decoys), using programmable signal-generating equipment and analog computers.

The initial conditions under which the airborne targets begin their passes at the bomber, and the maximum performance characteristics of the target are programmed. The system then computes range and azimuth data to simulate attacking vehicles.

When the operator gets "within range" of these target transmitters, he receives visual and audio alarm warnings of attack or detection. He then selects evasive action, ecm or chaff to combat the enemy threat. If his action is successful the target disappears from the radar scope and the warning alarm stops.

Bomber parameters are not programmed due to the particular evasive manuevers used by the

ECM SIMULATOR

By JOHN F. MASON
Associate Editor

B-58. Besides the standard heading change to throw off enemy radar, the B-58 has the capability of increasing speed. The instructor makes these changes manually while a computer changes the target course to adhere to the new relative position, azimuth and rate of closure of the bomber and target.

Target functions are programmed for each of the three target generators by inserting punched Mylar cards into a Hickhock Cardomatic switch. An analog electromechanical computer system produces pursuit or lead collision attack courses.

The pursuit attack simulates infrared missiles, or a fighter aircraft following the pursuit attack pattern. The lead collision attack simulates a ballistic-type missile or a fighter aircraft flying a lead collision course.

The development of accurate elevation signals is not necessary since the only elevation indication in the radar system is the relative time sequence in which the several target signals flash on the scope indicator. This function is provided, however, with initial elevation set in as a d-c voltage. For a collision attack, elevation remains constant, while for the pursuit attack, the elevation d-c is derived from a pursuit curve function potentiometer driven as a function of range.

Simulation of break away targets and decoy targets is achieved by programmer card selections which cause targets to deviate from their pursuit or lead collision path and fly off the scope.

The instructor's station contains both manual and automatic programmed punch tape equipment for controlling the mission. The flexible programmer has a repeatable capacity of 50 training conditions such as radar warning, airborne attack or system malfunction, which can be activated at a maximum rate of one every two seconds for ten hours, a total of 18,000 functions during a simulated mission.

The performance evaluation system limits the amount of recorded information to errors only. Real-time displays, duplicate controls and instruments and switch position "tell-light" indicators allow visual monitoring by the instructor. Student errors are automatically recorded and displayed until corrected. The reactions are recorded on paper tape, with voice commands or instructor criticism on magnetic tape for later review.

The mission programmer is an eight-channel punched tape reader capable of handling tape for a ten-hour mission. Individual items are programmed to a time accuracy of ±2 sec. The eight tape channels provide the 50 separate activation switching functions by a relay matrix. The relay matrix outputs are so terminated as to allow each switching function to control more than one item. At present 96 functions are controlled by the programmer, and the relay allows specific items to be readily changed.

The mission programmer establishes comparison data for the selective tell-light system, initiates six periodic recorder scans, inserts and clears malfunctions, initiates "fuse blow," bomber flight start, and airborne attack start.

Plan Research Park For Ann Arbor Area

TWO HUNDRED AND TEN ACRES of farmland at Ann Arbor, Mich. may be covered with the first research park in mid-America in about six years, if plans of some businessmen, professional men, and faculty members of the University of Michigan succeed.

According to a spokesman for the group, the Greater Ann Arbor Research Park will provide space for about 25 research and development facilities to be built by industrial firms at the $25-million site.

The backers say the city of Ann Arbor will develop the site by installing sewers and water services and building paved roads on a deferred payment plan.

Several firms have expressed interest in the new research site, including electronics companies. The University of Michigan has appointed a committee to cooperate in development of the park.

Malaya Increases Radio Imports 13%

KUALA LUMPUR—Radio equipment and parts imports into Malaya (including Singapore) totaled $7,719,000 in 1959, according to a recently completed survey here.

This is an increase of 13 percent from the $6,036,000 figure reported in a 1958 survey. In the first half of 1960, imports to the region totaled $3,935,000.

Prime supplier of radio gear to the Malayan area is Japan, which shipped 33.7 percent of all gear imported in the first half of last year.

In 1959 value of Japanese radio imports was five times bigger than in the preceding year. In 1958 the dollar total was $435,000. In 1959 it was $2,092,000.

In 1959 relative import figures were: Japan, 27.1 percent: Netherlands, 26.8 percent: United Kingdom, 24.8 percent: Federal Republic of Germany, 16.9 percent. U. S. share of Malayan trade in radio equipment was 3.6 percent in the last half of 1960, 3.0 percent in 1959 and 4.9 percent in 1958.

Present high sale items are transistor radios, high-fidelity equipment and stereo gear. Germany leads in radio-phonograph sales.

Midwest Research Group to Probe Solid State

By CLETUS M. WILEY
Midwestern Editor

AMES, IOWA—A Midwest-centered research program into solid-state electronics is being set up at Iowa State University to finance expanded research through continuing financial support from industrial affiliates all over the U. S.

Companies will get from the program new ideas, information, applications and the talents of 15 to 20 trained graduates as return on their research investment, say professors in four fields of electrical engineering at ISU.

The group plans broad investigations into new semiconductor devices and solid-state phenomena—probing commercially bypassed but promising ideas and encouraging fundamental investigations. Affiliated companies thus may save cost of developing and training staffs of their own for work in solid state.

Objectives of program are to provide unrestricted support for research in solid state, to create an atmosphere that will attract and retain a top-level staff and to develop a graduate program that will advance midwest area training of students of solid-state electronics.

Four major research areas will be covered by the program:

Devices and transducers for biomedical instrumentation:—Research will build on applications of solid-state research to biomedical electronic field at ISU including circuits and transducers already using solid-state devices. Additional study will delve into use of magnetostrictive properties of thin ferromagnetic films to create transducers, using implanted solid-state circuits to measure and telemeter physiological information, using solid-state materials to investigate feasibility of electronically activated limbs, using solid-state devices for instrumentation and using new materials to create artificial body organs.

Magnetic and nonmagnetic film materials:—Members of ISU's electrical engineering department have been conducting research, under National Science Foundation grants, into properties of magnetic films and into properties of devices made for them. Magnetic film parametric amplifiers, balanced modulators, parametrons and logical elements have been developed, and work on devices such as tunnel diode-magnetic film combinations will be expanded under the new affiliate program. Studies will also be made of properties of thin layers of conductors, resistive media and semiconductors.

Semiconductor materials research:—This work will build on work already underway on applications of semiconductor diodes at very high and ultrahigh frequencies as high-power vhf switches, varactor amplifiers, infrared detecting systems, reflection control devices and fabricating and applying silicon diodes as high-energy particle detectors. Research is scheduled into fabrication of diodes and transistors out of magnesium silicide and magnesium germinide. Circuit applications of other devices such as tunnel diodes are also planned.

Thermoelectric applications:—Research will be aimed at study of characteristics of thermoelectric energy conversion devices and their performance as part of a power system. Studies will be undertaken on steady state and transient conditions.

Planners expect about 30 percent of affiliate research activities will be strictly basic and fundamental, with about 70 percent into applications of fundamentals developed by the program.

Big difference between the midwest-centered affiliates program and its larger counterpart at Stanford University on the West Coast is renewable and continuing program of financing (about $5,000 annually per affiliate) in place of single lump sum grants from sponsors.

Program calls for a new campus research facility to be staffed by 15 to 20 of 86 E. E. graduate students at ISU, would not compete with industry for research contracts. Industrial affiliates would be invited to visit campus for annual review of programs.

Companies showing interest in program have included Bell Labs, Carrier Corporation, General Electric, IBM, Minneapolis-Honeywell, Motorola and Sperry Rand.

Airline Provides Closed-Circuit Radio

LONDON—Passengers on British Overseas Airways 707 jetliners will be able to listen to music, plays and lectures on personal receivers picking up broadcasts originated in the aircraft by induction loop.

Initial equipment installations are going into 15 of the big jets slated for flights between London and Lima, Peru. Passengers will be provided with self-contained receivers and earsets requiring no cords or other attachments. Selector buttons will give a choice of program fare. Each plane will be supplied with 40 hours of programming on tape.

The equipment is manufactured by an English firm, Esylon Receivers. BOAC officials say the Hi-Fli service, as it is now called, will be extended to other routes and aircraft. Plans are underway to produce programs in several languages, as well as special programs for children.

Congo Gets New Center For Air Navigation

BRAZZAVILLE—Radio air navigation center went into full activity here last week following inauguration of service earlier in March.

The center is operated by the agency for air navigation security in Africa and Madagascar (ASECNA). The agency's director general describes the system as the African equivalent of Eurocontrol, Europe's air navigation agency.

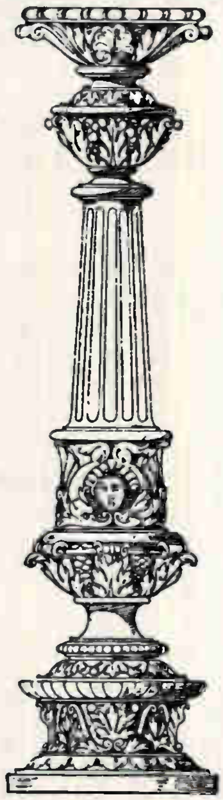
The African transmitter facilities, described as extremely powerful, are expected to supply radio air navigation data to aircraft throughout the African territory.

South African Gold Ore Sorted Electronically

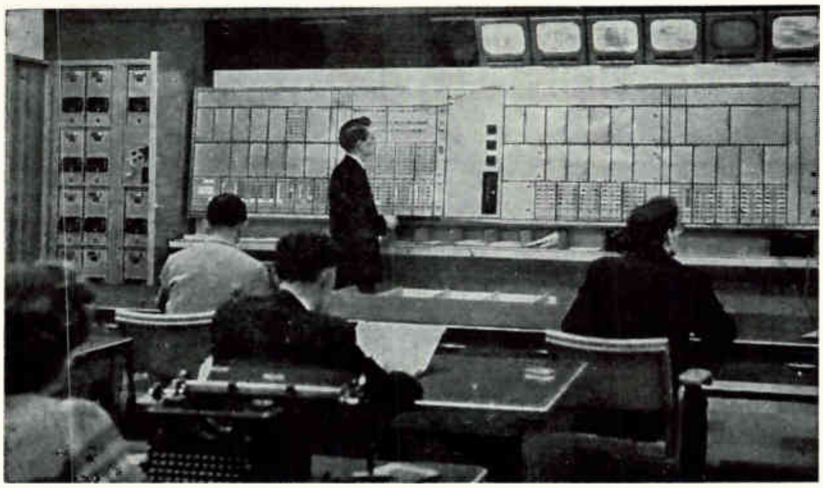
JOHANNESBURG — South African mining interests here are studying an electronic ore sorting machine able to distinguish gold and uranium bearing rocks from waste debris.

The underground equipment performs its sorting function before ores are hoisted to the surface. Saving in work required to haul out useless rock is expected to be considerable.

The equipment being used is manufactured locally under license to a Canadian firm. There are two such machines in Canada, four in Australia.



Inspecting Car Bodies by Television



Thirteen Marconi closed-circuit television cameras inspect car bodies at the Standard-Triumph Motor Company's Works at Coventry, England

Conference Explores Submillimeter Waves

SAN FRANCISCO—Increasing interest in generation and use of coherent light energy was shown as more than 500 scientists from both sides of the Iron Curtain met in Berkeley, Calif., recently for the Second International Conference on Quantum Electronics. Conferance was sponsored jointly by the Office of Naval Research and the University of California, and was fundamental in nature. While most attendees were from the U. S., there were representatives of Japan, USSR East and West Germany, Israel, England and France.

About 250 scientists attended the first Quantum Electronics Conference, held in September, 1959.

Conference chairman J. R. Singer of University of California opened the three-day meeting by noting that work in generation, detection and amplification of coherent electromagnetic radiation shorter than a few millimeters in wavelength has opened up exciting scientific and technical possibilities.

Singer enumerated applications in communications systems, chemical processing and scientific investigation. He said—development of communications systems at wavelengths shorter than a few millimeters was practical.

Photoexcitation of molecules by higher optical intensities may also be useful in catalyzing of entirely new reactions and compounds. In addition, photoexcitation can be used to change the orbits of electrons in an atom, or it can be used to ionize atoms by displacing electrons entirely. Either phenomenon can catalyze certain reactions, and some scientists have expressed the belief that entire new chemical industries may arise.

Quantum electronics creates a powerful new research tool in the optical maser, which will broaden the scope of research by optical spectroscopy into the study of nonlinear, large-amplitude oscillations of molecules. "We will undoubtedly soon be able to induce oscillations of sufficient strength to overcome the binding forces of molecules," said Singer.

Associated with applications research is a far greater degree of basic investigation into molecular energy levels, interatomic couplings, coherence properties of radiation and ultramicrowave resonant chambers. The majority of papers treated these subjects.

Typical of presentations were two on generating coherent light of short wavelengths. One, by Paul D. Colemen of University of Illinois, revealed progress in generating coherent submillimeter-wave power by an electron-beam device. Illinois approach uses the Cerenkov technique: a Teflon dielectric cone containing a 10-cm axial hole through which a one-megavolt, 40-milliampere bunched-beam traverses, can be shaped by physical optics to permit radiation in the desired pattern. It is believed that wavelengths below 0.3 millimeter can be produced.

A less mechanical approach to generating submillimeter waves uses multiple quantum transitions. This possibility was suggested by a trio of scientists from Stanford University, who said that if a two-energy-level system is subjected to sufficiently strong r-f pumping at a submultiple of the natural transition frequency, an interaction will occur between the system and the r-f input.

According to equations derived at Stanford, the system should absorb power at the pump frequency and emit it at the natural transition frequency. The principle is believed applicable at very short wavelengths.

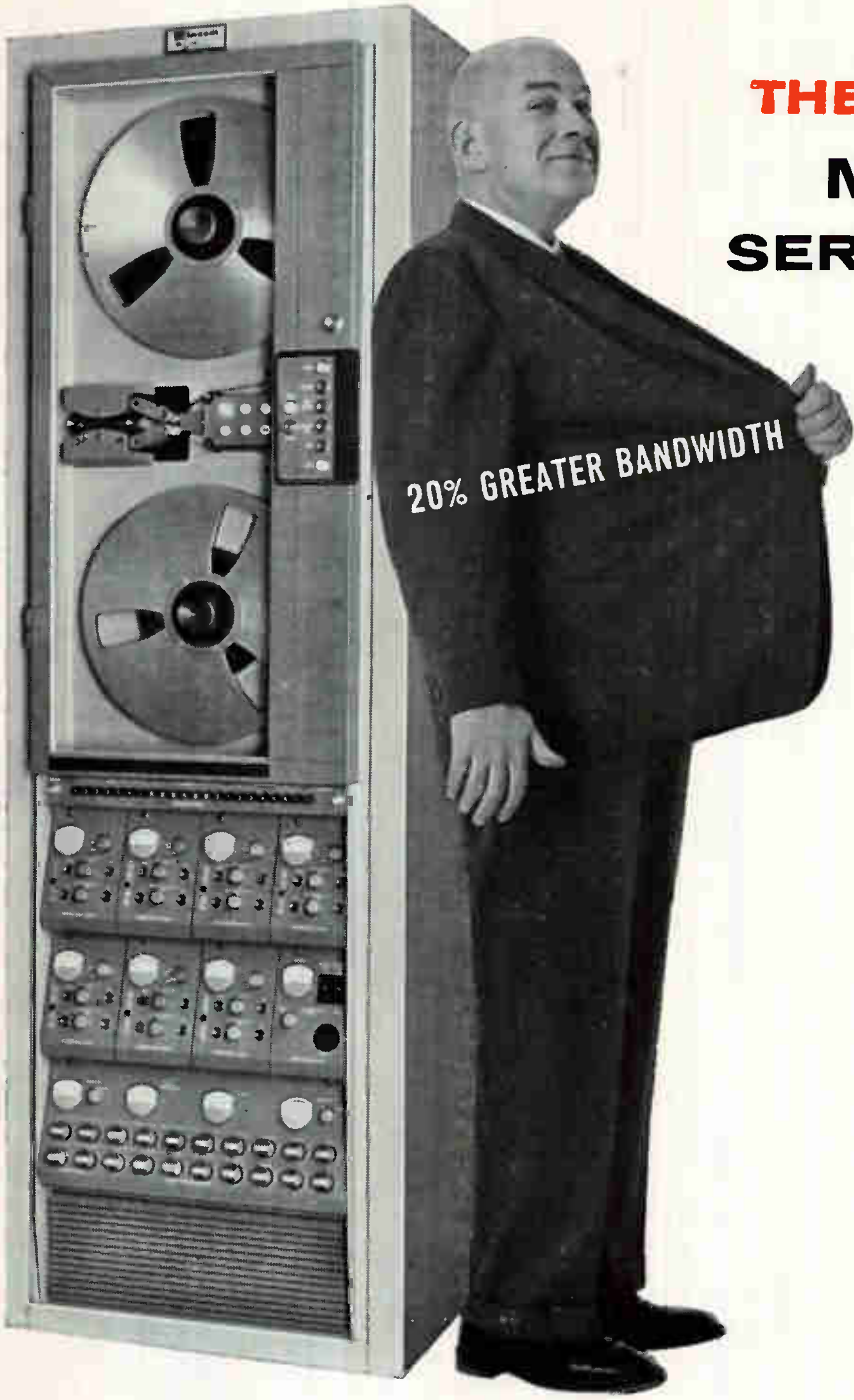
Japanese Phone Net Using Novel Tube

TOKYO—A 2,700-channel 12-Mc broadband coaxial cable carrier system is being installed this week on a trial basis between Tokyo and Yokahama by Japan Telephone and Telegraph Corp. The system will include 20 unattended repeater stations spaced 4½ kilometers apart, instead of current spacing of 9 kilometers.

Developed at a cost of nearly $300,000 over the past six years, the system, company officials say, has been successfully tested between Kumagai and Takasaki.

The new system, slated to begin operating next month, is a buildup of the present 960-channel installation between the two cities. A company official said specialized 6B-R23 tubes have been designed to amplify the broadband, stabilize and prevent mutual interference on the lines. The loss and gain of the tube is reportedly designed to be about 40 db maximum when used for a total of 600 repeater stations at 12 Mc. Designed lifetime is 20,000 hours minimum.

THE IMPROVED MINCOM SERIES CM-100 1.2 mc



At 120 ips the Mincom Series CM-100 now delivers 1.2 mc with the same reliability that has been typical of Mincom's 1-megacycle performance for years. 20% extended bandwidths also are obtained at CM-100's other five speeds (see table at right). Tape previously recorded at 1 mc can be played back on the CM-100 with improved reproduction. Consistently good pulse response, due to constant phase equalization at all speeds, enables this system to perform predetection recording/reproducing on an operational basis—in FM, FM/FM modulation, PCM and PCM/FM. Plug-in rack easily converts CM-100 from 7 to 14 tracks. Write for brochure and specifications.

New Series CM-100 Frequency Response

7½ ips— 75 kc	30 ips—300 kc
12 ips—120 kc	60 ips—600 kc
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Talks Stress Import Puzzle

WASHINGTON, D. C.—Foreign trade in electronics is slated for increased industry attention this Spring, according to observers here.

One commentator at a recent four-day meeting of Electronic Industries Association termed the foreign trade situation paradoxical in that on one hand the increasing rate of imports of electronic components from low-wage countries is beginning to hurt domestic producers. At the same time, however, the U. S. continues to export three times as much electronic merchandise as it imports. The result: many manufacturers view the situation with great caution.

This showed up in a plan disclosed by W. Myron Owen of Aerovox Corp., chairman of EIA's parts division. The plan calls for (1) an educational program aimed at labor unions and the community at large to encourage purchases of American-made products, and (2) voluntary quotas to limit imports.

A member of EIA's tube and semiconductor division reported that a small New England electronics manufacturer has started a unique "Buy American" plan on its own. The company is thinking of putting a special clause in all purchase orders requiring its suppliers to certify that all components sold to the company are U. S.-made, subject to a penalty of $100,000.

The company wants to protect itself on its claim that its end-item products are produced in the U. S.

Horace B. McCoy, former head of the Commerce Dept.'s Business & Defense Services Administration and now president of the Trade Relations Council, told EIA that current congressional efforts to give priority to import injury in the Area Redevelopment Bill was an "upside-down approach."

The Council advocates stronger enforcement of the present tariff law and opposes any further import duty reductions. EIA has become a member. EIA President, L. Berkley Davis of General Electric, is a member of the Council's Board of Directors.

McCoy termed the area redevelopment approach "Contradictory in its objectives. It assumes that imports will be permitted to create more unemployment. Instead of using the redress provided in the Trade Agreements Act—preserving the payroll before the plant is closed down—this legislation assumes that the plant will be closed down and that the government will have to come in with doles afterward in an attempt to rectify the situation. We hold that it is far better to preserve the egg in the first place, rather than to try to put Humpty Dumpty back together again."

Edward R. Taylor of Motorola, chairman of EIA's consumer products division, speaking on another topic at the EIA meetings, reported the Association opposes FCC's proposal to require television producers to provide uhf channels in all new sets.

EIA's opposition stems from two factors. First, a general objection to the principle of government edicts on how to produce. Second, a need for a definitive government decision on frequency allocations. Taylor said it is impractical to consider the proposed uhf requirement until the frequency allocation question is resolved.

Taylor said the requirement

Code Unit Sends Data

New device permits pilots to contact base by punching the coded data panels. Inventor Hughes Aircraft calls the device Digikey would add an average $30 to the cost of a television set and that "too many consumers would be forced to pay extra for a service they won't use and don't need."

Other highlights of the EIA Conference concerned the relationship between industry and the military.

Lt. Gen. Bernard A. Schriever, Commander of the Air Research & Development Command, urged industry to place even greater stress on miniaturization and reliability.

"Reliability must take on new meaning," he said. "We are interested in satellite systems having at least an 8,000-hour operable life with zero maintenance." The general said "total failure in launching and operating space vehicles could be made a thing of the past by patterning functions of man-made electronic nervous systems on the behavior of living organisms."

Paul S. Darnell of Bell Telephone Laboratories, chairman of EIA's military-industry study group, said more stringent military requirements for reliability will increase costs to electronic producers, but that the rise may be offset by increased yield and greater reliability of equipment.

His report recommends ways for specifying the reliability of electronic parts in military contracts.

Said Darnell: "With the intensification of military inspection practices and the addition of definite reliability level requirements to specifications, parts producers would be required on the average to do more testing and apply increased control in manufacture."

In a panel discussion on the Darnell report, E. J. Nucci, the Pentagon's electronic reliability coordinator, said the recommendations provide "a basic solution to strengthen the government position in the management of parts specifications."

Leon Podolsky of Sprague Electric Co. and chairman of EIA's component parts panel, said the plan will "affect everyone who sells electronics to the government. It may determine whether a company will have any government business."

Austria to Construct First Transistor Plant

VIENNA—Three Austrian factories for manufacture of transistors and capacitors will start going up next month near Klagenfurt. Blueprints call for total floor space of more than 120,000 sq ft, with production in full swing by 1962. The enterprise will employ about 1,000 workers.

The installation is being built by Philips Ges m.b.H, the Austrian subsidiary of Philips of Eindhoven in the Netherlands, and is said to be the first transistor manufacturing establishment in Austria.

Production programs call for an output by 1964 of about $7.69 million.

Company spokesmen say about 80 percent of the output will be sold outside Austria, but give no indication whether sales will be confined to Common Market, non-Communist or other areas.

Mexico Telephone Net To Carry Tv to U.S.

MEXICO CITY—Telefonos de Mexico, this country's big telephone utility formerly owned by ITT and Ericsson, has announced plans to pour some $120 million into an expansion program starting this year and extending into the Fall of 1965.

Plans include installation of 300,000 telephones, of which one-third will be in the nation's capital. When expansion is completed, the entire service will be automatic, allowing subscribers to dial their long-distance calls.

Also to be expanded is the phone company's microwave system linking Mexico City with the U. S. Working on a 4,000-Mc frequency, the completed hookup will tie into American Telephone and Telegraph facilities.

Channels will be set aside for tv and radio relay, allowing exchange of program fare between U. S. and Mexico. The Mexican system will enter the U. S. from Monterrey south of the Texas border.

Hot Test

Thermoelectric suit developed by Navy and Westinghouse withstands 135 F as butter melts. Interior temperature of the suit is 80 F

Dutch Airline Testing Automatic Landings

AMSTERDAM—A DC-8 aircraft here is being equipped with gear for fully automated landings. The system is called the Para-Visual Director. KLM, the Dutch airline installing it, says for the time being it will be used only on trial flights.

The instrument, developed by the British manufacturer Smiths Aviation, consists of three cylindrical glass tubes placed in the pilot's cabin in an easily visible location. Within the tubes are black and white coils. One tube lies horizontal to the plane's axis. The others are at right angles to it.

The device reacts to normal ILS signals in such a way that if the plane goes too far to the left, the black coils in the appropriate tube will curl to the right, indicating the plane should be steered in that direction. The same will occur in cases of deviations to the right or incorrect altitudes. When all three coils remain motionless, the glide path is correct.

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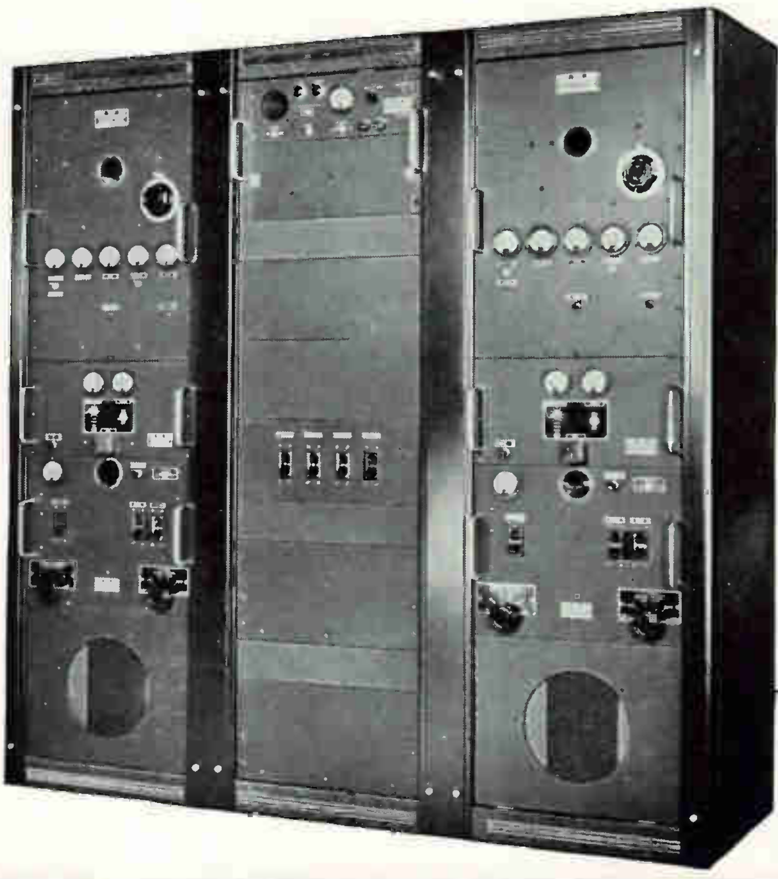
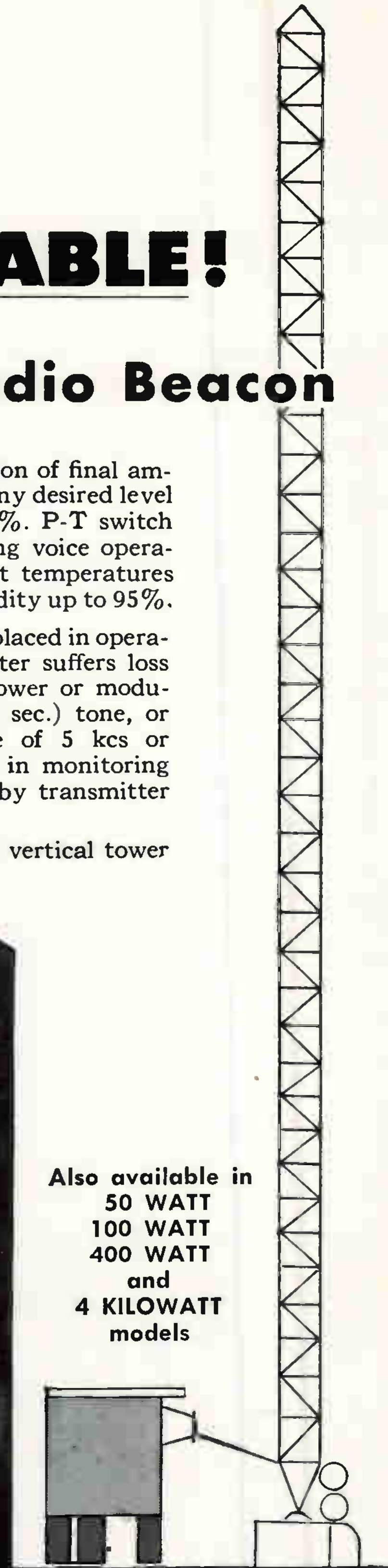
Uses single phase power supply, nominal 220 volts, 50 or 60 cycles. Consists of two 1 kw transmitters with 2 keyers, automatic transfer unit and weatherproof antenna tuner. Each transmitter housed in separate fan ventilated rack cabinet, with controls in center rack cabinet.

Nominal carrier power is 1000 watts. High level plate modulation of final amplifier is used, providing any desired level of modulation up to 100%. P-T switch interrupts tone, permitting voice operation. Operates in ambient temperatures from −35°C to 55°C, humidity up to 95%.

Standby transmitter is placed in operation when main transmitter suffers loss (or low level) of carrier power or modulation, or continuous (30 sec.) tone, or carrier frequency change of 5 kcs or more. Audible indication in monitoring receiver tells when standby transmitter is in operation.

Antenna may be either vertical tower or symmetrical T type.





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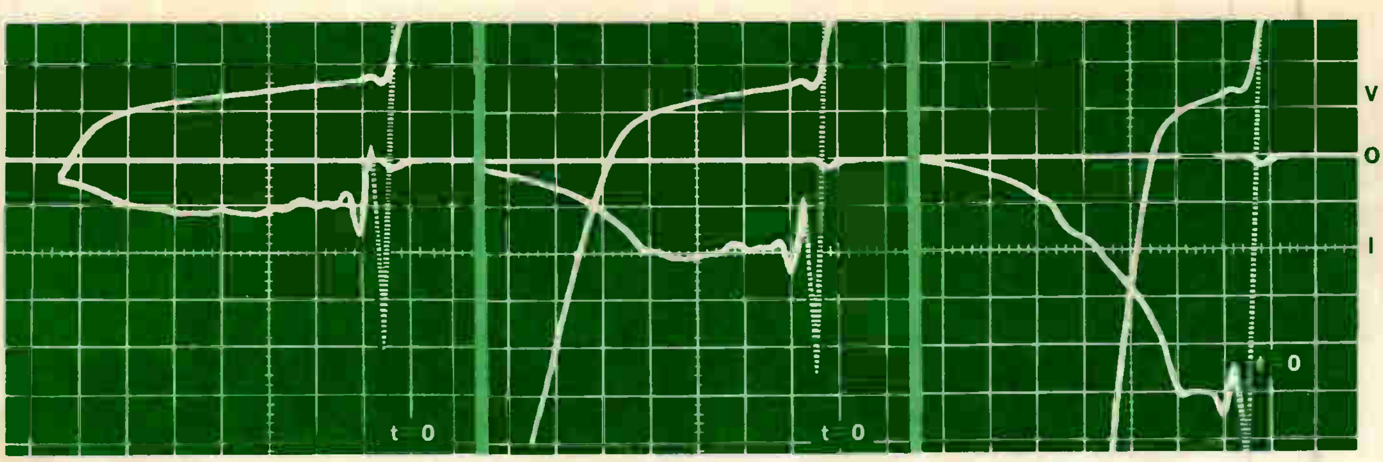


Figure 1 — 1ma., 10nsec., 185mv./div.

The usefulness of diode stored charge measurements

by DAVID E. HUMEZ

Technical Advisor to the Manager of Operations
Clevite Transistor, Waltham, Mass.

Because driving signals usually are of fixed amplitude and duration in a given circuit, it would be desirable to express the transient behavior of diodes in terms of the charge which must be removed during switching. It would be even more desirable if a simple method of measuring stored charge under a given set of circuit conditions could predict the diode behavior under different conditions.

Measurements of the charge represented by the product of reverse current (I_r) and the time (t_r) required for the diode junction voltage to drop to zero have been disappointing. For the same forward current (and therefore the same total stored charge) the charge measured varies widely with changes in the reverse current. Table 1 lists a series of measurements on a single, moderately-fast, diode. Note particularly that the measurement made from 10ma. to 18ma. shows a smaller ratio of t_r to τ, the effective total charge lifetime, than all the other measurements and yet does not show a maximum normalized value of $t_r I_r$. Very small values of t_r/τ do not give more understandable results.

Table 1

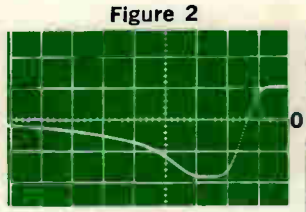
I_f ma	I_r ma	t_r nsec	$t_r I_r$ $\mu\mu$coul	τ nsec	τI_f $\mu\mu$coul
5	2	18	36	31.7	158.5
20	2.0	42	84	33.2	664.0
20	1.0	62	62	31.6	632.0
20	0.5	86	43	33.8	676.0
20	0.1	134	13.4	34.0	680.0
10	18	3.1	55.8	33	330.0
20	1.0	73	73	37.2	
20	2.0	48	96	33.6	
20	5.0	26	130	31.6	

The use of the popular expression $Q = \tau I_r (e^{t_r/\tau} - 1)$ at all, and particularly when $t_r << \tau$, gives rise to large errors because the derivation of the expression makes use of a fundamentally false assumption: viz., that at the time, t_r, the charge contained in the diode will have dropped to zero. Both theory and measurement show that the fraction of the total charge removed during this time is never larger than about one fourth, that it varies widely with the ratio of I_f/I_r and that it reaches a maximum at I_f/I_r of approximately 1.5 corresponding to $t_r/\tau = 0.35$ approximately.

The current and voltage traces displayed in figure 1 illustrate the variation in the fraction of charge removed during the time, t_r. The diode behavior shown is that of the diode of Table 1. The last three lines of Table 1 were derived from the photographs, whereas the first five lines were obtained with different equipment. Experimental difficulties in achieving simultaneous traces of current and voltage have given rise to small errors.

A general solution of the diffusion equation for a diode whose base is thick compared to a diffusion length ($W > L$) yields the expression, erf $\sqrt{t_r/\tau} = I_f/(I_f + I_r)$. By the use of this simple expression, values of τ and τI_f (the total stored charge) have been calculated in the last two columns of Table 1. For a wide range of values for I_f/I_r, remarkably uniform values of τ result. From the value of τ can be calculated t_r for any value of I_f/I_r. Assuming a value of $\tau = 33$ nsec t_r was calculated for $I_f/I_r = 0.55$. The result predicts that the constant current phase of recovery should be over in 3.1 nsec. Figure 2 illustrates this same diode performing under these conditions. The diode is being switched from 10ma forward to 3 volts and approximately 100 ohms external loop impedance. Note that with such a low voltage and loop impedance the voltage drop across the diode itself is not negligible. The reverse current is not 3/100 amperes but rather .018 approximately. Also at this speed the rise time of the generator and CRO are important. It is, none the less, encouraging that a measurement made at 134 nsec and an I_f/I_r of 200 to 1 should predict so well the behavior at 3.1 nsec and an I_f/I_r of 1 to 1.8.

Figure 2



10ma., 1nsec/div.

Table 2

I_f ma	I_r ma	t_{r1} nsec	t_{r2} nsec
20	2.0	42	140
10	1.0	42	200
5	0.5	42	260
2	0.2	42	330
1	0.1	40	380

Table 2 illustrates a simple test for the condition $W > L$. The diode yielding the results listed as t_{r1} satisfies the condition, the other diode does not.

Stored charge measurements can, then, be made at conveniently long times for a large group of moderately to very fast diodes intended for use in the low nanosecond range. A single set of test conditions could well be adopted as standard for a very wide range of end use conditions.

Detailed information on this subject is available. When writing please ask for Applications Bulletin 3.

CLEVITE TRANSISTOR
Waltham, Massachusetts

Shallcross

precision circuit news

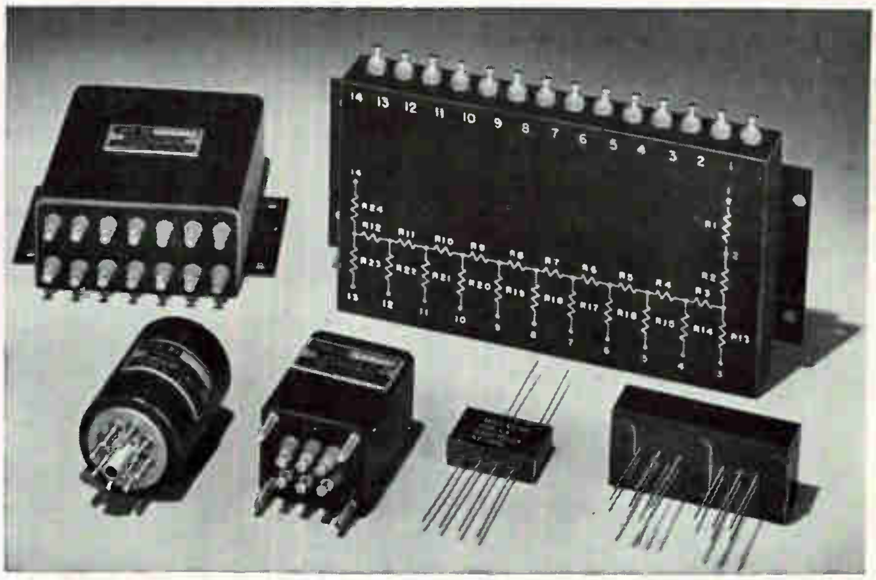
RESISTANCE NETWORKS

. . . the inside story on quality

In reading ads for wirewound resistance networks, you sometimes find the superiority of one technical characteristic emphasized to a misleading degree. Desired accuracy, temperature coefficient, stability, and voltage division obtained in one type of network may be impossible to achieve in another.

Essentially, network quality is determined by the quality of its individual resistors. Beyond this, network performance improves or deteriorates depending on packaging and mounting techniques, AC layout and trimming methods, accuracy of measuring instruments, the manufacturer's production standards and his knowledge of the latest developments in network theory.

Shallcross offers a unique background of experience, reliability data, manufacturing and testing skills to minimize what few error factors remain in Shallcross precision wirewound resistors when the networks are sealed. For a sample of this ability, submit your next network requirement for evaluation by Shallcross engineers. Meanwhile, send for Bulletin A-2 for a practical discussion of proper network design.



Temperature Stabilized COMPUTER NETWORKS

High reliability Shallcross P-Type precision wirewound resistors help these computer networks maintain close AC ratios over wide temperature ranges. To maintain these tolerances, Shallcross has refined resistor manufacturing techniques to provide TC tracking within ± 1 ppm in many cases. Individual resistor reliability is enhanced by stability "exercises" and by new tension relieving devices within each resistor. Beyond this, extremely accurate AC and DC measuring instruments help in final network design, trimming, packaging, and proof-of-performance testing.

From an extensive background of network engineering Shallcross offers analog to digital and digital to analog converters, voltage dividers, summing and integrator networks, and others to virtually any configuration.

WHY PACKAGE RESISTANCE NETWORKS?

Packaging does far more for resistor networks than provide convenient mounting and environmental protection. Some can also increase power dissipation, provide electrical shielding and increase network stability over extended temperature ranges. Principally however, enclosed networks maintain electrical performance by preventing "field introduced" errors brought about by improper mounting or damage to critical AC layouts through improper resistor replacement during maintenance. Where unusually critical voltage division tolerances must be maintained, the design engineer should make provision for a packaged network in his application.

Shallcross regularly supplies networks in many hermetically sealed, encapsulated, and plug-in designs. For a discussion of when to use which style, write for Bulletin A-2.

Shallcross Manufacturing Co. Selma, North Carolina

Precision wirewound resistors, Switches, Instruments, Delay lines, Resistance networks, Audio attenuators.

MEETINGS AHEAD

Apr. 10-14: International Air Symposium, FAA; Atlantic City, N. J.

Apr. 11-12: Instrument Automation-Electronics Exposition, Ohio Valley; Cincinnati Gardens, Cincinnati, O.

Apr. 11-13: Ultrapurification of Semiconductor Materials, Air Force Cambridge Research Laboratories; New England Mutual Hall, Boston.

Apr. 12-13: Information and Decision Processes; Engineering Dept., Purdue Univ., Lafayette, Ind.

Apr. 13-14: Society of Technical Writers and Publishers, Annual Convention; Mark Hopkins Hotel, San Francisco.

Apr. 17-19: Protective Relay Conf., A&M College of Texas, College Station, Tex.

Apr. 17-19: Instrumental Methods of Analysis, ISA; Shamrock-Hilton Hotel, Houston, Tex.

Apr. 17-21: Strain Gage Techniques, Southwest Research Institute; San Antonio, Tex.

Apr. 18-19: Organic Semiconductors, Inter-Industry Conference, Armour Research Foundation of Illinois Institute of Technology, and ELECTRONICS, McGraw-Hill; Terrace Casino, Morrison Hotel, Chicago.

Apr. 19-21: Southwestern IRE Conf. and Elec. Show, SWIRECO; Memorial Auditorium, Dallas.

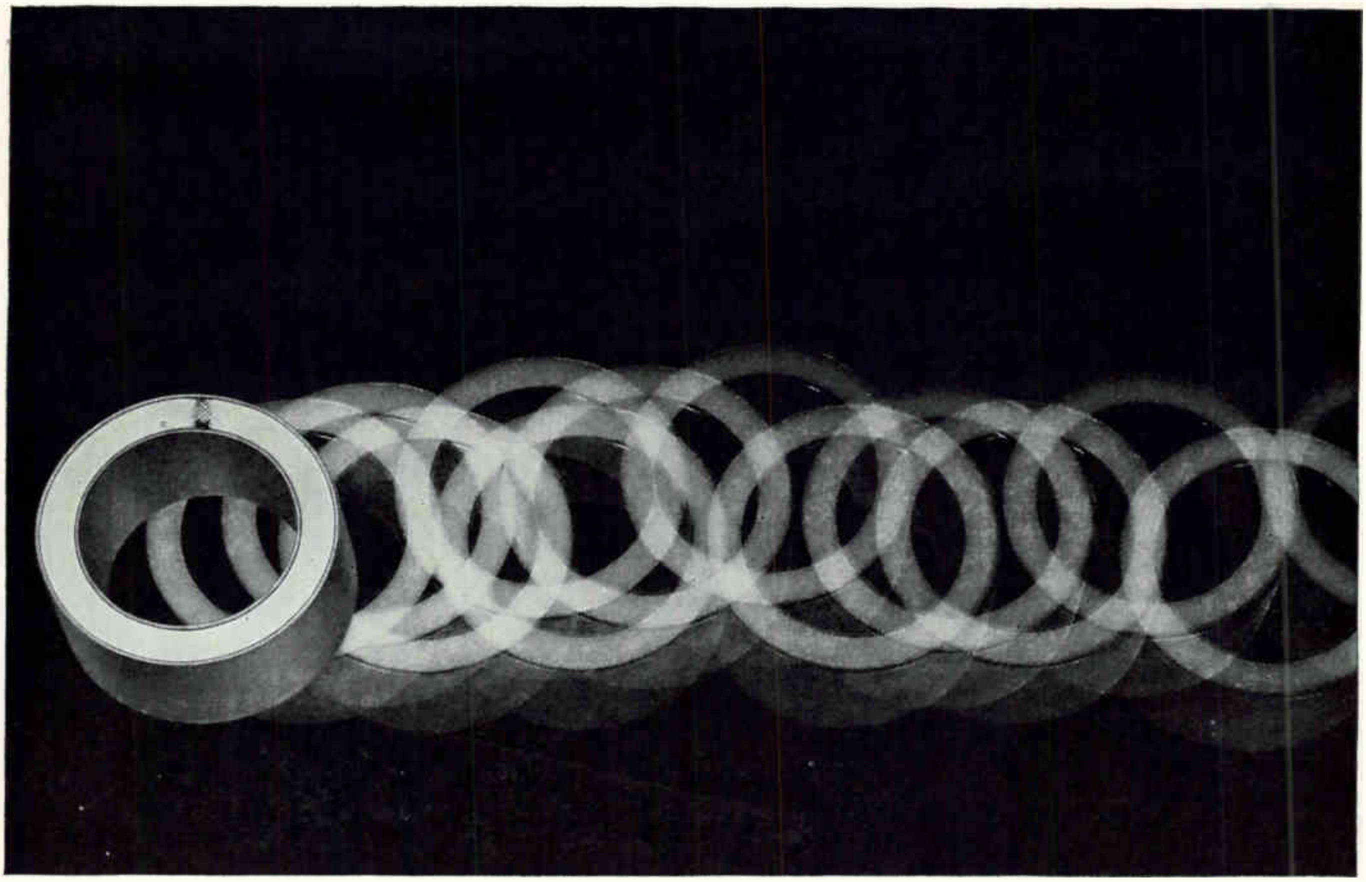
Apr. 20-21: Television & Film Techniques, British Kinematograph Society; IEE, Savoy Place, London.

Aug. 22-25: WESCON, L. A. & S. F. Sections of IRE, WCEMA; Cow Palace, San Francisco.

Sept. 11-15: Instrument-Automation Conf. and Exhibit, ISA; Sports Arena, Los Angeles.

Oct. 9-11: National Electronics Conf., IRE, AIEE, EIA, SMPTE; Chicago.

Nov. 14-16: Northeast Research & Engineering Meeting, NEREM; Commonwealth Armory and Somerset Hotel, Boston.



the strong case for Centricores®

When you're considering magnetic cores it pays to get down to cases. The sturdy aluminum case for Centricores assumes special importance where impact, vibration, heat or mechanical pressure could cause trouble in a control loop you're designing, or where you want to miniaturize an inductive component.

The case is ruggedly rigid, so that you can apply your circuit windings without danger of distorting the core's magnetic properties. And the case is absolutely leakproof. You can vacuum-impregnate Centricores without danger of their damping oil leaking out or foreign matter leaking in. The tightly sealed case also guards against leakage in applications where high ambient temperatures are present, or where Centricores are used in rotating equipment.

Here's a tip on miniaturization. The rugged design of the Centricore case permits use of a thinner gage aluminum that shaves fractions of an inch off their size—fractions that can add up to precious inches where you want to scale down component dimensions. *Centricores are the slimmest magnetic cores on the market.*

Centricores are the most uniform. They give the exact performance you want, from core to core and lot to lot. Their remarkable consistency in insulation, dimensions, squareness, thermal stability and gain is the product of unique quality controls that begin with the very selection of raw materials and extend through final testing.

Write for complete data. Centricores are available from stock from our East and West Coast plants in all standard sizes and magnetic qualities, and in both aluminum and phenolic cases. We will match them within 5 per cent over the entire voltage-current loop, in sets, units or in multiples up to twelve. Write for detailed specifications today.

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Hayes Avenue at 21st Street, Camden 1, N.J.
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transformer laminations • motor laminations • tape-wound cores
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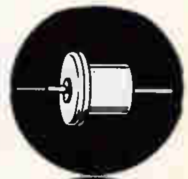
General Instrument Silicon Rectifiers

UP TO 25 AMPS...

PIV's—50v to 30,000v



225 Top Hats . . . from 50 to 1,500 PIV

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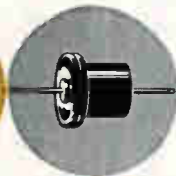
129 7/16" Medium Power Studs . . . from 50 to 1,000 PIV



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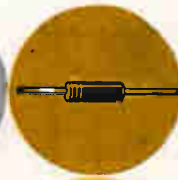

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38 Plastic Units . . . from 50 to 600 PIV

110 7/16" Hi Power Studs . . . from 50 to 600 PIV*

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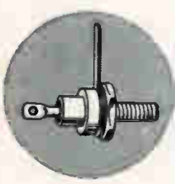
FASTEST DELIVERY...

• Immediately Available Off-The-Shelf • Realistically Priced • Contact General Instrument at the address below for the name of your local authorized stocking distributor.

**Also available with Reverse Polarity*

***Available on request up to 480,000 PIV*



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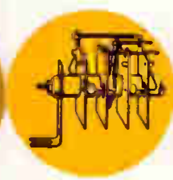
64 Hi Voltage Cartridges . . . from 600 to 30,000 PIV



700 Rectifier Stacks . . . from 50 to 4,800 PIV**

8 New 25-Amp Studs . . . from 50 to 600 PIV

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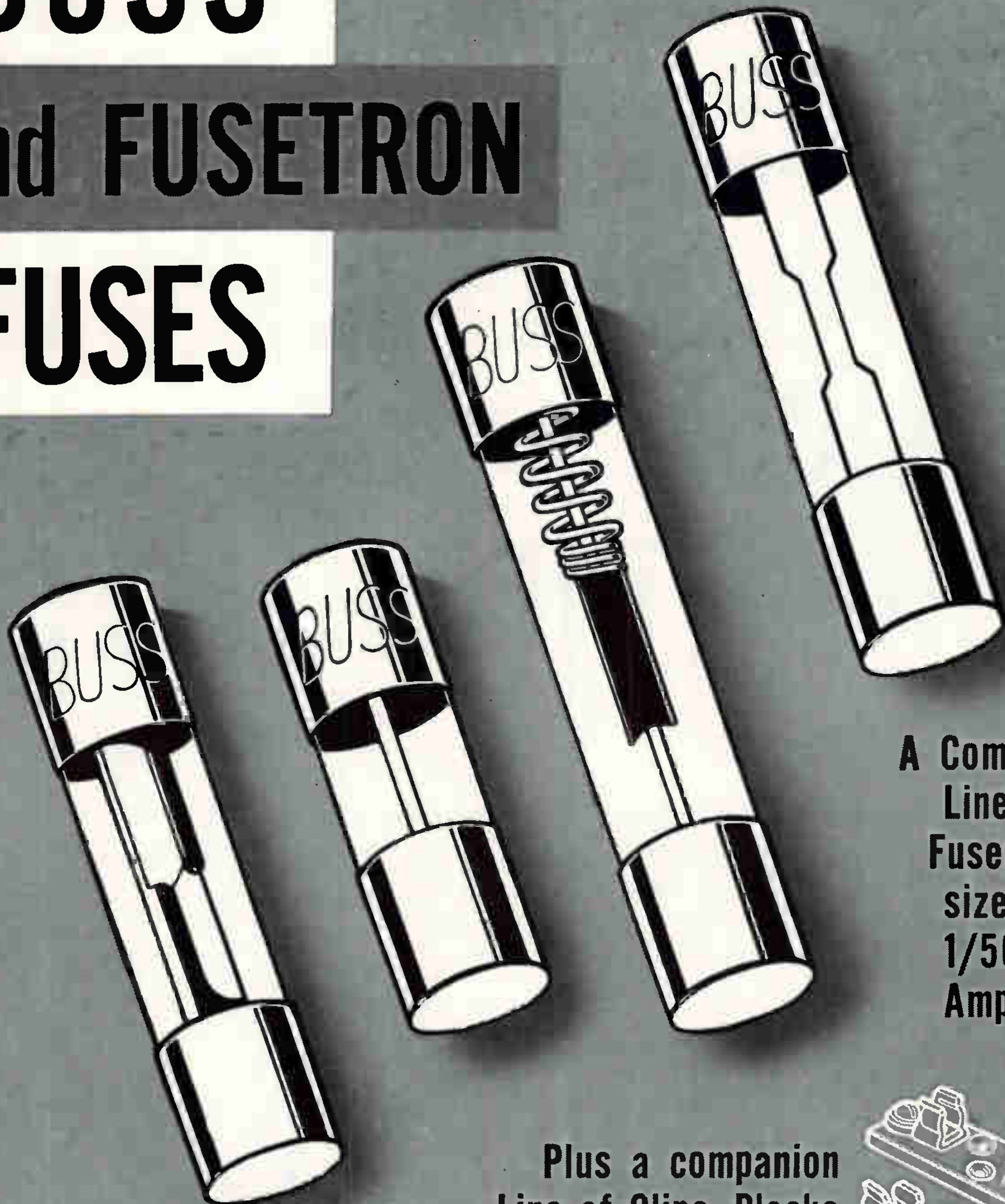
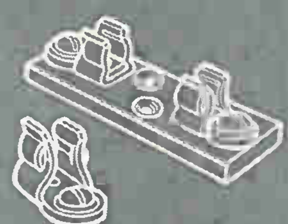
BUSS and FUSETRON FUSES



A Complete Line of Fuses in sizes from 1/500 Amps. up

Plus a companion Line of Clips, Blocks and Holders



When you specify BUSS and FUSETRON fuses you can be sure of safe, dependable, trouble-free protection for your equipment under all service conditions.

Every BUSS and FUSETRON fuse is tested in a sensitive electronic device that automatically rejects any fuse not correctly calibrated, properly constructed and right in all physical dimensions.

Chances are you will find in the complete BUSS line the fuse and fuse mounting to fit your requirements — but if your protection problem is unusual, let our engineers work with you and save you engineering time.

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

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(Advertisement)

TEMPERATURE TRANSDUCER

Small probe-type device for high and low temperature applications where high pressures and severe flow conditions are imposed. Precise liquid or gaseous measurements to 800°F. Tiny sensing element of deposited platinum film allows high base resistance, extreme linearity, wide range capability, and fast response. Approved for ICBM environments.

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WELDABLE STRAIN GAGE

Weldable-to-aluminum strain gage, less than 1-3/16″ long by 1/4″ wide, is capable of continuous operation at 700°F. Precise, rugged device consists of etched wire filament in swaged stainless steel tube, mounted on a special alloy welding flange. Installation is fast and permanent with stored energy welding equipment—no complicated bonding or curing processes necessary.

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AIRBORNE DC AMPLIFIER

Solid state, direct-coupled hermetically sealed instrument is less than 5 cu. in. in volume; weighs only 6 oz. DC gain is 200 to 1000 ± 5 V into not less than 20K (single ended).

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VHF-UHF TRANSMITTERS

Proved in history's most demanding environmental laboratory — outer space — the custom designed unit shown above is typical of the development skill and production capability available from Microdot. The unit shown in miniaturized, pressurized, and features a solid state power supply that cannot be damaged by input/output overloads. Units are available in a complete range of modulation — CW, FM, Phase, and Pulse, with frequency coverage 100 to 5000 mc/s and output from 100 mw to 10 watts.

Telemetry Capabilities at Microdot have been dramatically expanded with the recent acquisition of Spectralab Instrument Company. The highly regarded development skill, production capability, and working experience of Spectralab in the field of VHF and UHF cavities and related instrumentation is available from Microdot's Instrumentation Division. This equipment, outstanding in its attention to miniaturization and ruggedness, is a vital part of such important projects as Pioneer V, Jupiter, Atlas, Pershing, Redstone and Echo I.

UHF Telemetry Transmitters, Models 2406 and 2409, use a unique, automatically stabilized circuit, with the output frequency referenced directly to a quartz crystal. This approach allows a greatly reduced size compared to the multiplier chain conventionally required to achieve crystal stability, as well as increased reliability due to a fewer number of parts.

The transmitters have their own solid state power supply designed to provide a high ratio of rf output power to total power input. The frequency modulation circuitry is sufficiently linear to introduce completely negligible distortion to the modulation signal. For further information, Call Microdot or write for catalog sheet TT-1.

SPECIFICATIONS

Frequency Range:	
Model 2406	2200-2300 mc/s
Model 2409	1435-1535 mc/s
Frequency Stability:	±0.001%
Power Output:	10 watts
Power Output Stability:	1 db
Modulation:	PCM/FM, PAM/FM, FM/FM
Input Voltage:	28 vdc
Temperature Range:	−40°C to +70°C
Vibration:	10 g. 5-2000 cps
Size:	3⅜″ x 7⅜″ x 11″
Weight:	12 pounds

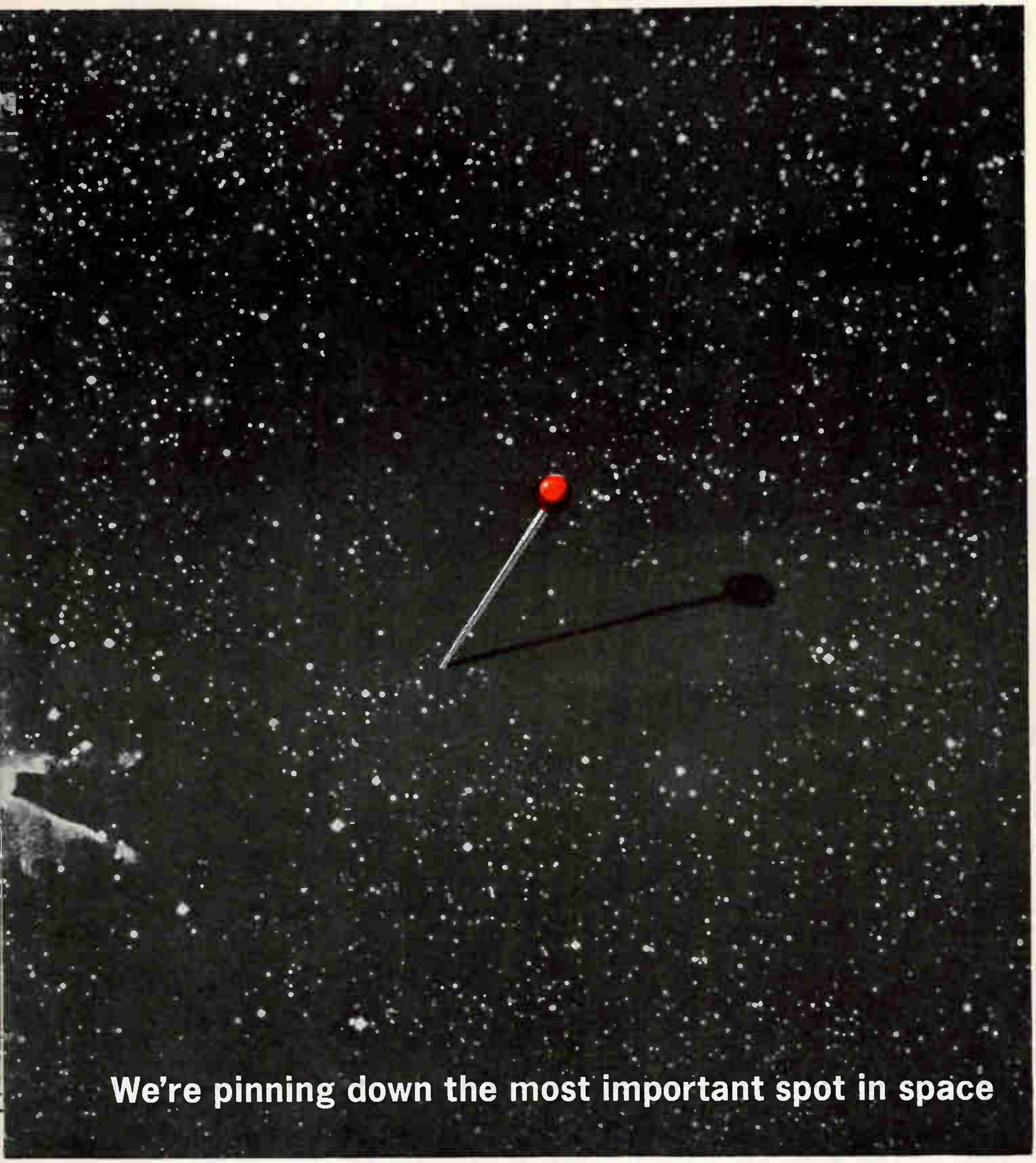
MICRODOT INC.

220 Pasadena Avenue. South Pasadena, Calif.

MUrray 2-3351 SYcamore 9-9171

It's the point where men will first rendezvous in space. It could be any point. The trick is getting two men there at the same moment when they're traveling at orbital speeds or greater.

Northrop is already working on many of the technical problems that are still to be solved before the first men can meet in space . . . rendezvous trajectory analysis, for instance, and spacecraft maneuverability, navigation and propulsion. Active studies are under way in various phases of space medicine and human engineering for crew survival in space, and on in-space rescue, repair and refueling techniques. Important new ground has already been broken in the area of re-entry, recovery and landing systems for space vehicles. In short, Northrop is active in almost every phase



of space research.

If you have the inquiring kind of mind that won't rest with easy answers, and welcomes new challenges to grow on, there's a spot for you at Northrop. You'll work in the invigorating company of like-minded scientists, engineers, and mathematicians on these and other advanced space research projects.

For full details about these opportunities and challenges, write Northrop Corporation, Box 1525, Beverly Hills, California, indicating your area of special interest.

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Northrop Corporation, Beverly Hills, California
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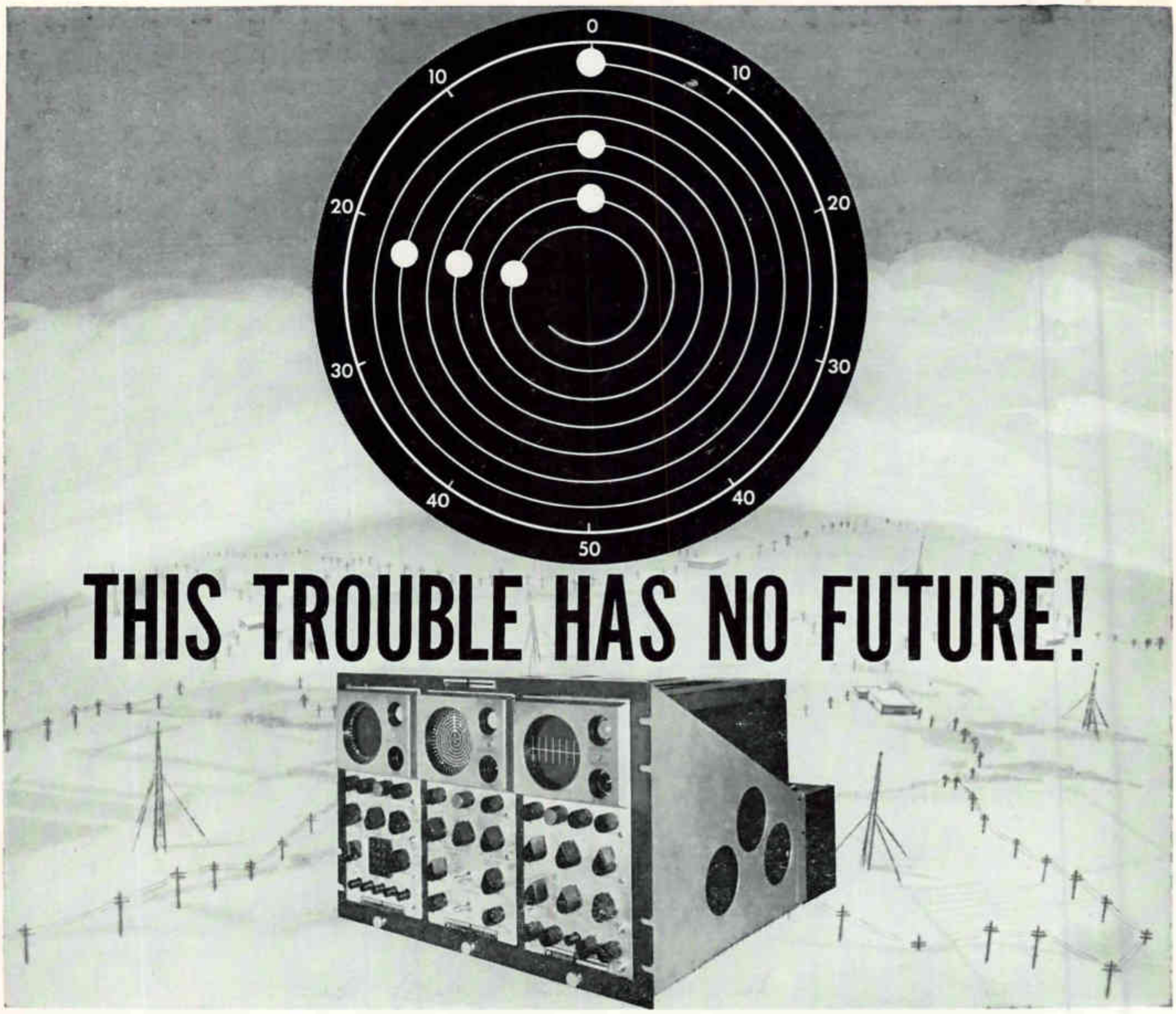


THIS TROUBLE HAS NO FUTURE!

Radiation's TDMS anticipates circuit failure in telegraph and data transmission links without interrupting traffic

Radiation's Telegraph Distortion Monitoring System—TDMS—is a compact, self-contained unit for continuous on-line monitoring, testing and analysis of telegraph and data transmission links.

Its sensitivity to signal distortion is so acute that it can locate and describe equipment misalignment *before* it becomes an operational problem.

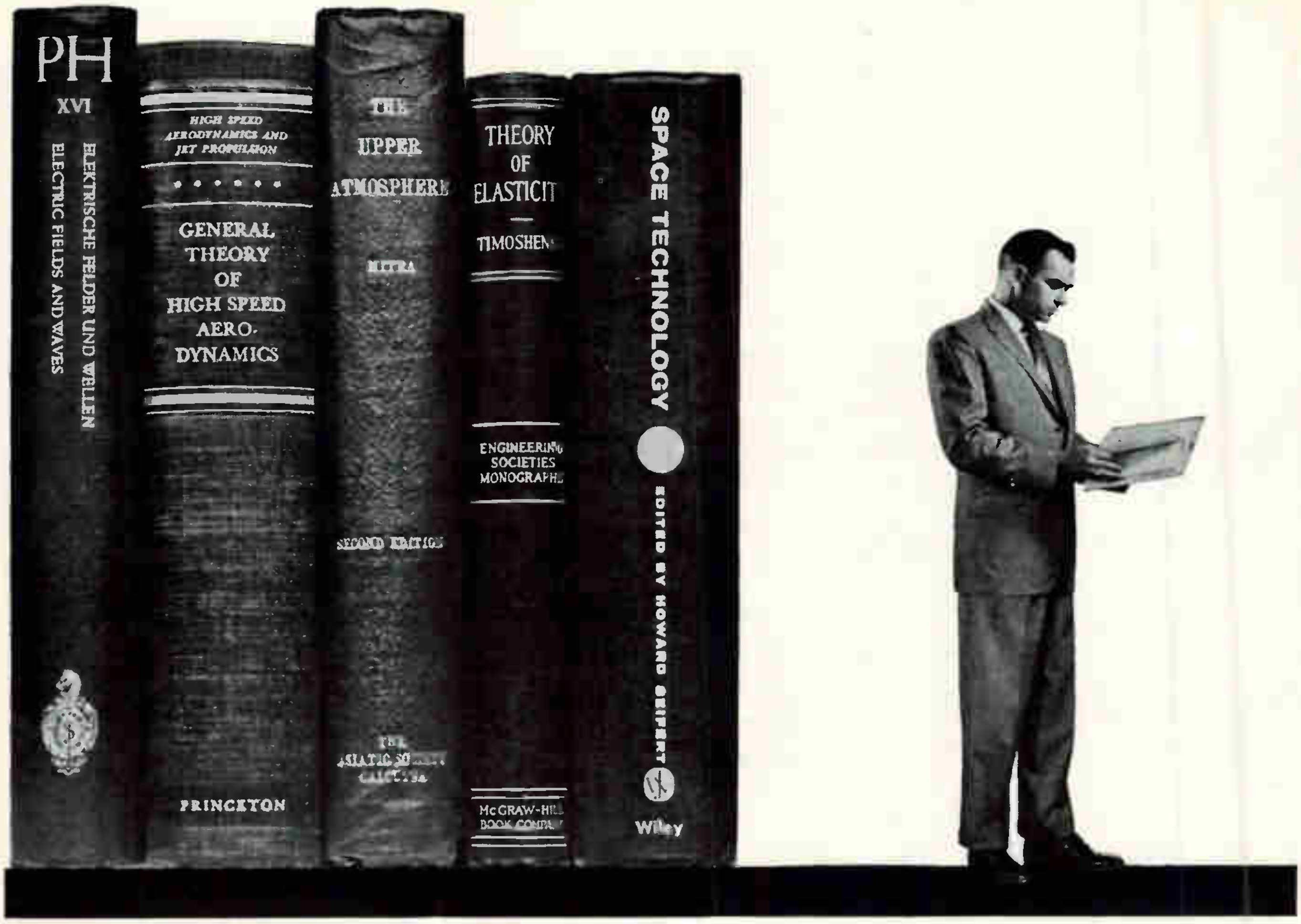
TDMS does its job without interrupting traffic and in a language that is easily interpreted by a nontechnical operator. Thus, in our illustration above, a line that is becoming increasingly capacitative can be located and rectified prior to circuit failure.

For detailed information on the TDMS, write Dept. EL-4, Products Division, Radiation Inc., Melbourne, Florida. Refer to Bulletin RAD-E-100B.

TDMS performs all of these *on-line* functions: 1. Distortion transmitter; 2. Test message transmitter; 3 Distortion analyzer; and 4. Linear wave-form analyzer.

Among available accessories are utility cart (shown above), portable power supply, and relay-test adapter.

RADIATION
INCORPORATED



scientists and engineers in a unique leadership role

Able minds are at work within Aerospace Corporation. The scientists and engineers of this leadership organization are the critical civilian link uniting government and the scientific-industrial team developing space systems and advanced ballistic missiles. In providing broad scientific and technical leadership to every element of this team, they are engaged in a balanced program of activities spanning the spectrum from basic research and forward planning through general systems engineering to technical review, monitoring, and steering of hardware development by industry. Their singular role installs the men of Aerospace Corporation in a position to make real progress. They are privileged to view both the state of the art and system development in their totality. They are thus able to implement objectively, decisively, and with all due timeliness and economy, major advances in the national interest. Now more men of their caliber are needed: highly motivated scientists and engineers with demonstrated achievement, maturity, judgment, and discretion beyond the norm. Such men are urged to contact Aerospace Corporation, Room 110, P.O. Box 95081, Los Angeles 45, California.

Organized in the public interest and dedicated to providing objective leadership in the advancement and application of space science and technology for the United States Government.

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13 MOVES TO RELIABLE TRIMMING

SPECTROL'S FULL LINE of trimming potentiometers features 10 of the smallest square trimmers ever made, plus the only *transistor-size* units for solid state circuitry. This selection covers almost every conceivable application—a sure way to avoid checkmate when you need reliable trimmers.

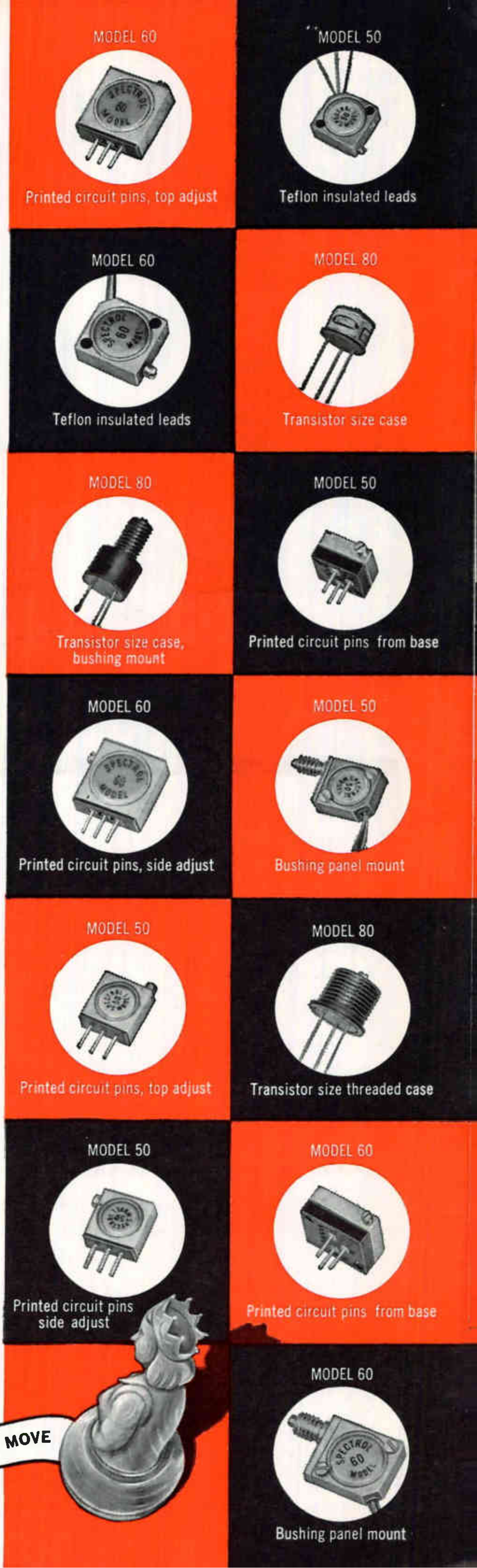
SQUARE TRIMMER DATA. Models 50 and 60 measure ⅜" and ½" square respectively • humidity proofing a standard feature • available in resistances to 100K • greater surface contact between mandrel and aluminum case for better heat dissipation, no external heat sinks needed • dual wiper for positive contact under all conditions of shock and vibration.

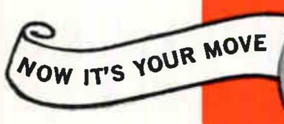
SINGLE TURN TRIMMER DATA. Model 80 built into TO-9 transistor type case • measures less than ⅓" in diameter, weighs 1 gram—smallest trimmer on the market • completely sealed against moisture and humidity • resistance element twice as long as ordinary trimmers • designed for complete package encapsulation with other printed circuit components • available in 3 case styles with resistance range to 20K.

IMMEDIATE DELIVERY. Your nearby Spectrol distributor stocks standard models of trimmers and miniature potentiometers as well as other standard Spectrol precision potentiometers and turns indicating dials. Prices are $6 to $8 in quantities of 1-9 for most styles and resistances.

MORE DATA AVAILABLE. Contact your Spectrol engineering representative or drop us a line at the factory. Please address Dept. 42.

ALL TRIMMERS SHOWN ACTUAL SIZE





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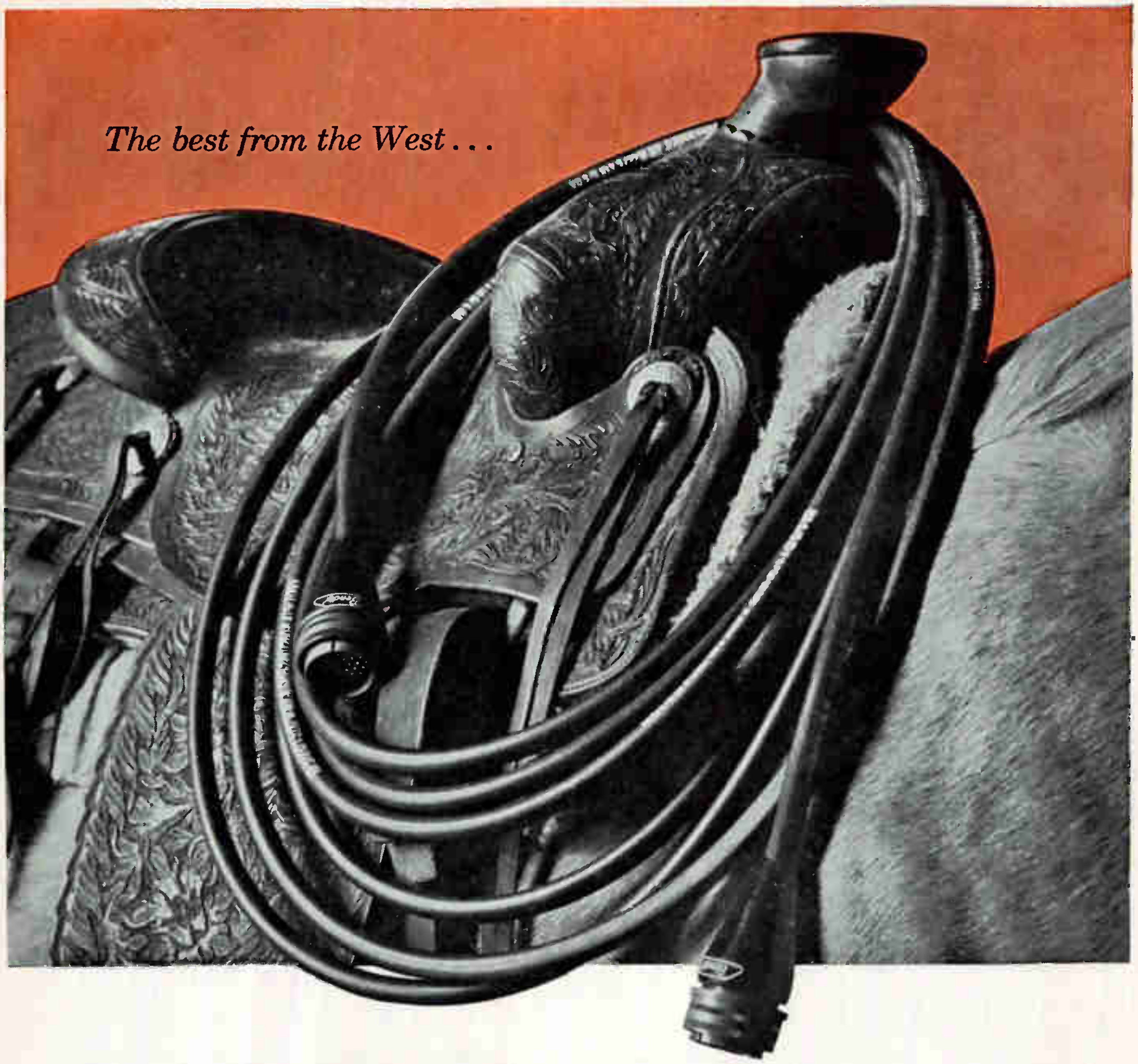

QUALITY CABLES AND CONNECTORS NOW PRODUCED AT NEW BENDIX SANTA ANA PLANT

For users of electronic cables and connectors, Scintilla Division's new plant in Santa Ana, Calif., is an important addition to West Coast industry.

Here are the finest, most complete, environmentally-controlled, air-conditioned facilities in the area devoted exclusively to cable development and manufacture. For West Coast electrical connector users the Santa Ana plant with its complete facilities also offers "short-order" assembly service on the extensive line of Bendix connectors.

The plant is designed to meet the standard and special-purpose requirements of aircraft, missiles and ground-based electronic equipment.

Sales and service for cables and connectors and all other Scintilla Division products will still be handled out of 117 E. Providencia Ave., Burbank, Calif.

Bendix Connectors — Bendix Cables: Designed together to work best together

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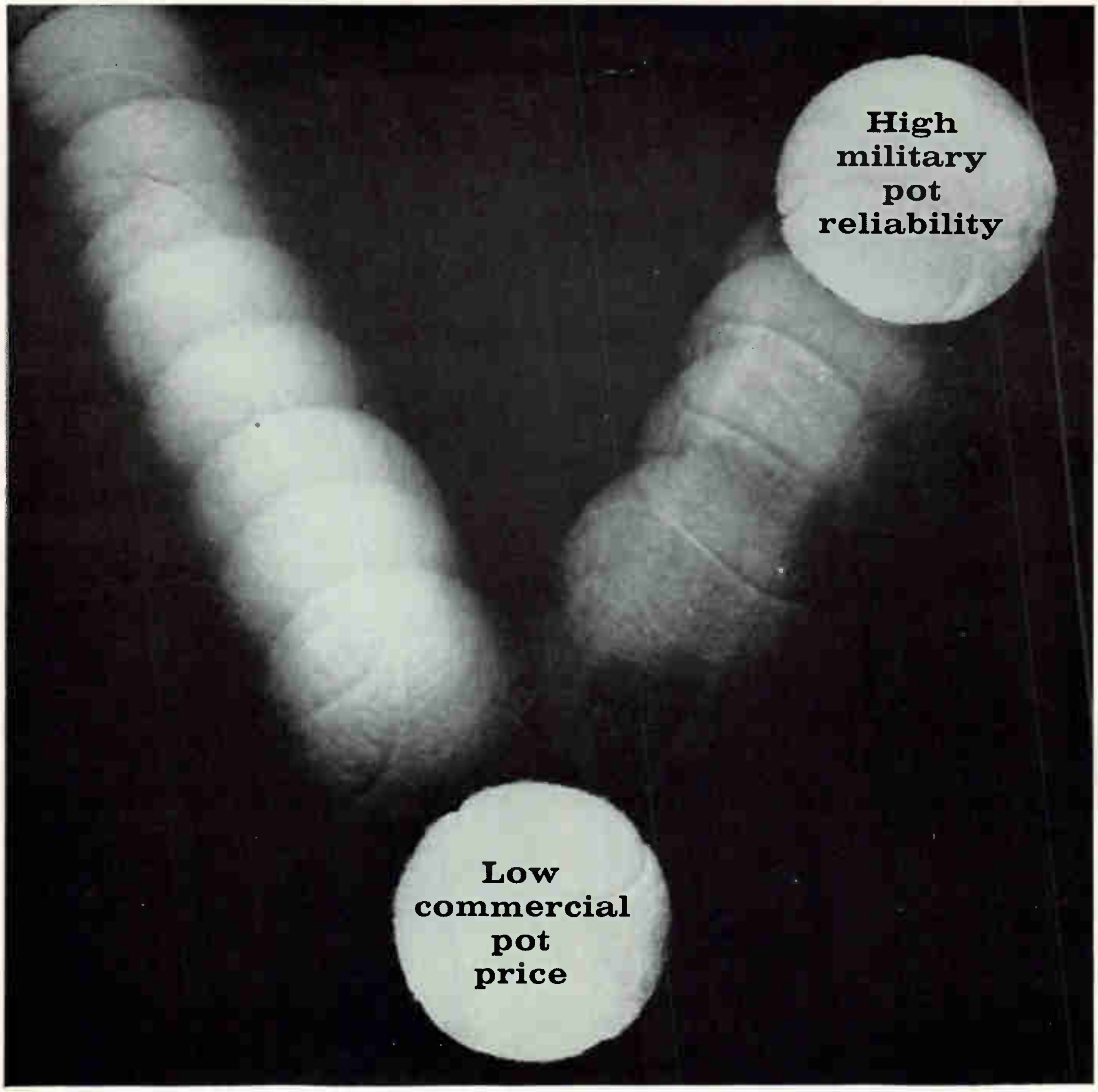
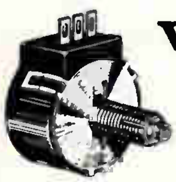


That's how the ball bounces with Waters new PT ¾



Dust! Corrosion! Moisture! Vapors! All are foes of potentiometer reliability, yet ordinarily costly to keep out. Now, however, Waters introduces a new ¾" plastic case pot, the PT ¾, meeting military sealed pot specs (MIL-R-19/1A), yet priced no higher than many commercial grade pots! "O" ring shaft seal and complete internal sealing virtually eliminate environmental problems. Resistance element is a copper mandrel wound with wire alloy which has a temperature coefficient of 20 PPM/°C. Resistance range 10 to 20,000 ohms ±5%. Dissipates 1.5 watts at 40°C. Available with split or plain bushings. Write for Bulletin PT 760.

Waters

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CONVAIR/POMONA is the developer of REDEYE, a one-man, shoulder-launched guided missile ... a new lightweight weapon that will strike swiftly with pin-point accuracy ... a weapon that will ensure our ground forces of the Army and Marine Corps an effective means of combatting low-flying enemy aircraft.

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ME	☐	☐	☐	____	Other: ____	☐	☐	☐	____
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Please indicate your fields of experience below.

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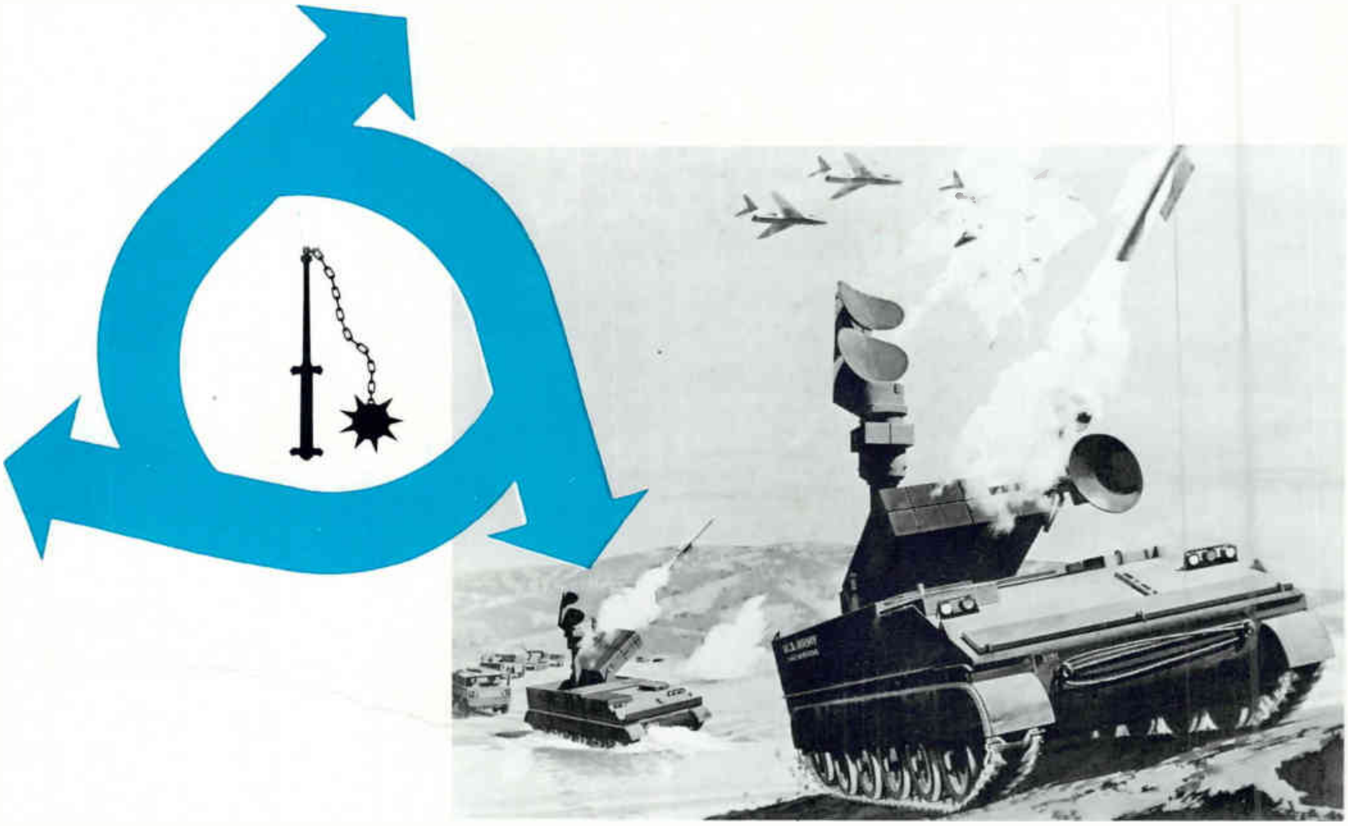

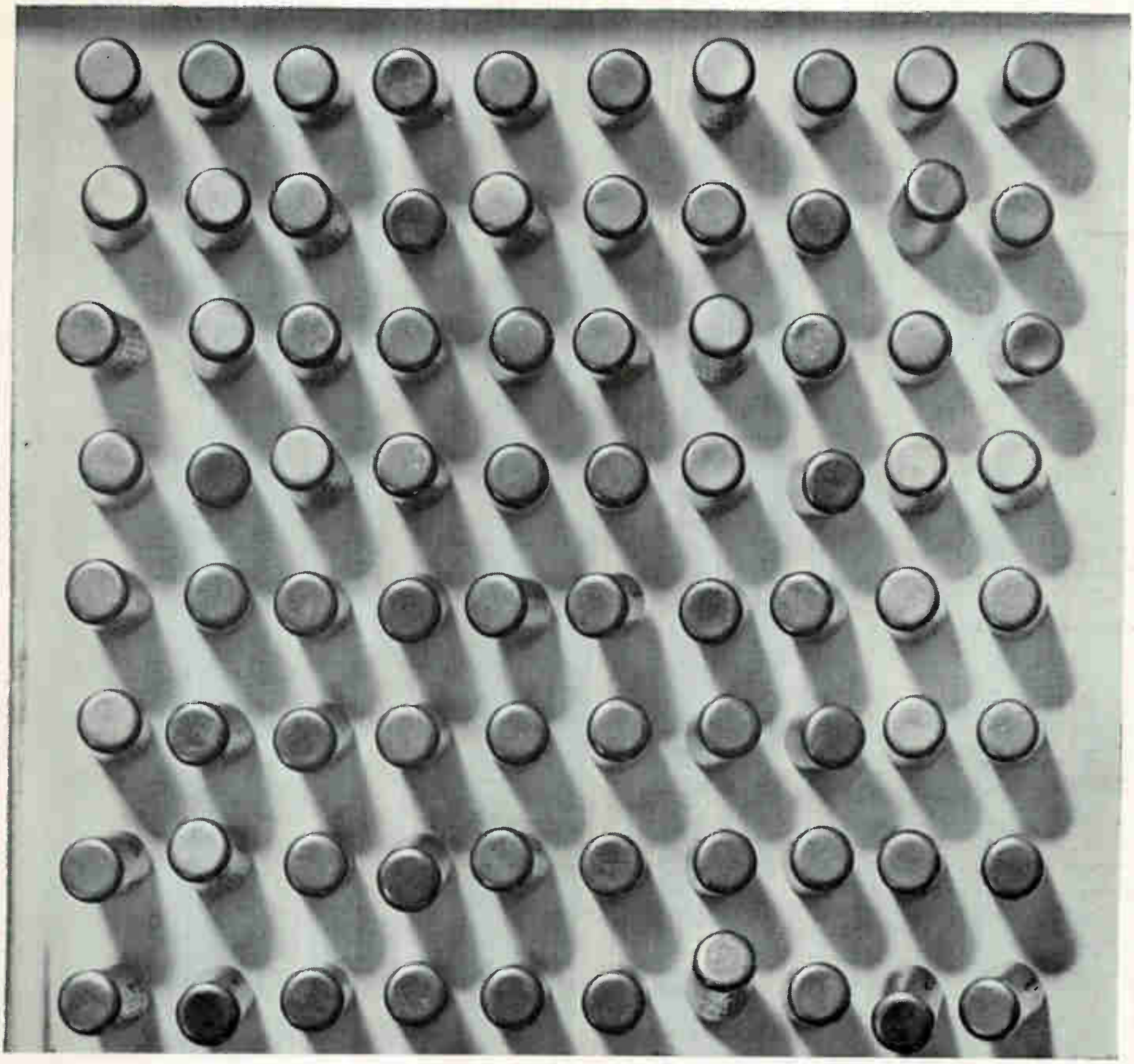

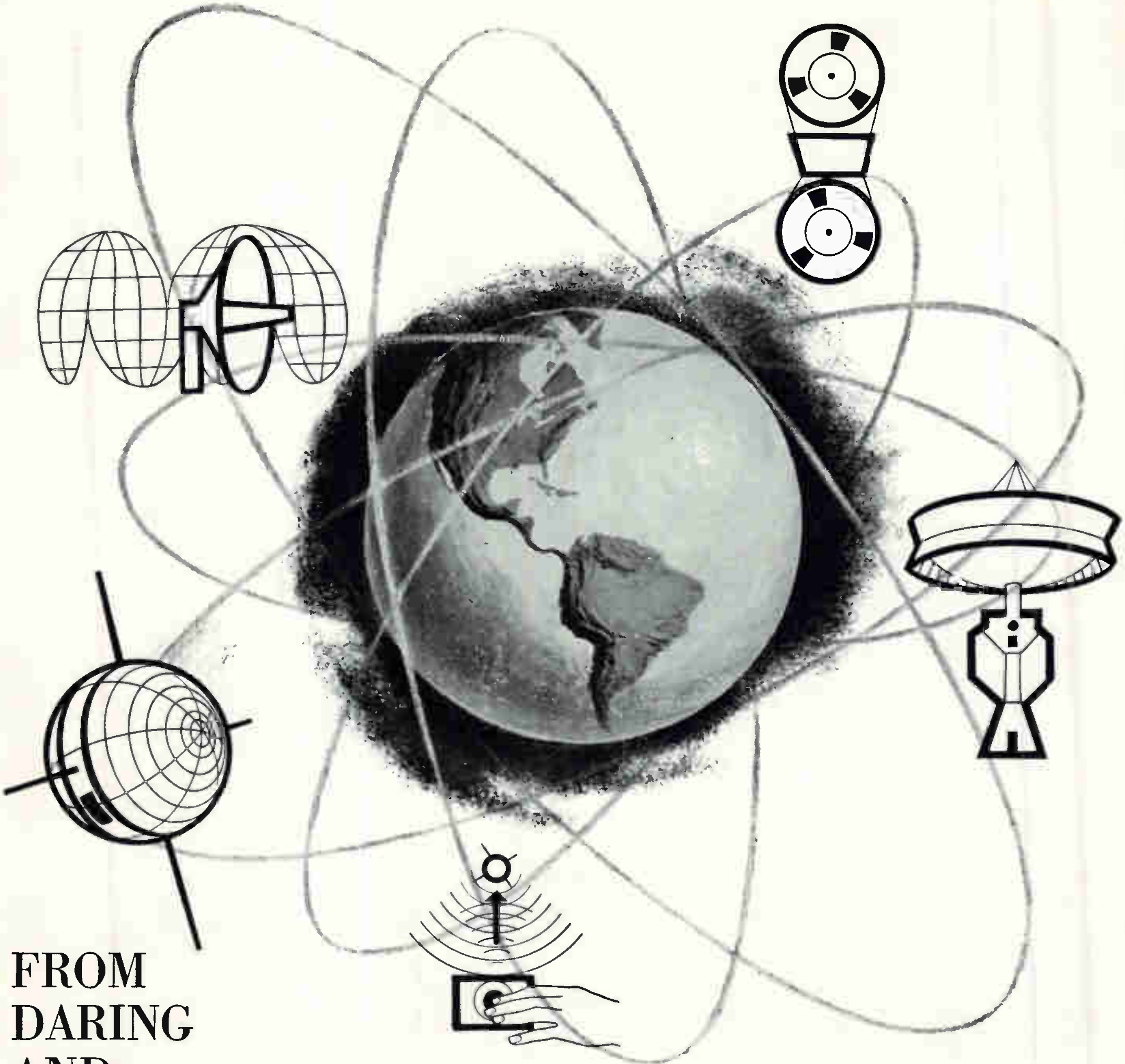

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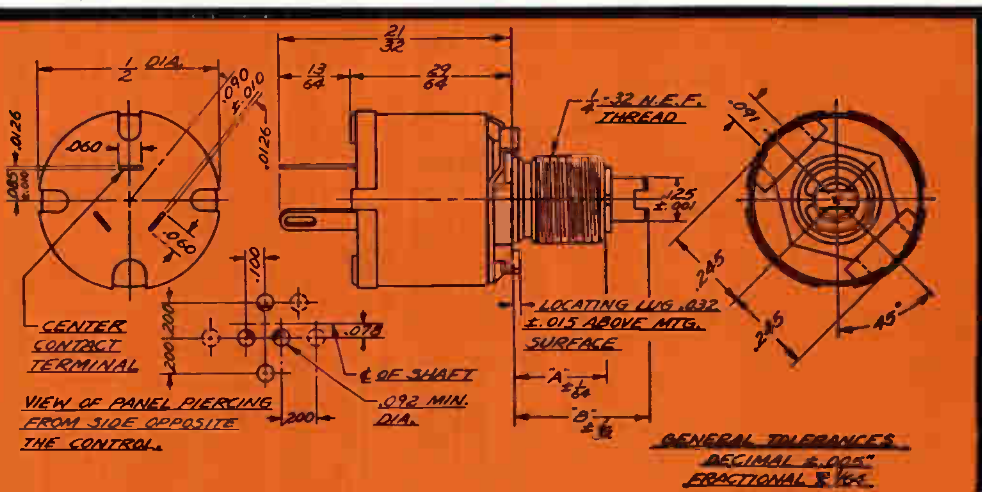

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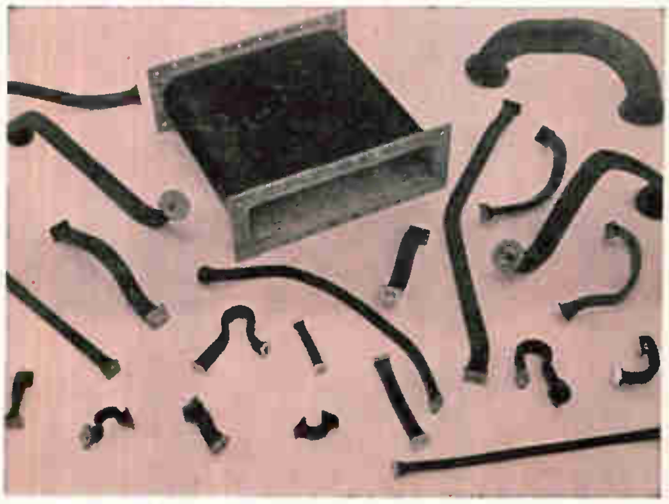

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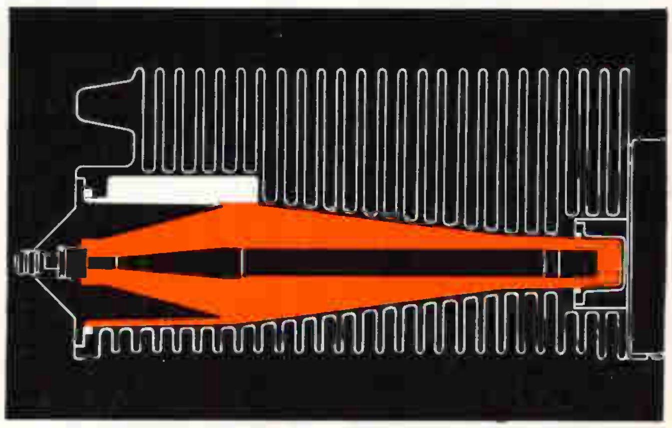

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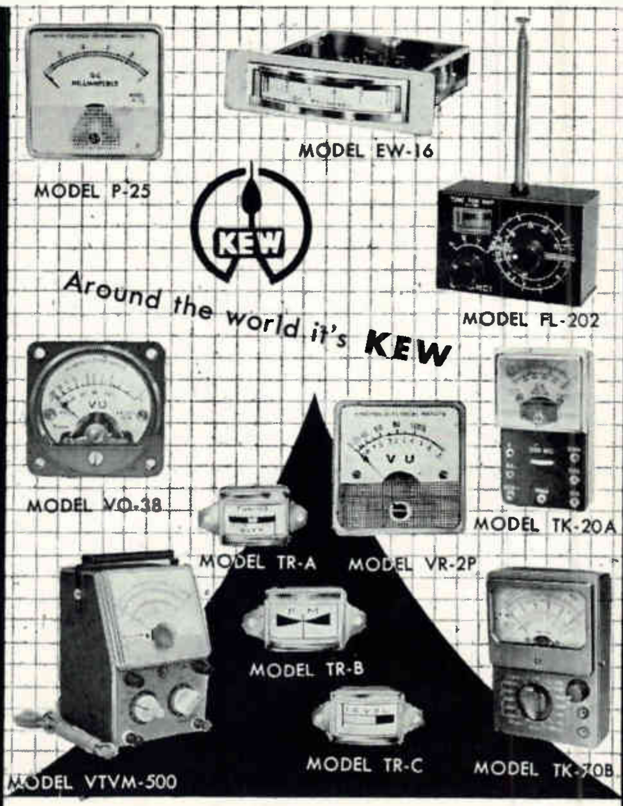

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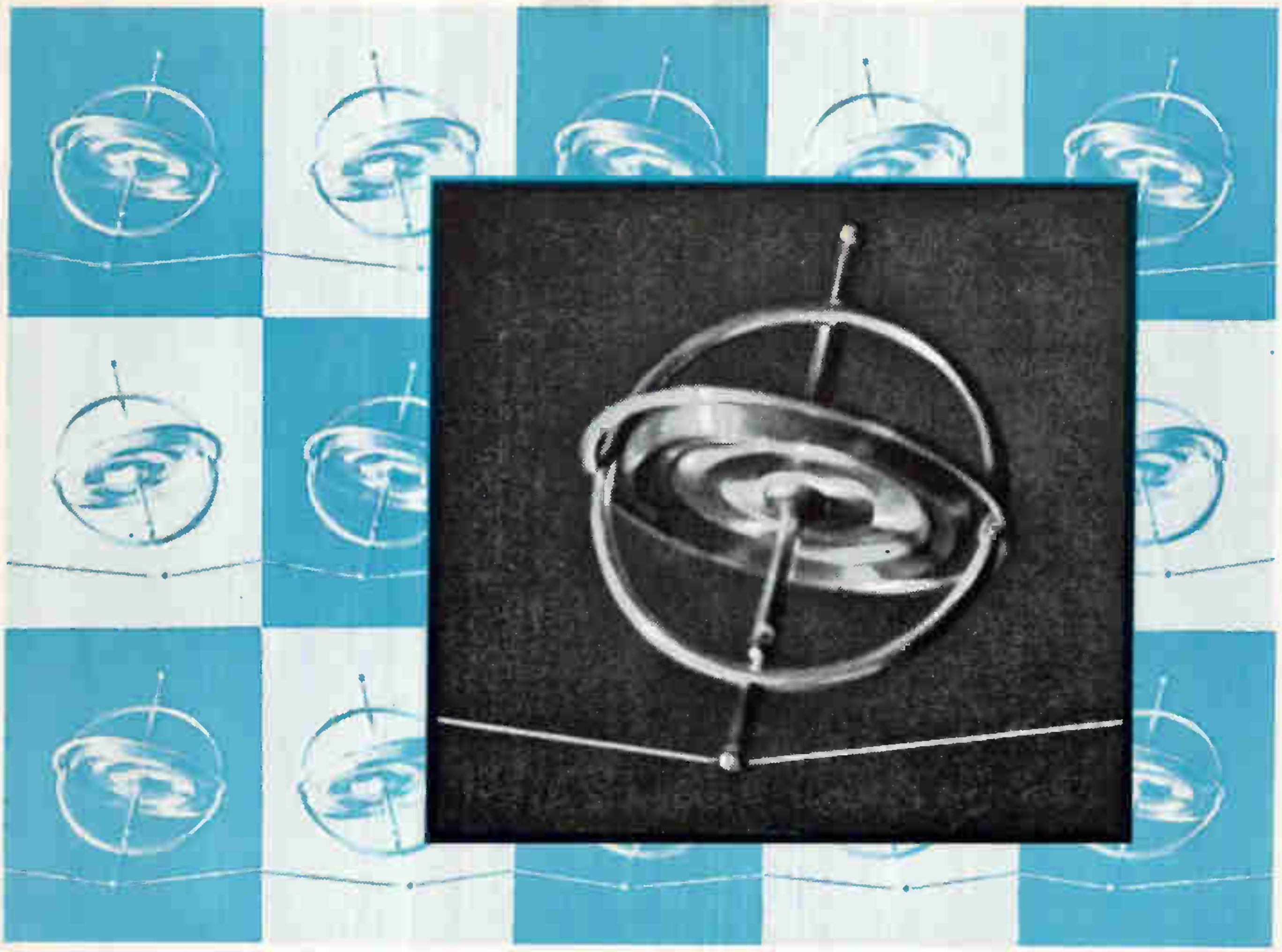

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PROGRAM SCHEDULE

TUESDAY, APRIL 18, 1961

8:30-10:00 A.M.

Registration, Terrace Casino, Morrison Hotel

10:00 A.M.

SESSION I. ANTHRACENE
Session Chairman: James J. Brophy
Invited Paper — CHARGE CARRIER MOBILITY AND PRODUCTION IN ANTHRACENE CRYSTALS
R. G. Kepler,
Central Research Department,
E. I. duPont de Nemours and Company,
Wilmington, Delaware

Invited Paper — ELECTRONIC TRANSPORT IN ANTHRACENE AND OTHER ORGANIC SYSTEMS
Oliver H. LeBlanc, Jr.,
General Electric Research Laboratory,
Schenectady, New York

12:00

CONFERENCE LUNCHEON
Constitution Room, Morrison Hotel
W. W. MacDonald, Toastmaster

Speaker:
J. F. Bourland, General Manager,
Central Research Laboratory,
American Cyanamid Company,
New York, New York
"A Management Appraisal of Organic Semiconductors"

2:00 P.M.

SESSION II. POLYMERS
Session Chairman: Donald J. Berets
Invited Paper — SEMICONDUCTION IN POLYMERS
Herbert A. Pohl,
Plastics Laboratory,
Princeton University,
Princeton, New Jersey

ELECTRICAL PROPERTIES OF PYROLYTIC GRAPHITES
Claude A. Klein,
Research Division,
Raytheon Company,
Waltham, Massachusetts

ELECTRICAL CONDUCTIVITY IN PYROLIZED POLYACRYLONITRILE
W. D. Brennan and J. J. Brophy,
Physics Division,
Armour Research Foundation,
Chicago, Illinois
and
H. Schonhorn,
Stamford Laboratories,
Central Research Division,
American Cyanamid Company,
Stamford, Connecticut

STUDIES ON SOME SEMICONDUCTING POLYMERS
H. A. Pohl, J. Bornmann, and W. Itch,
Plastics Laboratory,
Princeton University,
Princeton, New Jersey

THERMAL CONDUCTIVITY OF MOLECULAR CRYSTALS
R. W. Keyes,
Research Center,
International Business Machines Corporation,
Poughkeepsie, New York

WEDNESDAY, APRIL 19, 1961

:00 A.M.

SESSION III. SIMPLE MOLECULES
Session Chairman: William D. Brennan
Invited Paper — GENERATION OF FREE CARRIERS AND ELECTRODE EFFECTS
Marvin Silver,
U. S. Army Research Office,
Durham, North Carolina

ELECTRONIC PROPERTIES OF ORGANIC COMPOUNDS. I. HETEROCYCLIC COMPOUNDS
S. Aftergut and G. P. Brown,
General Engineering Laboratory,
General Electric Company,
Schenectady, New York

ELECTRONIC PROPERTIES OF ORGANIC COMPOUNDS. II. THEORETICAL CONSIDERATIONS ON THE EFFECT OF IMPURITIES
G. P. Brown and S. Aftergut,
General Engineering Laboratory,
General Electric Company,
Schenectady, New York

PHOTOCONDUCTIVITY AND INTERMOLECULAR INTERACTION IN NON-IONIC AROMATIC CRYSTALS
M. Y. Kleinerman and S. P. McGlynn,
Coates Chemical Laboratories,
Louisiana State University,
Baton Rouge, Louisiana

AN OPEN SHELL SELF-CONSISTENT FIELD METHOD FOR AROMATIC AND OLEFINIC ORGANIC MOLECULES
O. W. Adams,
Chemistry Division,
Armour Research Foundation,
Chicago, Illinois

12:00

CONFERENCE LUNCHEON
Constitution Room, Morrison Hotel
James J. Brophy, Toastmaster

Speaker:
W. O. Baker, Vice-President—Research,
Bell Telephone Laboratories,
Murray Hill, New Jersey
"Implications of Organic Semiconductors for Industrial Science"

2:00 P.M.

SESSION IV. CHARGE-TRANSFER COMPLEXES
Session Chairman: John W. Buttrey
Invited Paper — ELECTRONIC CONDUCTION IN MOLECULAR COMPLEXES
Jan Kommandeur,
Parma Research Laboratory,
Union Carbide Corporation
Parma, Ohio

ELECTRONIC CONDUCTION AND EXCHANGE INTERACTION IN A NEW CLASS OF CONDUCTIVE ORGANIC SOLIDS
R. G. Kepler, P. E. Bierstedt and R. E. Merrifield,
Central Research Department,
E. I. duPont de Nemours and Company,
Wilmington, Delaware

OBSERVATIONS ON THE PARAMAGNETISM OF SOME ORGANIC SEMICONDUCTORS
Charles M. Huggins,
General Electric Research Laboratory,
Schenectady, New York

A COMPARISON OF MEASUREMENTS PERFORMED ON SINGLE CRYSTAL AND COMPRESSED MICROCRYSTALLINE CHARGE-TRANSFER COMPLEXES
M. Labes, and P. L. Kronick,
Franklin Institute,
Philadelphia, Pennsylvania

Summary Invited Paper — PRESENT STATE OF ORGANIC SEMICONDUCTORS
David Fox,
State University of New York,
Long Island Center,
Oyster Bay, L. I., New York

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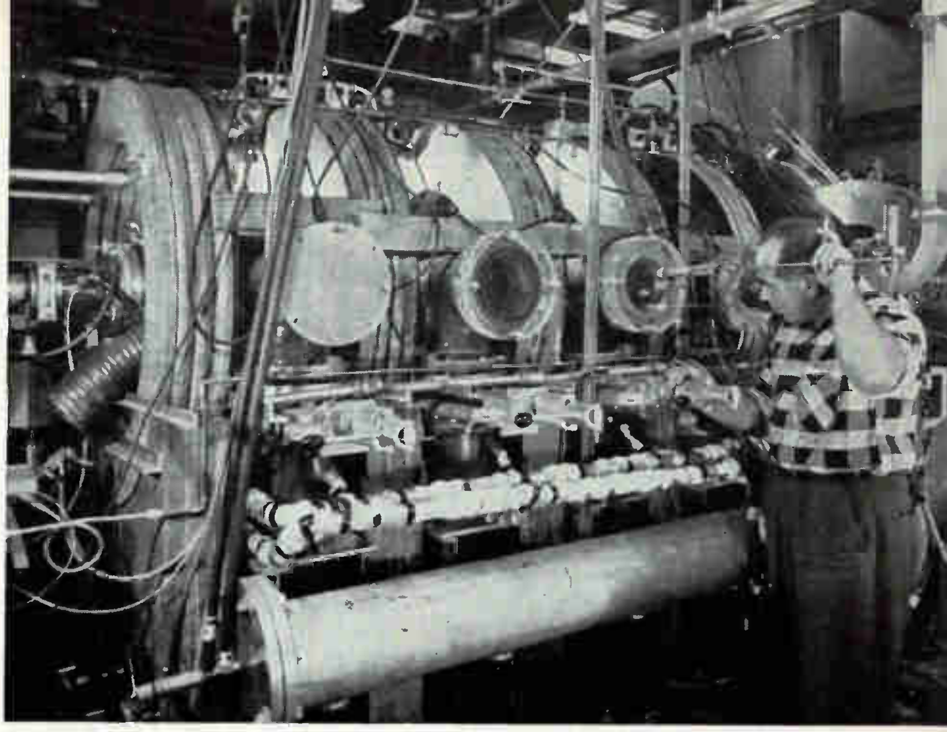
electronics
April 7, 1961

Use of microwave interferometer systems to determine electron density and distribution in low-temperature, magnetically contained plasmas is explained



Physicist performs experiment on P-4 steady-state plasma facility

Determining Electron Density And Distribution in Plasmas

By HARLIN L. BUNN,
Lawrence Radiation Laboratory,
University of California,
Livermore, California

PARAMETERS to be measured in a controlled thermonuclear reaction include the density and temperature of the charged particles in the plasma. Methods have been developed at Lawrence Radiation Laboratory for determining plasma electron density and density distribution with microwave interferometer systems. This article describes such techniques, which may also be extended to studies of ionized missile wakes and to such microwave components as harmonic generators, electronically controlled phase shifters, switches, and other devices derived from a waveguide filled with ionized gas.

Assume a slab of plasma that is contained by a magnetic field, and whose dimensions are large compared to the microwave wavelengths used to probe the plasma. This slab can be regarded as a dielectric that partially fills the waveguide transmission path, thereby causing a measurable phase shift.

Solving Maxwell's equations for the propagation coefficient in the case of the magnetic field parallel to the electric vector gives an approximate expression for the phase constant β of

$$\beta = (\omega/c)\sqrt{1 - \omega_p^2/\omega^2} = (\omega/c)\sqrt{K} \quad (1)$$

where ω = microwave radian frequency, c = velocity of light, ω_p = plasma radian frequency ($\sqrt{ne^2/m\epsilon_0}$), K = dielectric constant of plasma, n = electron density (electrons/M^3), m = electron mass (9.11×10^{-31} Kg), e = electron charge (1.6×10^{-19} coulomb) and $\epsilon_0 = 1/36\pi \times 10^{-9}$ farad/M.

This expression is for low-temperature plasma (kinetic temperature below a few million deg K where the collision frequency is small and the attenuation constant is assumed to be zero. Since Eq. 1 contains electron density, n, the problem of measuring electron density in plasma can be solved by inserting the plasma into a microwave transmission path and measuring the differential phase shift.

If microwave energy is propagated along a transmission path containing a plasma, a force is exerted upon each plasma electron, causing it to oscillate around some position. As the frequency of the microwave signal approaches the plasma frequency, the excursion of the electron becomes more violent, assuming collisions are taking place. This shows up in measurements as increasing attenuation of the microwave signal. Finally when $\omega = \omega_p$, the signal is cut off completely and no transmission takes place. (See Fig. 1.)

In an actual experiment something must be known about electron distribution before quantitative measurements of the density can be made. Consider first uniform dis-

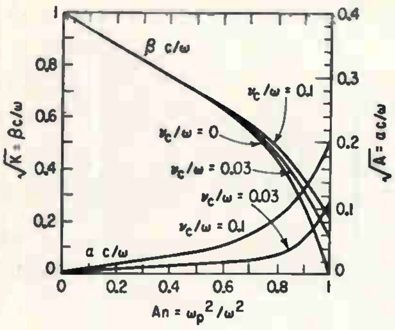


FIG. 1—Normalized phase shift and attenuation as a function of density and frequency

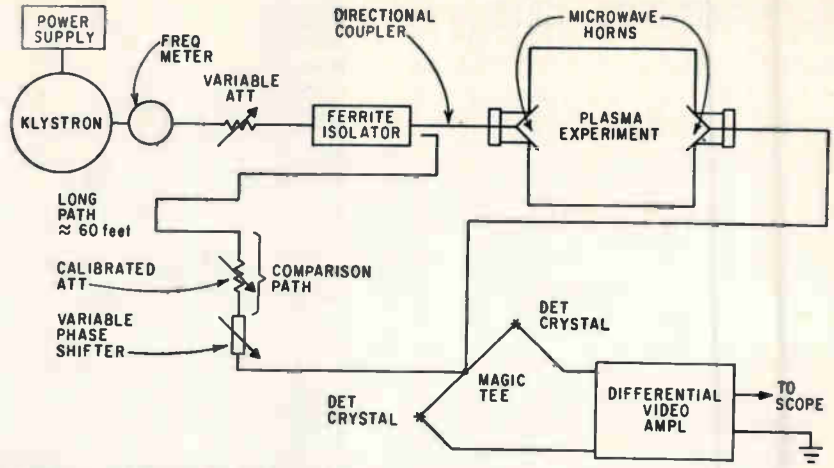


FIG. 2—Differential phase shift is measured with microwave bridge

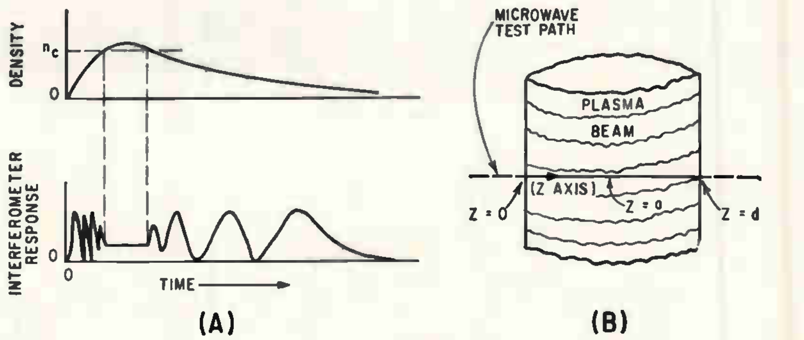


FIG. 3—Density as a function of time is shown in (A); plasma beam is traversed by microwave test path (B) along which there is a particular density distribution

tribution (electron density at a given instant the same throughout the cross-section of plasma traversed by the microwaves). For calculation, the horns are assumed to be in contact with the plasma although in practice they would not be since this would contaminate and cool the plasma. The phase shift before the plasma is inserted is

$$\phi = \beta d = (\omega/c)\, d = 2\pi d/\lambda \qquad (2)$$

where d = distance between transmitting and receiving antennas, f = frequency and λ = wavelength in free space. The phase shift with a plasma is

$$\phi_p = (\omega/c)\, d\, K^{1/2} = (2\pi d/\lambda)(1 - \omega_p^2/\omega^2)^{1/2} \quad (3)$$

The change in phase-shift due to introduction of the plasma is (ignoring phase shifts due to reflections at the interface)

$$\Delta\phi = (2\pi d/\lambda)\,[1 - (1 - \omega_p^2/\omega^2)^{1/2}] \qquad (4)$$

Defining a density n_c in terms of ω^2, $\omega^2 = ne^2/m\epsilon_0$ and taking the ratio ω_p^2/ω^2,

$$\omega_p^2/\omega^2 = \frac{ne^2/m\epsilon_0}{n_c e^2/m\epsilon_0} = n/n_c \qquad (5)$$

Thus

$$\Delta\phi = (2\pi d/\lambda)\,[1 - (1 - n/n_c)^{1/2}] \qquad (6)$$

Quantity $\Delta\phi$ can be measured with a microwave bridge, and λ and d are known. By varying the frequency until cutoff occurs, cutoff density n_c can be calculated from the expression for the plasma radian frequency. In its simplest form

$$n_c = (1.24 \times 10^{-8})\, f^2 \text{ electrons/cm}^3 \qquad (7)$$

Thus Eq. 6 can be solved for n once differential phase shift is measured.

Figure 2 shows one method of using a microwave bridge to measure differential phase shift. To determine the waveguide band to be used, the expected electron densities are estimated and the frequency of cutoff is obtained from Eq. 7. Use the waveguide band in which this frequency occurs, or the next higher one.

Power from the klystron is split by a directional coupler into a work path and a comparison path. The energy in the work path is fed to a transmitting antenna inside the wall of the vessel containing the plasma. A similar antenna, inside the wall of the vessel and at the opposite side, receives the radiated energy and channels it to one arm of a balanced mixer.

This is the ideal situation but often it is impossible to place the antennas inside the vessel walls and then it becomes necessary to transmit the microwaves not only through the plasma but through the vessel walls. This may cause considerable attenuation to the signal but does not invalidate the method.

The energy from the comparison path is fed to the other arm of the balanced mixer. Comparison path phase and attenuation are adjusted until there is no output from the bridge when no plasma is present.

In many experiments the plasma is transient. A typical plot of density as a function of time is shown in Fig. 3A. As plasma density increases, the dielectric constant changes with time, giving rise to a shift in phase through the work path. This causes the bridge to unbalance, and as the total phase shift increases by multiples of 2π, the bridge output takes on the form shown. When the phase difference between the two paths is an even integral multiple of π, the output is maximum positive. When the phase difference is an odd multiple of π, the output is minimum. When the density equals or exceeds cutoff (n_c), there is no output from the bridge.

Initially the bridge is set for no output. The klystron runs c-w with no modulation. A pulse generator such as a Hewlett-Packard Model HP212A can be used to pulse the klystron off. The klystron mode is adjusted so that the klystron is pulsed off, which shows on the oscilloscope as a wiggling of the base line. Looking at the output of the bridge fed through a differential video amplifier to an oscilloscope, the phase and attenuation can then be adjusted until no output is observed.

With the machine set for a cycle, the bridge in balance, and the oscilloscope set to trigger when the cycle begins, a cycle is started and a picture is taken. Then a count is made of the number of fringes occurring in the bridge output from zero to the cutoff density.

The differential phase shift due to insertion of the plasma in the work path is given by Eq. 6 and the distance from one peak to the next is $\Delta\phi = 2\pi$. Setting Eq. 6 equal to $2\pi N$, where N is the number of fringes, gives

$$n = n_c (2N\lambda/d - N^2\lambda^2/d^2) \quad (8)$$

This is the equation for determining electron density where distribution is uniform. All the quantities are known except n_c, which is determined by changing the frequency until no transmission occurs through the plasma, and calculating from Eq. 7. The quantity d is the distance over which the differential phase shift takes place or distance between antennas and λ is the wavelength used for determining the number of fringes N.

In most experiments the plasma electron density is not uniform, and therefore the expression for density given by Eq. 8 must be modified.

Figure 3B shows the plasma beam traversed by the microwave test path. It is the electron density distribution along this path that is of concern. For convenience the Z axis is taken along the microwave path, with $Z = 0$ at the near edge of the plasma, $Z = a$ midway through the plasma, and $Z = d$ at the far edge of the plasma. Here the antennas are assumed to be located just at the beam edges.

The density distribution can be represented by some function $n(Z)$. The differential phase shift caused by insertion of the plasma into the microwave path then becomes

$$\Delta\phi = (\omega/c)\left[d - \int_0^d (1 - n(Z)/n_c)^{1/2}\, dZ\right] \quad (9)$$

Now $n(Z)$ may be one of the following types of function: cosine, cosine squared, Bessel, parabolic, Gaussian, or triangular. This makes the integration in Eq. 9 difficult. However, the integration has been carried out by Wharton and Slager[1] for some of these functions with results as plotted in Fig. 4. The term n_0 is maximum plasma electron density. Again let $\Delta\phi$ equal $2\pi N$,

$$\Delta\phi = 2\pi N = (\omega d/c)\ (1 - \phi'),$$

$$\phi' = 1 - 2\pi Nc/\omega d = 1 - N\lambda/d \quad (10)$$

The method for uniform electron density can be used to determine N. Frequency and path distance d are known so that ϕ' is determined. Normalized electron density is then determined from Fig. 4 by assuming a density distribution or determining it by methods described in reference 1. It has been found that the trapezoidal distribution fits a large number of experiments. The cutoff density is determined from Eq. 7 and the actual electron density is thus determined.

Another method for determining differential phase shift is superior in some respects; namely, it eliminates the amplitude effects and the nuisance of frequency drift. In this second method a clipper is added to the output of the differential video amplifier and the clipper output is fed through a Z-axis amplifier to the oscilloscope Z axis where it is used for intensity modulation. The klystron is swept about 50 Mc by an external sweep. The klystron sweep voltage is also applied to the Y axis of the oscilloscope, which is swept horizontally from its internal sweep circuits. If, with no plasma present, the horizontal sweep frequency is adjusted for a single trace and the clipped output of the differential amplifier is applied to the Z axis of the oscilloscope, an intensity-modulated trace results as in Fig. 5A. Changing the horizontal sweep frequency gives the results shown in Fig. 5B. Finally, if the horizontal sweep frequency is adjusted correctly, a series of bars results as in Fig. 5C. Some experiments require the addition of a still, that is, a long length of waveguide rolled into a cylinder and inserted in the comparison path, when the differential phase shift between the two paths does not result in several bars as shown in Fig. 5C.

If now a plasma cycle is initiated that is short in time compared to the horizontal time base of the oscilloscope, position of the bars will shift or skew as shown in Fig. 5D.

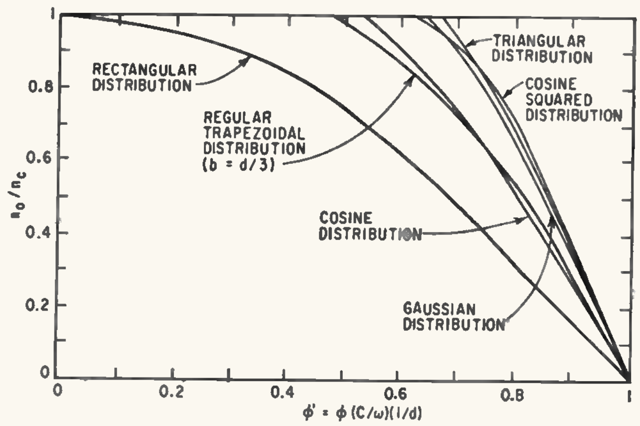


FIG. 4—Central plasma density as a function of corresponding normalized microwave phase coefficient

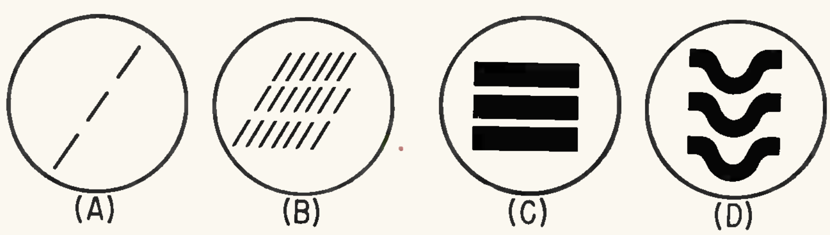


FIG. 5—With no plasma present, intensity-modulated trace is obtained (A); horizontal sweep frequency is then adjusted (B) to yield series of bars (C) that skew when plasma cycle is initiated (D)

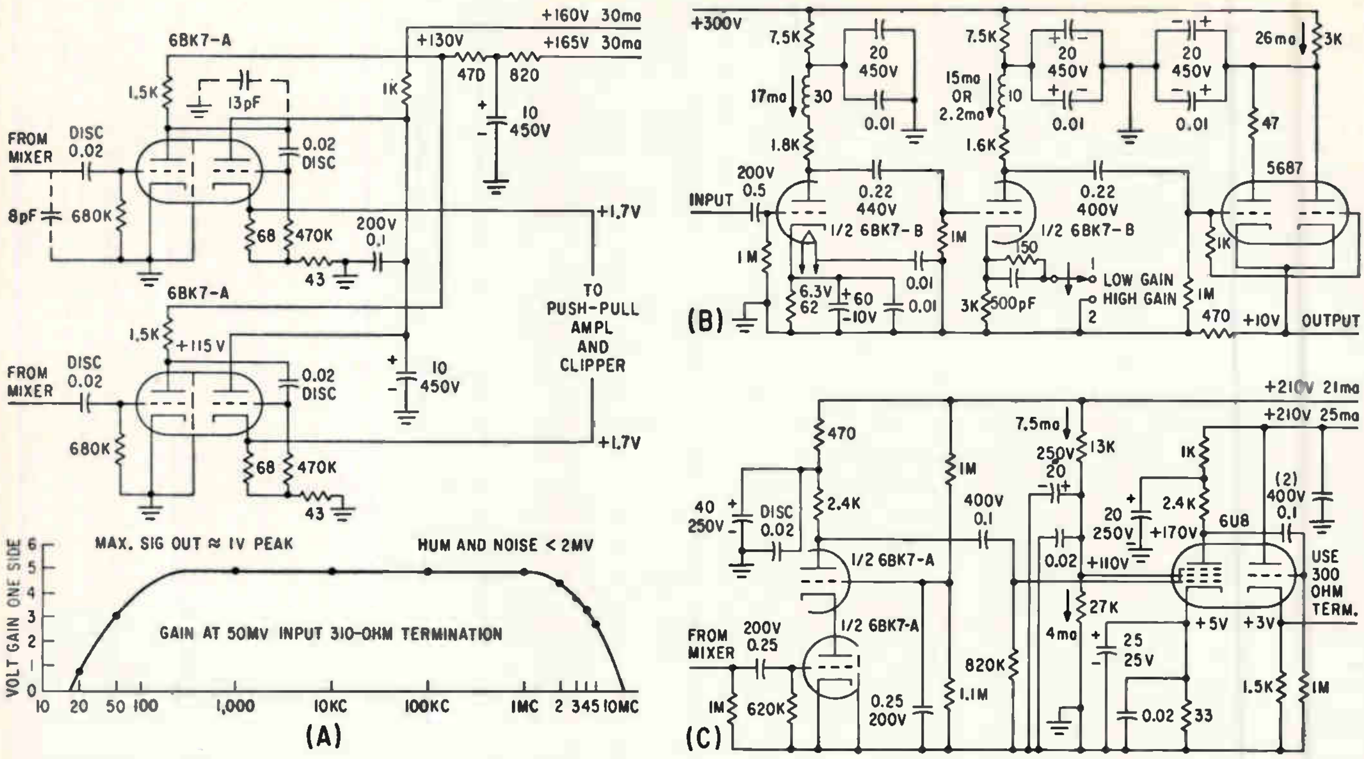


FIG. 6—Output of balanced mixer is fed to video preamplifier (A). For single-ended inputs, preamplifier shown in (B) can be used, and, for more gain, preamplifier shown in (C) can be added

If the peak of one bar shifts to the base line of the next bar, then one fringe shift has resulted. The differential phase shift is $2\pi N$, where N is the number of fringe shifts. By counting the number of fringe shifts and applying Eq. 10, the normalized phase shift can be determined. Normalized density is found by entering the horizontal axis of Fig. 4 at ϕ', projecting to the density distribution curve used for the experiment, and projecting over to the Y axis for n_0/n_c. By changing the frequency until cutoff occurs, which in this second method is where the center of the bar shifts vertically downward so that the bar becomes discontinuous, and applying Eq. 7, the cutoff density is found. The electron density in the experiment just performed then is determined since n_0/n_c is known.

Suppose 12 fringes are observed and d is 25 wavelengths. Then $\phi' = 1 - 12\lambda/25\lambda = 0.52$. Assume a rectangular distribution. From Fig. 4 n_0/n_c is about 0.7. Assuming $n_c = 10^{13}$ particles/cm^3, then the density is $n_0 = 0.7 \times n_c = 7 \times 10^{12}$ electrons/cm^3. This example applies to either method since N is the same.

Thus, it is relatively simple to determine electron density if the distribution is uniform. Density is found by measuring the total fringe shift and plugging into Eq. 8. However, in experiment, electron density cannot be determined until the form of the distribution is known. A fringe shift may represent entirely different densities for different experiments.

Assume a distance d between antennas of 10 cm. A microwave interferometer using either method is set up with the antenna oriented so that the electric field is parallel to the containing magnetic field.

(1) Adjust the frequency until cutoff occurs at maximum plasma density (that is, find the frequency for which cutoff density and maximum density are the same). Suppose this frequency is 20 Gc, and that 3.46 fringes are observed on the interferometer. From Eq. 10

$$\phi' = 1 - Nc/df = 0.48$$

(2) Determine maximum plasma density for this case by using Eq. 7.

$$n_0 = n_c = (1.24 \times 10^{-8}) f^2 = 4.96 \times 10^{12} \text{ electrons/cm}^3$$

(3) Increase the frequency by arbitrary amounts, each time counting fringes and calculating ϕ', and also the new cutoff density n_{co}.

(4) Tabulate n_0/n_{co} and ϕ' for the various frequencies and plot these points for comparison with the distribution curves of Fig. 4.

(5) Choose the distribution whose curve best fits the plotted points.

(6) Having thus determined what distribution function applies to this experiment, subsequent density measurements can be made. It is only necessary to count fringes and determine ϕ' from Eq. 10, then go to that value of ϕ' on the distribution curve in Fig. 4 to find the corresponding value of n_0/n_{co}. The cutoff density n_{co} can be calculated for the frequency, and hence the density n_0 can be determined. Suppose a value of 0.55 is found for n_0/n_{co}. Then electron density is $n_0 = 0.55 \times 4.96 \times 10^{12} = 2.73 \times 10^{12}$ electrons/cm^3.

This procedure for determining electron distribution is for a solid plasma beam and does not hold for a hollow beam where the region inside the shell is inaccessible at cutoff. For the present, electron distribution in hollow plasmas is determined by Langmuir probes or similar methods.

The circuits for making the measurements are shown in Fig. 6, 7 and 8. The output of the balanced mixer is fed to a video preamplifier, Fig. 6A, which has a

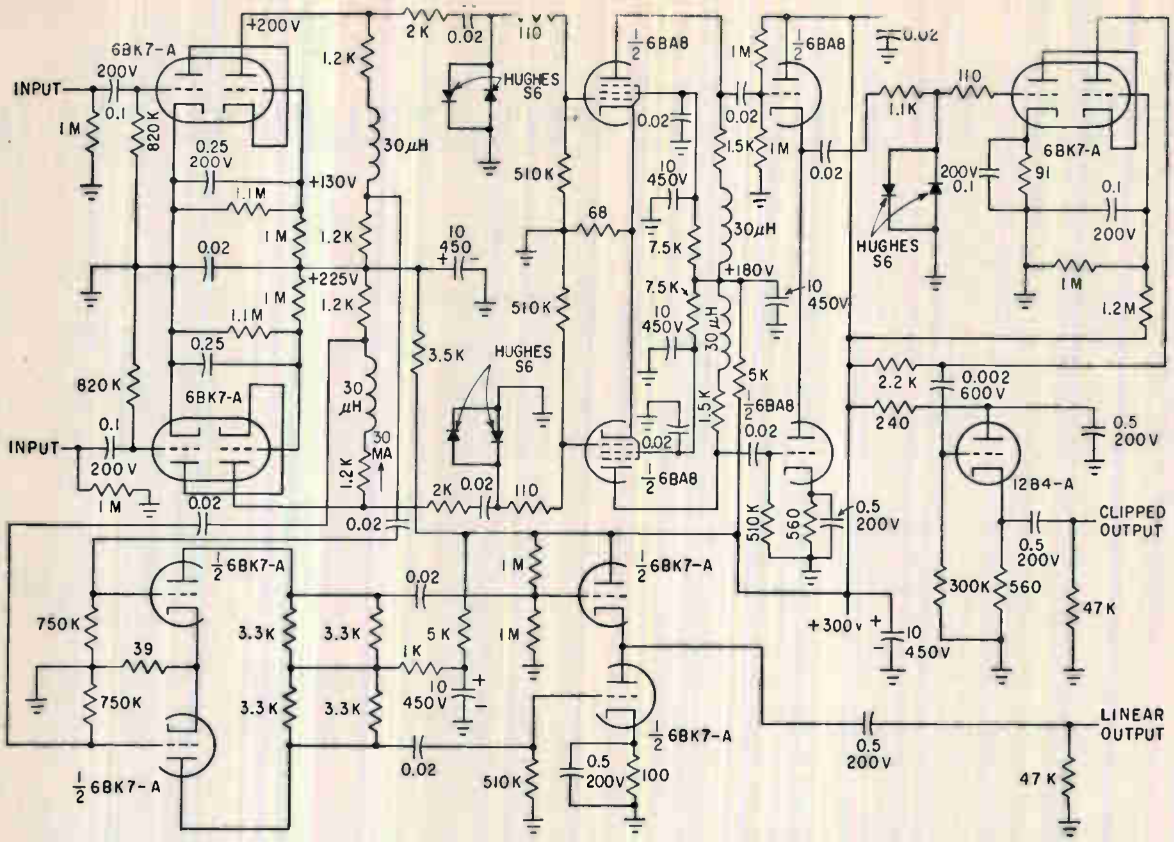


FIG. 7—Push-pull amplifier and clipper receive signals from video preamplifier

bandwidth of about 3 Mc.

In some cases a single-ended input might be desired. This is done by terminating one arm of the balanced mixer and using the single-ended preamplifier as shown in Fig. 6B. If more gain is required, the single-ended video preamplifier shown in Fig. 6C is used between the preamplifier and the fringe-scan interferometer chassis.

The signals from the video preamplifier are fed to the push-pull amplifier and clipper shown in Fig. 7. If the first method is to be used for density measurements, the linear video output is fed to an oscilloscope. For the second method, the clipped video output is fed to a Z-axis amplifier like that shown in Fig. 8A. The output of the Z-axis amplifier is used to intensity-modulate the oscilloscope.

The author thanks C. B. Wharton, originator of many of the techniques used in diagnosing plasmas; also J. Katz, W. Cummins and R. Senechal.

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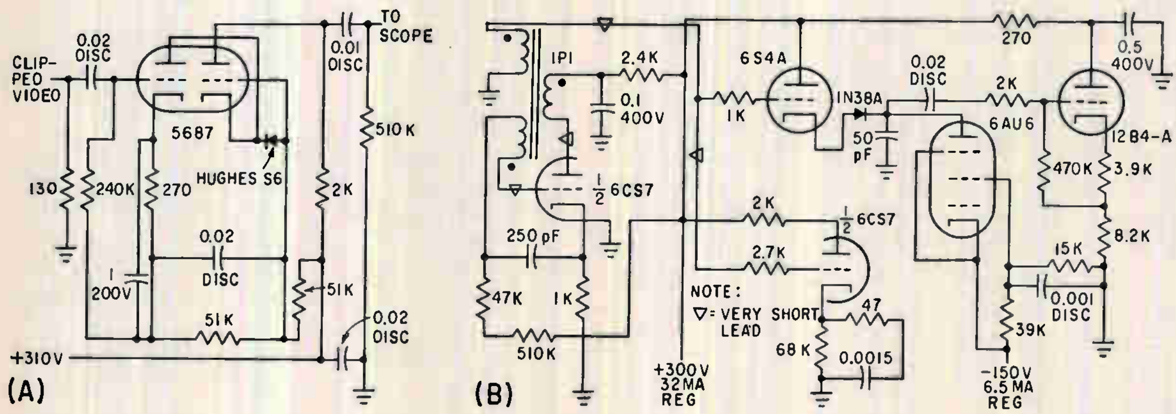

FIG. 8—Clipped video output is fed to Z-axis amplifier (A). Sweep and trigger generator (B) provides klystron sweep voltage, plus vertical sweep and trigger for oscilloscope

PIN Diodes Control Shorted Stub

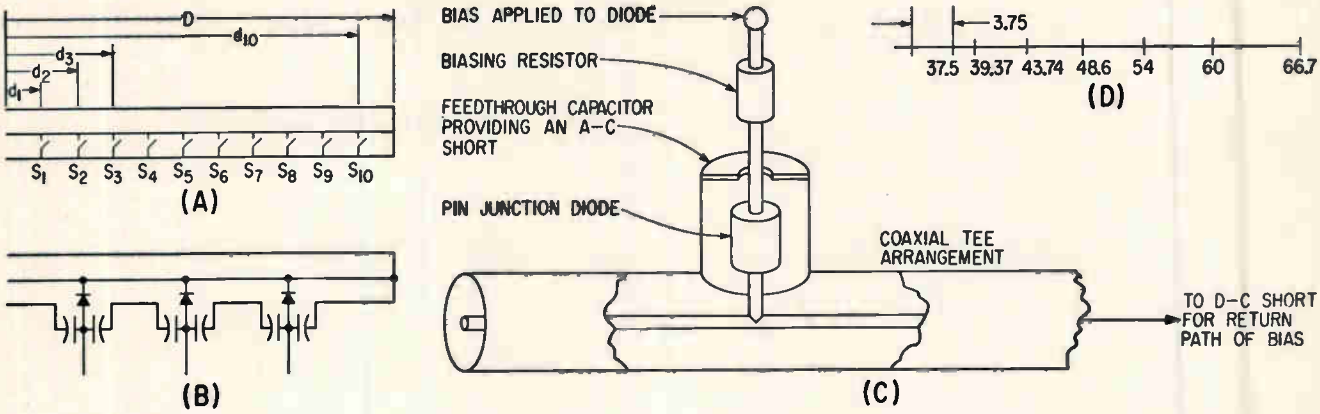

FIG. 1—Changing line length by switching (A) is accomplished using diodes (B) and (C). For incremental control of 0.05 wavelength, diodes are spaced as indicated in (D)

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IN TRANSMISSION LINE work it is often desirable to match a load to a line at a high carrier frequency over a narrow band of modulating frequencies, such as antenna matching for a voice modulated vhf communications transceiver. The carrier may be at any frequency between 225 and 400 Mc, with a bandwidth of less than 20 Kc. With a triple stub[1] tuner it is possible to match almost any load to a transmission line over a wide range of carrier frequencies.

A triple stub tuner requires three variable shorted stubs spaced about an eighth of a wavelength apart at the center frequency of the carrier band. The length of the shorted stub can be changed when the carrier frequency is changed, such as occurs when a different channel is chosen. A means for controlling the length of a shorted stub electronically in finite steps is proposed in this article.

An electronically controllable shorted stub should have little or no loss. Since the standing wave ratio on the stub should approach infinity, the current and voltage handling capabilities of the stub should be large. Fig. 1A shows a method of controlling the length of a coaxial shorted stub in discrete steps. If switch S_{10} is shorted and all other switches are open, the line is d_{10} long. With S_1 closed the line is d_1 long. Therefore the length of the line can be changed by controlling the switches.

Switching using *pin* (positive-intrinsic-negative) diodes has been proposed.[2, 3] From that concept Fig 1B shows an electronically controllable shorted stub using *pin* diodes. When one of the applied voltages is positive and the rest negative, one diode conducts and the r-f signal sees a low impedance through the diode and the feedthrough capacitor to ground, thereby causing a short on the line. The position of this short can be changed by changing the applied voltages. With all the diodes reverse-biased the line acts like a relatively long shorted stub, while with the first voltage positive the line is short.

Figure 1C shows a cutaway view of the diode and feedthrough capacitor. The diode is soldered to the center conductor of the coaxial line. It is then brought up through the tee to where the feedthrough capacitor shorts the high frequencies, and allows d-c bias to be applied to the diode. The bias return path is through the physically shorted end of the stub. A blocking capacitor must be used in series with this stub to prevent the bias from entering the coaxial line.

Properly designed *pin* diodes are good for this application since when forward biased they have a low impedance and good current handling capabilities, and when reverse biased there is an open circuit.[4] Diodes with these characteristics are now available, but when this work was done they were not.

The proposed stub is variable in finite steps which requires deciding how many *pin* diodes to use and how to distribute them on a section of line.

First determine the highest frequency f_h which in this problem is 400 Mc. Then determine the physical length of a half wavelength of the transmission line at this frequency from $D_1 = v/2f_h$, where v is the velocity of propagation of the transmission line. Physical length D, of the entire line can be found by replacing f_h by the lowest frequency which is 225 Mc for the problem. With an air-dielectric line, v is 3×10^{10} cm per sec, D_1 is 37.5 cm and D is 66.7 cm. If at the

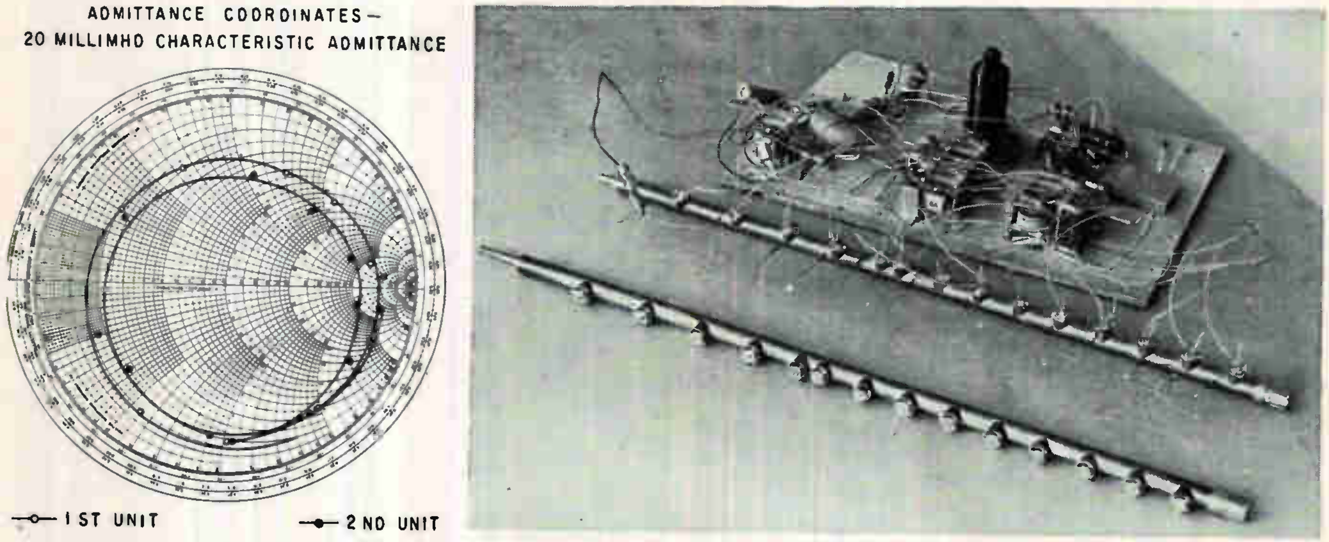

FIG. 2—Admittance at 250 Mc of experimental shorted stubs shown on the right

highest frequency it is desirable to break the stub into n steps in terms of wavelength then the diodes are spaced D_1/n cm apart on the first D_1 cm of the stub. If 10 steps were desired the diodes would be 3.75 cm apart, giving 0.05 wavelength between each diode at 400 Mc.

Spacing of the diodes from D_1 to D can be determined as follows. There would be a diode positioned some distance from the shorted end of the stub. This diode would be effective at only the lower end of the frequency band so it should be 0.05 wavelength from the end which at 225 Mc is 6.67 cm, or $0.1 \times D$, from the shorted end which leaves this diode 60 cm from the input end. The next to last diode should be 0.1×60 cm from the last diode or 54 cm from the input. Figure 1D shows the spacing between diodes acting as switches to give incremental control of at most 0.05 wavelength at any frequency; 15 diodes are needed.

These stubs allow finite steps in the input impedance of the stub. A vernier control on the steps can be obtained by using a *pn* junction varactor diode with a bias control in series with the input of the stub. The drawbacks of such a system are the current and voltage handling capabilities of the *pn* junction varactor diode.

Texas Instrument type 2071 diodes were used to fabricate two of these electronically controllable stubs. The standing-wave ratios of the stubs were of the order of 3.0 to one. To be perfect the stubs should have an infinite swr; however, the results were good enough to indicate promise for this idea as an electronically tunable element. Measured results at 250 Mc are shown on the admittance coordinates in Fig. 2 since the stubs are to be used as parallel tuning elements. The points are the input admittances of the stub with one of the diodes forward biased and the rest reverse biased.

If the diodes were better switches, the circles on the Smith chart would have larger radii since there would be little loss. Results with the stubs at all frequencies from 250 to 400 Mc were similar.

The stubs and associated circuits are shown in the photograph. The electronically controllable line was fabricated from half-inch copper tubing with a brass center conductor. Diodes were soldered to the brass and brought out through holes in the copper tubing. These holes were surrounded by a short piece of copper pipe which was terminated in a feedthrough capacitor that acts like a high-frequency short circuit.

The coaxial arrangement used to construct the test lines is not as good as a strip-line construction would be. This is because of the interference of the tee sections with TEM transmission, and the generation of other modes. The strip-line approach would confine the fields, and the diodes would not create such large discontinuities in the transmission-line characteristics. Using strip-type transmission line and newer diodes, a practical high-Q electronically variable shorted stub should be possible.

This work was done on a contract with the McDonnell Aircraft Corp. which was terminated July, 1959. The author is indebted to D. T. Ngo of the Electrical Engineering Department at Iowa State University for his aid in measurements and construction.

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FABRICATING THIN-FILM

Thin-film resistors can be formed by evaporation or deposition. They have low power ratings, but can be used in computer and logic circuits. Factors influencing design and application are discussed

UNIT FILM RESISTANCE

Resistance in ohms of films one unit in length, for various ohms-per-square resistivities

Line Width in Units	25 ohms per square	50	100	150	200	500	1,000	1,400	2,000
0.006	4,166	8,333	16,666	25,000	33,332	83,333	166,666	233,324	333,333
0.007	3,560	7,120	14,240	21,360	28,480	71,200	142,400	200,360	284,800
0.008	3,140	6,280	12,560	18,840	25,120	62,800	125,600	175,840	251,200
0.009	2,790	5,580	11,160	16,740	22,320	55,800	111,600	156,240	223,200
0.010	2,500	5,000	10,000	15,000	20,000	50,000	100,000	140,000	200,000
0.011	2,275	4,550	9,100	13,650	18,200	45,500	91,000	127,400	182,000
0.012	2,080	4,160	8,320	12,480	16,640	41,600	83,200	116,480	166,400
0.013	1,920	3,840	7,680	11,420	15,360	38,400	76,800	107,520	153,600
0.014	1,780	3,560	7,120	10,680	14,240	33,600	67,200	99,680	134,400
0.015	1,665	3,330	6,660	10,000	13,320	33,300	66,600	93,240	133,200
0.016	1,565	3,130	6,260	9,390	12,520	31,300	62,600	87,610	125,200
0.017	1,470	2,940	5,880	8,820	11,760	29,400	58,800	82,320	117,600
0.018	1,385	2,770	5,540	8,310	11,080	27,700	55,400	77,560	110,800
0.019	1,315	2,630	5,260	7,890	10,520	26,300	52,600	73,640	105,200
0.020	1,250	2,500	5,000	7,500	10,000	25,000	50,000	70,000	100,000
0.021	1,170	2,340	4,680	7,020	9,360	23,400	46,800	65,520	93,600
0.022	1,135	2,270	4,540	6,810	9,080	22,700	45,400	63,560	90,800
0.023	1,085	2,170	4,340	6,510	8,680	21,700	43,400	60,760	86,800
0.024	1.040	2,080	4,160	6,240	8,320	20,800	41,600	58,240	83,200
0.025	1,000	2,000	4,000	6,000	8,000	20,000	40,000	56,000	80,000
0.050	500	1,000	2,000	3,000	4,000	10,000	20,000	28,000	40,006
0.100	250	500	1,000	1,500	2,000	5,000	10,000	14,000	20,000

TO CONVERT a conventional circuit to thin-film topology, printed circuit techniques are used. A divergence from printed circuit techniques occurs only in the composition and control of the various films used.

In forming resistors, any film that can be evaporated or otherwise deposited can be used. In general, the film should have stable characteristics and should be thick enough to have approximately the bulk properties of the base material. Resistor materials include chrome and nickel-chrome alloys. Film thicknesses of 100 angstroms to 1 micron are the most feasible for resistor deposition.

The best way to determine film resistance would be a direct measurement where the resistance of the deposited film is monitored during evaporation. Film thickness measurements, using optical or other methods, are reliable with

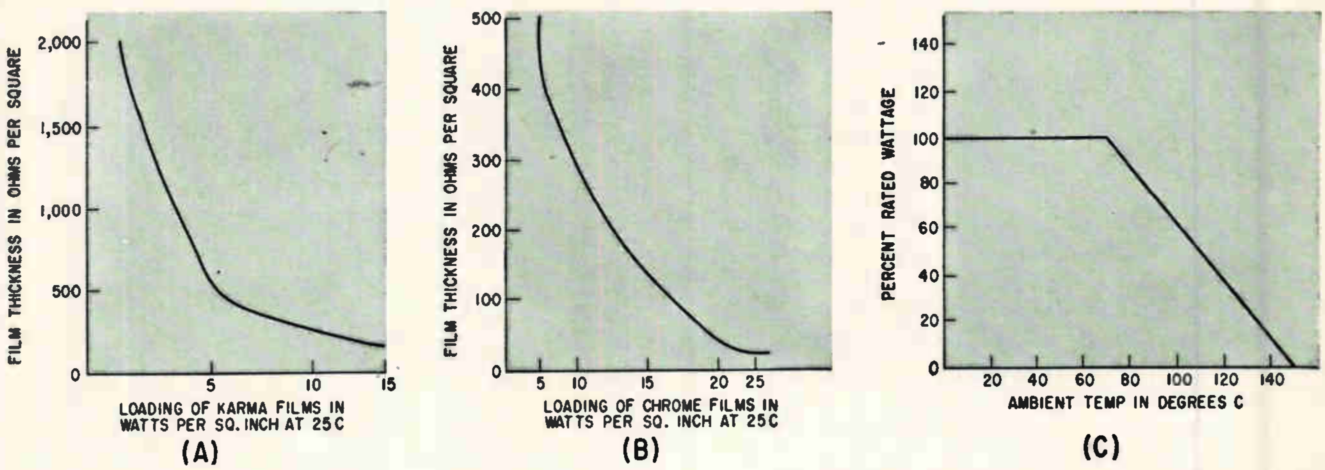

FIG. 1—Permissible wattage load is a function of film thickness. Karma (A) is a Driver-Harris alloy with a composition, in percent, of 73 Ni, 20 Cr, 7 Al and Fe. Loading for chrome film (B), derating curve for Pyrex glass and Photoceram substrate (C)

RESISTORS

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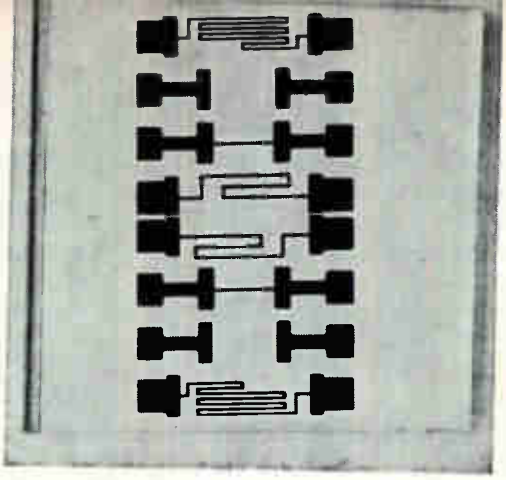

Typical thin-film resistors enlarged approximately three times

single metal depositions, but where alloys are evaporated, a composition change occurs due to the different melting points and evaporation rates of the elements comprising the alloy. The change in alloy composition, although small, changes the resistivity of the film.

Resistance of a thin-film square is the d-c resistance measured between opposite faces of the square.

The advantage in using ohms per square to specify resistance is that the measurement is independent of the size of the square. A uniform film of given thickness will have the same resistance per square cm as per square inch, or any other arbitrary unit of length. The table shows the resistance of films of various line widths for compositions with various predetermined ohms-per-square resistivity. Ohms-per-square resistivity is controlled by the thickness of the film. The unit film resistance table is independent of the material, provided the deposited film is of uniform thickness.

The geometrical design of thin-film resistors on microcircuit substrates can be completed if the following information is available: the value of each resistor; watts to be dissipated in each resistor; ambient temperature of the substrate; and the approximate area available for each resistor.

The table shows unit resistance values of line widths for 25 to 2,000 ohms per square films. The line widths of 0.006 and 0.1 are practical cut-off points.

Figures 1A and 1B relate film thickness in ohms per square to loading in watts per square inch which can be permitted on a glass or Photoceram substrate to maintain stability at 25 C ambient temperature. Experimental data are being accumulated to validate the curves. The stability objective is less than 3 percent change in resistance for chrome and less than ½ percent change for Karma, both for a rated 2,000-hour load life. Similar curves can be determined for other materials.

Thin-film characteristics are sensitive to the method of deposition and to post-deposition ageing. The resistance films discussed were deposited in a vacuum of 2×10^{-6} mm onto a polished Pyrex glass and Photoceram substrate at 300 C. The films were then aged at up to 500 C for 20 minutes, then cooled to room temperature. The glass and Photoceram surface was polished to 0.2 microinch. Connections to the film resistors were gold, 1.5 microns thick. Average change in resistance was minus 200 to 300 parts per million per degree C for chrome; Karma exhibited a positive shift of 15 to 20 parts per million per degree C.

Power dissipation tests were made without protective films and in normal atmospheric conditions. The design of the test pieces minimized thermal conduction through the test leads. Further power dissipation tests were conducted at five times the plotted level, at which point 10 percent shifts in resistance were observed. Resistor burnout at the junction of the conductor contacts occurred at 10 times rated load; at this loading, some cracking of the glass substrate was also observed.

Figure 1C gives the derating for ambient temperatures to 150 C, which must be applied to the permissible loading in watts per square inch (Fig. 1A and 1B) when a resistor is to operate above 70 C. The derating curve is consistent with characteristic B of MIL-R-10509C for fixed film resistors.

The desired value of a resistor R is related to unit resistance R_1 (from Table I) by $R = LR_1$ where L is length, in inches.

Only one accurately monitored thickness of film is desirable for all resistors on a substrate. The film thickness is chosen by considering both permissible loading and the area available for all the resistors being deposited.

A practical rule is to work toward the heaviest film or lowest ohms per square without losing sight of the physical dimensions of the resistor.

It is unfortunate in thin-film resistor topology that the area of the resistor is proportional to the resistance value. Thus the low-value resistors occupy the least area but carry the heaviest currents and must dissipate the most power. Thus it is necessary to design around the smallest resistor value in the circuit. The second major consideration is the maximum available area for the largest resistor. These two factors determine film thickness.

In some cases the two diametrically opposed requirements can not be resolved and dual evaporation using two film thicknesses is necessary. However, the manufacturing cost is substantially increased by dual evaporation.

Secondary considerations for film choices are line width and length of the resistors. Thin lines that vary only slightly in width can produce resistances that vary considerably in production. Extremely short lengths require high accuracy in the conductor registration to obtain accurate resistance values in production.

In circuit design, an idea of the several possible geometries is obtained from the table and a tentative film thickness is chosen.

For this film thickness, maximum permissible loading is obtained from Fig. 1A or 1B, then modified in accordance with Fig. 3 for the ambient temperature at which the substrate is to operate.

Knowing the permissible watts per square inch and the watts to be dissipated, the minimum allowable square inches can be calculated. Minimum Area = (Watts Dissipation of Resistor)/(Permissible Watts per Square Inch).

Area for resistance value R is then width times length. When the length of the resistor is greater than the length of the allocated area, the printed resistor line can be folded. Insulating distance between folds should be at least 0.002 inch.

Design ideas can be illustrated by working out the requirements for the circuit of Fig. 2A. It is assumed that the ambient temperature will be below 100 C and that the substrate has an area of ½ square inch. Only the resistors will be considered; no attempt will be made to calculate capacitor and semiconductor parameters. It is assumed that these components will be attached by soldering.

Circuit analysis establishes the maximum power requirements for each resistor in this circuit: R_1 = 2,000 ohms (12 v/2,000 ohms = 0.006 amp) or 0.072 watt dissipation; R_2 = 7,000 ohms (12 v/7,000 ohms = 0.00171 amp) or 0.0205 watt dissipation; power requirements of R_3 are negligible and need not be calculated.

The choice of space and loading determines film thickness, but considerable latitude is given the designer. In most cases, space requirement of one resistor (in this instance, R_1) will be the determining factor.

A film thickness giving 100 ohms per square is selected, an arbitrary choice and not restrictive. A 50-ohm or 150-ohm film will do equally well. Film thickness below or above would violate either space or loading requirements.

To find the area for the 2,000-ohm resistor, the loading characteristic for this film is obtained from Fig. 1A: 16 watts per square inch.

The derating factor from Fig. 1C is 0.62; therefore, 16 × 0.62 ≈ 10 watts per square inch.

The minimum area this resistor requires is: (0.072 watt to be dissipated)/10 watts per square inch) = 0.0072 square inch.

Next choose a line width from the table: a suitable width is 0.020 inch.

The length of film for the 2,000 ohm resistor is R/R_1 = 2,000/5,000 = 0.4 inch long.

Area of the resistor is 0.4 × 0.02 = 0.008 square inch. This is adequate for the design since it is above the 0.0072 square inch minimum area needed for power dissipation.

Now calculate the area for the 7,000-ohm resistor. The loading and derating factor were established in designing R_1; therefore, the minimum is found to be 0.00205 square inch. Choose 0.006 inch line width and determine resistor length: 0.42 inch. Resistor area of 0.0025 square inch is greater than the minimum requirement of 0.00205 square inch.

The 1,000-ohm resistor has no maximum loading requirement, and therefore the available area determines the size. With a 0.025 inch line width of 100-ohm per square film, the length is 0.250 inch. Figure 2B shows a configuration for manufacturing the circuit with film-resistor techniques.

Noise characteristics of thin-film resistors are, in general, better than those of other resistors. The first resistors manufactured showed a slight thermoelectric effect but using gold instead of copper for conductors and pads reduced the effect significantly.

Data are the results of tests on substrates approximately 1 inch square, with a density of six resistors per substrate. The resistors occupied approximately 15 percent of the total area and only one side of a substrate was used. Ratings will probably have to be reduced for higher resistor density.

A number of precautions have to be taken in thin-film resistor technology or the results obtained will not be those desired. In particular, results will be greatly modified by improper choices of substrate materials, conductor materials and conductor thicknesses. Contributory factors are vacuum conditions in the bell jar, impurities introduced from the evaporant source, leakage of the rotary seal mechanism, and improper diffusion pump operation.

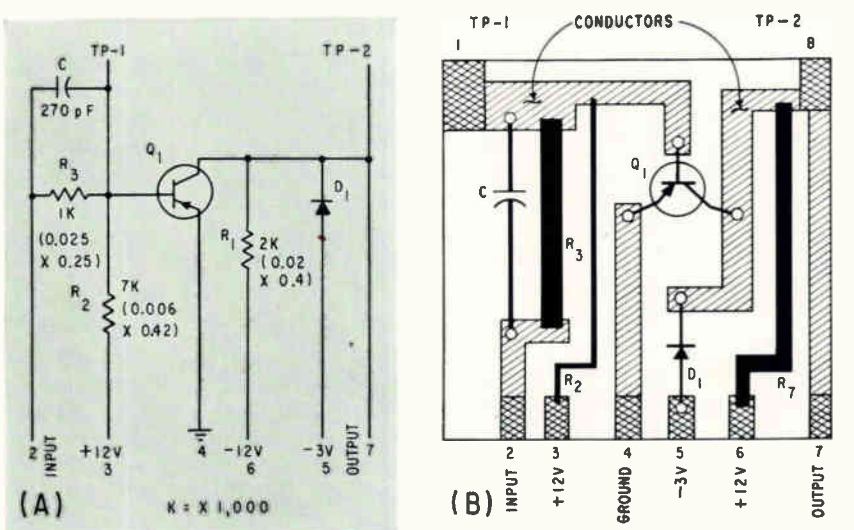

FIG. 2—Circuit (A) designed for thin-film resistor manufacturing (B)

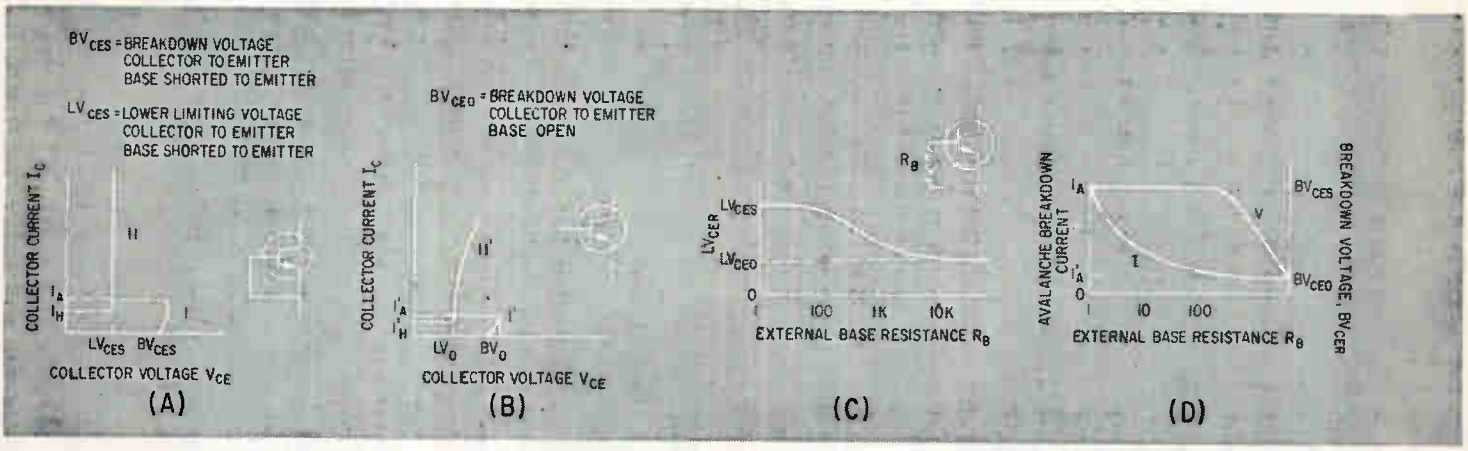

FIG. 1—Idealized characteristic of certain silicon mesa transistors with shorted base (A), and open base (B). The effect of an external resistor in the base on breakdown or avalanche is shown in (C) and (D)

Designing Avalanche Switching Circuits

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High power can be obtained from transistors operated in the avalanche mode. Avalanche operation is reviewed and a criterion is developed for selecting transistors with this property. The basic avalanche circuits are presented and factors influencing design and application discussed

HIGH VOLTAGE silicon mesa transistors can operate similarly to thyratrons. Upon being triggered, the transistor junction breaks down, or avalanches, and can conduct large currents for a short time. Rise time of the avalanche breakdown current can be short, and the delay between triggering and avalanching can be short and consistent. This phenomena is nondestructive if the peak and average power dissipated at the junction are limited by the circuit.

The avalanche action can be used to produce high-speed, high-current switching circuits; high-speed nuclear instrumentation is one important application.

The collector characteristic of certain silicon mesa transistors can be idealized as shown in Fig. 1A. Important features are: the collector-base junction behaves like a zener diode for small leakage currents; at leakage currents greater than I_A, the device exhibits negative resistance; two stable states, labelled I and II, are possible (the transition between states can occur in a short time).

In region II the voltage that can be supported across the transistor is less than in region I. After the transistor has switched from region I to II, the current must be reduced below I_H to return operation to region I. Current I_H is usually lower than I_A, but may not be.

Two conditions are shown in Fig. 1, open base, Fig. 1B, and base shorted to emitter, Fig. 1A. Open-base breakdown voltage from collector to emitter BV_{CEO} is less than shorted-base breakdown voltage BV_{CES}; I_A' is less than I_A; the difference in voltage between regions I and II is greater for shorted-base than for open-base, that is, $(BV_{CES} - LV_{CES}) > (BV_{CEO} - LV_{CEO})$, where LV_{CES} is the lower limiting voltage from collector to emitter with base shorted and LV_{CEO} is for base open; and $LV_{CES} > LV_{CEO}$.

The differences are outlined in Fig. 1C and 1D, which also indicate the effect of external base resistance. There is a value of R_B for which the difference between the BV and LV voltages is a maximum.

The avalanche breakdown phenomenon[1] can be summarized as follows.

At low values of I_C the leakage current flows out of the base through the base spreading resistance r'_{bb} (Fig. 2A) and through the external base resistance R_B (if included). Little leakage current flows out the emitter lead. This is

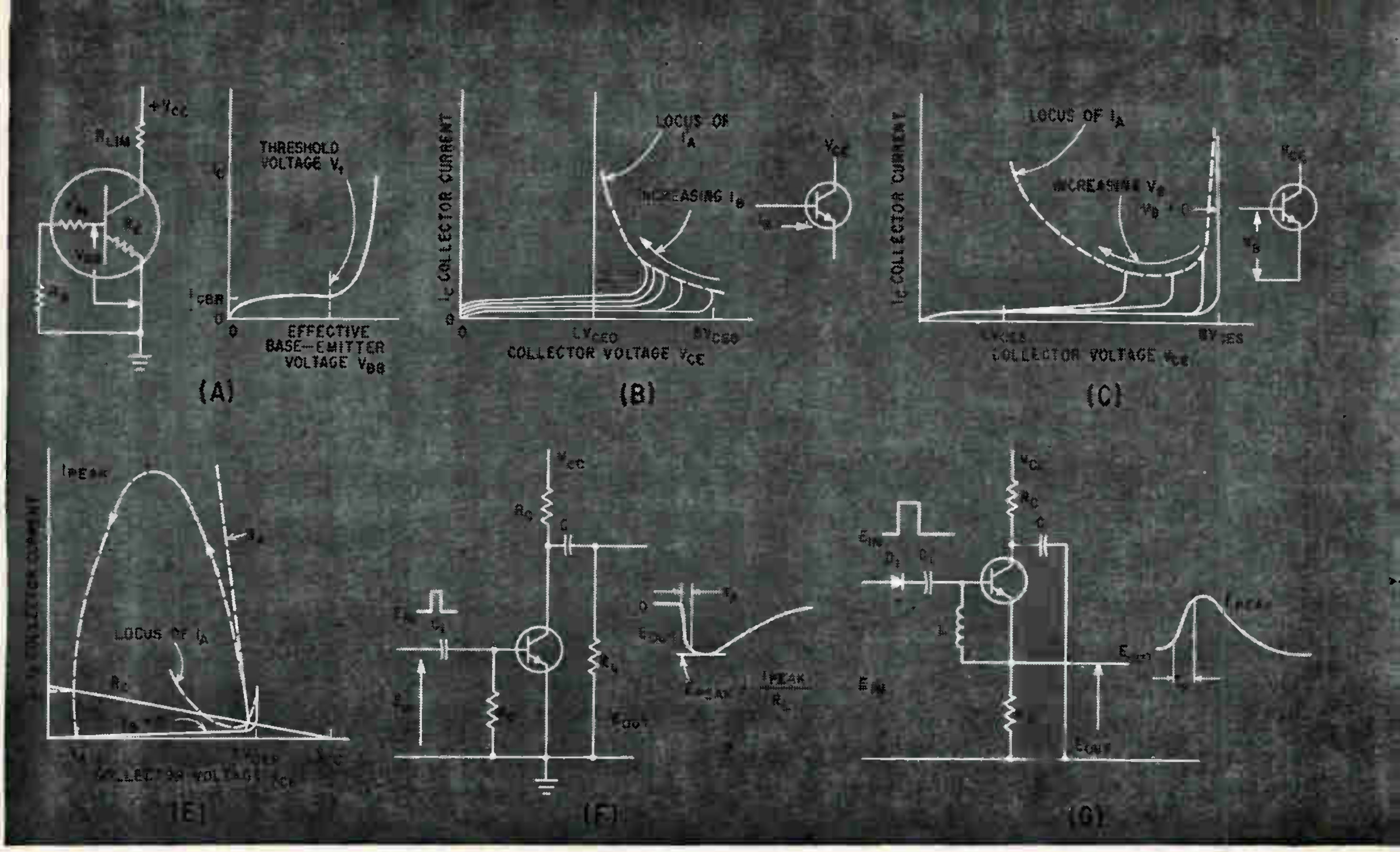


FIG. 2—Most of the leakage current switches to emitter ci rcuit when V_{bb} exceeds V_t and base-emitter junction becomes forward biased (A). Breakdown characteristic for base cur rent shown in (B); base voltage (C). Basic avalanche switch and waveforms (D); current excursions during switching (E). Differentiation of output—by adding R_L—increases pulse rise time (F). A positive output pulse is obtained with the circuit of (G). Blocking oscillator (H) has an output with rise time nearly independent of trigger rise time

because the built-in potential hill of the base-emitter junction causes this junction to be reverse biased.

The flow of leakage current through r'_{bb} establishes a voltage drop across this resistance, resulting in a potential of V_{bb} across the effective base-emitter junction. The current continues to flow out of the base as long as V_{bb} is less than V_t, the threshold voltage of the base emitter junction.

When V_{bb} becomes greater than V_t, the base-emitter junction becomes forward biased and most of the leakage current switches to the emitter circuit. This occurs when I_C is greater than I_A.

At I_A the transistor exhibits a negative resistance and can be in either region I or in region II. In region I, current flow is through the base while in region II most of the current flow is through the emitter. The transistor can support only a collector voltage of LV_{CER} (lower limit voltage with resistor in base) in region II so that a transistion in collector voltage takes place when I_A is exceeded. If the current is not limited by the external circuit, the transistor can be destroyed from internal heating caused by power dissipation in the broken-down junction. However, the transistor can handle large amounts of peak power for short times without damage.

Since the leakage current flows in the base circuit in region I, the base has control over this current. Figure 2B shows the collector characteristics in the region of I'_A and BV_{CEO}. The locus of I'_A has an upward slope as a function of V_{CE}. Figure 2C shows a similar characteristic for base voltage control of the same transistor. For a range of collector currents the locus of I_A is double valued.

A basic avalanche switching circuit is shown in Fig. 2D. Principal points in the operation of this circuit are (Fig. 2E):

(1) The load line of R_C intersects the curve $V_B = 0$ at a point where $I_C < I_A$. This establishes a stable operating point under static conditions.

(2) Capacitor C is charged to BV_{CER}.

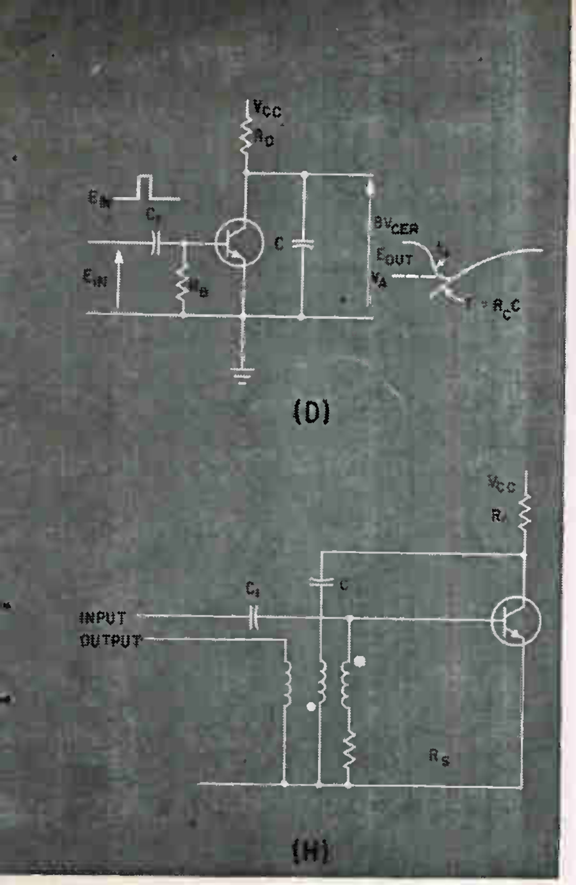
(3) Applying a voltage pulse to the base reduces the value of I_A so that the load line of R_C now intersects the locus of I_A. At this point the transistor avalanches.

(4) Collector current then rises abruptly to a high value (I_{peak}) along a load line of R_A, where R_A is the equivalent resistance of the transistor in the avalanche condition. Meanwhile the collector voltage drops to V_A. Voltage V_A is usually lower than any of the LV voltages and is controlled partially by C.

(5) The capacitor is discharged and when discharge current drops below I_B, the transistor ceases conduction. The capacitor then recharges toward V_{cc} with a time constant of R_cC.

(6) Switching time, t_s, is a property of the transistor, and R_A is a nonlinear function of current.

The amount of energy to switch the transistor is directly related to the value of R_B, since current that could be used to raise V_{bb} (Fig. 2A) is shunted past the junction by R_B. Operation with a high value of R_B will permit lower energy triggering, but the locus of I'_A



makes it difficult to have the load line intersect a stable operating point on the $I_B = O$ curve and also intersect the locus. This makes the control of V_{cc} more of a problem.

Differentiating the collector voltage by adding a small resistor R_L in series with C produces a voltage that rises faster than the avalanche voltage, as indicated in Fig. 2F. For fast, high-current pulses into transmission-line impedance loads, the circuit of Fig. 2D is useful. The output pulse of Fig. 2D is negative; to obtain a positive pulse, an inverting transformer can be used. A circuit that will provide a positive output pulse is shown in Fig. 2G. The transistor is connected as an emitter follower. Inductor L provides a low resistance path for the leakage current while providing a higher impedance for the trigger signal. This technique minimizes the shunting effect of R_B on the input trigger pulse while retaining the features of the shorted base mode. Diode D_1 prevents capacitor C_1 from adversely affecting circuit action when the input trigger drops below the output voltage.

This circuit can produce a rectangular output pulse if an open-ended delay line is used in place of C.

Rate of rise of the input trigger may affect the rise time of the avalanche current in some devices. An avalanche transistor used in a blocking oscillator can provide an output whose current-rise-time is less dependent on input trigger rise time than it is in conventional circuits (see Fig. 2H). However, output is reduced by feedback of energy.

Any of the circuits outlined will free-run if the collector supply voltage is increased past the point where I_A is exceeded at BV_{CER}. The repetition rate will be determined by R_c and C.

Selection of a transistor that exhibits the characteristics shown in Fig. 2B and 2C is a problem, since most transistors are not rated this way. No static characteristic given on data sheets has been found to relate amplifier performance to avalanche performance.

A test circuit to determine avalanche switching properties is illustrated in Fig. 3. Quantities that can be checked are:

(1) Voltage BV_{CER}: the breakdown voltage of the collector-emitter circuit with a resistance between the base and emitter (see Fig. 1C and 1D).

(2) Current I_A: the maximum that will flow in the collector circuit at voltage BV_{CER}.

(3) Minimum triggering level: the lowest amplitude base pulse that will cause the transistor to avalanche. Triggering is a function of input energy and therefore depends on both amplitude and pulse width. A convenient pulse width in 10 nanoseconds.

A quality factor has been derived to compare the performance of transistors in the test circuit.

$$QF = \frac{\text{Pulse Voltage Gain}}{\text{nsec}} = \left(\frac{V_P}{V_{trig}}\right)\left(\frac{1}{t_r + t_d}\right)$$

where QF is the pulse voltage gain per nanosecond, V_P and V_{trig} are the magnitudes of the output pulse and trigger, t_r is rise time of output in nsec (from the 10 percent to 90 percent level), and t_d is delay time—the time in nsec from input trigger until 10 percent of output is obtained.

The QF indicates the usefulness of the transistor for providing fast pulse timing. A transistor with high QF will produce a higher output at a shorter time after a minimum energy input pulse than a unit with low QF. The value of QF varies from unit-to-unit, with a typical 2N706 having a QF of 20

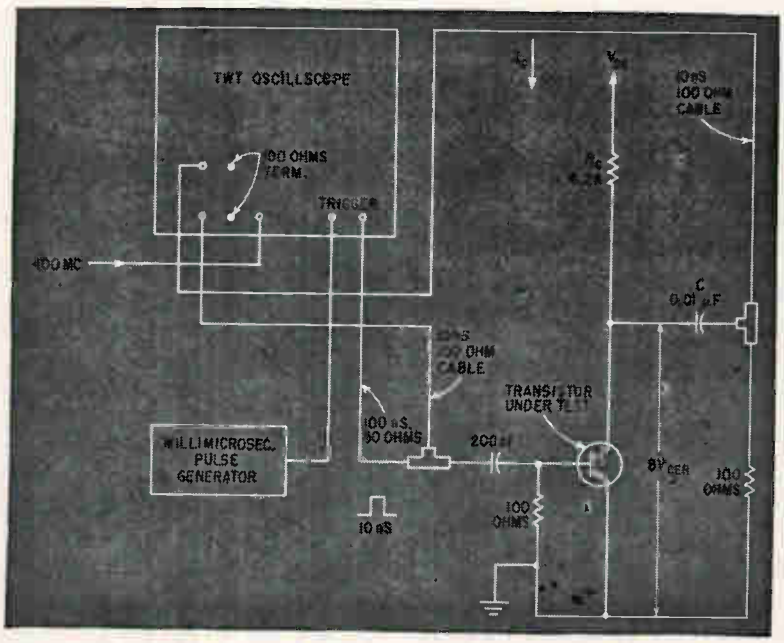


FIG. 3—Test circuit for determining avalanche characteristics

and a typical 2N696 having a QF of 2.

The requirements for avalanche breakdown are $V_C = BV_{CER}$ and $I_C < I_A$. The slope and location of the locus of I_A with respect to the BV_{CES} curve is important in selecting a unit to avalanche well. For a given collector supply voltage and collector resistor, devices with high values of I_A will be more tolerant of fluctuations in supply voltage.

For maximum output amplitude into a low-impedance load the unit with the highest BV_{CER} will be the best. However, it will require a trigger of more than the minimum triggering level to obtain maximum output. With overdrive it is possible to obtain output voltages nearly equal to BV_{CER}.

Ability to overdrive in the avalanche condition is an important factor in delivering large currents to low impedance loads. Overdrive can reduce the saturation resistance of the transistor in the avalanched condition and permit much higher peak currents to flow. By cascading avalanche stages, larger outputs can be obtained with rise times equivalent to single stages.

Figure 4A shows a cascaded avalanche pulse generator for applications requiring 1 to 2-amp pulses into loads of transmission-line impedance. The circuit will provide either a positive or negative output, or both. If a positive output is desired, the negative output terminal is grounded; if negative, the positive output terminal is grounded.

Waveshapes are shown in Fig. 4B. The first stage consists of a blocking-oscillator avalanche switch. Input to the base of Q_1 is shown as a slowly rising positive signal. When this signal reaches the threshold level of Q_1 the transistor avalanches and discharges C_1 through a winding of T_1. Part of this energy is fed back to the base of Q_1 through R_B to make the circuit regenerative and thus less dependent or the input signal rise time.

This feedback pulse usually is faster rising than the input. Diode D_1 blocks the input signal and prevents it from interfering with circuit action if it is of lower amplitude than the feedback pulse.

Operation of Q_1 as an avalanche switch in a blocking oscillator circuit gives two advantages: the delay time of the circuit is small compared with that of a transistor not operating in avalanche mode; the threshold of triggering, output pulse amplitude and waveshape are much less sensitive to the rate of rise of the input signal than a basic avalanche stage would be.

The energy that is not fed back to the base of Q_1 and T_1 is dumped into the base-emitter junction of Q_2. Transistor Q_2 is also operated in the avalanche mode. The base-drive pulse V_{B2} is much more than required to trigger the avalanche of Q_2, so Q_2 avalanches quickly. Transistor Q_2 is driven hard into saturation after avalanche and acts like a normal transistor, that is, the base has control over the collector current after the initial fast breakdown. Output, V_{out}, is produced by discharging C_2 through the load. Output current consists of two parts, that due to avalanche breakdown and that due to overdrive. Rise time is a combination of the avalanche switching time of the transistor and the switching time of the normal transistor. The use of avalanche mode eliminates the delay time of conventional switching.

Both Q_1 and Q_2 should operate in the avalanche region of their collector-base junction. This is done by controlling I_c with careful selection of R_1, R_2 and V_{cc}. Current I_c should be less than I_A for circuit stability.

The value of R_B is governed by several conflicting factors: a low value of R_B is desirable for circuit stability since I_A is dependent on R_B; better blocking oscillator action can be obtained with low values of R_B; lower triggering energy is required when R_B is large; and more energy is available to overdrive Q_2 when R_B is large. Typical values for R_B are 100 to 300 ohms when silicon mesa *npn* units (such as 2N706, 2N695 and 2N1505) are used.

The values of C_1 and C_2 are governed by output pulse requirements. Figure 4C indicates how output pulse characteristics can be changed by C_1, C_2 and R_L.

Maximum pulse width is limited by the amount of energy that can be stored in C_2 and that can be handled by the transistor without junction deterioration. A value of C_2 greater than 0.47 microfarad for transistor units with BV_{CES} exceeding 120 volts is not recommended. The principal application of this circuit is in fast-pulse timing where the fast rise time of the output is used. It is not usually necessary to provide wide pulses. If wide pulses are needed they do not typically need fast rise times and can be obtained using other devices such as 4-layer diodes, silicon controlled rectifiers or thyratrons.

Recovery time of the circuit is a function of the R-C time constant of the collector circuits. Since C_2 does not discharge fully, and C_1 does, C_1 controls the double pulse resolution of the circuit.

The effect of load resistance on the output pulse amplitude can be estimated with the equivalent circuit of Fig. 5A

$$BV_{CES} = I_L \times (R_{sat} + R_L) \qquad (1)$$

Capacitor C_2 is initially charged to BV_{CES} and discharges through the transistor and load in series. Voltage V_{out} (neglecting the discharge of C_2) is

$$V_{out(peak)} = I_L R_L = R_L BV_{CES}/(R_{sat}+R_L) \qquad (2)$$

As indicated in Fig. 5B, R_{sat} is a function of I_L. The value of R_{sat} and its dependence on I_L is a direct function of the transistor and varies widely from unit to unit. It can be determined by measuring the ratio BV_{CES}/V_{out} for different values of R_L.

$$R_{sat} = \left(\frac{BV_{CES}}{V_{out\,(peak)}} - 1\right) R_L \qquad (3)$$

It is significant to measure peak load power as a function of load resistance and determine maximum peak power. Note (Fig. 5D) that the unit is suited for use with transmission-line impedance loads when peak power output is considered.

A typical circuit using the cascade avalanche technique is shown in Fig. 6A. The transistors must be selected for avalanche properties and to have a larger I_A than the collector load resistor will allow to flow; otherwise the circuit will free-run. The triggering level of the input is approximately 0.2 volt and the input level is limited by the HD2151 diode to prevent slow pulses from causing double pulsing. Maximum repetition rate of the circuit is around 30 pps, de-

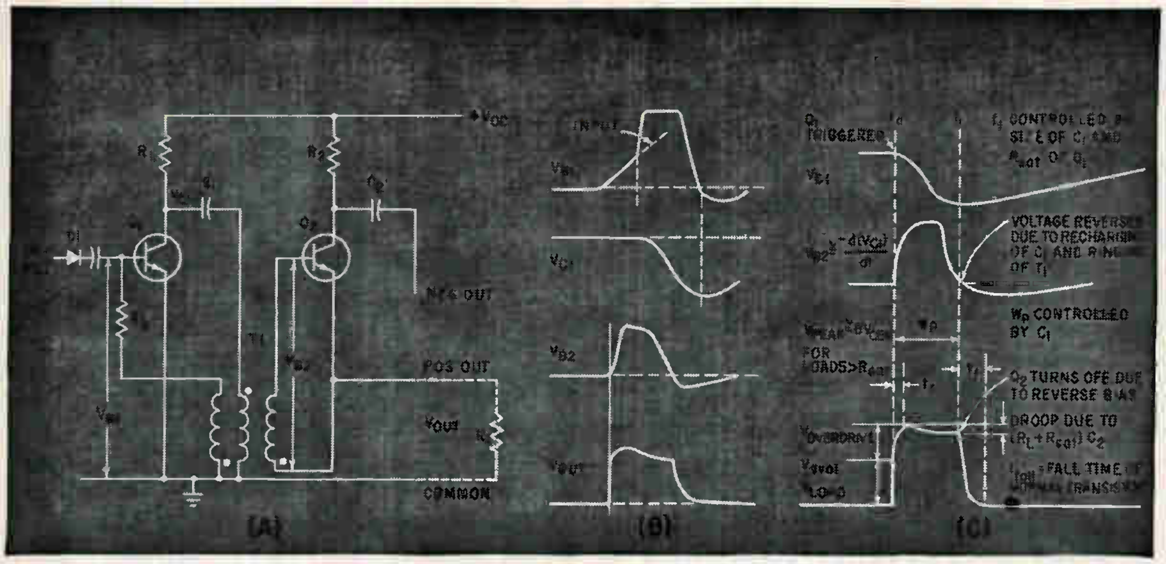


FIG. 4—Cascade avalanche circuit (A) will deliver positive or negative pulses; circuit waveforms (B); how circuit values control output waveform (C)

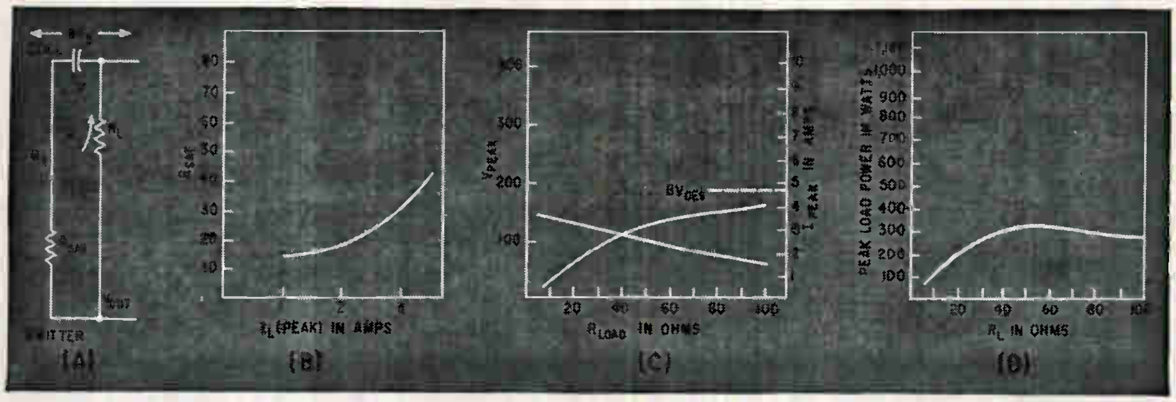


Fig. 5—Equivalent circuit of avalanche switch during output pulse (A); variation of R_{sat} with magnitude of I_L (B); voltage and current output as a function of load (C); power to load (D)

pending on the beta of the 2N706. Output pulse-width is around 1.5 microseconds with a 30 percent droop. The output reaches 100 volts in 25 nsec with a 100-ohm load (for 90 percent of 2N696's with BV_{CER} over 120). In a 50-ohm load the worst unit reached 50 volts in 40 nsec. The quiescent current drain of this circuit is less than ½ ma and does not change appreciably when operated at 30 pps. This design has been used to drive the launch coil of magnetostrictive delay lines, giving a compact package when a 300-volt battery is used.

This circuit can be used at repetition rates as high as 6 Mc with reduced output. Figure 6B outlines a design that will produce 200-ma pulses at a 3-Mc rate when the input is a sine wave. This design will provide a timing pulse for each cycle of a high-frequency sinewave from 500 Kc to 6 Mc. The timing pulse can be as narrow as 20 nsec, with a rise time of 5 nsec. Selection of transistors is critical and both units must have the same value of BV_{CES}. Power-supply voltage is also critical, since with only 1,000-ohm collector load resistors it is easy to over dissipate the transistors with a relatively small change in V_{cc}.

A characteristic of avalanche transistor circuits is their ability to free-run if I_A is exceeded. This property of the circuit has a protective influence on the transistor and is important in high-repetition-rate circuits where the collector load resistance is low. The free-running repetition rate is determined by the collector resistor-capacitor combination.

It may be necessary to provide double-pulse resolution with a low duty cycle; that is, a pair or more of closely spaced inputs will occur once or at a low repetition rate. The circuit outlined in Fig. 6C can be used to advantage. It has the inherent stability against free running of the large collector resistor R_1 and the repetition rate capabilities of R_2. Capacitor C_1 controls the number of pulses that can be resolved; C_3 is also large so it does not discharge appreciably during the time C_1 discharges.

To use avalanche switching circuits in single-pulse or lockout applications, a tunnel diode can be used. Figure 6D indicates a type

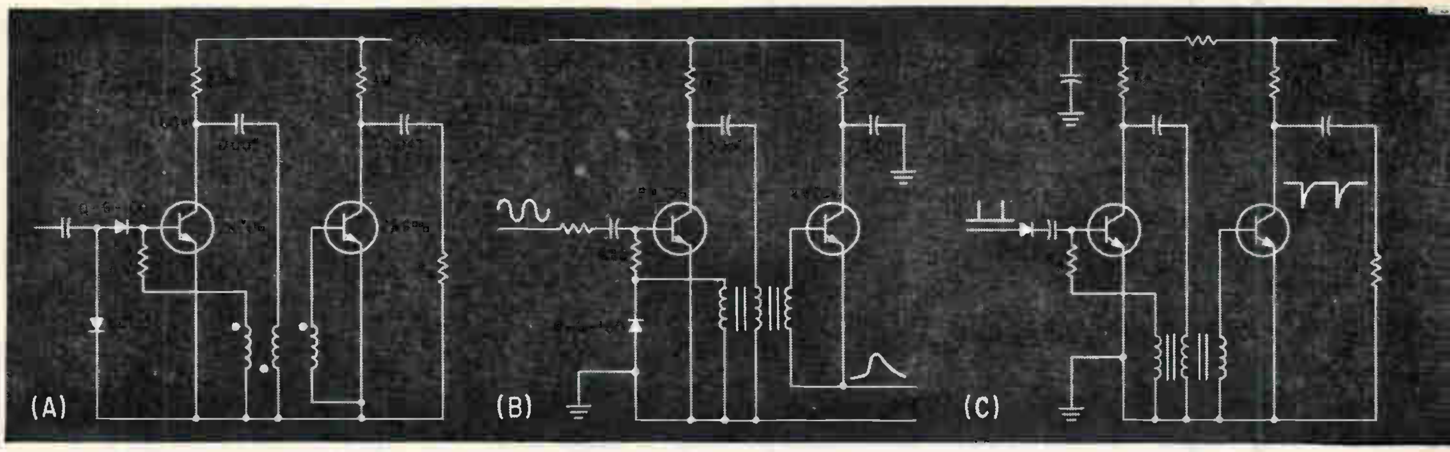


FIG. 6—Typical cascade avalanche circuit (A); high-repetition-rate pulse generator operates from 500 Kc to 6 MC (B): stable double pulse generator (C); single pulse generator with reset using tunnel diode (D); the sharper the knee of the curve (E) the better the transistor is for avalanche switching

of circuit that will produce only one output, with reset required. The *V-I* curve of the typical germanium tunnel diode used is also shown.

Salient features of this circuit when in the quiescent state are:

(1) Tunnel diode current is set at less than 1 ma by selection of R_1 and V_{cc}. Operating point is at P_1 in Fig. 6D.

(2) Voltage at P_1 plus the forward drop of diode D is less than the threshold of the base-emitter diode of transistor Q. This results in Q being off.

(3) Collector voltage of Q is at BV_{CER}. Leakage current of the collector-base diode flows through the tunnel diode, but this current is insignificant when compared to the V_{cc}/R_1 current.

When a pulse is applied to the base of Q through C_1, the current through the tunnel diode exceeds 1 ma and the diode switches to a higher voltage state. The voltage across the base of Q rises above its threshold and Q avalanches and turns on. The current I_1 then divides between Q and the tunnel diode, resulting in a new operating point P_2. Resistor R_2 is large enough so that base current ($I_1 - I_2$) causes Q to saturate. Transistor Q remains saturated until the current through the tunnel diode becomes lower than I_v, at which time the tunnel diode returns to a low voltage state. The circuit can be reset only by lowering the current in the tunnel diode below I_v. Reset can be accomplished by removing I_1 or by applying a negative pulse to the base of Q.

Diode D is necessary when Q is a silicon unit because the base threshold is higher than the voltage across the tunnel diode when it is in the high-voltage state.

The combination of avalanche transistor techniques and the tunnel diode results in fast switching. A 2N706 and a Clevite tunnel diode in the circuit of Fig. 6D resulted in a total collector voltage switching time ($t_d + t_r$) of less than 10 nsec. The circuit can be converted to a voltage discriminator by inserting a resistance in series with the input.

Comparison of this tunnel-diode circuit with the first stage of the cascade avalanche circuit (Fig. 4A) shows them to be functionally similar. In both types of circuits, some type of overdrive is required to cause the avalanche breakdown with minimum delay. In the blocking oscillator this overdrive is obtained by feedback; the tunnel diode provides overdrive with its switching behavior.

Each circuit has its advantages. Advantages of blocking oscillator stage are: only a low energy trigger is required; amount of overdrive is easily controlled by varying R_B.

Advantages of tunnel-diode stage are: the triggering threshold is stable and is determined only by the tunnel diode; overdrive energy is supplied fast due to the tunnel diode's high switching speed, resulting in a lower delay time; the circuit can reject multiple input pulses.

Although the principal use of avalanche switching is generation of pulses, the ability of the transistor to perform as a good switch can be used in nonpulse applications.

The ratio of off resistance to on resistance can be high. The on resistance, R_{sat}, and the factors influencing it have been discussed previously.

The off resistance can be found by $R_{off} = R_{leak} = I_C/V_{CE}$.

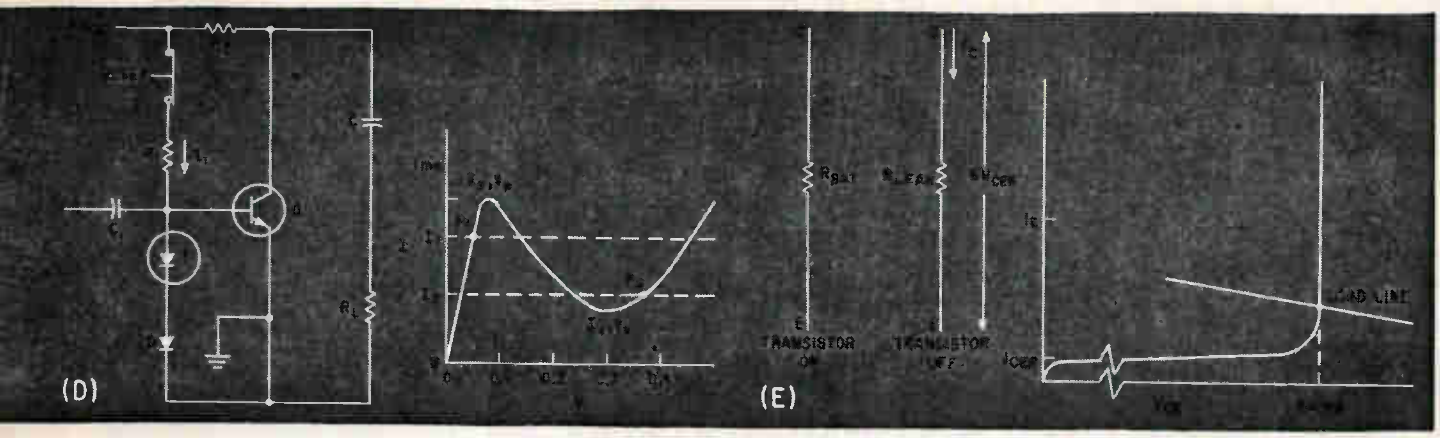
The maximum value of R_{off} occurs when $I_C = I_{CER}$, but avalanche action is optimum when I_C is such that $V_C = BV_{CER}$. The V_CI_C curve in the region of the knee ($V_C = BV_{CER}$, $I_C = I_{CER}$) is important and the sharper the knee is, the better avalanche switch the transistor will be (see Fig. 6E). The knee of a good transistor will be less than 1 microamp at 150 volts, which results in R_{leak} of 150 megohms.

An application of the transistor as a switch is shown in Fig. 7B.

Capacitor C is charged through Q_1 and discharged by avalanching Q_2. Characteristics of Q_1 are shown in Fig. 7A. Such a unit can provide a constant current over a wide range of V_{CE}. This transistor provides a constant current for charging C, thus producing a linear sweep. The voltage across C is limited to BV_{CES} of Q_2. Current I_4 of Q_2 must be greater than the charging current set by R_1 or the circuit will free-run.

Sweeps of 2.5 microseconds at 135-volt amplitude were obtained with the circuit, for a 2-milliamp charging current. Retrace time was 25 nsec.

Key parameters of avalanche transistors are BV_{CES} and I_4. Secondary parameters are the knee



characteristics and the locus of I_A. The spread in these parameters for transistors is large.

The ideal avalanche transistor would have an optimum BV_{CES}, usually the higher the better, and an I_A high enough so that dissipation would limit the value of I_C to less than I_A. Unfortunately, the circuits will probably be designed around the device and selection of transistors will be required for optimum performance. For most applications, specification of BV_{CES} and I_A should suffice in obtaining reproducible performance.

Certain techniques can make the circuit more transistor proof. A common departure from the ideal transistor is the unit which has a high BV_{CES} but a low I_A, for example 2N1505. Figure 8 indicates that a zener diode placed across the collector-emitter of the avalanche transistor will prevent the collector from reaching BV_{CES}, and the current in the transistor can never reach I_A.

This means this circuit cannot free-run. As long as BV_{CES} is greater than zener voltage V_z, and LV_{CES} is lower than V_z, the combination will avalanche, although the avalanche output will be lowered by the value $BV_{CES} - V_z$. Triggering sensitivity also will be decreased.

Transistors with higher breakdown voltages will enable the circuit designer to obtain with solid-state devices high-speed pulses that can presently be obtained only with vacuum tubes.

The author acknowledges the help of W. Karlotski.

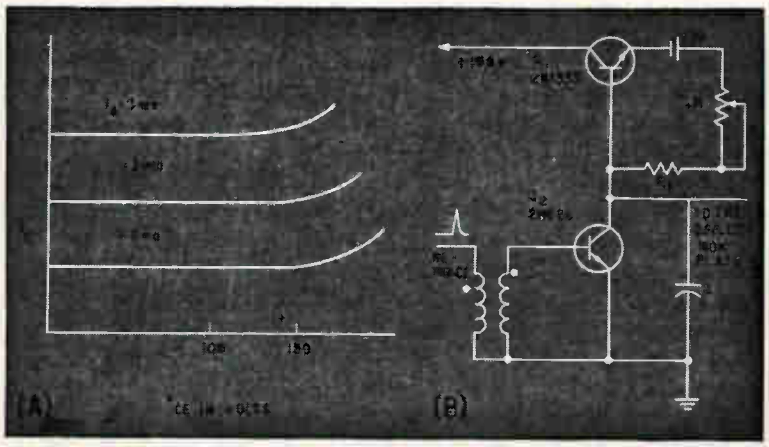


FIG. 7—Characteristic of a selected 2N1335 (A); avalanche sawtooth generator

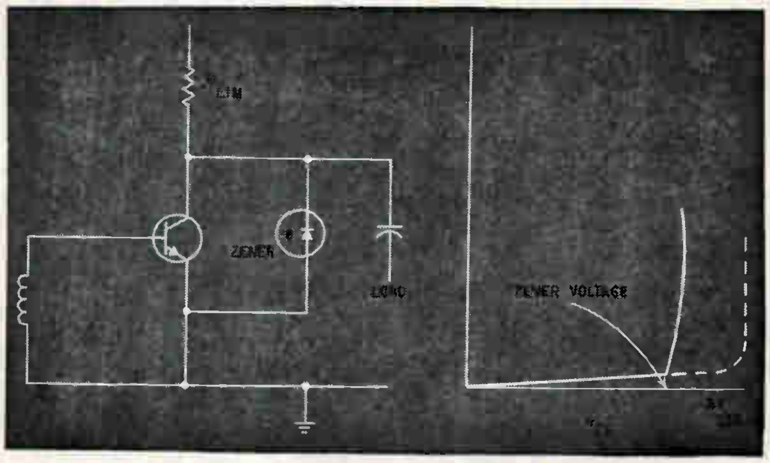


FIG. 8—Zener diode protection of transistor junction

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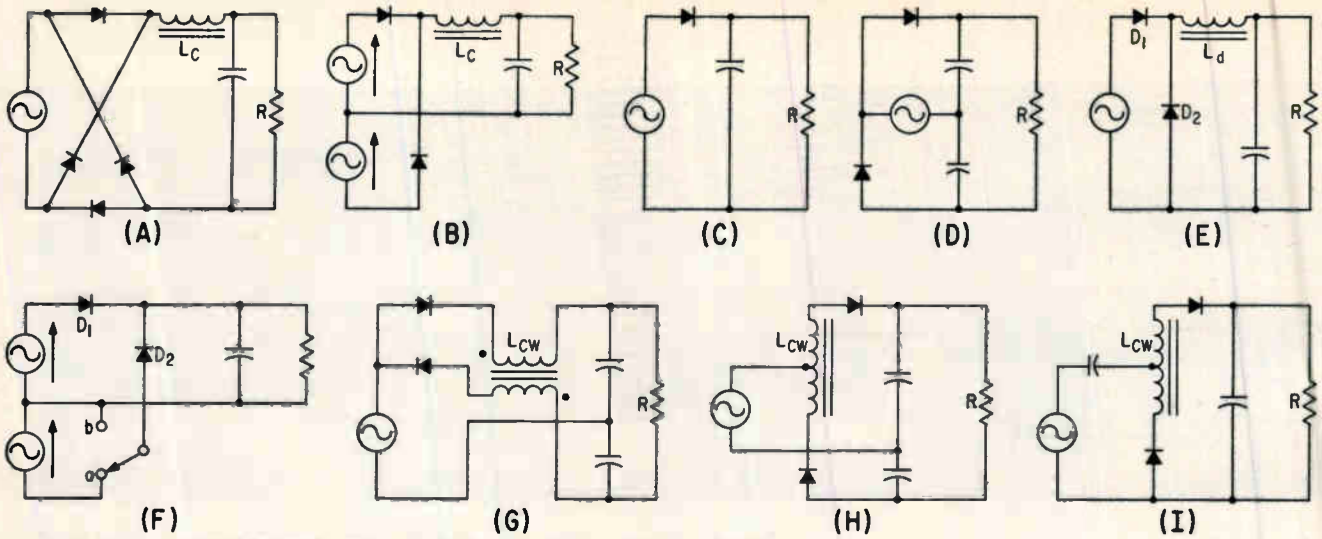

L_c = 0.05263 R/F WHERE R = OHMS AND f = FREQ IN CPS. AT 60 CPS: L_c = R/1140.
L_d = R/218 AT 60 CPS L_{CW} = R/4560 (EACH WINDING) ALL L IN HENRIES

Improving Rectifier Circuits

By G. FRANKLIN MONTGOMERY, National Bureau of Standards, Washington 25, D. C.

SINGLE-PHASE a-c power supplies are usually based on either the full-wave bridge (*A*), full-wave half bridge with a center-tapped source (*B*), half-wave rectifier (*C*) or voltage doubler (*D*). Half-wave and doubler circuits are economical but have poor load-voltage regulation, relatively large ripple and excessive peak rectifier current.

Bridge and half-bridge rectifiers can be used with an inductor-input filter to reduce peak rectifier current. If the input inductance is made greater than the critical value[1], the inductor current becomes continuous. Load-voltage regulation and smoothing are much improved compared to circuits where input inductance is small or zero.

Unfortunately, adding an inductor to the half-wave circuits of (*C*) and (*D*) merely limits the peak rectifier current. Ripple is not essentially reduced, and regulation may be poorer than with no inductor.[2] The single rectifier of (*C*) must be cut off during some part of the a-c cycle or rectification will not occur. Consequently, current to the filter must be interrupted, whether the filter includes an inductor or not. A large input inductance extends the conducting interval of the rectifier, but at the expense of reduced output voltage and maximum output current.

In circuit (*E*), diode D_2 in shunt with the filter input provides a path for the inductor current when D_1 is cutoff, and the current to the filter will be uninterrupted if L is chosen to exceed the critical inductance. Although two rectifiers are used, the circuit is still a half-wave circuit as far as the source is concerned, the source current being zero during the negative half-cycle of the source voltage. If L is sufficiently large, the inductor current is nearly constant and equal to the load current. Each rectifier conducts this current for exactly one half-cycle. For a sinusoidal source of rms potential E, the load voltage is 0.45 E, assuming no d-c drop in the inductor and rectifiers.

Circuit (*E*) is convenient for a well-regulated and filtered 50-volt d-c supply operating directly from a 117-volt a-c line and makes possible a useful modification of the usual half-bridge supply. In (*F*), switching rectifier D_2 from a to b halves the output voltage without sacrificing regulation.

A similar improvement of the voltage doubler is achieved by using a filter inductor having two equal windings. Three possible variations are (*G*), (*H*) and (*I*), two of which use a center-tapped inductor. In all cases, the source current is commutated between the two inductor windings. If the inductance of each winding is sufficiently greater than the critical value, each rectifier conducts a current equal to twice the load current for one half-cycle. For a sinusoidal source of rms potential E, the load voltage is 1.8 E, assuming no d-c drop in the inductor and rectifiers. These circuits make possible a 200-volt d-c supply operating from a 117-volt a-c line, with peak rectifier current limited to essentially twice the load current and voltage regulation superior to the usual voltage doubler.

The critical inductance (L_c, L_d and L_{cw}) is the smallest inductance that will maintain a continuous inductor current. If the input inductance is less than critical for a particular load current, both rectifiers will be cut off for some fraction of the a-c cycle, and the load voltage will rise considerably above its value for heavier loads.

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(2) M. B. Stout, Behavior of Half-Wave Rectifiers, ELECTRONICS, 12, p. 32, Sept., 1939.

Design Charts for Low-Frequency Antenna Efficiency

Nomograms help estimate conversion efficiency from transmitter to radiated power

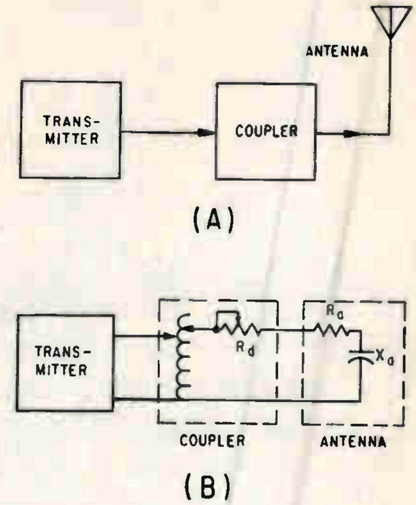


FIG. 1—Block diagram shows coupling of final output stage of transmitter to the electrically short antenna

By GEORGE J. MONSER,

American Electronic Labs, Lansdale, Pennsylvania

IN LOW-FREQUENCY SYSTEM DESIGN, a knowledge of the radiation capability of the antenna is necessary. The designer must be able to predict the conversion efficiency from transmitter output power to useful radiated power, compatible with the information bandwidth. The nomograms in Fig. 2 and 3 help estimate this conversion efficiency. They should be regarded as an extension of an earlier reference sheet.[1]

Figure 1A illustrates a technique for coupling the electrically short antenna to the final output stage of the transmitter.

Given a certain antenna size, operating frequency and bandwidth requirement, the technique finds attainable conversion efficiency. Conversely, for a given transmitter capability, radiated power and information bandwidth, the technique finds conversion efficiency and antenna

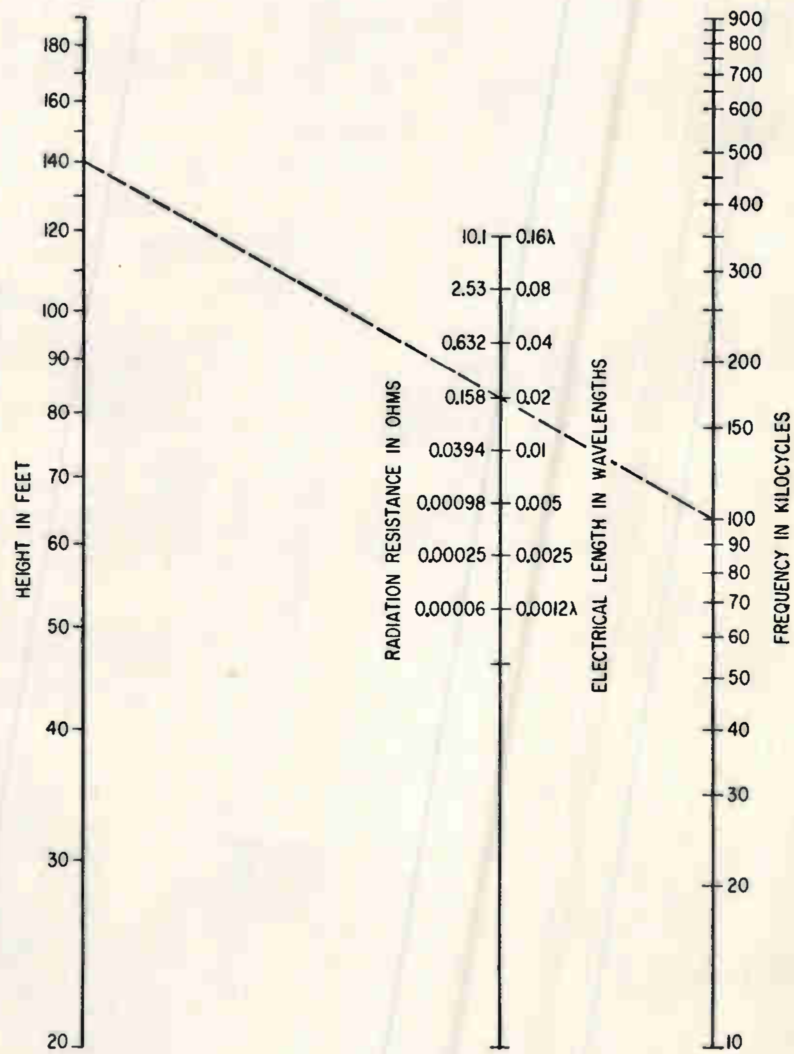
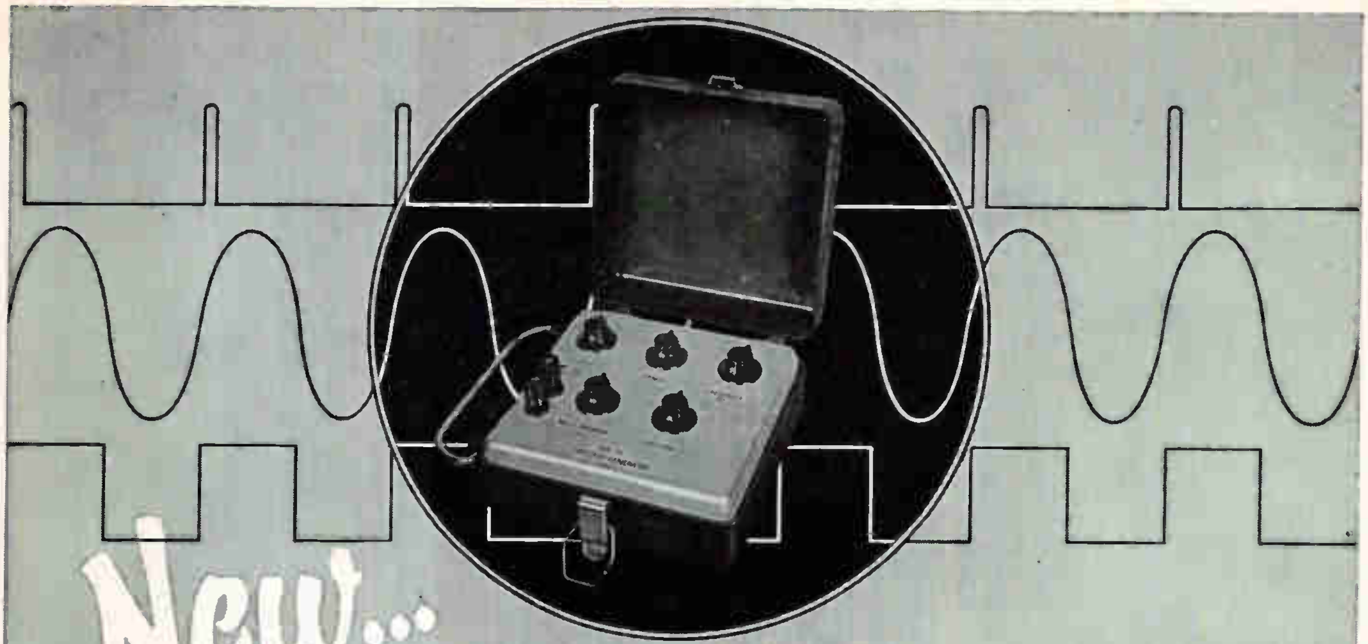


FIG. 2—Radiation resistance nomogram for vertical short monopole antenna, valid for lengths up to 0.1 wavelength



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size in a given case.

Under the tuned condition in Fig. 1B, the reactance of the tuner is adjusted to equal the antenna reactance, and $Q = f_o/BW \equiv X_a/R$, where f_o is the operating frequency, BW the circuit bandwidth, X_a the antenna reactance at frequency f_o, $R = R_a + R_d$ the total circuit resistance, R_a the radiation resistance and R_d the added dissipative resistance.

To use the equation, antenna reactance is expressed as $X_a = 31.9\ (\lambda/h)$ where (λ/h) is the reciprocal of the antenna electrical length. This was derived and presented in Fig. 4 of Reference 1. It is valid for short, thin vertical monopoles, that is, when electrical length is less than $\lambda/16$ and for height-to-radius ratios 60 to 90.

Normalized bandwidth $\beta = BW/f_o = (R_d/31.9)\ (h/\lambda) + 12.6\ (h/\lambda)^3$. Normalized efficiency of conversion $\eta = R_a/(R_a + R_d) \equiv 12.6\ (h/\lambda)^3/\beta$.

The nomograms relating the variables of these equations are given in Fig. 2 and 3. On each nomogram is a reference construction line.

As an example of a problem solution, suppose that 4 watts of radiated power are required, and a bandwidth of 3 Kc is required. Assume the transmitter output at 100 Kc is 1,000 watts. Size of the vertical stub antenna is to be determined, assuming no antenna top loading.

First compute normalized bandwidth, $\beta = 0.03$, or 3 percent.

Next compute efficiency $\eta = P_{\text{-radiated}}/P_{\text{-input}} = 0.004$, or 0.4 percent.

Enter Fig. 2 with these values and read $h/\lambda = 0.02$, and $R_a = 0.16$ ohms.

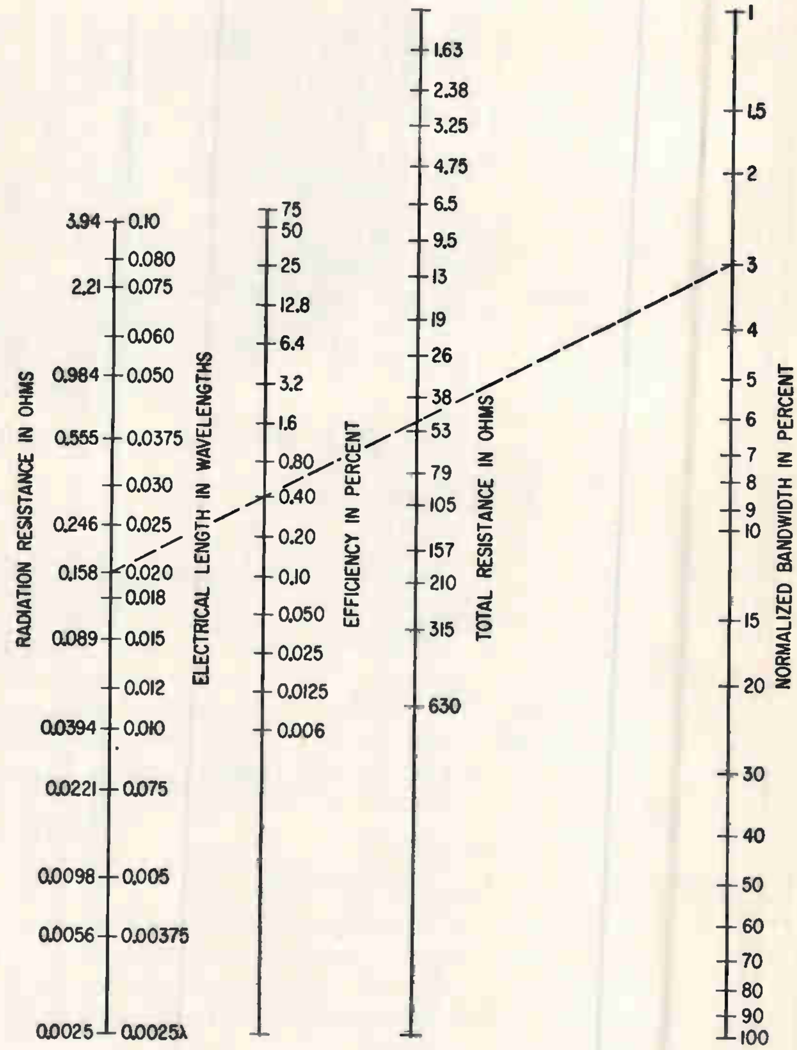

FIG. 3—Nomogram for determining efficiency in percent of short monopole antenna, valid for lengths up to 0.1 wavelength

Enter Fig. 3 with this value and the operating frequency, 100 Kc, and read the antenna height as 140 feet. The total circuit resistance can be estimated from Fig. 2 as $R \approx 40$ ohms.

Entries into the nomograms can be made in different order, depending on the known and desired information. Approximations were made in the derivation, restricting usage to electrical lengths less than $\lambda/16$ and thin vertical antennas. Accepting a small loss in accuracy, electrical lengths up to 0.1 λ can be considered.

REFERENCE

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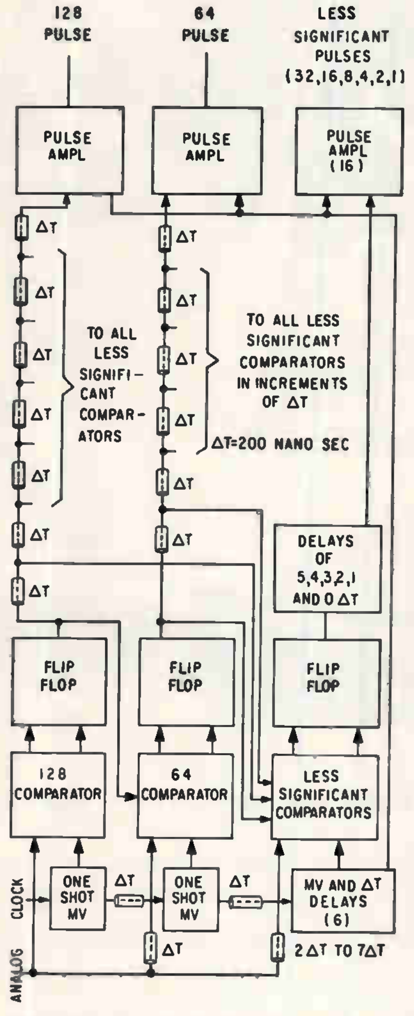
Converter Samples Analogs at 5 Mc

ANALOG-TO-DIGITAL conversion technique permits sampling speeds of 5 million per second with an eight-bit parallel binary output. Pulses less than 0.3 μsec can be digitized because of the 20 nanoseconds aperture time.

The converter was developed by Raytheon and has been delivered to the Applied Physics Laboratory at Johns Hopkins University. A wide variety of military, industrial and scientific applications are also expected for the converter. With optional input and output arrangements, it can readily be adapted to many systems requiring high sampling rates.



Simplified block diagram shows parts of pulse distributor and analog storage system that permit high sampling speeds

Synchronous and asynchronous modes of operation are possible. In the asynchronous mode, sample timing is determined by a crystal-controlled internal clock that is accurate within 100 cps at the 500-Mc clock frequency. A timing signal is provided on a separate line at the same time as the readout pulses.

In the synchronous mode, an external pulse can be applied at constant or intermittent rates up to 5 Mc to initiate the sampling process. Output for either mode is parallel six, seven or eight binary digits. Bipolar input and binary coded decimal output can also be accommodated.

The converter compresses the time interval between readouts to that required to produce a single bit. This increased speed is made possible by taking additional samples before previous samples have been completely processed.

The analog input is fed to an amplifier that drives a set of specially designed delay lines. The delay lines store the analog for processing, delaying it in increments of 200 nanoseconds. Output from each delay line goes to a comparator where it is compared to the signal that has already been received at the next more significant comparator. A comparison is made at each comparator when the particular comparator is pulsed by a sample pulse distributor. The sample pulse distributor also has taps at intervals of 200 nanosec.

Each comparator either sets or resets an associated flip-flop. The flip-flops in turn drive delay-line shift registers. The shift registers delay the decision at the less significant comparators to match the delay of the analog signal to them.

For an eight-bit unit, the complete digitized output appears in parallel at the delay line registers after 1.6 μsec (8 times the 200 nanosec delay). These delayed level outputs are then fed to gated pulse amplifiers that are fired by the delayed output of the sample pulse distributor. Readout is delayed so all pulse outputs can occur simultaneously within 20 nanosec.

The converter begins processing the next sample before completing processing of the preceding sample. The eight-bit unit handles eight samples simultaneously in different stages of completion.

The aperture time during which the converter can accept a sample is the maximum difference in delay between the pulse distributor and the associated analog storage delay line, which is 20 nanosec. With this narrow aperture, a sample-hold circuit is unnecessary if input remains constant within half a count, or 0.2 percent during the 20-nanosec period for the eight-bit unit.

Accuracy is specified as 0.39 percent ±½ of the least significant digit. The 0.39 percent is the maximum allowable nonlinearity in the input amplifier that will permit digital output to represent analog input voltage ±1 count. As amplifier nonlinearity is reduced, converter accuracy approaches the quantization error of ±½ of the least significant bit inherent in any digital device. The finite noise and hysteresis in the converter constitute 1/5 count. If total accrued errors are at the most equal to the quantization error, over-all accuracy is within ±1 count.

Seven basic modules constitute the majority of circuits in the converter. The unit is typewriter size and weighs about 20 lb.

Laser May Function As Space Vehicle Radar

EXPERIMENTAL system using light instead of microwave energy may perform the function of long-range radar in outer space. The small, light-weight equipment has low power requirements, making it feasible to launch in a satellite.

The coherent light detecting and ranging system (Colidar) was announced by Hughes Aircraft Company. Operation is comparable to radar except that the output signal

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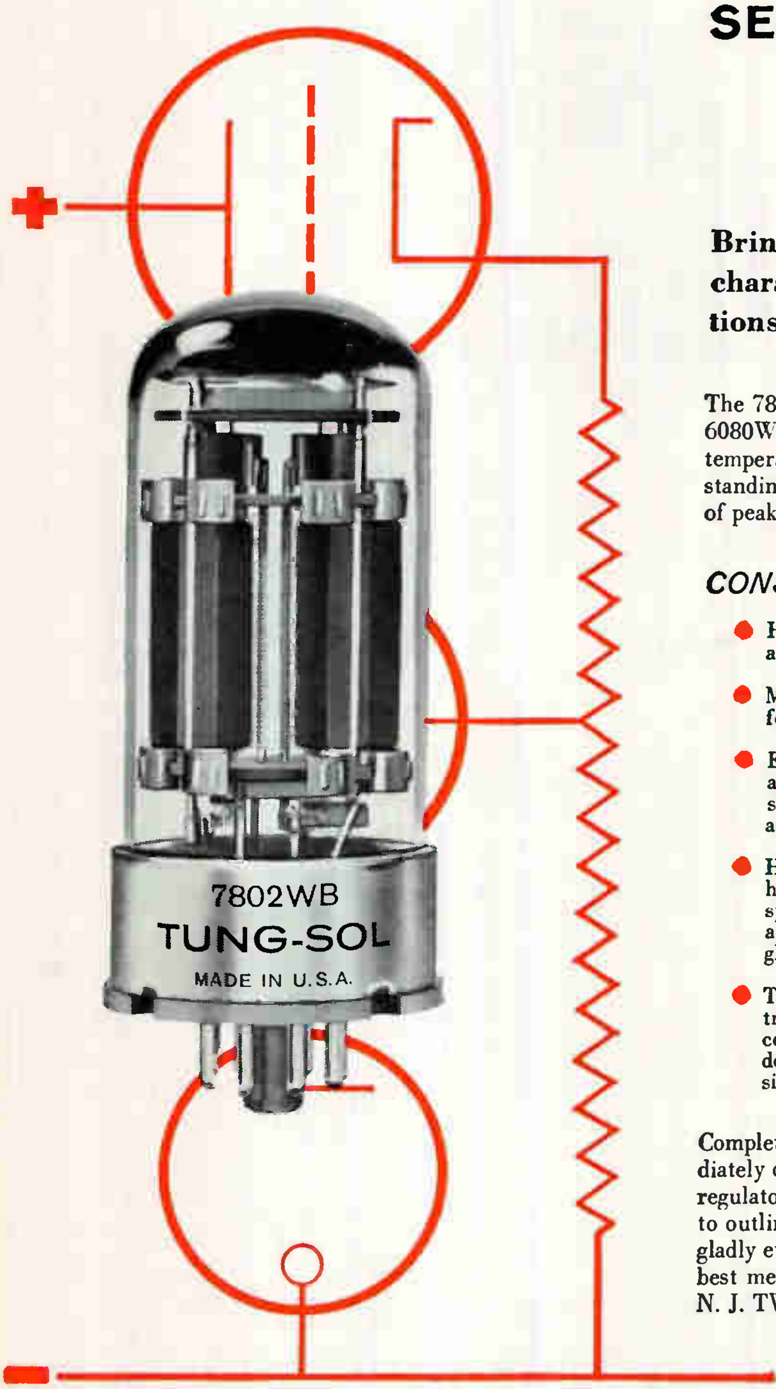

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is generated by a laser.

The transmitting function involves propagation of the nearly parallel, almost monochromatic light beam of the laser. The receiver is an optical system that couples light reflected from a target to a photoelectric tube. Like conventional radar, light pulses transmitted to and reflected from an object provide range, range rate, angles and angular rates of the target relative to the transmitter.

A working model of the system has a range of nearly six miles even with the attenuation caused by the atmosphere. At this distance, the system discriminates between two 10-ft wide diffuse gray objects side by side with the targets reflecting only 10 percent of the incident light pulse.

Longer ranges are foreseen using the narrow beam of the laser. Refinements in beam formation, power sources and receivers are expected to permit the Colidar to operate over hundreds of miles in space with slight power expenditure.

Wavelength of output from the ruby maser is 6,943 angstrom units, and the ruby crystal is ⅜ inch in diameter and 1½ inches long. When the spiral flash tube surrounding the ruby is discharged, the highly collimated red light beam emerges from the partly transparent silvered surface at one end. Pulse power outputs of more than 1 Kw have been observed. Beamwidth is less than a half deg, spectral line width less than 0.01 A.

By feeding laser output through a lens system, beamwidth can be narrowed considerably. Because of this characteristic, gain can be increased sufficiently to enable its use in systems like the Colidar.

The receiver is a 38-inch telescope with an 8-inch diameter mirror for collecting and focusing incident light. Because only the almost monochromatic light from the laser is of interest, a narrow-band filter reduces noise effectively.

A light pulse initiates a signal that triggers the pump power for the laser. The light from the laser passes through a lens and shutter to form the transmitted light pulse. The emerging light pulse from the laser in turn triggers a signal that is used as a time base for range and rate measurements.

Filters Aid Offshore Seismic Exploration

SUBSURFACE maps of ocean floors can be made more accurate as a result of specially designed filters. In some cases, accurate seismographic exploration of subsurface formations had not even been possible without the filters.

Geologists seeking the subsurface structures in which oil is likely to be found encountered severe interference. After more than four years of research, personnel at Gulf Research & Development Company working with a large computer acquired sufficient information to filter out the interference.

Following detonation of a seismic charge, sound waves travel through a hard bottom like that in the Eastern Gulf of Mexico much faster than they travel through water. Conversely, waves travel much slower through a soft bottom such as that of Lake Maracaibo in Venezuela than through water. When sound waves undergo a large change in velocity, much of their energy is reflected back toward its origin.

When sound waves under water encounter this condition, they are reflected back and forth between the bottom and the surface. Sound picked up by hydrophones under water after a seismic explosion is accompanied by these reflections. Tape recordings are characterized by smooth, undulating waves, with the jagged seismographic recordings that normally delineate subsurface layers blotted out by the interference.

To map this kind of bottom required that the undesired reflections be removed while the required information was retained. To solve the problem, an IBM 704 computer was used to try a large number of theoretical answers rapidly. With sufficient information about the characteristics of the interference and the conditions under which it was produced, it became possible to design complex electronic filters to remove it.

The filters have enabled geological teams to map large areas of Lake Maracaibo, which previously had defied seismic exploration because of the mucky bottom.

The Role of Rhenium in Electronics

MANY FAILURES in filaments, grids and heaters in electronic tubes result from embrittlement of the wire caused by recrystallization at high temperatures. This can cause catastrophic failures in critical guidance or control systems for space satellites and communication installations.

Rhenium-molybdenum alloys do not become embrittled upon recrystallization as do tungsten and pure molybdenum, the two metals most commonly used for these purposes.

The ductility of rhenium-molybdenum alloys permits fabrication or forming either cold or warm. Cold drawing is particularly important in the fabrication of components for electronic tubes as it results in much better surface quality, less danger of contamination, and improved properties of the wire following initial warm breakdown operations.

The first commercial production of these alloys[1] will make available improved materials to solve electronic materials problems at a cost significantly below that of pure rhenium.

Rhenium products are used in critical components. The material is extremely dense, silver-colored metal with a melting point of 5,756 F, a good combination of strength and ductility, and excellent electrical characteristics even at elevated temperatures. Only tungsten has a higher melting point.

In this country sales of rhenium have jumped 400 percent in the past four years. The importance of rhenium and rhenium compounds in electrothermics and metallurgy was gleaned by several papers delivered last year at the Electrochemical Society meeting[2-4]. Applications for rhenium alloys were promised for thermocouples, electrical contacts, and vacuum tube parts.

Molybdenum is a refractory metal with a melting point of approx. 2,600 C. It is one of the most widely used high-temperature metals and is used for structures as well as for tube components.

Molybdenum's most serious drawback is that it becomes embrittled in the crystallized condition, at below 20 C.

Successful alloying of rhenium and molybdenum represents a combination of the best characteristics of both metals. Elevated temperature strength exceeds that of molybdenum, while very good ductility is retained all the way down to the cryogenic range, minus 450 F.

Rod, wire and strip products are now available in 50 Re — 50 Mo, and 40 Re — 60 Mo (wt percentage) alloys.

Studies have been made of recrystallization of rhenium and of alloying with tungsten, nickel (in Ni-Cr alloys), and with titanium and its alloys. Rhenium additions improve both room and elevated temperature properties and increase the initial recrystalization temperatures. Solid solution tungsten alloys have increased workability and electrical resistance.

Data on fabrication of refractory alloys containing rhenium has been compiled[4], as well as information on powders giving the best results for blending, pressing, swaging, and drawing of fine wires (0.001-in.). A study has been started to develop the application of these alloys in the fields where their unique properties are the most valuable.

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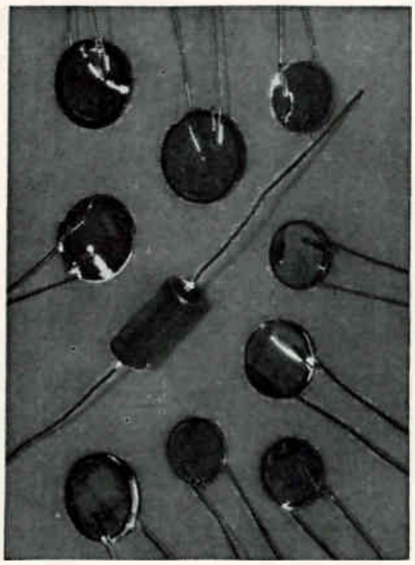
Spotting Tiny Defects



Leakages and cracks in transistors and diodes are detected by fluorescent penetrants perfected by Magnaflux Corp., Chicago. Components are inspected under high-intensity black light in a darkened area. Although Zyglo and Zyglo-Penetrex principles are not new, new developments broaden the range and sensitivity of these materials

Ion Exchange Unit Recovers Lost Gold

A COMMERCIAL UNIT for recovering gold lost in electroplating was introduced by Technic, Inc., a large producer of precious metal solutions for plating.

Until now between 4 and 10 per cent of all gold used in electroplating has simply gone down the drain, said F. K. Smith, president of the firm which is based in Providence, R. I. The loss to the plating industry runs to millions of dollars a year. Smith said, however, that one electroplater, using the new special resin Gold Saver on a trial basis, will recover enough gold in less than three months to pay for the unit, "and everything saved after that is 'found money.'"

The gold saver is designed to become part of the gold plating process. Basically, the unit consists of

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Convergence Cores	W-01	Low residual with large gap
I. F. Transformers	R-02	Low losses at low amplitudes. Good temperature stability of permeability
R. F. Tuning Coil (fixed or permeability tuned)	R-02	Low losses. Temperature stable permeability, minimum hysteresis for permeability tuning
TELEPHONE SYSTEMS Interstage and Matching Transformers	W-03	High permeability, low losses
H. F. FLUORESCENT LIGHTS Loading Reactors	W-07	High flux density
Transformers	W-04	High permeability, low losses, high Bmax
ELECTRIC ORGANS AND HI-FI STEREO Oscillator Inductors	W-03	High permeability, temperature stable, linear B vs. H
Output Transformers	W-04	High permeability, high Bmax, low losses
AUTOMATIC MACHINE TOOLS Magnetic Amplifiers	R-03	Rectangular hysteresis loop, high Bmax
Logic elements for high-power levels	R-03	Rectangular hysteresis loop, high Bmax
Matching Transformers	W-04	High permeability, low losses, high Bmax
MOBILE POWER SUPPLIES Static Inverters	R-03	Rectangular hysteresis loop, high Bmax
RADAR, MISSILES Pulse Transformers	W-04 R-02 (for short pulses)	High pulse permeability, high Bmax, low losses
PERMANENT MAGNETS	M-01	High energy factor Good mechanical strength

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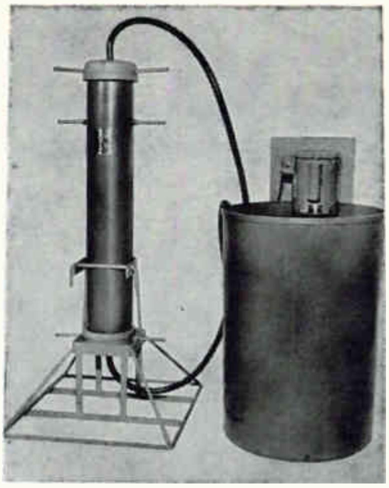


Gold headed for drain now aimed for pocket

a column of special resin, small "BB" size particles, which capture gold in solution that now is being lost; a pump for circulating through the resin column the water in which the gold is dissolved; and pipes, hoses, and connections between the pump and the special resin column.

After an item is plated with gold, it is immediately immersed in a tank of water to rinse off and save the plating solution, which frequently costs between $40 and $50 a gallon. This rinse tank is called a drag-out tank.

Over a period of time, the concentration of gold solution in the drag-out tank builds up until, because of its gold content, it is worth possibly $10 a gallon. Periodically contents of this tank are added to the gold plating tank to keep the plating solution at a workable level and to recover some of the gold.

In the past, the plated item was then rinsed in running water, and the gold drag-out from the drag-out tank was lost.

The gold saver comes before this running water rinse. The unit is attached to a tank into which the plated item is dipped, after the drag-out tank. The pump continuously circulates the solution through the special resin trap, where the gold is picked up. The work, free of gold, is then rinsed in running water.

When the resin is completely saturated with gold it may be burned by the plater to recover the gold, sent to a refiner, who would also recover the gold by burning, or it may be returned to the Technic laboratories for reclaiming.

The Gold Saver is designed for any acid or non-free cyanide golds, such as Technic's 24K acid, Orotherm HT, Orosene 999, or HG non-free cyanide gold baths.

Similar ion exchange traps for cyanide golds, rhodium, palladium, and platinum already are under development or test.

Low-Temperature Solder Has Lower Resistivity

USUAL SILVER SOLDERS made with epoxy binders sacrifice good adhesion to get low resistivity. Available conductive epoxies can have resistivity values of 0.1 to 1 ohms cm. But good bonding has been a problem when much lower resistivities are desired. Epoxy solders have two advantages over conventional soldering or brazing. They can be used at low temperatures for soldering heat-sensitive components, and they have no flux or residue that may contaminate a sensitive electronic device. When used with dissimilar metals, epoxy solder offers a bonding technique where no other type of soldering or brazing would be possible.

Problems involved in the use of low-temperature solders that require much lower resistances have been solved by a silver conducting epoxy that has a resistivity approaching that of metals: between 0.01 ohms cm and 0.001 ohms cm[1].

This epoxy solder is available in two paste forms: a one-component heat-curing paste (as low as 125 C); and a two-component room-temperature cure paste. This solder is now used in field-repair work, particularly on crowded printed circuits where higher solder temperatures can damage heat-sensitive components.

This new solder makes a good conductive bond with practically any material. Shear strength of a steel-to-steel bond is 3,200 psi.

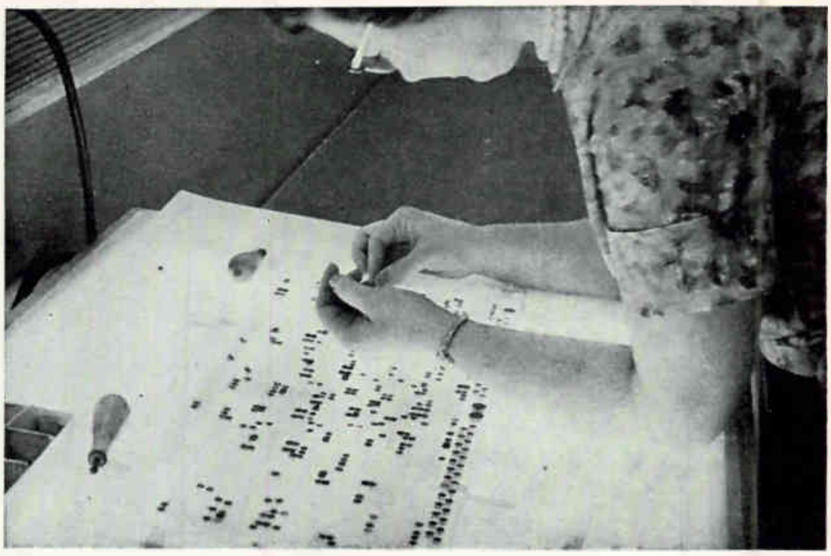
Typical applications include bonding tube caps to the glass tube, bonding the tantalum slug to the can of a tantalum capacitor, and grounding aluminum capacitors to steel chassis.

REFERENCE

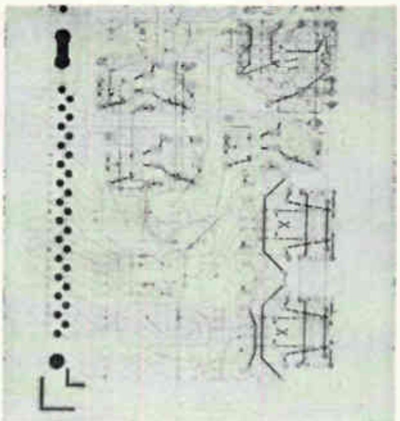
(1) Vince Sussman, Vice Pres. of Engineering, Epoxy Products, Inc., a Division of Joseph Waldman & Sons, 137 Coit Street, Irvington, N. J.

Photography Speeds Printed Circuit Design

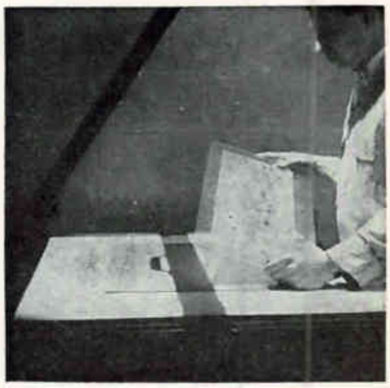
By F. E. BARROWS,
R. S. LADD,
IBM Federal Systems Div., Owego, N. Y.



Buttons are inserted in template over layout



Portion of layout on standard form



Contact printing the assembled template produces negative

HIGH ACCURACY and substantial savings in time are gained by mechanizing the preparation of artwork and drawings used in the production of printed circuit boards. Mechanization is accomplished by templates and the rearrangement of commonly-used photographic and engineering methods.

Layouts, prepared on forms with a standard grid pattern and scale, are converted directly to precision artwork. The artwork is then used to produce the board masters and production drawings. A common scale enables the layout and artwork to be checked quickly by overlay methods.

Layout and artwork are scaled at 2:1, allowing tolerances of ±0.003 inch to be held in finished boards ($\frac{1}{16}$-inch epoxy glass, 5.1 by 11.6 inches, double-sided with plated-through holes). This scale also minimizes handling and printing costs.

A 0.50-inch grid determines size and spacing of holes (minimum of 0.10 inch between centers), lands and wiring. The grid, generally accepted in the industry, meets engineering requirements and makes the boards compatible with automated drilling and assembly equipment. Two line widths are used, the narrower where space is limited and electrical requirements are critical. This practice also saves time by focusing attention on critical areas of the board.

Layouts are prepared on stable, transparent film preprinted with the grid pattern, edge connections, mounting holes and marginal data. Repetitive, fixed circuit patterns (in a logic system) are also preprinted in the 2:1 scale on films. These films are located on the underside of the form. Other components are drawn on the face of the form.

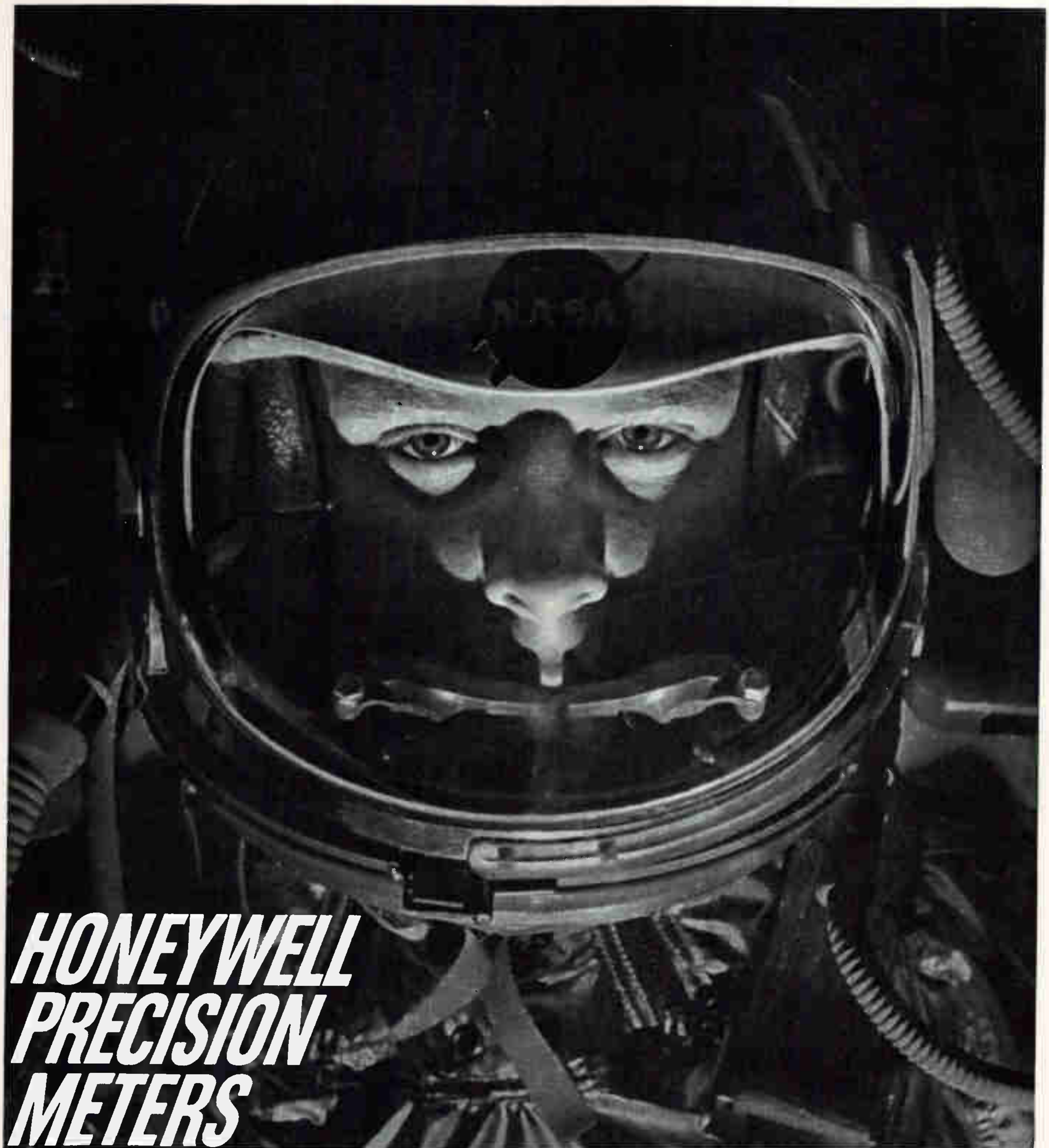
Wiring is drawn in colors which blueprint readily. Solid, orange lines represent the generally horizontal wiring on the face of the board; broken, green lines represent the generally vertical back wiring. The completed layout is blueprinted, checked and approved.

Instead of proceeding from layout to detail drawings to precision artwork, as is customary, the artwork is prepared directly from the layout. The templates used in this step provide the accuracy needed.

Templates are made of quarter-inch, transparent plastic. All available hole positions on the grid (0.100 ± 0.004 inch at the 2:1 scale) are drilled (0.062 ± 0.001 inch in diameter). There are some 18,500 holes for a 5.1 by 11.6-inch board. Each hole can receive the tenon of a brass button representing a land. Permanently placed buttons represent mounting holes and edge connections.

The layout is placed on a gridded light table and the template is positioned on the layout. Buttons are inserted in the template at each land position. Buttons must be flush with the template surface for sharp, accurate photography.

The template is put into a vacuum contact printer with a point-source light. The buttons are placed in direct contact with the emulsion of a thin-base, stable film. Exposure is timed so the buttons are not undercut. The negative is



HONEYWELL PRECISION METERS ASSISTING OUR FIRST MAN IN SPACE

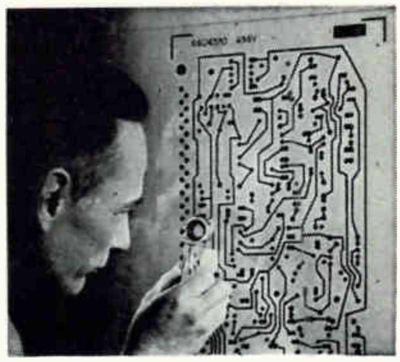
Our first Astronaut will be aided by an instrument designed to provide visual monitoring of his automatic re-entry equipment. The device is a product of the creative design and engineering skills of Honeywell. Components for it are being supplied by the Honeywell Precision Meter Division.

Maybe you have a mechanism problem that's looking for a solution. A quality product from Honeywell may be the answer. Just get in touch with our representative in your area — he's listed in the classified pages of your telephone directory. Or contact us: Honeywell Precision Meter Division, Minneapolis-Honeywell Regulator Company, Manchester, N.H., U.S.A. In Canada, Honeywell Controls Ltd., Toronto 17, Ont. HONEYWELL INTERNATIONAL Sales and service offices in all principal cities of the world.

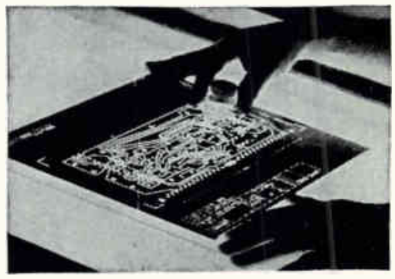
Honeywell

Precision Meters

processed, dried, opaqued and contact printed from both sides, yielding two positive transparencies of the land pattern. At the same time, by double exposures, standard titles and revision blocks are added to the transparencies.



Inspecting completed artwork



Final inspection of reduced negative

One transparency represents the front of the board and the other the back. These become the final artwork upon the addition of smooth, black tape, placed according to the layout and standards for line width and spacing. A final inspection is made with optical instruments which have etched scales accurate to 0.002 inch. Any deficiencies are corrected.

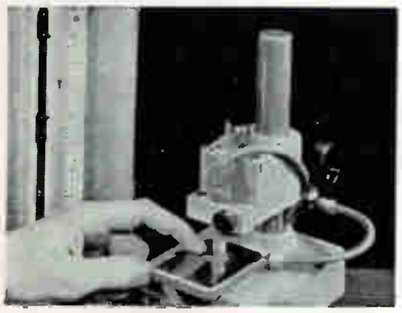
The artwork is reduced to glass negatives. These plates are made with transmitted light. Transmitted light avoids surface effects that the tape would produce in reflected light, thus avoiding time-consuming manual cleanup or opaquing. If the camera does not have a transparency holder for use with transmitted light, an alternate method can be used. A contact positive is made of the completed artwork and the glass negative is made from the positive using reflected light.

After either process, the negatives are checked with glass plate scales lined at 0.002-inch spacings, to insure correct reduction of all parts. Photographic tolerances of ±0.001 inch or less are obtained with a good process camera, periodically checked and aligned with an exact stable master and light collimator.

The artwork is also used to make thin film positives, which are applied to standard drawing forms. The forms contain all required marginal information, standard notes, dimension lines and accurate grids.

Previous methods of producing artwork required manual side-by-side transfer from board layout to artwork form. Now, this transfer and its checking are quickly and accurately done by overlay. Making detail drawings from layouts formerly required as much as two weeks of manual labor. The total average photographic and detail time with this method is three and a half hours.

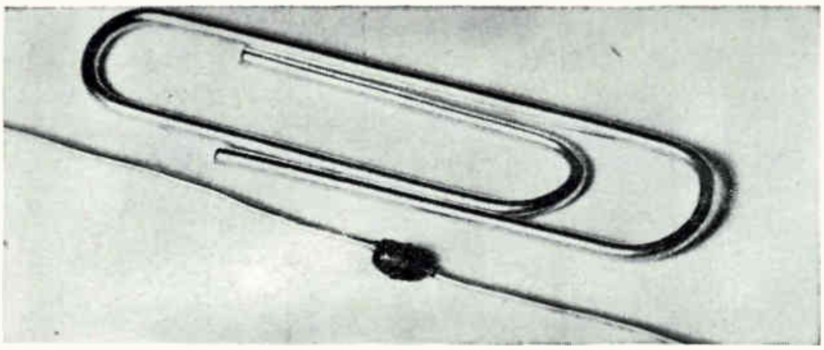
Gage Floats Fragile Parts in Air Jets



NEW AIR GAGE measures the thickness of fragile materials without gage point pressure by floating the part between two opposing air jets. It was designed by the Sheffield Corp., Dayton, Ohio, to measure semiconductor dice and wafers, plastic film, sheet rubber, thin glass and other materials. Polished metal can be checked without scratching.

Air flowing out of jets in the head and anvil caliper the parts. Thicknesses are indicated by position of the float in a Precisionaire column. A foot pedal can be used to turn on the air, allowing loading of very thin materials. Standard gages are adjustable from 0.0001 to four inches. Maximum and minimum size parts rather than masters are used for calibration.

New On The Market

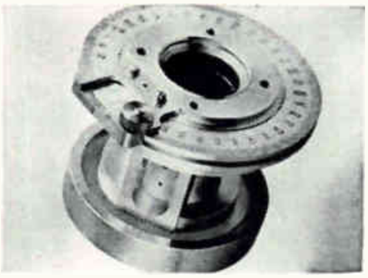


Miniature Wire-Wound Resistor
1 TO 100,000-OHM

MICROMINIATURE wire-wound resistor type TC041 is designed for military and industrial applications where weight and space are at a premium. The resistor is $\frac{1}{8}$ by $\frac{1}{8}$ inch, is available from one ohm to 100,000 ohms and in power ratings of 0.05 watt. Temperature range is from −55 C to 125 C; unit meets all appropriate military specs.

The resistors are now being manufactured with pilot production facilities but full-scale production is expected within the next few months. Manufacturer is Reon Resistor Corp., 155 Saw Mill River Road, Yonkers, N. Y.

CIRCLE 301 ON READER SERVICE CARD



Rotating Probe
FIELD ORIENTATION

CIRCULAR WAVEGUIDE rotating probe section provides a continuous 360 degree probe rotation for measuring electrical field mode orientation in circular waveguide. A universal probe mounting is provided with thumb screw lockings at three different longitudinal positions. A vernier protractor type scale is provided to read rotations to $\frac{1}{2}$ degree.

Model 55 R 5C has operating bandwidth from 5 to 5.9 Gc and residual vswr of 1.02 to 1; price is $850. Manufacturer is Applied Microwave Electronics, Inc., 114 West 25th St., Baltimore 18, Md.

CIRCLE 302 ON READER SERVICE CARD

Pulse Generator
USES Ga As DIODES

LINE of pulse generators with high repetition rates and fast rise and fall times has been introduced by Texas Instruments Inc., P. O. Box 6027, Houston 6, Texas.

The line includes two clock pulse generators and a programmed pulse generator. The clock pulse generators include a 3 to 25 Mc unit and a 25 to 100 Mc unit, with overlap to cover 3 to 100 Mc.

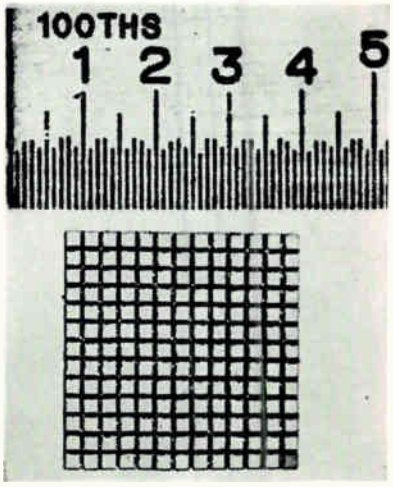
Specs include: rise/fall times of

less than four nanoseconds; a pulse width of less than eight nanoseconds at one-half pulse height; 0-4 v amplitude, continuously variable; and output impedance of 93 ohms.

The programmed pulse generator has an internal pulse repetition rate of from 3 to 25 Mc and provides for an external drive to allow repetition rates below 3 Mc.

Specifications for the programmed pulse generator include a repetition rate up to 25 mc; rise/fall times of less than six nanoseconds; 0-5 v amplitude, continuously variable; and an output impedance of 93 ohms.

CIRCLE 303 ON READER SERVICE CARD



Passivated Micro-Matrices
ACTIVE SUBSTRATES

SILICON micro-matrices—fully passivated active substrate diode arrays—are designed to customer specified geometry, size, electrical and contact requirements. The silicon matrix will withstand long term storage at 300 C.

Surface passivation method allows development and production of micro-size semiconductor devices having high reliability. The matrices are available from Micro-Semiconductor Corp., 11250 Playa Court, Culver City, Calif.

CIRCLE 304 ON READER SERVICE CARD

Glass Enclosure
FOR MICRO-TRANSISTORS

ALL-GLASS enclosure for micro-transistors consists of case and flat cover. Diameter of the enclosure is 150 mils, and height after sealing is 60 mils. Three coplanar, ribbon leads are an integral part of the case.

A glaze with a low melting point, applied to the top rim of the case,

Random Noise Source

Generates Noise From 5 cps to 500 Kcps

Raytheon Wide Band Noise Sources offer many exclusive features to designers requiring low power, DC-operated noise source modules.

For example, their small size, low power requirements, and rugged construction enable the design of extremely compact, portable test equipment and systems capable of reliable operation over wide extremes of shock, vibration, and temperature.

The use of DC power insures the absence of 60 cps or other coherent signals in the output. Handy volume control with knob lock allows a wide variety of chassis and panel mounting arrangements.

If you are interested in radar and communications system testing, ECM, audio and video testing, or other applications employing noise simulation, then by all means investigate the advantages offered by Raytheon's new Noise Sources. Please write to: Raytheon, Industrial Components Division, 55 Chapel Street, Newton 58, Massachusetts.

SPECIFICATIONS OF A TYPICAL MODEL (EM 1000)

Useful Noise Output:	5 cps to 500Kc
Output:	0-10 millivolts rms
Shock:	900 g, 1 millisecond half sine wave pulse (Taft-Pierce 60°)
Vibration:	15 g, 5 to 1000 cps
Temperature Range:	0°C to + 70°C
Supply:	+ or − 10 to 14 volts DC
Weight:	5 ounces
Size:	3-3/16" x 1-1/2" x 1-1/2"

For Small Order or Prototype Requirements See Your Local Franchised Raytheon Distributor.

RAYTHEON COMPANY

RAYTHEON

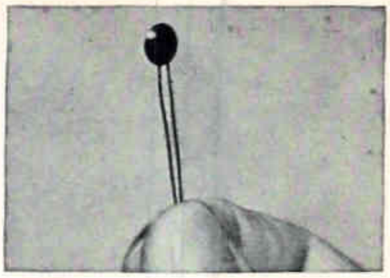
INDUSTRIAL COMPONENTS DIVISION

allows simple hermetic sealing without welding or soldering. Diameter is 15 mils less than the maximum recommended recently by the Subcommittee on Microminiature Components of EIA. The 60-mil height matches the committee's recommendation. Inside diameter is 100 mils and inside depth is 20 mils.

Leads, three mils thick, are oriented according to EIA recommendations. For lead identification, one lead is 15 mils wide and the other two are 25 mils wide.

The glass enclosures are being manufactured by Corning Glass Works, Corning, N. Y.; prices are available on request.

CIRCLE 305 ON READER SERVICE CARD



Silicon Oxide Capacitor
LOW SELF-INDUCTANCE

CAPACITOR using semiconductor principles is introduced by the Sprague Electric Co., 35 Marshall St., North Adams, Mass. The device uses silicon oxide as the dielectric material.

The capacitor will be marketed under the name Oxsil. Features include operating temperature to 300 F, high insulation resistance, low dissipation factor, and low self-inductance. Units are being furnished in both radial and axial lead wafer designs, type 10K and 11K.

CIRCLE 308 ON READER SERVICE CARD

Expanding Scale Meter
TWO-STEP METHOD

DIRECT SAMPLING, followed by expansion of any 10 divisions to cover a full 100-division scale, give electrical measurements to 0.025 percent accuracy in meters manufactured by Greibach Instruments Corp., 315 North Ave., New Rochelle, N. Y. By electrically folding an effective 5-foot scale into 10 equal sections, the third significant figure may be read exactly, and the fourth figure estimated to ¼ of a division.

High accuracy, inherent durability, ruggedness and overload capacity to 125,000,000 percent in some cases are features of the selective-expansion meters. The compact instruments, with multirange combinations in a single meter, are available for portable or panel use.

CIRCLE 306 ON READER SERVICE CARD

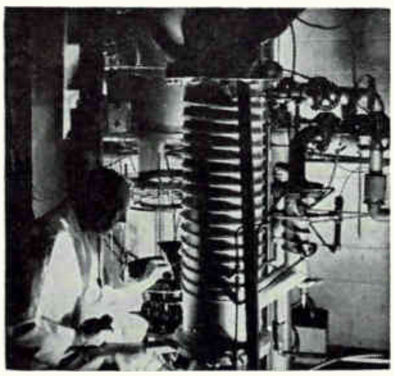
Sweeping Oscillator
LOW FREQUENCY

KAY ELECTRIC CO., 14 Maple Ave., Pine Brook, N. J. The Sona-Sweep model M adapts the accepted techniques of r-f swept-frequency alignment for audio and ultrasonic design and test work. It provides a complete measurement system. Sweep center-frequency is adjustable between 20 cps and 200 Kc. Sona-Sweep delivers a high-level output of 5 v rms into 600 ohms over the entire frequency range.

CIRCLE 309 ON READER SERVICE CARD

Production System
THIN-FILM CIRCUITS

PRODUCTION model EB-101 is a vacuum system for the manufacture of thin-film microcircuits. Included with the integrated equipment for the production of circuits composed of thin-film conductors and multiple resistors are detailed operating instructions and customer-training services.



The thin-film elements produced using the new equipment meet standard tolerances and offer high reliability. A continuing development program on the evaporation of dielectrics using electron beams is aimed at increasing the capability to include capacitors and active components. Information describing the system can be obtained from GVC Electron Heating Corp., 81 Hicks Ave., Medford, Mass.

CIRCLE 307 ON READER SERVICE CARD

Noninductive Resistor
10-WATT UNIT

OHMITE MFG. CO., 3654 Howard St., Skokie, Ill., has added a 10-w size to its noninductive, vitreous enam-

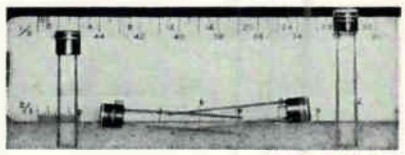
eled resistors. It is essentially a tubular type and mounts by means of nonmagnetic brackets (brass) on $2\frac{3}{16}$ in. centers. Core size is $1\frac{3}{4}$ by $\frac{5}{16}$ in. diameter. Ayrton-Perry type windings reduce the inductance to less than 1 percent of the regular solenoid type resistors with low effective series reactance.

CIRCLE 310 ON READER SERVICE CARD

Preamplifier

BRUSH INSTRUMENTS, division of Clevite Corp., 37th and Perkins, Cleveland 14, Ohio. A transistorized, plug-in, high gain preamplifier measures signals as low as 10 microvolts.

CIRCLE 311 ON READER SERVICE CARD



Inductances
ENCAPSULATED

JAMES MILLEN MFG. CO., INC., Malden, Mass. The J302 series of miniature encapsulated inductances for printed wiring have EIA values of inductances from 10 mh to 22 μh with $\pm$ 5 percent tolerance. Maximum d-c rating 60 ma to 1,210 ma. The series is wound with high temperature wire and encapsulated in epoxy for -55 C to $+125$ C ambient temperature.

CIRCLE 312 ON READER SERVICE CARD

Power Resistors
AXIAL LEAD

WARD LEONARD ELECTRIC CO., Mount Vernon, N. Y., announces four additions to its Axiohm power resistor line engineered for automation, printed circuits and advanced miniaturization use. The 2, 4, 7 and 12.5 w resistors plus the former 3, 5 and 10 w units make seven sizes available to design engineers. Watt ratings for all sizes are based on a 325 C rise, 25 C ambient. Featured are 0.7 to 75,000 ohms and ±5 percent standard resistance tolerances.

CIRCLE 313 ON READER SERVICE CARD

P-M D-C Motor
FOR TIROS SATELLITE

REFLECTONE ELECTRONICS, INC., Stamford, Conn. The PM-1 permanent magnet motor, originally developed for NASA's Tiros weather satellite, is now available as an off-the-shelf item. The vibration and shock resistant unit has found additional applications in integration and timing devices, recorders, controlling tv camera shutters, high speed blowers and d-c servo controls. Motors are priced from $14.50 each in quantity.

CIRCLE 314 ON READER SERVICE CARD

Filters

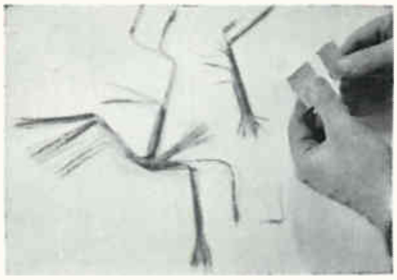
PANEL WIRES INC., Raytheon Co., 213 East Grand Ave., South San Francisco, Calif. Two filters, delta and gamma, eliminate back circuits and prevent interference with adjacent circuits in data processing equipment.

CIRCLE 315 ON READER SERVICE CARD

Patch Cords
DOUBLE BANANA PLUG

HERMAN H. SMITH, INC., 2326 Nostrand Ave., Brooklyn 10, N. Y. Line of patch cords employs $\frac{3}{4}$ in. double banana plugs cabled to a wide variety of plugs, connectors, clips and tips. The plugs were designed for interconnecting a-f and r-f circuits, providing high efficiency, low loss connections. They are available in 10 distinct terminations for connection with another double plug, alligator clip, stripped and tinned leads and phone tips among others.

CIRCLE 316 ON READER SERVICE CARD



Harnesses
CUSTOM-MADE

W. L. GORE & ASSOCIATES, INC., 555 Paper Mill Road, Newark, Del. Lowered cost, savings in weight and space are a few of the advantages claimed for harnesses being made from Multi-Tet ribbon cables. The harnesses, manufactured to customers' specifications, are insulated with Teflon. Abrasion-resistant and corona-resistant cables are also available. Since Teflon only is used in harnesses, they can be used at high temperatures and in corrosive environments.

CIRCLE 317 ON READER SERVICE CARD

Semiconductor Tester

MOLECULAR ELECTRONICS, INC., 85 Weyman Ave., New Rochelle, N. Y. The ICT-100 permits one-man testing of transistors, diodes, or rectifiers while in or out of circuit.

CIRCLE 318 ON READER SERVICE CARD

Power Supply
TRANSISTORIZED

DEL ELECTRONICS CORP., 521 Homestead Ave., Mt. Vernon, N. Y. Designed to supply regulated d-c at high current, type SCRT has an output of 0 to 60 v d-c at 0 to 7.5 amperes (both sides floating with respect to ground). Units feature firing angle control for minimum dissipation and transistor control for fast transient response and ripple reduction.

CIRCLE 319 ON READER SERVICE CARD

Electronic Multiplier

DONNER SCIENTIFIC CO., Systron-Donner Corp., Concord, Calif. A miniature solid state electronic multiplier can be plugged into any analog computer problem board with $\frac{3}{4}$" terminal spacing.

CIRCLE 320 ON READER SERVICE CARD

Corona Pick-Up
100 KV POTENTIALS

ASSOCIATED RESEARCH, INC., 3777 W. Belmont Ave., Chicago 18, Ill., introduces a corona pick-up network to extract the corona signal from a high potential circuit. Models are available for use with potentials to 100 Kv. Model 8562M1 consists of corona-free high voltage capacitor-divider circuit, associated filters, and circuitry.

CIRCLE 321 ON READER SERVICE CARD

Potentiometer
PRECISION UNIT

BOURNS, INC., 6135 Magnolia Ave., Riverside, Calif. Model 3030 Trimpot potentiometer is rated at 20 w and provides high temperature operation to 265 C. It features multiturn screw-driver adjustment and is designed for precision circuit adjustment and balancing in high power applications. Size is 1.07 by 0.50 by 1.25 in. Price (normal quantities) is $10 to $15.

CIRCLE 322 ON READER SERVICE CARD

Video Recorder
EASY TO OPERATE

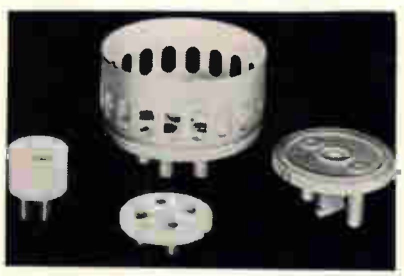
THE SONY CORP., Tokyo, Japan. The 2-head industrial VideoCorder runs 2,400 ft of 2-in. tape as used in ordinary tape recorders, for 66 minutes at the speed of 7 ips. It is easy to operate by push-button. Used in the circuits of the 90 by 90 by 60 cm console are about 100 transistors and about the same number of diodes, weighing 440 lb. Shown is a whole set of the VideoCorder, including a tv receiver, console, tv camera control unit and tv camera.

CIRCLE 323 ON READER SERVICE CARD

Seawater Battery

YARDNEY ELECTRIC CORP., 40-52 Leonard St., New York 13, N. Y. For torpedoes and antisubmarine warfare applications, the battery operates at a flat voltage and gives a uniform performance.

CIRCLE 324 ON READER SERVICE CARD



Tube Components
GLASS-BONDED MICA

ELECTRONIC MECHANICS, INC., 101 Clifton Blvd., Clifton, N. J., has replaced costly crt metallic guns with copper-coated or silver-fired Mykroy 789 glass-bonded mica. Thus, internal structural members

CIRCLE 207 ON READER SERVICE CARD

can be molded to tight tolerances with functional inserts. The molded device is then metalized. Maximum temperature is 810 F continuous, with less than 3 mil distortion. Mykroy will not outgas.

CIRCLE 325 ON READER SERVICE CARD

Oscilloscope

PACKARD BELL ELECTRONICS, 12333 Olympic Boulevard, West Los Angeles, Calif. Portable dual gun oscilloscope has d-c to 5 Mc bandwidth, 1 millivolt/cm sensitivity, costs $495.

CIRCLE 326 ON READER SERVICE CARD

A-C Power Supply
25 V-A OUTPUT

INDUSTRIAL TEST EQUIPMENT CO., 55 E. 11th St., New York 3, N. Y., has developed a precision 25 v-a a-c power supply that meets all MIL specs for ground support equipment. Output frequency is 350-450 cps (other frequencies fixed or variable are available), amplitude stability, 0.1 percent; frequency stability, 0.1 percent; regulation, 1 percent 0-full load; output voltage, variable 0-130 v.

CIRCLE 327 ON READER SERVICE CARD

Magnesium Cleaner
AND BRIGHT DIP

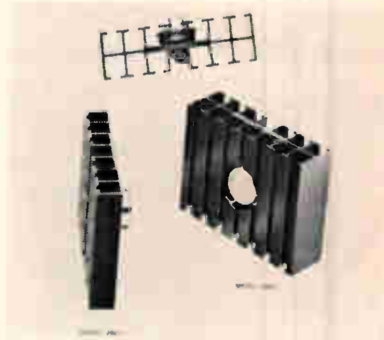
BERNARD CHEMICAL PRODUCTS CO., 98-21 Linden Blvd., Ozone Park 17, N. Y., has developed Bernite BR4, a cold magnesium cleaner and bright dip. Magnesium is finding wide use in casings of electronic components going into missile and aircraft equipment. Bernite BR4, a dry powdered cleaner, used cold, will remove the oxidation products, foreign matter and stains from the surface of magnesium leaving a mirror bright finish. A solution of this cleaner will provide a simple, efficient and rapid means of preparing magnesium for spot welding or welding.

CIRCLE 328 ON READER SERVICE CARD

Noise Generator

H. H. SCOTT INC., Instruments Div., 111 Powdermill Rd., Maynard, Mass. Random generator provides a source of "white noise" for laboratory applications.

CIRCLE 329 ON READER SERVICE CARD



Transistor Heat Sink
NATURAL CONVECTION

ASTRO DYNAMICS, INC., 200 Sixth St., Cambridge 42, Mass. Natural convection heat sink increases transistor performance by offering a thermal resistance of only 1.3 C/w. Model 2502 has a configuration that provides more surface area, a 47 percent lower thermal resistance and occupies less space than conventional designs. Measuring 4 in. wide by 3 in. high by 1.281 in. deep, it weighs 0.4 lb.

CIRCLE 330 ON READER SERVICE CARD

Capacitors
SOLID TANTALUM

KEMET CO., 11901 Madison Ave., Cleveland 1, Ohio. Series N capacitors for a-c circuits are made non-polar by the back-to-back connection of two Series J solid tantalum capacitors of identical value. The compact unit is then placed in a rigid plastic sleeve. Non-polar capacitors are available in capacitance values ranging from 0.16 to

160 μf, and in working voltages of 6, 10, 15, 30, 35 and 50 v for continuous operation at 85 C.

CIRCLE 331 ON READER SERVICE CARD

Broadband Amplifier
GAIN OVER 20 DB

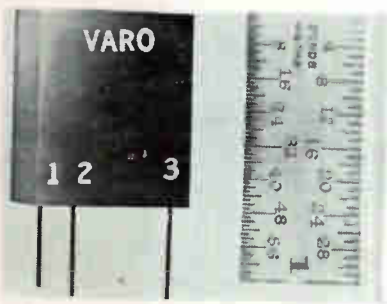
APPLIED RESEARCH INC., 76 S. Bayles Ave., Port Washington, N.Y. Model HFW-8(A)-49100 broadband amplifier covers an octave range frequencies of from 490 to 1,000 Mc. Synchronously tuned stages are used, with planar low-noise triodes as amplifiers. Gain of the amplifier is greater than 20 db, and noise figure is a maximum of 10 db. Vswr input and output is 1.75.

CIRCLE 332 ON READER SERVICE CARD

Terminating Device

THOMAS & BETTS CO., INC., 36 Butler St., Elizabeth, N. J. A solderless wire terminating device can be used as a multi-pin connector or terminal block, or both at the same time.

CIRCLE 333 ON READER SERVICE CARD



AGC Preamplifier
MICROCIRCUIT TYPE

VARO MFG. CO., INC., 2201 Walnut St., Garland, Texas, announces a microcircuitry preamplifier 0.1 cu in. in volume and weighing 3.5 grams. It consists of a low noise six stage audio amplifier, a d-c agc amplifier and associated agc diodes. The amplifier is encapsulated in an epoxy resin to form a rugged solid package measuring 0.7 in. by 0.65 in. by 0.22 in.

CIRCLE 334 ON READER SERVICE CARD

Alkaline Batteries

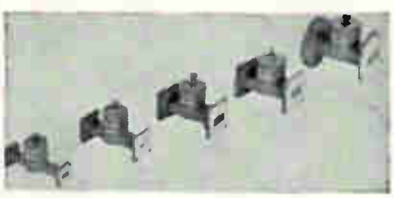
RADIO CORPORATION OF AMERICA, Electron Tube Div., 30 Rockefeller Plaza, New York 20, N. Y. Battery life is 2 to 8 times longer than the zinc-carbon type. Alkaline battery does not require a rest period.

CIRCLE 335 ON READER SERVICE CARD

Power Supply
10-KILOVOLT

FXR, INC., 25-26 50th St., Woodside 77, N. Y., offers a 10-Kv h-f regulated microwave tube power supply, model Z851-2. Output voltage can be precision set from 0 to 10 Kv, and current range is 0 to 100 ma. Ripple content is 0.4 percent max. An adjustable overload relay provides precision protection of a wide range and variety of components. Overload activation current is manually set within the range 25 ma to 100 ma. Price is $3,500.

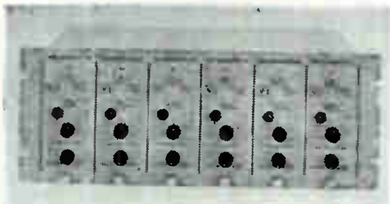
CIRCLE 336 ON READER SERVICE CARD



Shorting Switches
PLUNGER TYPE

WAVELINE INC., Caldwell, N. J., announces hand operated plunger type on/off switches that provide a convenient means of establishing a removable short in waveguide transmission systems. Series of eight separate switches have been designed to operate over the frequency range of 2,600 to 40,000 Mc with the following characteristics: vswr in the open position of 1.02 maximum; vswr in the closed or short position of 125 minimum.

CIRCLE 337 ON READER SERVICE CARD



Amplifier
DIFFERENTIAL TYPE

VIDEO INSTRUMENTS CO., INC., 3002 Pennsylvania Ave., Santa Monica, Calif. Model 602 chopper-stabilized differential amplifier has fully isolated input and output. Common mode rejection is 100,000,000:1 at d-c, 1,000,000:1 at 60 cps, even with a 10,000 ohm unbalance in the line. Zero stability is better than 0.05 percent of full scale for 1,000 hr. Output characteristics: $\pm$ 10 v at 200 ma into a 50-ohm load, and the output can tolerate capacitive loading up to 10 μf without going into oscillation.

CIRCLE 338 ON READER SERVICE CARD

Power Supplies

POWER SOURCES INC., Burlington, Mass. Low voltage, transistor regulated power supplies are available.

CIRCLE 339 ON READER SERVICE CARD

Vernier Pot
SIMPLE TO USE

MUIRHEAD INSTRUMENTS, INC., 441 Lexington Ave., New York 17, N. Y. The P.10 precision vernier pot can make measurements of emf, over the range 1 μv to 1.8 v, to an accuracy of 1 part in 100,000 of the 1 v setting. Standardization is effected by balancing the standard cell against a built-in auxiliary divider. All terminals, studs, etc. are of copper. Price is $995.

CIRCLE 340 ON READER SERVICE CARD

Literature of

ACCELERATION SWITCHES Donner Scientific Co., a subsidiary of Systron-Donner Corp., Concord, Calif. An illustrated brochure discusses accuracy in acceleration switches aboard operational missiles.

CIRCLE 341 ON READER SERVICE CARD

TEST LEADS Angler Industries, 75-77 Winthrop St., Newark, N. J. Selection catalog offers combinations of wire, terminations, and termination colors for shielded and unshielded test leads.

CIRCLE 342 ON READER SERVICE CARD

RESISTANCE BRIDGES Kearfott Division of General Precision, Inc., Little Falls, N. J. A synchro bridge and resolver bridge described in a single catalog sheet.

CIRCLE 343 ON READER SERVICE CARD

COMPONENTS Microlab, 570 West Mount Pleasant Ave., Livingston, N. J. A catalog of microwave components, 72 pages, includes product design sections to assist in component selection.

CIRCLE 344 ON READER SERVICE CARD

TELEMETRY SWITCH Electro-Tec Corp., 10 Romanelli Ave., South Hackensack, N. J., has published a bulletin describing a microminiature 450-circuit telemetry switch.

CIRCLE 345 ON READER SERVICE CARD

RECTIFIER ASSEMBLIES General Electric Co., Rectifier Components Dept., Auburn, N. Y. Brochure covers silicon high voltage potted rectifier assemblies.

CIRCLE 346 ON READER SERVICE CARD

ACCELEROMETER B & K Instruments, Inc., 3044 West 106th St., Cleveland, O. A 28-page catalog, "Vibration Exciter Characteristics", describes the electrical and mechanical characteristics of a high frequency calibration exciter.

CIRCLE 347 ON READER SERVICE CARD

MICROLOGIC Fairchild Semiconductor, 545 Whisman Rd., Mountain View, Calif. The first element of the micrologic family of digital functional blocks, the micrologic flip-flop, is described in an 8-page brochure.

CIRCLE 348 ON READER SERVICE CARD

INDICATORS A. W. Haydon Co., 232 North Elm St., Waterbury 20, Conn., has issued a data sheet on microminiature elapsed time indicators.

CIRCLE 349 ON READER SERVICE CARD

FLUTTER Amplifier Corp. of America, 398 Broadway, New York 13, N. Y. "Flutter, Its Nature, Cause, and Avoidance" presents a study of flutter and its associated disturbances.

CIRCLE 350 ON READER SERVICE CARD

COMPUTER SELECTION Philco Corp., Computer Div., Willow Grove, Pa. A 5-page booklet deals with the proper selection of a computer system according to system analysis, specifications and design.

CIRCLE 351 ON READER SERVICE CARD

PACKAGING AMP Inc., Harrisburg, Pa., has published a booklet on three-dimensional modular packaging and interconnecting of electronic components.

CIRCLE 352 ON READER SERVICE CARD

POTENTIOMETERS Maurey Instrument Corp., 7924 S. Exchange Ave., Chicago 17, Ill. Catalog covers single turn, wire-wound precision potentiometers from ½ to 3-in. diameter.

CIRCLE 353 ON READER SERVICE CARD

TAPE INSTRUMENTATION Sangamo Electric Co., Springfield, Ill. Tape handling and precision speed control featured in booklet on magnetic tape instrumentation.

CIRCLE 354 ON READER SERVICE CARD

CRYOGENIC INSTRUMENTATION Cryogenics, Inc., Stafford, Va. Data folder contains information on equipment for the measurement of parameters such as temperatures, pressure, flow and liquid level for use in cryogenic environments. Send requests on company letterheads.

General Vacuum Corp. Relocates

GENERAL VACUUM CORP., formerly situated in East Boston, has moved to a new multistory building in Medford, Mass. The new plant is specially built for the company's activities, which include the design and manufacture of high vacuum systems. The manufacturing area includes a high-bay section equipped for assembly and test of very large systems.

The company is growing as a producer of custom engineered high vacuum systems. These systems all take advantage of the ultra-purity of high vacuum and are used by the producers and fabricators of refractory, reactive, and nuclear metals. They are also used for brazing, sintering, welding and coating many products formerly produced in controlled atmospheres.

Systems are supplied to the aerospace and electronics industries as space simulators and for special applications for manufacturing and evaluating components for missiles and rockets and for developing outer space propulsion engines.

In addition, General Vacuum through its subsidiary company, GVC Electron Heating Corp., produces special equipment for manufacturing thin film electronic circuitry, and systems for employing the heating effect of high voltage electron beams for welding, sintering, and ultrahigh temperature processing in the high purity environment of high vacuum equipment.

The new plant, with about 12,000 sq ft of manufacturing, engineering and research space, meets immediate needs, and there is a planned expansion to double the area.

DCA Establishes European Division

DYNAMICS CORP. OF AMERICA has announced establishment of a European division, with headquarters in London, and appointment of W. Allen Bridges (picture), electronics and communications specialist, to head it up as director of European operations. The move, DCA president Raymond F. Kelley said, "is directed toward a major expansion of DCA's European activities through licensing and marketing agreements and also through projected corporate acquisitions of European companies."

Bridges, who joined DCA in January, previously had been European consultant, residing in France, since 1957, to a number of American companies.

Finke Assumes New Position

HERBERT A. FINKE has been named to the new position of vice president and general manager of Bomac Laboratories Inc., Beverly, Mass. He leaves his position as director of long-range planning for Varian Associates of Palo Alto, Calif., parent company of Bomac.

Amperex Promotes Jan Bleeksma

JAN BLEEKSMA was recently appointed vice president in charge of manufacturing of Amperex Electronic Corp., Hicksville, L. I., N. Y. His former position was plant manager.

A wholly owned subsidiary of the North American Philips Co., Amperex is engaged in the research and development, manufacture and sales of electron tubes and semiconductors for defense, communications and industry.

Wiesner to Receive EIA Medal of Honor

JEROME B. WIESNER, President Kennedy's special assistant for science and technology has been named by the Electronic Industries Association board of directors for award of the 1961 EIA Medal of Honor for "distinguished service contributing to the advancement of the electronics industry."

Wiesner is the first government

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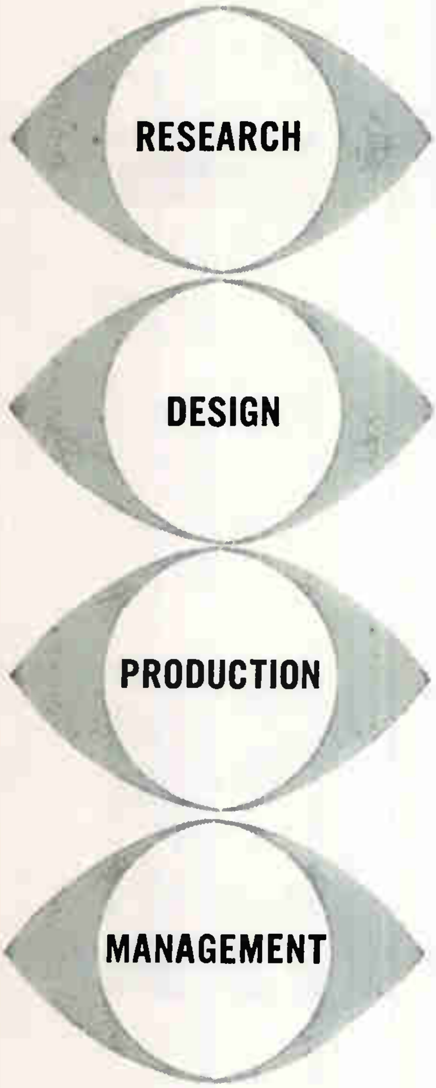

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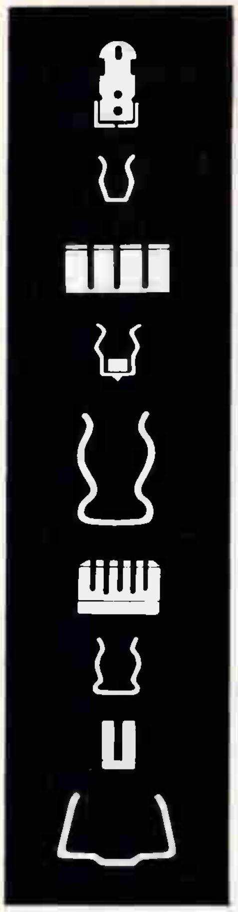

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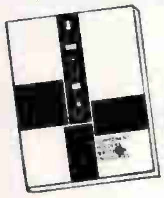

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James J. Brophy, Co-Chairman, Physics Division
Armour Research Foundation
Technology Center, Chicago 16, Illinois

official to be selected for the award since its establishment in 1952. Presentation of the medal is to be made at the association's annual convention in Chicago in May.

Metals & Controls Appoints R&D Head

JOHN ROSS has been named manager of research and development department of Metals & Controls Inc., Attleboro, Mass. Company is a corporate division of Texas Instruments Incorporated.

Since 1955 Ross has been with TI in its central research laboratory.

Shockley Transistor Hires G. D. Ewing

GERALD D. EWING has been appointed supervisor of application engineering for Shockley Transistor unit of Clevite Transistor, Palo Alto, Calif. He was most recently a transistor application engineer with Rheem Semiconductor Corp. in Mountain View, Calif.

Vitro Electronics Names Allison

DONALD M. ALLISON, JR. has been named president of Vitro Electronics, Silver Spring, Md., a division of Vitro Corp. of America. He formerly was a senior executive of Bendix Corp. located in its Washington, D. C. office.

Vitro Electronics specializes in telemetering, communications, broadcasting and photographic equipment for defense and industry.

Genisco Selects James C. Senn

GENISCO, INC., announces the appointment of James C. Senn as senior project engineer for subsidiary, Genistron, Inc., Los Angeles, Calif.

Senn, a specialist in the radio frequency interference field, was formerly with Ryan, Convair and with the U. S. Naval Civil Engineering Laboratories at Port Hueneme, Calif.

PEOPLE IN BRIEF

Raymond C. Skoe leaves Transistor Electronics to join Control Data Corp.'s Cedar Engineering Div. as product manager for digital products. **Philip H. Sayre**, formerly with Hoffman Electronics, appointed a senior consultant with MS&A, Inc. **Edgar Rafnel**, ex-Aeronca Mfg., accepts a post as senior projects engineer at Canoga Electronics Corp. **Nathan Marcuvitz** of the Polytechnic Institute of Brooklyn promoted to vice-president for research. **William K. Fortman**, formerly with General Precision, named director of project engineering for Astrosonics, Inc. **Bob McGaughey** transfers from Hoffman Electronics to Computer Measurements Co. as manager of the systems engineering dept. **William B. Snow** leaves Space Technology Labs to join the scientific staff of the Bissett-Berman Corp. **Monroe H. Postman**, ex-Philco Corp., appointed Western regional sales manager for Bryant Computer Products Div., Ex-Cell-O Corp. **Frank J. Sposato** advances at Consolidated Avionics Corp. to marketing manager for industrial products. **Louis Martin** transfers from Westinghouse to Eitel-McCullough as manager of marketing operations.

electronics

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3. Notice the key numbers.
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* This advertisement appeared in the 3/31/61 issue.

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HOME ADDRESS..

CITY.......................... ZONE...... STATE...........

HOME TELEPHONE..

Education

PROFESSIONAL DEGREE(S)..

MAJOR(S) ....

UNIVERSITY ....

DATE(S) ....

FIELDS OF EXPERIENCE (Please Check)

471

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

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RESEARCH (Applied)	......	......
SYSTEMS (New Concepts)	......	......
DEVELOPMENT (Model)	......	......
DESIGN (Product)	......	......
MANUFACTURING (Product)	......	......
FIELD (Service)	......	......
SALES (Proposals & Products)	......	......

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- Antenna & radome design
- Data link
- Navigation — doppler & inertial
- Communications
- Servomechanisms

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COMMUNICATIONS						
Multiplex Microwave	●	●	●	●		●
SSB Radio				●		●
DSB Transmitters	●		●	●	●	
Synchronous Receivers	●		●	●	●	
Data Links		●				●
DATA RECORDING & DISPLAY				●		●
Equipments		●	●	●	●	●
Advanced Techniques i.e. Thermoplastic Recording	●	●	●		●	
DEFENSE SYSTEMS — Underwater	●	●	●			
Missile Guidance & Navigation	●	●	●	●	●	●
Air Weapons Control	●	●	●	●	●	
COMPUTERS (Digital) Applications	●	●	●	●	●	●
MATERIALS & PROCESSES (Electrochemical, etc.)	●		●		●	
SEMICONDUCTORS-Circuitry, Devices	●		●	●	●	
PHYSICS (Military & Commercial Applications)						
Space	●	●	●		●	
Accoustics	●	●	●	●	●	●
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Transmitters (AM, FM & TV)			●	●	●	●
HF Video & Audio Techniques	●		●	●	●	
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Audited Paid Circulation

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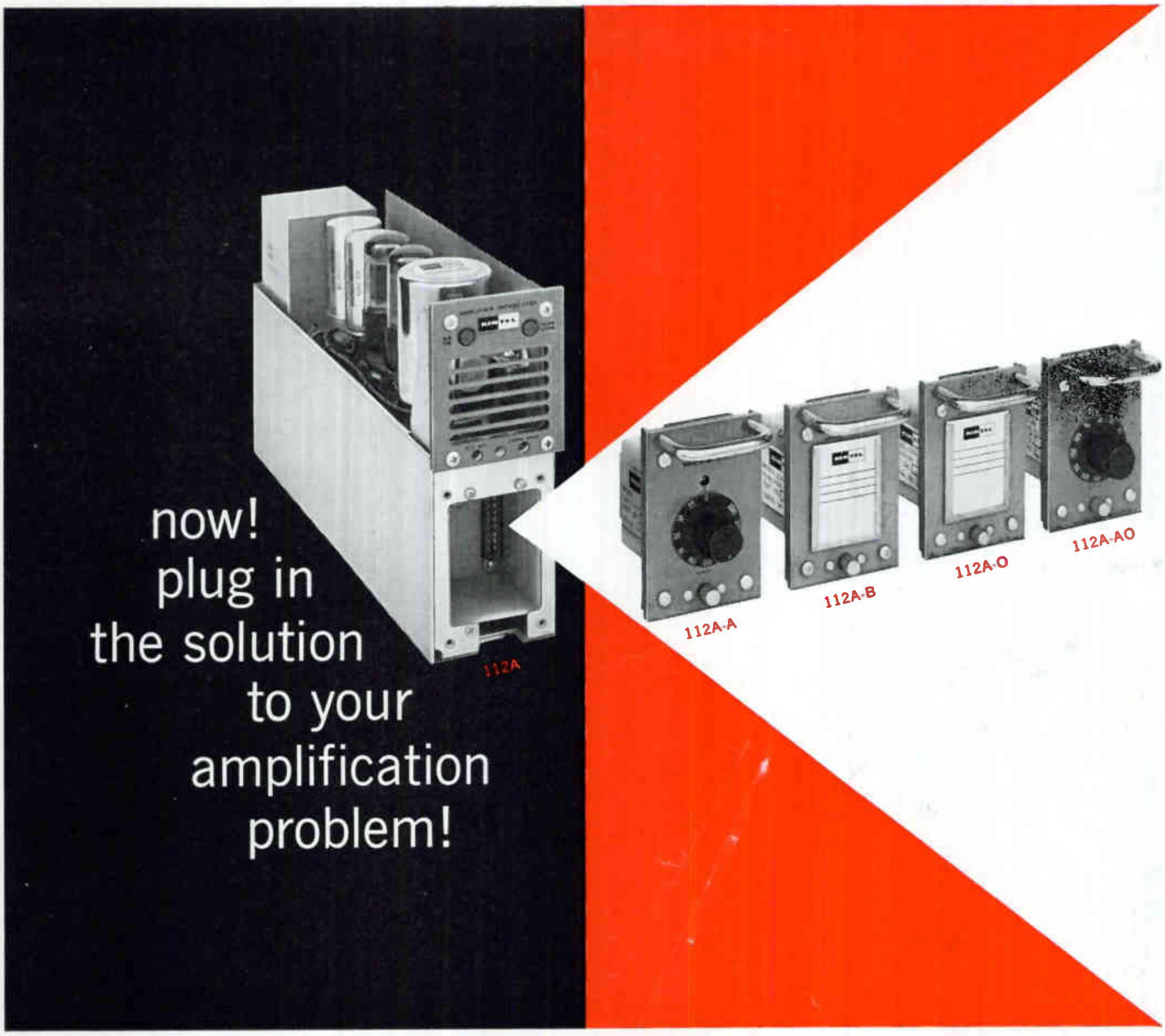

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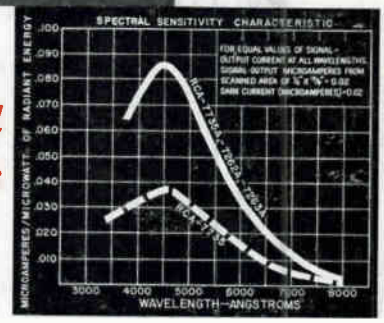

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