March 24, 1961

electronics

Navy trainer for target tracking and intelligence display combines electroluminescence and photoconductivity. *See p 31*

Video pulse compression circuit uses tunnel diodes. *See p 36*

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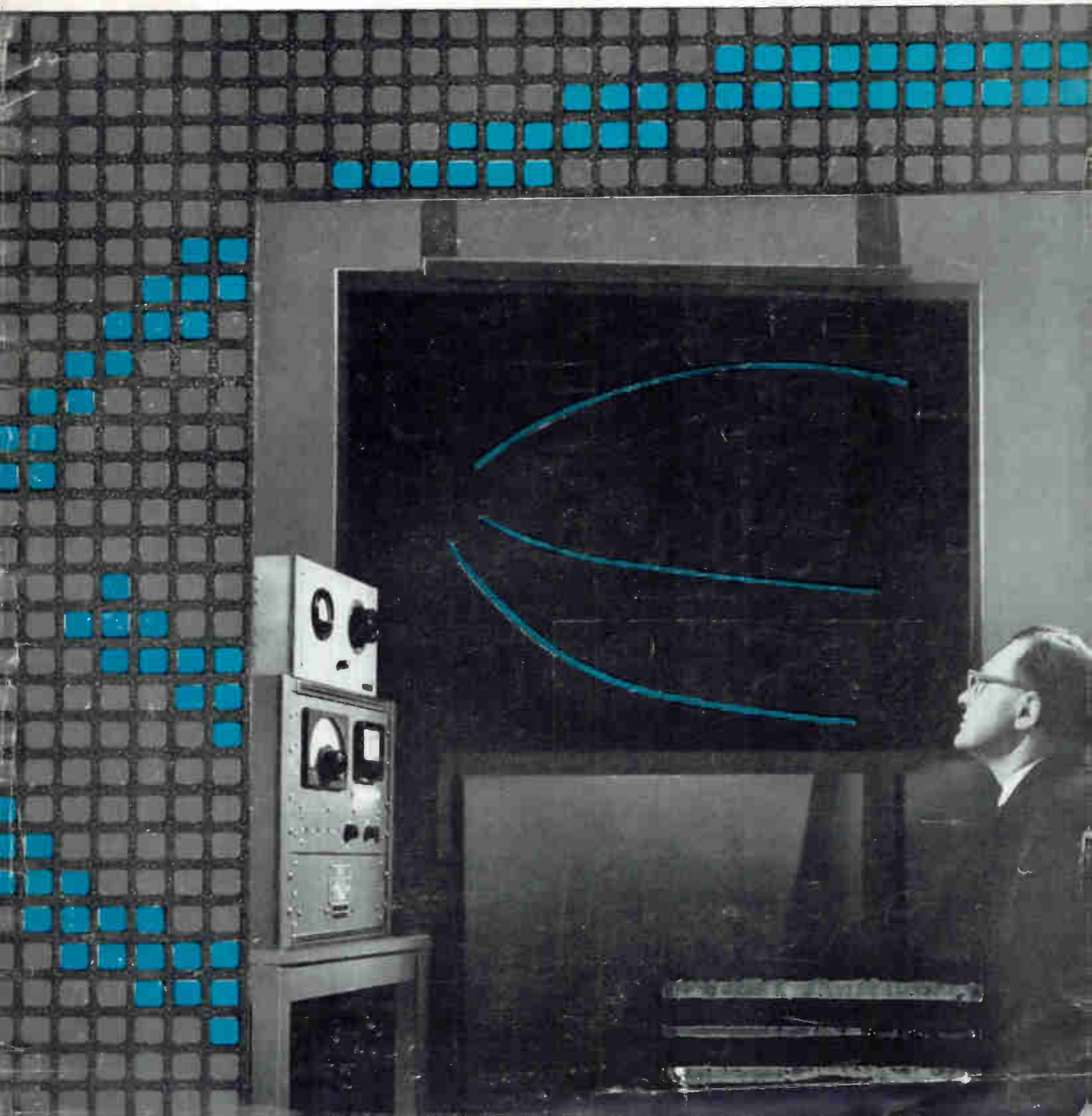

a new UHF OSCILLATOR

450 to 1050 Mc

Type 1361-A Oscillator........$285.

- Butterfly Tuning Circuit — no sliding contacts
- Frequency Scale Calibration Accuracy ±1%; constant 0.1% frequency change for each vernier division. Warm-up frequency drift is 0.2%, maximum.
- Modulation Capabilities — sine wave, square wave, or pulse from external source; 40v required to produce 30% sine-wave modulation.
- High Output — 100 mw minimum into 50-Ω load, adjustable at panel by calibrated 80-db attenuator.
- Complete Shielding, including use of ferrite-loaded filters and ceramic shaft, reduces stray fields to very low values.
- Sweep Drive Capability using G-R sweep and dial drives.
- Small Size: 8" x 7" x 8¼"; only 7 lbs.
- Power Supply Recommended: 1201-A Regulated Power Supply $85, for cw; 1263-B Amplitude Regulating Power Supply $355, for constant output level; 1264-A Modulating Power Supply (below).

Type 1361-A Oscillator and Type 1264-A Modulating Power Supply conveniently mount in a relay rack with Adaptor Plates, Type 480-P-416, $6.

NEW MODULATING POWER SUPPLY

. . . for high-level pulse and square-wave modulation of Vhf-Uhf Unit Oscillators.

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INPUT: 115v or 230v, 50-1000 cps, 85 watts
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12 Other Unit Oscillators Cover the Range from 20 cps to 7,425 Mc

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March 24, 1961

electronics

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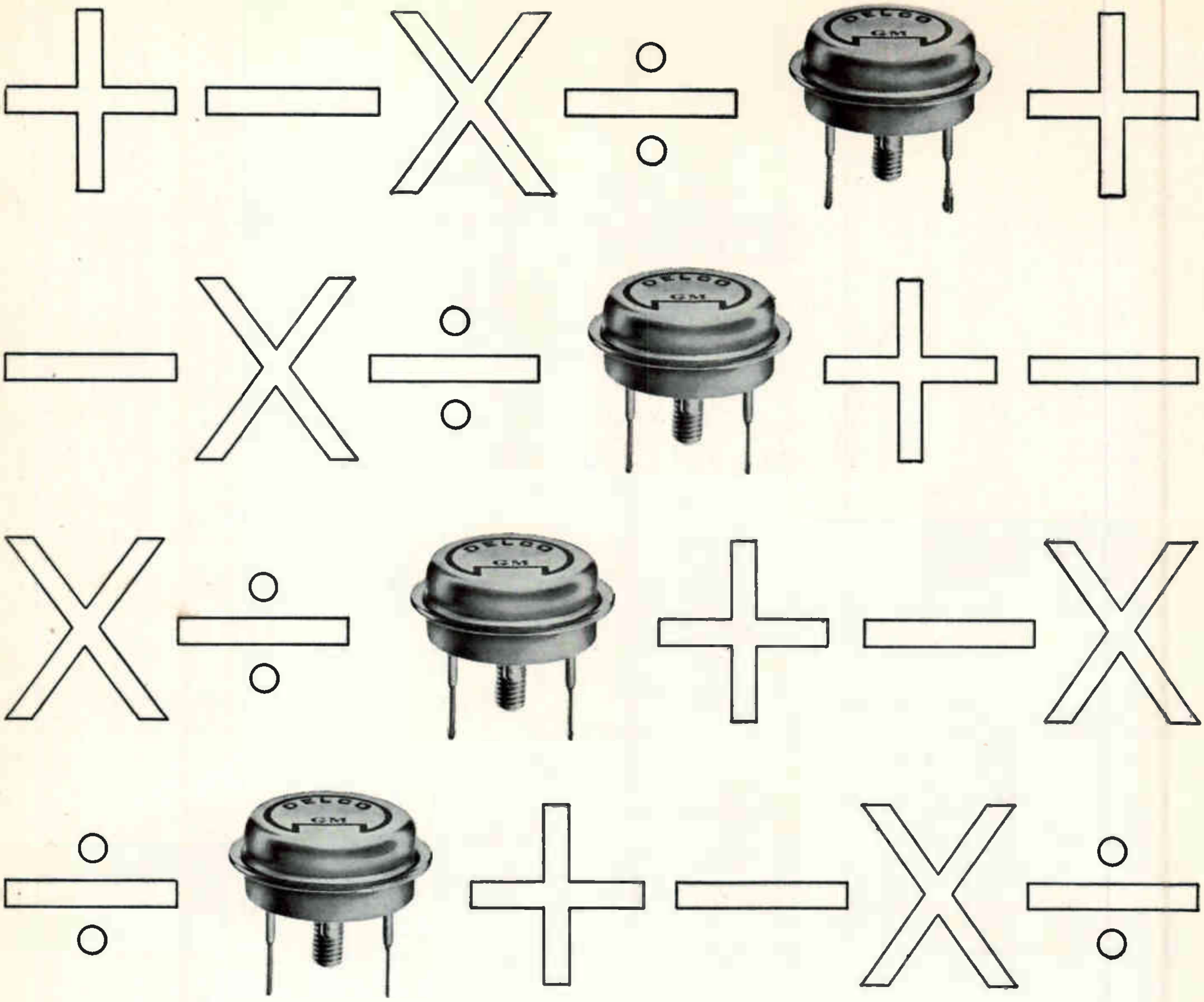
W. W. MacDONALD, Editor

BUSINESS

ENGINEERING

DEPARTMENTS



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by IBM, UNIVAC,® BURROUGHS, NATIONAL CASH REGISTER

Since Delco Radio produced its first power transistors over five years ago, no transistors have undergone a more intensive testing program to assure reliability—which accounts for their popular acceptance in hundreds of industrial and military uses. Before leaving our laboratories, Delco transistors must pass numerous electrical and environmental tests both before and after aging. This double testing, combined with five years of manufacturing refinements, enables us to mass produce any type of power transistors with consistent uniformity. And we can supply them to you quickly in any quantity at a low price. For complete information or technical assistance on our versatile application-proved family of transistors, just write or call our nearest sales office or distributor.

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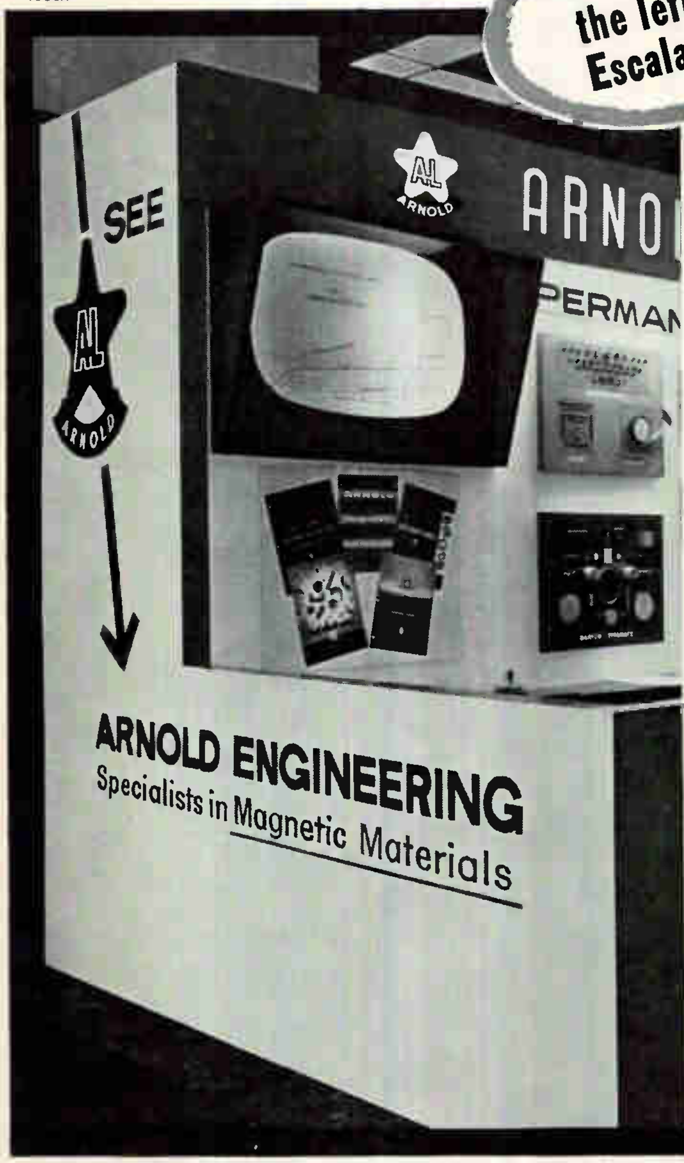

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CIRCLE 3 ON READER SERVICE CARD

electronics
Mar. 24, 1961 Volume 34 Number 12

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CROSSTALK

POLAR PILOT. Navigating nuclear submarines under ice-cloaked regions of the Arctic is one of our Navy's important tactical problems, and the subject of an exclusive story in this week's ELECTRONICS. Sonar has proven itself the tool best able to provide continuous information to these high speed craft on the tight confines of channels clogged with downward projecting ice formations, location of icebergs, and location of open water for surfacing in ice areas. Closed-circuit underwater tv helped to correlate the data obtained, and SINS (Ship's Inertial Navigation System) has provided true heading even in the magnetically unreliable northern areas. Turn to p 18 for a technical rundown of Navy's methods under the icecap.

PARIS SYMPOSIUM. An international symposium on semiconductor devices was held recently in Paris. After it was over, one of the 1,300 participants sat back and summarized this way: "If none of the 140-odd papers presented made a big technical splash, there were nevertheless ripples of interest in just about every sector."

Many companies discussed some of the things they are doing. For instance, Compagnie Generale de Telegraphie san Fil (CSF) told of a *pnp* germanium mesa transistor, with the emitter produced by vacuum evaporation, capable of 500 mw dissipation at frequencies to 500 Mc. Siemens of Germany reported their labs have prepared gallium arsenide diodes with peak-to-valley current ratios up to 50 to 1, and have run experiments with diodes in series with transistors (see p 20).

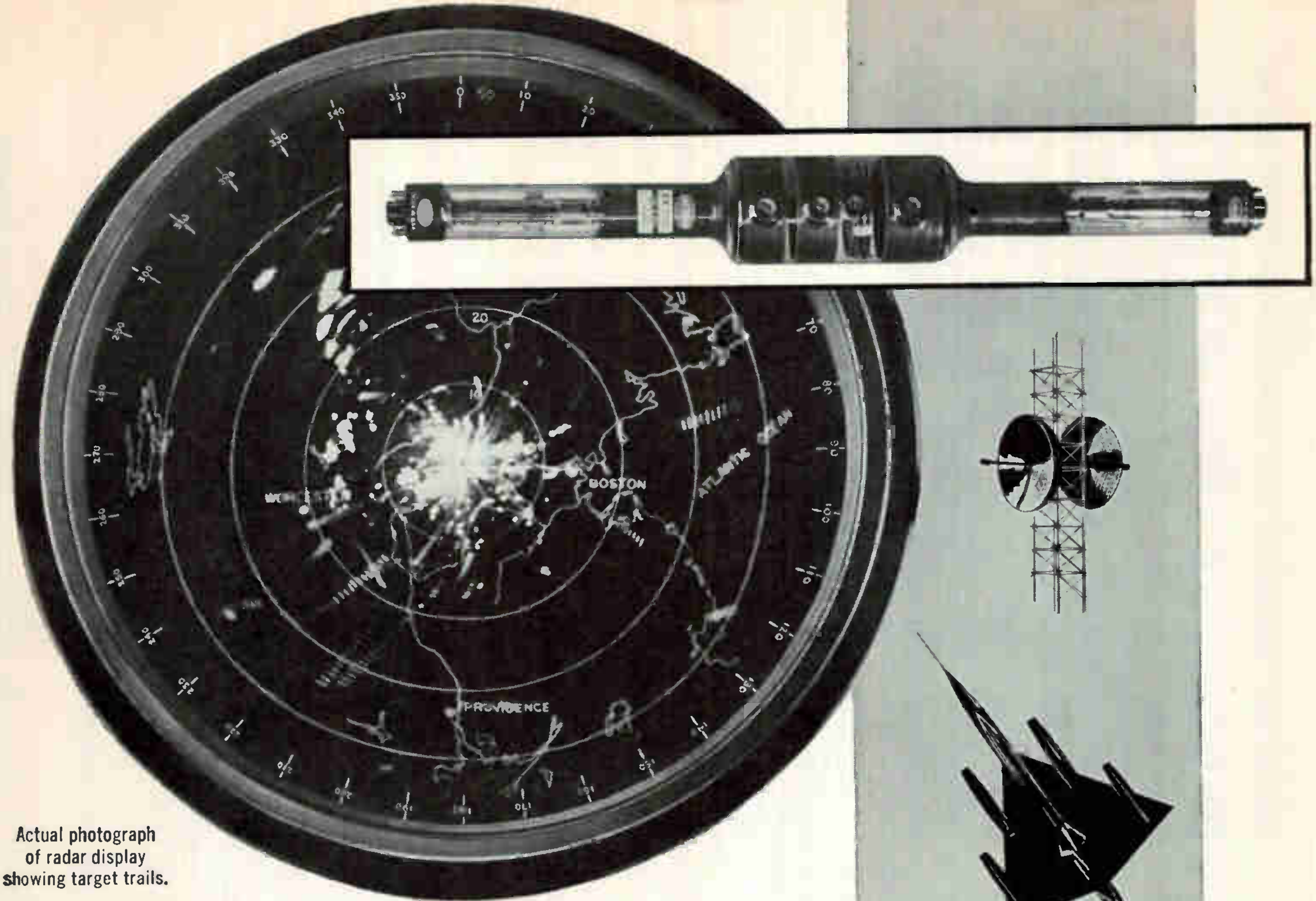
Coming In Our March 31 Issue

EPITAXIAL TRANSISTORS. Low saturation voltages, linear characteristics at low voltages and reduced storage time in switching circuits are characteristic of epitaxial transistors. The epitaxial process was discussed in a recent ELECTRONICS article (p 52, March 3); our next issue brings an article by D. Hall of Texas Instruments Incorporated in Dallas on circuit applications. Use of silicon epitaxial transistors in switching and r-f circuits is discussed.

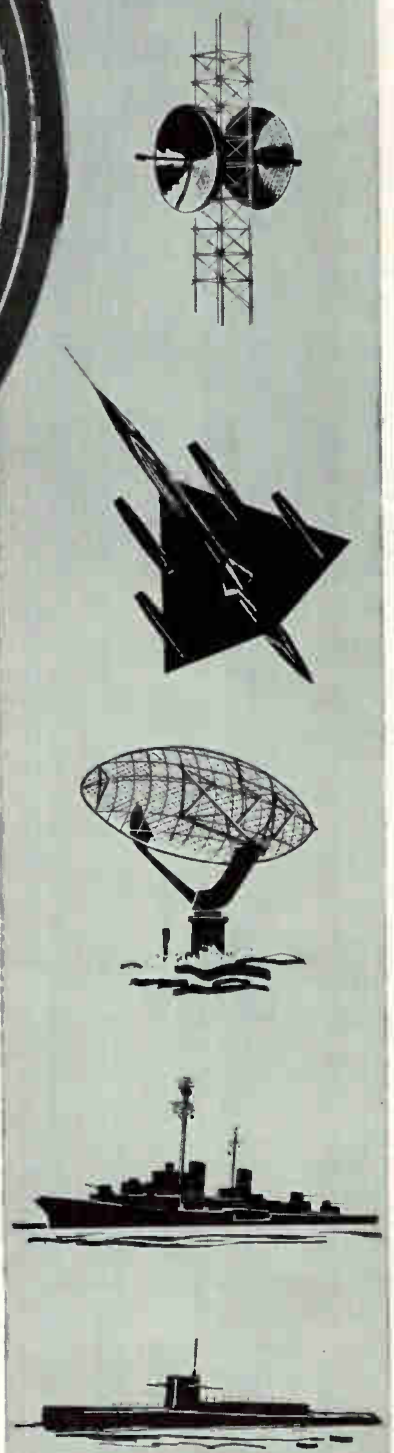
THERMOELECTRIC COOLING. In many circuit designs, thermoelectric coolers can be used for local cooling of hot transistors. Next week, J. R. Fortier of Westinghouse Electric Corp. in Youngwood, Pa. and C. S. Thompson of Magnavox Co. in Fort Wayne, Ind. discuss principles and results of using these elements on transistors operated below and above their maximum rated junction temperatures.

IN ADDITION: A variety of interesting feature material to appear next week includes: designing amplifiers with nonlinear feedback by J. C. Looney of Oregon State College; a hybrid H-guide feed for flush-mounted antennas by G. N. Voronoff of Dalmo Victor Co; and an artificial moving radar target generator by K. L. Chapman of Western Electric.

CIRCLE 5 ON READER SERVICE CARD→



Actual photograph
of radar display
showing target trails.



Raytheon Recording Storage Tubes Add Greater Capabilities to Your Radar System Designs

The advanced design features of Raytheon Recording Storage Tubes offer designers of radar systems many new application possibilities.

For example, the CK7702, a dual-gun type, is capable of simultaneous writing and reading. It has a minimum resolution of 1200 TV lines per diameter—substantially higher than the resolution available from any other tube presently on the market!

As a result, the CK7702 enables bright video display with high resolution and adjustable automatic priming which can be used to generate target trails for electronic plotting of even high speed jet aircraft. Stored signals can be held for many hours, read several thousand times, or erased in a fraction of a second if desired.

Raytheon's full line of single and dual-gun storage tubes adds greater capabilities to new equipment designs you may be contemplating, such as:

- Scan conversion for bright display and target trails.
- Slow-down video for transmissio of still pictures over telephone lin or other communication channel
- Stop motion to permit analysis o production machinery or to sto action in a sporting event.
- Signal-to-noise improvement of radar or other still pictures by integration.
- Conversion of television pictures from one transmission standard to another.
- Indication of moving targets by electronic comparison of pictures taken at different times.
- Storage of digital or analog computer data for rapid accessibility during readout.

Complete technical data can be obtained by writing to Raytheon, Industrial Components Division, 55 Chapel Street, Newton 58, Mass.

RAYTHEON COMPANY

INDUSTRIAL COMPONENTS DIVISION

RAYTHEON

COMMENT

Log-Periodic Antennas

Re.: "Broadband Log-Periodic Antennas," p 58, June 17 '60 . . .

Would you please advise us how to obtain further information on this subject? We would be particularly interested in information on typical dimensions for antenna systems for 2-15 Mc propagation over approximately a 600-mile path, with special regard to type of feeding, length of driven element, and tilt angle . . .'

C. A. GLOERSEN
FORSVARETS FELLESAMBAND
OSLO, NORWAY

The article was prepared for us by R. L. Bell of Granger Associates; a spokesman for the company replies:

For a propagation path length of approximately 600 miles (1,000 kilometers) and a virtual height of reflection of 300 kilometers, the one-hop mode propagation takeoff angle is 28 degrees. For two-hop propagation, the proper takeoff angle is 48 degrees.

Granger Associates has broadband log-periodic designs which will provide a variety of takeoff angles. One will provide constant takeoff angle radiation at 25 degrees from 5 to 30 Mc. Another provides constant radiation at 45 degrees from 4 to 30 Mc . . .

The dimensions of similar antennas for a 2-Mc operating frequency can be obtained by taking ratios of the lengths, where the length of the longest radiator is 0.52 wavelength at the lowest design operating frequency. A 2-Mc horizontally polarized log-periodic antenna is an extremely large and expensive structure. It is our opinion that for most applications, economic factors justify a 4 or 5 Mc lower cutoff frequency . . .

ROBERT W. BERG
GRANGER ASSOCIATES
PALO ALTO, CALIF.

Medical Electronics

I must congratulate you for your coverage of Medical Electronics (p 49, Jan. 20; p 46, Feb. 3; p 54, Feb. 24).

I would like to suggest that your series of articles be combined in one volume and made available to your readers . . .

H. P. HOVNANIAN
AVCO CORP.
WILMINGTON, MASS.

I am responsible for the maintenance of all the medical electronic equipment at Walter Reed Army Medical Center in Washington, D. C. I am also required to give technical assistance to the professional people at Walter Reed on electronic matters. So you can see that I have been very much interested in the articles on medical electronics in your magazine. To say I enjoyed them would be an understatement, for articles on my line of work are few and far between. I can only say, How about more in the near future?

WM. R. WIEGEL
ROCKVILLE, MD.

More coming; there will be at least two more articles in the series.

Biomedical Engineering

This refers to Academically Speaking, on p 33, Feb. 24 . . .

We here at Iowa State University are pleased to learn of the interest shown by ELECTRONICS in the biomedical engineering programs now being initiated at the University of Rochester, the University of Pennsylvania, and Johns Hopkins.

We believe you might be further interested in the biomedical electronics program at Iowa State University, which has been in operation since 1957. It has a documented history of being the first and most comprehensive of its kind in the world (it was the only one reported at the Third International Conference on Medical Electronics which met in London last July) . . .

VICTOR W. BOLTE
IOWA STATE UNIVERSITY
AMES, IOWA

NAB's Collins

Congratulations on your article on former Governor Collins of Florida (p 92, March 3). We in Florida believe that the National Association of Broadcasters' gain is Florida's loss. . . .

G. W. SODERQUIST
ASTRONAUTICS INC.
MELBOURNE, FLA.

"The definition of a farad unfortunately makes it a unit too large for general use. More convenient are the units micro-farads and micro-microfarads."

It is said that even Michael Faraday doubted if a farad could ever be realized. But then, he hadn't been exposed to the engineering and production capabilities of Sangamo . . . the first capacitor manufacturer to produce and establish standards in the production of electrolytic energy storage capacitors.

So now the "impossible"—a farad of capacitance capable of being held in one hand—has been achieved. Rated at 1½ volts, the one-half farad Sangamo Type DCM electrolytic carries the highest capacitance per unit volume in the industry. It is the product of Sangamo engineering imagination . . . the very real result of intimate product knowledge applied to quality materials and progressive production methods. It is ready for application in missiles, computers, and a wide range of power supply applications where peak power requirements exceed the maximum output of the supply. Phone near? Discuss your applications with your Sangamo Representative.

Occasionally applications call for energy-storage capacitors to meet special requirements, including higher temperature and higher ripple current. That's a good time to turn to Sangamo, where yesterday's impossibilities become capacitor facts such as this . . .

CAPACITY = ONE FARAD

EC61-1

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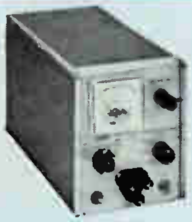
WHICH OF THESE 7 DC POWER

You want flexibility and versatility in the power supply line of highly regulated, ripple-free, temperature- current supplies, to heavy current-low voltage instruments,

NEW!

ⓗⓟ 723A, 500 ma output, 0 to 40 v. Transistorized, programmable remotely

ⓗⓟ 723A can be programmed remotely and is especially useful in systems applications where a number of measurements are made automatically at different voltages. Output voltage may be changed merely by changing the value of an external resistance, as with stepping switches for programmed tests. Low noise and ripple make the 723A particularly applicable to low level measurement. New, modular ⓗⓟ package combines compactness with rack-mount and bench-top versatility.



SPECIFICATIONS

Regulated Output:	0 to 40 v dc; 0 to 500 ma dc
Load Regulation:	< 0.1% or 2 mv (whichever is greater) change from 0 to 500 ma
Line Regulation:	< 0.05% or 5 mv for ± 10% line voltage change
Noise and Ripple:	< 200 μv
Remote Programming:	External resistance can control output voltage at rate of 25 ohms/volt
Output Impedance:	< 30 milliohms at 10 cps
Size:	6¼" x 5⅛" x 11"; 21 lbs.
Price:	$225.00

ⓗⓟ 722AR, 2 amps, 60 v output. Transistorized, easy monitoring

High regulation over complete voltage range, highly stable output. Extremely low noise and ripple insure clean measurements. High impedance remote sensing input, which connects directly to the load through wires independent from supply leads regulates the voltage at the load itself despite an IR drop in long supply leads. Separate meters measure current and voltage continuously for easy monitoring. Continuously variable control limits output current.

SPECIFICATIONS

Regulated Output:	0 to 60 v dc; 0 to 2 amps dc
Load Regulation:	< 5 mv change for 0 to 2 amps change
Line Regulation:	< 2.5 mv change for ± 10% line voltage change
Noise and Ripple:	< 250 μv
Output Impedance:	DC, < 2.5 milliohms; ac < 5 milliohms in series with 4 μh
Size:	19" x 5¼" x 12"; 34 lbs.
Price:	$525.00

ⓗⓟ 721A, 0 to 30 v, 150 ma output, versatile, only $145.00!

This ultra compact 4 pounds of power supply gives you easiest possible output voltage monitoring, with a large, easy-to-read meter, plus a four-step current limiter for positive overload protection. Several 721's may be operated in parallel or cascaded for extra flexibility.

SPECIFICATIONS

Regulated Output:	0 to 30 v dc; 0 to 150 ma
Load Regulation:	< 0.3% or 30 mv (whichever is greater) no load to full load
Line Regulation:	< ± 0.3% or 15 mv (whichever is greater) for ± 10% line voltage change
Noise and Ripple:	< 150 μv rms
Output Impedance:	< 0.2 ohms in series with 30 μh
Size:	7" x 4⅜" x 5¼"; 4 lbs.
Price:	$145.00

SUPPLIES BEST FITS YOUR NEEDS?

on your bench, and hp offers the world's most varied

stable laboratory power supplies! From high voltage-low

hp is ready to meet your requirement:

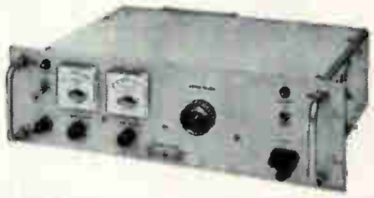
NEW!

hp 726AR, 2 amps, 45 v output. Transistorized, programmable!

This newest member of the hp transistorized power supply family provides remote programming plus the same high regulation, stable output over a wide range of line and load conditions as other instruments in the hp 720 Series. Model 726AR is especially useful for applications requiring accurate, repeatable voltages, such as component or production testing. A continuously variable current limiter protects circuits under test from accidental overload-damage. Remote sensing feature.

SPECIFICATIONS

Regulated Output:	0 to 45 v dc; 0 to 2 amps dc
Remote Programming:	External resistance can control output voltage at rate of 100 ohms/volt
Load Regulation:	< 5 mv change for 0 to 2 amps change
Line Regulation:	< 2.5 mv change for ± 10% line voltage change
Noise and Ripple:	< 250 µv
Output Impedance:	DC, < 2.5 milliohms; ac < 5 milliohms in series with 4 µh
Size:	19" x 5¼" x 12"; 34 lbs.
Price:	$500.00



PLUS THESE LAB AND FIELD-PROVED VACUUM TUBE POWER SUPPLIES

for high voltage-low current applications:

hp 711A Laboratory Power Supply	DC output 0 to 500 v, 100 ma max; ac output 6.3 v, 6 amps, or 12.6 v, 3 amps. DC regulation 0.5%.	Inexpensive, versatile high voltage, low current power supply. Metered voltage and current. hp 711A, $250.00 (cabinet); hp 711AR, $255.00 (rack mount).
hp 712B Power Supply	DC output 0 to 500 v, 200 ma max; bias supply 0 to —150 v, 5 ma max; ac output, 6.3 v, 10 amps max. Regulation 0.01% at 500 v.	High quality, high voltage supply; particularly good transient response, regulation and stability. hp 712B, $390.00 (cabinet); 712BR, $375.00 (rack mount).
hp 715A Klystron Power Supply	Beam supply —230 v to —400 v, 40 ma max; reflector supply 0 to —900 v below beam supply, 10 µa max; ac output 6.3 v, 1.3 amps. Modulation capabilities.	Klystron supply, inexpensive general purpose instrument. hp 715A, $325.00 (cabinet).

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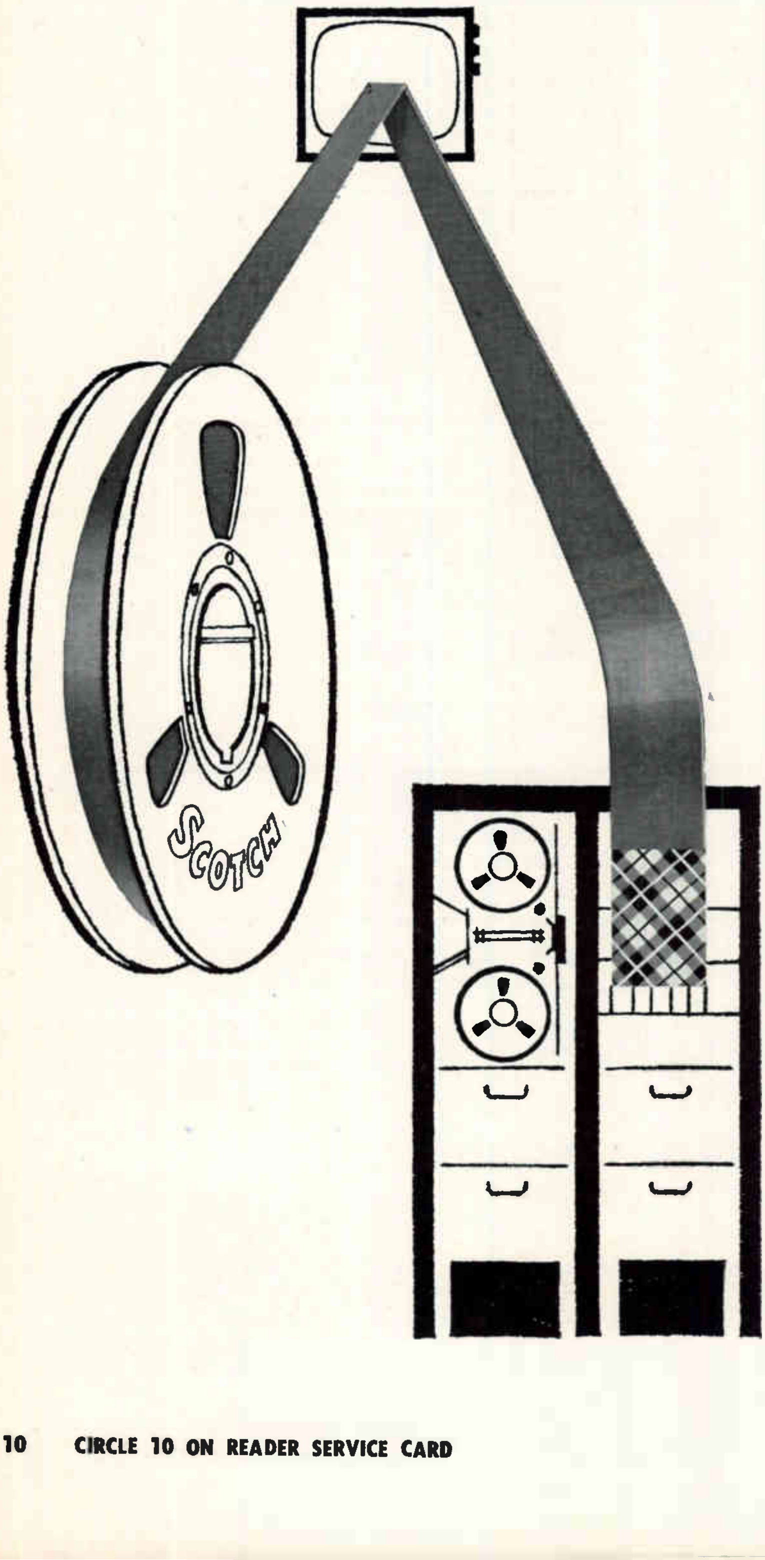
THE TAPE THAT CHANGED TV FOR ALL TIME

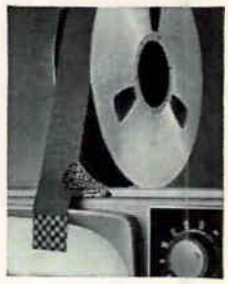
leads you right to rugged SCOTCH® BRAND Heavy Duty Tape



THE TIE that binds television's top performer to instrumentation tape is strong—and it goes beyond the fact that the same expert team produces the best of both. "SCOTCH" BRAND Heavy Duty Tapes share a common heritage—and uncommon endurance—with "SCOTCH" BRAND Video Tape, the tape that puts a network TV show on the same "clock time" from Maine to California.

Similarities worth noting between the two: a similar high-temperature binder system, famous "SCOTCH" BRAND high potency oxides, a similar ability to resist tremendous speeds, pressures and temperatures while providing high resolution.

Let's look at the record of "SCOTCH" BRAND Video Tape and see what message it has for the user of instrumentation tape. On a standard reel of video tape like that shown here, some 1½ million pulses per second must be packed to the square inch—on a total surface area equal to the size of a tennis court. The tape must provide this kind of resolution while defeating the deteriorating effects of high speeds, pressure as high as 10,000 psi and temperatures up to 250°F.



The fact is that video tape must be essentially perfect. And it's a matter of record that thus far only the 3M experts have mastered the art of making commercial quantities of video tape that consistently meet the demands of the application.

Significantly, the high-temperature binder system developed for "SCOTCH" Video Tape is first cousin, only slightly removed, to that used in the Heavy Duty Tapes. It's this special feature that has given Heavy Duty Tapes their exceptional wear life.

The moral emerges: for tape that provides the best resolution of high and low frequencies under the severest conditions, turn to "SCOTCH" BRAND Heavy Duty Tapes 198 and 199.

They offer the high temperature binder system, plus the same high quality and uniformity that distinguish all "SCOTCH" BRAND Tapes. As the most experienced tape-makers in the field, 3M research and manufacturing experts offer tape of highest uniformity—from reel to reel and within the reel. Check into the other "SCOTCH" BRAND constructions: High Resolution Tapes 158, 159 and 201; High Output Tape 128; Sandwich Tapes 188 and 189; and Standard Tapes 108 and 109.

Your 3M Representative is close at hand in all major cities. For more information, consult him or write Magnetic Products Division, 3M Co., St. Paul 6, Minnesota.

REG. U.S. PAT. OFF.

SCOTCH BRAND MAGNETIC TAPE

FOR INSTRUMENTATION

MINNESOTA MINING AND MANUFACTURING COMPANY
...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

ELECTRONICS NEWSLETTER

Two Trends At IRE Show: Digital Output, Solid State

TWO TRENDS at the IRE Show, that opened Monday in New York's Coliseum were digital output for instruments and almost universal use of solid-state components. There were digital output lights flashing all over the exhibit hall.

The Attenusuit, showed by Filtron, is a protective garment that enables personnel to work in r-f fields 10,000 times USAF safe levels.

Litton Industries displayed a klystron tube used in BMEWS. The tube is 10 ft tall, weighs 870 lb. Working about 400 Mc, it puts out 1¼ Mw peak, 75 Kw average. The firm also showed 8-mm, 30-w (c-w) floating-drift-tube klystrons made by arrangement with Elliott Bros. of England.

A 40-w thermoelectric generator was demonstrated by Westinghouse. The unit burns propane to heat hot junction to 450 C. Natural convection cools cold junction to 125 C.

The Dystac—dynamic storage analog computer—by Computer Systems Corp. has a memory, gives 500 solutions in one second.

Tung Sol showed an electronic ignition system that uses a conventional storage battery electrical distributor and sparkplug.

Texas Instruments displayed a metastable helium magnetometer that measures changes in the earth's magnetic field to one part in 5 million. Unit is unaffected by temperature or changes in orientation. Proposed consumer products using solid-state devices were shown by TI. These included: low-cost capacitance switch using one silicon controlled rectifier, one silicon transistor; home light dimmer using one; electric range control using two 25-w scr's and an electric motor control. General Electronic Control of Minneapolis plans to make the light dimmer.

Raytheon showed how new microwave tubes can form a master oscillator-power amplifier radar set that puts out 6 Mw, peak; 30 kw average at S band. Bandwidth is 200 Mc. Tube line-up includes: QK929 type-O backward-wave oscillator; a classified 1-Kw traveling-wave tube; QKW750A 100-Kw traveling-wave tube; one QKS622 Amplitron driver at 1 Mw and paralled QKS622's as output amplifiers.

Radio Tv Sales Register Severe Post-Xmas Drop

ELECTRONIC INDUSTRIES ASSOCIATION reported last week an unusually sharp post-Christmas drop in retail sales of radio and television sets. Only 580,680 radios and 399,791 television sets were sold at retail in January, compared with 803,388 and 590,867 respectively in January of 1960, and with 2,378,853 and 768,140 for the high month of December 1960.

January tube sales were mixed: tv picture tube sales rose over December's figure, with 707,835 units sold for $14,430,755. But sales of receiving tubes dropped by three quarters of a million to 26,343,000, ringing up $22,227,000 in revenue. Both sales figures are lower than January 1960 figures.

New Weather Sensors Needed For Global Forecasting

DIRECTOR of USAF's 433L program for global weather forecasting, Col. George A. Guy, points up the need for new ideas in basic weather sensing in a paper delivered at the IRE Convention this week. Most weather sensors, he says, were designed for visual reading and chart recording; translation into digital signals is awkward and expensive.

Federal Aviation Agency's automatic data-interchange system, Guy thinks, is the first major improvement in transmission since the teletypewriter. Facsimile has also demonstrated its worth. But with greater use of computers, new approaches are needed: to get sensory data directly into the computer, to get processed intelligence out in visual forms as maps and charts at local stations. Some of this equipment exists; Guy opines that much is needed.

Test Infrared Detector For Air Proximity Warning

INITIAL FLIGHT TESTS of an experimental aircraft proximity warning system using infrared detectors will be conducted soon by president A. G. B. Metcalf of Electronics Corp. of America. Metcalf is a former test pilot, thinks his firm's ir system presents an advantage over radio or radar APWs in that its effectiveness doesn't diminish as the aircraft near each other. He also points out that airborne ir systems don't need ground control, don't put out energy into the already crowded spectrum.

More Contracts Go Out For Big, Small Missiles

LARGE AND SMALL missiles continue to receive a hefty share of new funds turned loose by the Pentagon.

Air Force last week gave General Electric a $28-million incentive contract for development of the reentry vehicle for Titan II. The nose cone will have an improved shape, will be larger than Titan I reentry vehicle, will be capable of carrying a heavier payload, and will have a very quick reaction time. Martin Denver also subcontracted with Microdot Inc. for precision temperature-measuring systems for Titan II; the solid state systems will be built to operate in extreme environments.

GE also copped an additional $20 million from the Navy for Polaris fire control systems. The Mark 84 system—which will go into fleet use on the *USS Lafayette*—will make extensive use of digital computing techniques, will be more automatic than its predecessor Mark 80.

Army awarded a $5.4-million contract to Ford Motor's Aeronutronics division to continue work on the antitank Shillelagh. The vehicle-mounted missile is still under tight security wraps.

Bendix received $1.3 million in follow-on orders from the Navy for continued production of Terrier guidance systems.

In other developments last week, Martin Orlando put the inertial guidance system for the Mace B missile through its paces at Cape

Canaveral. The bird flew an evasive path following changes fed to it during flight. Guidance system was built by AC Spark Plug.

Electronic Specialty Co. received orders totaling $5 million for electrical and electronic gear for USAF's F-104 Starfighter. Hoffman Electronics got a $1.25-million contract for AN/WRT-4 submarine radio transmitters from the Navy. And the Air Force asked Electro Nuclear Systems to develop a special high-performance magnetic drum using advanced miniature design.

Sonic Height Sensor Developed for Hydrofoils

ULTRASONIC sensor for measuring the changing height of waves from crest to trough has been developed by RCA's missile electronics and controls division. The transitor device, now undergoing field tests, can be used to control and autopilot hydrofoil boats and hover (air-cushion) craft on or over heavy seas. RCA also figures the device can be used on seaplanes for landing control, and by oceanographers for sea-state measurement.

Portable Tv Sets Use Multifunction Tubes

PORTABLE TELEVISION sets introduced last Friday by Admiral make use of GE Compactron tubes. Each set uses one of the multifunction components, a triple triode (one medium-μ, two-high-μ, equivalent to a 12AU7 and two 12AX7s). Only transistors used in the new Admiral sets are in the remote tuning units.

Seated height of the Compactron is 1.5 in. Each of the three cathodes, grids and plates has its own pin connection (the device has a duodenary base). Typical operation puts 250 v on the plate; the medium-μ section dissipates about 2.75 w, the other two about a watt apiece.

Toshiba in Japan also recently announced portable television sets in which all-tube construction was used.

Suggest Rocket Exhaust As Spacecraft Antenna

ENGINEERS at ITT's Federal Labs this week are proposing a plan to use the exhaust gases from rocket and jet engines as antennas for radio communications between spacecraft. The ionized trails are electrical conductors, could conceivably operate as end-fed antennas. Length of the exhaust trail from a rocket is great enough to permit communication on low- and medium-frequency bands, normally not feasible because of the size of the antenna gear. Proposal arose from a study contract awarded ITT by Office of Naval Research.

Airborne Atomic Clock Developed for Air Force

ATOMIC CLOCK whose maximum error would not exceed a second in 1,271 years has been developed for the Air Force by the National Company. The device weighs 62.5 lb, is meant to replace numerous crystal oscillators used as frequency and time standards for navigation, guidance, fire-control, computing, and so forth (National estimates some 600 lb worth). Primary-standard airborne Atomichron uses the cesium atom as reference for frequency, has been simplified to the point where only an on-off switch is needed for control. Company spokesmen figure it will become operational next year.

Japanese Form Institute For Semiconductor Study

SIXTEEN Japanese electronics firms last week joined with academic sponsors to set up a research institute to do basic research in electronics generally and semiconductors in particular.

Institute is headed by Yasushi Watanabe, professor-emeritus of state-owned Tohoku University, Sendai; and Tomohiko Takano, also a Tohoku professor. The $149,000 plant that will initially house the institute will be built near Sendai; Tohoku professors will supervise research projects. Member firms will contribute scientists and engineers, will send some men for training.

Tv Travels Both Ways On Single Cable

TRANSMISSION ENGINEERING firm Entro Inc. has been issued a patent for a bilateral video transmission system which can send tv signals both ways on a single cable. Designer H. M. Diambra, president of Entron, proposes the system for closed-circuit educational and industrial tv systems, where it would eliminate a return cable if two-way conversations were required.

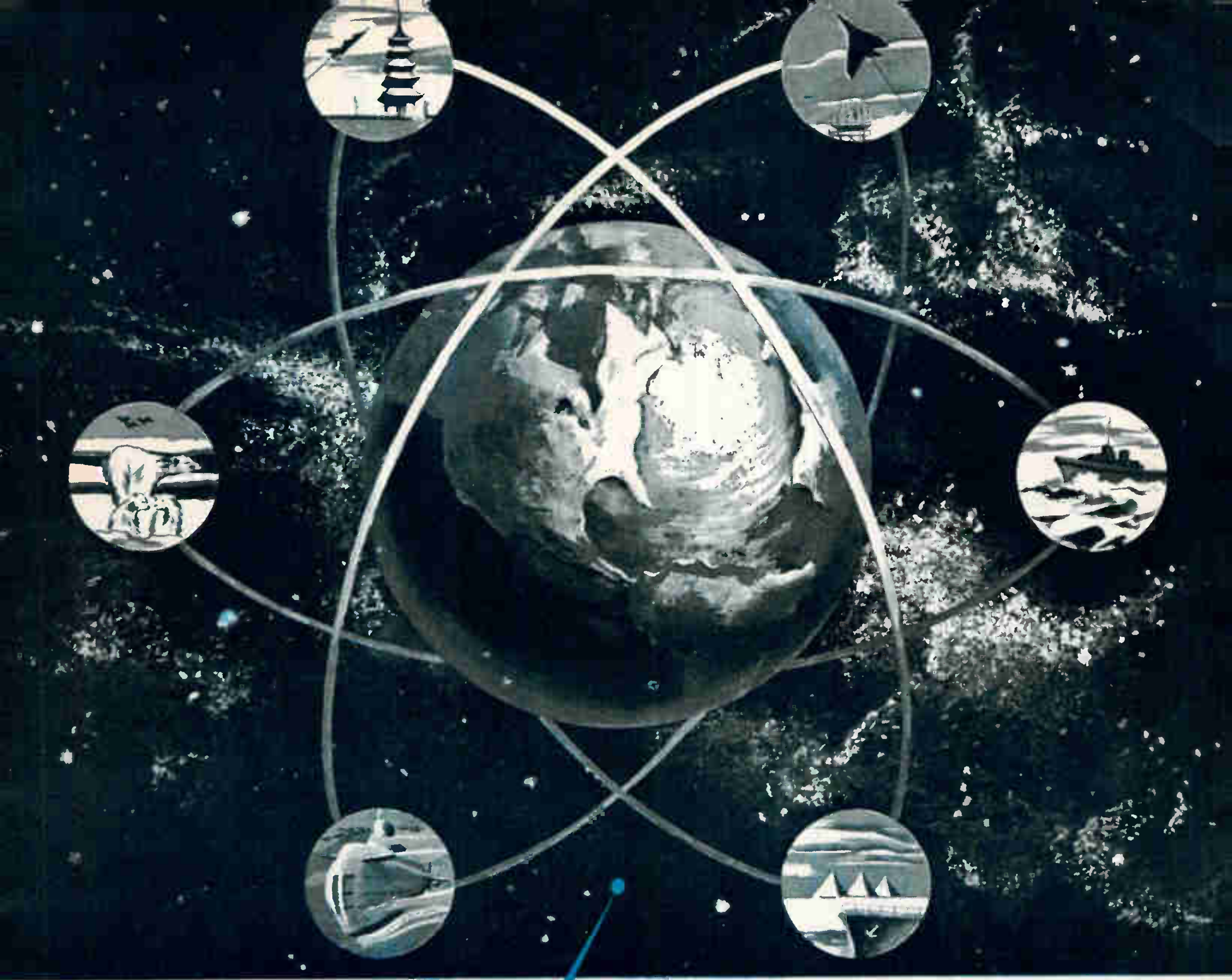
System uses coaxial cable, has 30-Mc bandwidth in simultaneous two-way transmission, can be switched over to one-way service at 60 Mc-bandwidth.

Epitaxial Silicon Mesa Switches in 46 Nanosec

COMBINED ADVANTAGES of mesa construction and epitaxial fabrication techniques have produced a silicon transitor with maximum turn-on time of 16 nsec and turn-off time of 30 nsec. Unit was announced last week by Sylvania. Saturation voltage is low, 0.16 v max at I_c of 10 ma, I_B of 1 ma. Sylvania prices the transitors at $15 apiece in lots of 100 or more.

Small Producers Ask Federal Risk Indemnity

SMALL BUSINESS COMMITTEE of Electronic Industries Association last Wednesday decided to press for Congressional action on legislation to indemnify defense manufacturers against uninsurable claims resulting from missile and rocket accidents. Electronic component manufacturers could now be held liable for damages caused by test rockets in accidents. R&D defense contractors are protected by law against such liability, but production contractors are not.



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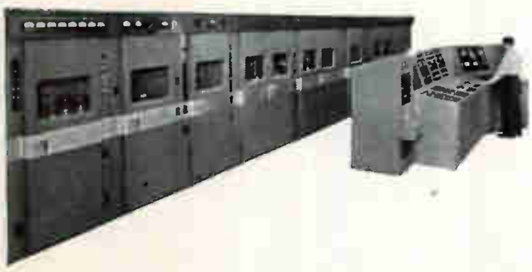
Two million watts will blast the U. S. Navy's radio signal anywhere in the world . . . even to a submerged submarine on the other side of the earth!

This new 2,000,000 watt VLF transmitter being built by Continental Electronics will be the most powerful in the world. With this transmitter the Navy can communicate dependably with any spot on earth. It is being built by the specialists in b-i-g power transmitting equipment.* Again, the Navy knows it is getting the very best available — another Continental Electronics transmitter.



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WASHINGTON OUTLOOK

DEFENSE PLANNING FORUM on limited-war requirements, which was part of the Electronic Industries Association spring conference last week, attracted some 500 industry people representing 250 companies. They heard defense spokesmen point up growing needs for tactical communications, combat surveillance and target-location equipment, and command and control gear.

Secretary of the Army Elvis J. Stahr pointed out the U. S. is "much more likely" to be involved in a limited war than in all-out nuclear conflict. But the experts spoke in very general terms. The White House has yet to spell out in detail the effect on the Pentagon budget of the latest shift in defense policy, which places a greater emphasis on limited-war preparedness (see ELECTRONICS, p 14, Mar. 3).

The question of spending for limited-war forces is complicated by the Pentagon's inability to break down its budget in terms of missions. There is no hard and fast measure of how much is to be spent for defense on a limited-war scale as compared with nuclear deterrent forces, although Charles Hitch, the new Defense Department comptroller, suggests that the budget should be outlined in such terms.

Right now the best estimate is based on these figures: roughly 35 percent of defense spending is earmarked for procurement, research and development, construction, and operation and maintenance costs of Strategic Air Command and North American Air Defense Command, plus the Navy's Polaris fleet. These are forces exclusively geared to the problems of defense and retaliation against nuclear attack.

Theoretically at least, the remaining 65 percent of military spending is devoted to limited-war readiness. But many experts, particularly those who plump for more limited-war defense, say these figures give a distorted view.

Army and Marine Corps procurement is already on the rise. Former President Eisenhower's fiscal 1962 budget sets aside $1.8 billion for Army contracts, $210 million more than this fiscal year; and $159 million for Marine Corps purchasing, a $22-million increase. Kennedy is expected to increase these sums alone by at least 12 percent.

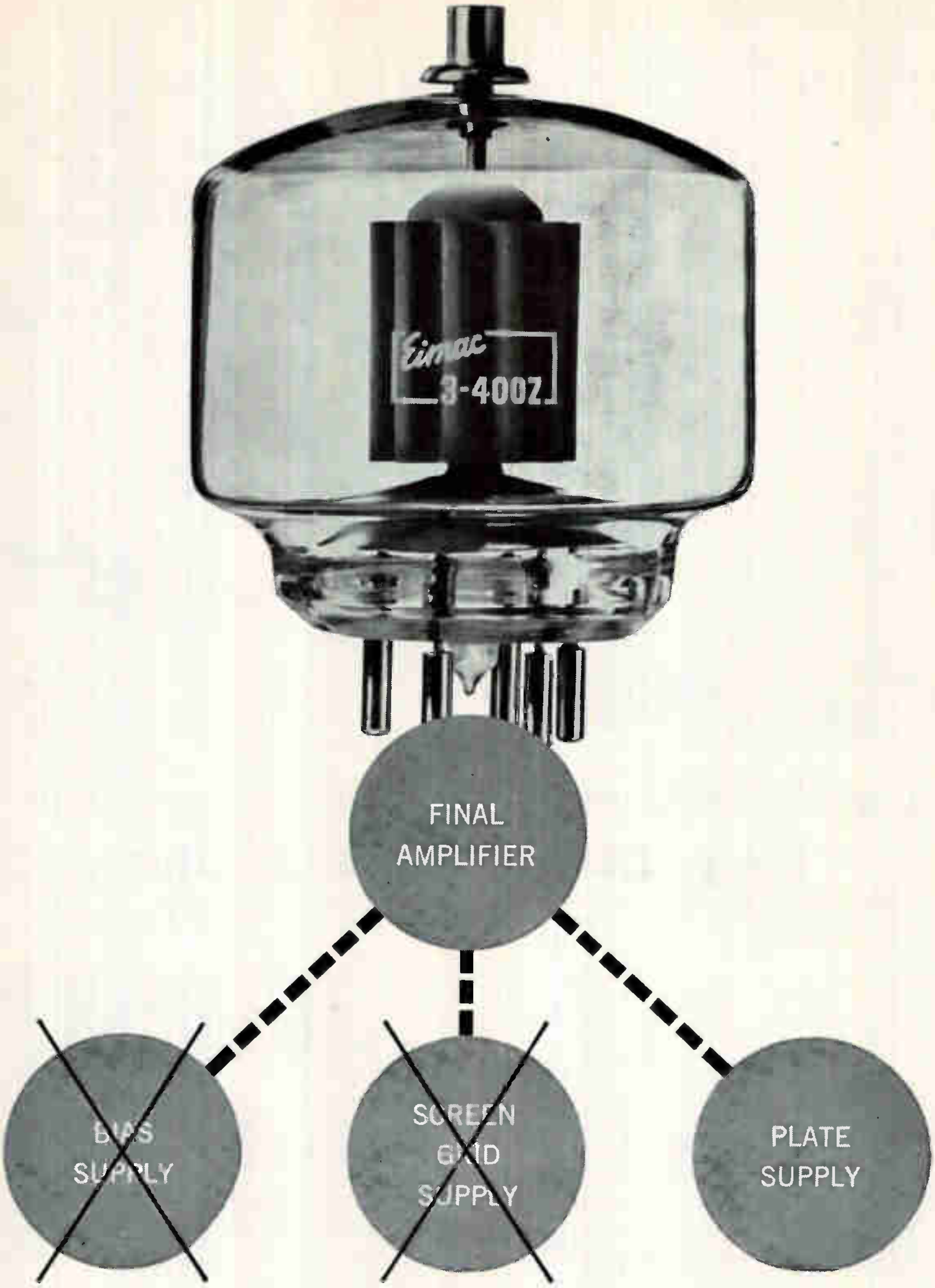
COMMERCE SECRETARY Luther Hodges has temporarily averted a threatened labor boycott of imported radio and tv parts in the Chicago area. He met with M. F. Darling, president of Chicago Local 1301 of the International Brotherhood of Electrical Workers, promised him to make a study of import problems. Darling's 23,000-member local had earlier threatened to refuse to handle foreign-made parts after May 1; on Hodges' urging, he agreed to postpone action until at least Aug. 1.

The union wants a tariff wall erected to guard against electronic parts made by foreign workers. Darling urged that imports be allowed only of goods produced by workers receiving an amount equivalent to the U. S. minimum wage. If tariff action cannot be taken, Darling proposed a requirement that radio and tv sets be marked to indicate manufacture in foreign countries or inclusion of foreign-made parts.

ARMED SERVICES COMMITTEE of the House has renewed its drive to increase the amount of advertised military procurement and cut negotiated contracting, and to put the lid on excessive cost estimates and profit allowances in incentive-type defense contracts.

Rep. F. Edward Hebert (D., La.), chairman of the group's investigations subcommittee, has introduced a bill to plug a major loophole in the law which allows negotiated contracting. Rep. Carl Vinson (D., Ga.), who is chairman of the overall committee, has unsuccessfully introduced similar bills in previous years.

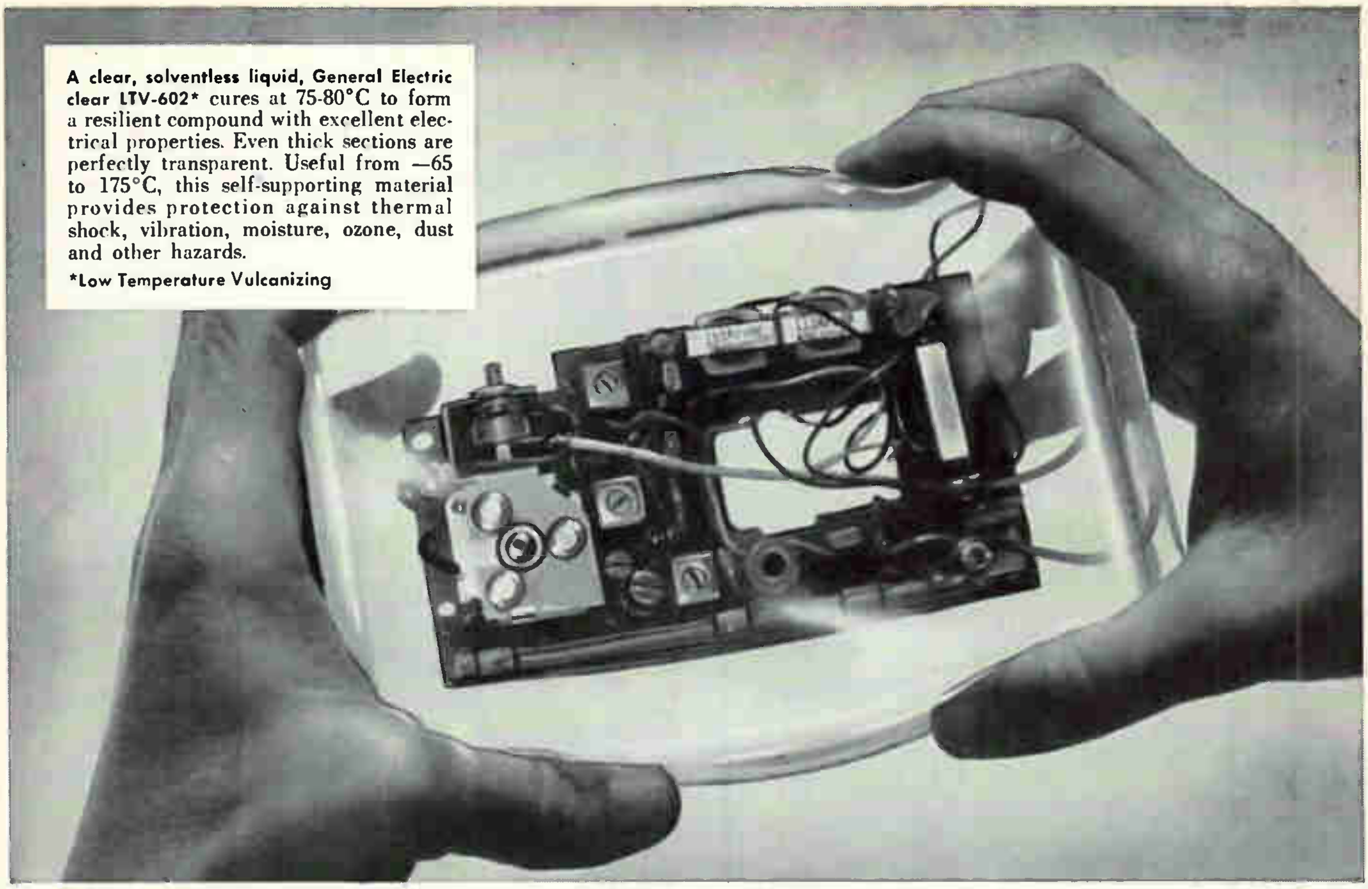
Two other provisions in Hebert's bill would provide for readjustment of target prices in incentive-type fixed-price contracts before final settlement with contractors; and push for greater competition in negotiated contracts by requiring the military to consult with all companies asked to make a proposal before final approval of the contract award.



Cross off two power supplies with one of Eimac's new zero-bias triodes!

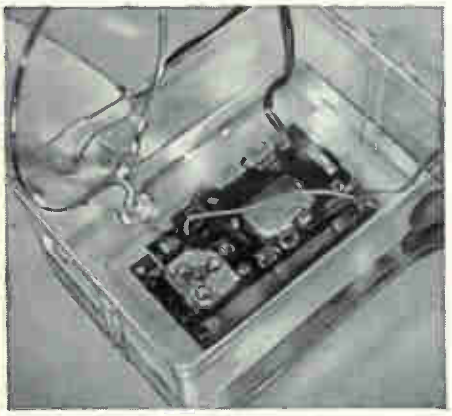
Another major advance from Eimac: the first high power zero-bias triodes anywhere. Just one of these new tubes will eliminate *both* screen grid and bias power supplies to simplify your circuit designs. Take your pick of the 3-400Z, shown above actual size, (plate dissipation: 400 watts) ... the 3-1000Z (1000 watt plate dissipation) ... the ceramic-metal 3CX10,000A7 (10,000 watt plate dissipation). Each offers a power gain of over *twenty times* in grounded grid service. And their small size accommodates today's lower, more compact equipment. You'll find these zero-bias triodes ideal for class B RF and audio amplifiers. And you'll find them *only* at Eimac... world leader in transmitting tubes. For ratings, specifications, other details, write: Power Tube Marketing, Eitel-McCullough, Inc., San Carlos, California.

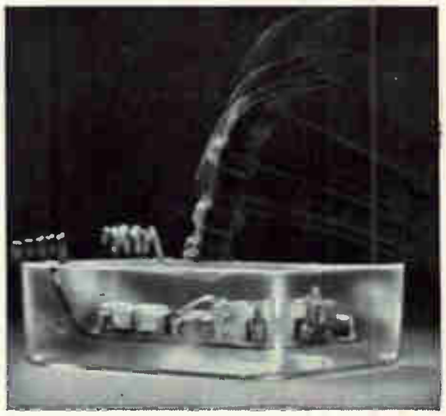
Eimac



General Electric clear LTV silicone compound for potting and embedding

Transparent, resilient, self-supporting and easy to repair





LTV-602 is easily applied, flows freely in-and-around complicated parts. Having a low viscosity in the uncured state, 800-1500 centipoise, LTV is ideal for potting and embedding of electronic assemblies. Unlike "gel-like" potting materials, LTV-602 cures to a flexible solid. Oven cure is overnight, or from 6 to 8 hours at 75 to 80°C.

LTV-602 is easy to work with and easy to repair. To repair parts embedded in LTV, merely cut out and remove section of material, repair or replace defective part, pour fresh LTV into opening and cure. Pot life, with catalyst added, is approximately 8 hours and may be extended with refrigeration. When desirable, LTV may also be cured at room temperature.

Resiliency offers excellent shock resistance. LTV-602 easily meets thermal shock tests described in MIL-STD-202A test condition B which specifies five temperature cycles from —65 to 125°C. Tests indicate that LTV retains protective properties even after 1800 hours aging at 175°C. Other tests confirm LTV's resistance to moisture and water immersion.

LTV-602 is the newest addition to the broad line of G-E silicone potting and encapsulating materials which also include the RTV silicone rubbers. For more information, write to General Electric Company, Silicone Products Department, Section N340, Waterford, New York.

GENERAL ELECTRIC

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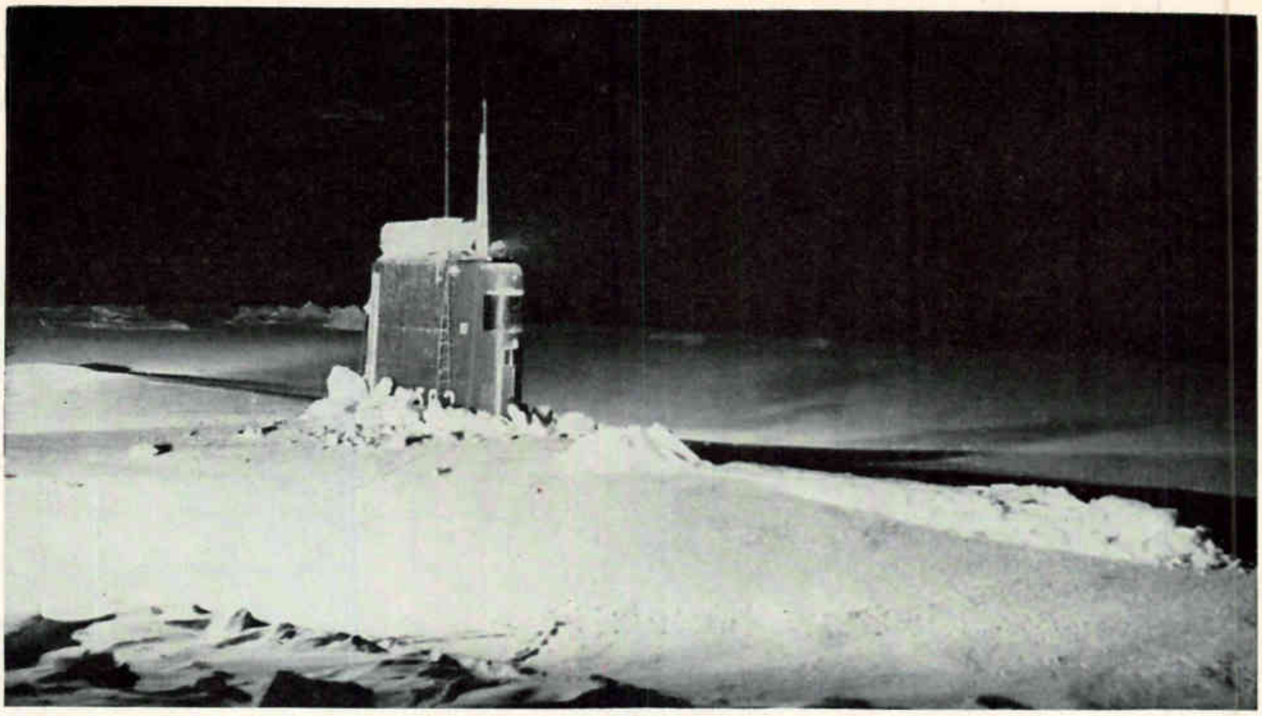


Nuclear submarines use sonar, underwater tv, inertial navigation, radar, to navigate Arctic waters. The Sargo, *at the North Pole, surfaced through ice*

SONAR GUIDES SUBMARINES

NAVY'S OPERATION of nuclear submarines while submerged under polar ice is now routine, with sonar and other electronic aids providing ability to avoid downward projecting ice formations and icebergs in open water.

The *Seadragon*, in its 8,000 mile Atlantic to Pacific under-the-ice-cap trip used specialized sonar instruments, underwater tv and inertial navigation gear in achieving a modern Northwest passage.

Sonar gave continuous information on: overhead ice thickness, sub-to-ice distance, sub-to-bottom distance, location of holes in the ice (called polynyas), details of polynya outline ridges to allow surfacing, and also provided continuous spotting of icebergs.

The Navy has said that with this recent voyage the Arctic was made just another sea, allowing nuclear subs to operate in such waters at any time. Surfacing in up to three feet of ice is now standard, cruising at high speeds in iceberg clogged waters can be done with sonar eyes picking out clear lanes.

Waldo Lyon of Naval Electronics Laboratory, San Diego, California was senior scientist for the trip. NEL developed the prototype versions of specialized sonar equipment used, tested them on previous Arctic trips by nuclear subs.

Arthur Roshon led a group at NEL that did pioneering work on iceberg detector design. The approach grew out of early mine detector work.

For the *Seadragon's* trip they supplied a sonar designed to automatically calculate and continuously indicate overhead ice thickness. Sounding the underside of the ice, and taking a depth gage reading of the level of submarine submersion, and subtracting the two gives ice thickness. The fact that ice is a poor conductor of sound, and that the depth gage treats ice as water when registering allows this technique to be used.

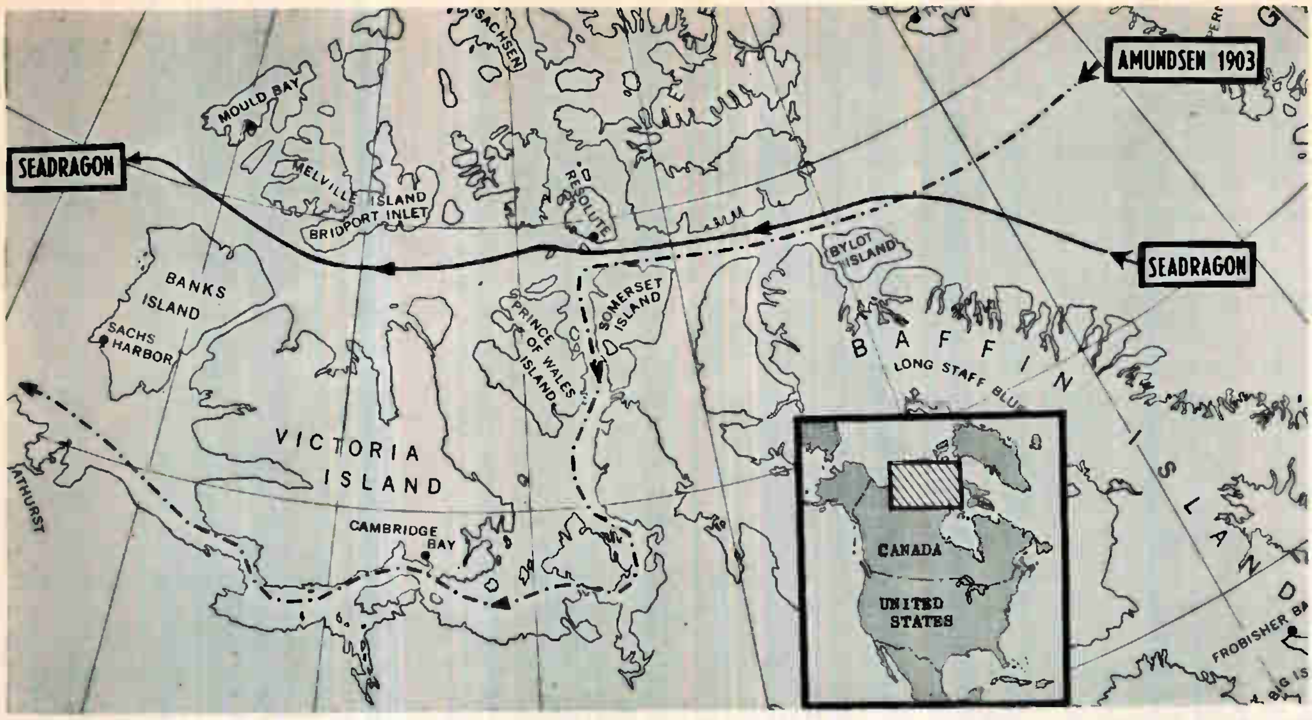
Sonar instruments, designed for specific purposes, were supplied for the *Seadragon's* voyage by EDO Corp., College Point, N. Y. The firm sent engineer Jonathan Schere along as technical advisor. He reported all instruments operated well, gathered data for an integrated sonar system planned for future installations.

Included was a bottom sounding sonar, type AN/UQN-1 with a 6,000 fathom range, using a broad beam to ensure bottom return during pitch and roll of the submarine.

A high accuracy, look-up sonar, type BQN-4A, gave distance to the underside of the ice when submerged. During a vertical rise in surfacing through a hole in the ice (polynya) overhead conditions of the sub were monitored at all times. Instrument range is 230 yd, accuracy is ½ percent of scale.

To determine outline of polynyas, for surfacing information, a special sonar, type BQS-7 was used. Called a polynya delineator, it directed a beam at an angle toward the underside of the ice, defining the outline of the pressure ridges formed when a hole is created.

Iceberg detecting sonar with direct reading display and high defi-



Route of the Seadragon *in 1960 in opening a direct Northwest Passage, a Navy first made routine by electronic aids. Passage in 1903 was first to be completed by a ship*

UNDER POLAR ICE

By LEON H. DULBERGER, Assistant Editor

nition, of special design, was carried. Icebergs are infrequent in the Arctic, the *Seadragon* encountered many in cruising off the west coast of Greenland. Definition and display were accurate enough to allow near-full cruising speed of fifteen knots to be maintained in iceberg fields.

A high sensitivity sonar listening system covering the low frequency spectrum was used as a passive listener. Various filters allow use in several modes of operation.

Sangamo Electric Co. supplied a standard SQS-4 echo ranging sonar for submarine detection.

A television system of extreme sensitivity, type BQX-1, with wide field camera mounted on forward deck, receiver in the control center, provided high definition undersea images of ice fragments when surfacing; helped to correlate sonar data. The system employs an image orthicon and electronic light amplifier; was designed and built by Bendix Corp., Friez div., Towson, Md. Bandwidth is 18 Mc, scene illumination of 20,000:1 can be accommodated through automatic control circuits.

Lens focus, light filter selection, iris diaphragm setting, and training of the camera in azimuth and elevation is done by remote control.

Sensitivity allows picture of ice formation at 400 ft with half moonlight filtered through 4 ft of covering ice; can reveal phosphorescent sea animals in dark water.

An RCA video tape recorder, and a 16-mm film camera made records of the tv coverage during the *Seadragon's* trip.

Navigation was done with Ship's Inertial Navigation System, (SINS) which gave accurate heading even at the magnetic anomaly areas at the pole. Position was at all times important.

CdS Stores Conductivity After Electron Bombardment

SCIENTISTS at Air Force's Cambridge Research Lab have observed that single crystals of cadmium sulfide store electrical conductivity after electron bombardment.

Small rod-type crystals with dark resistivity of the order of 10^{10} ohm-cm exhibit high photosensitivity and little fluorescence under ultraviolet stimulation from 80 K to room temperature. Simultaneous irradiation with band-gap light and monochromatic infrared showed photoconductivity quenching at 1.4 and 9 microns.

Crystals were mounted with sputtered platinum electrodes, bombarded with 100-Kev electrons; after bombardment for as little as ten minutes, dark resistivity fell to 100 ohm-cm. Quenching experiments produced no change in resistivity.

After 100 hours in the dark, in air or vacuum, the resistivity held stable at the lower figures. Heat treatment up to 200 C returned the crystals to original resistivity. Electron bombardment could be used to restore the storage state.

Paris Symposium Underlines Rapid Progress In

PARIS—New semiconductor devices and techniques were reported in depth here recently at an international symposium on semiconductor devices. If, as one of the 1,300 participants put it, none of the 140-odd papers presented made a big technical splash, there were nevertheless ripples of interest in just about every sector.

Compagnie Générale de Télégraphie sans Fil (CSF) told of a *pnp* germanium mesa transistor, with the emitter produced by vacuum evaporation, capable of 500 mw dissipation at frequencies to 500Mc. Through a combined diffusion and oxide mask technique, CSF also has been able to produce *npn* and *pnp* silicon transistors with alpha cut off frequencies in the 100 to 300-Mc range. And, through a new annular structure, CSF reported high power output and high-frequency for operation field-effect tetrodes. One grid is soldered directly to the can for dissipation of 5 to 6 watts. By suitably dimensioning the second grid, frequency can be boosted without reducing the slope. For a germanium element with 170 Mc maximum frequency, the firm reported, slope of 3 to 5 ma per volt was obtained.

Another French company, La Radiotechnique, described a technique that gives high-frequency transistors with alpha cutoff as high as 200 Mc. Double diffusion of gallium and phosphorous into *n*-type silicon results in an *npn* structure with diffused base and emitter. By changing only the dimensions and the geometry, the technique also produces power units capable of handling up to 5 amps.

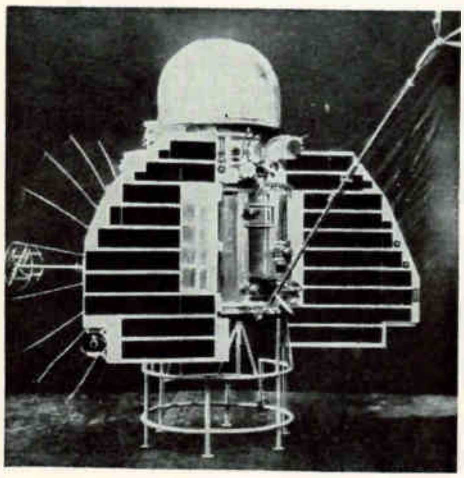
Alpha cutoff frequencies of 200 to 300 Mc are possible with bipolar transistors made from gallium arsenide and indium antimonide, according to a report made by M. E. Jones, E. C. Wurst Jr., and H. L. Henneke of Texas Instruments. In these experimental units, the base region was formed by gaseous diffusion into wafers cut from pulled single crystals, the emitter and the contacts to base and collector were made by alloying. For the gallium arsenide types, common emitter current gains greater than 20 were obtained, with typical values from 5 to 10. Alpha cutoff frequencies topped 200 Mc, indicating potential applications in fast switching circuits. The indium antimonide transistors showed current gains better than 100 at 77K. Alpha cutoff frequencies approached 300 Mc but breakdown voltages turned out to be low, 4 to 5 volts usually. These types show promise, for operation at 77K, in low-noise or high-frequency use.

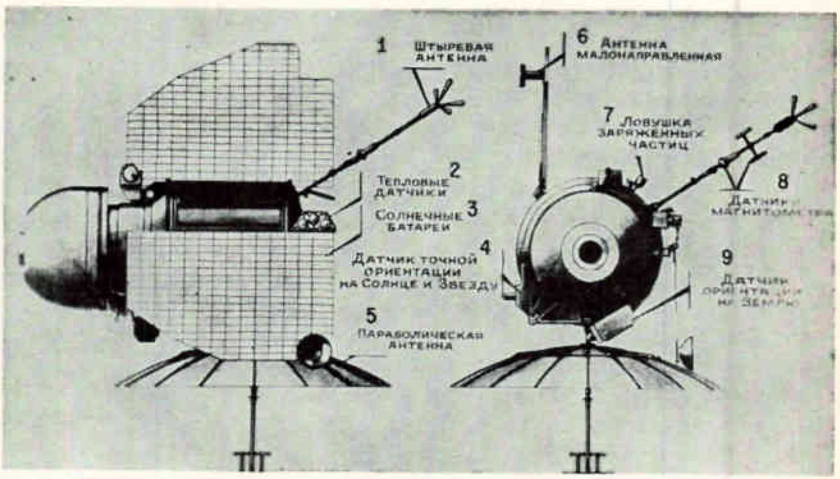
The French Ecole Nationale Superieure des Télécommunications reported it put germanium mesa transistors with 400-Mc cutoff to work in wide band amplifiers of two types. One uses emitter selective negative feedback for 36 db gain in three stages, with a 3-db pass band from 50 Kc to 100 Mc. The second type employs a grounded-base transistor with a 2:1 transformer wound on a ferrite core; performance for this type is 18 db of stable gain in three stages with a 3-db pass band extending from 400 Kc to 200 Mc.

Another French circuit development was an agc device for transistor amplifiers, presented by Société Alsacienne de Constructions Mécaniques. A transistor with its base grounded and its collector short-circuited is used to obtain a four-terminal network whose output voltage controls its input impedance. With the device, variation of gain at the output can be held within a 6-db range despite input variations up to 45 db.

W. R. Cady of General Electric reported that germanium and gallium arsenide tunnel diodes now in production could operate at frequencies in the gigacycle range and provide nanosecond switching times. This report received confirmation from a British researcher

Details of Soviet Venus Vehicle Revealed





Components of Soviet Venus probe vehicle (left) are shown in this Soviet drawing (right): (1) rod antenna; (2) heat sensor; (3) solar batteries; (4) indicator of the exact orientation of the sun and a star; (5) parabolic antenna; (6) low directivity antenna; (7) charged particles trap; (8) magnetometer sensor; (9) sensor, orientation to earth (Sovfoto) who described dynamic computer circuits operated with 2-nanosecond interval between clock pulses: the diodes used had a time constant of less than 0.05 nanosecond. For high-speed memories, he added, small arrays of tunnel diodes have been operated with a 20-nanosecond read-write cycle.

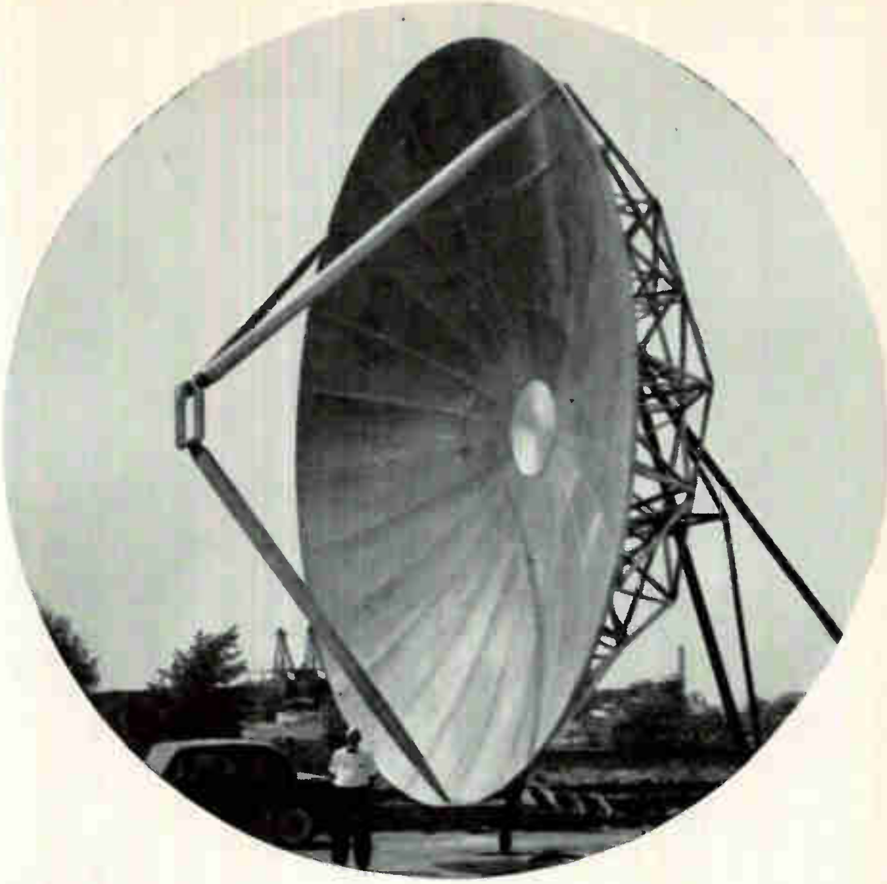
Standard Telecommunications Laboratories of England proposed a method of making tunnel diodes more versatile by adding a third terminal. Negative resistance between the two terminals of a tunnel junction can be varied by a lateral base current flow between two ohmic contacts in one of the degenerate regions of the tunnel junction.

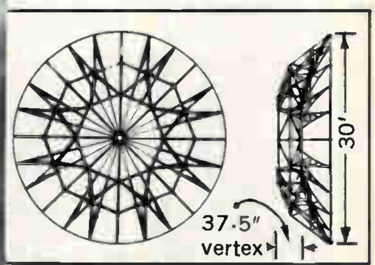
Siemens of Germany reported their laboratories have prepared gallium arsenide diodes with peak-to-valley current ratios up to 50 to 1, and have run experiments with diodes in series with transistors. They found that relaxation oscillation frequency could be varied that way, suggesting applications in remote controls.

Telefunken released details on nonreciprocal parametric and tunnel-diode amplifiers for uhf and vhf operation. The amplifiers, which function without isolators or circulators, consist of cascaded up- and down-converters. With two reactance diodes used in the converters, forward-to-backward gain ratio is about 40 over a 16-Mc bandwidth; with two tunnel diodes, the gain ratio is 25.

A. E. Brewster of Standard Telecommunications Laboratories said his research group has started to develop complex tunnel-diode circuits using an elementary pair assembled as a three-terminal device. The device provides a reliable two-state circuit and points the way to complex assemblies made up of encapsulated tunnel-diode functional blocks interconnected by printed or evaporated wiring.

I. Lagnado of Raytheon described a bistable multivibrator stage integrated into a silicon element. To extend the application of the basic block to binary computing machines, a directional diode circuit





Paris Symposium . . .

was incorporated.

The circuit block consists of two transistors, four resistors and six diodes laid out on the two faces of a silicon slab 0.63 cm square by 0.03 cm thick. The *n*-type silicon slab is diffused with gallium to get a sandwich made up of an *n*-region and diffused region 12 to 15 microns thick. To obtain the components, both faces are worked simultaneously by removing the diffused layer at certain spots and adding an *n* layer at other spots. The circuit provides input pulse width $\geq$0.4 microsecond, repetition frequency $\leq$200 Kc, output amplitude 6 to 8 volts, uses battery voltage 6 to 9 volts.

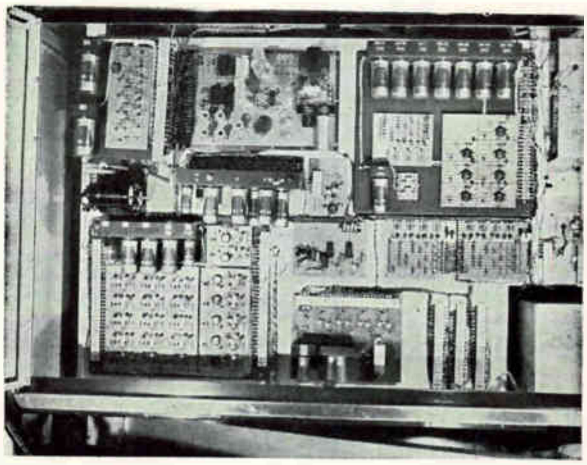
A French research team reported on a process of diffusing phosphorous into silicon at 1,100 C to obtain solar cells with an efficiency of 14 percent. This efficiency could be upped to 15 percent, they indicated, by adding an antireflective layer.

Another photocell development, this one from Germany, gives units that can resolve the movement of any small light spot. The cells take advantage of medium angle tilt grain boundaries of a *p*-type layer in *n*-type germanium. Width of the boundaries is about 10^{-5} mm and carrier concentration is high. That accounts for the high resolving power of the cells, which make sensitive indicators of surface treatments.

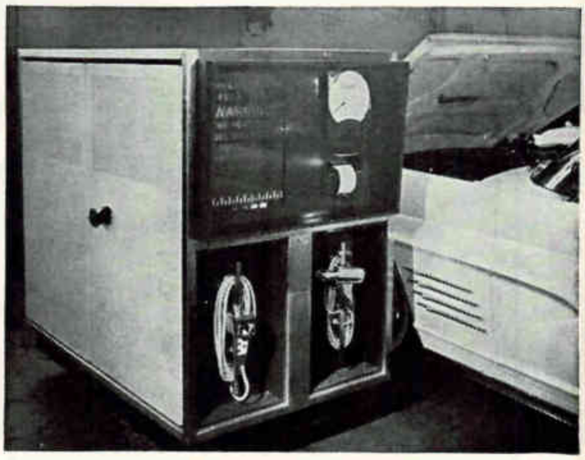
A Japanese research team described some applications of thermoelectric cooling with bismuth telluride junctions at the University of Tokyo. Along with a small refrigerator, they built a cooling system for the cathode of a multiplier phototube. The cooler consists of four single-stage panels, each with 40 couples. In 15 minutes, it brings down the cathode temperature 30 C, thus reducing the dark current to about 1/30; power consumption is about 300 watts d-c.

Semiconductors whose resistance increases in a magnetic field were another German development described at the symposium. One device, the field disk has a resistance less than 1 ohm with no magnetic field and its resistance increases by a factor of 38 in 10,000 gauss. Resistance of the field plate moves up from 60 ohms to about 700 ohms as the field is increased from nothing to 10,000 gauss. The field plate can be used directly in electrical circuits, dissipates 1 watt maximum.

Testing Automobile Electrical Systems



Electronic portion of checker including transistor-diode logic, which is fed from decoding silicon photocells used to read 35-mm programming film strip



Tester, called EAGER (Electronic Audit GagER), has projection screen, indicator and printer, pistol-shaped tachometer, remote-control hand unit

IN THE LAST ten years use of electrical components in automobiles has more than doubled. Reliability of parts becomes more important as warranty periods are being extended to the consumer. Both trends demand automation of production test procedures. Lincoln Continental has reduced automobile electrical system test time from two hours to 15 minutes using film programmed electronic checkout techniques.

The instrument, designed by Performance Measurements Co., Detroit, Michigan, is connected to the automobile under test by cables from a swing-out arm positioned under the hood.

The operator follows instructions which are flashed on a rear-projection screen, presses a button in the hand-held remote control unit, performs required operations on car, and notes results on performance indicator.

He checks results against screen projected standard, records reject or accept and test results on printers.

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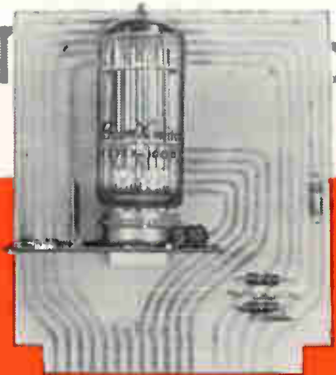

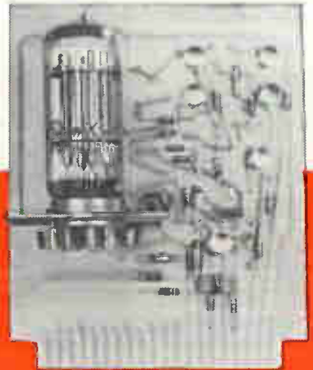

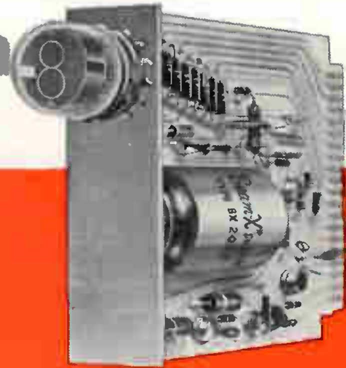

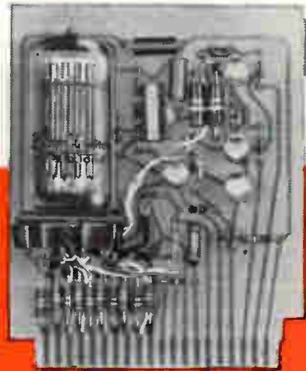

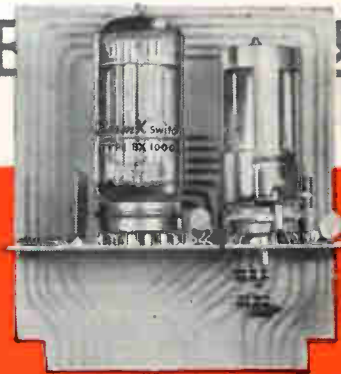

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DC-114
TRANSISTORIZED DECADE COUNTER

Utilizes the new shielded BEAM-X switch, BX-2000, to resolve pulses at 110 KC. NIXIE tube readout is provided on the plug-in module. Designed for use in military systems, electronic instrumentation, computers and test equipment.

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ELECTRONIC TUBE DIVISION

Plainfield, New Jersey

Report Plasma Results in

EXPERIMENTAL RESULTS are now appearing from research in applying magnetohydrodynamics — MHD — to power conversion and flight. This trend showed up at the recent MHD symposium in Philadelphia. It featured sessions on flight applications, power conversion, communications and diagnostics, and fusion.

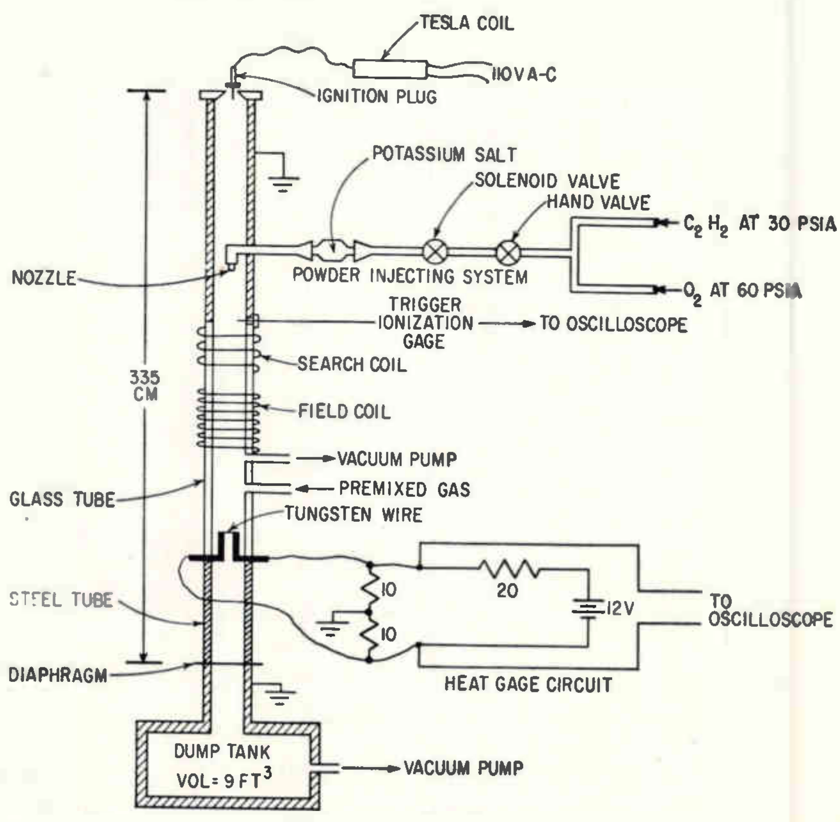
Sponsored by the AIEE, Institute of Aeronautical Sciences, IRE and U. of Pennsylvania, the conference drew 425 persons compared with 300 at first meeting in 1960.

V. H. Blackman of MHD Research described experiments on a combustion-powered MHD generator using alkali seed injection. Tests were conducted by his firm and Allis-Chalmers at Newport Beach, Calif. He reported power output on the order of 80 w per in. of length with heat transfer approximately 4 Kw per in., indicating that 2 percent of the reduction in enthalpy of the gas as it went through the generator was due to conversion of mechanical to electrical energy.

Total output reported on one run was 1,030 w with the thermal input power of the order of 500 Kw. Rectangular power channels constructed of MgO slabs backed by watercooled stainless steel operated for more than 15 minutes. Although a steady d-c level was generated, noise in the output was estimated as a variation at sonic frequencies of the order of 20 percent of the d-c level.

Reporting on progress at Avco, T. R. Brogan presented conductivity and open-circuit voltage data obtained from their new experimental MHD generator. Initially operated in Dec. 1960, the generator produced a total maximum output of 105 Kw when eight sets of triple ¾-in. carbon electrodes were used in midchannel. Peak field strength of the Bitter magnet is 32 kilogauss.

A paper submitted by S. Way of Westinghouse presented measure-



Heat transfer gages along shock tube measure detonation wave velocity in studies described by J. A. Fay of MIT of heat transfer to cold electrodes in a flowing ionized gas

Flight, Power

ments of open-circuit voltage, short-circuit current, conductivity and power for a generator that has been operated for 5 to 10-minute periods.

B. C. Lindley of C. A. Parsons & Co., Ltd. reported in his survey of MHD research in the United Kingdom that a project has been started at his firm on a closed-cycle MHD generator using helium gas with cesium seeding.

Experimental data is also being obtained in flight applications. Several speakers discussed work on plasma accelerators; S. T. Demetriades of Northrop reported measuring magnetogasdynamic thrust with a rectangular continuous flow engine mounted on a balance.

In a survey of MHD applications to reentry problems, R. X. Meyer of Aerospace Corp., commented that magnetic fields might improve r-f transmission characteristics by allowing transmission through an ionized gas layer at frequencies below the plasma frequency.

Fusion session was marked by optimism regarding the chance of building fusion reactors. This came from discussion of the Lawrence Radiation Lab experiments (ELECTRONICS, p 41, Dec. 2, 1960 and p 50, March 10, 1961) and the possibility of constructing 100-kilogauss solenoidal superconducting magnets with Nb_3Sn (ELECTRONICS, p 9, Feb. 10, 1961).

R. G. Mills of Princeton commented that if the physics problems are solved adequately, then it might be possible to build a small pilot machine using external magnetic fields before going to a commercial installation.

Ultrasonics Controls Slide Projector

ULTRASONIC ENERGY is used to focus and change slides in a slide projector introduced by Bell & Howell.

Remote control unit can operate from up to 40 ft away from the projector, has two miniature transmitters at 36.5 Kc for focusing and 40 Kc for changing slides. Receiver uses transistors, printed circuits.

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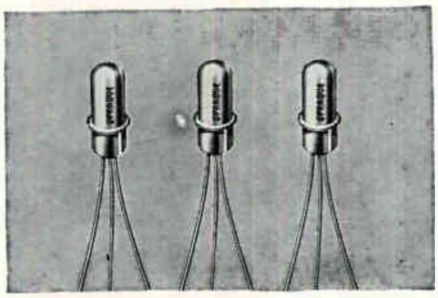

Sprague Germanium Micro-Alloy Diffused-Base Transistors, well known for their dependable vhf performance, are now reaping the benefits of perfected mass production techniques.

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2N504	High Gain 1F Amplifier
2N588	Oscillator, Amplifier, to 50 mcs

Off-the-shelf delivery at factory prices on pilot quantities up to 999 pieces can be obtained from local Sprague Industrial Distributors.

For complete engineering data on the types in which you are interested, write to Technical Literature Section, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts.

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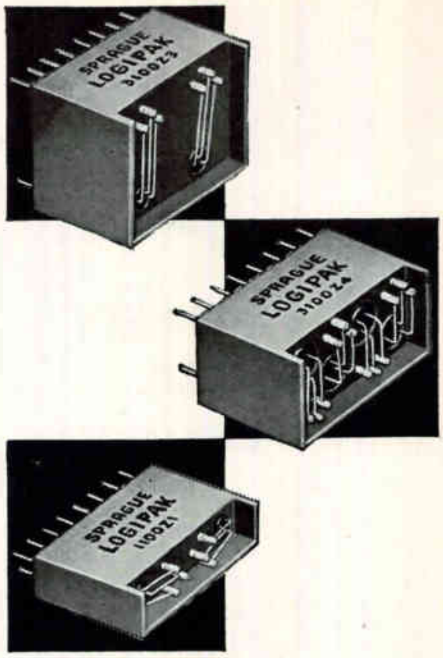

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Sees Pay Tv Lifting Consumer Sales

CHICAGO—PROGRAMS so good they'll make consumers buy the full-color 4-by-6-ft wall panel tv display devices of the future are one long-range reason for Zenith's sponsorship of the Hartford pay television experiment, president Joseph S. Wright told the 11th midwest forum of the Chicago Investment Analysts Society recently.

Other speakers covered different subjects, including computers, and how to start a firm.

Top quality programs will give consumer electronics the boost it needs to answer snowballing complaints, lessening of interest and dropoff in sales over the past few years, Wright said.

Pay tv's electronic switching system is activated by a square wave generator signal controlled by a combination of a random burst signal from an air code generator and a program code signal pattern predetermined and controlled by a punched film strip for each program, Wright explained.

Receiver delivers inverted blacks and whites. Cutting points of horizontal strips change periodically and shift from side to side before decoding.

Subscribers will probably pay $75 a year or more for the system, depending on whether more or less than 50,000 customers sign up for the service, according to an estimate by T. F. O'Neil, head of Hartford Phonevision Company.

Significant reductions in cost of color tv receivers won't come for a long time, Wright predicted, while commenting on the new line of color receivers his company announced recently. Simultaneous control over three electron guns makes color receivers at least three times as complicated, and so more expensive than black and white units, he explained.

Control Data credits "family plan" for computer construction with a big assist in holding its place in data processing industry, William Norris, president, explained to the computer industry forum. A building team develops management abilities, gains more satisfaction from the job and the unit is built and installed faster and develops fewer bugs over first months of operation, he said.

CD specializes in developing advanced circuits made up of conventional components, Norris said, adding that he expects transistors to be important for computers longer than many publications would lead the public to expect. Nevertheless the company is exploring tunnel diodes, microwaves, thin films and cryogenic circuitry.

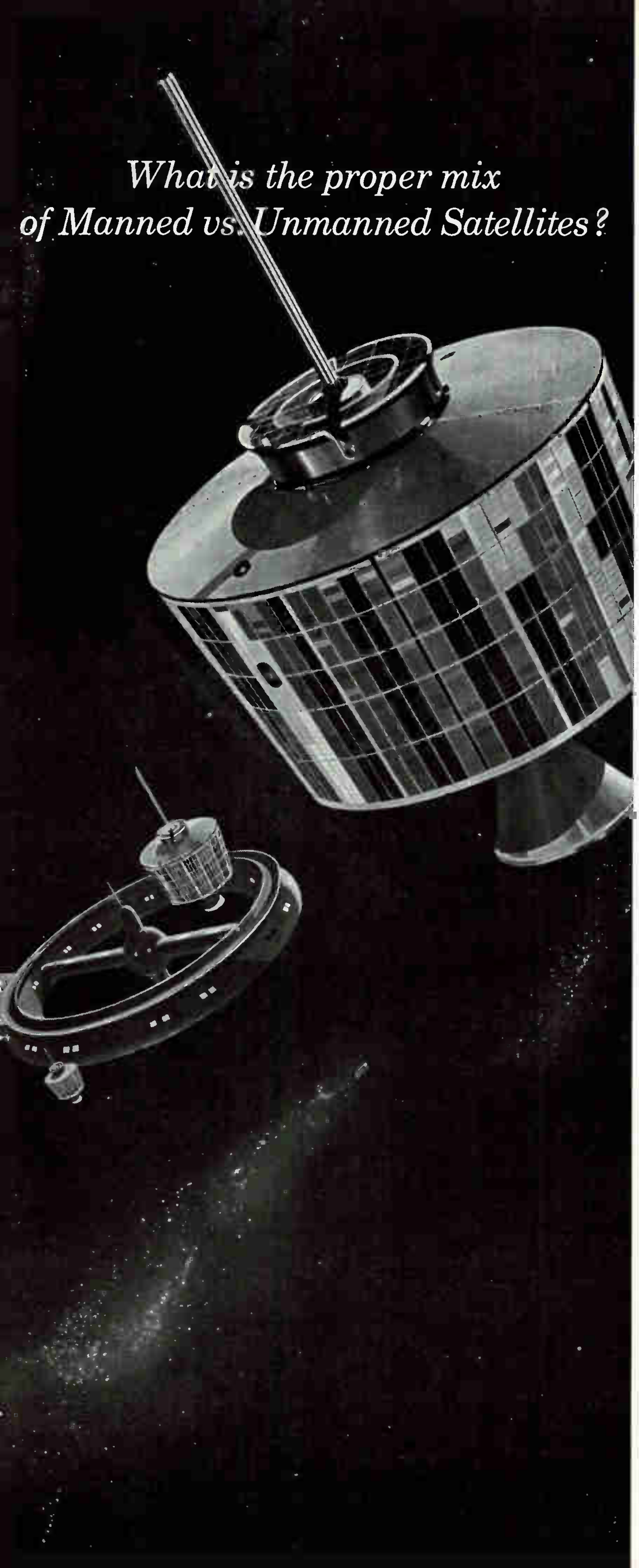
Digital computers are increasing their speed and capability advantages over analogue types while bringing costs down. George Dick, vice president, RCA electronic data processing, told the analysts. Herbert Robinson, president, Corporate Economic and Industrial Research, suggested suppliers of transistors, solid state components and business forms look like better investments than equipment builders among businesses peripheral to computers.

New ideas are not always the best basis for starting a new company, General Georges Doriot, president, American Research and Development Company, warned the analysts in his luncheon talk.

Expect to share in the struggle of building a new company, he advised, and keep a close eye on management, because often the promoter with talent for starting a company will not develop into the best manager of a firm later.

Thermoelectric Suit

Thermoelectric unit by Westinghouse is fitted into back of experimental Navy climatic suit



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Justify choice of systems considering trade-off of choice in terms of cost effectiveness.

Automatic target recognition requirements for high speed strike reconnaissance systems or unmanned satellites.

IR systems requirements for ballistic missile defense.

Optimum signal processing techniques for inter-planetary telecommunications.

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We promise you a reply within one week

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AEROSPACE ENGINEERING DIVISION

MEETINGS AHEAD

Mar. 23-25: Quantum Electronics, Office of Naval Research; Dept. of Electrical Engineering, Univ. of Calif., Berkeley.

Mar. 27-31: Temperature, Its Measurement and Control, ISA, AIP, NBS; Veterans Memorial Auditorium, Columbus, O.

Apr. 4: Automatic Control, AIEE, Boston Sec.; Northeastern Univ., Graduate Center, Boston.

Apr. 4-6: Electromagnetics and Fluid Dynamics of Gaseous Plasma, IRE, IAS, U. S. Defense Research Agencies; Engineering Societies Bldg., New York City.

Apr. 4-7: Audio Engineering Society; Ambassador Hotel, Los Angeles.

Apr. 5-7: Global and Space Environments, Institute of Envir. Sciences; Sheraton Park Hotel, Wash., D. C.

Apr. 5-7: Materials and Electron Device Processing, ASTM Committee F-1; Benjamin Franklin Hotel, Philadelphia.

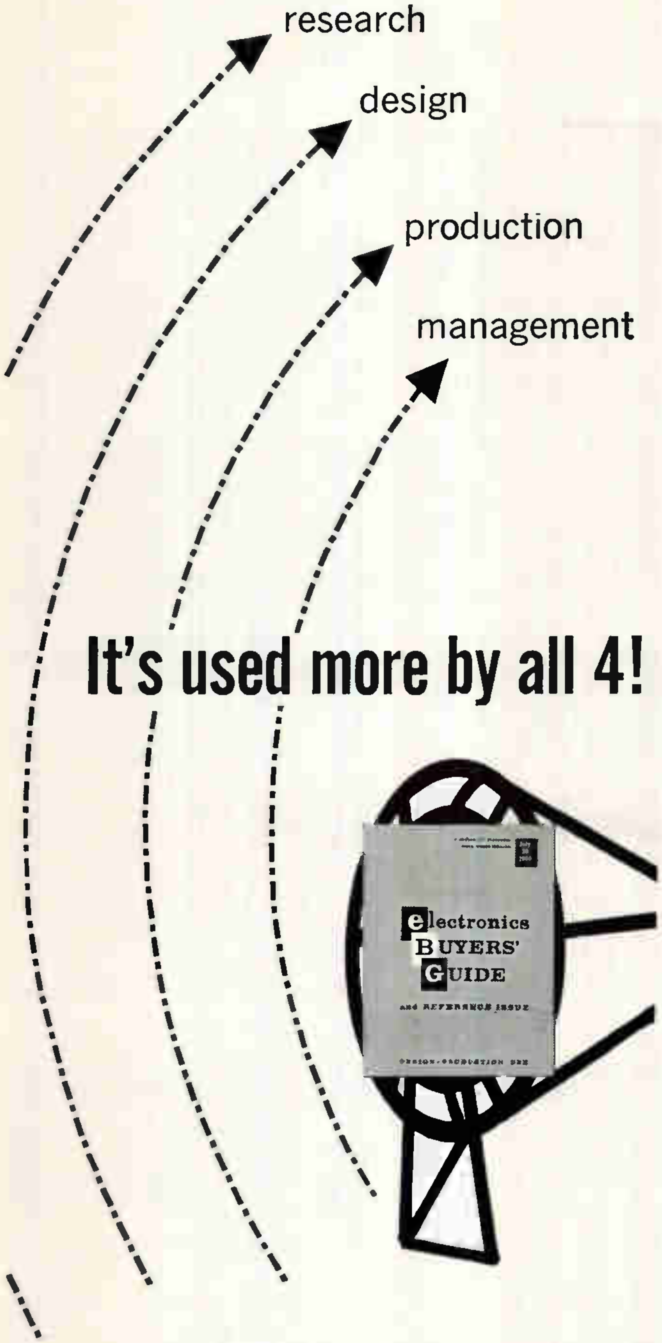
Apr. 11-12: Instrument Automation-Electronics Exposition, Ohio Valley; Cincinnati Gardens, Cincinnati, O.

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

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

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

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



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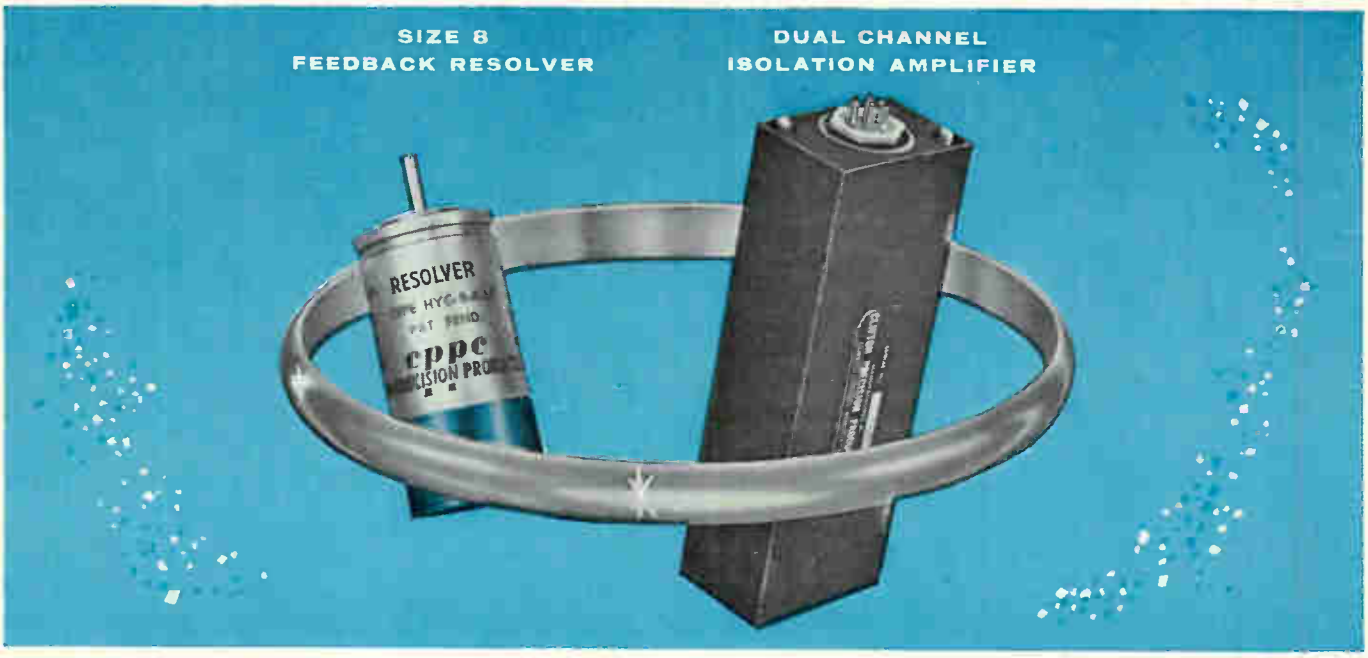

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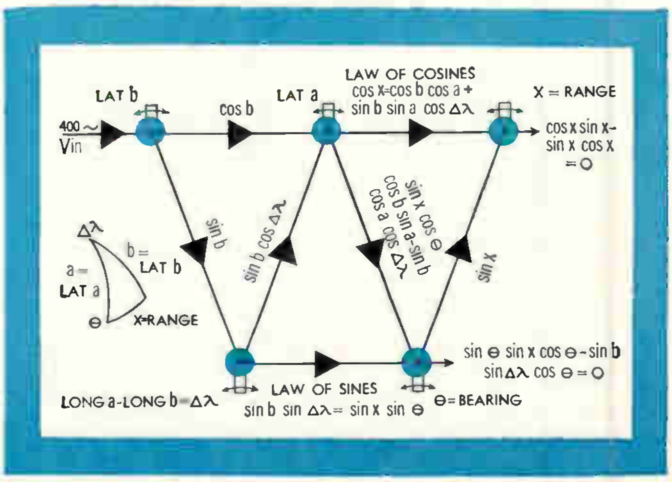

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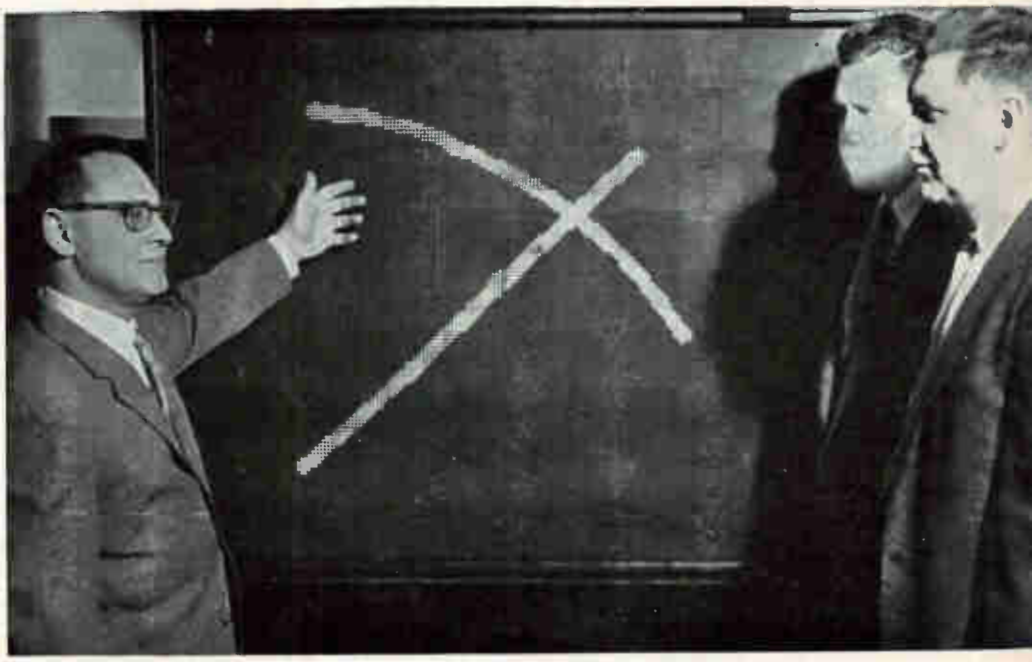
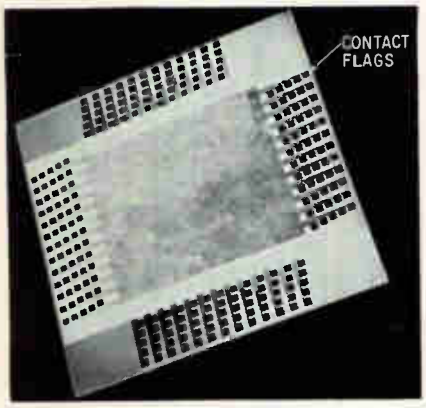


THE FRONT COVER—Automatic tracking board uses electroluminescence and photoconductivity to show and hold paths of moving targets



This crossed grid panel has resolution of 50 lines per inch

Electroluminescent Display And Logic Devices

By I. GREENBERG,
Sylvania Electric Products Co.,
Seneca Falls, N. Y.

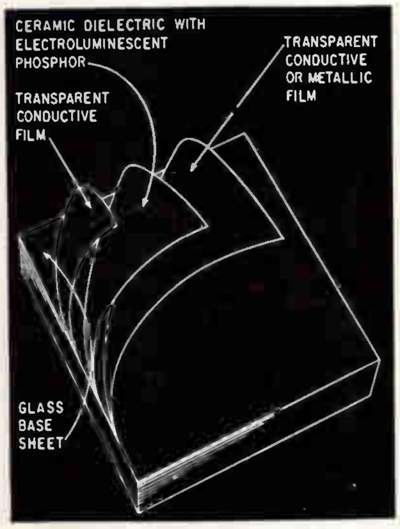


FIG. 1—Electroluminescent lamp is capacitor with phosphors embedded in dielectric

THERE ARE three commercial methods for obtaining light output from phosphors: photoluminescence, cathodoluminescence and electroluminescence. In photoluminescence, electrical energy is converted into ultraviolet photons that strike the phosphor and cause it to emit visible light. Cathodoluminescence is used in the conventional cathode-ray tube. Here the electrical energy is converted into the kinetic energy of a high-speed beam of electrons that strikes the phosphor, causing light emission. Electroluminescence is the direct conversion of electrical energy into light within a phosphor. This phosphor does not have to be in a vacuum and is imbedded in the dielectric of a capacitor (Fig. 1). This results in an area source of light.

At present, there are two types of electroluminescent (EL) lamps being manufactured. These are the plastic dielectric lamps and the ceramic dielectric lamps. Base material may be either metal or glass. Past experience indicates that the ceramic is superior to plastic as a dielectric in regard to lamp maintenance.

Advantages of EL lighting, as applied to display devices, are that the devices are flat and offer a wide viewing angle without paral-

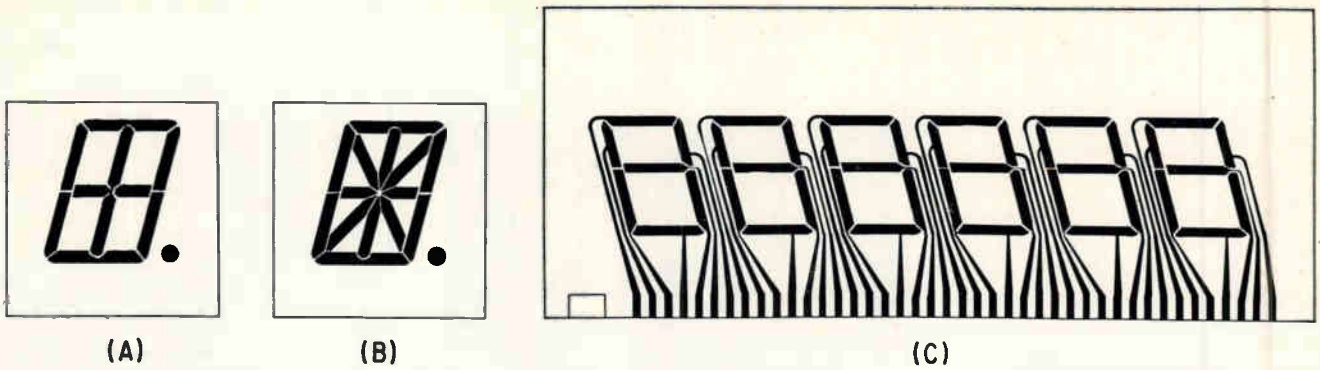


FIG. 2—Ten segment numeric (A) and 14-segment alphanumeric (B) displays can be made in multiples as shown in (C) for seven segment numeric

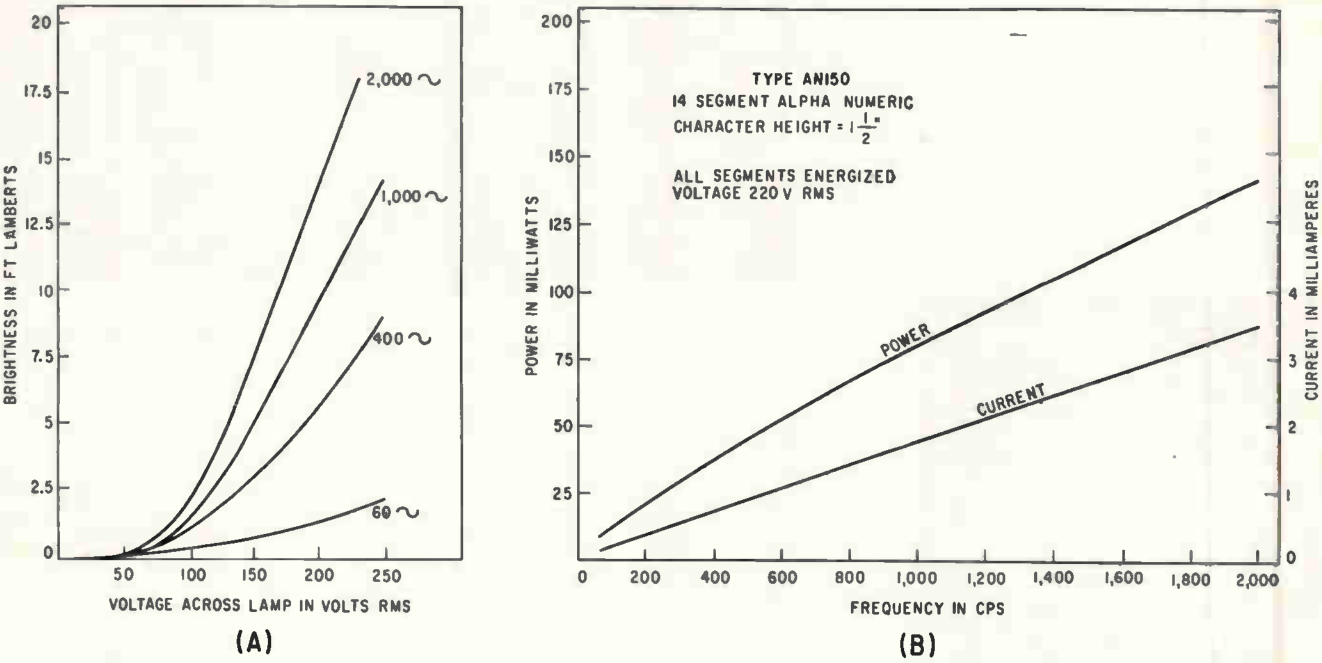


FIG. 3—Light output varies with frequency and voltage (A) while power and current are related to frequency (B)

lax. Power requirements are low and, since there is no vacuum or filament, catastrophic failures are minimized.

Since light will be produced only where a capacitor has been formed and a-c applied, a large number of display devices may be manufactured by using graphic arts and photographic techniques to form segmented electrodes. Examples of this are the 9-segment numeric (Fig. 2A), and the 14-segment alphanumeric (Fig. 2B). By applying an alternating voltage to the proper combination of segments, the numeric is capable of displaying any number from 0 through 9 as well as some letters, and some special symbols. The alphanumeric will display any letter in the alphabet, as well as numbers and many symbols. Display devices may be manufactured in almost any size and pattern. Multiple numerics or alphanumerics may be formed on one piece of glass resulting in an in-line display (Fig. 2C). The present limitations on size are determined by the density of segments and the ability to make contact to each individual segment. This results in an alphanumeric minimum character height of approximately ⅝ inch. Maximum size is limited only by the capacity of the production equipment. Character sizes as large as 10 in. high have been manufactured, and larger sizes are possible.

Typical operating conditions for display devices are 200 volts rms sine wave and 400 cps. These conditions result in a light output of approximately 7 foot-lamberts (Fig. 3A). The devices are provided with a blue filter that improves the contrast and reduces specular reflections.

At present four colors are obtainable by choice of EL phosphors in a ceramic dielectric. These are blue, green, yellow and white. Brightness of the present yellow and white phosphors is approximately half that of the blue and green phosphors. Red light output, which has been used in automobile dashboards, is obtained by applying a red fluorescent dye to a blue EL lamp so that red is emitted. Multilayer lamps have been constructed for special applications. Since the phosphors are translucent, special colors may be produced by making layered lamps.

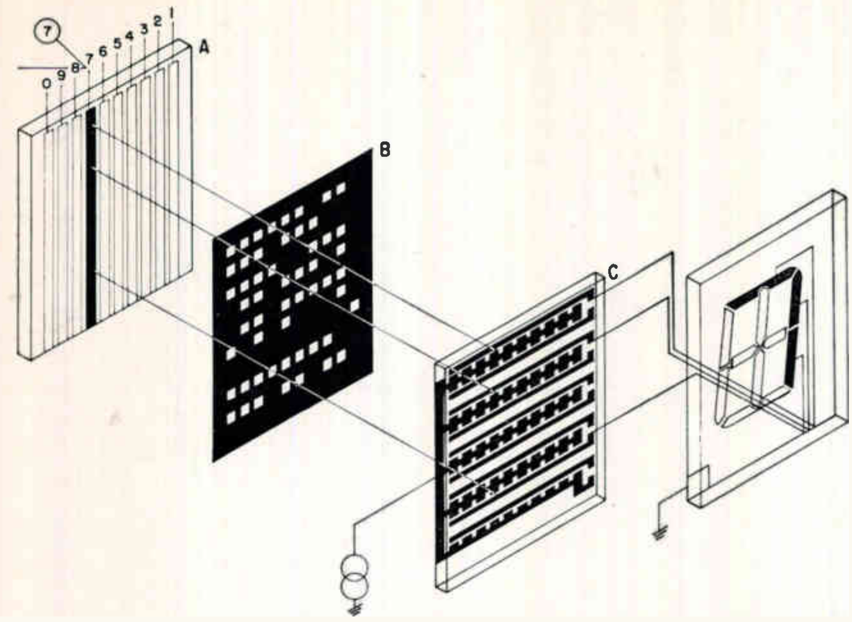


FIG. 4—Translator replaces electromechanical switches in display

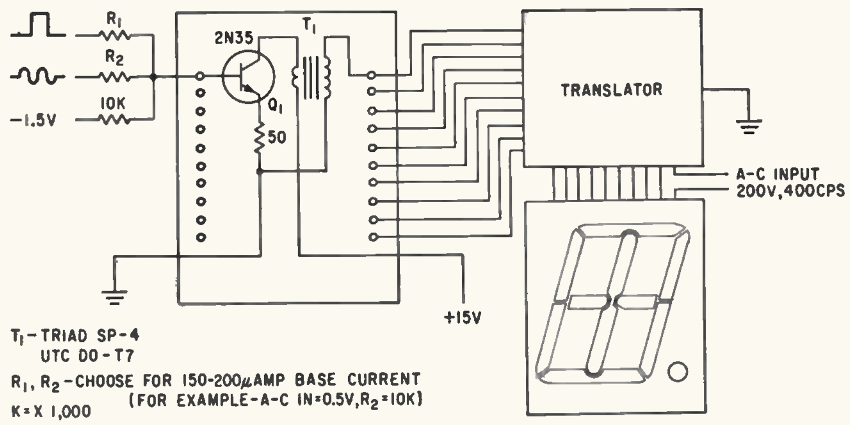


FIG. 5—Gating circuit is combined with translator in numeric readout

However, efficiency is reduced because light output from the layer farthest from the eye is attenuated in passing through the other phosphors. Rise time of these phosphors depends upon the frequency and full light output is reached after approximately three cycles of applied voltage. The EL phosphor decay times are approximately 5 to 10 μsec.

Power required for large displays may be estimated from Fig. 3B. The number 8 in a 1½ in. numeric, such as the 150, when operated at 200 volts rms and 400 cps, requires approximately 15 milliwatts.

Electroluminescent display devices may be switched by electromechanical switches; however, electromechanical switches are not always desirable because of either high power requirements or the need for automatic control of the display. The numeric translator shown in Fig. 4 has been developed. Plate *A*, which contains ten EL bar lamps, represents the decimal input. A second plate (*C*) contains nine PC cells. Plates *A* and *C* are aligned and placed together, forming a sandwich with a light mask or switching matrix *B* in between.

If it is desired to display the number 7, the signal is sent into the seventh bar lamp of the translator. Light is allowed to pass through only three apertures in matrix plate *B*, and in so doing, drops the impedance of the proper PC cells on plate *C*. This allows current to flow from the generator to the three segments forming the numerical 7 as shown in the drawing.

Switching time is limited by the response time of the photoconductive material, and when the EL lamps are driven at 200 volts rms and 400 cps, typical switching times of 100 to 200 millisec are obtained. While these times are not adequate for high-speed computers, they are sufficiently short for displays where the eye must take time to respond. The maximum rate of change for human observation is limited to two changes per second.

For numeric readout such as digital voltmeters, it is necessary to obtain a gated a-c. Fig. 5 shows a gating circuit. Since the display devices require low power, and are operated at audio frequencies, inexpensive transistors and transformers may be used.

In large displays, such as status boards and tote boards, or other displays fed from a computer, it is sometimes necessary to include a holding circuit. In a display board having many rows and columns of information, it is advisable to feed the information to the board in parallel form so that each character in a row turns on simultaneously. The hold circuit then takes over, and the output of the computer is stepped to the next row. Only one translator is required for each column, and a hold circuit is required for each character. Using PC techniques, two hold circuits have been designed. Figure 6A shows one element of a hold circuit using EL-PC switching. When S_1 is closed, voltage is applied to EL lamps *A* and *B*, causing them to light. The light output from lamp *B* is coupled to its photoconductive cell causing its resistance to become low. Current flows from the generator to lamps *A* and *B*. This is a bistable circuit since the photoconductor will remain low in impedance after S_1 opens.

A similar hold circuit, operated by neon lamps, is shown in Fig. 6B. Operation is the same as for the EL-PC hold circuit of Fig. 6A. Switching time for the EL-PC hold circuit is approximately 100 to 200 millisec, and the switching time of the NE-PC hold circuit is typically 25 millisec for turn on and 150 millisec for turn off.

Another form of code conversion

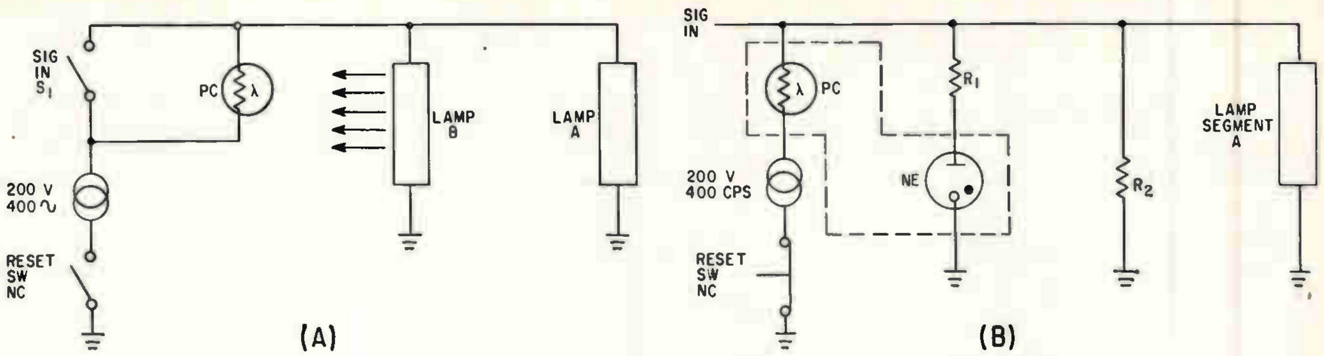


FIG. 6—Photoconductors can be held on by EL lamps (A) or neon lamps (B) in hold circuits

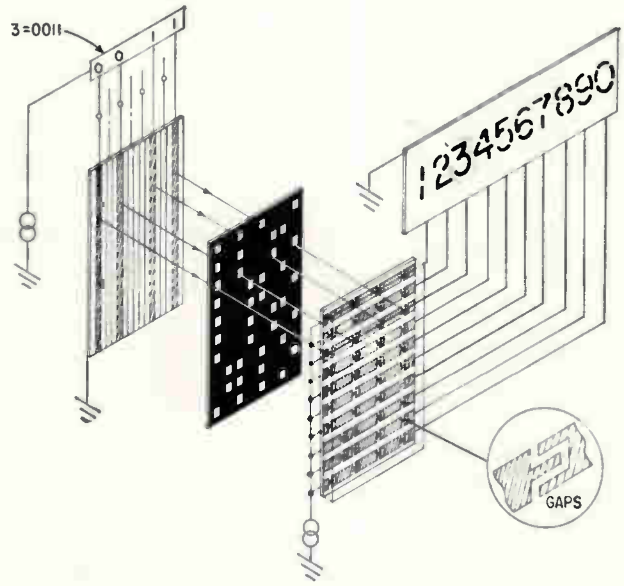


FIG. 7—Binary to decimal decoder has four-bit input

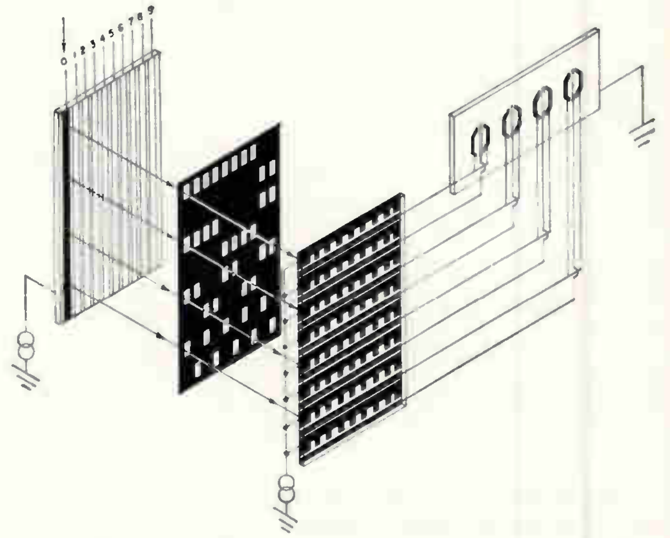


FIG. 8—Decimal to binary converter is similar to translator

being manufactured is the binary to decimal converter as shown in Fig. 7. This device is similar to the translator. The decoder accepts a four-bit binary-coded input. The eight EL bar lamps are divided into four pairs of ZERO and ONE information. Using a binary input of 0011, EL lamps 1, 3, 6 and 8 are lighted. The PC matrix consists of 10 rows with each row forming a four bit AND circuit. Line 3 is the only line where all four PC cells are illuminated. Consequently, current will flow from the generator through line 3 to its load.

Figure 8 shows a decimal to binary converter. The difference between the converters of Fig. 7 and 8 is in the construction of the PC cells. The decimal to binary converter is an OR circuit, while the binary to decimal converter is an AND circuit. Using these techniques, it is possible to design other code converters. For example, a converter has been designed to go from a four-bit binary code directly to a seven-segment numeric display.

The bistable memory panel device shown in Fig. 9 stores a considerable number of bits. The masking grid prevents optical cross triggering of the bistable photoconductive-electroluminescent elements. A voltage is applied across the bottom transparent conductive layer on the glass and the wire mesh on the PC layer. When no light is shining on the device, the PC retards the flow of current from the wire mesh to the EL layer. When light is allowed to fall on the PC layer, a current flows to the EL element corresponding to the segment where the light falls. With feedback resulting from the EL element to the PC element, the bistable ON state is obtained. The EL element will remain lighted until the voltage is removed. Thus, this device is capable of converting momentary light pulses impinging on the device into an image composed of many dots of light. This image can be stored for any hold period.

The memory is being manufactured in a size of 4 in. × 4 in., having a resolution of 4 lines per inch. There are a total of 256 individual bistable elements in each panel. Each edge of the device is made equal to one half of a line so that as these units are placed side by side, the overall display is continuous.

The panel may be triggered from a crossed grid behind the panel. Therefore, it is possible to feed information into the device sequentially and read out in parallel for permanent memory storage.

Another application using this technique is a tracking display. Since the devices may be placed side by side, display panels of any size may be fabricated.

Crossed grids, or X-Y panels, are useful for displaying information, since curves and symbols may be displayed on a flat surface having little depth behind the panel. In the crossed grids, as shown in Fig. 10, the electrodes on either side of the electroluminescent phosphor are divided into parallel strips with the directions of the two sets of strips usually at right angles. When voltage is applied between a row and a column, that portion of the panel, lying between the two electrodes, emits a bright square of light.

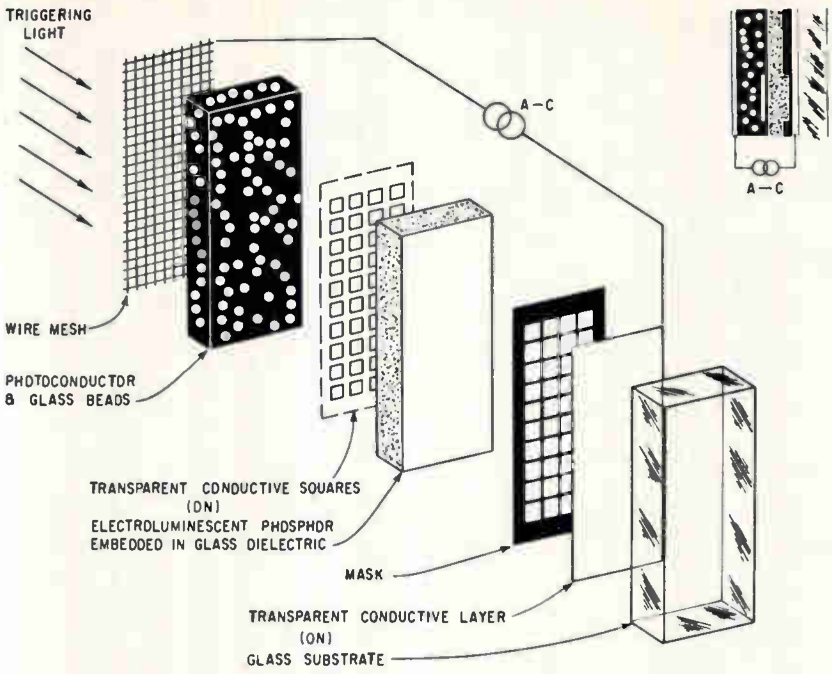


FIG. 9—Bistable memory uses masking grid

In addition to the light output at the intersection, there is also some light emitted along the entire length of each row and column. This phenomenon is called cross effect, and is a result of the electrode geometry. Examination of the equivalent circuit of a crossed grid shows that the intersection receives the total applied voltage, while all of the remaining capacitors in each line receive one half of the applied voltage.

Figure 3A shows that the light output of an EL lamp is nonlinear. With the present blue phosphor, the contrast ratio between the intersection and the rest of the line is approximately 4:1. By using a green phosphor, having a high slope characteristic, the contrast ratio is approximately 15:1.

Crossed grids of this type have been manufactured with a resolution as high as 50 lines per inch. Crossed grids with cross effect are useful for coordinate display systems or plotting tables where the panel is used with an overlay or projection.

For displays of information such as curves, the cross effect may be undesirable since a great deal of extraneous information will be visible. Here cross suppression is used. Cross suppression is obtained by the addition of a nonlinear resistive layer to the basic crossed grid. In this arrangement, there is a nonlinear resistor in series with each capacitor. Now, the half voltage that still appears along each row and column, results in less voltage across each individual capacitor due to the voltage drop in the nonlinear resistor. Contrast ratios as high as 20,000:1 have been made and, for practical purposes, visible light results only at the intersection.

Due to the increased complexity in the manufacture of cross suppressed panels it is not now possible to manufacture these with as high a resolution as in a noncross suppressed panel. At present, crossed grid panels of this type have been limited to a maximum resolution of 10 lines per inch. With large display boards with sizes of 4 ft. × 3 ft. or larger, a resolution of 10 lines per inch is adequate.

With resolutions of 10 lines per inch or less, it is possible to make cross connections from one panel to another to build up a large area display consisting of a number of individual crossed grids. By registering each line on adjacent panels, it is possible to build a large display board without discontinuity. This electrode geometry enables discrete element selection with a minimal number of terminals, all terminals being accessible at the edges of the panel.

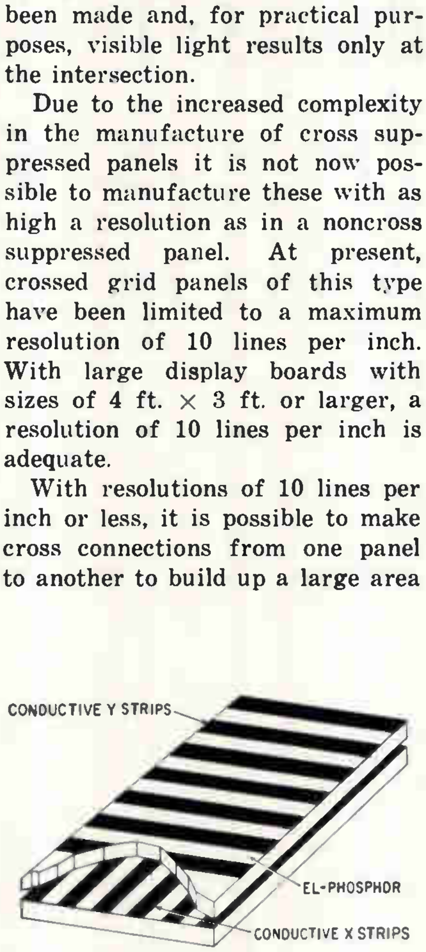


FIG. 10—Cross effect in crossed grids must be reduced in curve displays

Electroluminescence displays have proved to be excellent in photographic uses where permanent storage of information is required. Almost any reasonable size or shape may be made by graphic arts techniques. Individual dots as small as 0.020 in. have been fabricated for binary-coded-decimal information. Many numerics may be constructed on a single panel as shown in Fig. 2C. This device is being used to expose film directly in applications where permanent records are required.

The film is in direct contact with the device, eliminating optical transmission systems. The phosphor color is blue, and since the film is most sensitive to the blue end of the spectrum, the exposure times are short.

These devices represent second generation displays. They feature wide viewing angles without parallax, and because of their versatility, are opening up new fields of display capability.

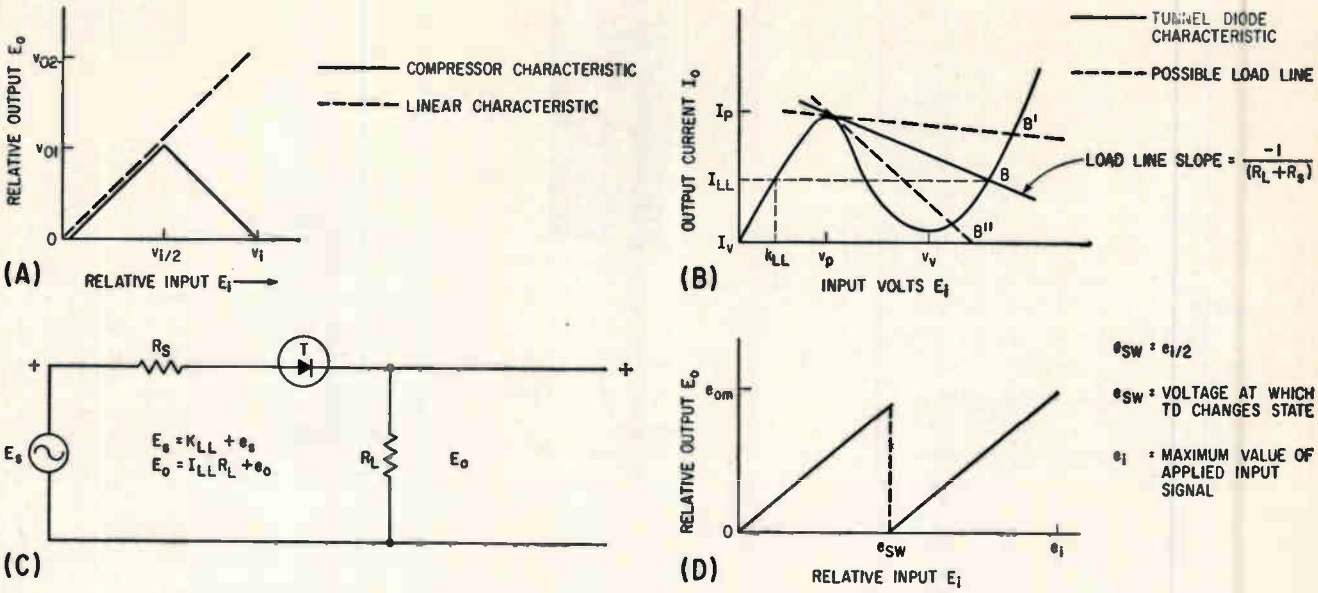


FIG. 1—Typical sawtooth compressor characteristic, (A), can be approximated by tunnel-diode characteristic (B). Tunnel-diode circuit in (C) gives 6 db compression of signal e_s; dynamic voltage transfer characteristic for this circuit is shown in (D)

Tunnel-Diode Pulse Compressor

Circuit compresses video pulse amplitude by 12 db without affecting any

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RAPID SWITCHING ABILITY of the tunnel diode can be used to reduce the amplitude range of video signals, while preserving the magnitude of wanted small signals that are superimposed on large video pulses. Three diodes, connected in series, can reduce the amplitude range by 12 db.

A small-amplitude perturbation of a pulse signal is often the desired quantity while the pulse itself is not wanted. If the pulse has a wide amplitude range, then the design of linear circuits presents problems. The result is usually a compromise between overloading the active circuit elements and losing small-signal sensitivity. This calls for dynamic pulse compression that can increase the sensitivity for the superimposed perturbations, and also prevent overloading of any other pulse processing circuits. A sawtooth dynamic range compressor is used.[1]

A typical transfer characteristic, shown in Fig. 1A, helps describe the sawtooth compressor's operation. The solid line is the compressor characteristic, and the corresponding linear amplifier characteristic is shown as a dotted line. Maximum output signal v_{o1} from the compressor is just half the corresponding amplifier output, v_{o2}. This characteristic thus provides a 6 db reduction in dynamic range, while perturbations in the amplitude of a large pulse are preserved equally well in both devices. The same concept can be extended to greater dynamic amplitude reduction. Such sawtooth characteristics are conventionally obtained with ordinary diodes and difference amplifiers, using vacuum tubes or transistors.

A new circuit produces the sawtooth transfer characteristic with tunnel diodes. The characteristic of the tunnel diode folds over, as seen in Fig. 1B,[2] and this makes it suitable for such applications.

Figure 1C shows a source E_s, containing an a-c signal e_s and a d-c level k_{LL} for biasing the tunnel diode in its first positive region to a bias current I_{LL}. Resistance R_s includes the internal resistance of E_s and the series resistance of the tunnel diode. The slope of the load line constructed in Fig. 1B then depends on the sum of R_s and R_L.

For any of the load lines in Fig. 1B, the circuit operates as follows: voltage e_s begins to increase in the forward direction, the loop current increases, and E_s increases correspondingly. When e_s brings the current to the value I_p, the diode switches to the second stable state condition. The switching time is

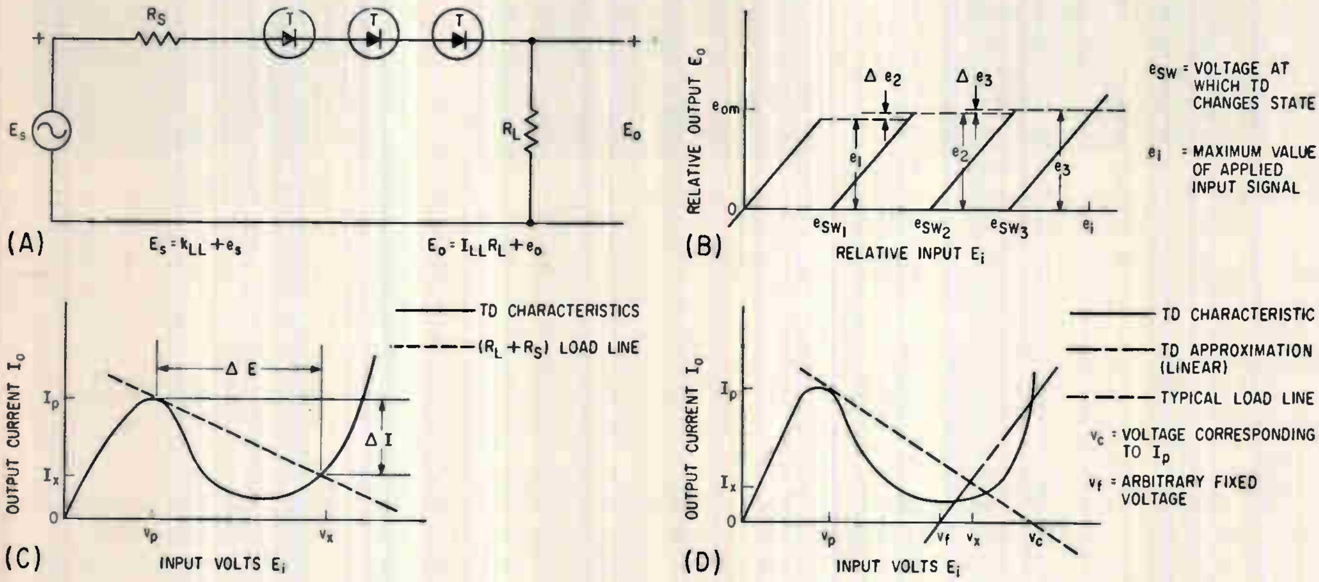


FIG. 2—Practical version of tunnel-diode sawtooth compressor circuit uses three diodes in series, (A); its dynamic voltage transfer characteristic is plotted in (B). Method of plotting typical load line for simple tunnel-diode circuit is shown in (C); linear approximation to the second positive slope portion of the tunnel-diode curve, (D)

Preserves Superimposed Signal

small superimposed signals or overloading components

short, and has been measured down to 0.5 nanosecond.[3] As e_s keeps increasing, the diode stays in the second stable region and the loop current increases. Figure 1D shows the linearized voltage transfer characteristic of the circuit in Fig. 1C, with respect to the a-c components e_s and e_o.

Comparison of Fig. 1D with Fig. 1A shows that both circuits are capable of the same degree of dynamic amplitude compression, in this case 6 dbv.

In equipment, more compression

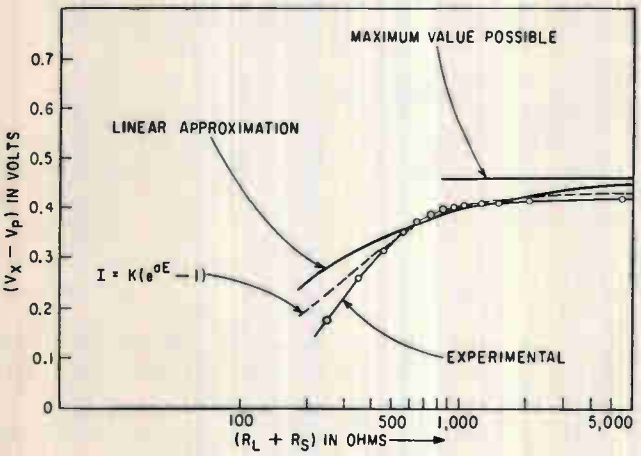


FIG. 3—Plot of Eq. 2 and Eq. 3 against experimental results obtained with a circuit similar to the one shown in Fig. 1C

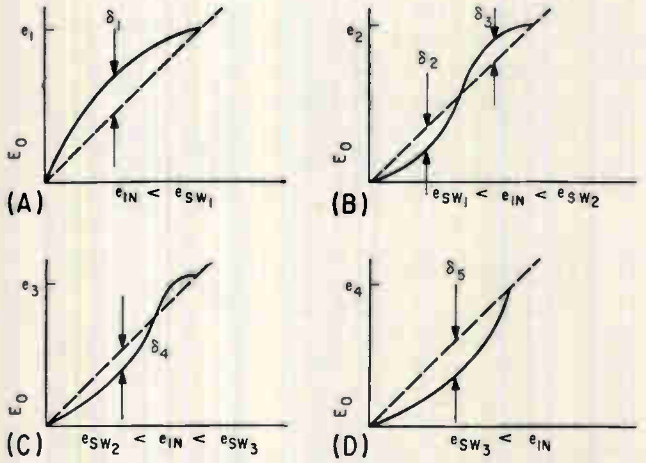
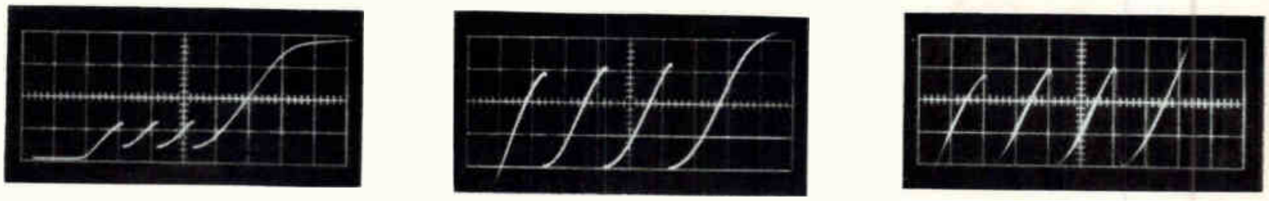


FIG. 4—Plots show approximate deviation from linearity for circuit in Fig. 2A. Actual characteristics are shown by solid lines, desired linear characteristics as dotted lines



(A) T ⟶ OVERALL RESPONSE SHOWING D-C LEVEL 50 μS/CM 0.2 V/CM $R_L = 200$

(B) T ⟶ SAME AS (A) D-C LEVEL NOT SHOWN 0.05 V/CM

(C) T ⟶ FAST TIME TIME PULSE 0.1 μS/CM 0.05 V/CM $R_L = 200$

FIG. 5—Oscillograms show the output response of pulse-compressing circuit using three tunnel diodes, as shown

can be achieved either by cascading the single diode slopes, or by extending the basic circuit of Fig. 1C to have several diodes connected in series as shown in Fig. 2A. The dynamic characteristic of this last circuit is plotted in Fig. 2B. Though it is the same as of the previous circuit, there are four positive slopes instead of two, and since the dynamic characteristic is broken up into four parts, the total reduction in dynamic signal amplitude is 20 log 4/1, or 12 db.

Small voltages Δe_2 and Δe_3 are necessary to control the number of diodes that change state at the same time. The desired Δe can be decided by considering the possible variations of the diode characteristics with environment, and may be adjusted by a shunting resistor across each diode. These resistors in effect stretch out the current-voltage characteristic of the diode along the current axis, which means that for the same load R_L the output current at which the tunnel diode switches will be higher than if there were no parallel resistor.

Next, R_L must be selected for best linearity and maximum output. The analysis is based on the circuit of Fig. 1C and results are then extended to the series circuit of Fig. 2A. Two assumptions are made: first, that a load line intersecting the tunnel-diode characteristic below the valley voltage is of no interest, and second, that the tunnel-diode characteristic beyond the valley voltage can be approximated by

$$I = k\,(\epsilon^{aE} - 1) \qquad (1)$$

Justification for using Eq. 1 rather than the linear approximation is now shown. An expression for the maximum output voltage (the jump from the first to the second stable state) versus the load value $(R_L + R_S)$ is derived from Fig. 2C. Although R_S is assumed much less than R_L it must be considered in most cases.

The load line $(R_L + R_S)$ for the circuit of Fig. 1C is plotted on a tunnel-diode characteristic in Fig. 2C. The equation for the slope of the load line is

$$S = -\,\Delta I/\Delta E$$

and

$$(R_L + R_S) = -\frac{1}{\text{Slope of Load Line}}$$

and from the figure

$$\Delta E = v_x - v_p$$
$$\Delta I = I_p - k\,(\epsilon^{a v_x} - 1)$$

which gives

$$(R_L + R_S) = \frac{(v_x - v_p)}{[I_p - k\,(\epsilon^{a v_x} - 1)]} \qquad (2)$$

and since v_p for a particular tunnel diode is constant at a given temperature, the quantity v_x is to be maximized. Consideration of Eq. 2 shows that v_x approaches a maximum as R_L approaches infinity. Experimental results from a circuit similar to that of Fig. 1C verified that Eq. 2 is correct over a wide range of R_L. Figure 3 is a plot of Eq. 2 and experimental results are shown by circled points. For values of R_L from 300 ohms and above, error in the predicted value of $(v_x - v_p)$ against the actual value is less than ±10 percent. Also plotted on Fig. 3 is a curve of theoretical values of $(R_L + R_S)$ against v_x for a linear approximation to the tunnel diode curve beyond the valley voltage. The error over the range of actual values of R_L is apparent. The equation for v_x against $(R_L + R_S)$ is obtained from Fig. 2D.

Considering the geometrical relationships

$$v_x = v_p\,\frac{(v_c - v_f) + I_p\,(R_L + R_S)\,v_c/v_p}{(v_c - v_f) + I_p\,(R_L + R_S)} \qquad (3)$$

where v_c, v_p, I_p and v_f are fixed. Considering the magnitudes of the quantities, v_x is constant for only large R_L which is not the actual case. The quantity v_f is usually chosen so that all three curves in Fig. 2D meet at v_x. The value of the constants a and k in Eq. 1 are obtained from considering the slope of the E-I curve

$$I = k\,(\epsilon^{aE} - 1) = k\epsilon^{aE} \text{ for large } E$$

which gives

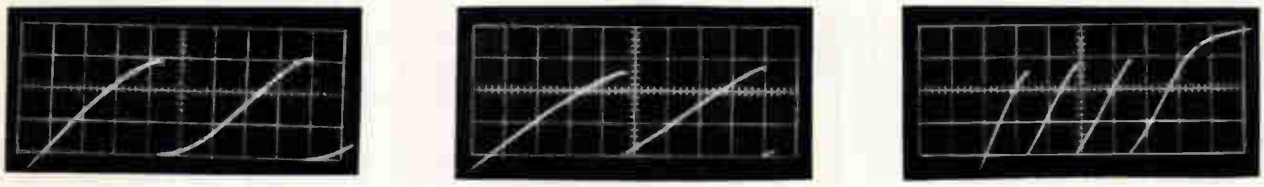
$$[d\,(\ln I - \ln k)]/dE = a$$

and so

$$a = [(d \ln I)]/dE$$

and when $I = I_p$, v_c for this value of current can be obtained, and so the value of k is then determined.

The value of R_L, for a given desired output jump is then calculated from Eq. 2. It is seen from Eq. 2 that large values of R_L do not effect the output voltage jump and that small values yield a highly nonlinear output. A plot of the actual E—I characteristics for a tunnel diode best shows the R_L for a linear output. A load line can be deter-



(D) T ⟶ EXPANDED INITIAL PORTION OF (B) NOTE LINEARITY

(E) T ⟶ EXPANDED INITIAL PORTION OF (F) (NOTE IMPROVED LINEARITY DUE TO HIGH R_L)

(F) T ⟶ OVERALL RESPONSE 50 μS/CM 0.1 V/CM R_L = 400

in Fig. 2A, to a ramp voltage input. Response is practically linear

mined to intersect the curve at any desired point. Then v_v and v_p are determined, and from Eq. 2 the value of R_L can be determined, keeping in mind the approximate range of values of R_L over which Eq. 2 is correct.

The discussion is extended to the circuit of Fig. 2A. The load line is determined from the sum of the source resistance, load resistance and diode resistance. It is true that the total load resistance varies as each diode switches but this effect is small as long as the external load resistance is large. A good value to use for diode resistance is the reciprocal of the slope of the straight-line approximation to the initial part of the tunnel diode characteristic. For large voltage jumps R_L should be large, while for fast switching a small load is desirable. Fast switching is desirable if fast rising pulses are to be handled. Thus for the circuit of Fig. 2A, a load R_L of about 300 ohms gives good linearity and allows a fast jump time (0.01 μs).

The linearity of the output of the circuit of Fig. 2A for input a-c signals less than $e_{sw(1)}$ (see Fig. 2B) is a function of the linearities of the initial parts of each of the diode characteristics, and therefore has the form shown in Fig. 4A. The maximum deviation from linearity is shown as δ_n. The error from linearity is determined from Eq. 4 where e_{max} is the value of output signal over the linear portion.

$$\text{Error} = \frac{\delta_n}{e_{max}} \qquad (4)$$

For signals in the range $e_{sw1} < e_{in} < e_{sw2}$ the output is a function of the second positive slope portion of the characteristic of one tunnel diode, and the initial position slope portions of the remaining two diodes. In general, it will then take the form shown in Fig. 4B. The quantities δ_2 and δ_3 show the degree of nonlinearity. Similarly for Fig. 4C, where the characteristic depends on the parameters of the second positive slope portion of the two diodes, and the first positive slope portion of the last diode. In Fig. 4D, all diodes have switched to their second stable state, and so the characteristic depends on the second positive slope portion of each diode. The deviation from linearity here is indicated by δ_5. Deviations δ_1 and δ_5 are the largest deviations to be found, and so a consideration of the nonlinearities of each diode separately is all that is necessary to analyze the circuit in Fig. 2A.

The equation that expresses the initial positive slope portion of the tunnel-diode characteristic curve may be approximated by the product of exponential and a straight line

$$I = K_1 E \epsilon^{-\alpha_1 E} \qquad (5)$$

where K_1 and α_1 can be found from experimental measurements of the diode peak current I_p and voltage v_p. Then Eq. 5 with Eq. 2 can evaluate the performance of the circuit in Fig. 2A.

Figure 5 shows the performance of a circuit, similar to that of Fig. 2A. The diodes are matched, so that Δ *e* is small. The input signal is a ramp voltage, and the folding of this ramp at the output can be seen. The deviation δ from linearity is small, and the improvement in linearity with increasing R_L is apparent when Fig. 5D, 5C, 5B and 5F are compared. Figure 5A shows the complete response, including the portion where the tunnel diodes are saturated. The circuit's ability to handle fast-rising pulses is shown in Fig. 5C.

Dynamic amplitude compression with a cascade tunnel-diode circuit has advantages over previous circuits, such as low power consumption, small size, and wide frequency response. It is easier to extend such circuits for greater amounts of compression, and this type of circuit could be used at typical i-f frequencies. Its ability to quantize the rise time of a pulse has other uses, as in logic circuits. A step output is available from this circuit if the output is taken across the tunnel diodes rather than across R_L, and again this type of signal has applications in logic circuits.

The authors express appreciation to the Engineering Design Center and the Electrical Engineering Department at Case Institute of Technology for the opportunity to conduct this research.

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Long-Wire Antenna for

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Antenna system is suitable for radio communications established by reflections from ionized meteor trails

THE ART OF METEOR-BURST communications has not reached a sufficiently high state of development to allow the designer to specify an ideal antenna system. However, general conclusions can be made about antenna characteristics. Theory, verified by experimental measurements,[1,2] indicates that radio signals propagating between two points on the surface of the earth through the ionization left by meteor trails, rarely follow the great-circle path between the two points. Angle of arrival measurements show a wide scatter in the range of 0 to 30 degrees on each side. The role of the antenna system is to illuminate a large enough volume of the ionosphere in the region between the two points, and to each side of the great circle path, so that there will be a reasonable probability of a communication path being established within a specified time interval.

Since higher antenna gain is always achieved at the expense of a narrower radiation pattern, higher antenna gain produces a decrease in the volume of the ionosphere illuminated, and hence a decrease in the potential number of useful meteoric propagation paths. Higher gain allows useful communications to be obtained from weaker bursts, thus compensating for the smaller volume illuminated. There is insufficient experimental data to specify optimum beam shape and gain; however, meteor-burst systems in successful operation are using antenna gains in the range 10 to 20 db with respect to an isotropic radiator. From the experimental evidence, it seems desirable for appreciable radiation from the antenna to extend as far as 30 degrees on each side of the great-circle path. It also seems desirable for the radiation in the great-circle direction to be suppressed in favor of the radiation to the sides. Optimum width of such a hole in the center of the antenna beam is not known, but the first several degrees on each side are of little value.

Meteor-burst systems have used Yagi antennas almost exclusively, either singly, or in arrays. In some cases (Stanford-Montana State College experimental system)[3] the arrays have been used to obtain power gain, the maximum of the main lobe of the radiation pattern being directed along the great-circle route. In other cases (the Canadian Janet system)[4] a pair of horizontally spaced Yagi antennas have been excited in phase opposition, to produce a null in the center of the beam. While such antennas function satisfactorily, the antenna described below functions equally well, has a broader impedance bandwidth and physical simplicity.

Radiation characteristics of a straight wire several wavelengths long are well known. While this antenna has been used by radio amateurs, it has little commercial interest, largely because it has a split-lobe pattern. This characteristic, however, makes it ideally suited for meteor burst communications.

The long-wire antenna is excited by a wave of current that propagates from the driven end to the far extremity, where it is reflected, producing a series of standing waves along the wire. The resulting radiation characteristic is bidirec-

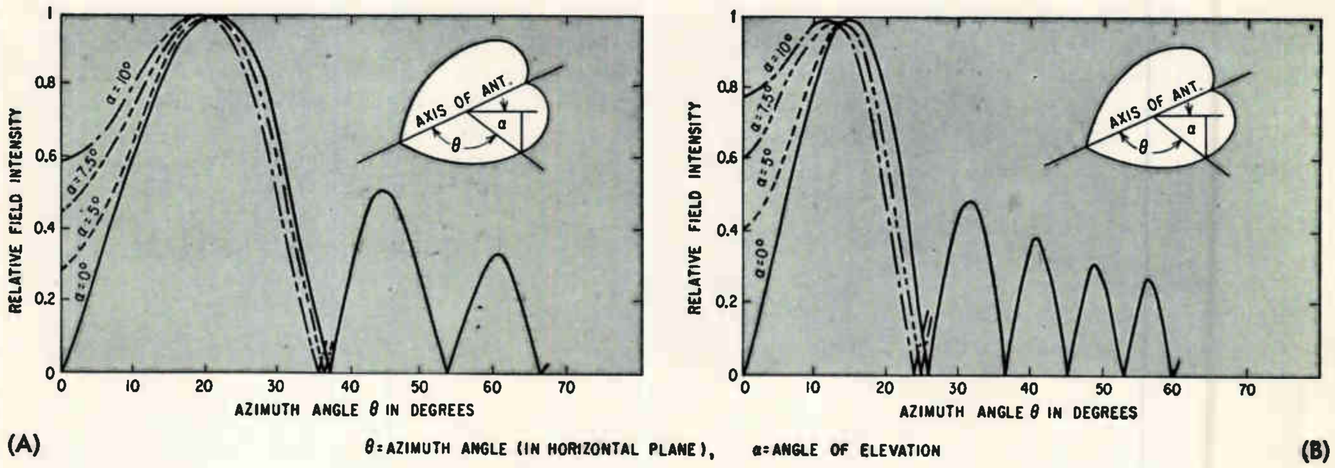

FIG. 1—Calculated radiation pattern of 5λ wire (A) and 10λ wire (B) excited by traveling wave

Meteor Burst Communications

in the 30-100 Mc region, with signals propagating along paths in the outer atmosphere. System offers simplicity, low cost

tional; however, radiation to the rear can be suppressed by a reflecting ground plane at the driven end. The antenna may consist of the extension of the center conductor of a coaxial transmission line, the outer conductor of which terminates in the ground plane. The radiation pattern will be nearly that of a long wire excited with a single outward-going traveling wave, since the radiation to the rear is suppressed by the ground plane.

The expression for the field pattern of a wire of total length l excited by a traveling wave of current of constant amplitude, propagating at free space phase velocity, is

$$F(\theta) = \frac{\sin\theta \sin[\beta (l/2)(1-\cos\theta)]}{(1-\cos\theta)} \quad (1)$$

where θ = angle off axis of wire, $\beta = 2\pi/\lambda$, and λ = free-space wavelength.

The three-dimensional pattern is a figure of revolution about the axis of the wire; thus the patterns in all planes containing the axis of the wire are identical. Equation 1 has been evaluated for lengths 5λ and 10λ (Fig. 1A and 1B).

Since the ionized meteor trails occur from 80 to 120 Km above the earth, propagation from the antenna will be at some angle of elevation above the horizontal, depending on the spacing of the sending and receiving points, and the location of the meteor trail providing reflection. Field patterns of Figs. 1A and 1B (the solid curves) do not pertain to the actual case, since these correspond to radiation in the horizontal plane. Accordingly, the modified patterns for three different angles of elevation, 5 deg, 7.5 deg, and 10 deg, have been computed, and are superimposed on the horizontal-plane patterns. The main effect is a filling in of the null of 0 deg by an amount depending on the elevation angle. This is a good effect since it helps to illuminate occasional meteor trails close to the great-circle path.

Polarization of the electric field in the radiation pattern is important in a meteor-burst communications system—theory predicts a 3-db advantage of horizontal polarization over vertical. Polarization of the signal from the long-wire antenna is vertical along the great-circle path, at all angles of elevation. As a function of the azimuth angle, polarization departs from the vertical.

Polarization, in terms of the angle between the electric field direction and the horizontal, has been computed for three different vertical elevation angles (Fig. 2). For the low vertical angles normally used in meteor burst systems (5 to 10 deg above the horizon) the electric field rapidly approaches horizontal polarization on each side of the antenna axis. Thus, at 20 deg off axis, and at a vertical angle of 7.5 deg, the electric field is polarized only 19 deg off horizontal, and the 3-db advantage of horizontal polarization is largely realized.

Power gains of the 5λ and 10λ antennas were computed by graphical integration of the power patterns derived from Eq. 1, and were found to be 10.8 db over an isotropic radiator for the 5λ antenna, and 13.4 db over an isotropic source for the 10λ antenna.

Optimum height of the antenna above the earth is computed as for any antenna, to produce phase addition of direct and earth-reflected signal components at the desired vertical angle. For example, at 60 Mc, for phase addition of direct and reflected rays at 5 deg above the horizon, the height must be 94 ft., and at 10 deg vertical angle, 47.2 ft.

Of the two antennas, the 5λ appears more suitable than the 10λ, since the main lobe width is larger, and is centered approximately 20 deg off axis. The side-lobe level of long-wire antennas in general is high, tending toward 6 db below the main lobe. This is a price paid for the simplicity of the antenna.

A 500 Mc model of a 5λ long-wire

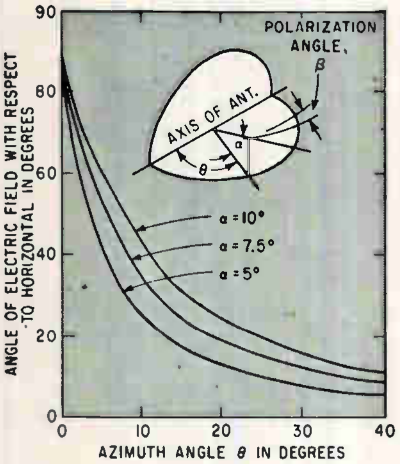

FIG. 2—Polarization angle of field radiated from wire antenna

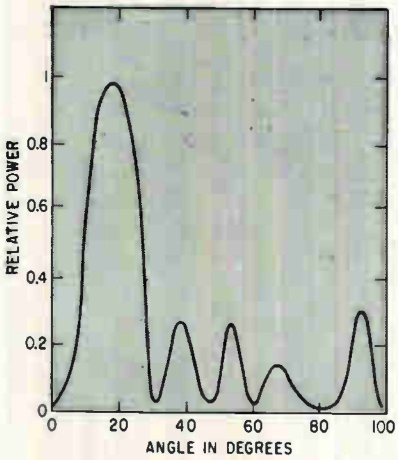

FIG. 3—Measured radiation pattern of 5λ wire antenna

antenna was constructed for pattern measurements. The model was used as a receiving antenna with a coaxial line coupling the antenna to a detector. A skeleton ground plane was used, consisting of four λ/4 rods perpendicular to the antenna. The measured pattern (partly shown in Fig. 3) compares closely with the theoretical pattern in Fig. 1A.

Power gains with respect to an isotropic radiator for the 5λ and 10λ model antennas were also computed by graphical integration of the measured power patterns. The gains found were 11.9 db for the 5λ antenna and 14.7 db for the 10λ antenna.

A full-scale model, designed to operate over a band of frequencies between 60 and 80 Mc, was made for impedance measurements, using No. 18 wire for the antenna and aluminum tubing for the skeleton ground plane.

The ground plane rods were adjustable in length and were mounted so that the angle between the rods and the axis of the antenna wire could be varied.

The expected impedance-against-frequency behavior of such an antenna is an alternating sequence of resonances, where the input resistance at the base is about 50 ohms, and antiresonances, where the input resistance may be high—perhaps 1,000 ohms, depending on the diameter of the wire. On the R-X plane, the impedance locus will be circular. The resonances occur when the antenna length is approximately an odd multiple of λ/4, and the antiresonances when the length is an even multiple of λ/4.

The measured standing-wave ratio on a 50-ohm coaxial line was close to unity at certain frequencies, verifying the prediction, and was high at frequencies in between. This behavior suggests installing the antenna with a standing-wave bridge, the total antenna length being adjusted such as to set the input impedance at a resonant point, corresponding to a point of minimum standing-wave ratio.

To bring down the antiresonant impedance, the single antenna wire may be replaced by two or more wires, fanning out to create a skeleton cone. This process was tried, using two wires, 65.5 ft in length, joined together at the feed end, and spread apart 3 ft at the far end (Fig. 4).

The maximum standing-wave ratio was brought down greatly by the skeleton cone construction. Since the range of impedance was now in the order of 50 ohms at resonance to 200 ohms at antiresonance, a quarter-wave matching section was used to bring the impedance circle down to the region above and below 50 ohms. A 2-ft 2-in section of RG-11/U (75 ohm) cable was used, this being λ/4 at 70 Mc.

The resulting standing-wave ratio-against-frequency over the 60-80 Mc band (Fig. 5) is under 2/1 over almost the entire range. This result was aided by experimental adjustment of the length of the ground-plane rods, as well as the angle of the rods with respect to the axis, to the final dimensions shown in Fig. 4.

The long-wire antenna offers a simple solution to the antenna problem in meteor-burst communications systems. The most desirable height above ground is exactly the same for the long wire as for a Yagi array, and installation at lower heights will reduce the performance to the same degree as with a Yagi.

Another way of mounting the long wire would require only a single mounting pole. The wire might be sloped from the single pole to the earth, thus forming, with the effect of the image antenna in the earth, a vertically oriented V-antenna. The feed point could be either at the top of the pole, or at ground. The optimum height of the pole could be calculated from V-antenna theory to produce maximum radiation at the desired vertical angle and azimuth angle. The pole height would be considerably less than that required for the horizontal long wire. Ground losses directly below the antenna, however, would be of greater importance in determining the efficiency of the antenna than with the horizontal wire.

The authors acknowledge the contributions of D. Sudman and P. Sorenson of Montana State College who participated in the development program.

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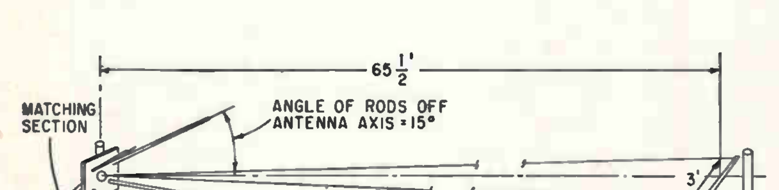

FIG. 4—Sketch of 5λ wire antenna with skeleton ground plane. With this construction, the maximum standing-wave ratio was brought down greatly

FIG. 5—Voltage standing wave ratio vs frequency on 50-ohm line exciting the 5λ wire antenna, with skeleton ground plane

Techniques embodied in this commutator simulator can be applied to generate almost any desired pulse group

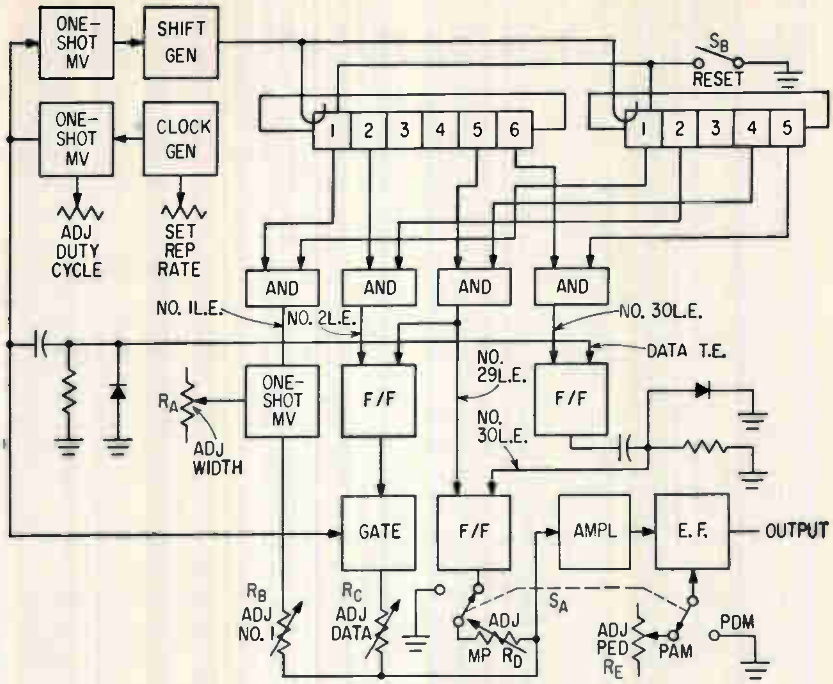

FIG. 1—Block diagram of pam/pdm commutator simulator shown for 30 pulses per frame with No. 1 adjusted in amplitude and width

Pulse Commutator Simulator Uses Magnetic Logic Elements

By JOHN PORTER,
Chief Engineer, Crestmont Electronics, Burbank, Calif.

IN THE testing or checkout of telemetry ground station equipment, it is convenient to simulate the output of the telemeter's commutator to avoid excessive wear on that device. It should be possible to vary the modulation on at least one pulse in the train and to provide for frame reference marks.

The techniques embodied in the device described here can be applied to generate nearly any desired pulse group. Some arbitrary pulse in a continuous train at the desired rep rate is selected and identified as No. 1 pulse.

For a 28-channel system, using two adjacent data pulses tied together as a master pulse, the next 27 pulses are then gated out. The master pulse is generated by a gate energized at the end of the count of 28, and turned off after 30 pulses. These three signals, the isolated No. 1, the gated 2 to 28, and the master pulse occupying positions 29 and 30 are ANDed and shaped to the proper level of amplitude and impedance.

Although a peak amplitude of 10 v is available with the transistors, there is no reason why the pulse train level cannot be made any level desired. To do the counting in this device, magnetic shift register elements are employed as synchronous or prime ring counters. This provides for a minimum number of elements, improves reliability and reduces power consumption. The device shown consumes 70 ma at 24 v d-c, or slightly over 1 watt of power.

In Fig. 1, a free-running relaxation oscillator, adjustable from 75 to 1,500 pps, furnishes clock triggers to a monostable multivibrator whose width is variable to control the pulse train duty cycle from 35 percent to 75 percent. The train consists of negative-going pulses whose leading edges trigger the shift pulse generator, another monostable multivibrator coupled to a power driver, where the width is set to 15 μsec. The trailing edges are used as the system clock, turning off the flip-flops.

A manual pushbutton inserts a ONE in the first element of each ring. Thereafter, the ONE's circulate or step along in each ring under influence of the shift generator. When an element contains a ONE, the shift pulse causes a voltage pulse to appear across the storage capacitor in that element of about 10 v amplitude, triangular shaped, and about 75 μsec wide at the base with a 1 μsec rise time. If the element is empty or contains a ZERO, the voltage pulse is about 1 to 1.5 v, thus enabling ready identification of the ONE's locations by amplitude discrimination. The rings have lengths of 5 and 6 elements, thus an ANDing circuit sampling the outputs of the No. 1 element in each ring will function only once for every 30 shift pulses. The ANDed outputs are thus completely unambiguous. The leading edge of No. 1 pulse is so obtained and used to turn on a one-shot multivibrator whose width is controlled by its R-C time constant. At the leading edge of No. 2 pulse, a second flip-flop is turned on and a trigger generated at the leading edge of pulse No. 29 turns it off. This wide pulse opens a gate allowing input data pulses to pass through. The leading edge of No. 29 pulse also turns on a flip-flop that initiates the master pulse. To shut off the master pulse at the trailing edge of No. 30 pulse, the leading edge of No. 30 is selected by similar ANDing and turns on a third flip-flop. The system clock (data pulse trailing edges) turns it off. Calibrated variable gain controls on the output of the No. 1 one-shot, wide gate and master pulse flip-flop allow each of the signals to be independently controlled, at the input of a linear summing amplifier. An adjustable negative pedestal is added at the output of the amplifier for true PAM simulation, while for PDM, the pedestal and master pulse amplitude are switched to zero to provide two consecutive missing pulses marking the PDM reference.

In the complete circuit (Fig. 2), which uses 22 transistors of a noncritical nature, Q_1 is a unijunction transistor forming a stable free-running oscillator whose frequency is determined by the R-C constants in its emitter circuit. The pulse train generator consists of the one-shot multivibrator Q_2-Q_3 triggered by Q_1 to form negative-going rectangular pulses whose duty cycle can be adjusted from 35 to 75 percent by the bias resistor in the base of Q_3. Leading edges of these pulses trigger a second one-shot multivibrator Q_4-Q_5 whose width is set to 12 to 15 μsec and a common emitter amplifier Q_6 amplifies these pulses to a 200-ma level. They are then applied to the shift windings of all the magnetic logic elements in series. The low-frequency register elements have a relatively wide tolerance curve, and a mean operating point of 200 ma at 15 μsec is applicable. The manual pushbutton S_B inserts the ONE in the first element of each ring by driving it to the $-B_r$ state and ZERO's in all other elements by driving them to the $+B_r$ state. The first shift pulse then sets the cores to the $+B_r$ state and generates a discrete positive output from the cores containing ONE's. As this voltage pulse decays, the next element is driven to the $-B_r$ state and the ensuing negative voltage pulse output is blocked by the diode in series with the output winding. Because the capacitor discharges slowly, the amplitude of the negative output is small. The second shift pulse drives the No. 2 cores to the $+B_r$ state and yields the usual voltage output. The ANDing circuits depend on the presence of two ONE's to turn off a *pnp* transistor (of which Q_7 is typical) that is normally just held in saturation; Q_7 generates a large negative spike during coincidence and triggers the following monostable vibrator Q_8-Q_9. Since PDM is required only at the fixed rate of 900 pps, the width control for Q_8-Q_9 one-shot is adjustable from 75 to 700 μsec by the panel control R_A (see Fig. 1). The amplitude of the pulse from Q_9 is determined by the setting of R_B, another panel control, to vary from zero to approximately the full supply voltage value. Another AND circuit Q_{10} functions at the leading edge of No. 2 pulse to turn on flip-flop Q_{11}-Q_{12}; Q_{13} is a similar AND circuit functioning at the leading edge of the 29th pulse turns Q_{11}-Q_{12} flip-flop off again. The wide positively going pulse at Q_{12} collector turns off gate transistor Q_{13} whose collector supply is the negative-going data pulse train from Q_3. Therefore, pulses No. 2 thru 28 appear at the collector of Q_{13} and are thus gated and applied to the emitter follower Q_{14}, which has level control R_C in its emitter circuit. This gate circuit is used instead of a diode gate because it is pedestal-free. The master pulse is generated by flip-flop Q_{16}-Q_{17}, which is turned on at the termination of the wide gate pulse from Q_{12}. The leading edge of No. 30 pulse is selected by Q_{18} AND gate and applied to flip-flop Q_{19}-Q_{20}. The positive-going trailing edges of the data pulses from Q_3 are obtained by differentiating, and restore Q_{19}-Q_{20} flip-flop to its original state. The trailing edge of No. 30 pulse is obtained by differentiating the output from Q_{19} and restores master pulse flip-flop Q_{16}-Q_{17} to its original state. This flip-flop is thus turned on by the leading edge of pulse No. 29 and off at the trailing edge of pulse No. 30. Should a 3 × master pulse be desired instead of the 2 × pulse described, the leading edge of pulse No. 28 would be substituted for that of No. 29. The master pulse level is determined by panel control R_D, a potentiometer across the output of Q_{17}. Negative-going pulses from controls R_B, R_C and R_D are summed through isolating resistors at the input of inverter Q_{21}, thence applied to Q_{22} emitter follower output stage. The positive-going pulses from Q_{22} are clamped to an adjustable negative pedestal by control R_E. For PDM operation, the master pulse from R_D is ignored and the summing resistor shorted to ground through a pole on switch S_A. In addition, the pedestal voltage is shunted to ground by another pole on S_A for PDM operation.

While but a single pulse is shown adjustable in either width or amplitude, the arrangement of having this as No. 1 enables worse conditions to be simulated and crosstalk evaluated. Other pulse trains can be generated; for example, an 88-channel system could use ring lengths of 8 and 11 with no other system change required. Power requirements for an 88-channel device are identical to the 28-channel system. The power requirements of these systems are met by a supply using a 26-v transformer, bridge rectifier, and pi-section RC filter. On the instrument, a panel meter monitors the level or width of the No. 1 pulse or the gated group of pulses No. 2 through No. 28. Packaged model has battery supply. Facilities are included for operation from an external trigger pulse source.

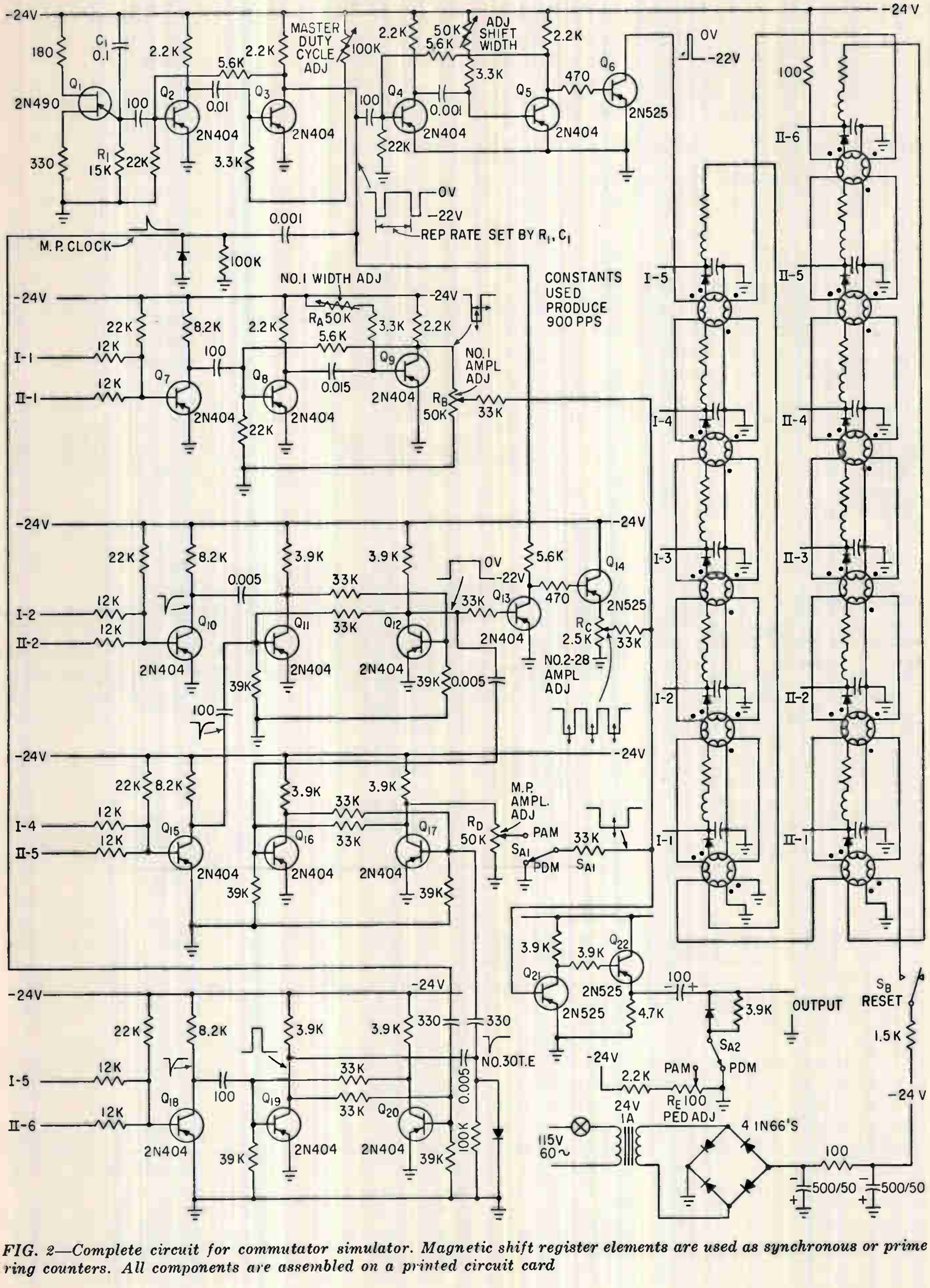

FIG. 2—Complete circuit for commutator simulator. Magnetic shift register elements are used as synchronous or prime ring counters. All components are assembled on a printed circuit card

Collecting Data From Live Missiles

Telemetering system small enough to go in operational missiles is silent unless abnormal condition is detected. Event commands are among data presented on oscilloscope

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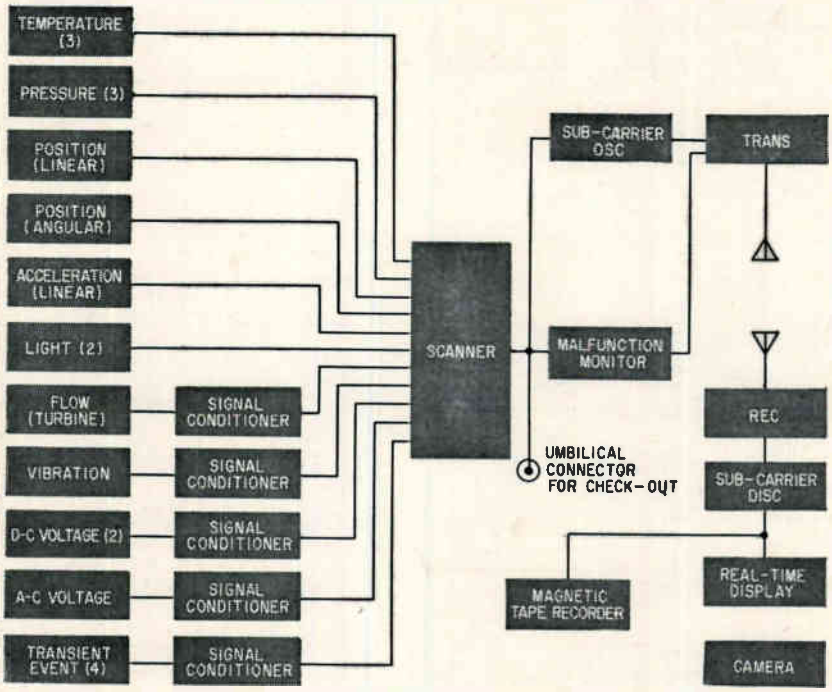


FIG. 1—Block diagram of missile monitoring system

IN-FLIGHT performance data on operational missiles is highly desirable to evaluate missile reliability and crew training, as well as to indicate the success of an actual wartime shot.

Conventional test data acquisition systems are not equipped to perform this function. Large quantities of information tax both the telemetry link and the data reduction and analysis system at the receiving end. Most data acquisition systems occupy as much space and weigh nearly as much as an operational missile's payload. Obviously, such telemetry systems are useless in an operational weapon.

To provide operational flight data, a tactical monitoring system was developed for the U. S. Navy Bureau of Weapons. The new system has demonstrated the following primary capabilities: simultaneous visual observation and analysis of a number of missile variables transmitted on a single telemetry channel; Go/No-Go monitoring, in which only abnormal signals are transmitted, thus permitting radio silence up to the final moment of attack; adaptability for use in a specific air-to-air missile, and real-time display of missile operation parameters.

The new tactical monitoring concept is accomplished with a system consisting of the following major function subsystems: a scanner to encode multiple input data, signal conditioning equipment, malfunction monitor, telemetry link, and simultaneous visual display of data.

Besides the requirements of maximum reliability with minimum size and weight, the instruments were also designed to cause no deterioration of missile performance. Solid-state electronics are used throughout, and moving parts used as little as possible. Input transducers were selected for simplicity and reliability. Input data selected for the prototype demonstration unit provides maximum information on a minimum number of channels. Figure 1 shows a block diagram of the system.

The solid-state scanner encodes multiple input data into a single pulse-coded signal for transmission over a single subcarrier channel of a telemetry system. The scanner, which consists of a free-running multivibrator developing a 960-cycle square wave output, is capable of handling 32 channels. The clock output is fed into a five-stage bistable multivibrator in a binary counter configuration. The counter drives a diode matrix so that, on any given binary count, 31 of the 32 matrix inputs are biased negatively with respect to ground, and the one remaining input is biased positively. An isolating diode connects each of the 32 inputs to a common output so that only positive input signals reach the output terminals. A series resistor in each input circuit prevents excessive loading.

With each successive clock pulse the binary counter transfers the effective output to a succeeding input channel. Automatic recycle occurs at the end of the sequence.

Only 20 of the 32 channels receive input variable signals. Channels 21 through 24 are connected to ground for zero reference. The

In Flight

Operator observes scope display of simulated missile in flight. Source of each signal is labeled on scope. All signals are within performance limits except Vibration and Voltage 2

remaining eight channels receive alternate ground and +5 volt inputs for calibration and synchronization. Binary outputs for scale of 16 and scale of 8 are brought out for synchronization or hold-off.

The high-speed scanner is constructed with rigid circuit design techniques. It has been operated over the temperature range of −6 to +200 F and a 25 percent change in input voltage with no degradation of performance. No crosstalk between input channels has been detected. Scanner output may be connected directly to the input of any of several commercially available subcarrier oscillators.

Since the prototype missile monitoring system was developed for no specific missile system, a wide range of input capabilities was demonstrated. The variables monitored in the prototype system include three temperatures, three pressures, linear and angular position, linear acceleration, light intensity flow, vibration, three voltages, two pulse commands, and two switched responses.

Other parameters could have been selected. Off-the-shelf transducers are available for measuring angular acceleration, target acquisition signals, and miss distance of active homing missiles.

The combination of analog measurements and Go/No-Go indications has been selected to provide maximum information with minimum burden on the human observer. An acceptance level on the face of the cathode ray tube permits the observer to ignore all signals that are within acceptance limits unless it is desired to analyze interactions between variables to pinpoint the origin of a malfunction.

The temperature ranges selected for monitoring are +70 to +200 F, +70 to −10 F, and +70 ±15 F. Any range between −100 to +600 F could have been selected and instrumented with stock-item thermistors. Thermistors that could be used above and below these limits are now under development.

The +70 ±15 F range was selected to demonstrate monitoring a narrow band of acceptable temperatures, as might be necessary with certain types of inertial guidance systems.

Since pressure measurements on board a missile range from thousands of pounds per square inch for hydraulic systems to millibars for altitude or velocity measurement, three ranges of pressure transducers were provided in the prototype.

Mechanical position is detected by potentiometers. Linear positions are sensed by a linear potentiometer in a voltage divider circuit and angular position by a sector potentiometer. Linear acceleration is measured by a potentiometer-type accelerometer.

Two channels are arranged to sense light intensity, using cadmium sulfide photodetectors. One provides increasing output with increasing light level and the other provides increasing output with decreasing light level. A similar arrangement could be used with infrared sensitive transducers for fire or overheat detection.

Flow measurement, such as that of a liquid propellant system, is made by a turbine flowmeter that generates an electrical pulse rate proportional to flow rate.

A piezoelectric vibration pickup measures vibration with a charge amplifier providing a suitable signal for wide-band telemetry. Since the bandwidth of this arrangement is too high for pulse-coded sequential telemetry, an average rms value is extracted to show acceleration due to sustained vibration. Conversion is accomplished with a transistorized amplifier.

Voltages are monitored by circuits which provide a +5 volt output when monitored voltage departs from preset limits. Three channels, each keyed to a different voltage range (two d-c and one a-c) are provided.

Two channels that provide a +5 volt signal in response to missile command are included. One responds to the opening of a circuit, such as rupture at a breakwire or actuation of a switch. The other responds to closure of relay contacts, as in monitoring a squibb-activated battery.

A command pulse detector monitors such missile-generated commands as activation, arming and fusing. This circuit requires no conductive connection to the monitor circuit, and can neither cause premature activation nor interfere with the monitored circuit. Connection to the monitored circuit is made through a wound toroid mounted on a bulkhead or bracket through which the monitored circuit passes. This weak electromagnetic coupling and low power level in the toroid insures against premature activation or weakening of the command pulse. The absence of metallic connection or break in the insulation precludes short circuiting of the monitored circuit. Two of these command pulse detectors are included in the prototype equipment. Their output is sustained until externally reset.

One of the pulse command monitoring circuits is shown in Fig. 2A. The command pulse conductor is fed through the toroid, which has a core with a rectangular hysteresis loop. The core is preset by current flow through R_1 and a portion of the toroid winding. When a current pulse of appropriate magnitude and polarity passes through the central conductor, the core material switches rapidly to the opposite magnetization. This large and sudden change in flux induces a large voltage pulse in the winding. The pulse is coupled through C_1 to the control electrode of Q_1, a solid-state thyratron or Trigistor, triggering it to the ON condition. This puts a +5 v output signal across R_2, indicating that the command pulse has occurred.

The toroid core was selected so that one ampere turn would take it through one complete state of magnetization to the other. Its core is grain-oriented, 50 percent nickel-iron with a wide, square hysteresis group. In locating the toroid, its orientation to the current flow in the signal conductor is important.

Nothing in the event command circuit compromises the integrity of the missile operating circuits. There are no direct connections, no terminals, no insulation breaks and no mechanical stress on the missile wiring system itself. The energy level of the toroid sensor is so small that it does not affect the missile wiring. The coupling to the missile conductor magnetic field is no greater than merely running the conductor through a bulkhead, so no appreciable energy is removed from the missile circuit.

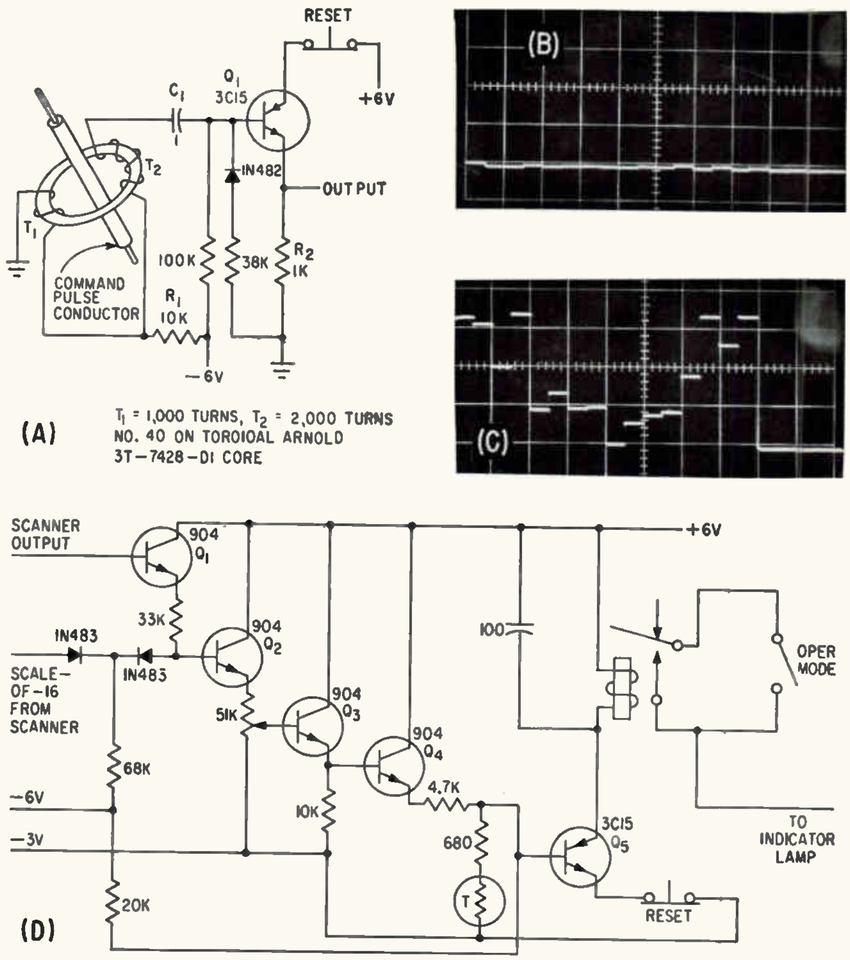


FIG. 2—Schematic of event command sensor (A); scope display (B) of 20 monitored channels shows no excursion from normal, thus missile functions perfectly, in which case transmitter would not be turned on until arming sequence begins; scope display (C) shows six channels are above X-axis limit, indicating malfunction of these six input variables; schematic of malfunction monitor (D)

This circuit has been tested to respond to all pulses of one or more amperes for one or more milliseconds over an operating range from −65 to +250 F.

Telemetry provided with the prototype consists of a 5-w transmitter crystal-controlled at a frequency of 237 Mc. Two subcarrier oscillators with center frequencies of 40 Kc and 70 Kc provide data and synchronization channels.

An unmodified cathode-ray oscilloscope provides visual display. No decoding equipment is necessary and the oscilloscope is operated directly from the discriminator output of a telemetry receiver (Figs. 2B and 2C).

In a tactical situation it may be desirable to maintain radio silence during most of a missile flight. Therefore the prototype contains a feature in which the telemetry transmitter is silent until the arming command is delivered unless an abnormal condition is detected. This circuit is shown in Fig. 2D.

Scanner output is fed to the base of transistor Q_1, and a signal from the scale-of-16 stage of the binary counter is fed to the base of Q_2. The signal from the binary counter is positive during the scanning of the first 16 channels, and negative during the last 16. When this signal is negative, the base of transistor Q_2 is held at a negative potential by current flow through the 68,000-ohm resistance to the −6 v supply. This biases the transistor to cutoff, and the circuit cannot be triggered to the ON condition.

The signal to the base of Q_2 during the last 16 scanning intervals is negative so that the calibrating pulses cannot trigger the circuit. The polarity of the base of Q_2 dur-

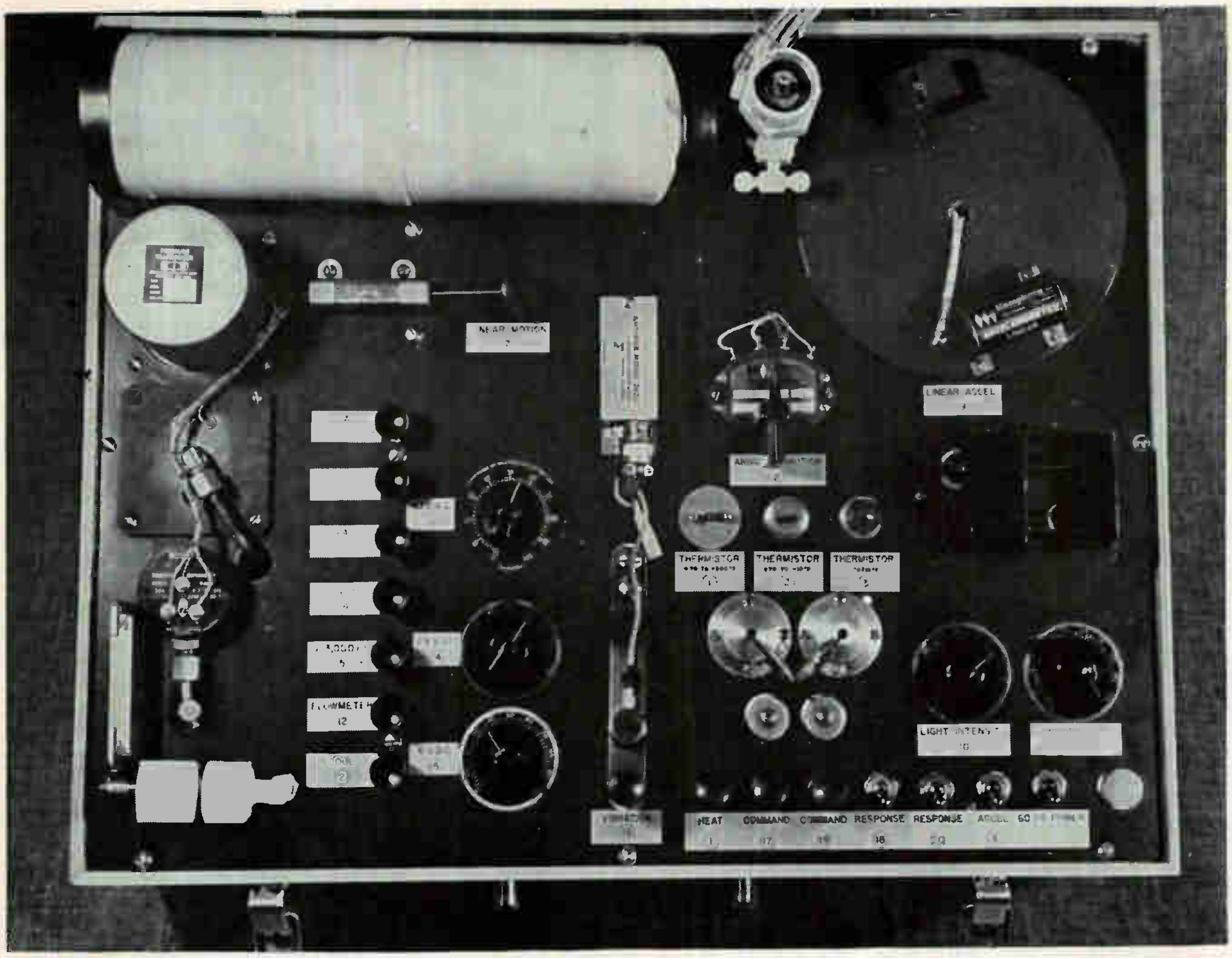


FIG. 3—Monitoring system is tested by transducer activator which presents physical or electrical variables to each transducer in a preprogrammed pattern to simulate actual missile flight and establish that each variable can be monitored effectively. The circled numbers refer both to channel order and to signal position on scope

ing the first 16 scanning intervals is positive, and any pulse of positive polarity reaching the base of Q_1 during this period causes current to flow in transistors Q_1 and Q_2. If the pulse is of sufficient magnitude, the potential at the tap of the 50,000-ohm potentiometer, which is connected to the base of Q_3, becomes high enough to cause Q_4 to conduct and initiate conduction in Q_5, a 3015 silicon Trigistor. Once current has been established in this element it continues until the supply voltage is removed. The current flowing in this element actuates the relay that supplies power to the telemetry link.

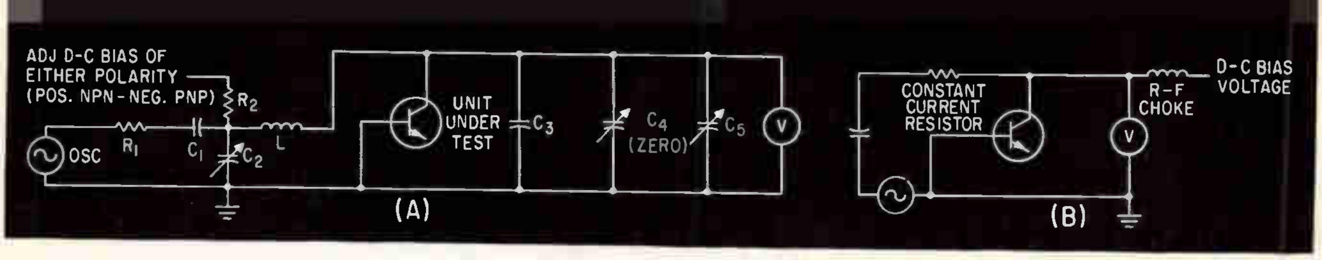
A switching arrangement permits this relay to be bypassed for firings in which continuous data is desired. If this switch is in the open position, however, the telemetry link is not activated until the arming pulse at channel 17 is delivered, or earlier if an abnormal signal has occurred in the first 16 channels.

To test the system, an input simulator was constructed to activate each input transducer with physical or electrical variables. Temperatures, voltages, pressures, accelerations, and other variables were presented to the transducers and measuring circuits to establish that each could be monitored without difficulty (Fig. 3).

A second device was fabricated to generate simultaneous scanner inputs in a preprogrammed pattern to simulate excursion of each variable as might occur during flight. A display pattern indicating perfect missile functioning is shown in Fig. 2B. Figure 2C shows a pattern indicating multiple malfunction.

The ultimate application of the system might be to determine the tactical effect of a long-range air-to-air missile to establish the need for launching a second missile at the same target.

The penalty associated with the penetration of a single enemy aircraft carrying modern weapons is so high that extreme measures are justified to make certain the maximum number of kills is achieved. The tactical monitoring system embodies the concept that rather than launch multiple missiles at each target, the probable effectiveness of each missile would be analyzed in real time, and a reserve missile would be launched only if the first did not accomplish its mission. The value of the system in establishing quality control and launching proficiency would be secondary.



Capacitance measurement techniques include the Q meter (A) and reactance drop methods (B)

MEASURING

Semiconductor Junction Capacitance

By GERALD C. SUMMERS,
Vice President, Summers and Mills, Inc., Dallas, Texas

IN HIGH-FREQUENCY and switching circuits, transit time phenomena and distributed capacitance are equally important. Diode and transistor junction capacitance is frequently not specified by manufacturers, or only an average or peak value measured at a single voltage is given. Capacitance varies with voltage and the design engineer often must fit a device to a need. This article describes instrumentation that can be used at the production or design level to control the capacitance factor.

There are several commonly used techniques by which junction capacitance can be measured, all requiring a measuring a-c voltage small compared to the d-c bias. Case, and to some extent, lead capacitance is incorrectly considered as part of junction capacitance since there is no easy way of separation. The test socket can be designed to eliminate most of the lead capacitance. In diodes it is occasionally desired to measure junction capacitance under zero bias. The peak value of the measuring a-c voltage must not approach the junction forward breakdown voltage, approximately 0.3 v for germanium and 0.6 v for silicon.

In the Q-meter method of capacitance measurement an oscillator signal usually at 1 Mc is injected into a tank circuit across a small resistor or a large capacitor (C_2 in Fig. A). Preliminary adjustment is made with zeroing capacitor C_4 so that with the incremental dial at zero or maximum capacitance the high-impedance meter reads maximum. Oscillator amplitude is varied by C_2 or other attenuating means so that the voltage across the tank circuit is approximately 0.1 v rms. Finally the transistor or diode to be tested is inserted into the test socket and incremental capacitor C_5 is reduced to the new resonant point indicated by peaking of the meter. The dial is calibrated in capacitance and the value is read directly. While not suited to high-speed production work this method is accurate when low-capacitance devices are involved. Instruments for operation at single frequencies from 100 Kc to 50 Mc employ low measuring voltage and give an accuracy of ±0.1 pf from 0 to 13 pf.

In the reactance drop method of Fig. B, an amplitude-regulated oscillator drives a large, nonreactive resistor, whose resistive impedance is much higher than the reactive impedance of the smallest junction capacitance to be measured. Therefore, a constant current flows. Range change is obtained by switching the constant current resistor. The signal level measured by the high-impedance, low-capacitance voltmeter is inversely proportional to junction capacitance. The method is useful in high production work and accuracy may be high. The method works best with high junction capacitance but at 1 Mc it can be made to measure accurately at capacitances above 10 pf. Readout can be on analog or digital meters.

The Tektronix Type 130 L-C Meter is frequently used for junction capacitance measurements. The unit consists of a fixed oscillator tuned to 140 Kc that is beat against a variable-frequency oscillator whose frequency is determined by a fixed known capacitance in parallel with the unknown. The two oscillators are zero beat against each other before the unit under test is inserted and thus the test junction reduces the frequency of the variable frequency oscillator. A frequency counter measures frequency difference and the meter is calibrated in capacitance in five scales, 0-3, 10, 30, 100 and 300 pf. At 300 pf the frequency shift is approximately 16 Kc.

The r-f voltage at the test terminal is specified to be less than 1 v rms, a high value for diode measurements.

Since the output terminal is grounded to d-c, an isolating capacitor, external power supply and r-f choke, must be used to apply the junction bias voltage. These instruments have been modified so that their internal power supply applies positive or negative biasing voltages of zero to 20 v at the output terminal. A jig then allows the instrument to become a complete junction capacitance test set. These instruments have also been modified to work at 100 Kc. A 1-Mc version has been developed. The advantages of this instrument are its economy and simplicity. Readout can be by the meter, or by a digital counter since capacitance is read as a frequency difference. The technique lends itself to high production work. Disadvantages are that accuracy is limited, measuring voltage is higher than can sometimes be tolerated and oscillator drift is a problem on measurements of 30 pf or less.

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Calculating Transformer Coupling Coefficients

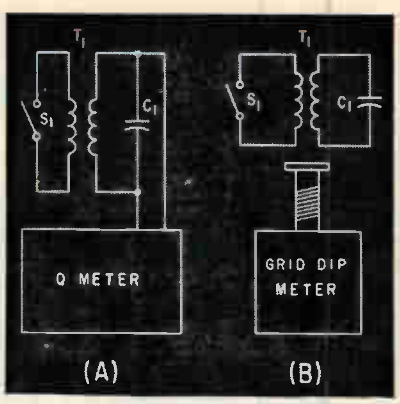

FIG. 1—Test setups for obtaining coupling coefficients of T_1

By DOUGLAS E. MacLAUGHLIN, HERBERT F. SPIRER,
Engineering Information Associates, Inc., Stamford, Conn.

THIS ARTICLE describes a test for determining r-f transformer coupling coefficients and gives two nomographs to calculate these coefficients rapidly.

The test setup is given in Fig. 1. Capacitor C_1 resonates the transformer primary. The resonant frequency is measured either with a Q meter, as in Fig. 1A, or with a grid dip meter, as in Fig. 1B. This frequency is first measured with switch S_1 open, and then with S_1 closed. The frequencies so measured are designated f_o and f_c. The value of coupling coefficient k is given by $k = (1 - f_o^2/f_c^2)^{1/2}$.

The form of switch S_1 will depend on the application. The main requirement of the switch is that its impedance at measurement frequencies be negligible compared to that of the transformer in the short-circuited configuration. Short test leads are desirable.

Figure 2 is a nomograph for calculating k from the measured values of f_o and f_c. Figure 2 is used for values of k from 0 to 0.92. For k's greater than 0.92, use Fig. 3. If a high value of k is expected, f_o must be measured first, and the value of C_1 adjusted so that f_o be greater than 0.7 Mc. Otherwise, f_o may not fall on the nomograph scale; indeed, it may be below the range of most Q meters.

The accuracy of the method and the precision of the nomographs decreases for lower values of k, reaching a practical limit below about 0.3. For coils with k less than 0.3, it is better and more convenient to perform the calculations, or use tables such as those contained in the reference.[1]

To use the nomographs, pass a straight line through the measured values of f_o and f_c. Read the value of k from the coupling coefficient scale. In the example indicated by the slant line in Fig. 2, f_o = 20 Mc, and f_c = 30 Mc. The intersection of this line with the k axis shows that k = 0.745.

REFERENCE

(1) Landees, Davis and Albrecht, "Electronic Designer's Handbook," p. 1-18 to 1-22, McGraw-Hill Book Co., Inc., New York, N. Y., 1957.

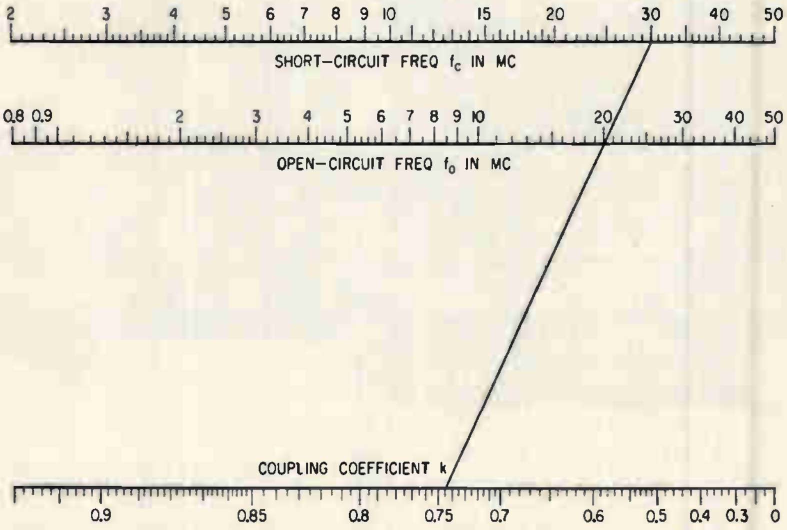

FIG. 2—Use this nomograph to obtain values of k up to 0.92

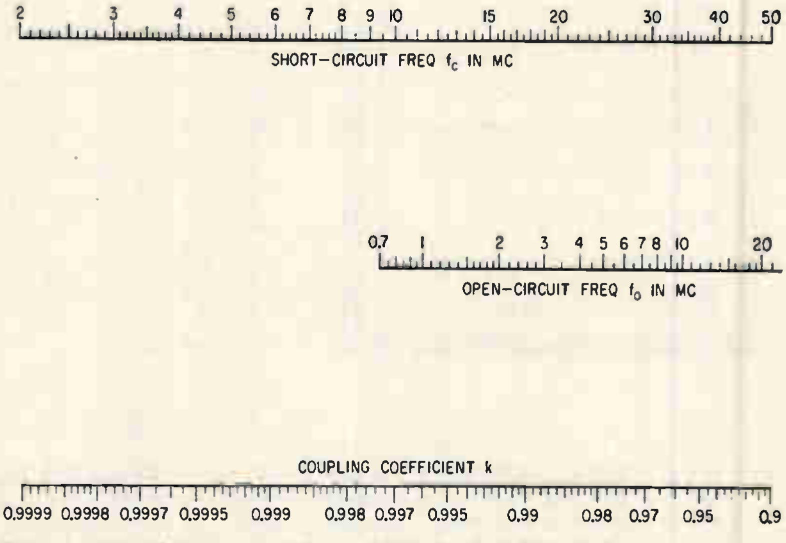

FIG. 3—Use this nomograph to obtain high values of k


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Innovations Simplify NMR Spectrometer

REDUCTIONS in complexity, size and cost of a new nuclear magnetic resonance spectrometer have been made possible by a number of electronic innovations. In combination they have made possible an instrument that is accessible to smaller laboratories and can be operated by personnel with limited training.

The new analytical tool was announced at the recent Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy by Varian Associates. It is expected to provide insight into the complex molecules of organic compounds. The spectrometer is applicable to products such as antibiotics, enzymes, vitamins and insecticides. It could significantly influence such industries as food and petroleum.

The nuclear magnetic resonance (NMR) spectrometer produces a permanent, repeatible record of the location and character of hydrogen atoms within a molecule, providing important clues regarding molecular structure. Operation is based on the behavior of nuclei of atoms such as hydrogen which precess when rotated from their spin axes by a strong magnetic field. Precession rate is determined by characteristics of the particular nucleus and is exactly proportional to magnetic field strength. The nucleus absorbs or releases r-f energy at the rate of precession.

The high-resolution spectrometer can distinguish between the nuclear magnetic resonances of different hydrogen nuclei because the applied magnetic field experienced by each nucleus in a molecule is altered a definite amount by the presence and position of adjacent nuclei and electrons. Because of the direct relationship between nuclear magnetic resonance frequency and intensity of the magnetic field, sweeping the field separates the resonant peaks of hydrogen nuclei characteristic of the structure of the particular compound.

Production of the highly uniform magnetic field required for this type spectroscopy was achieved with a 6-inch magnet. Although only half the size of the magnets used in laboratory-type NMR spectrometers, it provides the same field of 14,092 gauss. Other factors contributing to its high resolution (1 part in 10^8) are a solid-state, water-cooled current supply for the field coils and provisions for adjusting current through control coils to maintain a homogenous field.

A major factor contributing to the high resolution of the instrument is maintaining the relation ship between field strength and frequency, rather than controlling the two independently of each other. A water control sample is used as a constant reference to maintain the relationship.

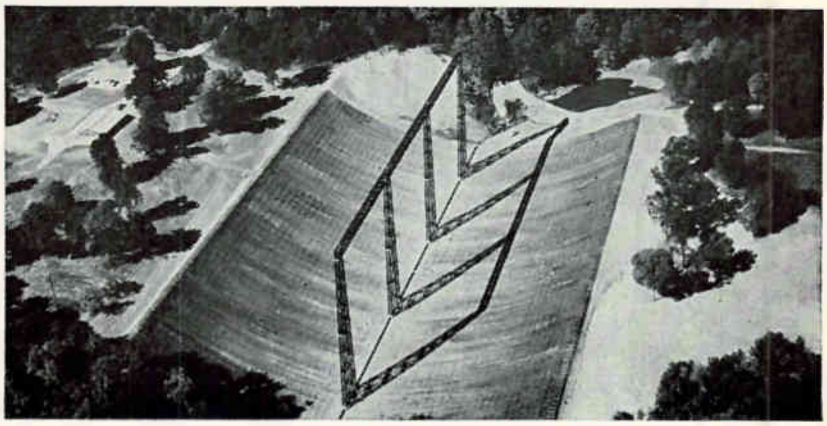
A double probe holds both the water sample and the sample to be tested. The two samples are shielded from each other and are prevented from affecting the magnetic field. A 60-Mc transmitter provides electromagnetic energy to both samples through coils.

A field modulator contains a nuclear sideband oscillator that provides a signal of about 5 Kc to modulating coils in the probe. The control sample is thus subjected to the 60-Mc carrier with sideband signals of 60 Mc plus 5 Kc and 60 Mc minus 5 Kc. Pickup coils in the probe provide this signal to a control receiver where it is demodulated and the 60-Mc carrier is removed. The upper 5-Kc sideband is selected, amplified in the field modulator and fed back to the modulating coils.

If the correct field-frequency relationship does not exist for nuclear magnetic resonance of the water sample, frequency of the nuclear sideband oscillator is altered in the appropriate direction. However, frequency of the sideband oscillator is limited to a range of about 4 Kc to 6 Kc. If a frequency change outside these limits is required, a d-c voltage is provided by the field modulator to the 60-Mc transmitter to provide a greater change in frequency to the sample.

To provide the spectral chart, field is changed in the magnetic field strength-frequency relationship by sweeping field current. A recording pen is swept across the calibrated spectral chart synchronously with the change in field strength. The nuclear resonances of hydrogen nuclei in the material being tested are detected and recorded as peaks on

Exploring Space for R-F Sources



Parabolic reflector 600 ft long at U of Illinois will be used in five-year project. Nonuniform spacing of 275 log spiral elements provides one-third degree width of steerable beam in installation sponsored by Office of Naval Research



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SM 36-5M	0–36	0–5	SM 36-15MX
SM 75-2M	0–75	0–2	SM 75-2MX
SM 160-1M	0–160	0–1	SM 160-1MX
SM 325-0.5M	0–325	0–0.5	SM 325-0.5MX

5¼" PANEL HEIGHT

0.1% REGULATION MODELS	DC OUTPUT RANGE VOLTS	DC OUTPUT RANGE AMPS	0.01% REGULATION MODELS
SM 14-15M	0–14	0–15	SM 14-15MX
SM 36-10M	0–36	0–10	SM 36-10MX
SM 75-5M	0–75	0–5	SM 75-5MX
SM 160-2M	0–160	0–2	SM 160-2MX
SM 325-1M	0–325	0–1	SM 325-1MX

8¾" PANEL HEIGHT

0.1% REGULATION MODELS	DC OUTPUT RANGE VOLTS	DC OUTPUT RANGE AMPS	0.01% REGULATION MODELS
SM 14-30M	0–14	0–30	SM 14-30MX
SM 36-15M	0–36	0–15	SM 36-5MX
SM 75-8M	0–75	0–8	SM 75-8MX
SM 160-4M	0–160	0–4	SM 160-4MX
SM 325-2M	0–325	0–2	SM 325-2MX

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HB 4M	0–325	0–400	HB 40M
HB 6M	0–325	0–600	HB 60M
HB 8M	0–325	0–800	HB 80M

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MODEL	DC OUTPUT RANGE VOLTS	DC OUTPUT RANGE AMPS
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PR 38-15M	0–38	0–15
PR 80-8M	0–80	0–8
PR 155-4M	0–155	0–4
PR 310-2M	0–310	0–2

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the chart. To provide quantitative information to the analytical chemist, the individual peaks can be integrated over the swept range.

Analyzer Shows Gamma Energy Distribution

ENERGY distribution of gamma radiation can be determined with an electronic gray-wedge pulse-amplitude analyzer. The equipment is less complex and less costly than a multichannel pulse-amplitude analyzer often used for the study of radioactive materials, and it operates about one hundred times as fast. The instrument is being developed for the United Kingdom Atomic Energy Authority by Telecommunications Ltd.

Scintillation counters convert gamma radiation into electrical pulses with pulse amplitude proportional to energy. Each pulse is used to deflect the beam of a crt horizontally a distance proportional to pulse amplitude. During the time that the beam is deflected horizontally, the spot is also deflected vertically by a sweep circuit. Hence each pulse produces a vertical line at a horizontal position determined by pulse amplitude.

A nonlinear vertical sweep is used so that brightness varies linearly from top to bottom. As a result, energy distribution across the display can be viewed at an intensity level where differences in brightness are most apparent.

A long-exposure photograph is made of the display so that many verical lines are superimposed. By making a high-contrast photographic print, pulse amplitude distribution is indicated by light and dark areas with sharply defined density boundaries.

The gray-wedge analyzer is capable of higher operating speeds because it will have a dead time of about one-third microsecond. A multichannel analyzer may have a dead time of about 100 μsec.

The principle of the electronic gray-wedge pulse-height analyzer has been in use for more than a year at Harwell. A modified Tektronix oscilloscope is being used and time resolution of about 4 microseconds is being obtained.

The instrument being developed

is planned to have amplitude resolution of 100 channels, time resolution of one-third microsecond and sensitivity sufficient to permit operation directly from scintillation counter output.

Weather Data Processor May Improve Forecasts

METEOROLOGICAL data processor is expected to provide information quickly and accurately to forecasters. Data about the vertical structure of the atmosphere will be electronically computed, eliminating errors of manual computation.

A feasibility model of the equipment has been received by the Meteorological Laboratory, Air Force Cambridge Research Laboratories. The special-purpose analog-digital converter is officially called Converter, Radiosonde Data CV-692/GMD, according to the Air Force Office of Scientific Research.

A feature of the system is a precision function generator that converts an input analog signal representing altitude into a digital output signal corresponding to pressure of the Air Research & Development Command Standard Atmosphere. This value of pressure is then modified using additional computing circuits in accordance with measured temperature and humidity distribution to yield the actual value of pressure.

The precision and versatility of digital computation are combined in the processor with low-cost analog techniques. As a result, a highly effective system is afforded for widespread field use at reasonable cost. The processed data is provided in the form of punched teletypewriter tape, which is suitable for transmission over high-speed communications networks.

Vertical distribution of temperature, pressure and humidity throughout the atmosphere is essential information for modern forecasting. The Air Weather Service uses radio direction finding and receiving equipment in conjunction with a balloon-borne sensing and telemetering device to gather this information. Processing the raw data into a form suitable for use by forecasters requires considerable computation.

Materials Push for Higher Temperatures

INCREASED TEMPERATURE timetables for electronics gear keep pushing up the heat requirements. The 200 C and 500 C performance objectives are now established in many areas such as component packaging, resistive elements, ceramic dielectrics, printed circuits, metal oxides, porous potting, and conductive materials. Some of these are now being pushed up into the 750 C and 1,000 C ranges.

Not long ago, Air Research and Development Command scientists stated their requirements for a woven fiber that can stand at least 1,500 C without melting or otherwise deteriorating. These needs arise from aerodynamic heating in reentry or boost phases of missiles.

Through an evaluation program, the government expects to come up with a replacement for nylon, to be used in decelerators, manned satellites and space suits. Nylon must be replaced because it melts at higher temperatures[1].

Scientists are now working on fibers made of gold-plated tungsten and molybdenum, glass, ceramics, super alloys and other materials to determine their use for outer space gear.

Although made of metal, these fibers are so fine they look like cobwebs, but they are not fine enough. The ideal metallic fiber must be at least as fine as a filament of nylon yarn—0.0002-mil in diam—finer than the average human hair. Then they can be woven to give resilience, flexibility and tear strength. The principle fiber work is now with a new class of metals, the superalloys, which are combinations of nickel, chromium, iron, molybdenum and other metals.

An all-organic, heat resistant fiber which retains its flexibility and part of its strength after exposure to intense heat was recently announced[2].

This fiber, called Pluton, can be worked into laminates reinforced with high-temperature phenolic resin to form structural parts or molding compounds. The fiber is entirely free from elemental carbon, and conducts very little heat or electricity. Potential uses are in missile motor case liners, insulation for drag-chute compartments in high-speed jets, antiarc wraps in power plants, and light-weight fire-protective curtains in mines, factories and buildings.

In the form of a laminate, approx 50-50 combination with phenolic resin, the fiber is being used in tests of rockets engine parts.

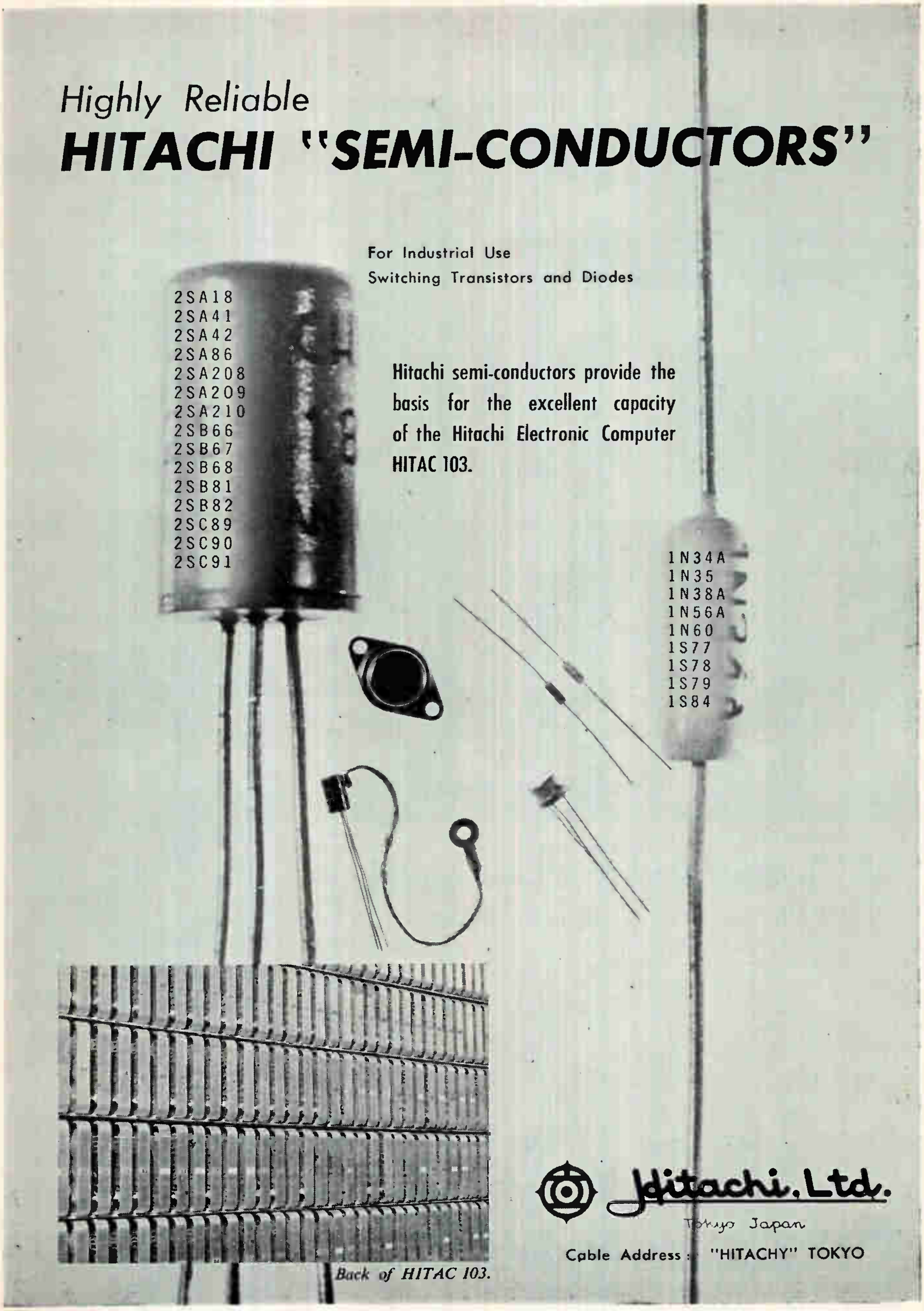
The fiber has been exposed in a plasma jet to temperatures up to about 975 C without melting. During a recent demonstration, a one pound slug of molten steel, heated to 1,650 C was poured into an unsupported one-pound-per-sq-yard sample of the fabric which was stretched across a frame. The molten steel solidified on the fabric without burning through it.

At this same company, other fibers are being developed which have a controllable degree of thermal and electrical conductivity. By mixing different types in a phenolic laminate, they expect to achieve any intermediate property of conductivity.

Experimental continuous-filament fibers capable of withstanding temperature degradation up to 850 C and exhibiting tensile strength of up to 132,000-lbs/sq in

Monkey Business at the IRE Show

Murph, a simian used for space research, has been performing at the International Rectifier booth at the IRE show this week. Here Murph is shown demonstrating a super power rectifier column used in early radar warning systems and linear accelerometers for nuclear research



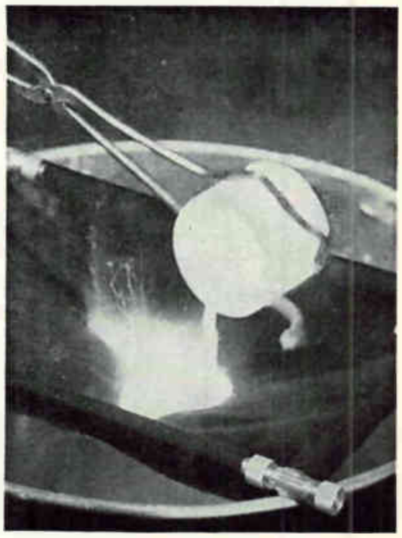
Back of HITAC 103.

at this temperature have been developed for the Air Force. High-temperature tests and melting, and fining of the fibers are described in a research report recently issued[3].

Protection of equipment and personnel from high-radient heats is now possible with an aluminized silicone rubber coated glass cloth[8].

Reflecting more than 90 percent of the infra-red rays generated by a thermal source, and absorbing much of the remaining heat, these SRGA fabrics are used as protective shields. Several types of these thermal barrier fabrics are now used.

Another company[4] has expanded its line of fire-retardant industrial laminates with the addition of a new glass-epoxy laminate which combines rapid self-extinguishing qualities with excellent electrical and machining properties. These laminates were developed to minimize the hazards of fires caused by high voltages in computer circuits. Their second new grade is a paper-base phenolic laminate for circuits which require flame-retardant and cold-punching properties.



Cradle made of organic fiber takes a slug of molten steel, heated to 1,650 C

Electronic circuits printed on metal, instead of the conventional plastic laminates are now available[5]. Capable of withstanding temperatures in excess of 500 C (nearly twice that of ordinary printed wiring), the new circuits will be marketed under the name Dielox.

The new printed boards are not limited in size and are not subject to the warping and breakage which

A ten-ply laminate of Pluton fabric, reinforced with a phenolic resin, withstands 2,750 C. Operator's fingers are just three inches from the hot spot

has hampered the clad resin laminates now in use. With superior thermo-dimensional stability, exacting fabrication dimensions can be maintained, even when formed for three-dimensional circuits. The Dielox base can be color-coded for identification.

A new mica and glass lead wire capable of reliable operation up to 538 C is now available[6]. Known as Tetralene MGT, the wire maintains a dielectric strength of 1,000-v and successfully sparked-tested at 2,000-v. Insulation resistance is maintained at above 10,000 megohms. Flexibility is more than satisfactory.

Insulated wire and cable suitable for 1,000 C[7] and application of high temperature insulation in materials to fuzes and terminals[8] were described at the Electrical Insulation Conference during the winter at Chicago.

REFERENCES

(1) Air Research and Development Command, Office of Information Services, Andrews Air Force Base, Washington, 25, D. C.

(2) Minnesota Mining and Manufacturing Co., 900 Bush Ave., St. Paul, Minnesota.

(3) W. A. Lambertson and others, Continuous Filament Ceramic Fibers, The Carborundum Co., for Wright Air Development Div., USAF, June 1960, 84 pgs., Order from OTS, U. S. Dept. of Commerce, Washington 25, D. C., $2.25.

(4) Formica Corp., a Subsidiary of American Cyanamid Co., Cincinnati, Ohio.

(5) H. E. Jones, Vice President, Electralab Printed Electronics Corp., Needham Heights, Mass.

(6) American Super-Temperature Wires, Inc., West Canal St., Winooski, Vermont.

(7) R. W. Anderson and A. Hubbard, Lewis Engineering, Naugatuck, Conn.

(8) M. D. Lazar, Burndy Corp., Norwalk, Conn.

Fusible Metal Makes Encapsulation Molds

By L. LEONARD and J. LOCKNER,
Assembly Supervisors,
Raytheon Co., Bristol, Tenn.

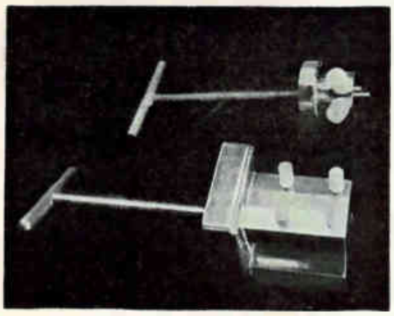
MOLDS FOR POTTING components are made at Raytheon-Bristol by an unusual method which eliminates problems of mold maintenance and replacement. The technique is used to make molding forms for all transformers produced here.

An aluminum master die is machined to the shape desired for the component and is highly polished. Pins and Teflon caps provide for mounting nuts which are molded in the component.

The die is dipped into a low-melting solder (Cerrotru, Cerro de Pasco Sales Corp.). The molten metal solidifies into a thin shell around the die. The die is removed from the pot and, while the metal is still hot, the shell is slipped off the die. The pins and caps are removed for this operation.

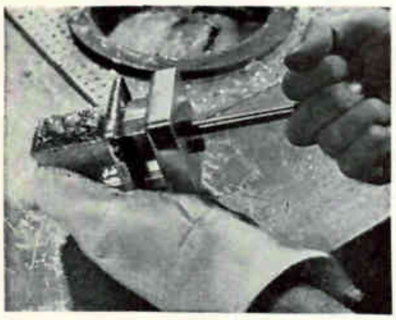
The transformer assembly is positioned in the mold. Silicone rubber inserts protect terminals from the potting compound and give the desired terminal height after potting. The molds are placed in pouring position, the resin is poured and the molded part is oven-baked.

The transformer is removed from the mold by tapping the mold with a plastic mallet. Damaged molds are tossed back into the melting pot. Any number of molds can be made easily. The mold material can be remelted and reused repeatedly.



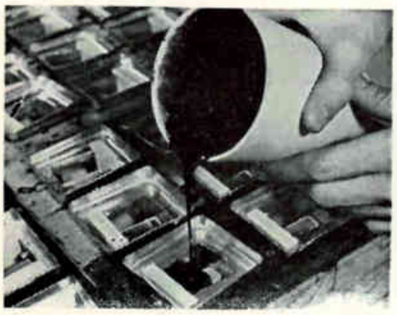
Master dies for transformer molds

Master is dipped into pot of metal



Thin shell of metal is removed

Transformer assembly is positioned



Resin is poured over transformers

Mold is tapped to release part

Solder Coated on P-C Conductors by Rollers

Bottom roller picks up solder

SOLDER COATING is frequently applied to printed circuit boards to protect the copper conductors and improve soldering. At the Convair Division of General Dynamics Corp., Pomona, Calif., the coating is rolled on with a machine similar to a printer.

The machine contains two three-inch steel rollers, one surfaced with Teflon and the other nickel-plated. The metal roller revolves partially submerged in molten solder. It transfers solder to the conductors when the boards are passed between the rollers. Solder temperature is maintained at 515 F, ± 10 degrees. A layer of wax and rosin floated on top of the solder bath prevents dross formation.

Boards are prepared for coating by scrubbing with cleanser, water rinse, chemical cleaning (Brite Dip C), water rinse and liquid flux dip (Divco 388). After coating, they are cleaned in solvent (Chlorothene) and rinsed.

Assembled boards are dip-soldered in a conveyor type machine. Boards are transported in multiple holders of stainless steel. They are dipped at a three-degree angle, to

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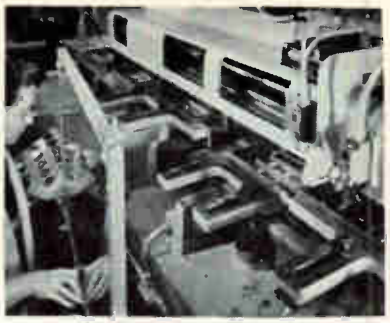


Dip-soldering machine

allow gas to escape, for 4.5 seconds, then held momentarily over the bath to level off solder buildup.

A eutectic solder (63-37) is used. The boards are used in missile systems. According to Convair, the combination of roller coating and dip soldering has reduced faulty connections and costs.

Infrared Optic Cone Is Polyester Film

By RUSSELL DeWAARD,
Head, Applied Physics Section,
Barnes Engineering Co., Stamford, Conn.

POLYESTER PLASTICS and cements are chief materials used in constructing the two-channel infrared radiometer sent aloft in Tiros II.

The cone is cut from 2-mil film, using a metal template. The shaped blank is held around a jig with string after a thin strip of cement has been inserted in the seam. Oven curing at 160 C for 10 minutes polymerizes the cement and firms the cone, which is then trimmed.

Two cones are cemented to an aluminum base plate, previously covered with a 3-mil insulating layer. A spring-loaded jig aligns the cones on the plate. The exteriors of the cones are cleaned with acetone and aluminized.

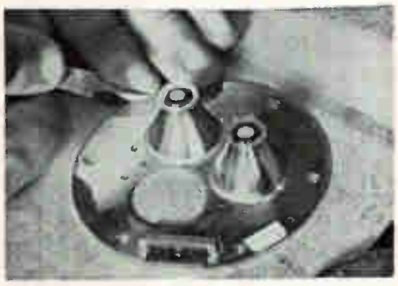
Thermistor detector flakes are mounted on a six-strand grid of acrylic fiber. Each strand, containing 20 filaments, is about three mils

Form is placed in mandrel and cementing strip put in seam in diameter. The grids are formed on a three-mil washer of polyester film and cemented between that and another washer. The completed grid is mounted on the cone.

Detector flakes are cemented to the grid and the leads are wrapped around the strands and cemented to the cones. Polyester discs are placed over the cone ends. The active sides of the flakes are coated with thinned polyester. Electrical connections are then made to resistors and the connector. Resistors are calibrated and rejacketed with film.

Spring-loaded jig aligns cone

Grid is prepared under microscope

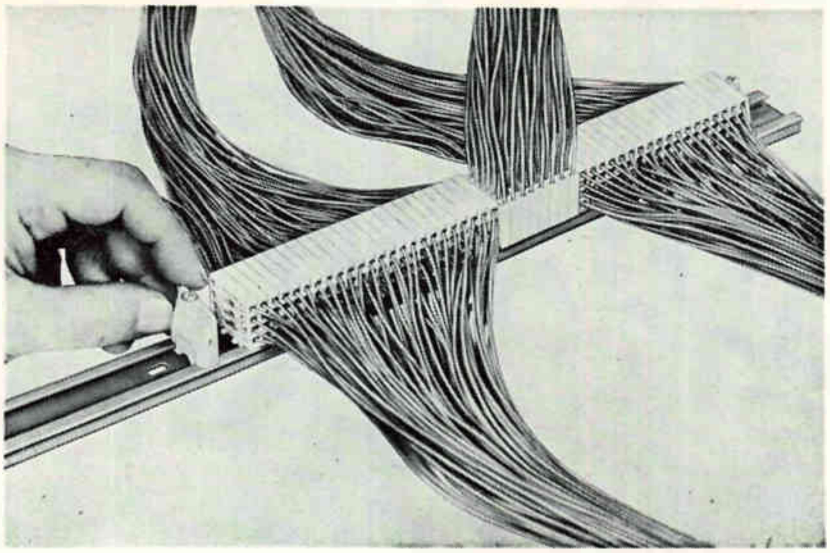


Grids are mounted on top of cone

Gold is vacuum-deposited on the back side of the cone to minimize heat transmission. The connector is cemented to the base plate. A preliminary calibration is made while the radiometer is in an environmental chamber.

Remaining components are added. The circuitry is coated with liquid polyester and cured at 160 C. One detector is coated with white and the other with black. The top of the cone receives a thin layer of polyester and another coating of gold.

New On The Market



Modular Connector
SNAP-IN CONTACTS

MODULAR terminal block with crimp contacts has been announced by Burndy Corp., Norwalk, Conn. The Minilok provides 100 connections in 2½ inches. Top and side feed nylon modules may be interlocked on a PVC rigid plastic track.

A variety of bussing configurations permit flexibility and snap-in contacts simplify wiring; sockets are heat treated beryllium copper springs.

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Microvolt Modulator
PHOTOCELL PRINCIPLE

TWO MINIATURE light sources, blinking on and off at up to 1,500 cps, are used in microvolt modulator now available from Apollo Electronics Inc., 301 S. Harbor Blvd., Fullerton, Calif.

The Autoverter achieves high modulating frequency and low noise level by an electrooptical system. Two light sources, driven by an internal oscillator at 50, 400, 1,000 or 1,500 cps, project onto two photoelectric elements. These convert the input signal, either d-c or low-frequency a-c into a full-wave modulated output.

The unit weighs less than 3.3 ounces, and fits into a chrome-plated aluminum can 1 inch in diameter, 2¼ inches long. Base fits 7-pin miniature tube sockets.

Noise level is less than 2 microvolts rms.

The oscillator drives the light sources and also produces two 5-

volt square-wave outputs for full-wave demodulation.

CIRCLE 302 ON READER SERVICE CARD

Silicon Regulators
LOW COST UNITS

LOW-COST line of one-watt silicon voltage regulators has been announced by Semiconductor Div., Sarkes Tarzian, Inc., 415 N. College, Bloomington, Indiana.

The one-watt, epoxy-enclosed units range from 6 to 105 volts in 20-percent increments, have a basic tolerance of 20 percent, with 10-percent and 5-percent tolerances available. Unit prices are in the one dollar range for production quantities; are under two dollars for sample quantities. The regulators are available from stock.

CIRCLE 303 ON READER SERVICE CARD

Timing Relay
SOLID STATE

SOLID STATE timing relay for high-current pulse applications in industrial, missile and aircraft systems is announced by Inter Mountain Branch, Curtiss-Wright Corp., P. O.

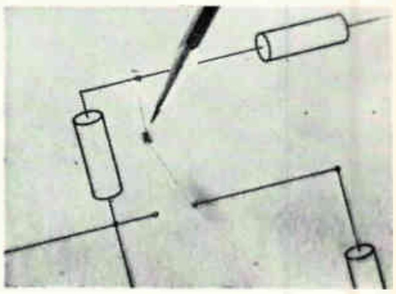
Box 8324, Albuquerque, N.M.

Model TR-12-50-.050 will carry 50 amperes, is designed to shut off after conducting for 50 milliseconds. Relay operates on 12 v d-c, requires a +17-volt pulse for triggering, has a pickup time of 10 microseconds.

CIRCLE 304 ON READER SERVICE CARD

Double-Ended Transistors
SEVEN SILICON TYPES

A LINE of double-ended subminiature silicon *npn* transistors has been announced by Raytheon Co., Semiconductor Div., 215 First Ave.,



Needham, Mass.

The seven electrically welded,

inter-industry conference on

ORGANIC SEMICONDUCTORS

April 18 and 19, 1961
The Morrison Hotel, Chicago, Illinois

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ARMOUR RESEARCH FOUNDATION
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and **electronics**
a McGraw-Hill publication

Technical sessions of invited and contributed papers on the present state and future potential of organic semiconductors in the electronics, chemical, and semiconductor industries.

Invited papers will cover the following areas:

David Fox, State University of New York
Theoretical Aspects of Electrical Transport

R. G. Kepler, E. I. DuPont de Nemours and Company
Conductivity in Anthracene Single Crystals

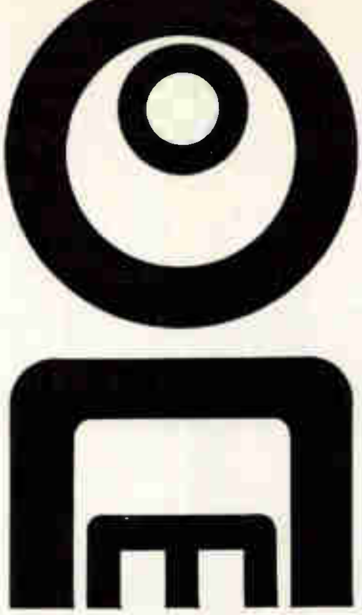
Jan Kommandur, National Carbon Research Laboratories
Characteristics of Charge-Transfer Complexes

Oliver Le Blanc, General Electric Research Laboratories
Interpretation of Conductivity in Molecular Crystals

Herbert A. Pohl, Princeton University
Electrical Properties of Pyrolyzed Polymers

Marvin Silver, Office of Ordnance Research
Surfaces and Contacts in Organic Semiconductors

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



Now—faster service on complete line of top quality Hipersil® cores

Eight stocking locations for Hipersil cores give fastest possible service: Greenville, Pa.; Boston; Chicago; Cleveland; Dallas; Hillside, N.J.; Los Angeles; Minneapolis. Line includes new EIA, RS-217 sizes.

- TYPE C: 12, 4, 2 and 1 mil sizes, in single- and 3-phase, fraction of ounce to 300 pounds.
- RING CORES: Untreated, edge bonded, impregnated and epoxy resin-coated Polyclad.
- SPECIAL CORES: To any specification and shape requirements.

Top quality: Performance of Hipersil cores in "iron-core" components is guaranteed to meet or exceed specifications.

Write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa., for *new* catalog.

You can be sure...if it's

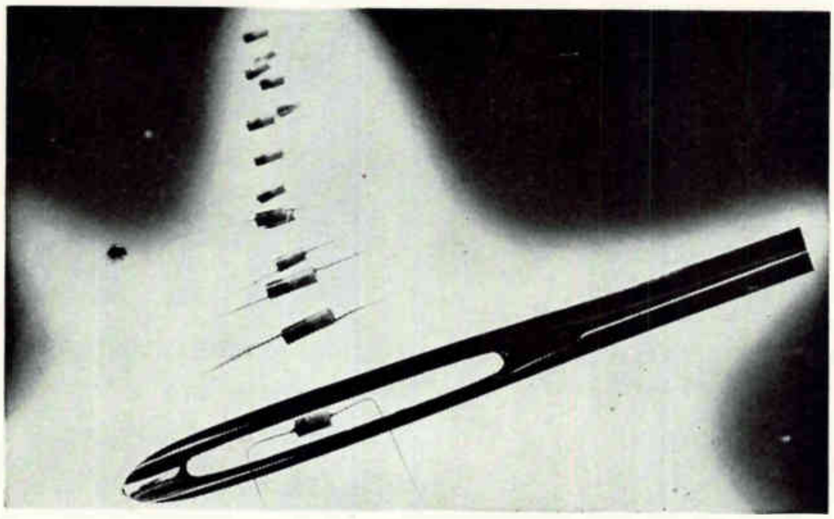
Westinghouse

J-70954

hermetically-sealed subminiatures are numbered 2N902 through 2N-908. With power rating of 400 mw at 25 C, they are equivalent to 2N789 through 2N793, 2N745 and 2N746, and to 2N332 through 2N338.

Volume is 21 times smaller than the standard TO-5 can; dimensions are 0.130 by 0.160. Immediately available in quantity, the double-ended transistors—which meet all MIL speeds and are suitable for amplifiers and switching circuits—are priced from $8 to $30.

CIRCLE 305 ON READER SERVICE CARD



Tantalum Capacitors
SMALL SIZE

SOLID-SLUG tantalum capacitors are announced by Transistor Electronics, Inc., West Rd., Bennington, Vt. Length over insulation is from 0.15 to 0.24 in. and diameter is from 0.065 to 0.07 in. Service temperature is from −55 C to 85 C.

The TS-type capacitors use a stable oxide, inert tantalum, and a solid electrolyte; the body is epoxy.

Capacitance and working voltages of capacitors range from 0.01 μf at 15 v to 20 μf at 4 v. The capacitors are available from stock.

CIRCLE 306 ON READER SERVICE CARD

Stepping Switch
104 POSITIONS

FAST-ACTING, solenoid-operated, rotary stepping switch has numerous pole configurations, including a shorting ring to short out any combination of contacts per deck.

Each deck has 104 contacts of beryllium copper, with various types of plating available. Each deck contains identical contact configurations, and decks may be stacked. The switch actuating mechanism is a vibration free rotary solenoid operated by external pulse. Standard input voltage is 24 volts d-c, with other coils available.

Contact carrying capacity is 2 amperes; voltage between adjacent contacts can be 3,000 volts d-c. Units are made to order from stock parts and can be delivered in 30 to 60 days. Prices start at $604.42, from Astral Electronics Inc., 14620 Arminta Street, Van Nuys, Calif.

CIRCLE 307 ON READER SERVICE CARD

Vibration Calibrator
PORTABLE UNIT

GENERAL RADIO CO., West Concord, Mass. Type 1557-A vibration calibrator checks the performance of transducers having mass of less than 300 grams; basically a transistorized 100-cps electrodynamic shaker that generates an acceleration of 1 g, rms. Price is $225.

CIRCLE 308 ON READER SERVICE CARD

Thermistors
SMALL PROBE TYPE

VICTORY ENGINEERING CORP., 524 Springfield Road, Union, N. J., presents a hybrid thermistor—a mating of characteristics of the plain bead type with those of a glass probe type. Unit is only 0.060 in. in diameter by 1/4 in. long. Dissipation constant is 0.6 mw/deg, and time constant is only 6 sec.

CIRCLE 309 ON READER SERVICE CARD

Tweezer Soldering Unit
TWO HEATING ELEMENTS

TWEEZER soldering instrument for production soldering microminiature semiconductors is announced by Oryx Co., 13804 Ventura Blvd., Sherman Oaks, Calif.

The instrument has heating elements in each arm, which develop 572 F at the 1/32 inch tips. Designed for use with low temperature solders to protect diodes, transistors and bimetals, the tweezers can be used to position and hold the work rigidly while soldering.

Weighing one ounce, the instrument is six inches long and operates on six volts d-c. The tweezers were designed in England, and will be sold in the United States for $14.95.

CIRCLE 310 ON READER SERVICE CARD

"You Rubbed, Sir?"

Reeves-Hoffman transistorized, proportionally controlled ovens *do* give almost miraculous service—in providing closer frequency control. These highly reliable ovens have no mechanical contacts. There are no spark-producing gaps. Radio interference is eliminated. Although it is difficult to measure temperature excursions beyond ±.01°C, it is reliably estimated that Reeves-Hoffman ovens provide control in the order of ±.001°C. If you have a problem involving reliable temperature control, contact Reeves-Hoffman for additional information.

REEVES HOFFMAN

WRITE FOR BULLETIN V1090.

DIVISION OF
DYNAMICS CORPORATION OF AMERICA
CARLISLE, PENNSYLVANIA

0/160

CIRCLE 204 ON READER SERVICE CARD

WHAT'S YOUR TRANSISTOR COOLING PROBLEM?

Whatever it is, you can probably find the solution with a Birtcher Radiator. Available in sizes and designs to most efficiently cool all popularly used (and many special) transistors. Test reports show up to 27% more transistor efficiency!

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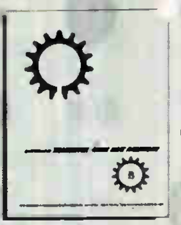

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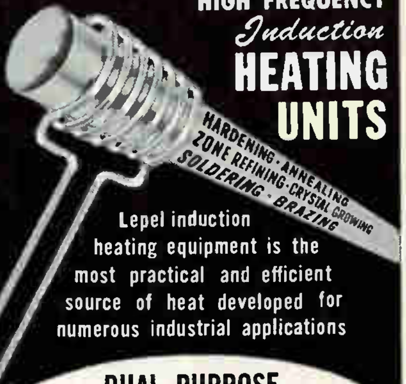
CIRCLE 201 ON READER SERVICE CARD

Lepel

HIGH FREQUENCY *Induction* HEATING UNITS



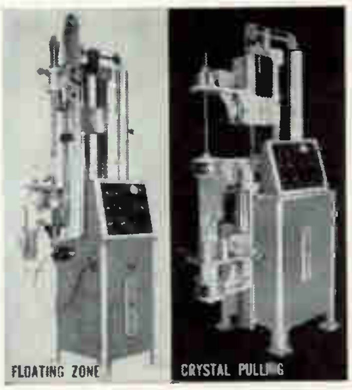
Lepel induction heating equipment is the most practical and efficient source of heat developed for numerous industrial applications

DUAL PURPOSE FLOATING ZONE AND CRYSTAL PULLING FIXTURE

A new fixture with separate attachments for crystal pulling and floating zone applications for use with a high frequency induction heating generator.

THE FLOATING ZONE METHOD is used extensively for zone refining and for growing crystals of high purity silicon for semiconductor devices by traversing a narrow molten zone along the length of the process bar in a controlled atmosphere.

THE CRYSTAL PULLING METHOD is used for growing single crystals of various materials, especially germanium, by bringing a seed of known crystal orientation into contact with the surface of the molten metal and slowly withdrawing the seed, producing progressive crystallization.



FLOATING ZONE — CRYSTAL PULLING

The Lepel Model HCP-D consists of the basic unit with the traverse mechanism and all the controls including the controls for the operation of the generator, and the floating zone and crystal pulling attachments. The same basic support, programming and control unit is used in either adaptation. The major variations are in the attachments and the induction coils. The change from one application to the other can be accomplished in a very short time.

Our engineers will process your work samples and return the completed job with full data and recommendations without cost or obligation.

WRITE FOR NEW LEPEL CATALOG
Lepel HIGH FREQUENCY LABORATORIES, INC.
55th ST. & 37th AVE., WOODSIDE 77, N. Y.
CHICAGO OFFICE: 6246 WEST NORTH AVE.

CIRCLE 71 ON READER SERVICE CARD

Literature of the Week

RELAY Electro-Tec Corp., 10 Romanelli Ave., South Hackensack, N. J. A technical bulletin describes the wedge action operation of the six-pole double-throw Mark II relay, which is suitable for stringent applications in military and space programs.
CIRCLE 311 ON READER SERVICE CARD

TEST EQUIPMENT Molecular Electronics, Inc., 85 Weyman Ave., New Rochelle, N. Y. Single data sheet lists features of a transistor tester which provides instantaneous indication of gain-bandwidth product.
CIRCLE 312 ON READER SERVICE CARD

TRANSISTORS Texas Instruments Inc., P.O. Box 5012, Dallas 22, Texas. The company's *npn* epitaxial double-diffused mesa silicon transistors are covered in a 4-page brochure.
CIRCLE 313 ON READER SERVICE CARD

CONTROL SYSTEMS Bendix Corp., Industrial Controls, 21820 Wyoming, Detroit 37, Michigan, has published a general catalog covering its numerical control systems. The DynaPath-20 contouring controls, the DynaPoint-20 series and Ferranti positioning control systems are included.
CIRCLE 314 ON READER SERVICE CARD

DISPLAY LIGHTS Transistor Electronics Corp., 3357 Republic Ave., Minneapolis 25, Minnesota. Bulletin describes the company's line of miniature indicator lights.
CIRCLE 315 ON READER SERVICE CARD

DELAY MODULE Harvey-Wells Electronics, Inc., 14 Huron Drive, Natick, Mass., has published a data sheet covering the Delay C, a dual-output variable delay logic module.
CIRCLE 316 ON READER SERVICE CARD

PRODUCT CATALOG Soroban Engineering, Inc., P.O. Box 1717, Melbourne, Florida. An illustrated catalog discusses applications and circuit characteristics required for mechanical and electronic tape readers, tape perforators, coding keyboards, electrically sequenced typewriters, switching mechanisms, and reperforator-comparator systems.

CIRCLE 317 ON READER SERVICE CARD

CONNECTORS Continental Connector Corp., 45-01 Northern Boulevard, Long Island City 1, N. Y. Right angle pin and socket connectors for printed circuit applications are reviewed in a 12-page bulletin.

CIRCLE 318 ON READER SERVICE CARD

ELECTRON GUNS Superior Electronics Corp., 208-212 Piaget Ave., Clifton, N. J. A 34-page color catalog of electron guns for all types of cathode ray tubes is available. Included is a cross reference chart specifying the correct gun mounts for tubes of domestic and foreign manufacture.

CIRCLE 319 ON READER SERVICE CARD

CARD READER Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif. The CR-201 card reader, designed to transport IBM cards at a speed of 30 cards/minute, is described in a single data sheet.

CIRCLE 320 ON READER SERVICE CARD

MAGNETIC SHIELDS James Millen Manufacturing Co., Inc., 150 Exchange St., Malden 48, Mass. A reference booklet on magnetic shields and shielding materials contains curves and tables which aid in shield selection. Bezels for cathode ray tubes, gear drives, shaft locks, bearings, couplings, knobs and dials are covered.

CIRCLE 321 ON READER SERVICE CARD

LIQUID LEVEL CONTROLS The B/W Controller Corp., 2200 E. Maple Road, Birmingham, Mich. Bulletin 334 describes and illustrates a line of electronic floatless liquid level controls.

CIRCLE 322 ON READER SERVICE CARD

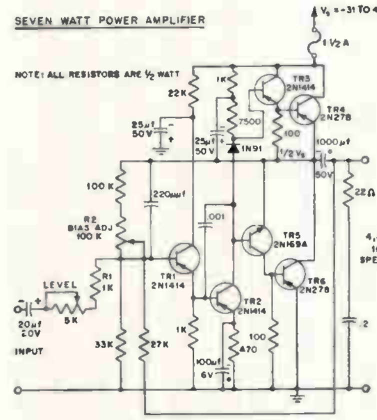
TAPE CONVERSION Auerbach Electronics Corp., 1634 Arch St., Philadelphia 3, Pa. Data sheet describes magnetic tape translation devices, developed to provide computers with low-cost on-line input conversion of foreign tape formats and signals. Send requests for bulletin AE305-53 on company letterheads.

semiconductor products news

The Fi is Hi but the cost is Lo

. . . with the 2N1414 PNP low current transistor in the seven watt power amplifier circuit shown below, that is. A direct coupled power amplifier with excellent low frequency response, the circuit also has the advantage of a feedback arrangement for current stabilization of all stages. And the sheer beauty of it all is that each G-E 2N1414 in the circuit saves you almost 50% of the cost of the type previously used to do the job. You also get higher reliability in the bargain.

Naturally you'll want a complete description of the circuit, and you'll find it on pages 63 and 64 of the G-E Transistor Manual (the new 5th Edition is now out). Incidentally, for an equally good ten watt power amplifier circuit also using a 2N1414, turn to page 66.



Breathes there the man with soul so dead who never to himself hath said, how can I design this control circuit cheaper? One very good answer for several years now has been the unijunction transistor, which can often replace two conventional transistors in a circuit. But hear this: the price of the 2N1671 Series unijunction transistors has been slashed 41% to make your overall circuit cost savings even greater. For complete details, ask your G-E Semiconductor District Sales Manager, or drop us a line at Section 25C93.

Better yet you get getters

You ask why? Because you get a better product! General Electric puts getters in transistors for the same reason they are used in tubes; the sorption of harmful residual gases and vapors unavoidably bottled up inside transistors when they are sealed (no matter *who* does it or *how* it is done). Atmosphere control experiments begun as early as 1955 demonstrated the fact that getters assure long-term electrical characteristic stability, with the most marked improvement at high temperatures.

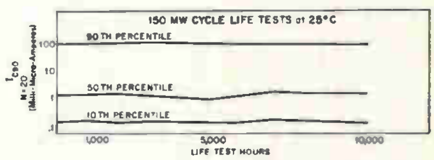
Want a for instance? We took an ungettered 2N40 Series, tested at 135°C storage, and more than half had I_{CBO} increases to 100 microamps within 125 hours. We then took G-E 2N40's *with* getters and tested under exactly the same conditions. They went to 20,000 hours before I_{CBO} increased to the same level. As a matter of fact, additional tests indicate we are closer to 50,000 hours. And remember, this unit is rated at 100°C storage. We test at 135°C.

So compare 125 hours with 50,000 hours, and never again seek to ask for whom the getter toils . . . it toils for thee!

Tunnel Diodes, anyone? The new G-E tunnel diode manual is hot off the press, and if we do say so, it's a beaut! Theory, ratings and characteristics, specific applications, test circuits . . . you name it, you got it. Get your copy today from your Authorized G-E Distributor.

Where there's life . . . there's test data

. . . and the 2N332 NPN transistor series is a good case in point. No less than four 1000-hour life tests are regularly performed (125°C operating, 200°C storage, 25°C cycled power, 25°C shelf), with sample sizes for each test averaging over 50 samples per test per week. Samples are then taken from these groups and testing extended to 10,000 hours. Now, for just one example of the extreme stability demonstrated by these tests, take a look at the chart below showing I_{CBO} for a typical lot. Not bad. Not bad at all!



Semiconductor Products Dept., Electronics Park, Syracuse, New York. In Canada: Canadian General Electric Co., 189 Dufferin St., Toronto, Ont. Export: International General Electric Co., 150 East 42nd Street, New York, New York.

GENERAL ELECTRIC

CIRCLE 73 ON READER SERVICE CARD

GI Opens Transistor Factory

A $3 MILLION research and mass production facility for second and third generation transistors and other semiconductors was recently opened by the General Instrument Corp. at Hicksville, L. I., N. Y.

Using electronically-regulated automatic and semiautomatic processes, the new 50,000-sq-ft plant is now in large-scale production, according to board chairman Martin H. Benedek. The plant is situated on a nine-acre tract, and so designed that space can be doubled, tripled or quadrupled at will.

Supplementing the Semiconductor division's three other major facilities (at Newark, N. J., Jamaica, N. Y., and Woonsocket, R. I.), the new plant will mass-produce only the newer, sophisticated devices that are capturing a growing share of the over-all semiconductor market (estimated at $500 million in 1960 and expected to reach $1 billion by 1965), Benedek says. Already in production, or in advanced development stage, are solid state devices ranging from ultrahigh speed switching transistors and tunnel diodes to solar cells and tiny microcircuits.

First units placed in commercial mass production are ultrahigh speed germanium and silicon transistors (used by the thousands as switching devices in the fastest business computers, missile and satellite guidance and other military systems) which operate at speeds of up to 0.02 μsec. Germanium tunnel diodes also are in commercial production.

In advanced development, it was disclosed, are such other devices as miniature infrared detectors, for use in space vehicles to detect and measure infrared (heat) radiation; new types of thin film solar cells; epitaxial mesa transistors; and microcircuits, which contain an entire circuit on one semiconductor wafer.

To permit fullest production flexibility, equipment for different types of semiconductor devices can be shifted or added at will. Machines are plugged in at virtually any point in the production area to a complex network of feeder lines; these pipe in from a central service facility de-ionized water, nitrogen, ultra-dry compressed air, high pressure steam, and other materials required in semiconductor manufacture. A central electrical busduct system similarly provides electricity anywhere needed.

Research activities are provided for on the rim of the production area. Six laboratories are designed for stage-by-stage development of new devices, from basic metallurgical experimentation to design and pilot operation of actual equipment to mass-produce the new semiconductors.

Reeves-Hoffman Gets RIQUAP Award

THE U. S. ARMY SIGNAL CORPS recently presented its RIQUAP award to the Reeves-Hoffman Division of Dynamics Corp. of America, Carlisle, Pa., for "consistent production of high-quality quartz crystals over a long-term period. "RIQUAP", which stands for "Reduced Inspection Quality Assurance Plan", is the highest quality-recognition and honor the Army Signal Corps can bestow upon a manufacturer.

GPE Corp. Moves To New Headquarters

GENERAL PRECISION EQUIPMENT CORP. recently moved into its new corporate headquarters in Tarrytown, N. Y.

The newly constructed, two-story, 40,000 sq ft building also provides headquarters and needed expansion facilities for General Precision's growing electronic subsidiary, General Precision, Inc. GP, Inc., comprises GPL Division, Pleasantville, N. Y.; Kearfott Division, Little Falls, N. J.; Librascope Division, Glendale, Calif.; and Link Division, Binghamton, N. Y.

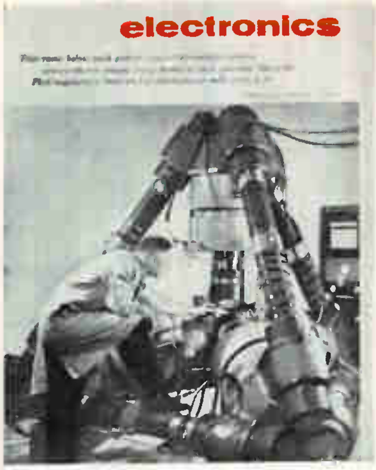
The new location will also house management and staff of National Theatre Supply Co., another GPE subsidiary.

DiToro Joins Cardion As V-P For Research

CARDION ELECTRONICS, INC., Westbury, N. Y., announces that Michael J. DiToro has joined its technical staff as vice president for research.

Organized last year by a group of engineers headed by Orville M. Dunning, president, Cardion Electronics designs and manufactures electronic equipment in the radar, communications, and navigation fields for both the military and commercial markets.

DiToro comes to Cardion from



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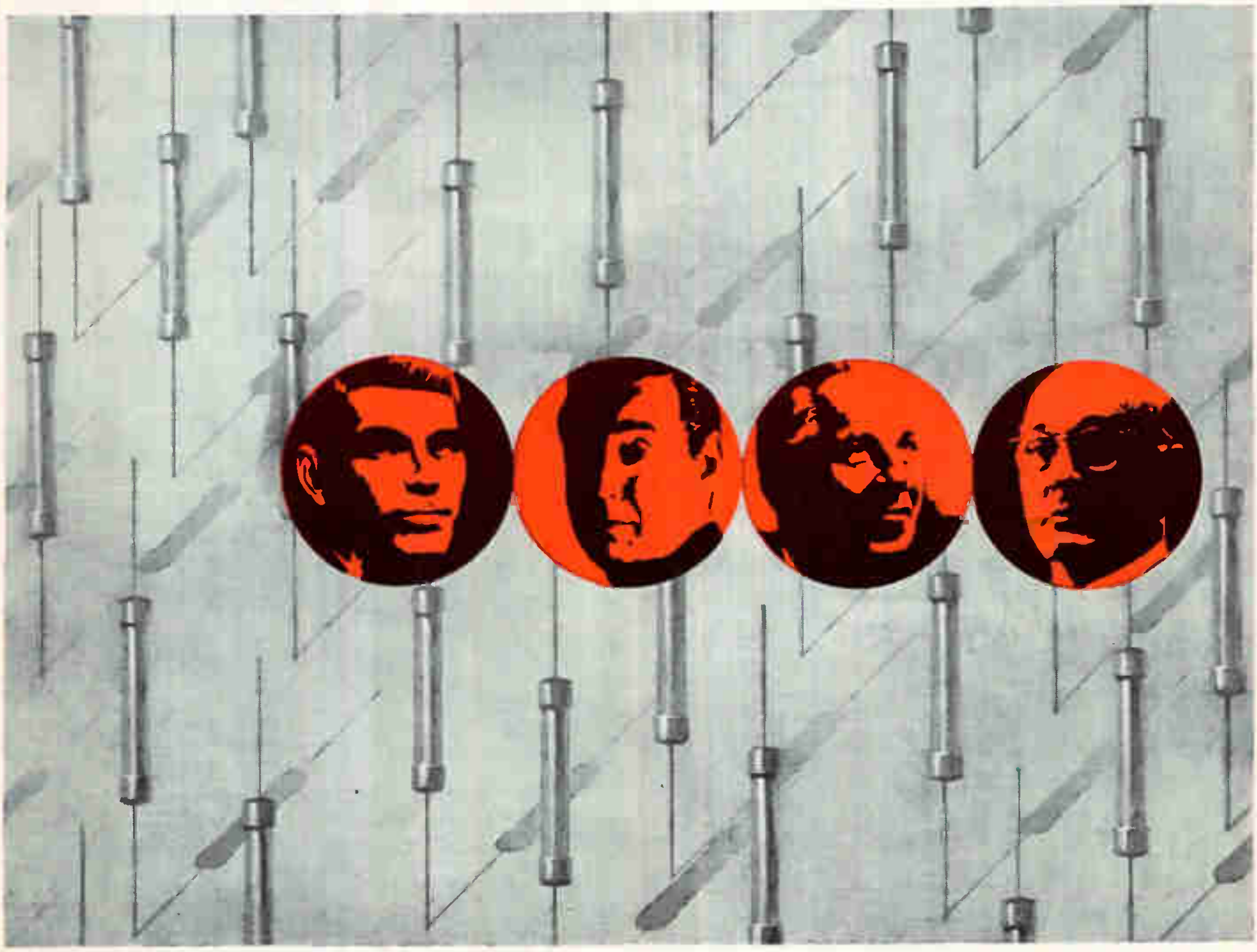

PRD Electronics, Inc., Brooklyn, N. Y., where he was director of engineering since 1956.

Hudson Wire Company Promotes Simmons

JAMES T. SIMMONS has been named vice president-operations of Hudson Wire Co. He will have direct responsibility for sales, engineering, and manufacturing of all Hudson divisions, including plants in Ossining, New York; Winsted and Norwalk, Conn.; and Cassopolis, Mich.

Simmons joined Hudson Wire in 1959 as plant manager for the Ossining division.

DCA Unit Elects Potter President

ELECTION of Horace R. Potter as president of the Reeves-Hoffman Division of Dynamics Corp. of America has been announced. With the company since 1951, he had been vice president and general manager of the division since 1959.

Space Electronics Advances Lehan

FRANK W. LEHAN has been elected executive vice president of Space Electronics Corp., Glendale, California. Since 1958 he has been vice president of the firm.

Previous to helping found SEC in 1958, Lehan served as associate director of the electronics laboratory at Space Technology Laboratories, Inc.

Defiance Relocates In Massachusetts

DEFIANCE PRINTED CIRCUIT CORP. recently moved from its quarters in Wakefield, Mass., to a new 12,000 sq ft building in Malden. The interior has been fitted out to provide all utilities with 5 year expansion in mind. Included is 1,000 ft of modern office space. Also, engineering and quality control have been given more space and utilities.

PEOPLE IN BRIEF

William A. Rabe, formerly with the Avco Corp., appointed manager of surface radar and electronic warfare development labs at General Dynamics/Electronics, military products division. **Peter Georgiev** transfers from General Electric to the Lenkurt Electric Co. as senior electrical engineer in advanced development. **Edward W. Warnshuis,** ex-Nortronics, joins Data Systems Lab as manager of advanced planning. **J. Howard Schumacher, Jr.,** leaves the Society of Motion Pictures and Television Engineers to take a staff engineer's post with EIA's engineering dept. **Harold R. Luxenberg,** formerly with Ramo-Wooldridge and Litton Ind. named reconnaissance systems head at Westwood Div., Houston Fearless Corp. **William O. Thompson,** ex-RCA, appointed chief industrial engineer for C. P. Clare & Co. **Austin F. Platt** chosen European sales manager for Brooks Instrument Co. **Robert S. Senator** leaves ITT to join Philco Corp.'s computer division as manager of the systems engineering lab. **William F. Cairns,** previously with the Chicago Steel and Wire Co., named manager of the Cambridge div., Airpax Electronics Inc. **Eugene R. Heath** of Diamond Electronics appointed manager of the company's applied electron physics.

electronics
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FEDERAL ELECTRIC CORP. A Div. of I T & T Corp. Paramus, New Jersey	61	6
THE HALLICRAFTERS CO. Chicago, Illinois	106*	7
MANSON LABORATORIES Stamford, Connecticut	97*	8
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MOTOROLA, INC. Chicago, Illinois	107*	12
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SIKORSKY AIRCRAFT Stratford, Connecticut	81	15
SKELLY ASSOCIATES Union, New Jersey	108*	16

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Please indicate number of months experience in proper block(s)

	Technical Experience (Months)	Supervisory Experience (Months)
RESEARCH (pure, fundamental, basic)	☐	☐
RESEARCH (Applied)	☐	☐
SYSTEMS (New Concepts)	☐	☐
DEVELOPMENT (Model)	☐	☐
DESIGN (Product)	☐	☐
MANUFACTURING (Product)	☐	☐
FIELD (Service)	☐	☐
SALES (Proposals & Products)	☐	☐

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

POSITION VACANT

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career positions of unusual scope and interest in

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Instrumentation operations experience with oscillograph, strip chart and digital data acquisition systems desirable.

INSTRUMENTATION ENGINEERS: (BSME or BSEE)

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CONNECTICUT OPPORTUNITIES (CANEL)

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Please submit complete resume, including minimum salary requirements, to:

Mr. J. W. Morton, Office 65
Pratt & Whitney Aircraft
West Palm Beach, Florida
— or —
Mr. L. T. Shiembob, Office 65
Connecticut Aircraft
Nuclear Engine Laboratory
Box 611, Middletown, Connecticut

All replies will be handled promptly and in complete confidence.

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To conduct investigations related to high-voltage power engineering, with special emphasis on impulse generators. Incumbent will have a MSEE and a strong theoretical and laboratory background in the above.

Please direct your inquiries to Mr. L. G. Olsen, Personnel Department, 220

CHRYSLER MISSILE DIVISION

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Floyd Hargiss,
Manager Professional Personnel
16555 Saticoy Street, Van Nuys, California

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