Electronics®

March 8, 1965
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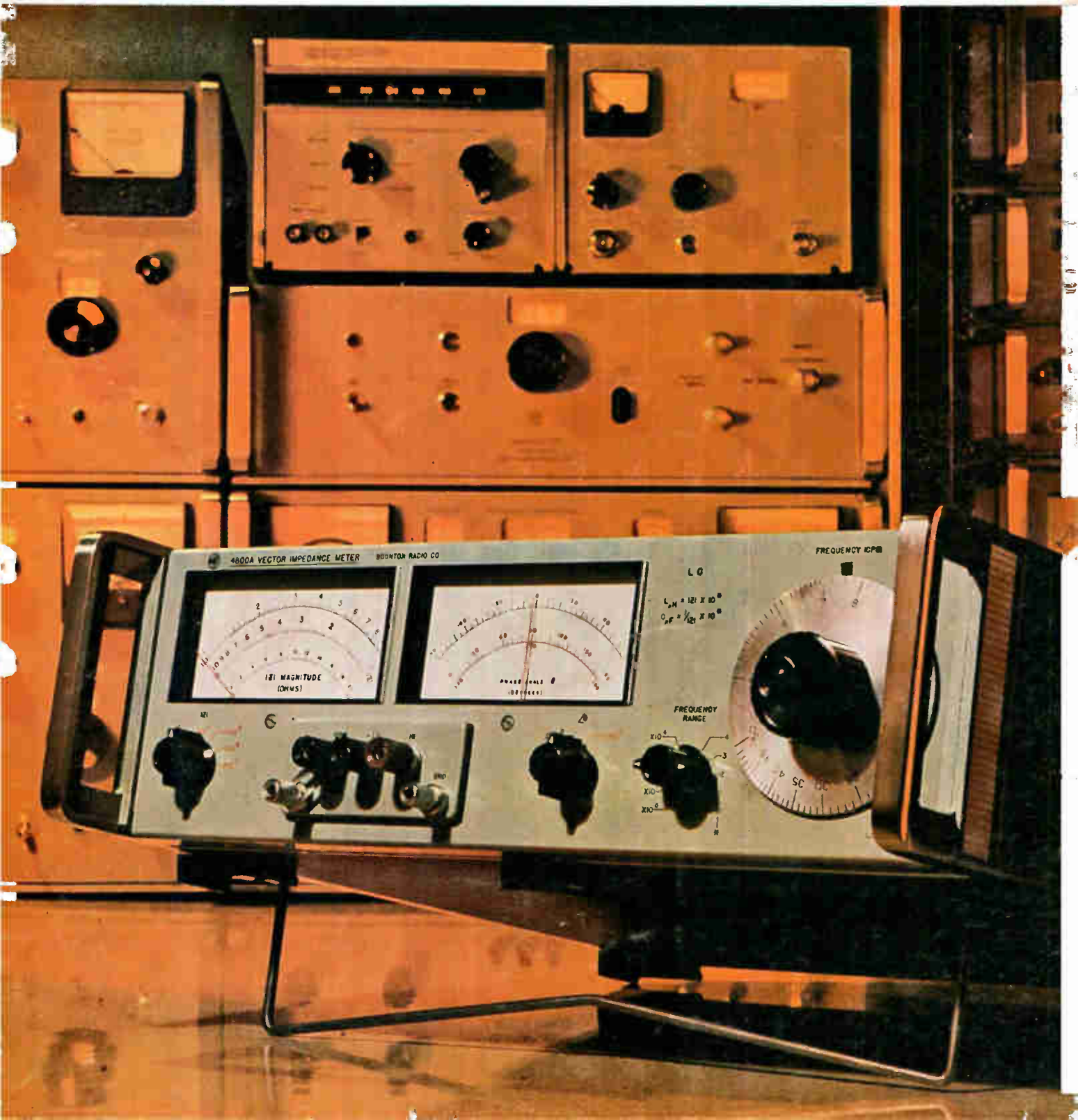
Below: new impedance meter tests the market at IEEE Show, page 74



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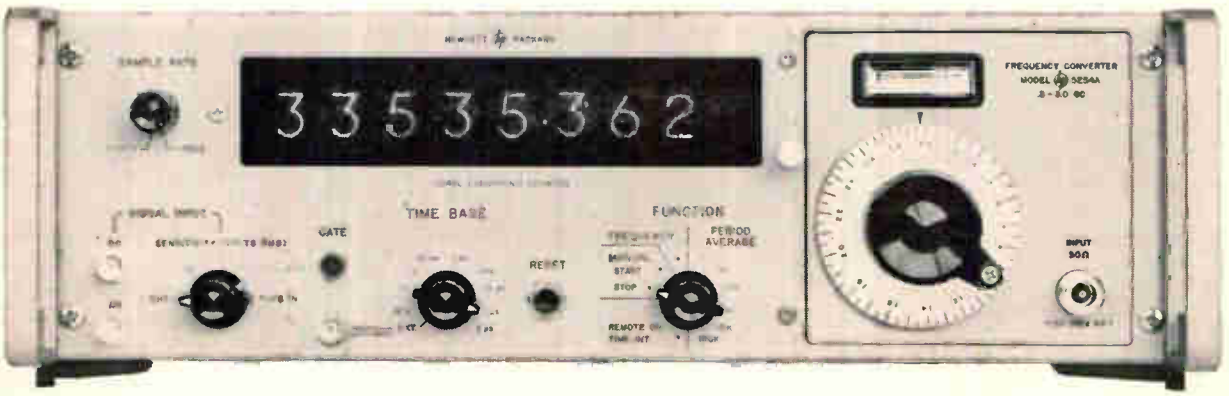

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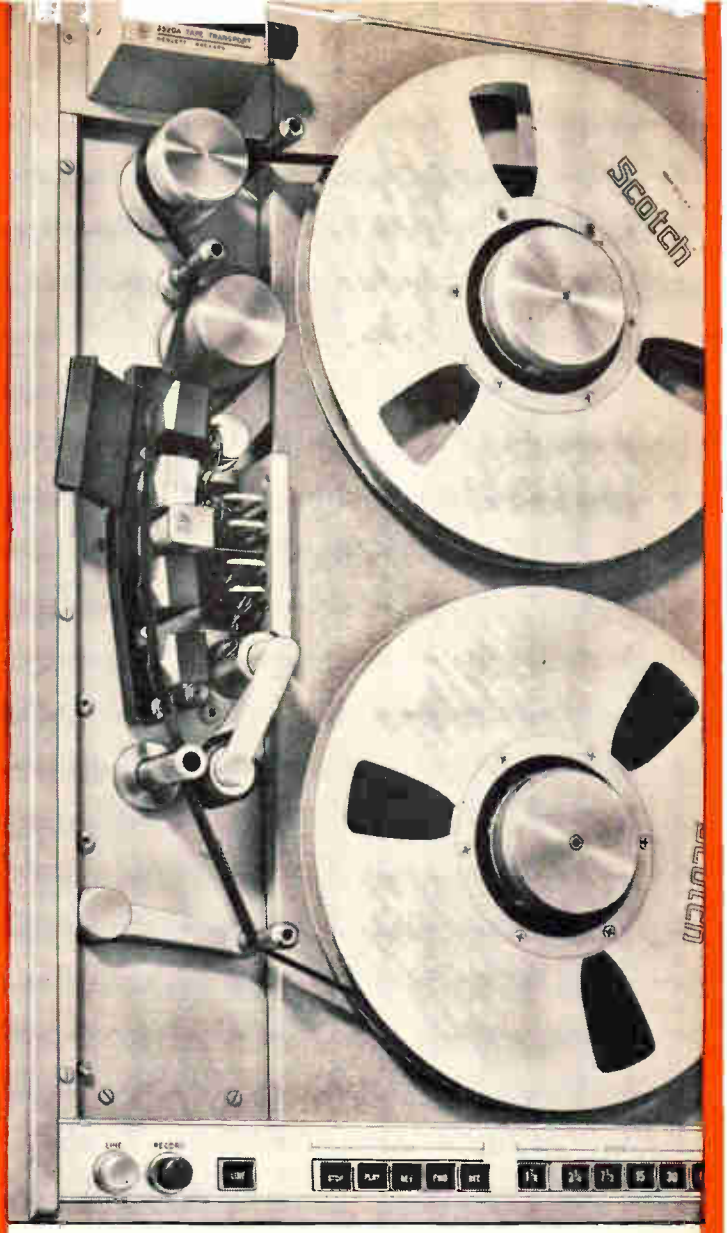

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Electronics

March 8, 1965
Volume 38, Number 5

Electronics Review

Electronics Abroad

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II. Applications

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Readers Comment

That cascode follower

To the Editor:

Regarding Per Bugge-Asperheim's letter [Feb. 8, p. 6] in which he makes reference to R. W. Johnson's article "Circuit with a twist: the cascode follower" [Dec. 6, 1963]:

Both gentlemen err in considering that this is a new circuit.

The basic circuit has been used by the writer, on and off, for nearly 20 years.

In fact, a multivibrator version of the circuit was the subject of a U. S. patent application filed by the writer on Nov. 13, 1952 . . . and the patent application described, among the various modifications, a transistorized version of the circuit (as per Bugge-Asperheim).

Louis E. Garner Jr.
Silver Spring, Md.

To the Editor:

. . . the cascode follower in tubes was seen as early as 1946. David Greene, then doing circuit design at Submarine Signal in Boston, asked me as a technician to breadboard it to check the actual output impedance. Having made a phone amplifier with voice coil feedback (similar to the Williamson circuit, but using pentodes), he thought of this as a way out of using the output transformer.

John E. Adams
Burlington, Mass.

To the Editor:

. . . I, and associates of mine, have used the circuit or adaptions since before 1951. A particularly interesting version, couping two double cathode followers, is used in amplifiers marketed by Cohu Electronics, Inc.

The direct-coupled output circuit uses one DCF to divide the power supply and provide biases for the other DCF, which is used as a direct-coupled output stage. Cross-couplings balance currents in the power supply, or make output impedance zero or negative dependent on values selected. Power-supply ripple and variations may

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be balanced out. The balanced circuit also minimizes drift due to tube aging and heater voltage fluctuation. The neon lamp indicates overloads. The currently marketed version of the amplifier is the Model 112A.

James L. Kimball
Chief Engineer
Kintel Division
Cohu Electronics, Inc.
San Diego, Calif.

To the Editor:

. . . the cascade follower appears as a "double cathode follower" on page 157 of "Electronic Engineering," by S. Seeley, McGraw-Hill Book Co., 1956. Seeley indicates that the circuit was discussed by C. Hammock in MIT Radiation Laboratory. Report 469 of 1943, six years before the transistor appeared on the scene . . .

James A. Cronvich
Electrical Engineering Dept.,
Tulane University
New Orleans, La.

To the Editor:

. . . The cascode-follower is frequently referred to as the "White cathode-follower" after the man who I think invented it: E. L. C. White, U. S. Patent No. 2,358,428, September 19, 1944. (An earlier patent was issued to him in Great Britain.) The circuit is also attributed to Forbes, who "invented" it during World War II at the M.I.T. Radiation Laboratory. This "invention" was not published in the open literature. Since then, the circuit has been reinvented at least 8 times (Electronics published at least two of these "originals"), and has been variously called a "cascode follower," "stacked cathode-follower," "augmented cathode-follower," etc. Mathematical analyses have appeared in Review of Scientific Instruments (Moody, Batell, Howell, and Taplin, Rev. Sci. Instr. 22, 557 (1951) and Brown, Rev. Sci. Instr. 31, 403 (1960).

In my lifetime, I expect to see the circuit reinvented and reanalyzed several more times.

Edward Fairstein
President
Tennelec Instrument Company, Inc.
Oak Ridge, Tenn.

▪ Reader Fairstein sums up why we ran engineer Bugge-Asperheim's letter. Classical circuits continually are rediscovered. And it proves "there's nothing new under the sun."

Party line

To the Editor:

In the story "Party-line radio" [Jan. 25, p. 40], you say the network was developed by Motorola Communications & Electronics, Inc. Actually, the USC-3 was designed by Motorola's Military Electronics division. One part of the system, the oscillator, was designed by the Communications division.

Peter J. DeTroy
Military Electronics division
Motorola, Inc.
Chicago

New argument

To the Editor:

In Readers Comment [Jan. 25, p. 6] I find the "correct expression" for the noise figure to be in error. The argument x of log x must be dimensionless. Hence

$$\left[\frac{N_T^2 + N_R^2}{N_R}\right]^{\frac{1}{2}}$$

which has the dimensions of $(\text{volts})^{1/2}$, cannot be the argument. I would wager that

$$\text{N.F.} = 20 \log \frac{[N_T^2 + N_R^2]^{1/2}}{N_R}$$

$$= 20 \log \left[\frac{N_T^2 + N_R^2}{N_R^2}\right]^{1/2}$$

is correct. Note that the argument of the logarithm is dimensionless. A way to see that the equation is correct is to rewrite the noise figure as

$$\text{N.F.} = 10 \log \frac{N_T^2 + N_R^2}{N_R^2}$$

Here we see that the argument of the logarithm is a ratio of powers, assuming both numerator and denominator are referred to the same resistance. The numerator is the power due to signals N_T and N_R are uncorrelated, so the power due to N_T and N_R is simply $N_T^2 + N_R^2$.

Douglas Daetz
University of California
Berkeley

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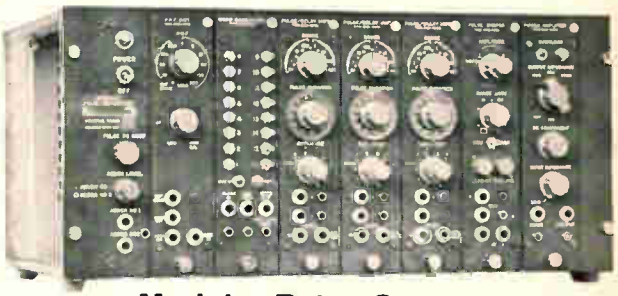

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Add the Type 1133-A Frequency Converter for coverage to 500 Mc/s . . . sensitivity better than 10 mV from 100 kc/s to 500 Mc/s . . . choice of narrow-band operation for measuring noisy signals or wide-band operation for routine measurements . . . useful with any frequency measuring system where a 5-Mc reference signal is available (reference signal can be derived from 1153-A Counter).Price, $1525.

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100-kc, 1-Mc, and 12-Mc models . . . frequency increments as small as 0.01 c/s and 0.1 c/s . . . models with calibrated continuous tuning and sweep capability . . . programmable models. Prices start at $3200.

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Circle 7 on reader service card

People

Engineer, administrator, teacher, science-fiction buff, amateur actor and wine-maker—they all describe **Bernard M. Oliver**, the new president of the Institute of Electrical and Electronics Engineers.

The 48-year-old scientist, who holds a doctorate (magna cum laude) in electrical engineering, is vice president of research and development at the Hewlett-Packard Co. Previously, he worked for Bell Telephone Laboratories on automatic radar tracking systems and television transmission.

Oliver's chief interest is the future of man and science. An article he wrote on the radio search for life in space has been placed in a time capsule at the World's Fair.

He lives with his wife and three children on a 150-acre ranch near Santa Cruz, Calif.

The glamour phase of the integrated-circuit field is over. Producers are starting to slug it out on cost and performance, and that's where discipline counts.

Providing the discipline for the semiconductor division of Sylvania Electric Products, Inc., is 37-year-old **Alvin B. Phillips,** who was recently given the job of converting the company, a subsidiary of the General Telephone and Electronics Corp., into a heavyweight in integrated circuits. For example, his engineers are holding dimensional tolerances of the devices to one-half micron.

The division is spending several million dollars to build a production capacity of 100,000 circuits a month. This is the second time that Phillips has taken on such a job. Before joining Sylvania, he headed Motorola, Inc.'s integrated circuits engineering and production.


Swimmer cracks world backstroke record
t the Tokyo Olympics last summer, the world record for
e 200 meter backstroke was broken in the new time
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ISA National Conference on Instrumentation for the Iron and Steel Industry, ISA; Pick-Roosevelt Hotel, Pittsburgh, **Mar. 17-19.**

Management Conference on Operations Research, Systems Engineering and Electronic Data Processing, University of Pennsylvania, Philadelphia, **Mar. 17-19.**

Goddard Memorial Symposium, AAS; Marriott Key Bridge Hotel, Washington, **Mar 18-19.**

Society of Broadcast Engineers Annual Meeting, SBE; Shoreham Hotel, Washington, **Mar. 21.**

IEEE International Convention, IEEE; N.Y. Coliseum and New York Hilton Hotel, New York, **Mar. 22-25.**

Society of Motion Picture and Television Engineers Semiannual Conference and Exhibit, SMPTE; Ambassador Hotel, Los Angeles, **Mar. 28-Apr. 2.**

Association of Electronic Manufacturers National Convention, AEM, Inc.; New York Hilton Hotel, New York, **Mar. 29-Apr. 1.**

Electron Beam Annual Symposium, Pennsylvania State University, Alloyd Corp.; Pennsylvania State University, University Park, Pa., **Mar. 31-Apr. 2.**

Electronic Parts Distributors Show, Electronic Industry Show Corp., New York Hilton and Americana Hotels, New York, **Mar. 31-Apr. 4.**

IEEE Seminar on Space Vehicle Reliability, IEEE; Airport Marina Hotel, Los Angeles, **Apr. 2.**

National Packaging Exposition, AMA; McCormick Place, Chicago, **Apr. 5-8.**

IEEE Lectures on Microelectronics, IEEE; Chicago Lane Technical Institute, Chicago, **Apr. 5, 12, 19, 26.**

Cleveland Electronics Conference, IEEE, ISA, CPS, Western Reserve University, Case Institute of Technology; Cleveland Public Auditorium, Cleveland, **Apr. 6-8.**

Conference on Impact of Batch-Fabrication on Future Computers, PGEC/IEEE; Thunderbird Hotel, Los Angeles, **Apr. 6-8.**

Airlines Electronic Engineering Committee General Session, AEEC of ALCAC; Eden Roc Hotel, Miami Beach, **Apr. 7-9.**

IEEE Region 3 Meeting, Robert E. Lee Hotel, Winston-Salem, N.C., **Apr. 7-9.**

Electronic Components International Exhibition, FNIE, SDSA, Parc des Expositions (Fair Grounds), Paris, **Apr. 8-13.**

IEEE Region Six Annual Conference, Las Vegas Convention Center, Las Vegas, **Apr. 13-15.**

Telemetering National Conference, AIAA, IEEE, ISA; Shamrock-Hilton Hotel, Houston, Tex., **Apr. 13-15.**

Specialists Conference on Thin Film Action Devices, G-ED/IEEE, NASA; Johns Hopkins University, Baltimore, **Apr. 14-15.**

Numerical Control Society Annual Meeting, NCS; La Salle Hotel, Chicago, **Apr. 21-23.**

Society of American Value Engineers National Convention, SAVE; Statler-Hilton Hotel, Boston, **Apr. 21-23.**

Anti-Missile Research Advisory Council Meeting, IDA; Institute for Defense Analyses, Arlington, Va., **Apr. 26-30.**

Rocky Mountain Bioengineering Annual Symposium, IEEE, USAF Acad., Fitzsimmons Gen. Hospital, et al; Brown Palace Hotel, Denver, **May 3-4.**

American Astronautical Society Annual Meeting, AAS, IIT Research Institute; Conrad Hilton Hotel, Chicago, **May 4-6.**

Packaging Industry Annual Conference, IEEE; Milwaukee Inn, Milwaukee, Wis., **May 4-6.**

Call for papers

Reprogramming Conference, ACM, Applied Data Research, Inc.; Nassau Inn, Princeton, N. J., June 1-3. **Mar. 15** is deadline for submitting 1500-word summary to H. R. Wallenden, Applied Data Research, Inc., Route 206 Center, Princeton, N. J. 08540.

Military Electronics Conference (MIL-E-CON 9), IEEE; Washington Hilton Hotel, Washington, Sept. 22-24. **Apr. 15** is deadline for submitting in triplicate 500-word abstract to Leon H. King, Technical Program Committee, Atlantic Research Corp., Shirley Hwy at Edsall Rd., Alexandria, Va.

Astrodata's New Astrolock*-loop FM Subcarrier Discriminator

Stability

Within ±0.01% of center frequency for 24-hours after a 5-minute warm-up.

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Better than ±0.02% of full bandwith, best straight line.

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This completely new and different type of locked-loop discriminator gives performance exceeding that of both conventional phase-locked-loop and pulse-averaging types of discriminators.

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The Model 402-201 introduces a new method of tape-speed compensation in which the reference frequency is processed in the frequency domain. As a result, tape speed compensation is perfect at any fixed frequency from lower bandedge to upper bandedge, and is better than 30 db for intelligence frequencies up to a modulation index of 4. Deviations of more than ±3% anywhere in the band can be accommodated. No adjustments are necessary.

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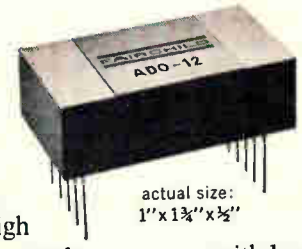

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Editorial

IEEE's technical sessions

The engineer who comes to New York on March 22 to attend the IEEE technical sessions is in for a big disappointment. From the program, the sessions seem to be poorer in quality then ever, a continuation of years of steady decline.

The merchandising aspects of IEEE completely outshadow the technical.

There was a time when an electronics engineer attended the annual meeting of the International Radio Engineers—one of IEEE's two forebears—to hear about the latest technical developments. The exhibits were lagniappe. IEEE's other forebear, the American Institute of Electrical Engineers, held only technical sessions—no exhibits at all—at its annual conclave until just before it merged with IRE.

Today the tail is wagging the dog. The merchandising aspects have assumed such importance that the technical sessions suffer seriously from lack of attention. IEEE has diluted the quality of the sessions even further this year by designing them to be "tutorial." That's a euphemism for no new technical material, a rehash of established techniques.

In the planning sessions at technical societies' headquarters, there's always somebody who thinks that tutorial sessions are the way to improve attendance because more people say they are interested in established techniques than in advanced technology. The real complaint, however, is that most advanced technology sessions are conducted so badly nobody can bear to sit through them. So nobody attends.

The tutorial role belongs to short courses and seminars at colleges, to regional and sectional meetings of IEEE, and to books and magazines. The IEEE meeting in March should be something special—technically.

Certainly the business side of IEEE week is essential to the industry. In fact this year's show will be crucial for a lot of companies that plan to introduce products there [see p. 74]. Many a company's future will hang on how well its new products are received by the potential customers who attend the show.

Further, the show acts as a rallying point for the industry. Its arrival forces engineers to solve that last problem on the product scheduled for introduction; its size makes it a bonanza for the tireless salesman; and the appendages set up around the show by recruiters help a job-hunting engineer solve a career problem.

Yet these are basically business benefits. The technical sessions ought to be at least on a par in importance. Just how badly the sessions stack up can be seen by the attendance figures. Although 75,000 people will push their way into the show, only about 5,000 will take in the sessions and many of them will be college students.

Attendance at the technical sessions can be stimulated if they are made as important as the exhibits. And there is an easy way to do this: insist that the presentations report only significant advances in technology.

If anybody wants a model, the American Association for the Advancement of Science has been following this prescription for years. Any paper accepted for presentation at one of the AAAS's annual sessions must make a contribution to technology. In recent years AAAS audiences have heard some truly exciting reports, such as the first detailed description of the Van Allen radiation belts in space and a new theory on the composition of matter.

In addition to insisting on a significant development, IEEE could require each author to prepare his presentation in such a way that an engineer can understand it; that it puts the technical development in proper perspective with respect to the work of others; and that it explains the significance of the development for engineers who are not specialists in his field.

There's no substitute for a dialogue between the man who has done an important piece of work and the engineer who is anxious to learn about it. The only way to arrange such a transfer—in large numbers— is to establish good technical sessions.

The annual electronics meeting in March was born as a technical affair. It should become technical again.

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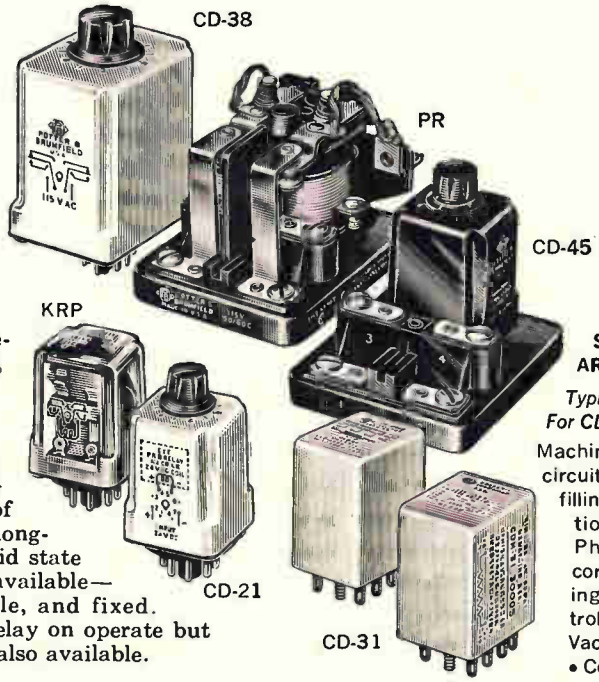

A wide range of time delay requirements can be met with these accurate, easy-to-use solid state relays. All built to P&B's exacting standards of reliability, this new series offers a multitude of advantages, including timing repeatability of ± 2%; nearly instantaneous (milliseconds) reset; a choice of sizes, mountings and terminations; long-life inherent with non-mechanical solid state switching. Three modes of timing are available—knob-adjustable, resistor-adjustable, and fixed. Most standard relays provide time delay on operate but relays with time delay on release are also available.

CD-38 HAS RELIABLE P&B DPDT RELAY MOUNTED INSIDE CASE
An internally mounted DPDT relay has contacts rated to 10 amps, 115V AC, resistive. Fixed time delay can be specified or relay can be adjusted with knob or external resistor.

CD-21 TIME DELAY PAIRS WITH POPULAR P&B KRP SERIES RELAYS
Compact AC or DC units available to time in increments from 0.1 to 180 seconds. For use with popular P&B KRP relay which provides up to 3PDT switching. Delay time may be fixed or adjusted with knob or external resistor.

USE CD-45 WITH PR RELAY FOR HEAVY DUTY APPLICATIONS
Designed for use with PR power relay in elevator controls, machine tools and other industrial applications. Contacts will switch up to 25 amps at 115V AC non-inductive, or 1 HP at 115/230V AC single phase. Heavy-duty screw terminals. Time delay: fixed or knob-adjustable.

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Only slightly larger than one cubic inch. Available with fixed or resistor-adjustable time delay. Match with KHP relay for up to 4-pole switching capacity. Plug-in convenience when used with socket having solder or printed circuit terminals.

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THESE STANDARD TIME DELAY RELAYS ARE AVAILABLE FROM ELECTRONIC PARTS DISTRIBUTORS

Type	Time Delay in Seconds	Input Voltage	Notes	Sugg. Resale Price
CDB-38-70003	0.1 to 10	115V AC	1	43.80
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CDD-38-30003	0.1 to 10	24V DC	1	41.55
CDD-38-30005	1.8 to 180	24V DC	1	41.55
CDB-21-70003	0.1 to 10	115V AC	2	38.70
CDB-21-70001	1.8 to 180	115V AC	2	38.70
CDD-21-30003	0.1 to 10	24V DC	3	38.35
CDD-21-30001	1.8 to 180	24V DC	3	38.35
CDH-31-30005	180 (note 5)	24V DC	4 & 5	38.90
CDB-45-70002	0.6 to 60	115V AC	6	37.05
CDB-38-70012	0.6 to 60	115V AC	1 & 7	52.45
CDD-38-30012	0.6 to 60	24V DC	1 & 7	49.50

NOTES

1. Has internal relay with DPDT contacts rated at 10 amperes, 115V AC. **2.** Use with Potter & Brumfield relay KRP5AG—115V AC, KRP11AG—115V AC or KRP14AG—115V AC. **3.** Use with Potter & Brumfield KRP5DG—24V DC, KRP11DG—24V DC or KRP14DG—24V DC relay. **4.** Use with Potter & Brumfield KHP17D11—24V DC relay. **5.** Resistor-adjustable. **6.** Use with Potter & Brumfield PR11AY—115V AC relay. **7.** Provides delay on release; all others have delay on operate.

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Electronics Newsletter

March 8, 1965

Semiconductors make laser news

Semiconductors are making laser experimentation news at the Massachusetts Institute of Technology's Lincoln Laboratory. In one test, indium antimonide was optically pumped; in another, coherent emission, parallel with, rather than perpendicular to, the diode current was obtained with the same material.

Robert H. Rediker and Robert J. Phelan Jr. used the emission from a gallium arsenide laser to pump the n-type indium antimonide. It was the first time a semiconductor had been optically pumped; indications are that the technique can be used for most present-day diode laser materials, according to Rediker.

Ivars Melngailis obtained the parallel laser action. His technique could free designers from some structural restrictions and permit, for instance, diode laser arrays.

Dispute closes satellite tracker

Grumbling about the younger generation is nothing new, but the military has good reason to be unhappy about its new generation of satellite trackers.

First the giant radar at Eglin Air Force Base, Fla., burned to the ground; now a dispute has its little brother—the only other member of the family—under lock and key. It's a $5-million electro-optical sensor at Cloudcroft, N.M. The Air Force blames a contract dispute with the developer, the Radio Corp. of America. "There are certain things that have to be done to meet performance requirements," an Air Force spokesman says. "The government says the contractor should do them under the original contract."

Not so, says RCA. There is no "contract dispute"; the building has been shut down because "the tests there are completed and we are writing our reports now."

Presumably RCA and the Air Force will eventually come to terms. And word is that the $30-million Eglin installation will be rebuilt.

Government to end computer babble

The federal government will concentrate on getting its computers to talk the same language, rather than attempt to standardize all its electronic data-processing equipment. The Budget Bureau, wrapping up a two-year study of computer policies, says that the government spends $3 billion a year in acquiring and operating computers, and controls nearly one-third of the computers in the nation.

FCC would widen tv reception

The Federal Communications Commission plans to liberalize its regulations in an effort to broaden television reception for sparsely populated areas in the United States. The agency also is seeking to encourage applications for assigned but unused tv channels.

The agency has invited comments by March 15 on its proposal to extend 100-watt output translators—unmanned stations that pick up and amplify existing tv signals—to ultrahigh-frequency channels 14 to 69. Current rules limit uhf translators to channels 70 to 83. In addition, the proposed rule would permit a boost in power output for unoccupied

Electronics Newsletter

very-high-frequency tv channel allocations to 100 watts from 1 watt.

The agency says it will give translator operators an opportunity to originate tv broadcast operations if their local markets develop.

Hybrid circuits vs. monolithics

The debate over which microcircuits perform best at the lowest cost (see p. 125) is about to become very real for two companies: the Electronic Components division of the Burroughs Corp. and the Semiconductor division of the Fairchild Camera & Instrument Corp.

Fairchild is readying integrated circuits that will compete directly with the hybrid-circuit modules Burroughs is introducing to drive Nixie indicator tubes (see p. 75). Fairchild has developed a single-chip decade counter with 23 transistors, 10 diodes and 25 resistors and a single-chip binary-to-decimal decoder with 26 transistors and 25 resistors. Each chip is only 0.05 inch square.

J. E. Price, a Fairchild engineer, disclosed the designs at the Solid State Circuits Conference last month. He said the circuits would drive Nixies and would be priced competitively. The initial price for a counter would be above $10. The family will include a buffer-storage circuit.

Blast ruins pad, delays moon shot

The space agency's man-on-the-moon program, already three years behind schedule, hit another snag last week: a test rocket that was to carry a model of the Surveyor moon explorer exploded on the pad. The blast destroyed the only Cape Kennedy pad that can accommodate such a launch vehicle.

5 firms to study avionics for F-111A

Five companies will conduct four-month definition studies for the Mark II avionics subsystem to be installed on the Air Force F-111A fighter-bomber. The five, picked from a field of 10, are the General Dynamics Corp., prime contractor for the plane; Hughes Aircraft Co.; Sperry Gyroscope Co.; Autonetics division of North American Aviation Corp.; and Westinghouse Electric Corp.

Bombproof radio planned for SAC

The Air Force has awarded a $27 million contract to the Westinghouse Electric Corp. for a low-frequency communications network. **The major role of the top-secret system; to provide reliable communication for the Strategic Air Command during and after a nuclear attack.**

The major item in the contract is the erection of an undisclosed number of tower antennas, nearly as high as the Empire State Building (1,472 feet). Among the technical requirements are a 100-kilowatt solid-state transmitter and a technique for using 20,000 feet of wire, which acts as a low-frequency antenna, trailing from a SAC plane.

Addenda

The launching of the Communications Satellite Corp.'s Early Bird satellite, initially set for March 23, was delayed because of transistor failures. The maker, Texas Instruments, Inc., is replacing the transistors. . . . The Air Force has selected four companies—the Boeing Co., General Electric Co., Douglas Aircraft Co., and Lockheed Aircraft Corp.—to perform 60-day preliminary design studies on its manned orbiting laboratory.

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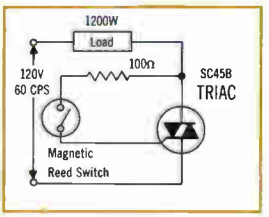

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Advantages:

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Innovator: Tube Department, Owensboro, Kentucky.

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VERY SENSITIVE

This electrostatic I.O. reduces power requirements of comparable, low-light-level systems 30 to 1, weight 20 to 1, and size 5 to 1. Measures just 13.125", weighs 11 oz. Focussing and deflection are self-contained. Available with S-10 or S-20 photocathodes. Innovator: Tube Department, Syracuse, N. Y.

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NEW SHAPE IN COMMERCIAL USE CAPACITORS

For test and measurement rigs, communications equipment, and consumer product applications. *Black Hawk* capacitors deliver unusual mechanical advantages . . . special features like molded encapsulation, welded leads, precise dimensions (±.005"), mounting feet, damage resistance, extended foil construction and modern design. Humidity and moisture resistance, efficient space utilization, and ease of handling are also well worth checking. *Black Hawk* capacitors will operate at temperatures up to +125°C. Innovator: Capacitor Department, Hudson Falls, N. Y.

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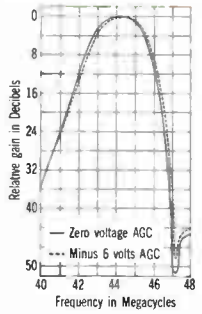
COMPACTRON REPLACES 2—EVEN 3—IF AMPLIFIER TUBES

Lower cost, improved performance level, reduced space requirements—all are GE 9BJ11 COMPACTRON advantages.

Inside it—a double-pentode with dual-control input section and sharp cutoff output section. This new unit may be used in a 2-stage *IF* amplifier with performance level comparable to conventional 3-stage amplifiers in monochrome TV receivers. It reduces sockets required, associated circuitry, and labor costs; and eliminates need for an unbypassed cathode resistor to utilize full gain capability. Innovator: Tube Department, Owensboro, Ky.



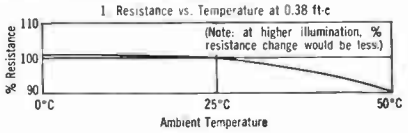
Response of 9BJ11 IF amplifier

QUICK ON THE TRIGGER

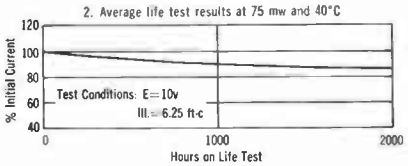
CADMIUM SULFIDE CELL WITH 5 MILLISEC. MAX. RISE TIME

Response speed of GE's A36M1 cadmium sulfide cell approaches that of cadmium selenide cells while retaining excellent temperature (see curve 1) and life test stability (curve 2). Notice how the GE A36M1's resistance changes rapidly with small changes in illumination (curve 3). Ideal for electronic shutter controls on cameras, computer readout cards, and similar applications requiring fast response times. Innovator: Tube Department, Owensboro, Ky.

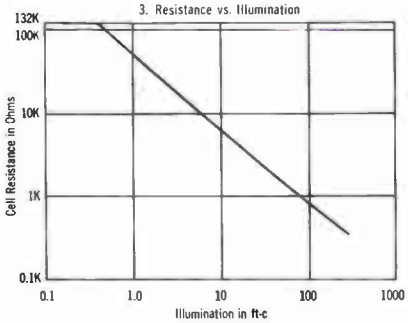
1. Resistance vs. Temperature at 0.38 ft-c



2. Average life test results at 75 mw and 40°C



3. Resistance vs. Illumination



FOUND: SMALL PACKAGE

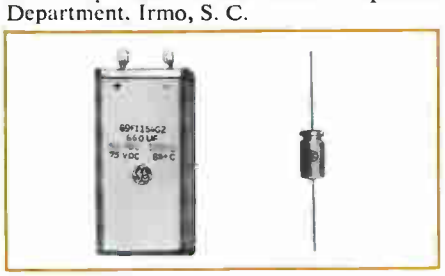
ZP-1061 TRIODE SIMPLIFIES CAVITY DESIGN FOR OSCILLATOR SERVICE

This new high performance, metal-ceramic coaxial triode for NAVAID application features internal feedback that simplifies cavity design for oscillator service. Large cathode area offers long and reliable tube life. Grid-pulsed oscillator service simplifies modulator requirements, and small tube-cavity package size is ideal for miniaturization. Innovator: Tube Department, Sch'dy, N. Y.

JOINS WET SLUG GANG

NEW LOW IMPEDANCE CAPACITOR

The key is simplicity. GE has eliminated 75% of the internal connections found in packaged competitive Tantalum capacitors. This reduces chance for failure and helps eliminate high resistance contact—the primary cause of high impedance. High volt-μf rating remains stable throughout life, and all capacitors in the line meet Mil-C-3965 requirements. Innovator: Capacitor Department, Irmo, S. C.

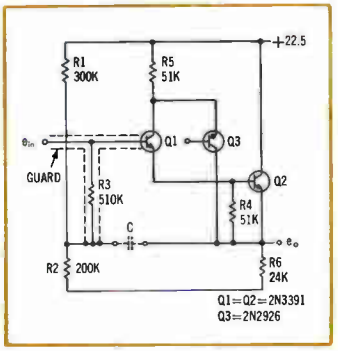


FEEDBACK
TEMPERATURE
SIZE
SHOCK
Radiation
VOLTAGE
Reliability
COST
FREQUENCY
WEIGHT
current
SPEED
VIBRATION
TIME
POWER
MIL
LIFE
RESISTANCE
MOUNTING

CIRCUIT-COST ROBBERS

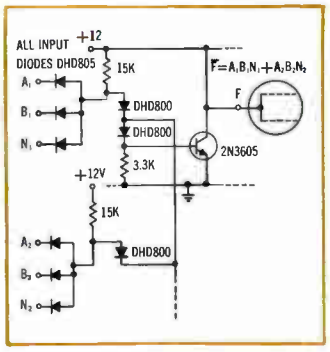
AMPLIFIER—TRANSISTORS COST < $1

Utilizing GE Economy transistors 2N2926 and 2N3391, the Darlington Amplifier below gains you excellent economics through high current gain at low collector circuits, low leakage currents, low collector capacitance and good f_t at low currents. These transistors provide an input impedance greater than 50 megohms up to 25 kc, with a circuit input capacitance of only 0.25 pf.



VERSATILE LOGIC—SEMICONDUCTORS COST < $1

2-level gate in this circuit permits fan-in in excess of 10 into either the AND or the OR gate. Use of a gold-doped, GE Economy transistor 2N3605 with a f_t of 300 mcs. lowers the propagation delay to well under one microsecond under any combination of inputs and outputs. Innovator for both: Semiconductor Products Department, Syracuse, N. Y.



NOTICE

We don't offer everything you want from one supplier. We just come a little closer than anyone else.

Be sure to visit General Electric's IEEE one-source capabilities exhibit. All innovations described on these pages, plus many more, are displayed for you in Booths 2906 through 2944. Ask any GE engineer/salesman there for specs, price details, or application help. Call or write any regional or local Electronic Components Sales Office. Write us at 1 River Road, Schenectady, N. Y. or ask your local GE distributor.

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Innovations in Action

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ELECTRONIC COMPONENTS SALES OPERATION

TWO GREAT NEW CHAMPS

See them at IEEE
March 22-25
Booth 3038

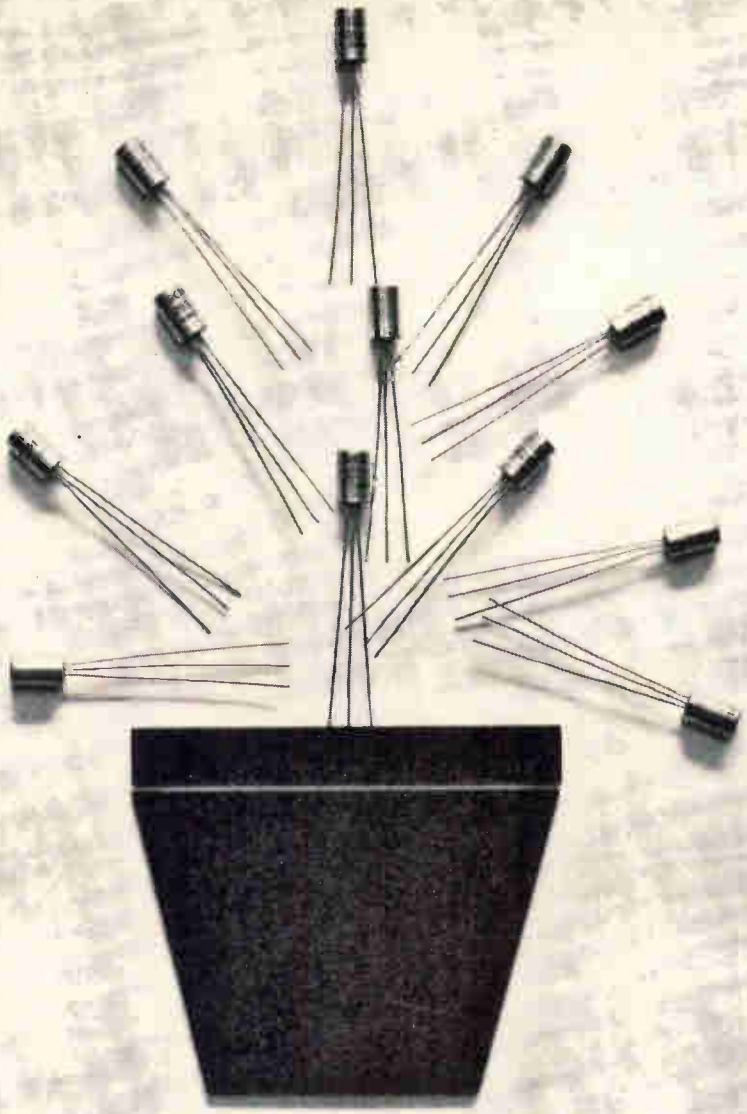
NEW COAX

Recording 1.5 mc on as many as fourteen tracks, Mincom's new Portable Coaxial Recorder offers the industry's highest performance per cubic foot. Stands under two feet high. 14-inch NAB precision reels. 1⅞ to 120 ips. Two playback channels. RFI-shielded, this new system is unequalled for van, shipboard and similar installations.

NEW PCM

Digital data in an improved parallel format at 120,000 bits per second per track — that's the story of Mincom's newest solid-state system. Sixteen channels for NRZ digital input, clock, timing and voice. Seven push-button speeds from 1⅞ to 120 ips. Controls and adjustments front-accessible for CRT display and digital electronics.

Mincom Division 3M COMPANY
300 South Lewis Road, Camarillo, California



Tree of plenty

And Hitachi invented the way to make it grow. The fruits of this invention are called PM-type silicon transistors. Hitachi is now the only electronics manufacturer in the world that can produce such transistors by the millions! ■ This transistor family began as an idea. That idea was to develop Planar-type transistors that could eliminate surface contamination and retain optimum efficiency. This was achieved. The PM transistor was developed. But, only on a small scale. And it remained at this stage until Hitachi took over the task of mass production. ■ This proved to be almost as difficult as the original conception. But by the pains-taking development of a special sealing technique the problem was solved . . . mass production was possible for the first time. ■ The windfall of advances this brings to the electronics field are considerable: a transistor that is dependable due to longer lasting efficiency . . . a high collector inverse voltage . . . a small collector saturation current . . . current gain that does not drop off in low current operation . . . and, most important, a cost rate that makes it financially more than practical. ■ This is our tree of plenty . . . this is how to enjoy its benefits. Write to the addresses below.

Hitachi, Ltd.
Tokyo Japan

HITACHI SALES CORPORATION: 333, N. Michigan Avenue, Chicago 1, Ill., U.S.A. Tel: 726-4572/4 / 666, 5th Avenue, New York, N.Y. 10019, U.S.A. Tel: 581-8844 / 12715, S. Daphne Avenue, Hawthorne, Calif., U.S.A. Tel: 757-8143
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Circle 25 on reader service card→

NOW! Measure Noise and Field Intensity INSTANTLY with ONE Integrated Unit 1-10 gc

EXPANDABLE WITH ONE MODULE 10-22 gc

NEW!

Empire* NF-112-F
Noise and Field Intensity Meter

- Automatic Variable Speed Scanning (Full and Sector)
- Impulse Noise Generator Calibration
- X-Y Plotting Provision
- Average, peak and metered slideback detection
- Dual Bandwidths—Narrow and Broadband

NOW you can measure noise and field intensity INSTANTLY over the entire 1-10 gc frequency range with ONE integrated unit, and CONVENIENTLY over the entire 10-22 gc range with ONE tuning module.

The new EMPIRE NF-112-F Noise and Field Intensity Meter combines advanced versions of the 1-10 gc tuning modules of the field-accepted NF-112 into one convenient package — your assurance of *dependability* and *full compliance* with the most stringent of military and commercial test requirements.

PLANNED UN-Obsolescence — is the unique METRICS concept of designing state-of-the-art instruments capable of fulfilling your expanding needs. Typical is the Empire NF-112-F, which provides modular range expansion from 10 to 22 gc, and anticipates dramatic operational improvements. You save today *and* tomorrow through *Planned Un-obsolescence.*

INSTANT INTEGRAL operation is possible through Automatic Scanning and complete functional one-unit design. The NF-112-F is the world's only NFI Meter to provide Automatic Variable Speed Scanning, Impulse Noise Generator Calibration, and range-extendability *all in one light, integral package.* It is ideal for rack or field vehicle installation.

With the NF-315 (*20 cps - 15 kc*), NF-105 *(14 kc - 1gc)* and NF-112 series, the entire frequency range of *20 cps to 22 gc* is covered with just three instruments.

MATCHED SYSTEMS CAPABILITY

Another exclusive! Typical is the *Empire* PA-210 Spectrum Signature Analyzer, which provides rapid display of RFI signals, and is matched to the NF-112-F and other *Empire* NFI Meters.

Empire devices are designed to match existing and planned instrumentation—minimizing complications in systems design—such as impedance matching and extra calibration.

Contact your Metrics Representative for descriptive literature and demonstration.

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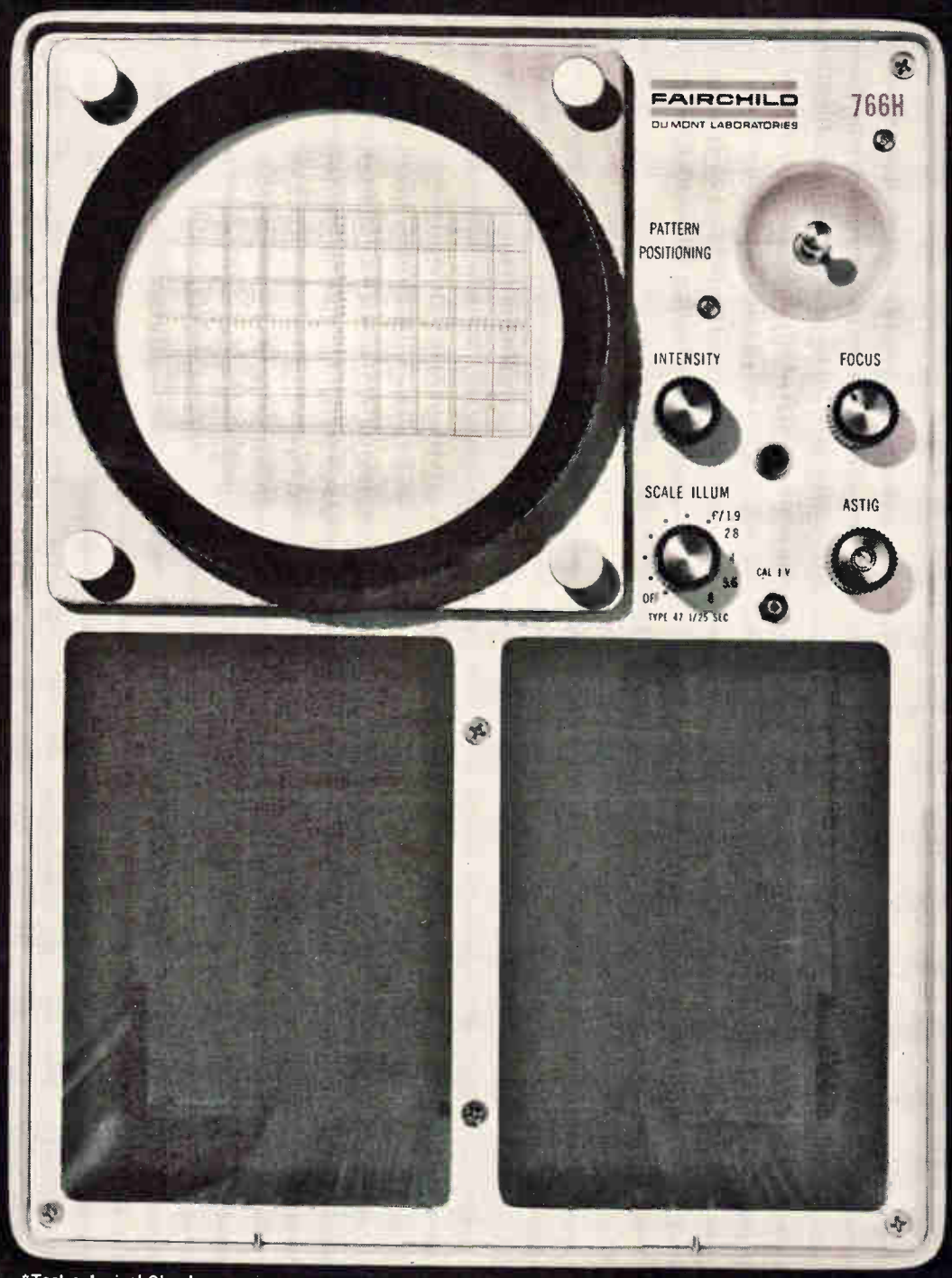
Design and production of PANORAMIC • SENSITIVE RESEARCH • EMPIRE • GERTSCH instruments for measurement

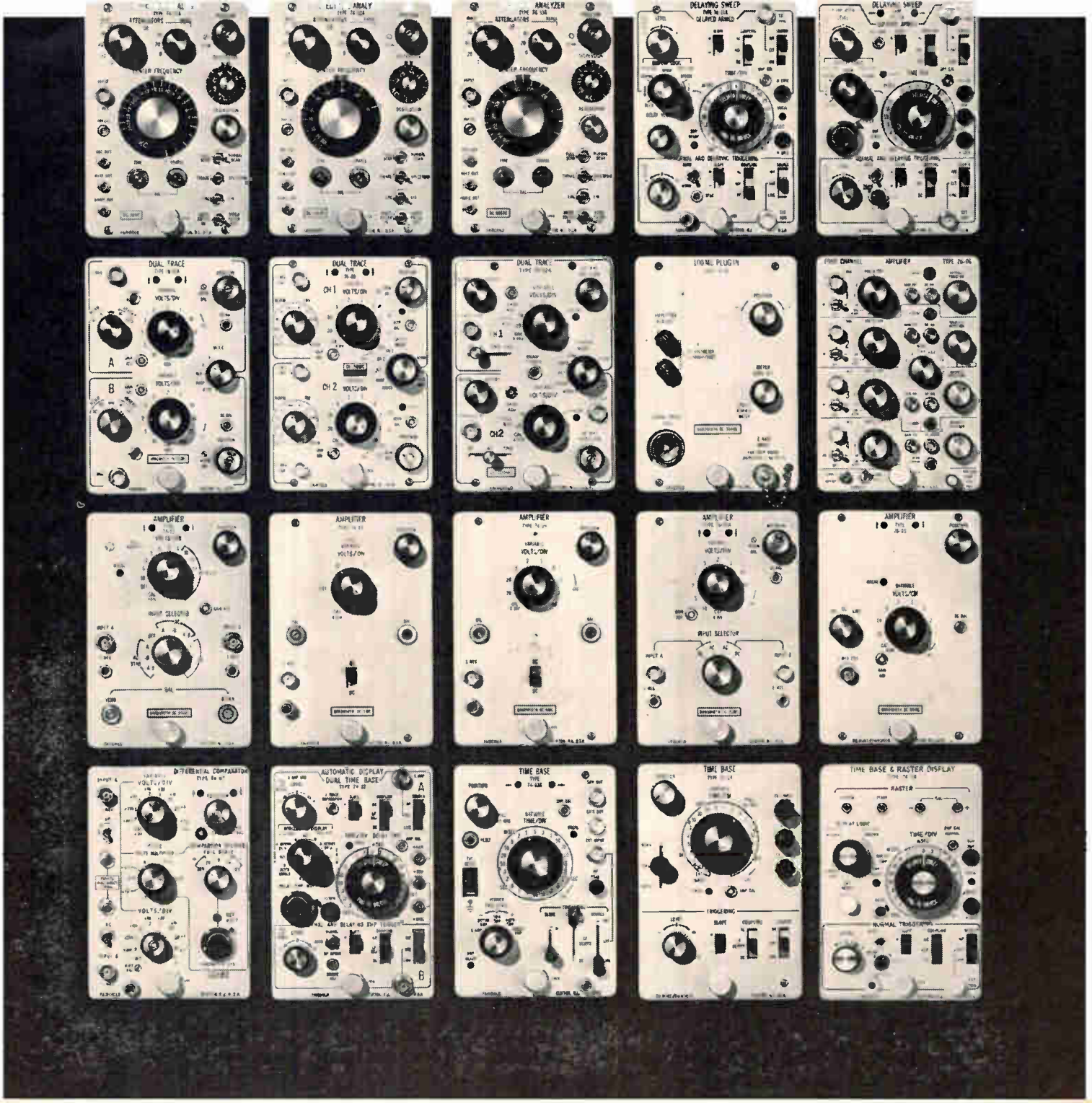


BEAT T.O.* WITH FAIRCHILD

*Technological Obsolescence

WITH THIS SCOPE AND THOSE PLUG-INS...

Your oscilloscope applications change with the work you're doing and the state-of-the-art. Over the years, you **could** buy a lot of special purpose scopes for that reason. But you don't have to. There are now 20 plug-ins available for the Fairchild Series 765H main frame (and more are on the way). The versatility not only helps you beat the gh cost of T.O.—Technological Obsolescence; it lets you add new capabilities at low cost if and when you need em. Other factors that contribute to Fairchild value are . . . all solid-state circuitry for long term reliability . . . deflection circuitry in the plug-in . . . four main frame configurations (bench, rack, portable, and dual gun).



...WHO NEEDS COSTLY SPECIAL PURPOSE SCOPES?

Ask your Fairchild Field Engineer for a demonstration of the Series 765H. Judge it on performance and by your own standards of value analysis. For a new catalog describing the Series 765H and other Fairchild scopes write Fairchild Scientific Instrument Dept., 750 Bloomfield Ave., Clifton, N. J. Visit Fairchild at the IEEE Show — Booth Nos. 2701 thru 2717.

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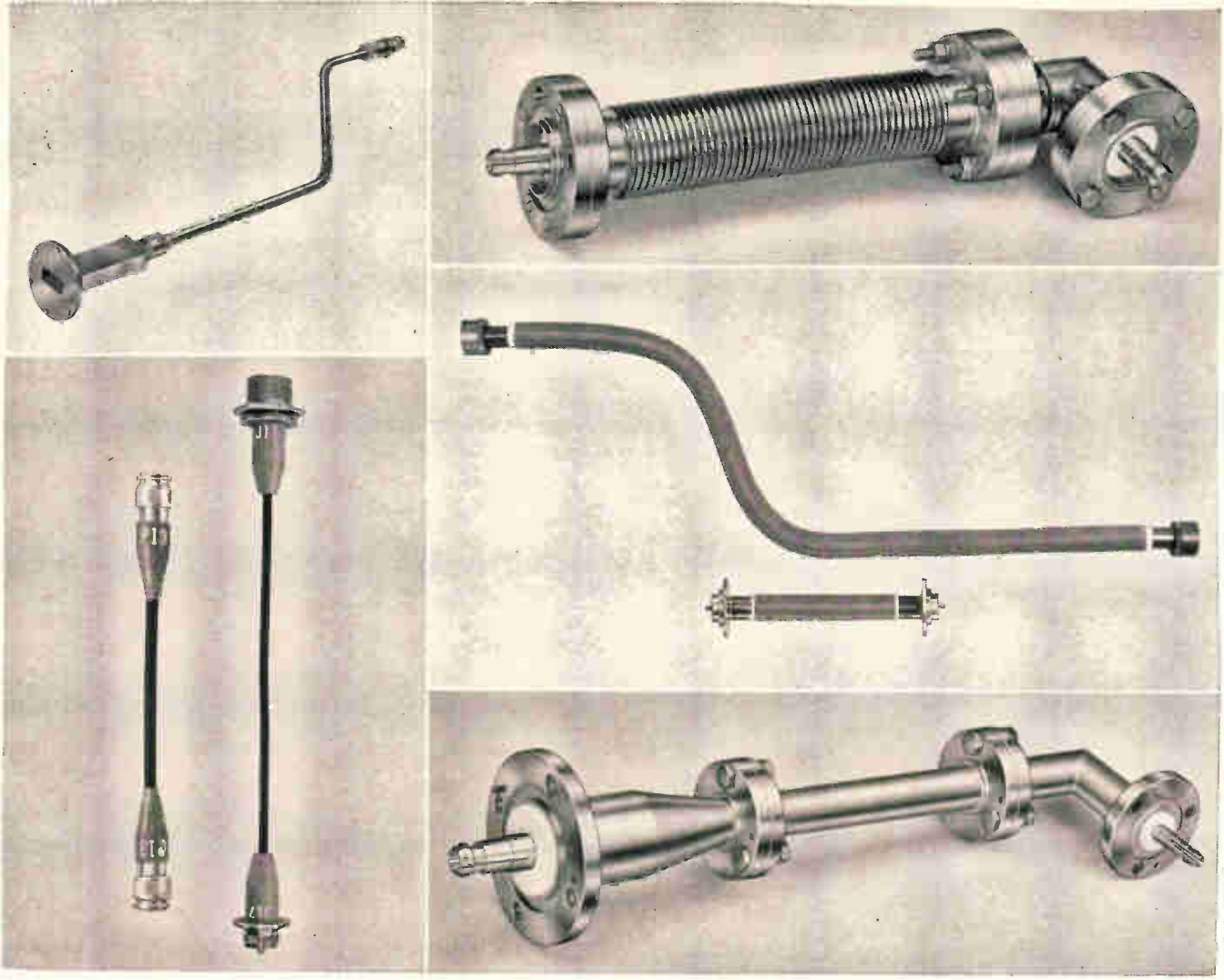
SCIENTIFIC INSTRUMENT DEPARTMENT

Circle 27 on reader service card



Coaxial cable assemblies. Ingenious solutions to very special installation and transmission problems.

Phelps Dodge Electronic's coaxial cables are available by the mile or by the foot. They are also available in unique, one-of-a-kind shapes and configurations which greatly extend application parameters. For instance, in transmitter installations, a cable assembly can eliminate the need for elbows and other high cost RF plumbing. In tight physical confines, or under difficult environmental conditions, a special cable assembly might well be the answer.

We have made hundreds. And, they are all different. Tracking antenna harnesses, as an example, sections of cable which accurately place each antenna element in phase with other elements. Special local oscillator and receiver lines, each a section of Styroflex® coaxial cable cut to very tight electrical length for transition to waveguide. An airborne vibration isolator, an extremely flexible corrugated assembly connecting rigid line to shock mounted gear. Or, in equalizing and balancing networks. Matching sections.

We would like to hear about your needs. Write for Bulletin CC-1.

PHELPS DODGE ELECTRONIC PRODUCTS
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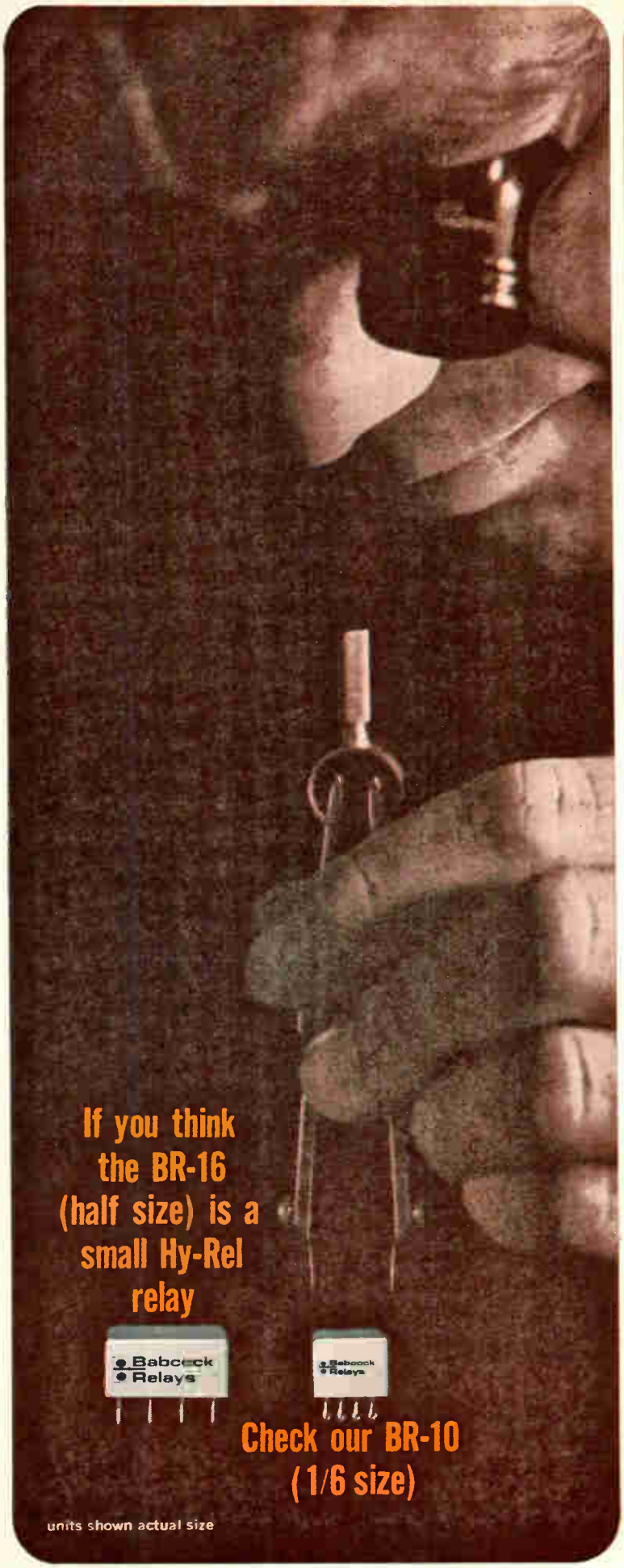

Babcock's new BR-10 1/6-size crystal can relay will switch dry circuit to 1-amp loads with the same sensitivity as DPDT types many times its size. Designed for low profile mounting, it exceeds MIL-R-5757D requirements and withstands severe environmental conditions encountered in airborne applications. Available both single pole and double pole.

For 2-amp contact requirements, the Babcock BR-17 (latching) and BR-16 (non-latching) half-size crystal can relays provide the same reliability and, like the BR-10, incorporate the exclusive Babcock Vycor getter to adsorb outgassed organic contaminants after production degassing. Various mounting arrangements and either plug-in or solder hook terminals can be supplied as standard. Write for complete details in our new 24-page catalog.

	BR-16	BR-17	BR-10T	BR-10W
Operation	Non-Latching	Latching	Non-Latching	Non-Latching
Contact Arrangement	DPDT	DPDT	DPDT	DPDT
Construction	All Welded	All Welded	Solder Seal	All Welded
Sensitivity	175mw	175mw	100mw	100mw
Contact Rating	2A @ 26VDC	2A @ 26VDC	1A @ 26VDC	1A @ 26VDC
Size	.131 cu. in.	.131 cu. in.	.046 cu. in.	.046 cu. in.
Weight	.25 oz.	.25 oz.	.15 oz.	.15 oz.
Vibration	30g 30-2000 cps	30g 30-2000 cps	30g 40-3000 cps	30g 40-3000 cps
Shock	50g 11 msec.	50g 11 msec.	150g 11 msec.	150g 11 msec.

See us at Booth 2927 IEEE

BABCOCK RELAYS

A DIVISION OF BABCOCK ELECTRONICS CORPORATION
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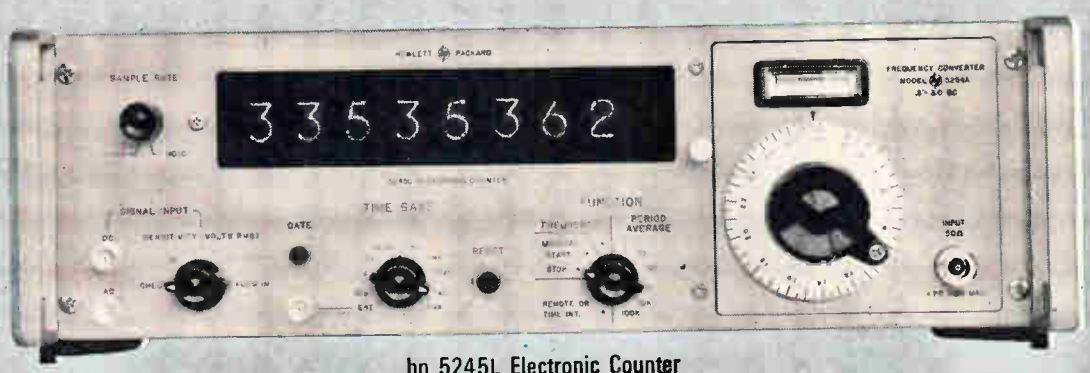
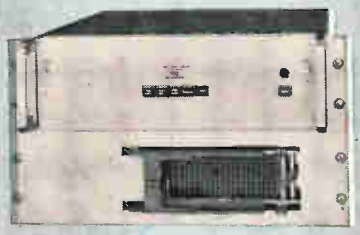
Circle 29 on reader service card

How to increase the utility of your Hewlett-Packard Counter:

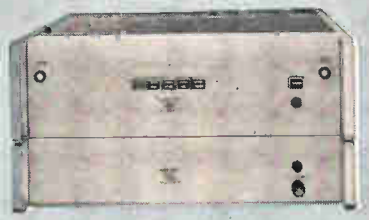


hp 5245L Electronic Counter

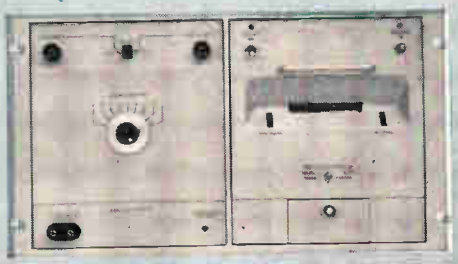
DY-2546



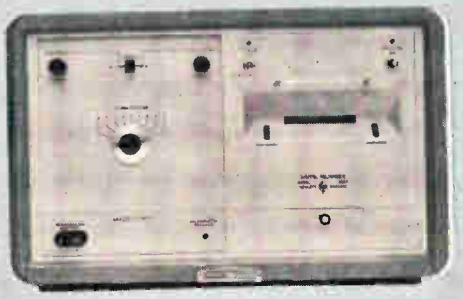
DY-2526



DY-2545



hp 562AR

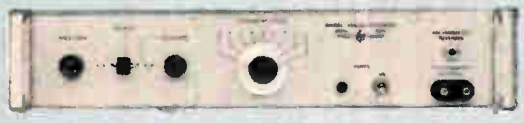


hp 562A

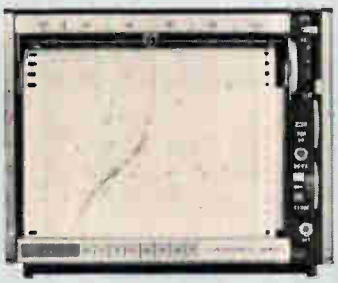
DY-2514A

Make permanent records of your hp counter measurements

- printed paper tape
- punched paper tape
- punched cards
- magnetic tape
- x-y plots
- analog strip-chart records
- analog voltage and current



hp 580A



Moseley 680A

hp 581A

Moseley 7000

Use these accessories to increase the usefulness and value of your counter:

These instruments, available from Hewlett-Packard and its Dymec and Moseley Divisions, increase the usefulness of your counter measurements by permitting you to make a wide variety of permanent records ideal for later study or processing.

hp 562A Digital Recorder— Solid-state device with parallel data entry and low-inertia moving parts allowing printing rates as high as 5 lines/sec, each line up to 11 digits (12 on special order); data transfer as fast as 2 msec; available for BCD and 10-line codes, $1600, depending on options; 562AR rack mount, $1575.

DY-2545 Tape Punch Set—Operates with Teletype BRPE 11 Tape Punch, records at 110 characters/sec; accepts 10 input digits in BCD form from electronic counter, produces IBM 8-level code; up to 16 input characters and other 5 to 8-level output codes optional; features data storage for high speed; all solid state; $3900, including tape punch.

DY-2526 Card Punch Set—Couples counter to IBM 526 Card Punch; standard model accepts 10 input digits in BCD form; features data storage; all solid state; $3100.

DY-2546 Magnetic Tape Recorder Set—Operates with Cook Model 150 Incremental Tape Recorder; records at 150 characters/sec; standard model accepts output format for maximum computer compatibility; data storage; all solid state; $8565, including tape transport.

hp 580A, 581A Digital-to-Analog Converters—Accept 4-line BCD output from counters, provide output for galvanometer and potentiometer strip-chart recorders; differ only in physical dimensions; $525.

DY-2514A Digital Scanner—Scans up to 6 data sources, up to 10 digits from each source; compatible with BCD output of all hp solid-state counters; sequential and random scanning modes, transfers data as fast as 20 readings/sec; $2500.

Moseley 680A Strip-Chart Recorder—Solid-state 6" recorder; 8 chart speeds; continuous zero set; zener reference; 10 ranges, 5 mv to 100 v full scale; accuracy better than 0.2% of full scale; $750.

Moseley 7000 X-Y Recorders—Variety of 11" x 17" recorders; accepts dc inputs on each axis; 10, 11 or 16 ranges; most models with built-in time sweep; one model omits time base, is designed for computer use, will accept ± 100 v computer reference; $1490 to $2050.

Discuss how to get maximum usefulness from your hp counter with a call to your local Hewlett-Packard field engineer. Or describe your problem and request complete data with a letter to Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva; Canada: 8270 Mayrand Street, Montreal.

Data subject to change without notice. Prices f. o. b. factory.

HEWLETT hp PACKARD

An extra measure of quality

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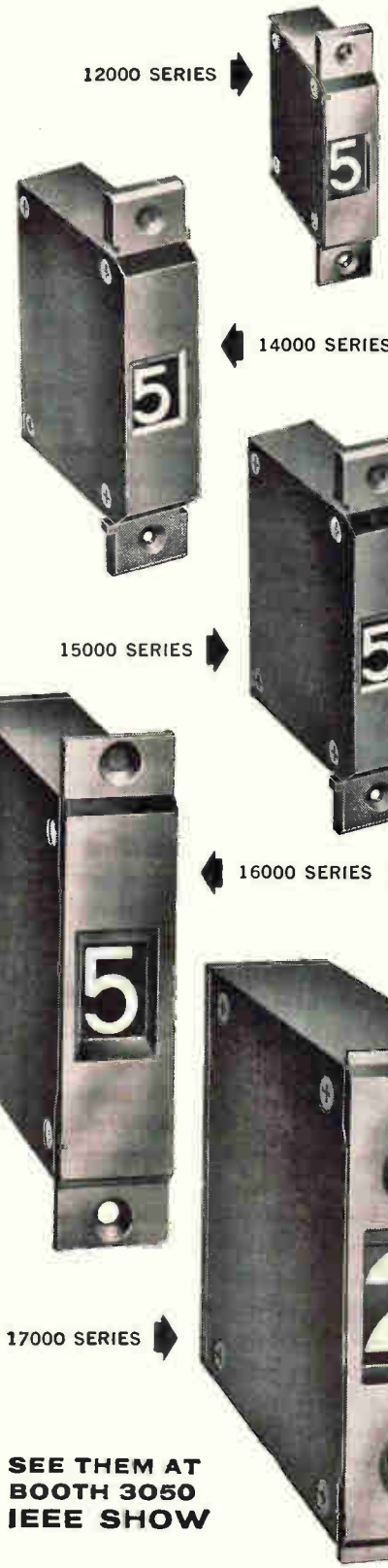
Magneline®

THE INDICATORS WITH INHERENT MEMORY



12000 SERIES

PANEL SPACE.....$\frac{25}{64}$" wide x $1\frac{9}{16}$" high ($\frac{25}{64}$" x 1" if bracket mounted)
NUMBER OF CHARACTERS....up to 10
NUMBER OF TERMINALS.....5, plus a common*
WATTS.....3
PULSE TIME.....500 milliseconds
DUTY CYCLE.....25% (pulsing same coil)

**Requires switching of lead in conjunction with reversal of polarity to change character*

14000 SERIES

PANEL SPACE.....½" wide x 2¼" high (½" x 1⅝" if bracket or earless mounted)
NUMBER OF CHARACTERS....up to 11
NUMBER OF TERMINALS.....11, plus a common
WATTS.....2.5
PULSE TIME.....500 milliseconds
DUTY CYCLE.....50% (25% if pulsing same coil continuously). Continuous duty available in some voltages.

15000 SERIES

PANEL SPACE.....½" wide x 2¼" high (½" x 1⅝" if bracket or earless mounted)
NUMBER OF CHARACTERS....up to 10
NUMBER OF TERMINALS.....5, plus a common*
WATTS.....1.5
PULSE TIME.....500 milliseconds
DUTY CYCLE.....50% or continuous (must be specified)

**Requires switching of lead in conjunction with reversal of polarity to change character*

16000 SERIES

PANEL SPACE.....⅞" wide x 3¾" high (⅞" x $2\frac{15}{16}$" if bracket or earless mounted)
NUMBER OF CHARACTERS....up to 12
NUMBER OF TERMINALS.....12, plus a common
WATTS.....3
PULSE TIME.....650 milliseconds
DUTY CYCLE.....50% or continuous (must be specified)

17000 SERIES

PANEL SPACE.....1½" wide x 5" high
NUMBER OF CHARACTERS....up to 12
NUMBER OF TERMINALS.....12, plus a common
WATTS.....3
PULSE TIME.....2 seconds
DUTY CYCLE.....50% or continuous (must be specified)

All MAGNELINE® Indicators are available in 6, 12, 24 or 28 volts (as specified) and the standard operating temperature range is from −20 deg. C to +71 deg. C. Options, at extra cost, include special voltage, broader temperature range, special characters, trim-spacer strips, internal lighting, solder terminals, dust tight–drip proof construction, and dummy models with fixed digit or black window.

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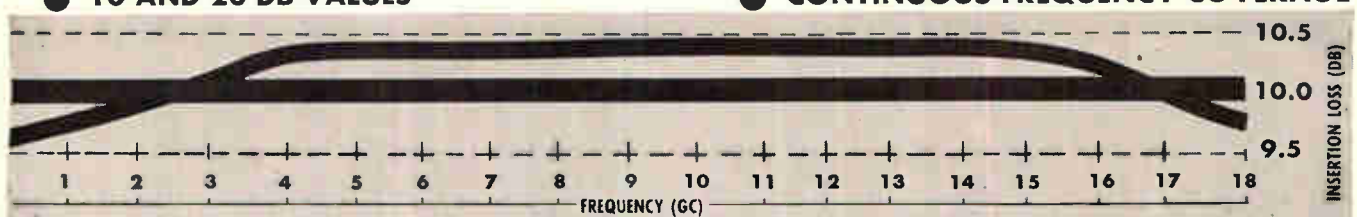
new....
dc to 18 gc fixed attenuator

MODEL 2
ACTUAL SIZE

- **LOW VSWR AND FREQUENCY SENSITIVITY**
- **10 AND 20 DB VALUES**
- **NEW TYPE N CONNECTORS**
- **CONTINUOUS FREQUENCY COVERAGE**



TYPICAL CHARACTERISTICS OF A MODEL 2 (10 DB UNIT)

Designing this new DC to 18 Gc attenuator required the unique combination of ℍ experience in developing attenuators, connectors and test equipment. The ℍ Model 2 will broaden the range of applications for coaxial systems—including use of the 12.4 to 18 Gc band usually reserved for waveguide.

An entirely new semi-precision Type N connector, plus a 7 mm slotted line and accessories, had to be developed before work could start on the attenuator. The new connector can be mated and used with older Type N fittings. This is an important factor in the use of the attenuator. These 18 Gc upper limit connectors together with the test equipment will soon be available commercially.

The flat attenuation and low VSWR characteristics of the Model 2 Fixed Attenuator are based on design principles* used by ℍ in the DC to 10 Gc Model 1 attenuators introduced last year. An attenuating card, with a recently developed ℍ resistive film deposited at red heat on a ceramic base, is the key to the design. Elements of this type have been proven through use to be stable with time. They are also able to withstand overloads of either CW or pulse power without damage.

*Patent No. 3,157,846

SPECIFICATIONS

Frequency Range—DC to 18 Gc
Standard Nominal Values—10 and 20 db
Maximum Deviation from Nominal Value**—±5% in db
VSWR—DC to 3 Gc—1.2 Maximum
3 to 10 Gc—1.35 Maximum
10 to 18 Gc—1.50 Maximum
Input Power—1 Watt CW Maximum; 1 KW Peak Maximum
Power Sensitivity— ≺ 0.001db/db/Watt
Temperature Coefficient— ≺ 0.0001db/db/°C
Calibration Frequencies—(with insertion loss values stamped on nameplate)—DC, 4, 8, 12, 16, and 18 Gc
Connectors—Type N, 50 ohms, stainless steel — One male and one female
Length—2.85"
Diameter—25/32"
Weight—3¾ oz.

**Includes frequency sensitivity

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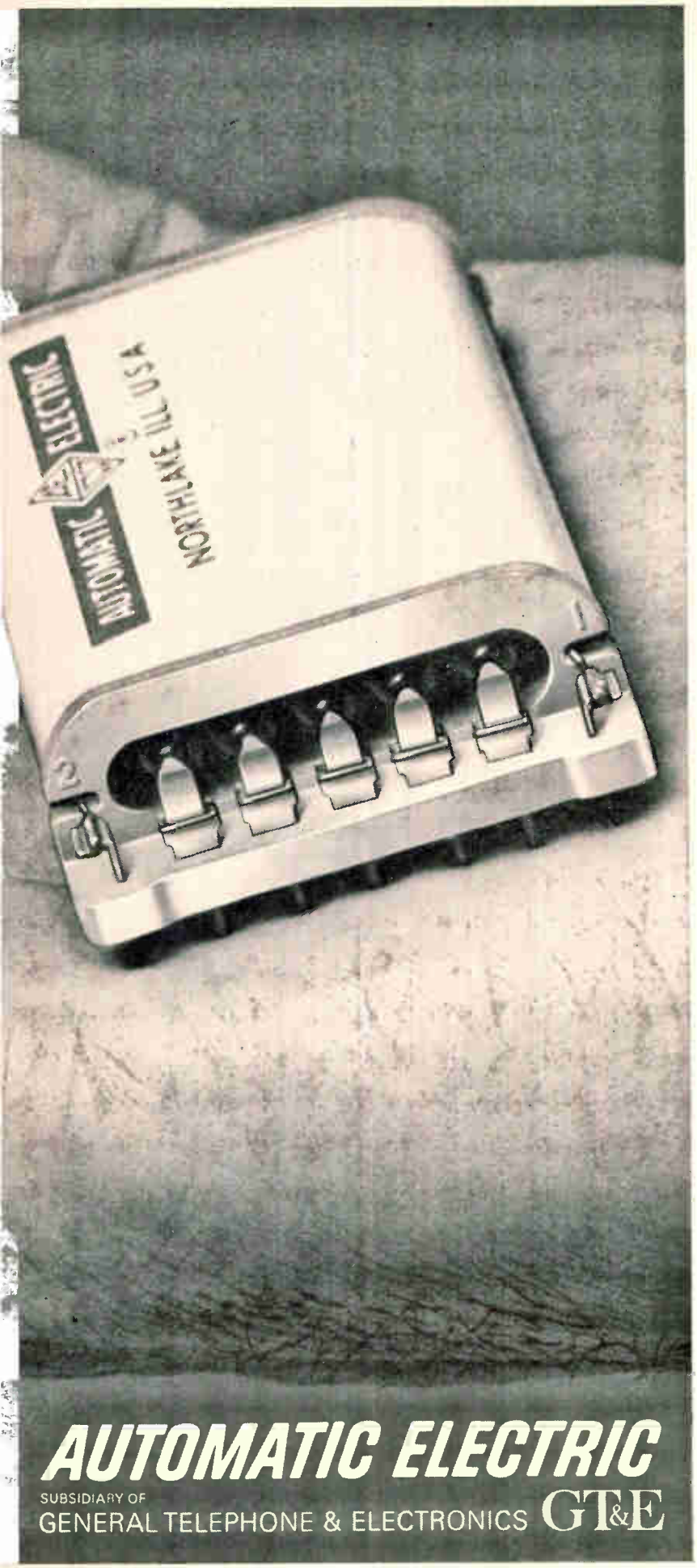

AE has developed a new Correed that overcomes the principal mechanical and electrical shortcomings of conventional dry-reed switches designed for mounting on printed circuit boards. The result: new 1-, 2-, 3- and 5-capsule PC Correeds* and a single-capsule magnetic latching type, all incorporating the five advanced features...

1 Separate Terminals—The capsule leads are not used as terminals. Separate terminals provide superior electrical contact and eliminate strain on the glass capsules.

2 "I-Beam" Strength — The terminals are longitudinally "ribbed" for added strength and rigidity. This facilitates insertion into printed circuit boards.

3 Welded Connections — The contact terminals are welded—not soldered — to the capsule leads, assuring serviceable connections. Capsules can be removed without having to remove the entire package.

4 Moisture Resistance — AE uses glass-filled plastic bobbins for greater strength and to eliminate electrical failure due to moisture absorption.

5 "Standard" Measurements — Measurements between terminal centers are multiples of 0.200 inches, in accordance with industry standards for circuit boards. Standardized terminal size and spacing also allow for greater package density.

These new PC Correeds have magnetic shields surrounding the coils, to avoid interaction between adjacent Correeds; also provisions for soldering diodes directly to the upper side of the terminals.

For the full facts on how these new AE Printed Circuit Correeds meet the requirements of modern electronic circuitry, write to the Director, Electronic Control Equipment Sales, Automatic Electric Company, Northlake, Illinois 60164.

(*U. S. Patent applied for.)

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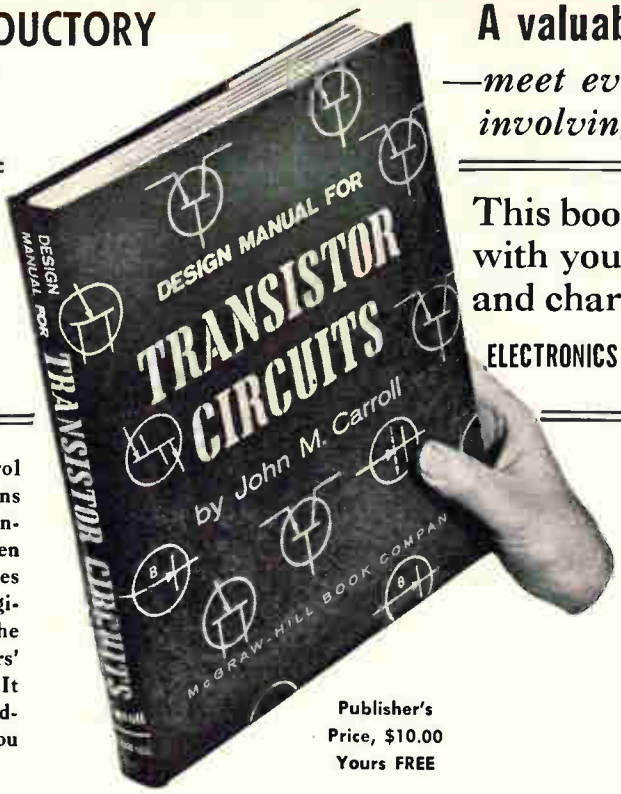

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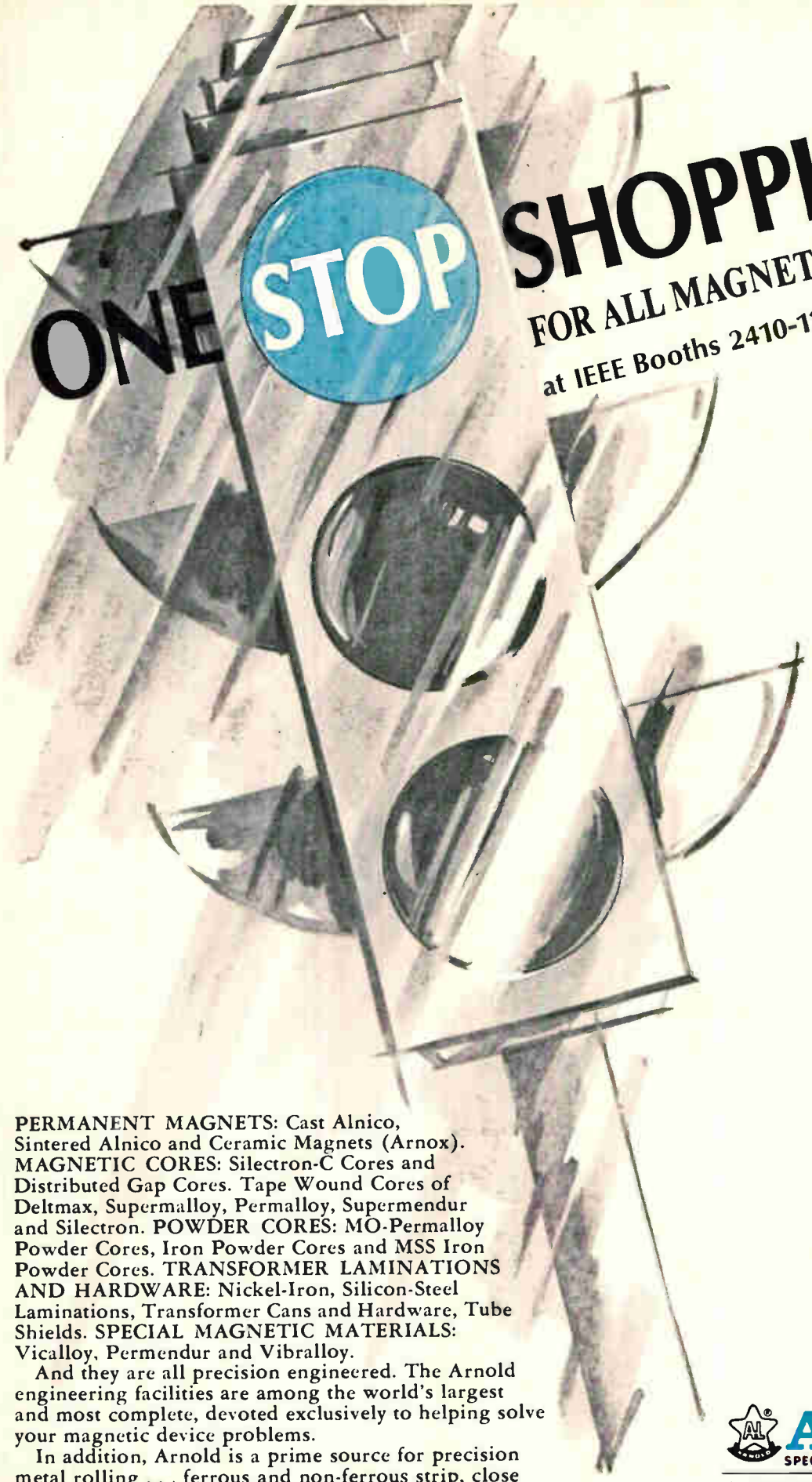

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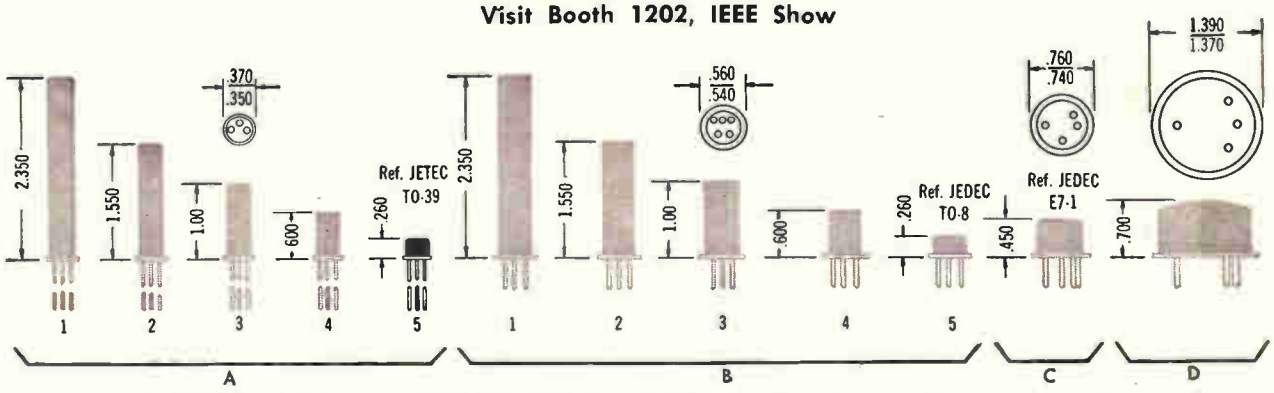

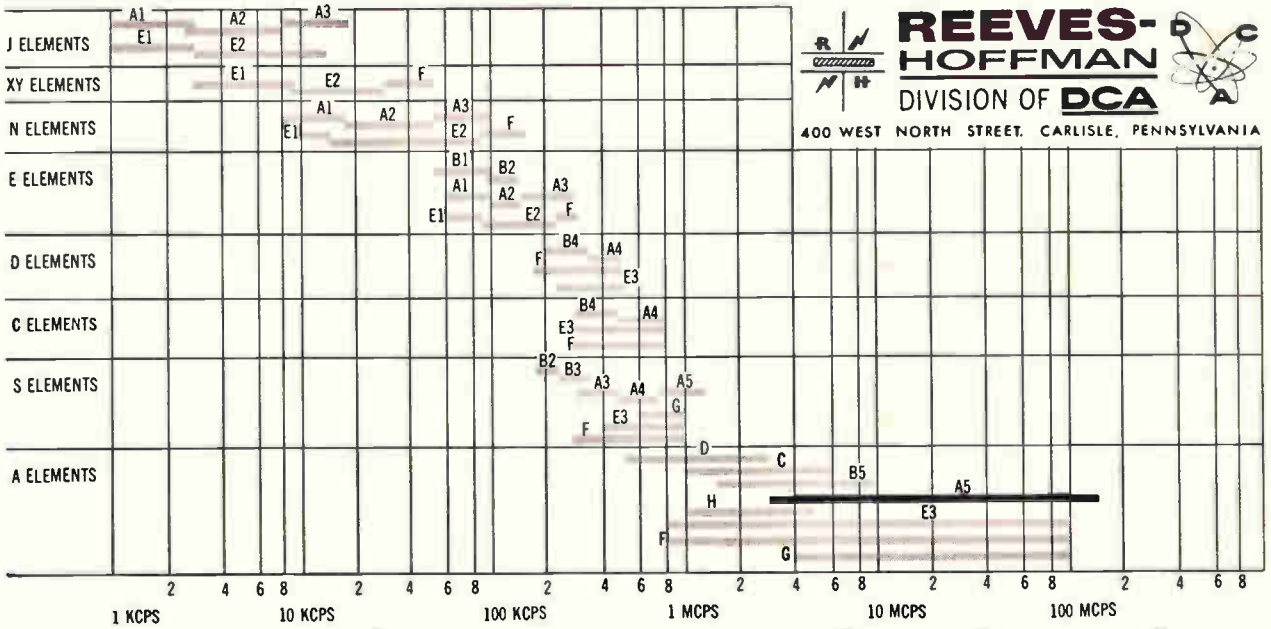

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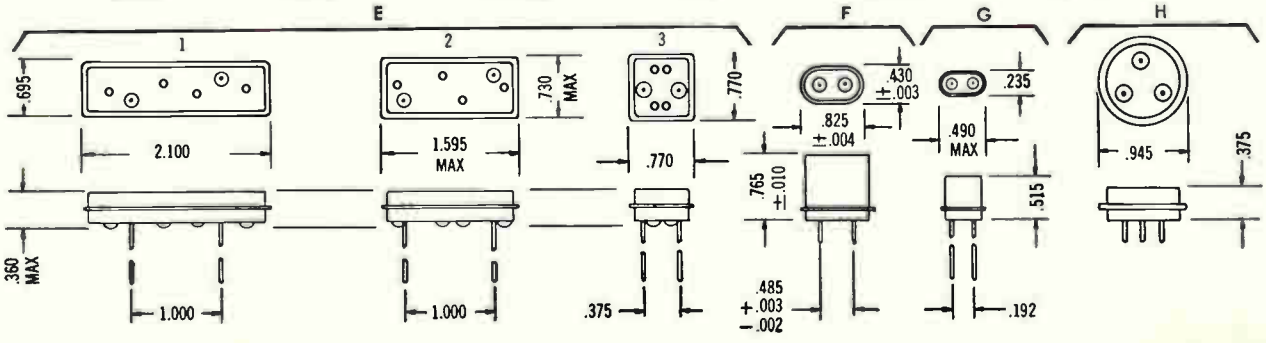

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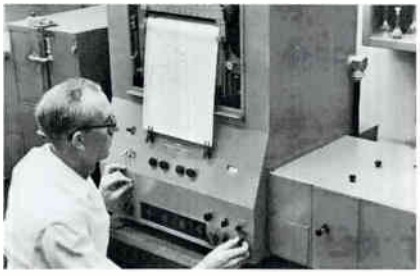

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Chlorides as Cl	Max. 0.00005%
Sulfates as SO_4	Max. 0.00005%
Iron (Fe)	Max. 0.00002%
Heavy Metals as Pb	Max. 0.00005%
Substances reducing $KMnO_4$	Pass ACS Test
Dilution Test	Pass ACS Test

NITRIC ACID

Nitric Acid (HNO_3)	Min. 70.0%, Max. 71.0%
Chlorides as Cl	Max. 0.000008%
Residue after Ignition	Max. 0.0002%
Heavy Metals as Pb	Max. 0.00001%
Sulfates as So_4	Max. 0.00008%
Iron (Fe)	Max. 0.00001%
Arsenic (As)	Max. 0.0000005%
Chromium (Cr)	Max. 0.00001%
Phosphates as PO_4	Max. 0.00002%
Copper (Cu)	Max. 0.000005%
Nickel (Ni)	Max. 0.000005%

AMMONIUM HYDROXIDE

Ammonia (NH_3)	Min. 28.0%, Max. 30.0%
Chlorides as Cl	Max. 0.00005%
Phosphates as PO_4	Max. 0.00005%
Heavy Metals as Pb	Max. 0.00005%
Substances reducing $KMnO_4$ as SO_2	Max. 0.002%
Carbon Dioxide (CO_2)	Max. 0.002%
Residue after Ignition	Max. 0.0003%
Total Sulfur as SO_4	Max. 0.0002%
Iron (Fe)	Max. 0.00002%

HYDROCHLORIC ACID

Hydrochloric Acid (HCl)	Min. 36.5%, Max. 38.0%
Sulfites as SO_3	Max. 0.00008%
Sulfates as SO_4	Max. 0.00008%
Free Chlorine (Cl)	Max. 0.00005%
Heavy Metals as Pb	Max. 0.00005%
Residue after Ignition	Max. 0.0004%
Iron (Fe)	Max. 0.00001%
Arsenic (As)	Max. 0.000001%
Ammonium (NH_4)	Max. 0.0003%

SULFURIC ACID

Sulfuric Acid (H_2SO_4)	Min. 95.0%, Max. 98.0%
Nitrate (NO_3)	Max. 0.00005%
Chloride as Cl	Max. 0.00002%
Ammonium as NH_4	Max. 0.0001%
Residue after Ignition	Max. 0.0004%
Iron (Fe)	Max. 0.00002%
Heavy Metals as Pb	Max. 0.00005%
Arsenic (As)	Max. 0.0000005%
Substances reducing $KMnO_4$ as SO_2	Max. 0.0001%

FORMIC ACID 90%

Formic Acid (HCOOH)	Min
Dilution Test	Passes ACS Test
Residue after Evaporation	Max 0.002
Acetic Acid (CH_3COOH)	Max 0.4
Ammonium (NH_4)	Max 0.005
Chloride (Cl)	Max 0.0001
Sulfate (SO_4)	Max 0.002
Sulfite (SO_3)	Passes ACS Test
Heavy Metals as Pb	Max 0.0005
Iron (Fe)	Max 0.0005

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Electronics Review

Volume 38
Number 5

Computers

Faster memories

If you ask a computer to print the names of all the redheads it knows, the machine has to question in sequence every item it has stored before it can come up with an answer. That's a relatively time-consuming job. But if the computer could fetch the data from its memory without reference to the location of the bits of information, it could answer in one swift memory cycle.

It's the difference between calling out to an audience: "Will all redheads please stand up?" and going through it to ask each person in turn to remove his hat.

Such a concept, called associative memory, has been incorporated in a memory delivered to the Navy's Bureau of Ships by the Goodyear Aerospace Corp., a subsidiary of the Goodyear Tire & Rubber Co. The technique represents one of the early steps toward developing a new generation of computers that use parallel processing instead of the conventional sequential processing.

Experimental stage. Several companies have been experimenting with associative memories in one form or another. Various memory elements are being investigated, including cryotrons, thin films, tunnel diodes, transistors and the ferrite cores that Goodyear used in its associative memory.

Here are four stunts an associative memory could perform if it contained personnel records: Let one associative memory word contain a complete personnel record, such as, Jones, Harold, bookkeeper, age 35, $60/week.

Then a search for a whole word would yield all employees whose names are Harold Jones, who are bookkeepers, who are 35 years old and who make $60 a week. Another search could also yield Jones and all the names that follow his in alphabetical order, or all the names that precede his, or all the names between Jones and Smith.

In any order. The records need not be arranged in alphabetical order in the storage. This is one of the prime advantages of associative memory.

Goodyear's associative memory contains 256 words of 30 bits and the cycle time is 6 microseconds. The memory, which is connected with either of two computers via a standard input-output channel, is built of Goodyear's multiple aperture logic elements [Electronics, Nov. 15, 1963, p. 43].

Memories are made of this. Goodyear Aerospace technician checks circuit of an associative memory, a technique that may lead to a new generation of computers.

The Navy is only peripherally interested in lists of redheads. But an associative memory can provide answers to military questions in real time.

For instance: there are 250 planes, friendly and unfriendly, under surveillance. Which friendly craft are closest, suitably armed, and adequately fueled to carry out an attack mission on the enemy planes? The answer would come in microseconds.

Check the spelling

The Air Force is testing a computer to proofread words being fed into another computer by optical readers.

The proofreading computer contains shift registers that work with an optical reader and a disk-memory file. If the computer's shift register can't match a word read with any of the words on file in its memory, it calls for a correction.

The machine, being tested at the Rome Air Development Center, was developed by the Philco Corp. for military applications.

One error in 1,000 words. Air Force engineers hope the system will catch spelling errors made by either the optical reader, the operator or the machine that printed the document. The goal is to reduce the error rate to 0.1%. The machine can't catch all the errors—only errors in numbers or letter combinations that are stored in its memory.

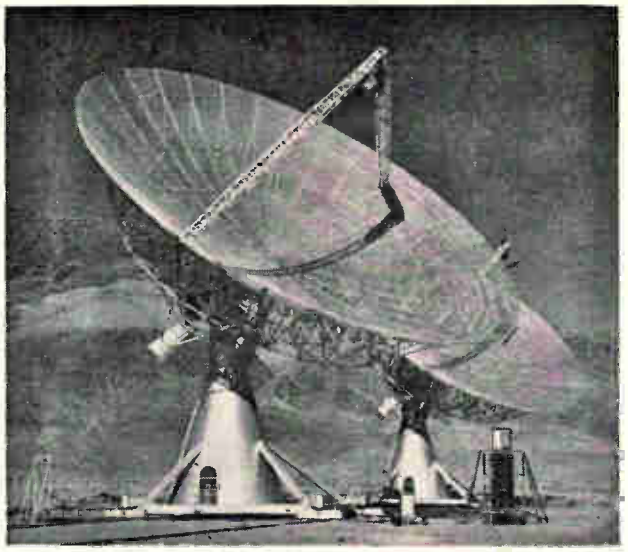
The present machine can only read words that are presented to it in a special form. The next step is to improve the machine so it can handle words in any form.

The optical reader was supplied by Philco under an earlier contract. It can read 16 printing fonts, plus special symbols, at 2,000 characters—about 125 words—a minute. A keypunch operator can only put about 20 words a minute into a computer. The disk file was made by Laboratory for Electronics, Inc.

Advanced technology

Bigger ears

Space beyond the solar system will be more closely examined by a new family of radio telescopes:



Listening to space. Twin 90-foot dish antennas will be linked next year with 130-foot antenna planned for the Owens Valley Radio Observatory of the California Institute of Technology.

mobile dishes that are nearly half the size of football fields.

The first of eight to ten such telescopes, with 130-foot dishes, is being built now by the Westinghouse Electric Corp. for the California Institute of Technology's Owens Valley Radio Observatory. It will be completed by the middle of next year. The initial cost of the project is being financed by a $1.6 million grant from the National Science Foundation. Additional 130-foot dishes are expected to cost $1 million each.

The antenna, mounted on wheels, can be moved along tracks that form an inverted T. The stem of the T will ultimately extend three miles and the bar of the T will measure 7,500 feet. The antennas will be linked to an existing pair of 90-foot dishes.

The mobility of the antennas will permit the telescopes to aim at large or small sections of the universe. They will be able to aim sharply at a point in space that is only 10 seconds of arc wide. Resolution limits on existing radio telescopes is in minutes of arc.

The principal target of the Owens Valley radio telescopes, until something more exciting comes along, are quasars—quasi-stellar sources of radio signals recently discovered in far space.

Originally, optical astronomers interpreted them, as stars; however, recent data indicates they are receding into space at speeds of 0.4 to 0.6 the speed of light. They are believed to be some four billion light-years away—near the absolute limit of the observable universe. While they appear to be stars, they radiate energy at a rate equivalent to 100 times the energy of a galaxy the size of the Milky Way. The energy ouput, according to astrophysicists, is beyond anything that can be explained by nuclear or other known phenomena.

Consumer electronics

No more shock

The do-it-yourselfer standing on a wet cellar floor is in trouble if there's an electrical defect in the power drill he's using. The fuse box protects the house against currents exceeding 15 amperes, but it only takes about 9 milliamperes to give Mr. Handyman a lethal shock. A faulty electric tool and a wet floor could lock him into the 110-volt current, and 250 milliamperes could leak through him to ground.

A device called Circuit-Tron, developed at a small laboratory in Lee, N. H., is designed to detect such leakages and cut off power, its inventor says. Circuit-Tron senses leakage of current and opens relay contacts to shut down the line. It cannot be reset until the fault has been corrected.

The device was developed by Andrew J. White, of Lee, and Joseph P. Marino, of Lincoln, R. I. The units are being manufactured at the Electronic Instruments Corp. in Lincoln.

Wet hands. In a laboratory demonstration, White placed a lighted lamp with its wires exposed into a large glass tank of water. He held one hand in the water, wet the other hand thoroughly, and touched a steel sink nearby. The light went out before the current could give him a shock.

Circuit-Tron monitors the current in the line, and any deviation from the usual flow activates the device. The unit can be set for various values; 9 milliamperes is usual. Response characteristics of the device don't vary with changes in the load, Marino says.

The heart of the Circuit-Tron is a transformer, which provides a high degree of voltage regulation. The transformer is center-tapped. Under usual conditions, the transformer and other components aren't energized; they are in a passive, steady state on the line. When a leakage occurs—from an electrical defect or from a person who may "tap" himself into the circuit—it shows up on either leg of the transformer, and current flows. The current operates the relay contacts and they cut off power.

In tests at the University of New Hampshire, the device detected leakages as small as 0.38 milliampere.

$500 a home. The first devices were bulky and expensive; they are being used to monitor industrial equipment. White estimates it would cost about $500 to protect all the circuits in a home at the present stage of development. "We are working on a design using smaller components. This, together with volume production, might eventually bring the unit cost down to about $75," he says.

Meanwhile, a portable model costing $179.50 is being used by several construction companies in Rhode Island to protect workers running power tools in wet areas.

A Circuit-Tron at the Bostitch Co. in East Greenwich, R. I., monitors the assembly line where portable electric tools are handled by women. At the Draper Co. textile mill in Hopedale, Mass., it is

plugged into the power line when maintenance workers are working with electric tools in hazardous areas.

White says the Circuit-Tron is fast enough to shut down a faulty electric line in an explosive atmosphere before arcing can take place. Tests are now being made to determine its effectiveness in operating rooms, where explosive anesthetics are used. And plans are under way for installation of a Circuit-Tron at an oil tank farm of the Sonneborn Refining Corp., Butler, Pa., where electric cables crisscross the oil tank field.

On the front burner

Some airline hostesses will soon be cooking with microwaves.

Trans World Airlines, Inc., has warmed to the idea of microwave cooking and expects to have the new equipment on all its jet aircraft by late fall.

Although the cost of the airborne ovens hasn't been disclosed, industry sources estimate a price tag of about $1,200 plus substantial installation costs. The units were developed by the Atherton division of Litton Industries, Inc.

Several other airlines are weighing the use of fast-cooking microwave ovens for in-flight food preparation, and for warming precooked food. One carrier, American Airlines, Inc., is understood to be testing the Litton unit also.

Price a problem. Although microwave ovens have been around for many years, the public has been slow to accept them. The main reason is price—microwave units still cost several hundred dollars more than conventional ovens. Generally, demand for microwave ovens has come from institutions and commercial operations, where fast cooking has a priority over price. One railroad, the New York Central, has been using a microwave oven on one of its dining cars for some time. The line hasn't decided yet whether to expand their use.

The oven that TWA will be using weighs 60 pounds and measures 12 inches wide, 17 inches deep and 22 inches high. The oven's tube, a magnetron, operates at 2,450 megacycles and its input power to the cooking cavity is 1,200 watts; the line power into the unit is 200 volts at 10 amperes, 3 phase and 400 cycles per second.

Extra care. Litton is taking extra precautions to shield the oven. It's using power-line filters, special radio-frequency cases and connector fittings. Should r-f energy leak out of the oven door, a crystal-operated radiation detector circuit will shut off the oven and turn on a warning light.

Added fare. Because the ovens cook five times faster than the electric ovens being replaced, TWA plans to broaden its menu. It expects to be able to provide freshly cooked meals of greater variety to more than 120 passengers in 30 minutes.

Avionics

Flying low

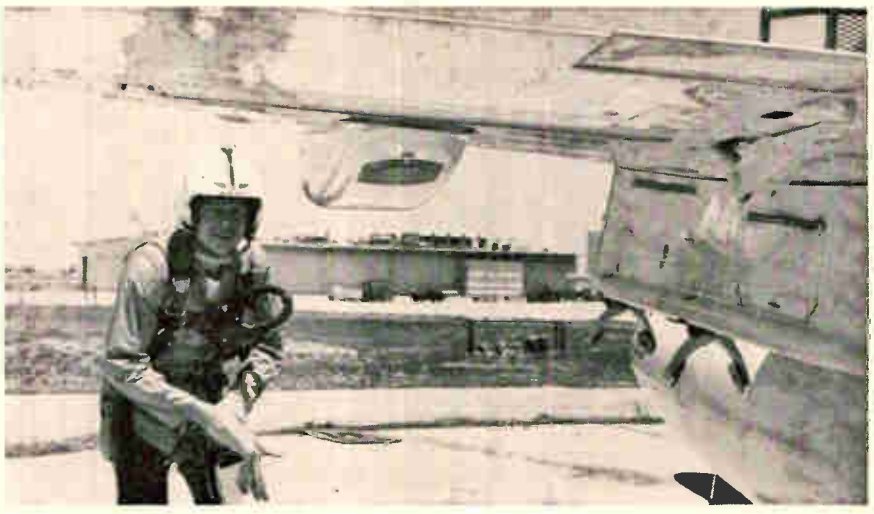
When a plane drops from the sky to tree-top level to make a bombing run at speeds up to 800 miles an hour, the pilot's best friend is his altimeter. It helps him fly at a safe distance above the ground no matter what the weather and no matter what the terrain. And he depends on the altimeter to make safe landing approaches to carriers or airfields.

Many of the Navy's fighter planes, based on aircraft carriers, are now being equipped with highly accurate pulse radar altimeters that measure the precise distance between the plane and the ground or other objects below.

The unit, designed and built by the Bendix Corp., is being installed on Douglas A4's, Grumman A6's, Ling-Temco-Vought F8's, McDonnell F4B's and the North American T39D, a trainer.

The altimeter, which transmits at C-band (4,300 megacycles) operates from 0 to 5,000 feet and has an absolute accuracy of ±5 feet or ±5%, whichever is greater.

Check bounce. Altitude is measured by determining the time it takes for a radar pulse, transmitted from the craft, to bounce off the ground and be received by the plane. The technique eliminates errors caused by doppler shifts or averaging returns that are inherent in nonpulse altimeters; fast, low-flying craft accentuate these errors. The pulse width of the transmitter's signal is only six nanoseconds.



Tucked under the wing of a fighter plane is Bendix Corp's highly accurate radar altimeter. The instrument is being installed on many Navy fighter planes.

The entire radar unit is solid state, except for one ceramic triode in the final stage of the transmitter and another ceramic triode in the receiver's front end. High-density welded circuits are used through-

out the system, and the total unit—which consists of a receiver, transmitter, microwave switch, cockpit indicator and two antennas—weighs 11½ pounds and takes up 175 cubic inches of space.

The Navy is testing the AN/APN-141 for use with reconnaissance and antisubmarine warfare planes.

Materials

Thin shield

A new family of ultrathin plastics with a high dielectric constant may help make miniature circuits even smaller. The plastics are polyparaxylylenes—parylenes for short. The Union Carbide Corp., the developer, is test-marketing parylene capacitors one-fifth the size of comparable capacitors that use polystyrene as an insulating material.

The parylenes can be deposited as a thin layer on a substrate, or they can encapsulate tiny components. They are applied by heating them until they vaporize and letting the vapor condense. Surface replicas can be formed that reproduce details only 100 angstroms high, the company says.

Union Carbide is investigating the use of parylenes in integrated circuits and magnetic computer memory elements, and as insulation in logic and memory circuits. The company believes that they can be etched by the same photomasking or photoresist techniques that are used for thin films and silicon chips.

Blow hot, blow cold. Early tests indicate that the material withstands wide fluctuations in temperature. The parylenes melt at about 750°F; near absolute zero their insulation is better than other plastics', Union Carbide says. The company reports that cycling the temperature from 2°K to room temperature does not significantly affect the electrical or physical properties.

The parylenes are also an effective shield against reactive chemicals. For example, an aluminum sheet coated with a layer 0.016 mil thick is protected against the corrosive attack of sodium hydroxide.

Manufacturing

Cool soldering

The vexing problem of bonding large numbers of contacts or leads simultaneously to complex microcircuits may have been solved by a technique in which the molecules of two metals are mixed.

Arthur Shafran, an engineer with the Lockheed Aircraft Corp.'s Missiles and Space division, uses gallium, which is liquid at room temperature. He coats a gold-plated surface with the liquid and puts it against another gold-plated surface. After a few hours at room temperature, the gold and the gallium form an alloy and the resulting bond has a temperature limit of 400° to 500°C. The bond has a shear strength equal to soldered joints, although the bend strength is less because the gallium alloy is brittle.

But the long-term stability of such bonds is still in doubt. The oldest experimental bonds date back only a few months. Results so far show that alloys of gallium-gold, gallium-tin and gallium-cobalt are satisfactory, but gallium-silver bonds fell apart after a few months.

Refrigerated leads. The liquid gallium can either be wiped onto gold-plated leads, such as Kovar, Dumet or copper, or the gallium can be electroplated at 40°F and the leads kept in a refrigerator until ready for use. When leads previously coated with solder as well as gold are used, the gallium, gold and solder diffuse into one another.

Besides bonding small leads, Shafran has also bonded integrated circuit leads to copper-clad printed circuit boards and has lap bonded two solar cells to connect them in series.

Shafran will report on his work this month at the IEEE Convention in New York. The technique is based on a method devised by the National Bureau of Standards about two years ago to bond thermocouple leads. However, NBS mixed gallium with other metal powders to raise the melting point above room temperature and packed the powder and the leads into a hole. This method could not be used for lap bonds because the powder particles prevented good contact between the surfaces.

Packaging

Flatpack conflict

A committee representing integrated-circuit users, unhappy about the flatpack size standards approved by a circuit manufacturers' committee, is asking producers to revise them.

The users want to minimize problems in equipment packaging design and in automating production-test and assembly machines by using only two standard sizes. However, the manufacturers have agreed on 11 sizes, basically the same as those proposed last fall by the Joint Semiconductor Committee 10 (JS-10) of the Electronic Industries Association and the National Electrical Manufacturers Association [Electronics, Nov. 2, 1964, p. 28]. By mid-February, JS-10 had registered eight package outlines, a procedure that has the effect of making the outlines (package configurations) standard.

JS-10 has only put "an envelope" over the existing flatpack variations, complains the users' committee on Microcircuit Applications (MCA), another EIA-NEMA joint committee. Last month, MCA drafted its own proposal for a size standard.

Users' proposal. MCA's two sizes are 0.050 inch high and up to 0.185 inch wide, and 0.065 inch high and up to 0.260 inch wide. This would eliminate several larger package sizes now being made and simplify assembly machines.

Package length would standardize on the present 14-lead package that has five leads coming out each

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side, plus two dog-leg leads at each end, with the leads spaced 0.050 inch apart. Leads would be numbered from 1 to 7 up one side and 8 to 14 down the other side.

The 14-lead package could be converted to a 10-lead one by eliminating the dog-leg leads numbered 1, 7, 8 and 10, and decreasing package length. If two such packages were butted together, the distance from the number 5 lead of the first package to the number 1 lead of the second package would be 0.050 inch.

This standard, MCA says, would enable any number of flatpacks to be mounted on standard interconnection arrays and be welded or soldered in place automatically by going from lead to lead.

JS-10 allows lead thicknesses to be from 0.0035 to 0.006 inch thick. This complicates the setup of welding schedules, MCA says. It wants only one thickness—0.004 ±0.0008 inch after plating—and only one width, 0.014 to 0.016 inch.

Carriers, too. Manufacturers now use various types of molded plastic holders and miniature printed circuit boards as test and shipping carriers for circuits in flatpacks. MCA wants these standardized, too, so they can be plugged in for breadboarding equipment or loaded into standard magazines for production testing, lead trimming and equipment assembly.

MCA hasn't set the carriers' specifications, but it has decided on design criteria: a carrier has to be suitable for loading into magazines; it should carry the circuit's serial number; it should have a place for writing or color-coding inspection markings and the circuit type should be identified by a color code, because the small lettering now used is difficult to read.

A five-cent cost for the carrier is another target.

Solid state circuits

Scratchpads

Is $5 per bit too much for a computer memory? Not if it's an all-integrated-circuit memory nearly as fast as the fastest logic circuits. At any rate, that's the way the Fairchild Semiconductor division of the Fairchild Camera & Instrument Corp. sees it.

"It's a bargain," said Rex Rice, manager of digital systems techniques, who believes the cost may drop to around $2.50 a bit in volume production.

More bits. Fairchild has developed small buffer memories that operate in 50 nanoseconds. The upshot is more bits per dollar in a given time. The semiconductor memories are about six times as fast as the fastest thin-film memories, which cost up to $1.50 a bit, and they are about 20 times as fast as the small, high-speed core memories priced at around 50 cents a bit.

Although buffer memories cost far more than large, conventional core memories, they can lower the over-all system cost by increasing computing speed and efficiency. Some computers use them as "scratchpads," or temporary storage, during logic operations, instead of relying on the slower mass memories.

Other memories. Rice described Fairchild's $5-a-bit buffer at a panel discussion during the International Solid State Circuits Conference in Philadelphia last month. He claims it is the first semiconductor memory that is competitive on cost-performance terms.

At the same session, J. L. Buie, a researcher at Thompson Ramo Wooldridge, Inc.'s Space Technology Laboratories, reported on one that was built two years ago, but had an access time of 200 nanoseconds.

Donald Murray, an engineer at Motorola, Inc., said his company is developing one that will operate at 30 to 50 nanoseconds. Faster memories are wanted, he noted, to complement the 2-nanosecond logic circuits that can now be built.

Some new digital computers are already using semiconductor scratchpads. Electronic Associates, Inc., put an integrated-circuit, register-type, 100-nanosecond scratchpad inside the otherwise discrete-component data-processor section of its EAI 8400 computer. The

International Business Machines Corp. plans to use scratchpads as well as local storage memories in the large Model 92 of the System 360 series.

Radical change. Rice expects this trend—toward the use of buffers or scratchpads to balance logic and memory speed in a system—to accelerate and to result in radical changes in computer organization. Designers, he thinks, will begin scattering high-speed semiconductor memories throughout computer logic sections. Mass memories would only be used for bulk storage, such as programs, and not for actual processing.

As an example, Rice mentioned a computer named Solomon, developed by the Westinghouse Electric Corp. It uses concurrent arithmetic units, each a sort of baby computer. One Solomon, constructed with 4,000 integrated circuits for the Air Force, has 100 such units.

Memory on a board. Fairchild's working model has 92 flatpacks of integrated circuits mounted on a double-sided printed circuit board 7 by 9 inches. Of the 92 flatpacks, 64 contain storage elements and the others contain auxiliary circuits such as drivers.

Each storage-element package contains two bits—two input gates, two flip-flops and two output gates—for a buffer total of 16 words of eight bits each.

The number of words in the buffer can be multiplied by adding more circuits, at the expense of three to five nanoseconds of additional delay for the drivers. A 256-word buffer would still operate in the 50-nanosecond range, Rice said. It will soon be possible, he added, to put eight or nine storage elements on an integrated-circuit chip, so that the same card could carry 24-bit words.

Information, please

Integrated circuits are winning wide acceptance, but users are worried that they may soon face a problem that hurt them with transistors. They want to make sure, it was made clear at an informal

panel session at the Solid State Circuits Conference that they are forewarned of any change in manufacturing techniques.

Barely was the session under way when one panelist charged manufacturers with altering the characteristics of commercially available transistors by changing production techniques. The user, Jack Fort, manager of the National Cash Register Co.'s component department, said he was afraid the practice might spread to the integrated circuit field.

Useless data. His complaint: reliability data compiled for a type of transistor becomes useless when the production methods are changed. The problem is compounded because producers' data sheets are incomplete, he added.

His suggestion: that integrated circuit makers include in their data sheet information about materials, production methods, device geometry, layout and interconnections.

Defending the producers was Gerry Luecke, manager of the advanced integrated circuit department of Texas Instruments, Inc., who claimed that the release of such data might restrict the manufacturer, and keep him from improving the product. All a user needs, he explained is a guarantee of a device's electrical specifications.

The moderator, Phillip G. Thomas, represented a company that is both a producer and a user. He's manager of the digital section of the integrated circuit department of the Sperry Rand Corp. Thomas said that changes in production techniques often make a device useless for some applications, even though the modified device works in most places for which the original was designed.

Space electronics

Satellite static

Satellite communication systems—who will build them and who will use them—have government and industry in synchronous orbit. But they're at opposite poles.

The military has been rebuffed by the White House in its bid for an advanced satellite system. And the Communications Satellite Corp. —consequentially or merely sequentially—has been turned down for the third time in a bid to provide a communications system for the Pentagon.

Military satellite communications powerful enough to overcome enemy interference will have a large excess capacity during peacetime. The industry is worried about just how far the Pentagon intends to go in providing government communications.

Billion-dollar baby. The stakes are high. The government spends about $1 billion a year on communications. The bulk of the amount is for overseas communications, although there is no official breakdown.

Last December, the Pentagon asked some 20 companies for proposals on an advanced satellite system that is to be in service by 1968 or 1970. Classified specifications called for a capacity of 13 color television channels—about equal to 3,000 voice channels—plus a power output of 6 watts.

When word of the specifications got out, the Federal Communications Commission went right to the White House to protest. President Johnson tried to calm industry fears with a statement that the decision to build a separate military satellite system "does not alter the policy under which the national communications system and other government services will use the commercial satellite and other common carrier communications systems for the transmission of the bulk of their traffice between the U.S. and overseas areas."

No more color. Shortly thereafter, on Feb. 18, the Defense Communications Agency dropped the requirement for the 13 color tv channels, and postponed the date for submission of proposals to March 17 from Feb. 24.

The Pentagon contends the matter is classified and thus won't discuss it. One spokesman, however, says that the "net effect of the

change is a decrease in requirements."

Industry spokesmen contend that the change is largely for the record, and amounts to little substantively. The 6-watt power requirement they say, gives the satellite a large inherent channel capacity.

The issue boils down to a matter of use. The military wants the high power in order to be certain of forcing a few clear communications channels through even under enemy interference. But in peacetime, industry wants a safeguard against the military's becoming the government communicator because of available capacity. Multiple access to the military system by global defense units will sop up some of the extra capacity, but probably not all of it.

Three strikes. Comsat has made three unsuccessful bids to supply the military with satellite communications service. Initially, it wanted the Pentagon to share in Comsat's basic system. When this was rejected last November, Comsat quietly offered to put up a net of six synchronous satellites for a flat $50 million. This offer, too, was rejected.

Comsat's latest offer, made early this year, was to build 24 satellites for launch by the military, then charge only for the actual use of the system. Total cost to Comsat would have been about $14 million.

The Philco Corp., however, which held a $24.6-million contract to build 24 communications satellites for the Air Force, cried tilt over Comsat's plan to make the Hughes Aircraft Corp. its sole source. Philco got FCC backing and Comsat was forced to throw the procurement open to competition. By then, only Philco and Hughes were interested in competing, though a dozen or so companies considered the matter.

Meanwhile, the Pentagon decided it wasn't interested in the offer anyway, so the whole plan was dropped. The Pentagon contended that the satellites being developed by Philco were superior to Comsat's from a cost and performance standpoint. Comsat questions the decision, but can't do anything about it.

Solid state microwave using new transistors

Low noise amplification to 15 Gc, useful power to 17 Gc, clear way for all-solid-state microwave communications equipments

Improved reliability, smaller size and reduced power consumption are among the benefits users will reap from all-solid-state communications equipments. Now, for the first time, it is practical to design such equipments using new transistors and varactor diodes from Texas Instruments.

Semiconductor devices of proven performance are now available to replace older devices. Benefits include smaller size, simpler circuitry, improved reliability, reduced power consumption, fewer heat dissipation problems, improved reliability, and — in many instances — reduced bill of material costs. Here are some of the applications that can now employ TI transistors and diodes.

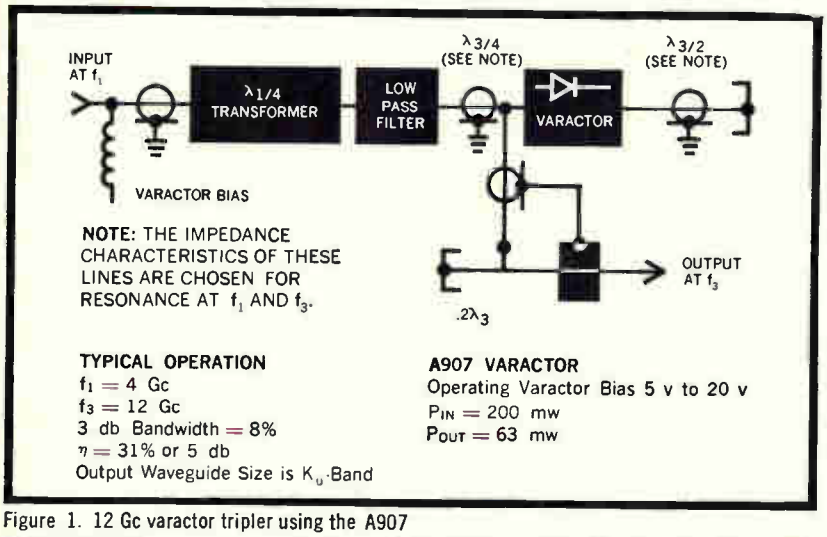

Figure 1. 12 Gc varactor tripler using the A907

Type & Package	f_{max} Guaranteed Minimum	F_T Typical	F_T Guaranteed Minimum	Noise Figure Typical	Noise Figure Guaranteed Maximum	Fundamental Oscillator P.O. (mw) Typical	Fundamental Oscillator P.O. (mw) Guaranteed Minimum	Area of Operation
High Frequency Silicon Transistors								
TIXS12							250 mw at 1.5 Gc 15 v, 100 ma	L Band Oscillator
TIXS13							125 mw at 1.5 Gc 15 v, 100 ma	L Band Oscillator
TIX3016A		1.7		6 db at 1 Gc		50 mw at 2.0 Gc	30 mw at 2 Gc 20 v, 15 ma	L & S Band Oscillator
TIXS09		1.4		3.5 db at 450 mc		60 mw at 1.5 Gc	30 mw at 1.5 Gc 20 v, 15 ma	L Band Oscillator
TIXS10		1.2		4.5 db at 450 mc		70 mw at 1.0 Gc	30 mw at 1.0 Gc 20 v, 15 ma	L Band Oscillator
2N3570-72	2.75 Gc	1.7	1.5 Gc	6 db at 1 Gc	7 db at 1 Gc R_g = 50 ohms	60 mw at 1.0 Gc		UHF & L Band Amplifier
High Frequency Germanium Transistors								
TIX3024	4.5 Gc	1.7 Gc	1.5 Gc	1.6 db at 200 mc 4.5 db at 1 Gc	5.0 db at 1 Gc			L & S Band Amplifier
2N2999	3.3 Gc	1.6 Gc	1.4 Gc	5.0 db at 1.0 Gc	7.0 db at 1.0 Gc			L Band Amplifier S Band Oscillator
2N2998	2.2 Gc	1.0 Gc	600 mc	6.5 db at 1.0 Gc	8.0 db at 1.0 Gc			UHF Amplifier L Band Oscillator

NOTE: The above devices can be supplied in TO-18, μmesa*, or μline packages. Please contact your nearest TI sales office.

Figure 2. High-frequency small-signal TI transistors

Unit Type (Series)	Package	f_{co}	CT (Range)	BV_R (Range)	Operating Range	Primary Application	Technology
A706	Cartridge	140 Gc	0.4-30 pf	24-120 v	1-5 Gc	Harmonic Generator	Si Epitaxial
A900	Dbl. Pill Prong	300 Gc	0.4-1.4 pf	30-50 v	1-10 Gc	Harmonic Generator	GaAs Epitaxial
A580	Moly/G*	5 Gc	22-47 pf	35-65 v	dc-500 mc	Electronic Tuning (Voltage Variable Capacitor)	Si Epitaxial
XD500	Cartridge	150 Gc	0.4-1.0 pf	8 v	1-5 Gc	Parametric Amplifier	Diffused GaAs
TIV01	Pill	100-300 Gc	0.35-1.0 pf	6 v	1-15 Gc	Parametric Amplifier	Diffused GaAs
A612	Pill	150 Gc	0.45-1.0 pf	8 v min	1-18 Gc	Parametric Amplifier	Diffused GaAs
A660	Uni/G*	11 Gc	9-17 pf	15 v min	dc-1 Gc	AFC Electronic tuning	Diffused Si

NOTE: Where range is given, it means that family of devices covers the range — not necessarily each device.

Figure 3. TI varactor diodes — summary of characteristics

Microwave power generation

Harmonic generators. Figure 1 shows the block diagram of a varactor tripler that delivers 63 mw at 12 Gc — an output and a frequency designed to serve as a pump source for a parametric amplifier.

The diode employed is the new epitaxial gallium arsenide A908 from TI. While A900-908 varactors have been optimized for harmonic generator service such as this, they also may be used as tuning elements, microwave switches and parametric amplifiers.

A612 varactors have been used in two varactor triplers that deliver 7 mw output power at 16.5 Gc. These triplers are part of the local oscillator for the TI K_u-band preamplifier converter shown in Figure 6.

TI also offers the A706 series of epitaxial silicon varactor diodes for harmonic generation, tuning and switching in the 100 mc to 5 Gc range.

Like all TI varactors, both these new series feature uniformity that permits plug-in replacement. This minimizes circuit design and production problems encountered using some other varactors.

Oscillators. TIXS-12 and TIXS-13 silicon transistors are offered in a new low-loss coaxial package. They will deliver a guaranteed P. O. minimum of 250 mw and 125 mw respectively at 1.5 Gc. 25 mw at 12.3 Gc has been produced by a TIXS-12 driving two X3 multipliers.

The TIX3016A silicon planar epitaxial transistor has the highest frequency capability of any silicon unit presently on the market. It has delivered 25 mw at 9.2 Gc when operated as a 2.3 Gc fundamental oscillator driving an X4 multiplier.

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communication now practical and varactors from TI

A special version of the TIX3016A transistor is operated at 1.8 Gc to deliver 60 mw output to varactor triplers in the preamplifier converter shown in Figure 6.

Low-noise microwave amplification

Low-noise solid state amplification of microwave frequencies is a reality today using TI varactors and transistors in parametric amplifiers. The noise figure chart in Figure 5 shows that the A612 varactor diode has demonstrated typical noise levels of 3 db at 8 Gc and 4 db at 15 Gc. These same varactors have also been operated in 8 Gc cooled parametric amplifiers. Noise temperatures of 50°K have been obtained at 77°K and 18°K at 4°K.

An A612 varactor is used in the nondegenerate paramp of the K_u-band preamplifier converter shown in Figure 6. Over-all noise figure is typically 4 db — far lower than the 10 db encountered when other converters are used. Measured noise figures for the paramp are 3.6 db typical at 13.5 Gc. The new TIXV01 series offers even better performance through improved cut-off frequencies.

Conventional transistor amplifiers in the 1 to 3 Gc range may be designed using the TIX3024 germanium epitaxial transistor. This same unit is also ideal for broadband amplifiers in the 0.5 to 1.5 Gc range.

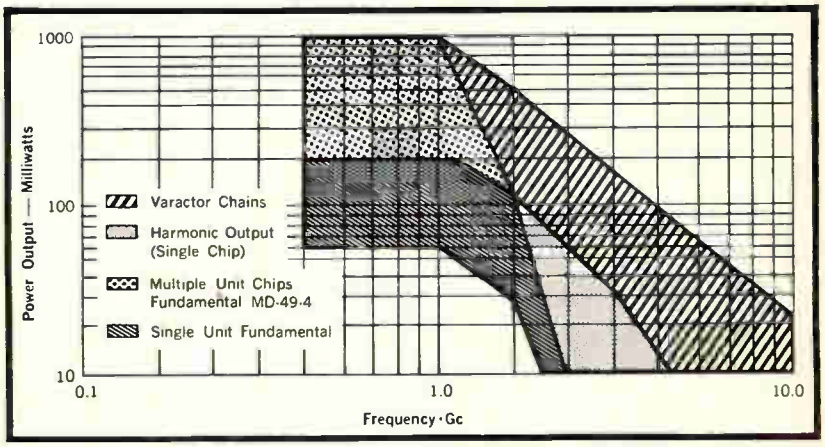

Figure 4. Output power vs frequency . . . TIX3015-16 transistors

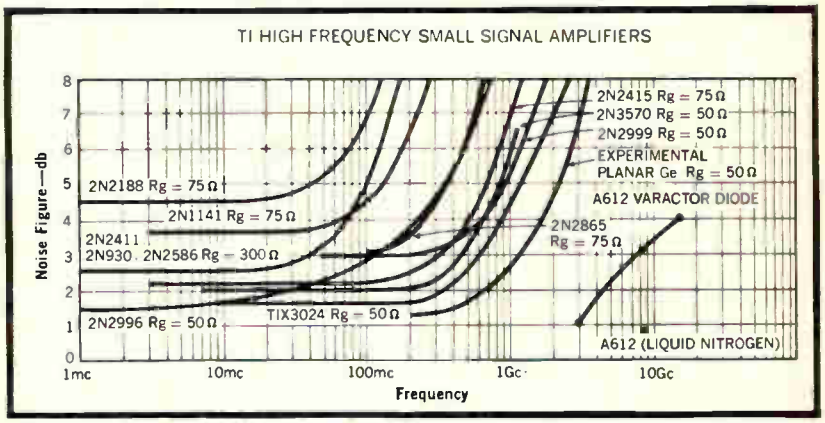

Figure 5. Noise figure chart . . . high frequency transistors and varactor diodes from TI

Figure 6. 12.5-17 Gc TI K_u-band preamplifier converter uses TIX3016A transistors and A612 varactors

Figure 7. New two-part TI communication handbook

Just Off the Press — TI Communications Handbook

Here is the latest communication reference library available. In two volumes shown in Figure 7 you will find answers to questions most often asked TI specialists. The two 6″ x 9″ paperback volumes total 366 pages and contain 417 illustrations. Here are just a few of the subjects covered:

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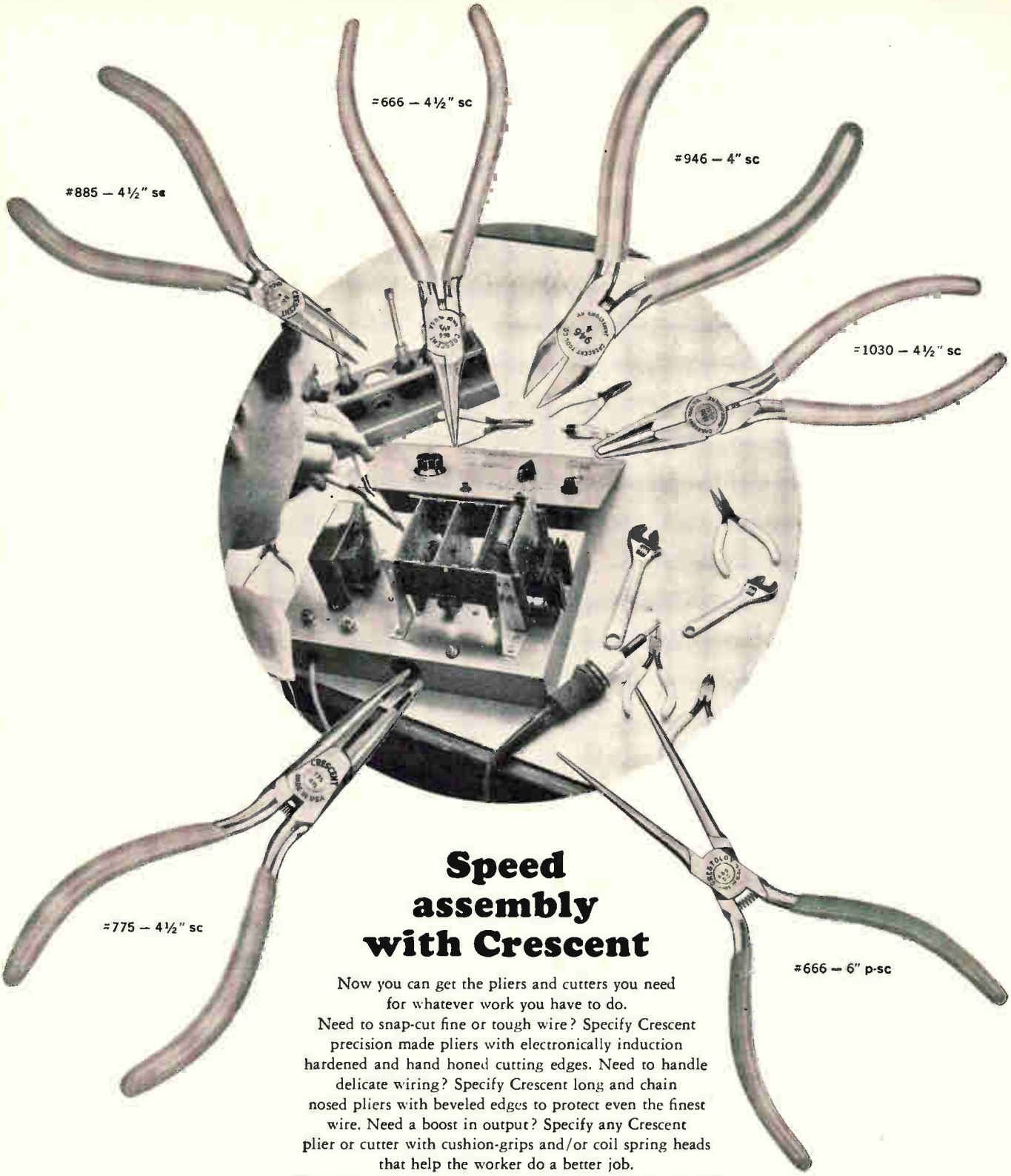
Price is $3.50 per two-part set. Send check or money order to MS-75, Texas Instruments Incorporated, P. O. Box 5012, Dallas, Texas 75222. If you prefer, you may purchase from your TI distributor.



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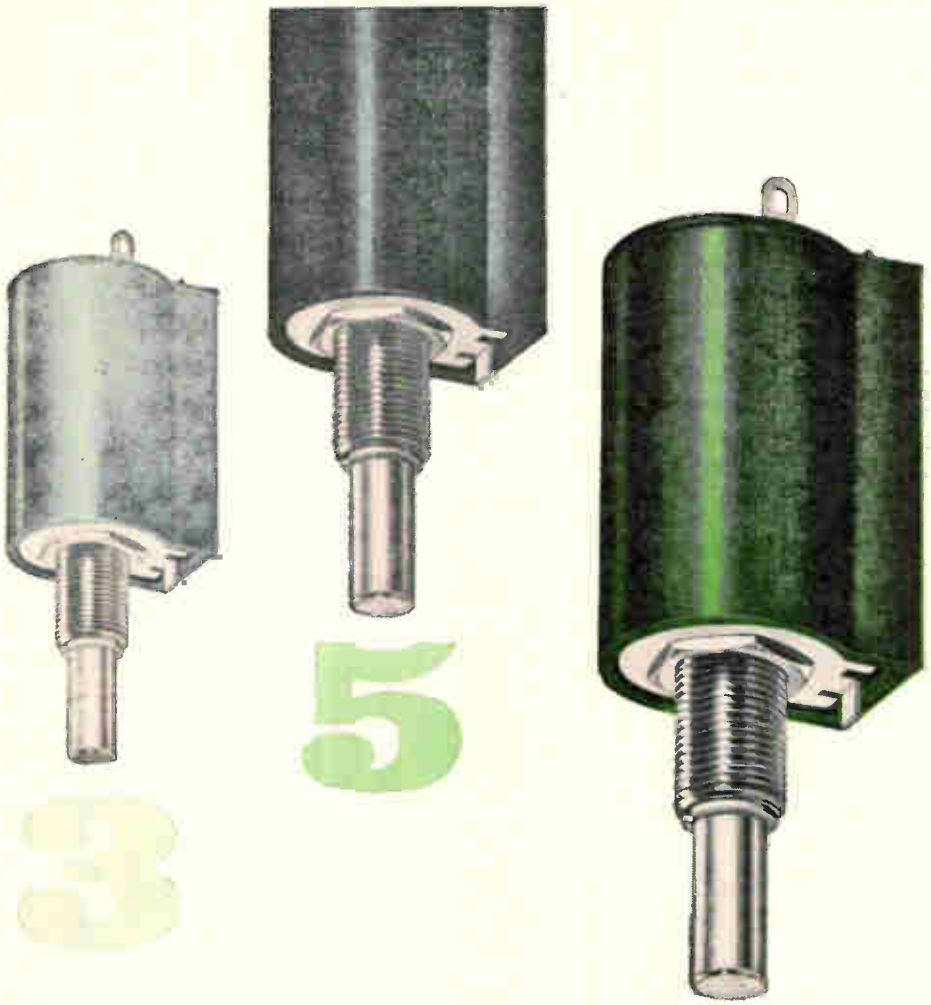

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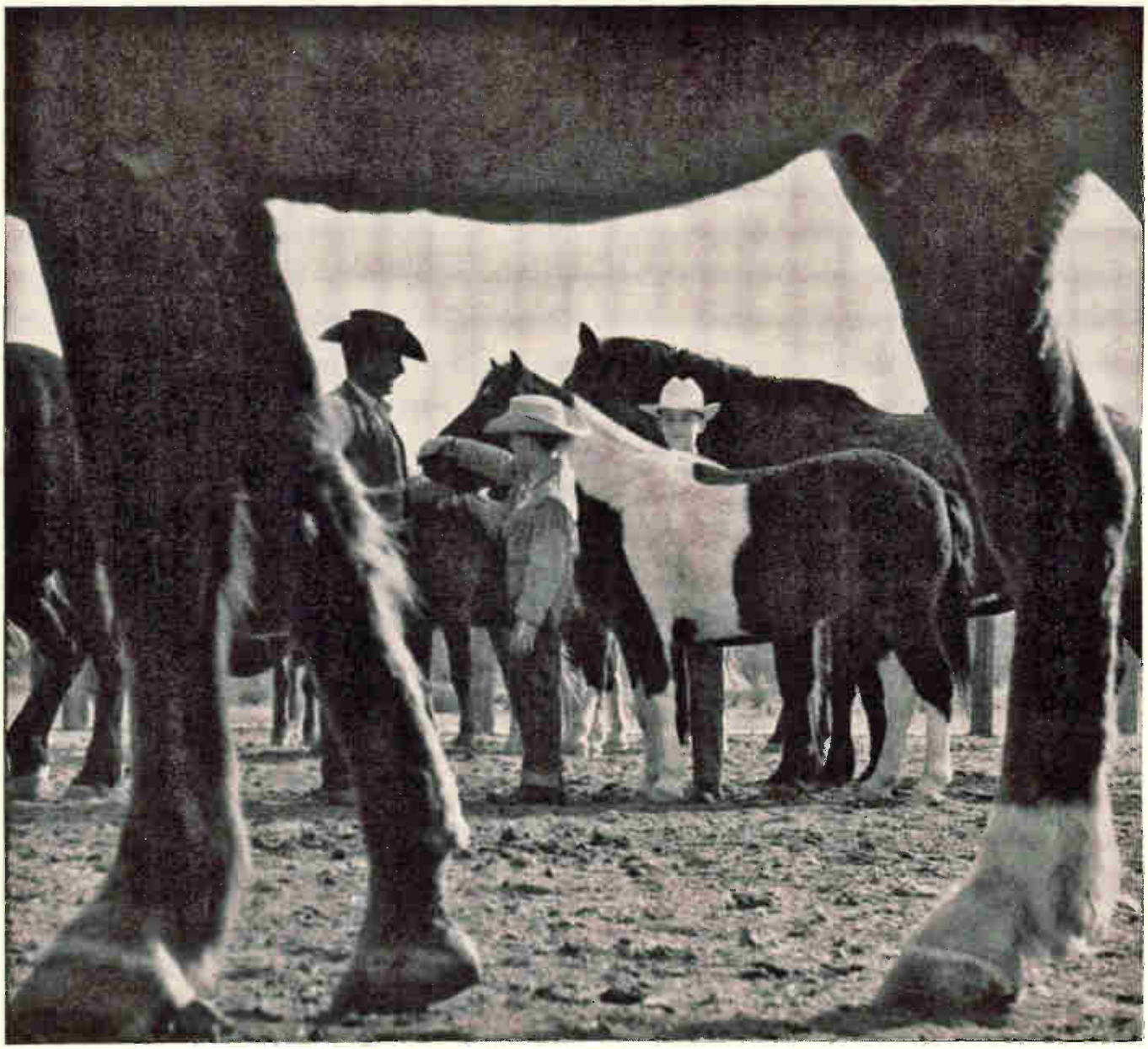


Investment Opportunity

A dozen years from now these boys will be riding trail for real—herding cattle to help feed your children.

Till then, how much patience and love and planning must go into their training? How much effort into keeping our society free and our economy stable, so young people can develop into responsible, productive adults?

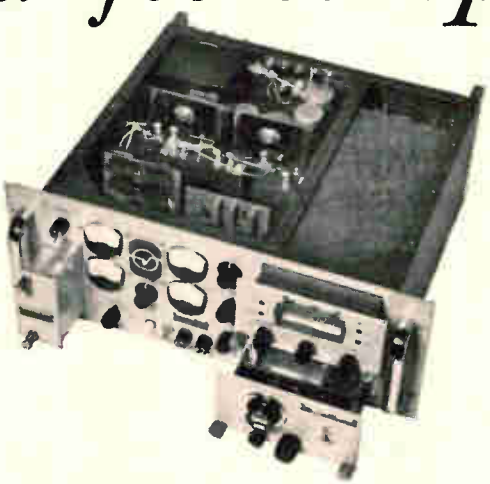
You have an investment in these boys. To protect it, you can join with other leading American businessmen to promote the Treasury's Payroll Savings Plan for U. S. Savings Bonds. The Treasury Department's Plan helps to encourage the habits of self-reliance and thrift we so need in all our citizens . . . it helps us maintain that love of individual liberty which is basic to the well-being of our nation.

When you bring the Payroll Savings Plan into your plant—*when you encourage your employees to enroll*—you are investing in the young people who will help feed the world a decade from now. You are investing in all the ranchers and herders and farmers of America's tomorrow. In America's future. In freedom itself.

Don't pass this opportunity by. Call your State Savings Bonds Director. Or write today directly to the Treasury Department, United States Savings Bonds Division, Washington, D.C. 20226.

In your plant...promote the PAYROLL SAVINGS PLAN for U.S. SAVINGS BONDS

This is Vitro Electronics' Telemetry Receiver • It is Type 1037A • It is not new It is thoroughly field-proven • It is in its fifth production run • It is the standard for comparison



The 1037A is still the only advanced type telemetry receiver that is in full production with a long and successful history of field-proven performance and reliability. The 1037A offers a wide choice of off-the-shelf plug-in RF tuners covering a range of 55-2300 mc and the most versatile group of IF demodulators available which include true phase with long or short loop, linear phase for special PCM applications, phase tracking, high capture ratio, phase lock, FM and AM for all known telemetry formats. Integral plug-in predetection converters and spectrum display units optional. Improved adjacent channel rejection and optimum combination of RF nuvistors and solid state design avoid the dynamic range problems inherent in solid state RF tuner designs.

Vitro Electronics is also the only manufacturer with a complete line of off-the-shelf solid state pre- and post detection combiners, dual diversity receivers, up and down converters, multicouplers, preamplifiers, etc.

For a complete new catalog or additional details please write to Vitro Electronics, 919 Jesup-Blair Drive, Silver Spring, Maryland.

VITRO CORPORATION OF AMERICA • 90 PARK AVENUE • NEW YORK, N.Y. 10016

Vitro

10^{12} traces/sec. 500 traces/in. is this enough- or do you need more?

This is the writing speed and resolution of a new Du Mont cathode ray tube with fiber optics faceplate (Type K2427). In addition, the tube was designed to occupy minimum space and to withstand severe environmental conditions.

Maybe you don't need this kind of performance—or maybe you need more. In either case look to Fairchild's Du Mont Laboratories first. Du Mont has designed and built over 4,000 discrete tube types — CRTs, Storage Tubes, PMTs and Power Tubes. Many of these are off-the-shelf, the rest quickly available. If the tube parameters of your job are so far-out that no existing tube meets them, that's all the more reason to talk to Du Mont first. No one is better equipped to design and build it for you. That's how most of our 4,000 types came into being. Call your Du Mont sales engineer or get in touch direct with the Electronic Tube Div. of Fairchild's Du Mont Laboratories, Clifton, New Jersey.

Selected career engineering opportunities are available. An equal opportunity employer.

FAIRCHILD

DU MONT LABORATORIES
ELECTRONIC TUBE DIVISION

Washington Newsletter

March 8, 1965

Monmouth probe appears unlikely

The planned Senate investigation into contract awards made by the Army Electronics Command at Fort Monmouth, N. J., will probably be dropped. When seeking operating funds, the preparedness investigation subcommittee told the Rules Committee it wanted to probe allegations that Monmouth employees had accepted "excessive gratuities and entertainment" from some companies and had given those companies favored treatment. Subcommittee sources now say that no evidence has been found that's strong enough to warrant public hearings.

But the issue of gifts to and entertainment of government defense and space employees is far from dead. The General Accounting Office has conducted an extensive investigation into the activities of more than 30 companies. A draft of a forthcoming report to Congress is now awaiting comments from the Pentagon and the National Aeronautics and Space Administration. The report is expected to be made public within two or three months.

The GAO won't discuss its findings at this stage. But congressional sources feel the report will be a "hot one," possibly leading to hearings on contractor attempts to influence government personnel and a tightening of conflict-of-interest laws.

The use of a Michigan hunting lodge for entertaining defense personnel is said to figure prominently in the GAO report.

The "clean-living" edict issued by Defense Secretary Robert S. McNamara last year was a backfire set against the GAO report. To jump the gun on GAO disclosures, McNamara barred defense employees from accepting virtually any favors from contractors.

CATV regulation favored by FCC

The Federal Communications Commission went on record last week as being strongly in favor of federal regulation of community antenna television (CATV) systems. There is some question as to whether the FCC already has the authority to regulate or must seek legislation. A handful of CATV stations transmit by microwave and thus come under federal control; the rest pick up television signals and carry them to homes entirely by cable, thereby escaping federal jurisdiction under the present interpretation.

Commercial broadcasters see in CATV a threat to free television, and have been pressuring the FCC to impose some kind of controls. The agency on its part, fears that CATV competition might undercut its effort to pump new life into ultrahigh-frequency tv. With both commercial broadcasters and government favoring control, the only question is how. **FCC chairman E. William Henry promises a decision on policy within a month.**

2 firms to study copter substitute

Divisions of the Lockheed Aircraft Corp. and the United Aircraft Corp. beat out 10 other competitors for project definition studies in the Army's Advanced Aerial Fire Support System (AAFSS). The new vehicle, to replace present armed helicopters, will be equipped with advanced integrated avionics.

The Army wants a vertical-takeoff craft somewhat like a helicopter with fixed wings—shades of the old Autogiro—that can fly more than

200 miles per hour and come to a hover quickly. It must have considerably more stability and control and greater firepower than existing helicopters.

Present helicopters are largely restricted at night and in bad weather. The new vehicle will require automatic navigation, terrain-avoidance radar and electronic means for maintaining separation in formation flying during such periods of near-zero visibility.

The Army will consider the Integrated Helicopter Avionics System, which the Navy expects to develop for use on AAFSS.

Competition cuts subcontract costs

The Pentagon soon will require more competitive subcontracting on its main awards. The Air Force recently recruited six companies—the Avco Corp., Martin Co. division of Martin Marietta Corp., General Electric Co., Douglas Aircraft Co., Hughes Aircraft Co. and Lockheed Aircraft Corp.—to field-test the idea, and found that preliminary estimates of 25% savings were conservative. As a result, tougher requirements for competitive subcontracting will show up soon in revisions of the Air Force purchase system review manual (70-3). **Within six months, a version of the Air Force system will be adopted throughout the Defense Department.**

The new regulations mean that engineers will have to begin working earlier and more closely with their companies' purchasing departments. The Air Force found that large sums can be saved in early design stages if some parts can be purchased competitively.

Radio crowding: FCC grinds slowly

Nearly a year ago, the FCC said it would form a government-industry advisory committee to investigate the complex problem of crowded land-mobile radio channels [Electronics, Dec. 28, p. 84]. **Late last month Commissioner James E. Cox, who is directing the effort, announced that his personnel had been selected and his organization table perfected.** There will an executive committee; standing committees on operations, technical aspects, and frequency utilization and administration; and a number of working groups for each committee.

The time needed to enlist the more than 200 persons on the committee and the diversity of the organization indicate the long-range nature of the study.

Snooping probe a surprise hit

Sen. Edward V. Long (D., Mo.) aroused more interest than he expected with his Congressional hearings on electronic surveillance. "Bugged" roses and eavesdropping martini olives make for good reading. **Long has been encouraged to pursue his investigation,** which he believes will at least reduce the use of spying devices by nonsensitive government agencies. **His goal is legislation to restrict snooping generally.**

Meanwhile, a New York state court declared unconstitutional a state law that allows police to use electronic bugging devices in a suspect's premises. The decision is expected to be appealed.

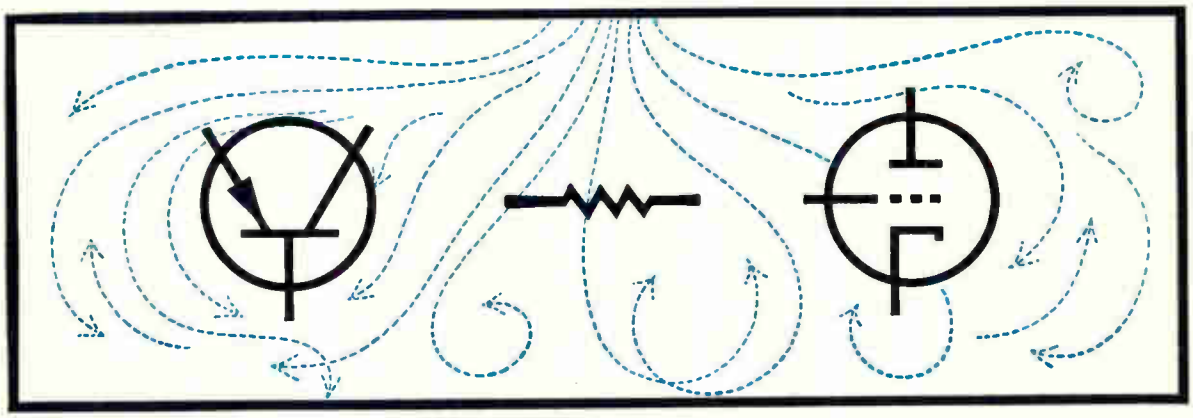
Pentagon to pool data with NASA

The Defense Department and NASA are establishing a system for pooling descriptions of current research work. The material will be stored in an automated data bank.

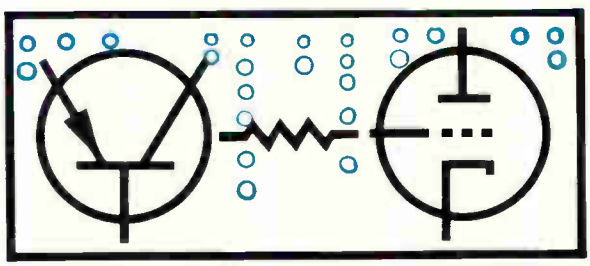
The new system will make available to both agencies a comprehensive picture of current research.

You can cool with air...

(if you have a lot of space)



or



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FREON carries heat away hundreds of times better than air. Close-packed assemblies can operate efficiently at safe temperatures. FREON compounds have outstanding characteristics as heat transfer media either by boiling or by convection.

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These five FREON dielectric coolants range in boiling point from +38.8°F. to +237.0°F., offering a wide range of use:

FREON-114	$CClF_2CClF_2$	B.P. + 38.8°F.
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FREON-112	CCl_2FCCl_2F	B.P. +199.0°F.
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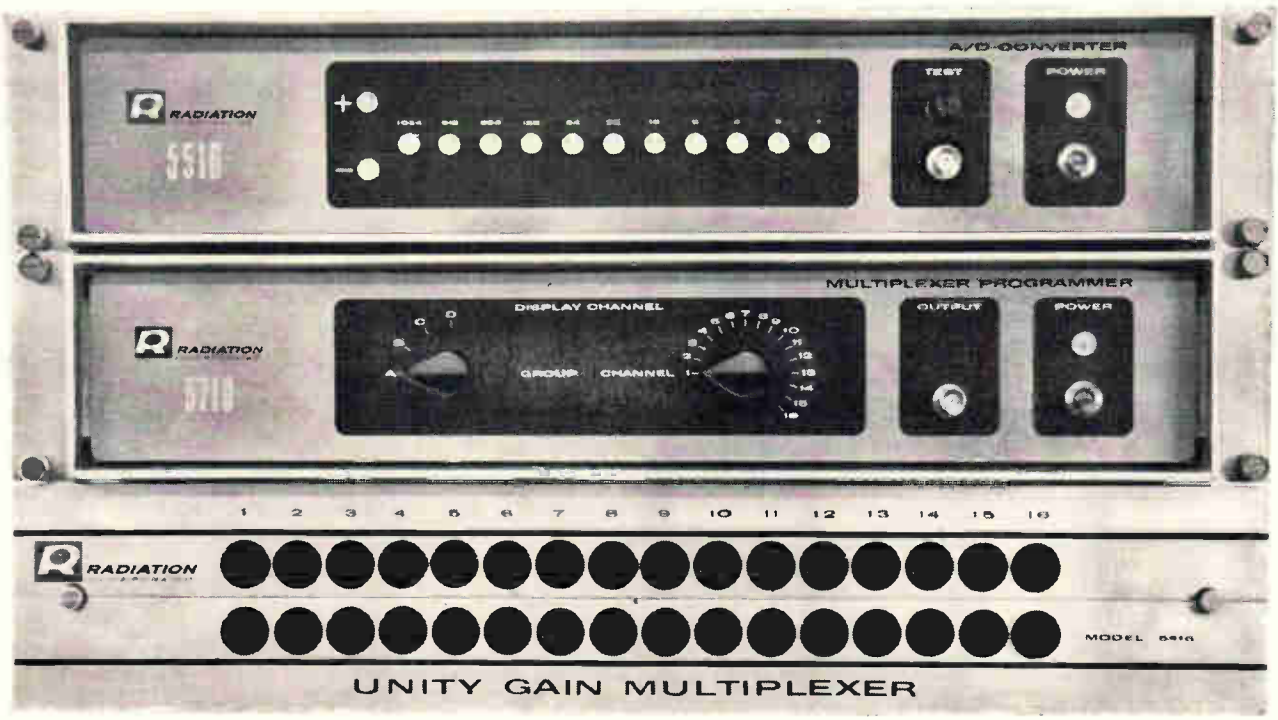
New Model 5013 data acquisition system...



From analog data to computer tape for only $9,500 plus cost of recorder

- 50,000 samples/sec
- 12-bit resolution
- 16 analog inputs

New Radiation high speed system provides outstanding performance at unusually low cost

Do you acquire analog data which eventually must be processed in a digital computer? If so, now you can do it more economically and in one step with this new Radiation system, the Model 5013.

The basic system consists of A/D converter, multiplexer programmer, unity gain multiplexer, and formatting logic. Yet, this compact system requires only 10.5" of vertical panel space. While intended for rack mounting, the system is also available in a portable cabinet for desk-top use.

Model 5013 accepts analog data from up to 16 sources. The inputs are multiplexed, and each is converted into a 12-bit binary word. The system then formats these data for entry into the write amplifiers of the digital tape recorder of your choice.

Radiation's new Model 5013 is available for delivery. If you wish, we will be glad to provide interfacing equipment for the digital recorder of your choice or engineer a complete installation based on this unique, low-cost system. Additional options offered are: up to 64 input channels, pre-set digital information inputs, digital time coding, gapped-tape capability—using core buffer, plus any of the equipments shown at right.

Send the coupon for technical details or contact Radiation for applications assistance. Radiation Incorporated, Products Division, Department EL-03, Melbourne, Florida 32902. Phone: (305) 723-1511.

MODEL 5013 SYSTEM—BRIEF SPECIFICATIONS

High reliability and long life are assured by solid state modular construction and wire-wrap connections. Circuit changes and maintenance are simplified through use of plug-in Radiation Digital Logic Modules. The three units comprising Model 5013 are human-engineered for ease of operation. Each is only 3.5" high, resulting in unusual compactness. The system consists of:

A/D Converter (Model 5516) **$3,741**

Has input of ± 5 v, full scale, 50 kc word rate, is self-contained unit. Output format is 12-bit binary or 11-bit binary plus sign. Options are: 1. built-in sample and hold, add $233; 2. display, add $293; 3. buffered output, add $83.

Multiplexer Programmer (Model 5710) **$1,995**

Incorporates selector for displaying each individual channel on the A/D Converter without interrupting the normal coding process. Supplies necessary sequencing and programming signals to accommodate up to four Unity Gain Multiplexers for a 64-channel system. Derives clock from Model 5516 or may be externally synchronized.

Unity Gain Multiplexer (Model 5416) **$1,995**

Has wide input flexibility and high reliability (MTBF 16,767 hours). This modular building block accepts single ended, differential or mixed inputs. Offset and zero drift are less than 5 μv, 20 to 30°C. Maximum sampling rate is 50 kc, two or more channels.

OPTIONAL UNITS—BRIEF SPECIFICATIONS

The highly stable, solid-state units below are designed to increase the flexibility of the basic Model 5013 System:

D/A Converter (Model 5610) **$3,950**

Accepts 8-bit parallel binary multiplex, provides 12 inputs, 12 D/A converter outputs. Adjustment free. Output: 0 to −5 v excursion for zero to full scale. Voltage resolution: 0.39% (9.76 mv). Settling time: less than 2 μsec. Available without display at $3,750.

Read/Write Electronics (Model 5810) **$6,000**

Adaptable to 7 or 9-track requirements. Binary or BCD: 200, 556 or 800 bits/inch. Manual write lockout control. Contains parity generator on write and parity check on read. Adaptable to write heads with either center-tapped or single winding.

RADIATION PRODUCTS DIVISION
A DIVISION OF RADIATION INCORPORATED

MELBOURNE, FLORIDA 32902

Gentlemen: Please send technical data on products listed below:

☐ Model 5013 ☐ Model 5516 ☐ Model 5710 ☐ Model 5416 ☐ Model 5610 ☐ Model 5810

Name _____ Title _____

Firm _____

Address _____ City _____ State _____ Code _____

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Immediate Availability—sold by leading Industrial Electronic Distributors* in major marketing areas — AT OEM PRICES IN ANY QUANTITY.

Highest Quality—millions of controls—field proven under most exacting requirements —have earned mass market customer acceptance.

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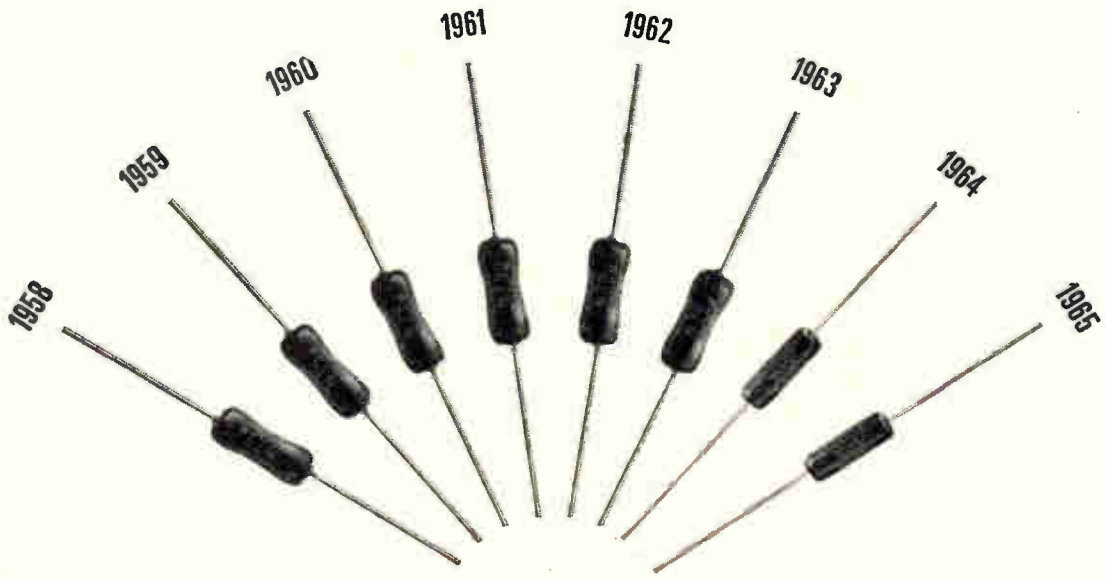


The eighth year of significant improvements in CORNING® precision resistors

You'd never know it just by looking at them, though. Our engineers don't even have taillights to change from year to year.

But on the little things inside, they're tigers.

Take TC, for example. Back in 1958, our CORNING® N-Insulated Series of resistors went on the market with a TC of ±500 ppm. Not too bad, not too good.

We went to work on it and whittled the TC down to ±300 ppm in our 1960 model. In 1961, we'd squeezed TC down to ±200 ppm—it was getting tougher.

Then, in the 1962-63 versions of CORNING RN Resistor types, we screwed the TC down to ±150 ppm.

And last year, in the CORNING® NA Resistor Styles, we held TC to ±100 ppm. But TC isn't everything.

Soon we will announce a major advance in the over-all stability and performance of CORNING precision resistors—once again improving our basic glass tin oxide component which already holds well-established benchmarks for long, flat load-life performance.

Actually, we made a big interim improvement in that stability with the CORNING® NA-Resistor. Look at the Design Tolerances we've assigned to the Characteristic D NA-Resistor—±1.9%/20,000 hours for the NA55D and NA60D; ± 3.2%/20,000 hours for the NA65D, and ±4.3%/20,000 hours for the NA70D—all calculated within 3 sigma limits.

These Design Tolerances *include* the 1% purchase tolerance and all ΔR due to TC and load-life drift.

With the CORNING NA-Resistor, you *know* the parameters of its performance under load.

PHYSICAL CHARACTERISTICS

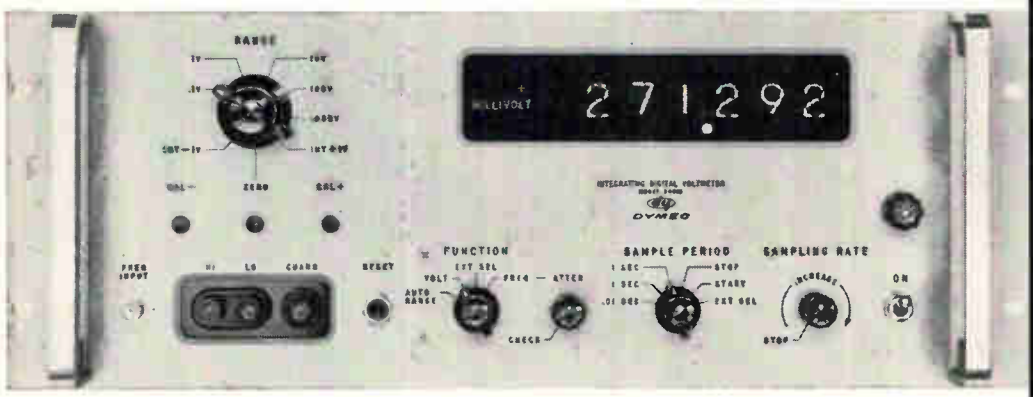
Mil Type	Corning Type	Wattage	Resistance (ohms)	
			Min.	Max.
RN55D	NA55D	⅛	51	150K
RN60D	NA60D	¼	10	249K
RN65D	NA65D	½	10	500K
RN70D	NA70D	¾	51	1 Meg.

Order from your nearby Corning distributor, or write for full technical data to Corning Glass Works, 3913 Electronics Dr., Raleigh, N. C.

CORNING
ELECTRONICS

WIDE DYNAMIC RANGE

(up to 3 times full scale)



BACKED-UP BY FAST AUTORANGING

(< 6 milliseconds/range)

The wide dynamic range offered by the new DY-2401C Integrating Digital Voltmeter from Dymec lets you measure signals up to three times full scale. It has 5 ranges with highly accurate 300% overranging on the most sensitive 4. Get the convenience of one-setting measurements in the much-used 1-to-3 area (e.g. 3 volts on the 1 v range, 30 v on the 10 v range, etc.) A 6th digit displays the most significant figure.

Should the measured signal exceed 310% of range setting, overload circuitry changes range to 1000 v and tells you your dvm is overloaded.

The autoranger available for the solid-state DY-2401C requires only 6 milliseconds per range to change and lets you take successive readings at opposite ends of the measuring range with <34 milliseconds range-change time. This is the fastest autoranger available. For data acquisition system applications, this means less time changing range, therefore less per-channel time.

Not only are you able to range the 2401C, but you can also set the sixth (10 mv) range provided by the accessory DY-2411A Preamp. When using the DY-2410B AC/Ohms Converter, you can automatically change ac and resistance ranges.

Increases or decreases in signal magnitude are precisely tracked, range is changed where necessary and only the correct answer is displayed. With noisy signals, no waiting while the meter hunts for the answer, and no bad guesses or indecision. You get the right answer the first time.

DY-2401C improvements include a new reversing counter—you can accurately measure signals in the zero region, even with positive/negative going noise on the signal. No zero fold-over problems. You also get higher instrument accuracy: Now 0.01% of reading, +0.005% of full scale +1 digit (at 25°C).

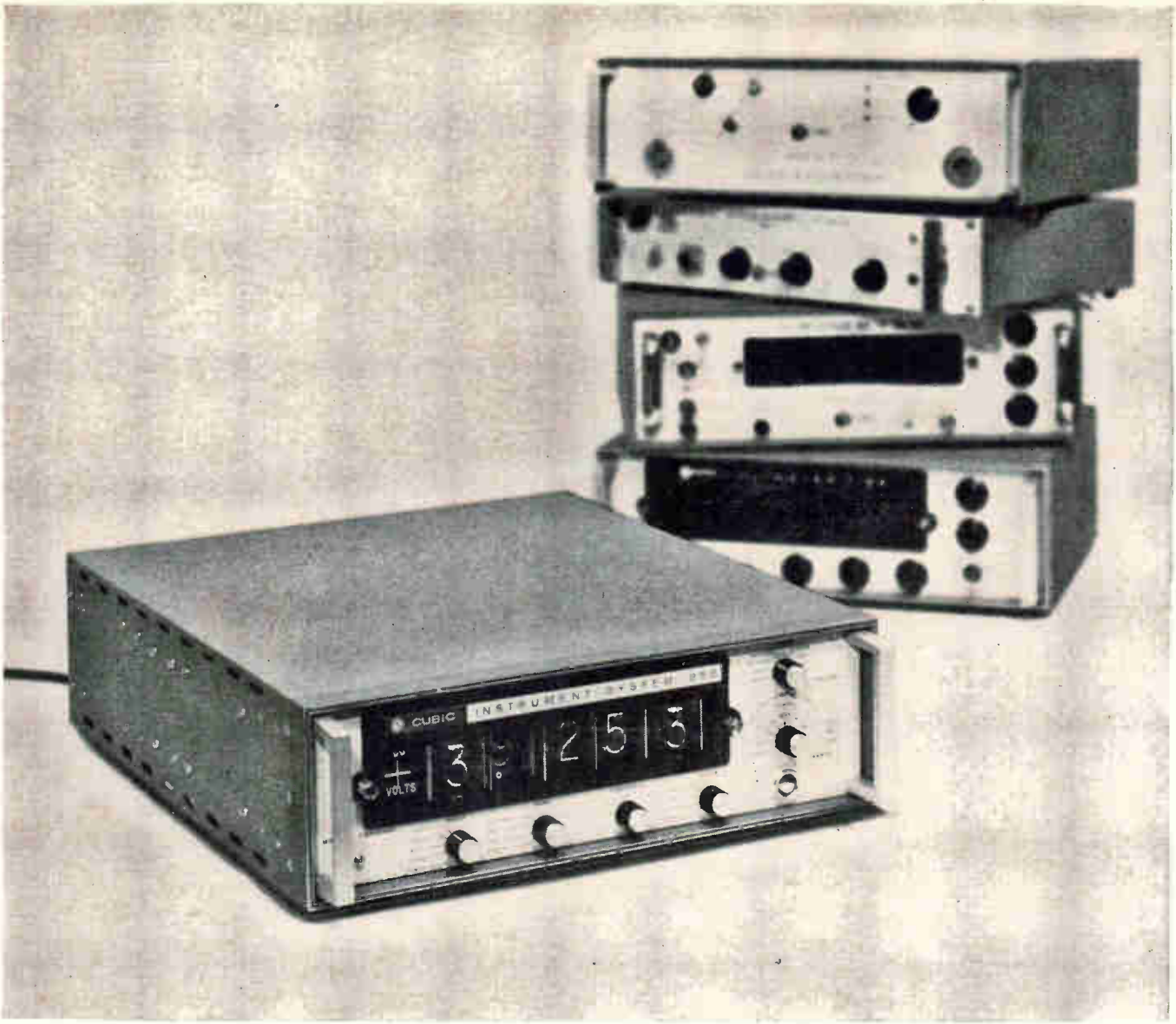
DY-2401C, $3950; autoranger adds $250.

Call your local Hewlett-Packard field engineer for information and complete specifications, or write direct to Dymec, 395 Page Mill Road, Palo Alto, California 94306. (415) 326-1755. *Data subject to change without notice. Prices f.o.b. factory.*

See the new DY-2401C at IEEE

HEWLETT PACKARD hp DYMEC DIVISION

t2507



One Cubic Instrument System performs the function of four separate instruments!

The industry-leading approach to digital instrumentation is offered by Cubic Corporation's Instrument Systems. Each employs plug-in modules to perform five different measurements. These include DC volts, bipolar DC ratio, AC volts, ohms, and low-level DC to 1 microvolt. Function Selector Knob on the instrument face changes function . . . without changing plug-in modules. A Cubic Instrument System eliminates the need for other instruments to make basic measurements.

Designed for easy expansion

Each Instrument System is based on a flexible design. Adding basic input and output devices or separate peripheral equipment quickly alters capabilities. Accessory connector modifications or field programming of accessory plugs also changes an Instrument System to meet new requirements. Front panel functions are programmable, for adaptation to varied systems.

Four models available

Instrument System 150—Low-cost industrial 5-digit DVM unit.

Instrument System 250—Current-summing, reed relay DVM for reliability.

Instrument System 350—5-digit DVM features solid state switching for speed.

Instrument System 240—Cubic's rugged 4-digit, reed relay DVM.

Accessories

Input Modules: Preamplifiers, AC-DC Converters, Ohms-to-volt Converters, Scanners.

Output Modules: Data Translators and Buffers.

Peripheral Accessories #640 Scanner, #800 Data Translator, #811 Printer, Typewriters, Tape Punches. For information about Instrument Systems, write: Cubic Corporation, Dept. D-128, 9330 Balboa Ave., San Diego, Calif. 92123.

CUBIC
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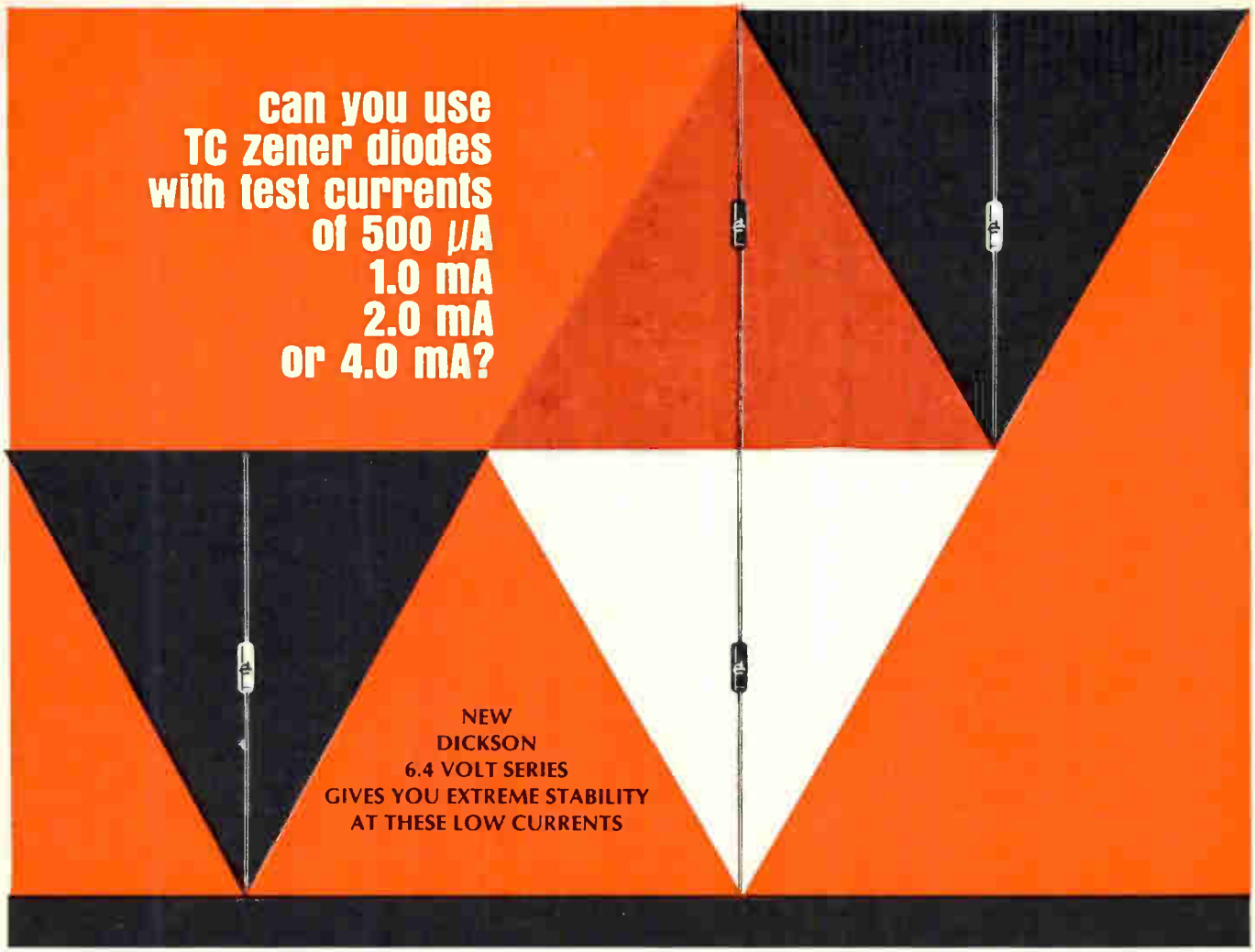
can you use TC zener diodes with test currents of 500 μA 1.0 mA 2.0 mA or 4.0 mA?



■ These new Dickson temperature compensated zener diodes are ideal for applications requiring extreme stability at a 6.4 Volt reference level where power is at a premium. Temperature coefficients to ±.0005%/°C are available over a temperature range of −55°C to +100°C and 0 to +75°C at test currents of 500 μA, 1, 2, and 4 mA. Coefficients of ±.01%/°C to .001%/°C are also available for less critical applications.

LIFEGUARD PROCESS

■ The Dickson 1N4565-1N4584A series is produced by the Dickson "Lifeguard" process. This exclusive new technique—

a — decreases the electrical field at the surface of the junction to make the unit non-sensitive to airborne impurities, micro-cracks, and other undersirable surface effects.

b — completely eliminates the thermally induced stresses which cause bonding cracks and shifts in device operating characteristics.

■ The result is a diode with a level of reliability and stability that far exceeds that of comparable devices. Analysis of over two million hours of life test data has indicated the complete elimination of catastrophic failures. The units are so stable as a function of time that it is difficult to establish adequately stable test instrumentation to yield significant results.

DICKSON 6.4 VOLT TEMPERATURE COMPENSATED REFERENCE DIODES

JEDEC TYPE NUMBER	ZENER TEST CURRENT	MAXIMUM TEMPERATURE COEFFICIENT	MAXIMUM DYNAMIC IMPEDANCE
	mA	±%/°C	ohms
1N4565A	.5	.01	200
1N4566A	.5	.005	200
1N4567A	.5	.002	200
1N4568A	.5	.001	200
1N4569A	.5	.0005	200
1N4570A	1.0	.01	100
1N4571A	1.0	.005	100
1N4572A	1.0	.002	100
1N4573A	1.0	.001	100
1N4574A	1.0	.0005	100
1N4575A	2.0	.01	50
1N4576A	2.0	.005	50
1N4577A	2.0	.002	50
1N4578A	2.0	.001	50
1N4579A	2.0	.0005	50
1N4580A	4.0	.01	25
1N4581A	4.0	.005	25
1N4582A	4.0	.002	25
1N4583A	4.0	.001	25
1N4584A	4.0	.0005	25

TEMPERATURE RANGE – "A" suffix = −55 to +100°C
No suffix = 0 to + 75°C

VISIT IEEE BOOTH 1122

See these low current "Lifeguard" diodes sealed and tested at the Dickson booth . . . and, if you like, make your own free sample.

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Manufacturers of quality zener diodes, rectifiers, tantalum capacitors, solid state circuit breakers, field effect transistors.

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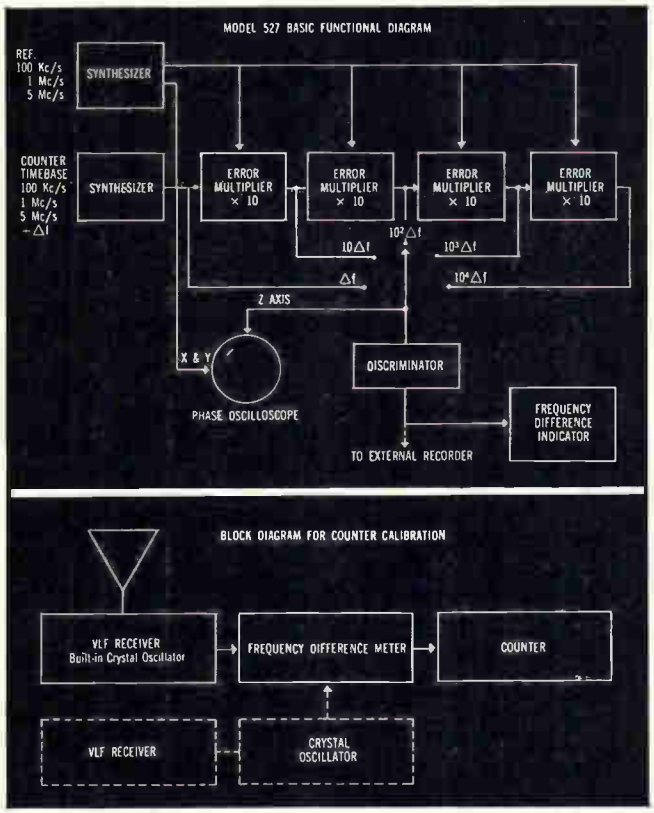

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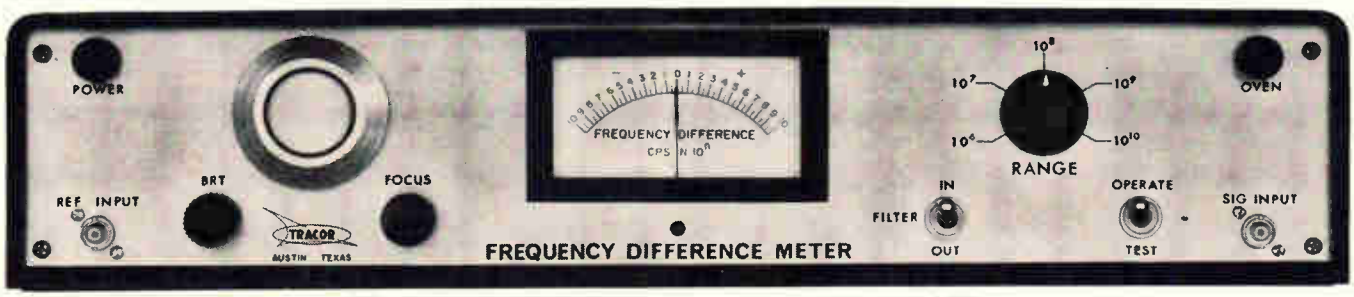
TRACOR IEEE Booth #3946 features oscillator calibration to 1 x 10^{-11}. A TRACOR representative will demonstrate equipment in your laboratory on request. Telephone 512-476-6601 collect or write: TRACOR, Inc., 1701 Guadalupe Street, Austin, Texas 78701 for complete information.



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1. MORE POWER in MIL SPEC SIZE

G SERIES*

DALE TYPE	MIL-R-26C TYPE	MIL-R-23379 TYPE	POWER RATING (WATTS)		RESISTANCE RANGE (OHMS)	
			Dale	Mil.	.05%, .1%, .25%	.5%, 1%, 3%
G-1	—	—	1.0	—	10 to 950	1 to 3.4K
G-3	RW-70	RWP-18	2.25	1	1 to 2.7K	.1 to 10.4K
G-5C	RW-69	RWP-20	5	3	1 to 8.6K	.1 to 32.3K
G-15	RW-68	RWP-23	15	10	.5 to 73.4K	.1 to 273K

HG SERIES

DALE TYPE	MIL-R-18546C TYPE	POWER RATING (WATTS)		RESISTANCE RANGE (OHMS)	
		Dale	Mil.	.05%, .1%, .25%	.5%, 1%, 3%
HG-5	None	15	—	1 to 6.5K	1 to 24.5K
HG-10	RE-65	20	10	1 to 12.7K	.1 to 47.1K
HG-25	RE-70	35	15	.5 to 25.7K	.1 to 95.2K
HG-50	RE-75	50	20	.5 to 73.4K	.1 to 273K

Major Environmental Specifications: LOAD LIFE: 1% Max. ΔR in 1000 hours at full power. OVERLOAD: .5% Max. ΔR at 3, 5, or 10 times momentary overload per applicable Mil. Spec. OPERATING TEMPERATURE: −55°C to +275°C

*G Series models are typical: 10 resistors in complete line.

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DALE G-1

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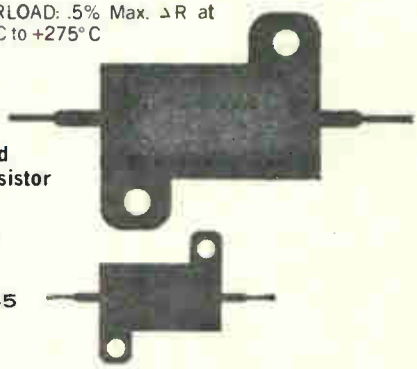
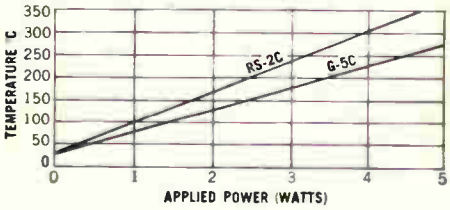
Conventional MIL-R-18546C Size



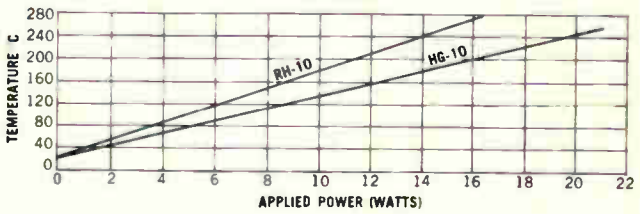
DALE HG-5

3. EXCEPTIONAL STABILITY at CONVENTIONAL RATINGS

Two RW-69, MIL-R-26C resistors (Dale G-5C and conventional silicone-coated wirewound) operated at Mil power levels.

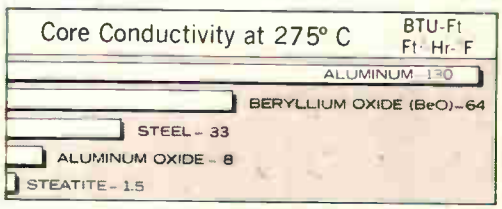


Two RE-65, MIL-R-18546C resistors (Dale HG-10 and conventional housed power wirewound, RH-10) operated at Mil power levels.



4. IMPROVED THERMAL EFFICIENCY

The chart at right shows the outstanding heat dissipation advantages which the beryllium oxide cores used in Dale G and HG resistors have over conventional core materials. To complement this advantage, Dale uses a special high temperature silicone coating on the G Series and a new extruded aluminum housing for the HG Series.



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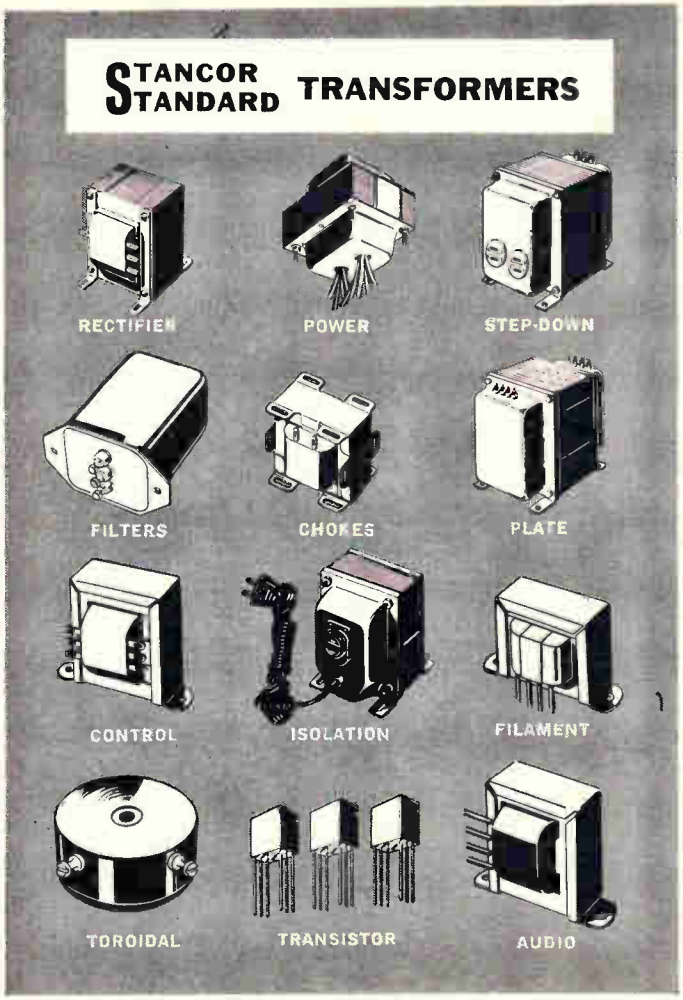

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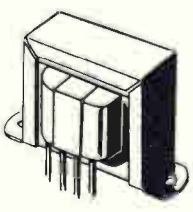

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Technical Articles

IEEE Show: Crucible for new products
page 74

Today, an electronics company's growth and future depend more than ever on its ability to generate successful new products. Many of those scheduled to be introduced at this year's IEEE show will solve hardware engineering problems. But to engineers, a key question is how the products were developed, and where the idea came from. (More new products on pages 149 to 207.)

Nonreactive filter converts triangular waves to sines
page 98

The field effect transistor's design makes possible many unusual applications. For example, the drain characteristic of the FET can be exploited in a nonlinear, nonreactive filter when it is necessary to convert triangular waveforms to sinusoidal waveforms. The major caution, however, is to minimize the introduction of harmonics. One approach produces distortion of less than 1%.

Digital system converts data to meaningful units
page 102

Data from a missile or industrial control system test arrives in the wrong form—d-c voltages or pulse rates. It has to be converted to usable units—degrees of temperature, pounds per square inch, etc. A new technique provides direct readout in meaningful units. It is more accurate and more flexible than normal analog methods.

Modernizing the range: Part 2
page 108

Pulse and continuous-wave radars on the missile range are being debugged to support our ambitious space programs. Future plans call for putting pulse radar in aircraft and satellites.

Coming March 22

- The international controversy over color tv
- Using varactor diodes for r-f switching
- Starting a series on cold-cathode tubes
- Bonding techniques for hybrid circuits

IEEE Show: New product crucible

Engineers under pressure to come up with new products, will be looking at this year's crop for help in understanding why, how and where good ideas develop

The route from inspiration to production is rarely a short, straight path. After more than four years of painstaking effort, marked by as many disappointments as successes, Boonton Radio has perfected a vector impedance meter (cover) that takes the tedious manual work out of measuring complex impedances. The company will exhibit the first working model of this significant instrument at the IEEE show in New York on March 23.

Boonton won't be the only company to show a new product that represents the culmination of development processes which are often long, painful, tedious and expensive. Traditionally, the week of the annual meeting of the Institute of Electrical and Electronic Engineers (going back to the time, before 1963, when it was the Institute of Radio Engineers) has been the occasion to introduce major new products. This year, the pressure is on. With government research and production money harder to find, many companies are banking their future on the commercial success of the items they will show at the IEEE convention. That's why Electronics is taking a close look at a number of important new products to analyze why and how they were developed.

A good new product idea can come from anywhere. It may

- Answer a long-term need—the precision insertion loss measuring system (page 89) developed by DeMornay-Bonardi for use at microwave frequencies.
- Improve the capability of an established device —the new phase-sensitive meter (page 80) to be previewed by the Industrial Test Equipment Co.
- Be purchased from somebody who doesn't have the facilities to manufacture the product—Raytheon's new digital strobe display (page 85) is an example of this.

Culling the most interesting and significant products from this year's offerings, Electronics' editors identified a few important trends.

Companies are attacking the price barrier on a lot of products, bringing out new components, instruments and systems that are markedly cheaper than current models. Collins Radio has a mechanical filter (page 81) for citizens' band equipment, costing only a third as much as other filters.

New materials are responsible for some other new products. For example, Varo Inc. (page 84) can offer microelectronic devices of high power—up to 18 watts—because new materials have been worked into them.

Reducing the size of devices has led to a variety of new equipment. By water cooling a high-power microwave termination instead of air cooling it, and using a dielectric with high thermal conductivity as good as metals', Bird Electronics has produced a unit (see page 88) that is far smaller than air-cooled units. New high power varactor diodes to be offered by Motorola (page 83) will shrink the size of some microwave equipment by replacing traveling-wave tubes with significantly smaller solid-state components.

Advanced techniques and new components have produced some other items. Field effect transistors shrink the size of a sine/square-wave generator built by Waveforms, Inc. (page 76).

More than ever before, new products are the fruit of ideas bought outside a company. It's partially a sign of the pressure on companies to develop more new products. And partially, it's an indication of companies' efforts to diversify. Raytheon is not the only company that will show a new product whose design or idea was purchased. Materials Research Corp. bought the idea for its new thin-film x-ray diffractometer from Franklin Institute Laboratories (page 90).

The IEEE show is more than a panorama of new equipment. It can supply an insight into some of the major changes that are taking place in the electronics industry and indicate the pace at which these changes are happening. Here, then, is an examination of some of the significant new products to be introduced at the show. Other new products, examined in less detail, will be found on pages 149 to 207.

Changing direction saved a product program

While engineers at the Burroughs Corp.'s electronics division in Plainfield, N. J., were doing the final testing on a new hybrid mircrocircuit last year, the International Business Machines Corp. announced its System 360 computer line, taking almost an identical approach to modular components. Burroughs decided to carry its work a step further in hopes of topping IBM in quality if not in timing.

From that extension has come a development that adds significantly to the hybrid circuit. Burroughs has perfected a technique for passivating silicon semiconductor devices with pyrolitic glass, eliminating the ordinary packaging or encapsulation, the hermetic seal, and the leads to the active components.

The coating is similar to the one that IBM has put on System 360 components. IBM deposits its coating by centrifuging a glass frit onto the silicon chip and baking it. Burroughs passes a gas mixture that contains silicon oxide over the chip, which has been heated. The high temperature causes the glass to deposit and coat the chip.

Picking up the pieces of its development work that had been aced out by IBM, Burroughs changed direction, determined to develop an inexpensive line of microcircuit products. Studying microelectronic equipment, Burroughs learned that the package was the best candidate for cost reduction. It represented nearly 75% of the cost of a microelectronic device. Previous study at Burroughs' corporate research laboratory in Paoli, Pa., had shown that glass passivation was technically feasible. Only a commercial process was needed.

To develop such a process, the company hired a materials specialist from a pharmaceutical company where he had learned to work with silicon and silicon dioxide. Burroughs won't talk about how its high-temperature process works, but the resultant glass-like seal is so good that the company tests it for pinhole leaks by inserting it in an atmosphere of hydrochloric acid gas at high pressure and 1,200°F.

The new package is so inexpensive that Burroughs offers a silicon controlled switch with three resistors—the equivalent of a high-voltage flip-flop —for only $1.25 in quantities of a thousand. Normally, a microelectronic flip-flop would cost at least $3.

With its new process, which company people call glassivation, Burroughs has three new product lines that will be introduced at the IEEE show: components, circuits and equipment.

First, Burroughs will show glass-passivated components such as silicon controlled switches (a Burroughs semiconductor specialty), some transistors and diodes. In addition, it will offer custom-made hybrid microcircuits. These are ceramic rectangles, postage-stamp size and single-sided, meaning that all contacts are brought out on the same side. A typical circuit contains resistors, capacitors and conductors, positioned according to a customer's specifications. Active devices, in the form of tiny silicon squares, have metal contact pads on one surface and are dropped into place in the circuit before the ceramic stamp is passivated.

In such circuits, the new process does away with hermetic sealing operations, wire bonding to device header and posts, and certain tests that usually have to be performed before and after each production step. Instead, all testing can be done before the active device is diced.

Finally, the hybrid microcircuits are being used in Burroughs hardware products. Burroughs, which pioneered the Nixie tube for display purposes, has produced a tiny—0.490 inch wide, 0.650 inch high and 0.775 inch deep—Nixie tube to work with the microciruits. The first application is in a tiny binary decoder with memory for an airborne navigation system. Shortly after the IEEE show, the first unit will be flight-tested in a latitude-longitude indicator.

The unit, complete with Nixie tube, sells for only $49 in quantities of thousands. Without the new microcircuits, such a unit would cost at least $250 because of the work needed to miniaturize the circuitry.

The miniature decoder memory has two main parts: a 12-diode decoder and a 12-silicon-controlled-switch memory-driver circuit. The decoder is biquinary: it converts the binary signal into one of five pairs of odd-even numbers instead of directly into one out of ten. The driver then converts the biquinary number to a decimal.

One feature of the unit is its low power consumption, only 670 milliwatts. That includes the Nixie tube, which draws up to 340 milliwatts.

Instruments

Impedance measurement without knob-twiddling

A measuring instrument should be easily applied and easily read, but sometimes the complexity of the measurement and the accuracy desired smother the goal of simplicity. Such was the case with impedance measurement. But now the Boonton division of the Hewlett-Packard Company has devel-

Direct reading of magnitude and phase is provided by two large meters on Vector Impedance Meter.

oped a self-contained instrument that provides complex impedance measurements directly on two front panel meters.

The instrument, the Vector Impedance Meter model 4800A, overcomes the frequency limitations of bridge-type measurements. Its accuracy—5% of full scale—is independent of the operator's ability to determine a null by using earphones or an oscilloscope. It avoids the errors introduced by the resolution limitation inherent in dial settings.

The 4800A measures impedance from 5 cycles per second to 500 kilocycles per second. The panel meters provide the magnitude Z of any impedance from 10 ohms to 10 megohms and its phase angle θ from 0 to 360 degrees. The test frequency is selected by a range switch and dial.

The measurement technique employed is as old as Ohm's law itself. On the lower impedance ranges, the measurement is made by applying a constant alternating current to the unknown and reading the voltage across it. This voltage is proportional to the magnitude of the impedance, Z. On the higher ranges, a constant voltage is applied to the unknown and the current is measured. The applied voltage levels are minimized so that nonlinear devices may be measured under small signal conditions for best accuracy. Phase angle is measured with a synchronous detector which reads the difference between the phase of the current through the unknown impedance and the phase of the voltage across it.

Besides being an impedance-measuring device, the 4800A is useful as a direct reading L-C meter. It can measure inductance from 1 microhenry to 100 kilohenries and capacitance from 0.1 picofarads to 10,000 microfarads.

The meter can also be used as a Q-meter over its entire frequency range. This is accomplished by using the "Q by delta f" approach. The frequency response of the component under test is measured on the Z meter, which has an additional scale calibrated in decibels for convenience, and the Q is easily computed as the ratio of the center frequency f_o to the bandwidth Δf between 3-db points.

Analog outputs proportional to impedance magnitude, phase angle and frequency are an optional provision so that a direct plot of impedance as a function of frequency can be obtained when connected to an X-Y recorder. These outputs could also be used to actuate limit switches or operate digital or expanded scale voltmeters.

Specifications

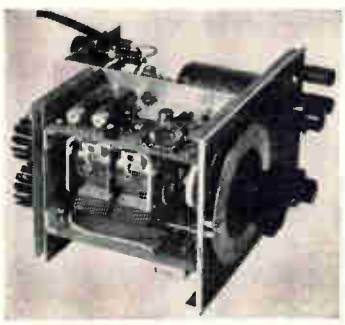
Frequency range:	5 cps to 500 kc in 5 bands
Impedance magnitude range (Z):	1 ohm to 10 megohms in 7 ranges, accuracy: 5% of full scale
Phase angle range (θ):	0 to 360 in 2 ranges (Both ranges are zero centered to facilitate easy reading of leading or lagging value of θ), accuracy: 5% of full scale ±2°
Inductance range:	1μh to 100,000 h in 11 ranges
Capacitance range:	0.1 pf to 10,000 μf in 11 ranges
Power requirement:	115/230 volts, 50-60 cps, 15 watts
Dimensions:	5 7/32" x 16¾" x 16⅜"
Weight:	25 pounds
Price:	$1,490
Delivery:	From stock after September.

Kit bag holds trouble-shooter

Component developments are putting laboratory instruments right into the field service engineer's briefcase. Waveforms, Inc., of New York City has built an audio-video sine and square wave generator, dubbed the 511A, that includes an audio oscillator, a radio-frequency oscillator, a square wave generator and an attenuation system in a 6-pound, 153-cubic-inch package. Designed primarily for testing audio and data tape recorders, the basic design can be adapted to field uses in the railroad and telephone industries, and to a number of other applications.

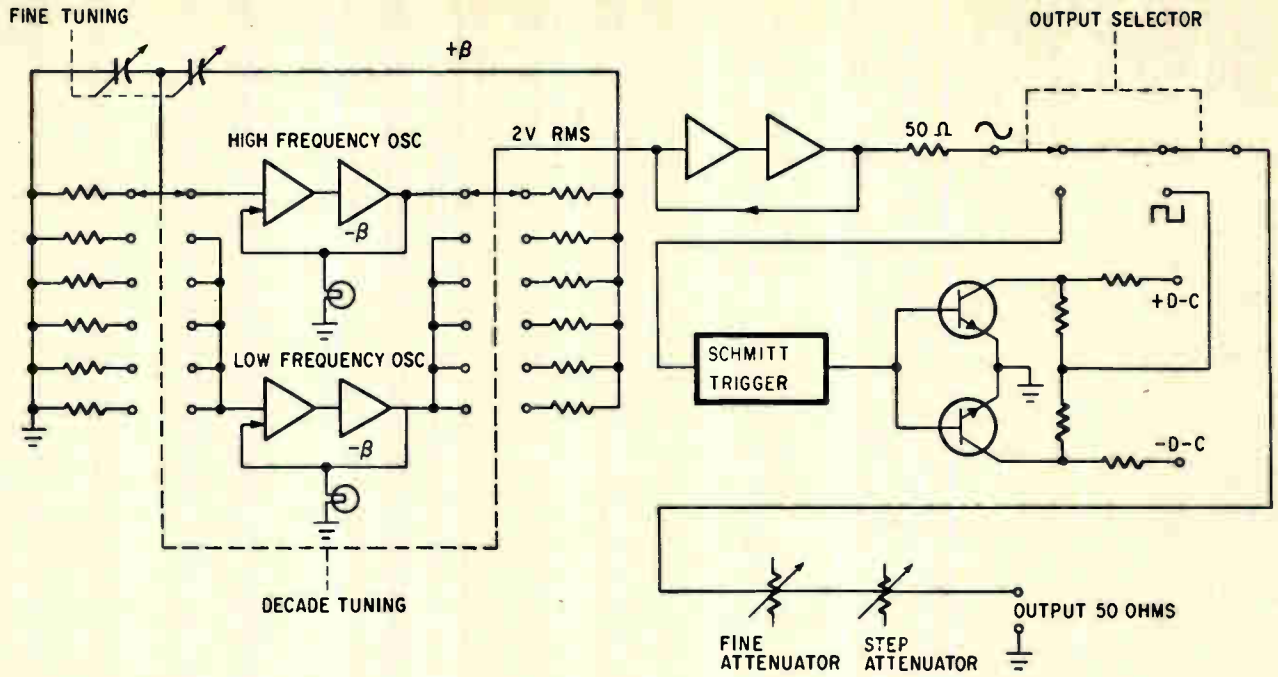
Even with solid state circuitry, the package could not have been built without two key component developments: field effect transistors of the metal oxide semiconductor type, and miniature tantalum capacitors.

To achieve the design and packaging objectives, all solid state design was necessary. But, according to Waveforms, traditional solid-state audio os-



Internal view of portable generator shows solid-state design.

Field engineer can pack his lunch along with sine and square wave generator (lower left) and other equipment.



The complementary symmetry output switch in the Waveforms, Inc., sine/square-wave generator is used as the square-wave output circuit and allows direct coupling to the output, maintains constant output Z for both the positive and negative portions of the waveform, and is short-circuit proof.

cillators were not desirable, and what was desirable was not available.

There were solid state RC audio oscillators of the fixed capacitance, variable-resistance type. But the design engineers were reluctant to use composition, ganged "pots" for resistive tuning because they do not age well and because their temperature coefficient was not considered ideal. With variable wire-wound controls, on the other hand, infinite tuning resolution is a two-step process: the small but discrete stops in the wire-wound control, and a vernier to adjust between them.

According to the Waveforms engineers, a variable capacitance approach combines all the advantages of composition and wire-wound controls with none of their disadvantages.

Electron tube audio oscillators have been built with variable capacitors for years. But it was not possible to construct a simple transistor amplifier with sufficiently high impedance to operate with a variable-capacitance network. The impedance must be on the order of a few hundred megohms, because the available capacitance of variable capacitors is small. To load the RC network with a low-impedance amplifier would destroy its tuning properties.

Then came the MOS FET, opening up new possibilities to the solid-state circuit designer. It has an input impedance even higher than that of electron tubes. By incorporating the RCA 3N98 FET in the 511A, Waveforms engineers arrived at their double design goal, variable-capacitance tuning and solid state.

The circuits in the 511A, Waveforms engineers say, are conventional adaptions of electron tube circuits in use for many years. For example, the low frequency oscillator (10 cps to 120 kc) is a Wien bridge audio type consisting of a 3N98 and 2N3053 in cascade. The high frequency oscillator (100 kc to 12 Mc) is of the same type, but with the transistors and operating points chosen for use at the higher frequencies.

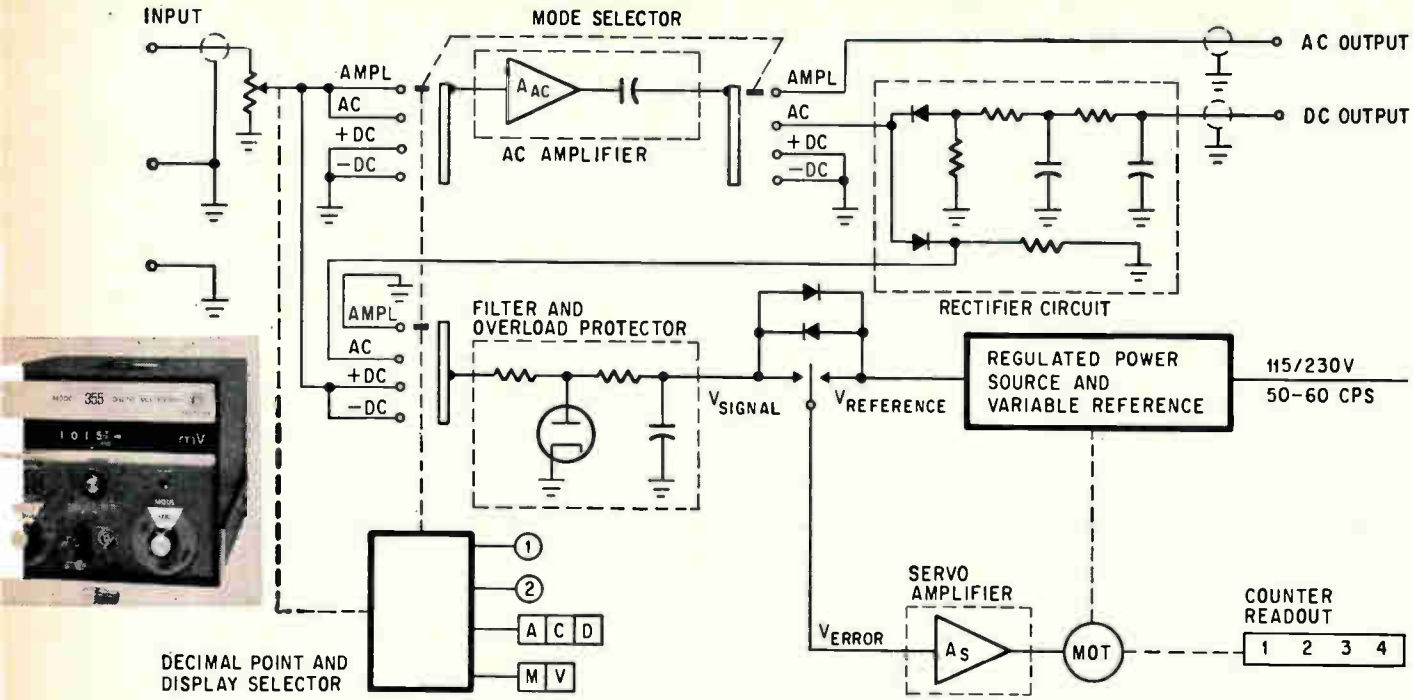
For a square wave output, the low frequency oscillator actuates a Schmitt trigger which activates the two output transistor switches in sequence. These transistors are fed from a positive and negative d-c supply. Current through them and their associated load resistors develops the square wave output voltages.

The step attenuator is a four-position device using pi configuration attenuators. The attenuation ratio is 20 db per step. While this system is conventional, the video attenuator of 60 db requires careful layout of components.

Connections are made at the front of the instrument, and the frequency is set by turning a large dial.

Specifications

Frequency range:	sine waves: 10 cps to 12 Mc square waves: 10 cps to 0.1 Mc
Dial accuracy:	±3%
Output level:	3 v into 50 ohms; 6 v open circuit
Response:	±1 db
Attenuator steps:	3 v, 300 mv, 30 mv, and 3 mv
Fine attenuator control:	continuously variable
Sine wave distortion:	0.25% at 1 kc; 1% at 1 Mc; 2% at 10 Mc
Square wave rise time:	0.5 microsecond
Power requirements:	33 volt amps, 110 or 220 volts a-c, 50 to 400 cps
Size:	6" x 4¼" x 6"
Price:	$700
Availability:	immediate



Ballantine's model 355 digital voltmeter uses a servo moto r to drive its digit counter. Mechanically coupling the counter and a reference supply provides the se rvo amplifier with feedback. The amplifier drives the motor until the output of the reference supply an d the unknown signal are equal but of opposite polarity. The "stop" position of the motor is a me asure of the input to the dvm.

(Photo inset) The vernier enables the last figure to be read to the nearest tenth.

Cutting the cost of digital voltmeters

Digital voltmeters are easy to read and thus well-suited to production line and quality-control applications, in which a yeoman might be confused by the dial of an analog meter. But the development of digital meters has concentrated on increased accuracy—some instruments have five or more digits—and the result has been price tags that begin at about $1,000. Ballantine Laboratories, Inc., fills a gap with its new 355 digital meter, which it says matches the accuracy of analog meters in its price range ($590).

Ballantine combined a drum-type digit counter, a servo motor, and low-cost analog circuitry to produce an a-c/d-c digital meter capable of making measurements up to 500 volts with an accuracy of 0.25%, full scale. A vernier added to the fourth digit drum eliminates the normal plus or minus one digit of fully-digitized displays. The user can interpolate the last digit to the nearest tenth.

The instrument can't complete with more expensive digital meters for accuracy, but it is good enough for the production line, Ballantine says. The meter won't be available until August.

Digits on the 355 are large and well-lighted. The mode and range switches light up "d-c" "a-c" and the "mv" or "v" indicators, and the proper location of the decimal point. A warning light indicates the requirement for manual range switching. A hand- or foot-operated switch may be used to hold readings and reduce the time between successive readings.

The front or rear of the meter may be elevated for easier reading; and with the use of an accessory kit, one or two of the meters can be mounted in a standard 19-inch relay rack panel without any modifications in the basic instrument.

Preliminary specifications

	a-c	d-c
Voltage range	10 mv to 1000 v in 6 ranges (30 cps to 250 kc)	100 mv to 1000 v in 5 ranges
Accuracy (% full scale)		
(1 mv to 500 v)	50 cps to 10 kc ——±0.25% 50 kc to 250 kc ——±1%	±0.25%
Maximum balancing time	4 sec	
Input impedance		
All ranges, excluding most sensitive	2 megohms in parallel with 25 pf	
Most sensitive	2 megohms in parallel with 40 pf	
Stability		
Line voltage	Less than 1 digit change per 10% deviation from 115 V	
Drift	Less than ±0.2% after 10 min warmup	
A-C rejection in d-c mode	60 cps 45 db 120 cps 40 db	
Common mode rejection		
(a-c mode, input shorted)	At 60 cps >100 db At 100 kc >80 db	
Availability (from stock)	after July	
Price	$590	

FET's raise accuracy of distortion analyzer to within 0.03%

A 15-year-old instrument is finally succumbing to the increasingly rigid demands on distortion analyzers. The Hewlett-Packard Co. has redesigned its model 330 to increase accuracy and take advantage of improvements in components. The results are the models 331-A and 332-A.

Stricter specifications stem from the growing interest in high-fidelity music and from the cramming of more and more voice channels into narrow bands for telephony.

In telephony, where distortion appears as crosstalk between channels, distortion must be held under 0.1%. The new Hewlett-Packard instruments give meaningful readings to 0.03%.

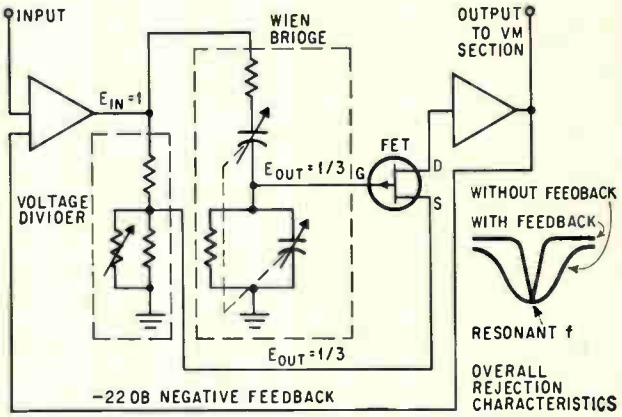
Low harmonic content is also a requirement in broadcasting. Measuring this requires an instrument capable of operation at high frequencies. The new analyzer's broad range extends to 60 megacycles.

The model 331A consists of a broadband amplifier, a frequency-selective circuit and a high-impedance voltmeter. The 332A is similar, but adds an amplitude-modulation detector for design-testing high-quality broadcast facilities. By using field-effect transistors, both instruments can measure distortion at levels hitherto undetectable.

Two FET's are used: one in the impedance converter, another in the notch filter. The necessary high input impedance, unattainable with regular solid-state devices, was accomplished by using an FET. However, to reduce the distortion that could occur from the voltage-sensitive junction capacitances in the FET's Hewlett-Packard designers bootstrapped elements of the FET. In bootstrapping, the gate voltage is lifted above ground by a value derived from its output voltage. This also increases the FET's input impedance. Clamp diodes protect the input FET from burnout.

The tunable notch filter consists of an input amplifier, a Wien bridge feeding into the high-impedance FET, and an output amplifier. The voltage from the input amplifier is fed simultaneously to the tunable Wien bridge and to a voltage divider. The output of the divider goes to the source of the FET and the output of the Wien bridge goes to the gate of the FET. The attenuation of the divider and the bridge are equal for the desired frequency, and the voltages at the source and gate are of equal amplitude and phase. Thus at resonance, the drain voltage on the FET is zero. At other frequencies, there is a drain voltage and the FET has zero attenuation. The notch filter rejects the fundamental frequency; therefore only harmonics pass through the FET to the output amplifier. The notch-filter characteristic is sharpened by adding about 22 decibels of feedback around the loop.

Model 331A distortion analyzer can be bench- or rack-mounted. Controls are simple to use; meter, calibrated in decibels, percentage and volts, is easy to read. The frequency, set with the large dial, is accurate to within 2%.



Sharp over-all rejection is achieved in the tunable filter section of the distortion analyzer. The combination of the capacitively tuned Wien bridge and 22 decibels of negative feedback in this section give more than 80 decibels of fundamental frequency rejection.

The notch-filter circuit also bootstraps the source of the FET and increases the gate impedance to thousands of megohms. This results in a high output impedance of the Wien bridge, avoids the nonlinearities that would have prohibited tuning the bridge to low frequencies, and allows the instrument to be rated down to five cycles per second.

Specifications

Distortion	0.1% to 100% in seven ranges of any fundamental frequency from 5 cps to 600 Kc
Voltage	300 microvolts to 300 volts rms full scale over frequency range from 5 cps to 3 Mc

Accuracy of harmonic frequency measurement

harmonic frequency	input		
0.3% to 100% full scale	0.1% full scale	zelow 30 v	above 30 v
10 cps–1 Mc	20 cps–200 kc	± 3%	± 3%
1 Mc–3 Mc	500 Kc–1 Mc	± 5%	±12%
	10 cps–20 cps	±12%	±12%

Fundamental rejection	better than 80 decibels
Voltmeter accuracy	±5% from 20 cps to 1 Mc
Weight	15 pounds
Price of Model 331A	$590
Price of Model 332A	$620 (includes precision a-m detector for distortion analysis of modulated envelopes)

Vector voltmeter can measure in-phase and quadrature components of voltage while rejecting noise and harmonics over the entire frequency range.

Phase-sensitive voltmeter goes wideband

When the makers of inertial guidance components for missiles began shrinking them by moving into higher audio frequencies, the makers of test equipment had to follow.

"Time was when we had to concern ourselves with 400 cycles and a couple of other frequencies," says sales engineer Melvin Schreibman of Industrial Test Equipment Co., Port Washington, N. Y. "Now we've been pushed into wideband."

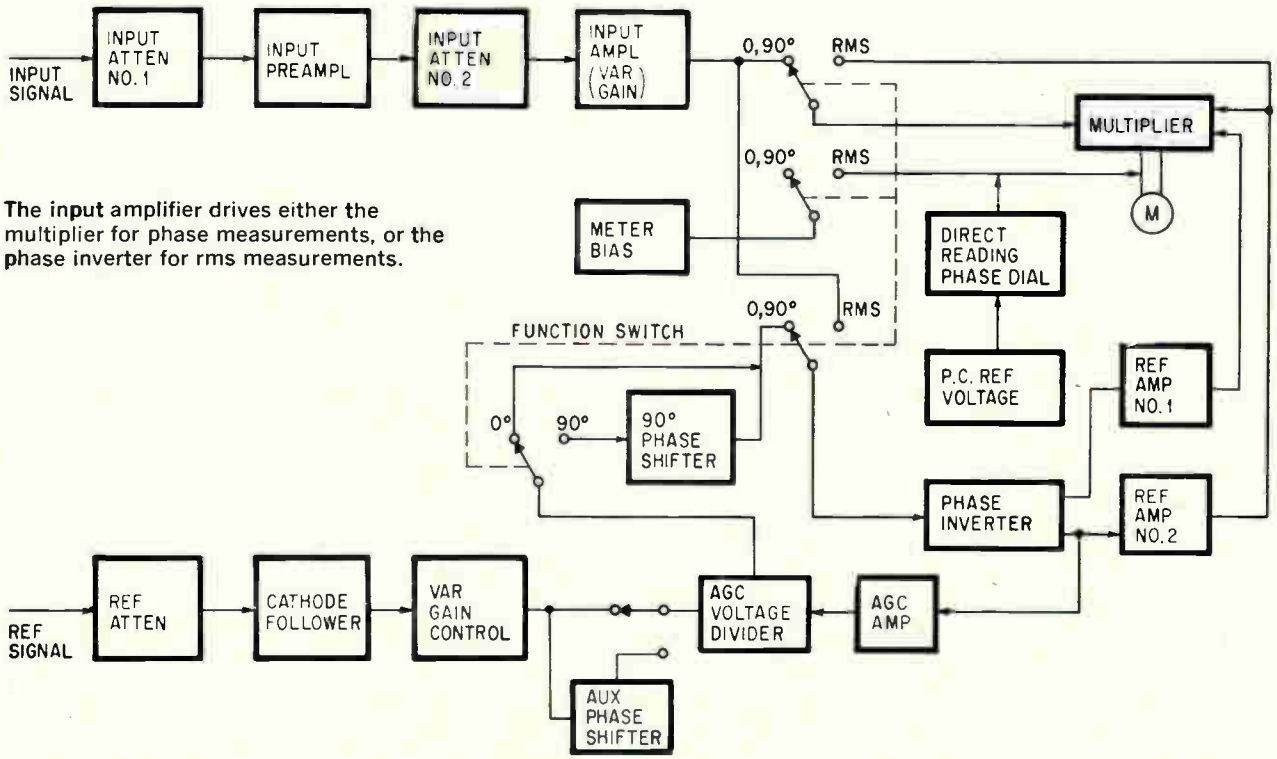
His company is introducing a vector voltmeter which can make measurements at many fixed frequencies. It can also operate over a selected band of audio frequencies without realignment at each frequency change. In addition, it goes a long way toward simplifying phase measurements, one of the most difficult aspects of component testing.

The Phazor vector voltmeter 300B is designed for use by manufacturers of rate gyros, tachometers, synchros and resolvers who need accurate measurement of residual null components, phase angle and total voltage.

Most such voltmeters use a linear discriminator to derive phase sensitivity, and filters to eliminate harmonic components and extraneous noise in both the input and reference channels. Phase misalignment is a problem when sweeping over the frequency bandwidth of a filter, so a large number of filters must be used.

Model 300B avoids the costly and error-susceptible multiple filter concept through the use of an electronic multiplier. The new circuit multiplies the instantaneous amplitudes of the input and reference signals. The meter then displays the time average of the resultant product. Since the multiplier responds only to input frequencies that match the reference, it rejects all harmonics and noise to give a true phase-sensitive reading.

The meter deflection is proportional to the product of the input and reference voltage and the cosine of the angle between them. To measure the in-phase (cosine) component of the input voltage as well as the quadrature (sine) component, it is necessary to maintain the reference amplitude constant over the entire frequency range and also be able to shift its phase a precise 90°. The phase shift is controlled by a 90° amplifier in the reference channel, and the amplitude is controlled by



The input amplifier drives either the multiplier for phase measurements, or the phase inverter for rms measurements.

an automatic gain control amplifier. Phase angle can be read off a dial even though the signals may be complicated by harmonics and noise. A simple nulling procedure will adjust the dial to any angle from 0° to 360° without ambiguity as to quadrant.

Measurement requirements usually include total voltage, and phase-sensitive meters generally employ a conventional vacuum tube voltmeter for this purpose. In the Model 300B however, this is done with the input signal impressed on both the input and reference channels while the multiplier performs a squaring function. This results in a meter readout which is true root mean square.

Conventional meters give a true rms reading only for a pure sine wave.

Specifications

Accuracy:	±2% of full scale
Crest factor:	3 (For rms measurements)
Noise & harmonic rejection:	40 decibels down
Nulling sensitivity:	10 microvolts
Sensitivity:	1 millivolt full scale
Max. input voltage:	300 volts rms
Max. input dc component:	400 volts
Input impedance:	10 megohms shunted by 25 picofarads
Max. reference voltage:	220 volts rms
Min. reference voltage:	0.5 volts rms
Max. reference d-c component:	400 volts d-c
Reference input impedance:	2 megohms shunted by 25 picofarads
Phase angle range:	0°-360°
Phase angle accuracy:	±1°
Power supply:	115 volts at 60 cps
Dimensions:	5¼" high, rack panel is 19". Depth behind panel is 13".
Weight:	35 lbs. approx.
Price:	$1,100
Delivery:	8 weeks

Components

Filtering the chatter on citizens' band

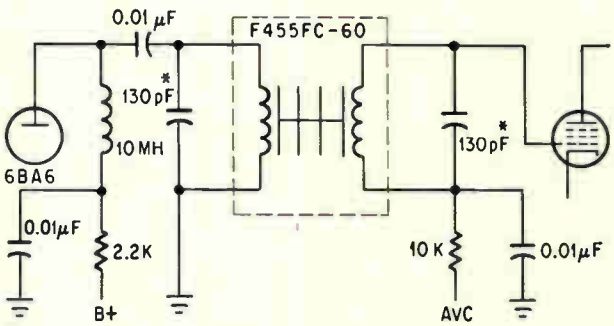
It took overcrowding of the citizens' band to reduce the price of an electromechanical filter. When Collins Radio Co. surveyed the CB market, it discovered such a potential that production engineers went directly to work. Collins already made a filter for the military; dropping military environmental requirements and stepping up production made possible a 455-kilocycle, 6-kilocycle bandwidth filter, with signal-to-noise improvement up to 8 decibels, at no more than $7 a unit.

That price is for quantities of more than 100. Single units are $12—still far below the price of present hand-built filters.

Under Federal Communications Commission rules, the power output of CB transmitters is severely limited. Satisfactory reception, especially in noisy locations or when nearby transmitters are operating on adjacent channels, is a problem. Collins says that the way to solve it is to use a filter to increase selectivity and sensitivity.

The Collins filter offers narrower bandwidth than an intermediate frequency transformer and its electrical characteristics are several times more stable, especially under severe temperature changes and with rough handling. Its variation due to aging is less than that of a transformer.

The unit is essentially a transformer in which the primary and secondary are mechanically coupled over a narrow frequency range. The manufacturer recommends that signal input voltage be limited to 5 volts root-mean-square and direct current to two milliamperes. Shunt feed to eliminate direct current from the transducer coils can be provided by a suitable choke or resistor. A common ground, effective shielding between input and output and short leads are required to enhance rejection of unwanted signals by the filter circuit.



Representative i-f stage using the electromechanical filter. Direct current is blocked from the transducer coils by shunt feet.

The Collins mechanical filter has been packaged to mount on the chassis of a CB receiver.

In electron-tube circuits, the filter is tuned to parallel resonance with a fixed capacitor shunted by a variable capacitor to peak the filter for maximum output at its center frequency. Both input and output must be resonated.

As the coupler in a transistor i-f amplifier, the filter is tuned to series resonance for low impedance and to parallel resonance for high impedance.

Specifications

Center frequency:	455 kc
Frequency bandwidth;	
3 db attenuation:	6 kc
60 db attenuation:	20 kc
Resonating capacitance:	130 pf
Direct voltage, maximum:	300 v
Source and load impedance;	
parallel resonance:	60,000 ohms
series resonance:	500 ohms
Price, more than 100, per unit:	$7.00
less than 100, per unit:	$12.00
Delivery:	60 days (prototypes from stock)

Constant-voltage transformer unaffected by frequency shifts

Since its invention in 1938, the Sola Electric Co.'s constant-voltage transformer has crossed the two-million mark in sales. Only one "bug" has limited its application somewhat: its inherent frequency sensitivity in lower power units. When line frequency changes only one cycle per second, the transformer output may change as much as 1.8 volts.

At the IEEE Show, Sola Electric, a division of the Basic Products Corp., will demonstrate its answer to the problem: a regulating transformer that's completely insensitive to frequency shifts.

The original Sola Electric device is a static magnetic regulator that depends on the transformer's core-saturation characteristics; it's controlled by a capacitor across one of its windings. Based on the principle of ferroresonance, it achieves 1% regulation for line variations up to ±15% without any moving parts or complex electronic circuitry.

The new version, a 150-volt-ampere unit, retains ±1% regulation of output voltage while operating from 50 to 400 cycles. Its other characteristics are the same as in the standard Sola Electric device.

Although patent considerations prevent Sola from giving design details on its frequency-insensitive transformer, Donald A. Davenport, Sola's director of electronic research, says compensation for ferroresonant frequency sensitivity involves a capacitance effect that tracks linearly with the frequency of the impressed voltage. He says the new transformers develop "unusual flux paths" using four secondary windings on four-legged laminations in an auto-transformer configuration.

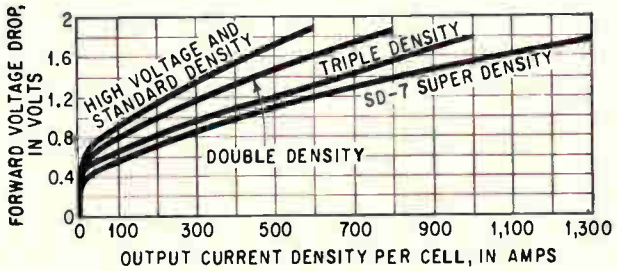
The new transformer should find military applications because gasoline- or turbine-driven standby power lacks close frequency regulation. This has precluded use of constant-voltage transformers for equipment that must be operated with standby rigs, such as communications, radar and computers.

They may also eliminate much special equipment now needed to regulate voltages on systems that operate off foreign power sources. Such sources are lax on frequency control by United States standards, according to Davenport, ranging over ±2% to ±3% compared with the typical U.S. standard of one cycle variation in 24 hours, an infinitesimal error.

The standard product line for the new transformer will include 50- 60- and 400-cycle units. Pilot designs of 40, 60 and 120 volt-ampere units will be supplemented by designs ranging from 10 to 1,000 va. Sola Electric says it will offer custom-made, frequency-insensitive, constant-voltage transformers for sale after the IEEE Convention.

Selenium rectifiers challenge silicon

Silicon has always been considered superior to selenium for high-voltage applications, because it has lower leakage current. It has also been considered better for use in high temperature environments. As a result, selenium ran far behind in the rectifier market.



Typical forward voltage drop vs. current density of four types of selenium cells.

Now a new technology for selenium, developed over a four-year period by the International Rectifier Corp., El Segundo, Calif., results in smaller rectifiers that combine improved forward characteristics for higher cell-current with higher peak inverse voltage ratings. IRC claims its process increases voltage capabilities, permits fewer units in a series, improves uniformity and requires less power dissipation per cell.

In addition to improving three existing lines, IRC has added a fourth, featuring higher current-carrying capability and called SD-7 superdensity rectifier cells.

Price has always been an important advantage of selenium over silicon rectifiers. The company sees markets opening up in conversion of older equipment to solid-state circuits. Arc welders, electroplating equipment, and devices now using high-current glass diodes are some possibilities.

Selenium units have self-healing properties that lets them recover quickly after being subjected to excess voltage surges. IRC claims their selenium

rectifiers now have the added virtue of higher current density levels. In addition, IRC engineers say the new process has increased the life expectancy of selenium, previously its major drawback. According to Frank Gift, chief engineer, short-term and accelerated life tests show better stability.

IRC says the new selenium process has resulted in a 25% increase in voltage ratings and a 20% reduction in cubic volume, in addition to greater current-handling capability—1.3 amperes per square inch of surface fan-cooled at a rate of 1,000 linear feet per minute. Standard density plates are now rated at up to 50 volts; the double density, up to 50 from 36 volts; and triple density, increased from 33 to 40 volts.

The process, IRC says, does not sacrifice selenium's ability to recover from transients with little or no deterioration of performance. No complex protective circuits are needed, IRC engineers add.

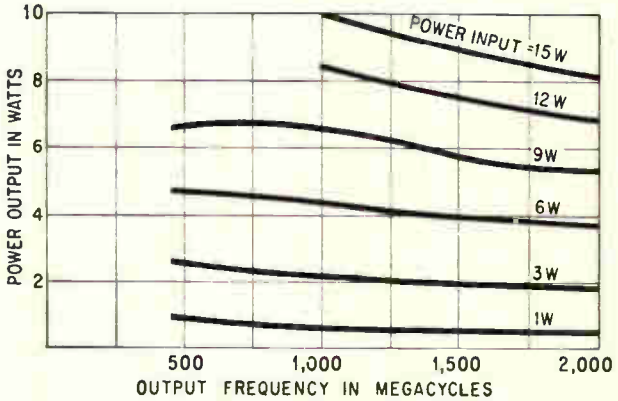
The plates are now being manufactured in loose form for customer assemblies and in preassembled stacks for installation in circuits. Prices will be about 10% higher than for equivalent items made by previous processes.

Semiconductor

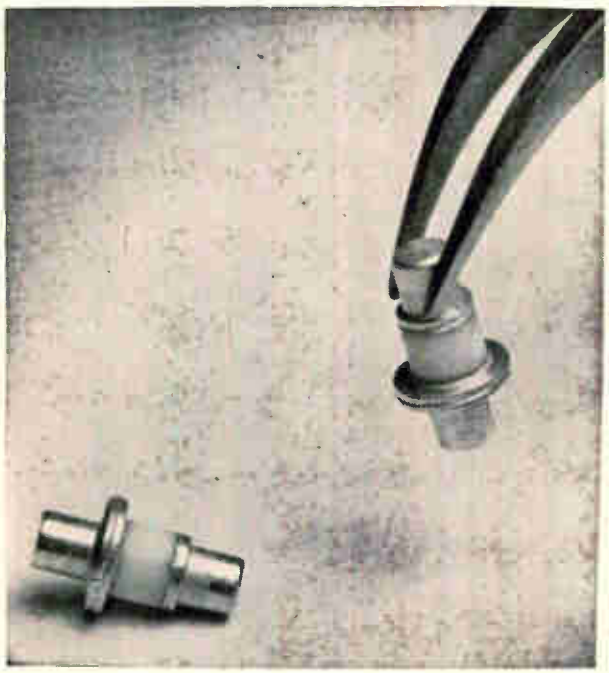
Pill-size power varactor for solid-state telemetry

The latest high-power varactor at Motorola, Inc., is a pill-type prong-mounted power unit that can handle a 12-watt input at one gigacycle with a typical efficiency of 58% in frequency-doubler circuits. The previous power limit at 1 Gc was 6 watts.

According to Gerald Schaffner, group leader of research on microwave-devices, pill-sized varactors of this type will be able to replace traveling-wave tubes in many space applications. Designated the MV1808B, this varactor makes possible completely solid-state microwave radio relay systems, solid-state telemetry, and high power all-solid-state television transmitters. It will be useful in any application where light weight and the inherent reliability of a solid-state device is desired.



Efficiency of pill size varactor is 58% at 12 watts in frequency-doubler circuit.



High power output at frequencies in the gigacycle range are provided by Motorola's new varactor diode.

The diode's typical Q is so high at 70 volts and 50 megacycles that it cannot be readily measured for many units. However, Motorola guarantees a minimum Q of 1,000. The typical Q at six volts and 50 Mc is 400. The silicon device has a diameter of only 0.16 inch.

This is the first step in an expansion of Motorola's line of varactor diodes. Other packages electrically equivalent to the MV1808B are planned, as are devices with higher power capabilities.

Motorola's varactor diode line also includes larger stud-mounted varactor diodes, but this is the company's first venture into the ultraminiature varactor diode field.

Specifications

Minimum reverse breakdown voltage:	75 volts
Typical reverse breakdown voltage:	80 volts
Typical reverse current at 65 volts and 75°C:	0.5 microamperes
Typical efficiency at 1 Gc:	58%
Maximum input power:	12 watts
Over-all physical dimensions:	0.215 by 0.16 inches
Price per unit (100 or more):	$28

Backward diode uses germanium at 150°C

The Navy's Bureau of Ships wanted a highly reliable germanium backward diode for microwave mixing and detecting in its electronic countermeasures systems. Specifications called for the diode to operate in X-band (9.375 Gc) at 150°C. Using aluminum alloy-junction construction the Philco Corp. produced a device that is expected to penetrate the silicon point-contact mixer diode market.

The devices, designated L14164 through L14167 depending on the packaging, are the first germanium backward diodes that operate at high temperature. They exhibit a much higher impedance level than previous devices, and they are thus more compatible with existing video detecting systems. Further, the detected output voltage of the diode does not vary with temperature, so that temperature stability is no longer a problem.

The diodes offer 30 db improvement over silicon point-contact diodes in receiver noise figure in mixer systems with 1 kc i-f frequencies. They are available as welded ceramic cartridges, pill-prong cartridges, pill packages, or pill packages with tabs.

Specifications

Burnout rating by single pulse	3.0 ergs
Typical noise figure at:	
f_{rf} of 9.375 Gc and f_{if} of 30 MC	7.5 db
f_{rf} of 9.375 Gc and f_{if} of 20 Kc	12 db
Detector data at f_{rf} = 9.375 Gc and video bandwidth = 10 Mc:	
Figure of merit (typical)	250
Tangential sensitivity (typical)	54 db
Video resistance (typical)	5000 ohms
Package dimensions:	
Welded ceramic	0.23" by 0.78"
Pill-prong	0.12" by 0.20"
Pill	0.123" by 0.058"
Pill with tabs	0.123" by 0.058"
Price per unit (100 or more)	$98 to $110
Price per matched pair (100 or more)	$39 to $44

Hybrid microcircuits handle 18 watts in memory cores

In any argument that pits hybrid against monolithic microcircuits, the discussion inevitably gets around to the power-handling limitations of microelectronics. Clearly, hybrid circuits can handle larger power. Varo, Inc. has enhanced this advantage of hybrid microelectronic devices by devising a line that can handle 18 watts—twice as much as anybody else can handle, according to Varo.

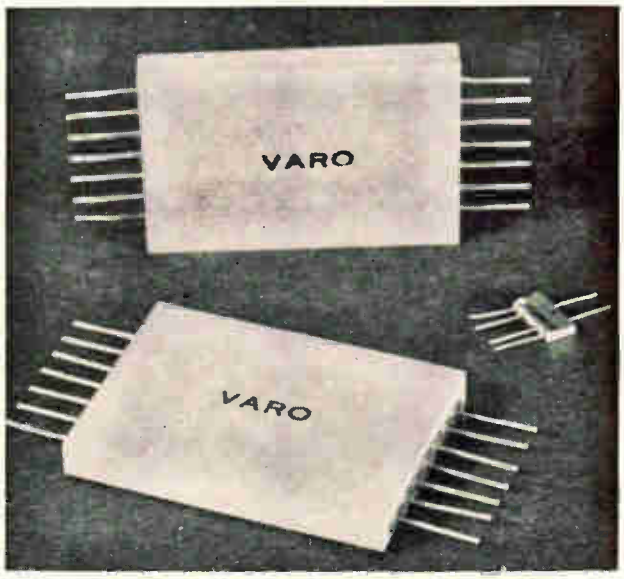
This development is made possible by new materials. The Varo line uses an epoxy-filled aluminum case banded to an alumina substrate by a high-conductivity material.

With these devices, circuits that have high-power outputs—such as memory-core drivers and servo amplifiers—can be converted to thin-film hybrid microcircuits.

Varo developed the hybrid device specifically to drive a thin-film memory core, and expects to begin full production this month.

With a heat sink at 100°C, the interior surface of the substrate undergoes a temperature rise of 3°C per watt per square inch over that of the heat sink. Although designed primarily for mounting on a heat sink, the device can also be mounted in free air; then the rise is 40°C per watt per square inch above the air temperature.

The package accommodates any circuit using TO-50 or TO-51 flat-packs or tab transistors. The packing density of a typical circuit permits including 8 flatpack transistors, 20 resistors (11 to 1,800 ohms) and 6 capacitors (two 470-picofarad, two 300-picofarad and two 150-picofarad). Gold-plated ribbon leads on 0.1-inch centers are used and may be brought out of any two opposite ends. The price of the module depends on the type of transistor used and the complexity of the circuit.



Thin-film hybrid module dissipates 18 watts when mounted on a heat sink. It can drive a core memory. Small unit is conventional two-transistor flatpack version.

Specifications

Dimensions:	1.2 x 0.8 x 0.15 inches
Leads:	14 total, 7 at each 0.8" x 0.15" end
Power dissipation:	3°C per watt per square inch (substrate-to-heat sink)
Typical density of circuit:	8 flat-pack transistors 20 resistors (11 ohms to 1,800 ohms) 6 capacitors (2-470 pf, 2-300 pf, 2-150 pf)
Power density thin-film can withstand	300 watts per square inch
Price per module:	$150 to $350 (depends on transistor used and complexity of circuit)

Subassemblies and systems

Now an electronic use of the strobe: display

The stroboscope, or speedlight, can make whirring gears and turbine blades stand still for inspection. Now the Raytheon Co. is using the same techniques to generate flickerless displays.

Fewer components, low operating power and high reliability are the result of coupling the stroboscopic principle with time-sharing of electronic circuits in the Datastrobe, a new readout device.

The company also sees advantages of simplicity and versatility over other projection readouts and over glow discharge, electroluminescent, electromechanical and edgelighted displays. Datastrobe needs no amplifiers, switches, relays or other mechanical devices for intermittent motion. Any type of character or symbol can be etched into the drum. The optics permits printout, including microfilming.

Last fall, Raytheon bought from Norman J. Appleton, a New Jersey inventor, the rights to his stroboscopic readout device. Six months and many market-research hours later, the company will show the first production model at the IEEE show. Some of the engineering has been simplified, but the device is basically the same. Appleton has joined Raytheon and is helping to develop a series of Datastrobes, some with memory and printout features.

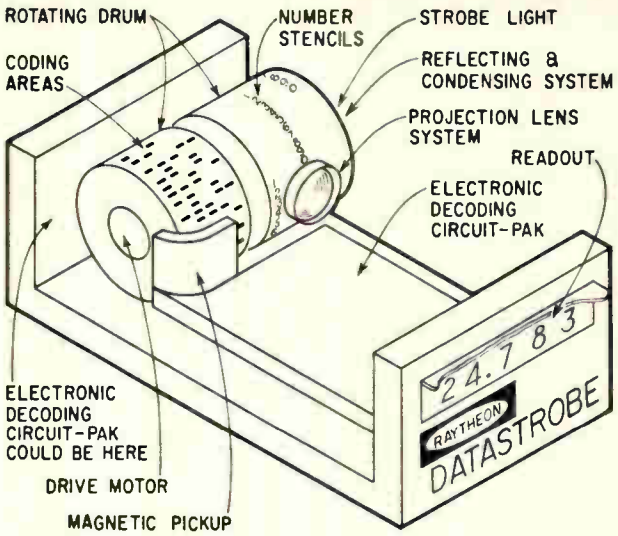
Datastrobe uses rotating drums, a xenon flash lamp; all-solid-state circuits; and an optical projection system, to produce a high-contrast, white-on-black multidigit display from binary coded decimal (BCD) input signals.

The flash tube is surrounded by a continuously rotating cylinder, which has transparent characters on it. The tube replaces as many as 66 incandescent bulbs in conventional project displays.

The readout operates directly from the four-bit BCD input, using a one-volt signal and four milliamps per bit. The basic device can be modified to give full alphanumeric or other symbols in any number of columns. In the first production model, the numbers will be five-eighths of an inch high.

Datastrobe's time-shared, all-solid-state logic reduces the number of components. This means increased reliability at lower cost, according to Raytheon's engineers. The decoding system works so that either the correct readout is given or the device fails. "Erroneous readouts are virtually impossible," says a Raytheon design engineer.

In the first production model, two drums are used, one with coding and the other with six columns of characters etched into it. Both drums are mounted on the same shaft, and rotate at 2,500 rpm.



First production model of the Datastrobe has two rotating drums mounted on a single shaft and turning at 2,500 revolutions per minute. The coding columns are on one drum and the readout characters etched into the other.

The basic Datastrobe accepts up to six columns of parallel, four-bit BCD information directly from the user's output. This information is serialized by the gating logic, actuated by signals from its drum column pickup. As each column comes to the proper position, the corresponding four bits are supplied to the single decoder-comparator circuit. When the desired number is in the viewing area, a trigger pulse from this circuit fires the flash tube. Because of the high scanning rate, the six-digit presentation appears on the screen in parallel as a sharp, high-contrast, flickerless display. The decoder in the first model uses a reluctance type pickup of voltages in an 8-4-2-1 code.

The time-sharing principle permits low voltage, low current operation. A six-column readout has a maximum of four bits energized at any one time. This time-sharing of a single tube and single decoding logic circuit over all six character-columns reportedly gives advantages in reliability and economics over systems which require a separate decoding matrix per column or a separate strobe tube per column.

The rotating drums, Datastrobe's only mechanical moving parts, require no close speed control, the logic being self-synchronizing. No brushes or rubbing contacts are used, and no gears. The six-digit display is expandable to 12 by putting two drums on a single shaft.

"Everyone seems to want digital readouts today," commented Niles P. Gowell after extensive market research. "It's just a matter of economics and device engineering." The Datastrobe inherently lends itself to customizing, so prices will vary greatly. A basic Datastrobe, without accessories or special features such as memory, is expected to sell for $50 to $60 per character available for readout. Gowell, who is special programs manager for Raytheon's component division, sees the Datastrobe as competitive with any readout device of three digits

or more. "The more digits, the more competitive we are," says Gowell.

Applications are being explored in radar range readout, industrial process control, flight control displays, and navigation system readouts. Datastrobe is considered specially attractive for on-the-bridge displays aboard automated ships. Only four bits per digit are required for input, and this significantly reduces the number of wires needed from remote data points.

Specifications

Speed of drum:	2500 rpm
Presentations per second:	45
Input:	110 v 60 cps.
Character height:	Typically ⅝"
Number of digits in display:	5 to 50
Lamp power:	A few watts
Motor power:	A few watts
Over-all dimensions:	9" x 5" x 3" high
Required input:	4 bit BCD
Estimated price:	$50-$60 per readout character
Floating decimal point availability	

The compleat receiver

A 15-watt bulb won't give out enough light to read by, yet 15 watts is all the power needed to run a new communications receiver of unparalleled versatility—covering the entire frequency range from 5 kilocycles to 30 megacycles.

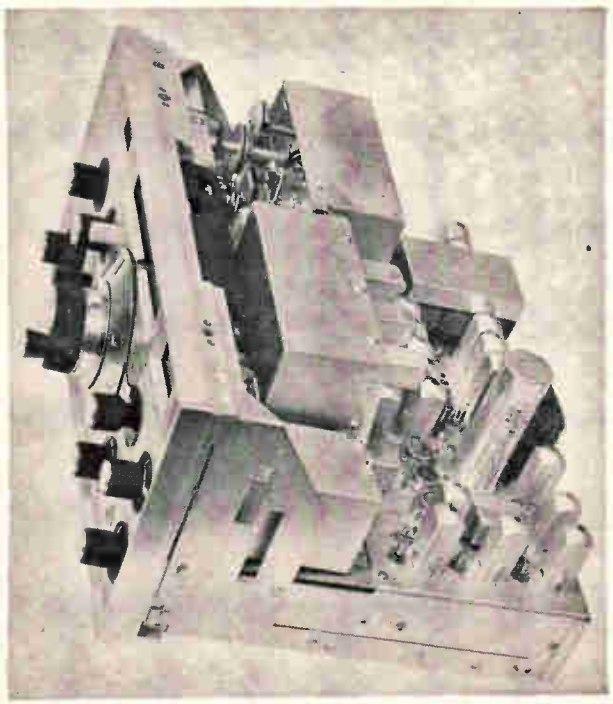
Solid-state technology also provides high reliability in a variety of fixed and portable applications for the HRO-500, manufactured by the National Radio Co., Melrose, Mass.

Now in prototype production, it is described by National as the only transistorized professional receiver on the market and the single unit with the widest frequency coverage. The HRO-500 was developed for applications in government, commercial ship-to-shore, amateur communications, and laboratory work.

For hams, this receiver is in the Cadillac class; the wider market will be in military and other government applications. The HRO-500 has been designed with airliftable shelters and moving vehicles in mind. Low power consumption makes it attractive where concentrations of military electronic gear cause a heat-dissipation problem. Other government markets include monitoring, surveillance and direction-finding tasks of the Federal Communications Commission and the Central Intelligence Agency, the radio-teletype system of the Federal Bureau of Investigation, and point-to-point communications for the National Aeronautics and Space Administration.

The totally transistorized receiver covers the very-low-frequency through high-frequency spectrum in 60 500-kc bands, with identical dial calibration and tuning rate throughout that range. Single sideband sensitivity is better than 1.0 microvolt for a signal-plus-noise to noise ratio of 10 decibels in the 500-kc to 30-Mc range, with minimum image rejection of 60 db.

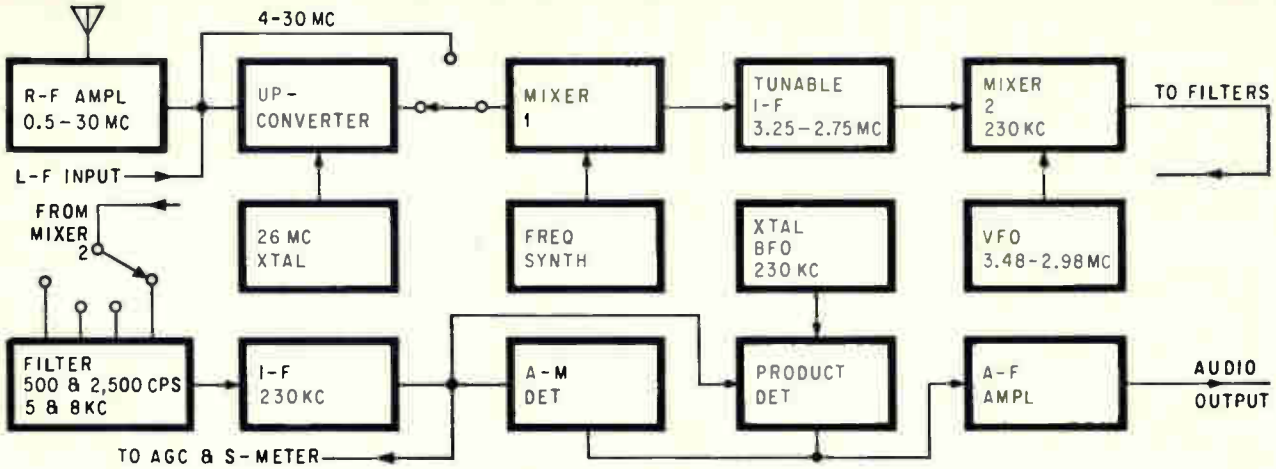
Its frequency range and stability, sensitivity and high image rejection qualify the HRO-500 as a



Compact receiver weighs only 32 pounds, was designed primarily for mobile military applications, also for low power consumption.

Specifications

Frequency range:	5 kc to 30 Mc in 60 500 kc bands, continuous coverage
Modes:	Upper sideband, lower sideband, a-m, c-w
Calibration accuracy:	Within 1 kc over entire 500 kc tuning range of the beat frequency: within 250 cps when zeroed to nearest 50 kc calibration point
Frequency stability:	Over-all stability from turn-on, 100 cycles per second in any 10-minute period including 30° C change in ambient temperature or plus-or-minus 20% a-c line voltage variation
Receiver a-m sensitivity (nominal):	5 kc to 30 Mc with very-low-frequency preselector; better than 2 microvolts for 10 db signal-to-noise. 5 kc to 500 kc without preselector; 25 to 50 microvolts for 10 db signal-to-noise.
Receiver single sideband/ continuous-wave sensitivity (nominal):	Better than 1 microvolt for 10 db signal-to-noise (between 5 kc and 30 Mc with very-low-frequency preselector).
Selectivity at 6 db points:	500 cycles, 2.5 kc, 5 kc, 8 kc
Image rejection:	Minimum 60 db between 500 kc and 30 Mc. Minimum 80 db between 5 kc and 500 kc when used with preselector
Automatic gain control merit:	Less than 10 db change in output for input variation between 5 and 50,000 microvolts
Size:	Seven and five-eights inches high, 16½ inches wide, 12¾ inches deep.
Weight:	32 pounds
Price:	$1295



Circuit of the HRO-500 solid-state receiver features triple conversion, high sensitivity, unusual selectivity, and frequency synthesis.

laboratory instrument for wide range detection, calibration, spectrum analysis and frequency measurement.

The receiver can operate on 200 milliamps directly from a 12-volt d-c battery supply or on 15 watts from 115/230 volts a-c. Transistors give instant-on operation without delay or warm-up drift.

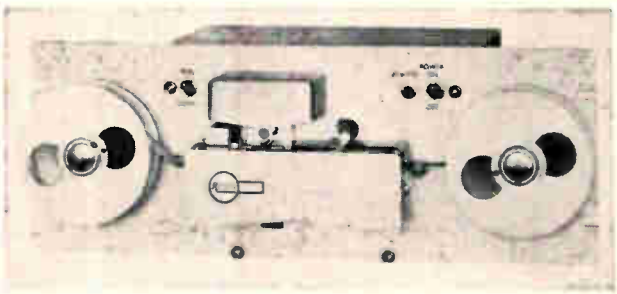
Frequency is determined by a phase-locked crystal frequency synthesizer which eliminates multiple crystal oscillators for high frequency oscillator injection. Band-to-band calibration is eliminated. A tunable oscillator is phase-locked to the output of a 500-kc master reference oscillator, so that any time a 500-kc segment is changed, the tunable oscillator is locked to another harmonic of the master oscillator. There is no difference in accuracy, therefore, between any of the 500-kc segments.

Intermediate-frequency selectivity in the HRO-500 is obtained by means of a tunable six-pole filter employing ferrite cup-cores at 230 kc. Bandwidths (at 6 db) available are 500 cycles, 2.5 kc, 5 kc and 8 kc to meet any combination of single sideband, continuous wave, or amplitude modulation receiving conditions.

Selectable sideband or single signal c-w reception is available by means of passband tuning in the 500-cycle and 2.5-kc bandwidths. The frequency of the filter is moved across the intermediate-frequency sideband with the front panel passband tune control to enable the operator to "drop out" interfering signals without changing the frequency of the desired signal.

A rejection tuning filter with an extremely sharp rejection notch may be controlled from the front panel to eliminate interfering heterodynes. The filter's heterodyne rejection capability is 50 db.

Space-saving solar cells get jobs in industry

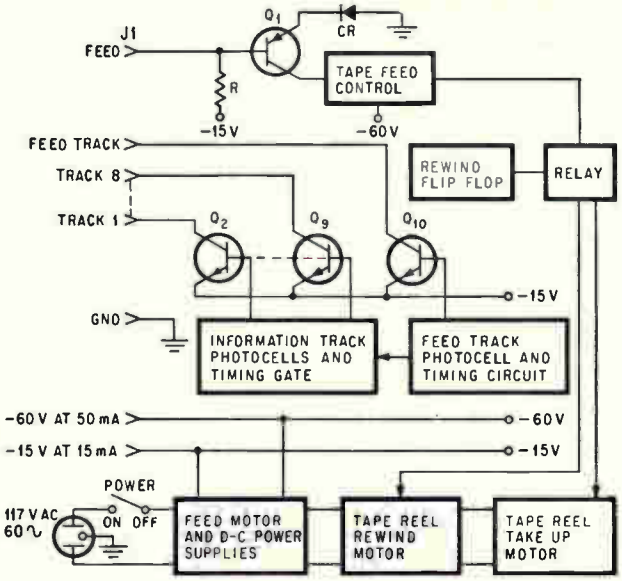


Reader-spooler combination uses photovoltaic cells for more reliability and longer life and has a "soft" take-up feature that prevents tape breakage.

Silicon solar cells, widely used to supply power to satellites in the space program, are finding their way into industrial equipment. Used in a new tape reader, the result has been more reliable operation for longer periods of time—up to 15,000 hours without error. Use of the cells in the Rheem Electronics Corp. model RRS 302 combination tape reader-spooler also resulted in a 40% cut in the number of electronic components required. The resulting space savings have enabled engineers to fit in switches and circuitry needed to actuate the spooler. This solved a serious design problem of providing space in the chassis for the spooler as well as the reader while keeping the unit small.

Use of the cells improves system life and reliability because the low deterioration rate of the cells gives the reader-spooler an indefinite life cycle. Competing systems that use photodiodes for character reading require replacement of the diodes periodically, while solar cells last indefinitely, the manufacturer claims.

Created with company funds in a two-year de-



Eight information track outputs and one timing track output are provided for use with standard five, seven and eight channel tapes.

velopment program by a team of electrical and mechanical engineers, the model RRS-302 will soon be in use by the National Aeronautics and Space Administration at Cape Kennedy in Saturn V telemetry systems.

The photovoltaic cells are light-sensitive silicon slabs divided into nine etched elements to give nine outputs and wired with one common cathode or anode (either is available) for sensing. The nine elements provide eight information track outputs and one timing track output for use with standard five, seven and eight channel tapes. The eight information track outputs are gated by the timing track so that all outputs appear simultaneously.

The spooler portion of the unit has a "soft" take-up. When the tape is rewound, the spooler accelerates slowly until servo arms pull the tape to its limit. A motor-driven potentiometer built into the chassis then increases the power slowly, preventing breakage in the standard 11/16-inch tape sometimes caused by the sudden spooling normally found in such units.

The present design is faster than available mechanical readers, Rheem claims. The unit is capable of reading 300 characters per second compared with 120 characters per second by its closest mechanical counterpart.

Specifications

Reading speed:	300 characters per second continuously, 100 characters per second asynchronously.
Tape start time:	8 milliseconds from rest position.
Tape stop time:	Less than 0.5 milliseconds.
Tapes:	Reads 5, 7 or 8-track tapes.
Amplifier outputs:	0 volts at 5 ma., —15 volts at 50 microamperes in mode 3.
Drive control inputs:	0 volts to —1 volt at 0.2-ma max; —10 volts to —15 volts at 5 ma max.
Weight:	32 pounds
Price:	$1,150
Delivery:	Immediate

Microwave

Tiny r-f load handles l-kw coolly

The customer had a problem: he needed a one-kilowatt average power r-f load as big as a blunt cigar—about one-thousandth the volume of a conventional air-cooled load with the same dissipation rating. Since he was an old customer, Bird Electronic Corp. went to work and came up with the water-cooled Termaline Model 8710.

The miniature load is nonmagnetic and can be used to terminate a 50-ohm coaxial line where space is limited or difficult of access—for instance, inside the focusing coil of a tube.

Many bends, twists and connectors are often required to run a coaxial cable from a tight interior space to an external termination. Bends and mechanical connections in a coaxial cable system cause high voltage standing-wave ratio. The 8710 can be located close to the power source; its vswr is less than 1.2 from d-c to 3,000 megacycles, and slightly higher at frequencies up to 4,000 Mc.

Other than indicating that their customer is nonmilitary, Bird won't say who he is. They feel they've

Both of these r-f terminations can dissipate 1,000 watts. The smaller is the Termaline Model 8710, made by Bird Electronic Corp. It is the only direct water-cooled load of its capacity available. The miniature r-f load can be located in tight physical spaces eliminating most vswr problems.

got a lead in a new market and want to keep it.

Bird isn't telling how the load is made, either, except to say that it uses a dielectric having a thermal conductivity as good as metals'. The resistor is deposited on one side of the dielectric and the cooling water runs on the other. With a water flow rate of one quart per minute in the unit and at 1 kilowatt dissipation, the resistor is cool to the touch.

The miniature termination costs less than its air-cooled equivalent, but the microwave system designer must consider the cost of providing plumbing for the 8710.

The problem in designing the unit was one of finding the proper material and then obtaining maximum heat transfer. Leo Lesyk, Bird Electronics' project engineer and a specialist in the heat transfer field, conceived, developed and built the miniature load.

Bird has several 8710s available at $200 each. There is a substantial discount for quantity orders.

Specifications

Average power dissipation:	One kilowatt
Impedance:	50 ohms
Weight:	5 ounces
Frequency range:	d-c to 4,000 Mc
Water coolant:	One quart/minute to 30° input temperature
Connector type:	N
Price:	Under $200 in quantity orders
Delivery:	30 days

Bridging a loss easily and precisely

Measuring insertion loss and attenuation required a whole battery of instruments until DeMornay-Bonardi division of Datapulse, Inc., came up with a device that does it more simply and more accurately to boot. The Model 1500 Precision Insertion Loss Measurement Set (PILMS), a microwave analog of the wheatstone bridge, makes the measurements with one basic instrument and two accessories—an amplitude modulated radio-frequency generator and a voltage standing-wave ratio meter. DeMornay-Bonardi claims an absolute accuracy of ±0.003 decibels and a relative accuracy of ±0.001 db, 10 to 20 times better than the old rigs.

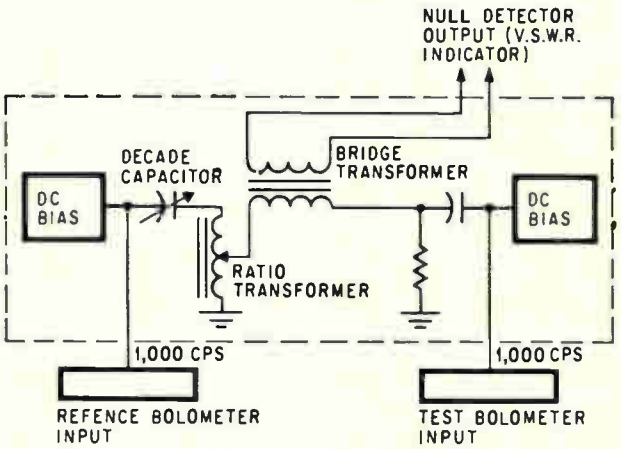
The accuracy makes the 1500 suitable for the microwave standards laboratory, where it can be used to verify and calibrate the accuracy of other standards. The instrument can also be used in radioastronomy where measurement of insertion loss can be used to discriminate between outer space noise and environmental noise. And the 1500's portability makes it ideal for field use. It weighs only 17 pounds.

The 1500 uses a dual-range audio bridge to compare the input and output signals from any two-port network. The audio signal is derived from the demodulated r-f signal, which is fed into the network under test. R-f signals up to 90 gigacycles can be handled.

Readings are made by comparing the signals from a reference bolometer and a test bolometer. The bridge is balanced, both before and after insertion of the test device, by adjusting a ratio transformer until a null is indicated on the vswr meter. The dial of the ratio transformer provides a direct readout of the transformer's setting.

The 1500's dynamic range is 20 decibels for a single-step measurement. This range can be extended by using two or more steps with calibrated standard attenuators.

All controls, including the bolometer connecting points, are on the front panel of the model 1500. It requires only two additional instruments to measure insertion loss.



Simplicity of the measuring scheme is evident from the block diagram. The ratio transformer is used to balance the signals from the reference and test bolometers and the null is read on the external vswr meter. The ratio is then read directly from the dial.

Specifications

Frequency range:	100 cps to 1kc (direct input)
R-f range:	any signal that can be modulated at 1 kc rate with an accurate square law detector up to 90 gigacycles
Dynamic range:	20 db maximum single-step measurement
Accuracy:	±0.001 db (relative) ±0.003 db (absolute)
Input power:	115 v, 60 cps, 0.5 amps
Dimensions:	17" x 5" x 15"
Weight:	17 pounds
Price:	$2245 f.o.b. Pasadena
Delivery:	from stock

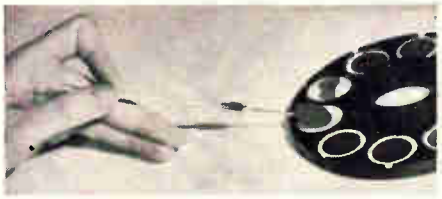
Machine whirls wafers through chemical processes

In the past, the Kulicke and Soffa Manufacturing Co., of Fort Washington, Pa., has concentrated on equipment for the tail end of semiconductor processing lines—automatic probes that test all the devices on a silicon slice, and machines that cut the slices apart and bond leads to the devices.

This year, K&S is introducing a machine that can be used all along the line. It's a wafer wet-processing machine. The etching, washing and rinsing jobs (repeated again and again when making a transistor or integrated circuit) are done automatically in the machine.

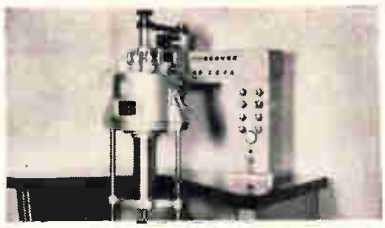
It was designed, says a K&S spokesman, "to transcend the beaker-on-a-bench approach"—the familiar method of having a girl pick up each wafer with a pair of tweezers and put it into a wet processor or simply slosh the wafer in a rinse tank.

The new machine processes 10 wafers at a time, with as many as eight liquids. The operator picks up the wafers with a vacuum pencil and puts them on a circular carrier. After the carrier is put in the machine, it drops down, leaving the wafers



Wafers go onto carrier

Carrier fits on chuck



Chuck rises and closes machine

X-rays to evaluate thin-film processes

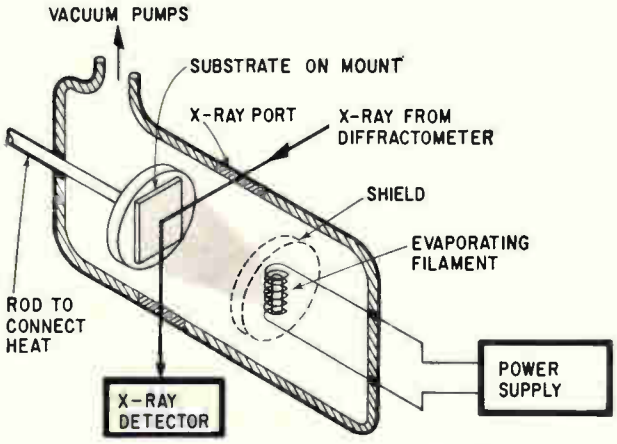
The answers to thin-film processing problems can be found more quickly if an x-ray diffractometer can be used to measure the effects of process changes on properties of the films.

This is the sales logic behind the introduction of an unusual little vacuum-deposition system by the Materials Research Corp., of Orangeburg, N. Y. Thin films can be grown and annealed under varying deposition conditions, while the chamber is in a diffractometer.

A diffractometer is a laboratory instrument that is used to determine the structure and defects of crystals, or polycrystalline materials like thin films, by the way in which the material reflects x-ray beams of varying angles of incidence.

Usually, the analyses of thin films are qualitative. For example, the x-ray photos will indicate what the grain structures look like. Materials Research says that its system is the first commercially available system that will provide quantitative measurements as well as qualitative measurements.

The vacuum chamber contains the fixtures needed to grow a film at various rates and temperatures. The film-substrate temperature can be varied from —190°C to about 300°C. The chamber also has beryllium windows so the x-ray beam can enter, strike the film and leave the chamber where its presence is recorded by a geiger counter and pulse-height analyzer. The complete angular range of a



Vacuum-deposition system has ports which allow x-rays to enter and leave vacuum chamber.

mounted on vacuum chucks. The chucks rotate under the nozzles, which spray the wafers with liquid or air while the wafers rotate for even distribution of the fluid over the wafer surfaces. Afterwards, the carrier can be used to carry the wafers to the next processing station.

The spraying is done in a pressure-tight vessel that is opened and closed by a ram which moves the chuck up and down. Spray timing and flow is preset into a control panel. The liquids can be heated by hot-air nozzles.

In a typical cleaning cycle, the wafers would be sprayed with detergent or solvent, drained, sprayed with deionized water, drained, sprayed with alcohol and dried with warm air. The machine can also be set up to develop and strip photoresist and etch passivation layers or thin-film contact coatings.

K&S cites two chief advantages of using the machine. Since vacuum pencils, instead of tweezers, are used to handle the wafers, there is less physical damage. Also, processing is more uniform because 10 wafers are processed in a batch; there is less batch-to-batch variation because process times and temperatures are controlled.

The spray technique results in less undercutting during etching. "No one is sure why this happens," says K&S, "but they are not displeased."

Price is approximately $3,000, depending on accessories. The machine operates with normal line current and factory air and water supplies. Delivery is eight weeks.

standard diffractometer can be used.

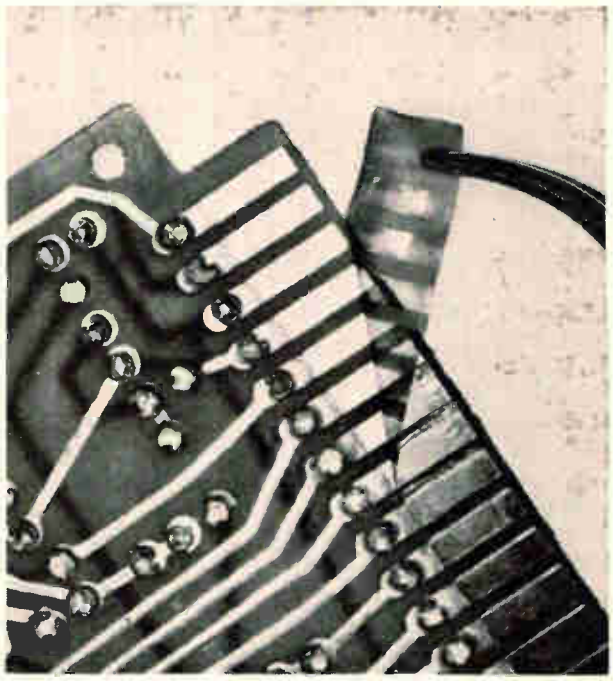
This enables diffraction profiles to be directly compared for the same films before and after process changes, at different film thicknesses, before and after the films are annealed or after other temperature changes. Such comparisons cannot be made with precision if the substrates must be removed from the chamber for analysis.

The prototype for the chamber was developed in 1963 by R. W. Vook and F. R. L. Schoening at the Franklin Institute Laboratories in Philadelphia. At the time, there was no suitable method for making quantitative analyses of thin films under processing conditions.

Vook and his associates used the chamber and pulse-height analysis for an intensive study of evaporated copper films. The method proved to be very sensitive. For example, comparison of diffraction profiles for two copper films showed distinct variations—possibly because in one case the copper was evaporated from a tungsten basket while in the other case a tantalum basket was used. Apparently, some of the tantalum was evaporated with the copper, although tantalum isn't supposed to be soluble in molten copper.

Materials Research has not yet set a price for the chamber, but it is expected to be around $6,000, including power supply.

Instant solder mask peels from workpiece



Vinyl-film solder resist is peeled off printed circuit board contacts after board has been dip soldered.

A solder resist that can be peeled off by hand is expected to simplify two-step soldering of printed circuit boards. According to Alpha Metals, Inc., of Jersey City, N. J., it is the first liquid-type resist that does not require heat-softening or solvents for removal.

The material, a vinyl plastic called Stripcoat, is applied by brushing, dipping or flowing. It dries in air in a few minutes, or can be cured by hot air in a few seconds. After soldering, the coating is simply pulled off the workpiece.

A typical application is where some components are dip-soldered into a printed circuit board and heat-sensitive components are soldered later by hand. The Stripcoat is used to prevent the extra mounting holes from being plugged by the solder during dip-soldering.

The material can also be used for other solder-resist needs, such as keeping solder from coating the gold-plated contact fingers on circuit boards.

Stripcoat is available in pints, quarts and gallon containers.

Specifications

Stripcoat material:	vinyl-type polymer
Drying time, 70°F:	1 to 2 minutes
Flash point:	35°F
Density, 77°F:	0.888 grams/cc
Color:	deep red

Designer's casebook

Designer's casebook is a regular feature in Electronics. Readers are invited to submit novel circuit ideas, packaging schemes, or other unusual solutions to design problems. Descriptions should be short. We'll pay $50 for each item published.

Electronically tuned hybrid notch filter

By Morris Cohen and George Rullman

Loral Electronics Corp., Bronx, N.Y.

Nonreflective, hybrid stop-band microwave filters are usually made up of a short slot hybrid and two resonant elements. The resonator elements can be two-port, band-pass filters having matched load terminations, or one-port cavity resonators that are loaded with lossy dielectric material. For the two constructions, both resonant elements and the filter frequency are fixed, or the resonant elements are mechanically adjusted for variable filter frequency.

If a narrow band-pass filter consists of a short slot hybrid and two yttrium-iron-garnet (YIG) spheres as resonant elements, it can be tuned electronically.

A single crystal YIG sphere contains unpaired electrons that yield magnetic moments as a result of their spins. A d-c field applied to the sphere, causes a change in the orientation of these magnetic moments about the axis of the applied field, H. The change occurs at a rate $f_o = 2.8H$ called the ferrimagnetic resonant frequency (f_o is in megacycles and H is in oersteds).

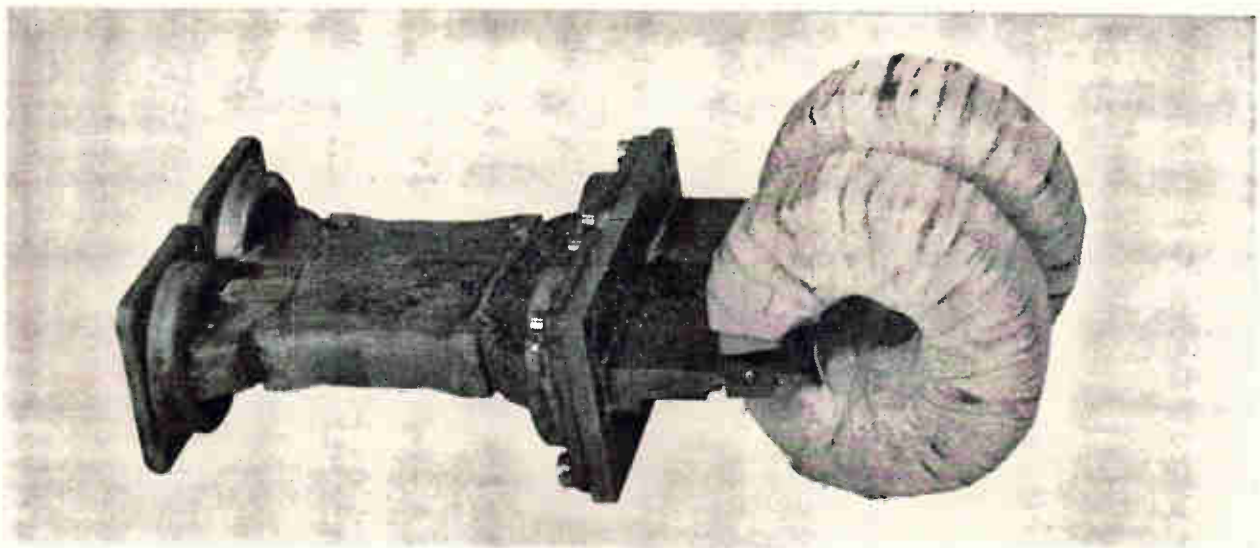
This resonance phenomenon is the basis for the electronically tuned YIG resonator. The YIG sphere behaves like a resonant circuit at frequency f_o. The magnetic field, H, is electronically controlled by the current through the coil of an electromagnet.

As in standard cavity type microwave resonators, the frequency rejection in a YIG resonator depends upon the unloaded Q (Q_u) and external Q (Q_e). The unloaded Q is a function of the quality of the yttrium-iron-garnet and its degree of surface polish. The unloaded Q can be calculated from the linewidth, ΔH, of the YIG sphere. Linewidth is a specific characteristic associated with a YIG crystal sphere and is analogous to the unloaded bandwidth Δf, of standard cavities. where

$$\Delta f = 2.8 \Delta H$$

and Q_u can be calculated from

$$Q_d = f_a / \Delta f.$$



Electronically tunable hybrid filter has a very narrow rejection band and is nonreflective. The resonant element is a YIG crystal sphere mounted near the end wall of each shorted transition section, and within the field of the electromagnet. The rejected frequency band varies as the intensity of the magnetic field. The field of each magnet varies equally and simultaneously. The height of the X-band waveguide was reduced in four sections from 0.40 inch to 0.05 inch to obtain maximum filter rejection loss.

The external Q is determined by the magnetic saturation flux density, the volume of the YIG sphere, and the microwave structure containing the sphere. The external Q of a YIG sphere, centrally located one-half wavelength from a short circuit in standard waveguide operating in the TE_{10} mode is

$$Q_e = \frac{60\,\pi\,ab}{\mu_o\,\omega_m\,V_m}\left(\frac{\lambda_g}{\lambda}\right)$$

where

a = guide width in meters
b = guide height in meters
μ_o = intrinsic permeability of free space, 1.256×10^{-6} henries/meter
V_m = volume of YIG sphere
ω_m = angular frequency, $6\,\pi$ (1670 Mc) for YIG
λ_g = wavelength in guide
λ = wavelength in air

For a particular frequency band, Q_e can only be varied by a change in guide height, or diameter (i.e., volume) of YIG sphere, or both.

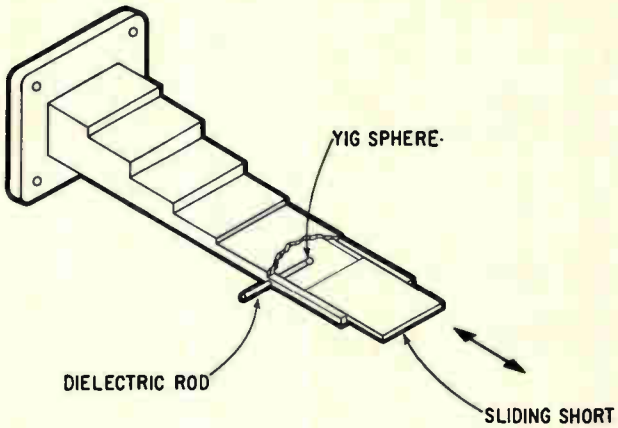
The loaded Q (Q_L) is determined from the standard equation,

$$\frac{1}{Q_L} = \frac{1}{Q_e} + \frac{1}{Q_u}$$

and the maximum rejection loss, L_a, is

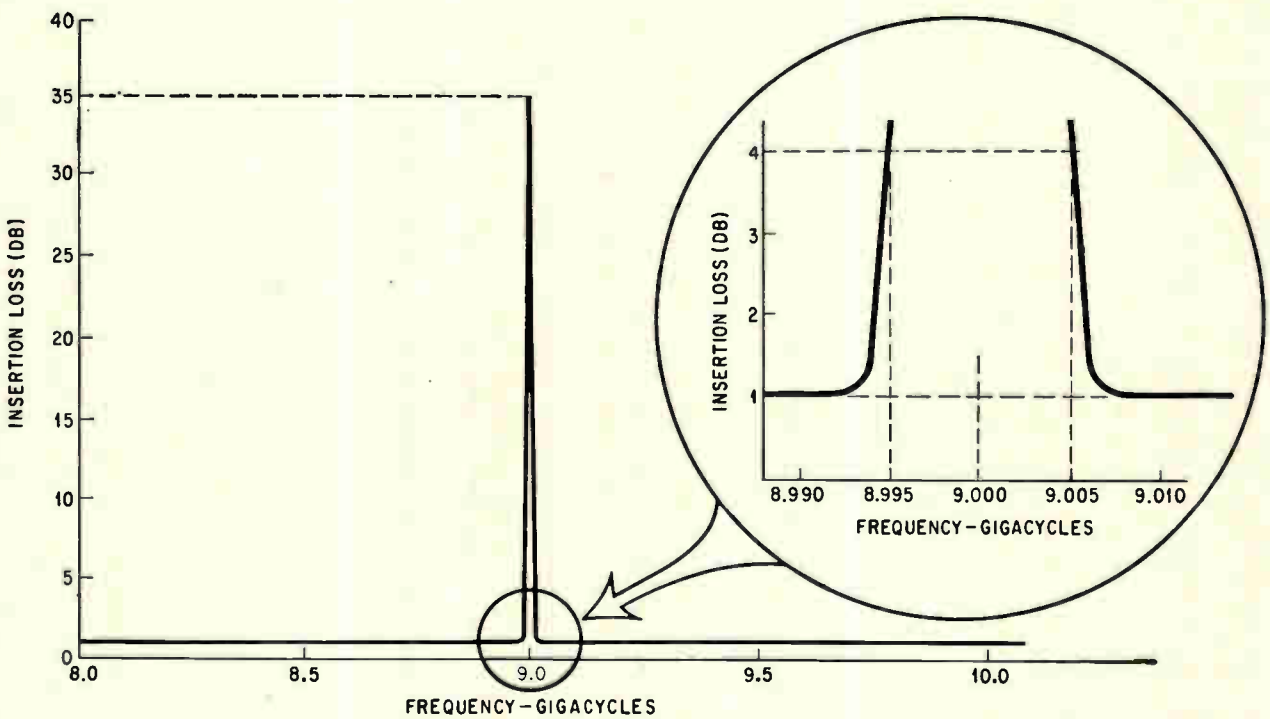
$$L_a = 20n \log\left(\frac{Q_u}{Q_L}\right)$$

where n is the number of resonators having equal Q_u values, and L_a is in decibels.

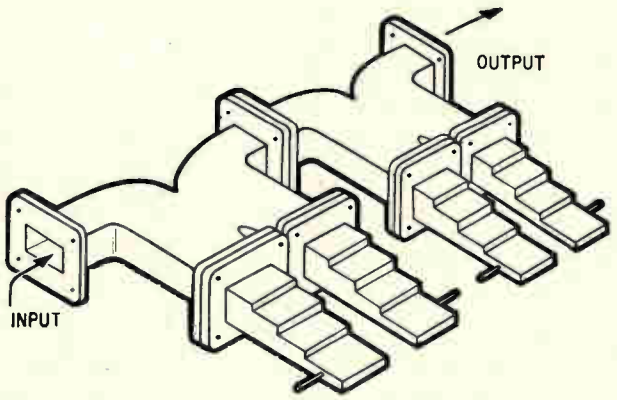


Distance between the YIG sphere and end wall of the transition section affects the magnitude of the rejection loss. The sliding short is first adjusted to obtain maximum rejection.

The filter design was based on the fact that a YIG sphere located near the shorting end-wall in a waveguide, exhibits an absorption type cavity response (analogous to matched terminations at the adjacent ports of a hybrid) when resonated by an applied magnetic field. The frequency at which this effect occurs is given by the first equation. At all other frequencies, the waveguide input appears reactive due to the shorting end-wall. The amount of power absorbed by the resonant YIG sphere is a function of Q_u and Q_e, that is, the surrounding



Measured insertion loss versus frequency performance characteristics of the hybrid notch filter. The notch (rejection) frequency for this measurement was tuned to 9.0 gigacycles. The notch is nominally 0.010 gigacycles wide, and can be tuned over a range of 8.2 to 12.4 gigacycles with a rejection of 30 to 36 db. The input vswr is less than 1.5.



Cascading two hybrid notch filters results in a significant reduction in vswr. It is also possible to tune each hybrid filter to a separate notch frequency with no interaction between hybrids.

microwave structure.

A YIG sphere was mounted near the end wall in each of two equal lengths of shorted X-band waveguide. The waveguides were affixed to the adjacent ports of a short slot hybrid. Electronic tuning was achieved by means of external electromagnets located directly over the YIG spheres in each guide, as shown in the photo. The magnetic fields were varied equally and simultaneously.

The filter was designed as a two-resonator filter. The pertinent parameters of the YIG were,

$\Delta H = 0.3$ oersteds

diameter = 0.025 inches

The center frequency was 10 gigacycles.

Maximum rejection was achieved by reducing the height of the X-band guide from 0.400 inch to 0.050 inch by a four-step transition section (transformer). The shorting end-wall in the transformer section shown on page 93, is adjusted to optimize the distance between the YIG sphere and the end wall for maximum rejection loss. The YIG spheres were mounted on dielectric rods and inserted in the side wall of each transformer section.

The filter was tested over a range of frequencies from 8.2 Gc to 12.4 Gc. Measured data indicated filter rejection notches of 30 to 36 db over the frequency band with an input vswr = 1.5. A typical response curve is on the preceding page.

Higher values of nonreflective loss can be achieved by cascading filters. With nonreflective filters it is possible to cascade filters tuned to different frequencies with no interaction.

A notch filter requiring only a single electromagnet could be fabricated with a half-height folded hybrid (0.900″×0.200″).

Reference

1. R. D. Wanselow, "A Nonreflective Hybrid Stop-Band Filter," IRE Transactions on Microwave Theory and Techniques (Correspondence), Vol. MTT-10, Jan., 1962, p. 91.

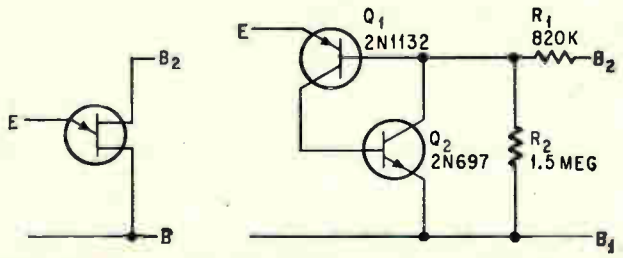
Pnp plus npn equals unijunction transistor

By Roy A. Wilson,

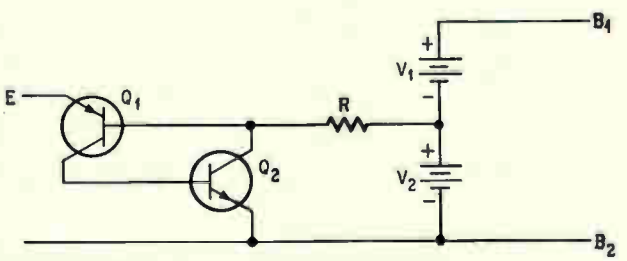
Hycon Mfg. Co., Monrovia, Calif.

Unijunction transistors are often used in trigger and oscillator circuits. But in low power versions of these circuits, the designer finds that the interbase resistance of the UJT, usually about 9,000 ohms, is too low. With normal semiconductor supply voltages, the UJT dissipates from 10 to 150 milliwatts in the interbase resistance during its quiescent state. A more expensive circuit that behaves like a UJT but dissipates only microwatts of quiescent power is shown at right.

A positive voltage V applied to terminal B_2 in the simulated UJT circuit, biases the base of transistor Q_1 at a voltage $VR_1/(CR_1 + R_2)$. If the emitter of Q_1 is less positive than this bias voltage, both Q_1 and Q_2 turn off, and only a few microwatts of



Circuit has same characteristics as a single unijunction transistor but dissipates no power during quiescence.



Resistor divider is unnecessary if precise bias voltages are available.

power are dissipated in the resistor divider. When the voltage on the emitter of Q_1 becomes greater than the base bias voltage, transistor Q_1 conducts current to the base of Q_2 and Q_2 starts to conduct. As Q_2 turns on, it reduces the impedance between the base of Q_1 and terminal B_1, lowering the base bias voltage and causing Q_1 to conduct harder. This regeneration continues, thereby simulating the negative resistance characteristics of a unijunction transistor.

If two separate supply voltages are available, such as clamp voltage and collector voltage supplies ordinarily used in digital circuits, the voltage divider can be eliminated.

The value of R is selected to meet the requirements of the designer.

Scr multivibrator switches reliably

By H. D. Valliant

Dominion Observatory
Department of Mines and Technical Surveys, Ottawa

The multivibrator shown below uses silicon controlled rectifiers as switching elements. This circuit switches 0.75 amperes into a solenoid load at a frequency of about 20 cycles per second.

When silicon controlled rectifier Q_2 is conducting and scr Q_1 is turned off, capacitor C_3 charges through R_3 and Q_2. When the voltage across C_3 equals the zener voltage of D_1, the zener diode begins to conduct current in the reverse direction. Q_1 is switched on, its anode potential suddenly falls to ground, and the resulting negative-going pulse is coupled to the anode of Q_2 through commutating capacitor C_2, turning off Q_2. Then, C_1 charges through diode D_2 and Q_1, and the cycle is repeated.

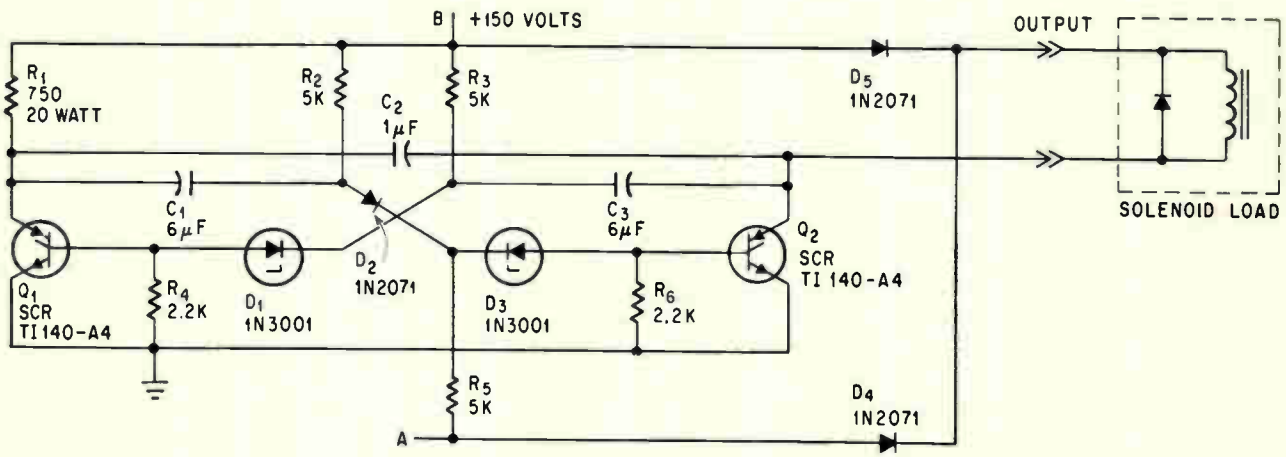
Zener diodes D_1 and D_3 improve the temperature stability of the circuit. The instant of triggering is defined by the zener voltage rather than by the highly temperature-sensitive gate current of the scr's. In this circuit, the frequency varies less than 0.2% per degree centigrade.

The circuit includes the option for the monostable mode of operation. The supply voltage is removed from terminal B and the load can be energized by a single +150-volt pulse applied to terminal A. This pulse is simultaneously applied to the gate of Q_2 (through R_5 and D_3) and to the anode of Q_2 (through D_4 and the load). Q_2 is turned on and supplies power from the trigger source to the load, for the duration of the input trigger pulse. Diodes D_2 and D_5 prevent the trigger pulse from entering the unused portion of the circuit.

Diode D_4 prevents continuous Q_2 conduction when +150 volts is applied to terminal B and the multivibrator is operated in the free-running condition.

The advantages of an scr multivibrator are high reliability, simplicity and low cost. A disadvantage exists in the power wasted in the dummy load R_1, but this power can be reduced by operating the circuit in an unbalanced condition, where R_1 does not match the load resistance. Tests showed that for the scr's used, R_1 may be increased to a maximum of 2,200 ohms, and Q_1 maintains conduction. With R_1 and load resistance unequal, the value of C_1 must be increased slightly to maintain the desired duty cycle. The power lost in R_1 may be reduced to about five watts for a 50% duty cycle.

The circuit has been tested at up to 50°C.



Scr's switch up to 750 milliamperes at 20 cycles per second. The zener diodes stabilize the switching frequency with temperature by fixing the trigger level. The circuit may be operated in a monostable mode by removing the d-c supply voltage from terminal B, applying a + 150-volt pulse at terminal A.

Solid state

Nonreactive filter converts triangular waves to sines

Less than 1% total harmonic distortion is achieved with a field-effect transistor filter. It accepts wide range of frequencies and requires only 2 critical adjustments

By R.D. Middlebrook

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I. Richer

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The drain characteristic of a field-effect transistor can be exploited to advantage in a nonlinear, nonreactive filter. Such a filter is useful in applications where it is desirable to convert triangular waveforms to sinusoidal waveforms. Many systems, telemetry for example, require this type of conversion. However, care must be taken to minimize the introduction of harmonics of the input waveform.

The most straightforward method of reducing harmonics is to use a linear filter containing reactive elements, but this is only satisfactory over a narrow frequency band. A second method uses a filter comprising nonlinear elements to provide a shaped characteristic to attenuate harmonics of a particular input waveform.

The new filter contains a single section, and requires only two critical adjustments to provide a total residual harmonic distortion under 1%. One adjustment is of a linear resistor; the other is of the input-signal amplitude.

Circuit operation

The basis for the filter action is the drain characteristic of a field-effect transistor below pinch-off. For a fixed gate voltage, the drain current as a function of the drain voltage between zero and pinch-off resembles a quarter sinusoid. Therefore, a full-wave rectified triangular voltage waveform of appropriate amplitude V_m between drain and source will give rise to an approximately sinusoidal full-wave rectified drain current. The basic circuit shown on page 97 uses a bridge rectifier and an n-channel FET with gate bias fixed at zero volts. The output signal is the current I into the bridge, in the form of a restored approximate sinusoid as indicated by the waveform construction shown on page 97. The bridge rectifier effectively reflects the first-quadrant drain characteristics into the third quadrant, so that the residual distortion in the output current contains only odd harmonics.

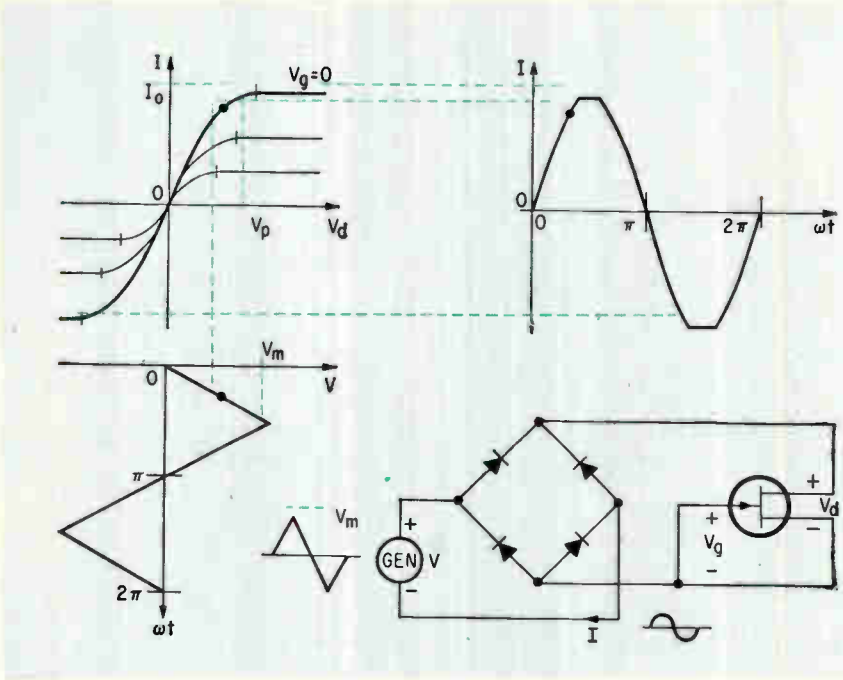
FET properties

To evaluate the total harmonic distortion (see equation 6) it is necessary to know I as a function of V. This function is determined by the FET properties in the basic filter shown on page 97. The drain current I as a function of the gate voltage V_g of an FET in the pinch-off region can be approximated by a power law.[1] This power law may be generalized to include operation below pinch-off. The complete drain characteristics in the depletion mode are then given by:

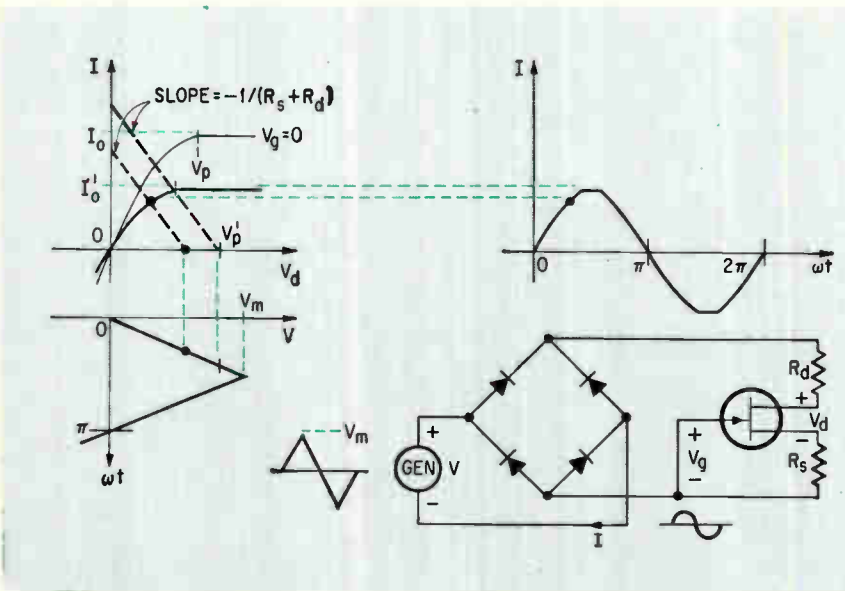
$$\frac{I}{I_o} = \left(1 + \frac{V_g}{V_p}\right)^n - \left(1 + \frac{V_g - V_d}{V_p}\right)^n, \quad \begin{cases} -V_p \le V_g \le 0 \\ 0 \le V_d \le V_p \end{cases} \tag{7a}$$

$$\frac{I}{I_o} = \left(1 + \frac{V_g}{V_p}\right)^n, \quad \begin{cases} -V_p \le V_g \le 0 \\ V_p \le V_d \end{cases} \tag{7b}$$

where V_g and V_d are the gate-source and drain-source voltages for an n-channel FET (see page 00), V_p is the pinch-off voltage, I_o is the pinch-off drain



Basic filter circuit uses a bridge rectifier and an n channel FET with fixed zero gate bias. The bridge rectifier reflects the first-quadrant drain characteristics into the third quadrant.



Modified filter circuit produces additional shaping, reducing distortion further by use of drain series resistance, R_d and source degeneration resistance, R_s.

current at zero-gate voltage and n is an exponent that lies in the range $2 \leq n \leq 2.25$, the value depending upon the physical construction of the device.[2] For most FET's it is sufficiently accurate to take $n = 2$, in which case equations 7a and 7b reduce to

$$\frac{I}{I_o} = 2\frac{V_d}{V_p}\left(1 + \frac{V_g}{V_p} - \frac{V_d}{2V_p}\right), \qquad \begin{cases} -V_p \leq V_g \leq 0 \\ 0 \leq V_d \leq V_p \end{cases} \quad (8a)$$

$$\frac{I}{I_o} = \left(1 + \frac{V_g}{V_p}\right)^2, \qquad \begin{cases} -V_p \leq V_g \leq 0 \\ V_p \leq V_d \end{cases} \quad (8b)$$

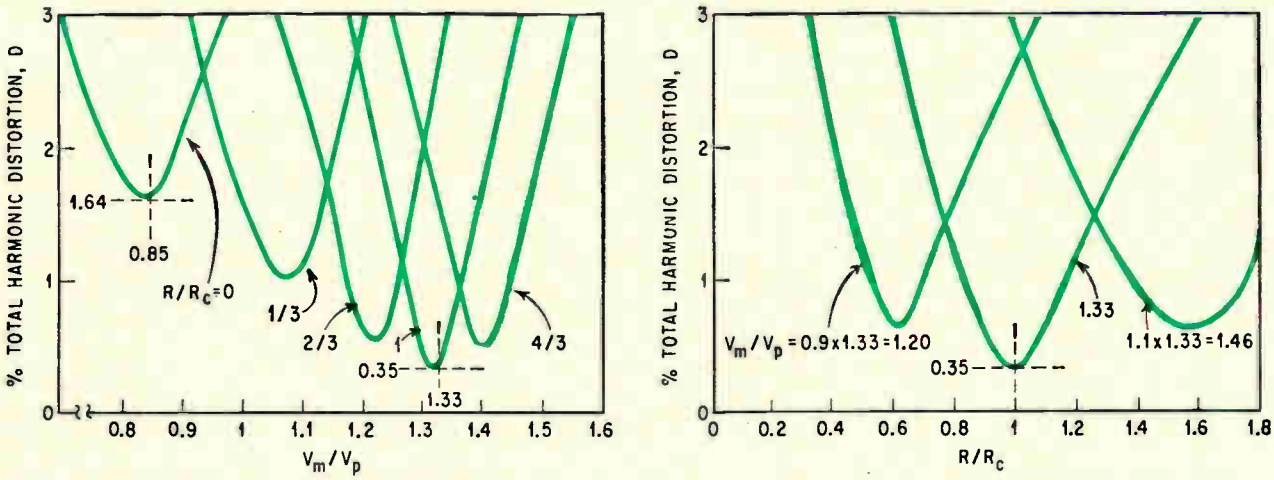
In the basic filter circuit shown above, $V_g = 0$ and $V_d = V$ if voltage drops in the diode bridge are ignored. Thus equations 8a and 8b reduce to

$$\frac{I}{I_o} = \frac{V}{V_p}\left(2 - \frac{V}{V_p}\right), \qquad 0 \leq V_d \leq V_p \quad (9a)$$

$$\frac{I}{I_o} = 1 \qquad V_p \leq V_d \quad (9b)$$

Harmonic distortion

Equations 9a and 9b may be substituted into equation 6 to find the output total harmonic distortion as a function of the single parameter V_m/V_p, which is identified as the amplitude of the input triangular voltage waveform normalized to the FET



Solutions obtained by computer show the total harmonic distortion as a function of two parameters for the modified filter circuit. The $R/R_c = 0$ curve corresponds to the solution obtained in equation 10 for the basic filter circuit.

pinch-off voltage. The result is

$$D = 100\sqrt{\frac{\pi^6}{15\times 2^6}\,\frac{3(V_m/V_p)^2-15(V_m/V_p)+20}{8[V_m/V_p+(\pi/2)(1-V_m/V_p)]^2}-1},$$
$$0 \le V_m \le V_p \qquad (10a)$$

$$D = 100\sqrt{\frac{\pi^6}{15\times 2^6}\,\frac{15(V_m/V_p)-7}{8(V_m/V_p)^5[1-\cos(\pi V_p/2V_m)]^2}-1},$$
$$V_p \le V_m \qquad (10b)$$

Both expressions are equal at $V_m = V_p$. When the amplitude of the input voltage just reaches the FET pinch-off voltage, the output total harmonic distortion is

$$D_{(Vm=Vp)} = 100\sqrt{\frac{\pi^6}{15\times 2^6}-1} = 3.82\% \qquad (11)$$

However, this is not the smallest value of the distortion that can be obtained. By differentiating D with respect to V_m/V_p in equation 10a, setting the result equal to zero and solving for V_m/V_p, we get $(V_m/V_p)_{min} = 0.85$ (12)
Then substituting this optimum value into equation 10a we get D_{min}:

$$D_{min} = 100\sqrt{\frac{\pi^6}{2^{10}}\,\frac{1}{4\pi^2-25\pi+40}-1} = 1.64\% \qquad (13)$$

The minimum distortion of 1.64% is not low enough for precision instruments. However, further shaping for the nonlinear filter characteristic is achieved by introducing drain series resistance R_d and source degeneration resistance R_s. This circuit, together with the modified graphical construction for the output current, is shown on page 97. The gate and drain voltages are now related to the input voltage by $V_g = -IR_s$, $V_d = V - I(R_s + R_d)$. Substitution into equation 8a shows that pinch-off occurs at a current I_o' and an input voltage V_p' given by

$$\frac{I_o'}{I_o} = \left(\frac{\sqrt{1+2R_s/R_c}-1}{R_s/R_c}\right)^2 \qquad (14)$$

$$\frac{V_p'}{V_p} = 1 + \tfrac{1}{2}\left(\frac{R_d}{R_c}\right)\left(\frac{I_o'}{I_o}\right) \qquad (15)$$

where $R_c = V_p/2I_o$ is the channel resistance at zero gate and drain voltages. The over-all filter characteristic is then described by:

$$\tfrac{1}{4}\left[\left(\frac{R_d}{R_c}\right)^2-\left(\frac{R_s}{R_c}\right)^2\right]\left(\frac{I}{I_o}\right)^2+\left(1+\frac{R_d+R_s}{R_c}-\frac{R_d}{R_c}\,\frac{V}{V_p}\right)\left(\frac{I}{I_o}\right)-\frac{V}{V_p}\left(2-\frac{V}{V_p}\right)=0,$$
$$0 \le V \le V_p' \qquad (16a)$$

$$\frac{I}{I_o} = \frac{I_o'}{I_o}, \qquad V_p' \le V \qquad (16b)$$

Harmonic distortion

To examine the residual output harmonic distortion as a function of the input triangular voltage waveform amplitude, the output current I is expressed as a Fourier series of the form

$$I = I_m \sin \omega t + (\text{odd harmonics}) \qquad (1)$$

where ω is the fundamental angular frequency of the input triangular voltage waveform, and I_m is the amplitude of the output fundamental given by:

$$I_m = \frac{1}{\pi}\int_0^{2\pi} I \sin \omega t\, d\omega t \qquad (2)$$

The total percentage harmonic distortion D is defined as 100 times the square root of the mean square of the total signal minus the mean square of the fundamental component, divided by the rms value of the fundamental component:

$$D(\%) \equiv 100\,\frac{\sqrt{\frac{1}{2\pi}\int_0^{2\pi} I^2\, d\omega t - \tfrac{1}{2}I_m^2}}{I_m/\sqrt{2}} \qquad (3)$$

and the total harmonic distortion is obtained by insertion of the solution of equations 16 for I/I_o into equation 6 thus giving D as a function of the three normalized parameters V_m/V_p, R_s/R_c, and R_d/R_c.

This procedure cannot be conducted analytically in closed form, but numerical results may be obtained by digital computer. Preliminary computations showed that the value of D with respect to the three parameters is a minimum very close to $R_s = R_d = R_c$.

The resulting minimum value of the total harmonic distortion is

$$D_{min} = 0.35\% \tag{17}$$

which occurs at a normalized input voltage amplitude

$$\left.\frac{V_m}{V_p}\right|_{min} = 1.33 \tag{18}$$

From equations 14 and 15, $V_p'/V_p = 3 - \sqrt{3} = 1.27$ for $R_s = R_d = R_c$, so that $(V_m/V_p')_{min} = 1.045$. This shows that in the optimum condition the minimum distortion occurs when the input amplitude is sufficient to carry the FET just beyond pinch-off, in contrast to the condition for zero external resistance in which minimum distortion occurs when the FET remains substantially below pinch-off.

It is important in practical applications to know both the minimum distortion obtainable and how sensitive the value of distortion is to change in circuit adjustment or environmental conditions. Since the minimum in D occurs for $R_s = R_d$, considerable simplification results if the two resistance variables are combined into one normalized variable $R_s/R_c = R_d/R_c \equiv R/R_c$. In particular, equation 16a then reduces from a quadratic to a linear equation. However equation 6 still cannot be solved in closed form.

Numerical results

Numerical solutions of equation 6 give the total harmonic distortion, D, as functions of the two remaining circuit parameters V_m/V_p and R/R_c. On the left, page 98, D is plotted as a function of V_m/V_p for five values of R/R_c, including $R/R_c = 1$ for which the minimum occurs. The curve for $R/R_c = 0$ corresponds to the analytical solution obtained in equation 1 for the basic circuit which is shown on page 97. On the right, page 98, D is plotted as a function of R/R_c for three values of V_m/V_p, including $V_m/V_p = 1.33$ for which the minimum occurs.

Temperature dependence

Numerical solutions of equation 6 for D as a function of the important environmental parameter, temperature, are shown below, right. A reference condition is chosen such that the circuit parameters R and V_m have their optimum values R_c and $1.33V_p$, respectively, at room temperature of 25°C. The temperature dependence of the circuit is assumed to reside solely in the device normalization parameters R_c and V_p such that

$$R_c[T] = R_c[25°C]\left(\frac{T}{298}\right)^m \tag{19}$$

$$V_p[T] = V_p[25°C] + (dV_c/dT)(T - 298) \tag{20}$$

where T is the absolute temperature. Equation 19

By substitution for I_m from equation 2, this becomes

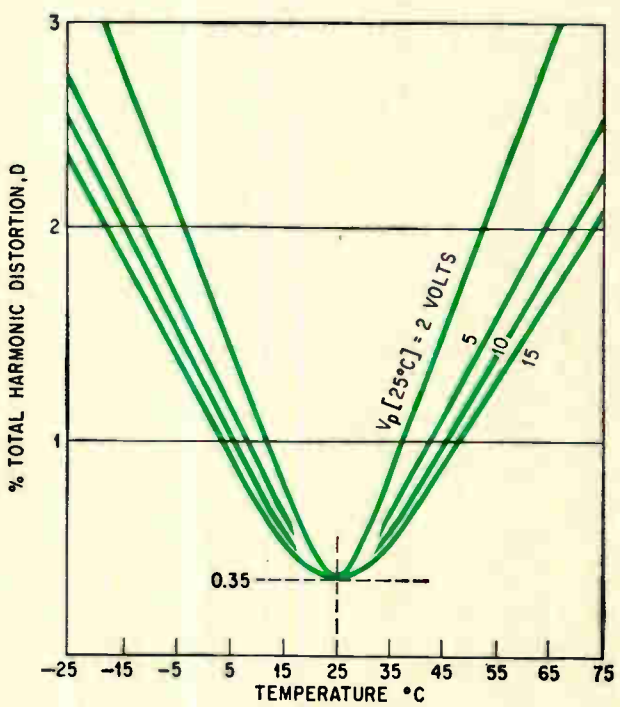
$$D = 100\sqrt{\frac{\pi\int_0^{2\pi} I^2\, d\omega t}{\left[\int_0^{2\pi} I \sin\,\omega t\, d\omega t\right]^2} - 1} \tag{4}$$

Since the input signal is triangular, each integration in the above equation need be performed over only a quarter cycle instead of a full cycle of the fundamental. Over this range the input voltage V is linear with time:

$$V = V_m \frac{\omega t}{\pi/2}, \qquad 0 \le \omega t \le \pi/2 \tag{5}$$

For analysis, it is more convenient to express equation 4 in terms of V/V_m. With these changes in variable and in integration range, the result for the output total harmonic distortion becomes

$$D = 100\sqrt{\frac{\int_0^1 I^2\, d(V/V_m)}{2\left[\int_0^1 I \sin\,(\pi V/2V_m)\, d(V/V_m)\right]^2} - 1} \tag{6}$$



Temperature has an effect on the total harmonic distortion as is shown by numerical solutions of equation 6.

expresses the power-law temperature dependence of the channel mobile-carrier mobility,[3] and equation 20 expresses the linear temperature dependence of the gate-channel contact potential, V_c.[4] Because of the forms of these two temperature dependences, V_p (25°C) remains as a parameter while R_e (25°C) does not. Although both m and dV_c/dT vary somewhat in different FET's, the typical values m = 2 and $dV_c/dT = -2$ millivolts/°C have been used in obtaining the temperature dependent curves.

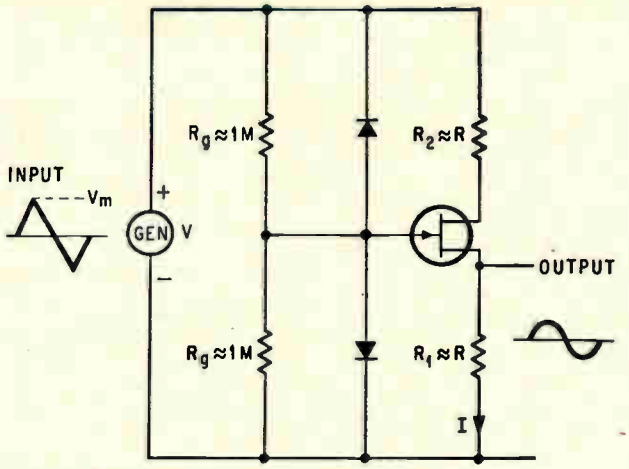
Examination of the numerical results shows that D is quite sensitive to V_m. Nevertheless, for the optimum case the distortion remains under 1% if the input amplitude is stable to within about ±3%. On the other hand, D is relatively insensitive to R in the neighborhood of the minimum value of D and the distortion remains under 1% even if R is off as much as ±15%. The total distortion is relatively independent of temperature. Higher pinch-off voltage FET's give less sensitivity than low pinch-off voltage units because the temperature variation of the contact potential represents a smaller fraction of the applied voltage. However, little further improvement is realized for pinch-off voltages greater than about 5 volts. For V_p (25°C) = 5 volts, the total filter distortion remains under 1% for temperature variations up to about ± 17°C.

Practical design

In the practical realization of the nonlinear, nonreactive filter it is desirable to make some changes in the actual circuit. If the bridge rectifier shown on page 97 is used, crossover distortion is caused because of the nonzero forward-voltage drops of real diodes. A more satisfactory practical circuit is shown above, right, in which need for signal rectification is eliminated by using the symmetrical properties of an FET with respect to source and drain: the diodes and resistors R_g effectively switch the gate between source and drain when the input triangular voltage changes sign every half cycle. The resistors R_1 and R_2 therefore each play the role of R_s and R_d alternately.

Since the theoretical discussion has shown that the optimum condition is $R_s = R_d$, it is merely necessary to make R_1 and R_2 equal. (Had the optimum condition occurred for $R_d > R_s$, additional resistance $R_d - R_s$ could have been inserted in series with the signal source. However, a condition $R_d < R_s$ could not be realized with this circuit). A further advantage of the practical circuit is that the output signal is developed as a voltage across R_1 or R_2, and a relatively large fraction of the filter input is available as output.

Ideally, only odd harmonics of the fundamental signal frequency exist anywhere in the filter circuit. In practice, some even harmonics are also present; these may be introduced by asymmetry of the FET characteristics with respect to source and drain, or they may be brought in as distortion of the original input triangular waveform. FET



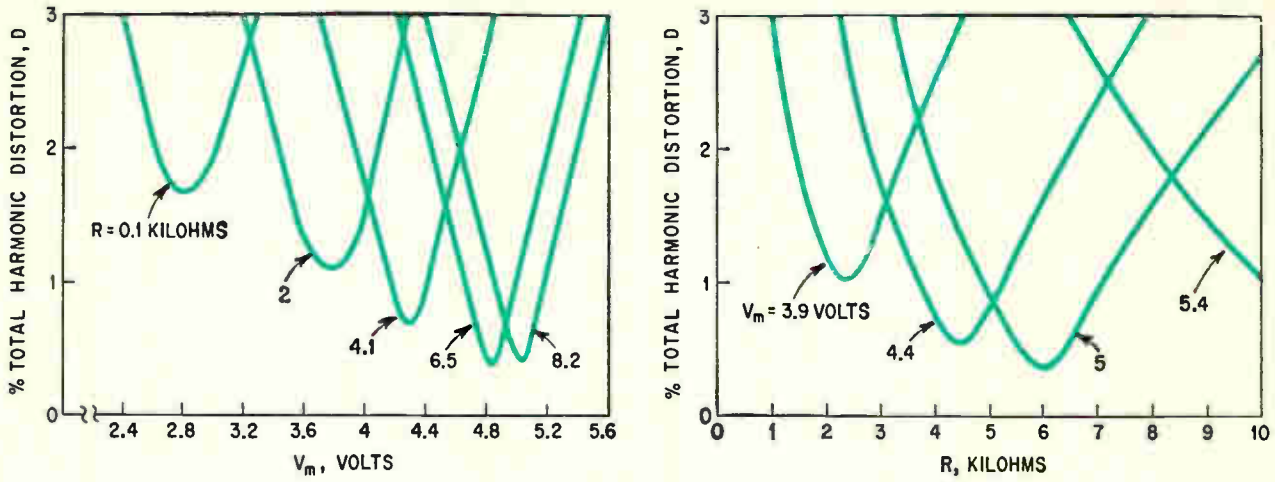
Practical filter circuit eliminates the need for signal rectification by using the symmetrical properties of an FET with respect to source and drain.

asymmetry is due primarily to unequal bulk resistance in series with the internal source and drain (especially in units that have large structural asymmetry). The harmonic distortion can be minimized by a compensating unbalance in the external resistances R_1 and R_2. The adjustment of the unbalance of R_1 and R_2 can simultaneously compensate for even harmonic distortion present in the input signal, to the extent that the total even harmonic distortion at the output of the filter can actually be less than that at the input.

Selection of FET type

Several types of FET's have been used in the practical circuit to test the validity of the theoretical results. For p-channel units, it is necessary merely to reverse the diodes. Plots of total harmonic distortion for a Fairchild FSP 401 characterized by $V_p = 2.9$ volts and $R_e = 6.2$ kilohms are shown on page 101. The temperature dependence has not been checked. The input signal was a one-kilocycle triangular wave derived from a function generator (Exact Electronics Type 240) and applied to the filter through an audio power amplifier to ensure low source impedance. The filter output harmonics were measured individually by a wave analyzer (Hewlett-Packard Model 310A). The even harmonic distortion (mostly second) at the input to the filter was 0.4%, and for each nominal value $R \approx R_1 \approx R_2$, R_2 was adjusted to minimize the second harmonic distortion in the output. The resulting even harmonic distortion in the output was about 0.3%, and was essentially the same for all conditions anywhere near the optimum for minimum total distortion. The distortion curves include the even harmonics.

It may be noted that the minimum total distortion observed was slightly over 0.3% so that the odd harmonic distortion was less than the theoretically predicted minimum of 0.35%. Therefore, the departure of the actual FET characteristics from the theoretical forms of equations 8a



Total harmonic distortion for the practical circuit is plotted against two parameters, the input amplitude V_m and the external resistance, R.

and 8b allow the theoretical performance to be slightly exceeded. As a consequence, a little more leeway is available in adjustment of the actual circuit than is theoretically predicted: maladjustment of the input amplitude by ±3.8%, or of the external resistance by ±19%, ensures that the total output harmonic distortion remains under 1%. Comparison of the harmonic distortion curves suggests that the theoretical FET characteristics of equations 8a and 8b are adequate for the design of practical circuits.

Design considerations

It has been demonstrated that a simple, nonlinear, nonreactive filter containing an FET can be designed to convert triangular to sinusoidal voltage waveforms with residual total harmonic distortion that should be reliably maintained at under 1%.

The design requires only a characterization of the FET by approximate values of the pinch-off voltage V_p and the zero-bias channel resistance R_c. In the practical filter circuit R_1 and R_2 are each set roughly equal to R_c, and the amplitude of the input triangular wave is set roughly to $1.33V_p$.

Choice of diodes and gate bias resistors is noncritical. Diodes of the same semiconductor material as the FET are to be preferred, since at least a partial compensation of the second-order effects due to gate-channel contact potential and diode forward drop may be achieved. Any gate bias resistance is satisfactory that is high enough not to load the signal source and low enough adequately to forward bias the diodes. Such a reugh design will ensure operating conditions in the neighborhood of the optimum for minimum total harmonic distortion. Only two critical adjustments are then needed: R_2 is trimmed to minimize the output second harmonic distortion, and then V_m is adjusted to minimize the output total harmonic distortion.

Alternatively, and perhaps even more simply, R_2 and V_m can be adjusted simultaneously to minimize the output total harmonic distortion. This method requires only a total distortion meter rather than a wave analyzer.

Acknowledgement

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Digital system continuously converts transducer data into meaningful units

More accurate and flexible than analog methods, it allows engineers to monitor complex processes and to spot trends before they become big problems

By Peter Johnson

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When testing a missile or studying an industrial-control process, the engineer receives information from transducers about such variables as temperature, pressure, speed and fluid flow—but often in the wrong form. The data comes to him in the form of d-c voltages or pulse rates; he has to convert it into more meaningful units such as degrees of temperature or pounds per square inch. This can require correction for scale factor, transducer offset and linearity [see glossary at end of article].

If he performs the correction manually—a slow, tedious process—the engineer has to refer repeatedly to the transducer's characteristic curve to correct his measurements. If a computer is available, this correction can be done automatically, but usually this involves a lengthy wait to get the data processed. Also, computer time is expensive. Existing methods to perform the conversion in the measuring equipment are analog in nature. Some examples are: nonlinear recording paper, nonlinear operational amplifiers, nonlinear potentiometers in servo systems and nonlinear shaft digitizers. These methods are inflexible, inaccurate and unstable.

A new digital technique eliminates these problems and provides direct readout in meaningful units of transducer measurements. This system employs a Dymec DY-2401C integrating digital voltmeter. It allows the engineer to monitor his measurements continuously, spotting trends before they become big problems.

Unlike analog methods, which require changes in measurement hardware for different types of transducers, the digital system can be adapted easily to different transducers.

The digital system has the added advantage of high accuracy and resolution; analog components are usually no better than 1% accurate. The system's flexibility allows any necessary linearization to be performed as accurately as desired.

Because digital techniques are inherently free of drift effects, the new method is stable. Analog systems, in contrast, are subject to zero drift and to variations in gain; they're also difficult to calibrate, requiring a precise voltage source, usually in the millivolt range. The use of an internal reference in the digital system also allows easy, precise calibration.

Digitizing is accomplished by converting the analog input into a proportional pulse rate in the voltage-to-pulse rate converter and counting these pulses over a fixed sample period. The sensitivity of the rate converter is 100,000 cycles per second—for full scale inputs of 0.1, 1, 10, 100 and 1,000 volts. Sample periods of 0.01, 0.1 or 1 second, therefore, give a display reading directly in volts or millivolts (with appropriate positioning of the decimal point). This principle of operation lends itself readily to scaling, zero offsetting and linearizing.

Translating into meaningful units

For scaling an input, the digital voltmeter can be programed externally for a sample period of any duration. For example, in the idealized thermocouple characteristic shown in the graph at top left on the facing page, the sample period could be preset to 0.25 second instead of 0.1 second, and the display decimal point positioned appropriately. Then an input of four millivolts could be displayed as

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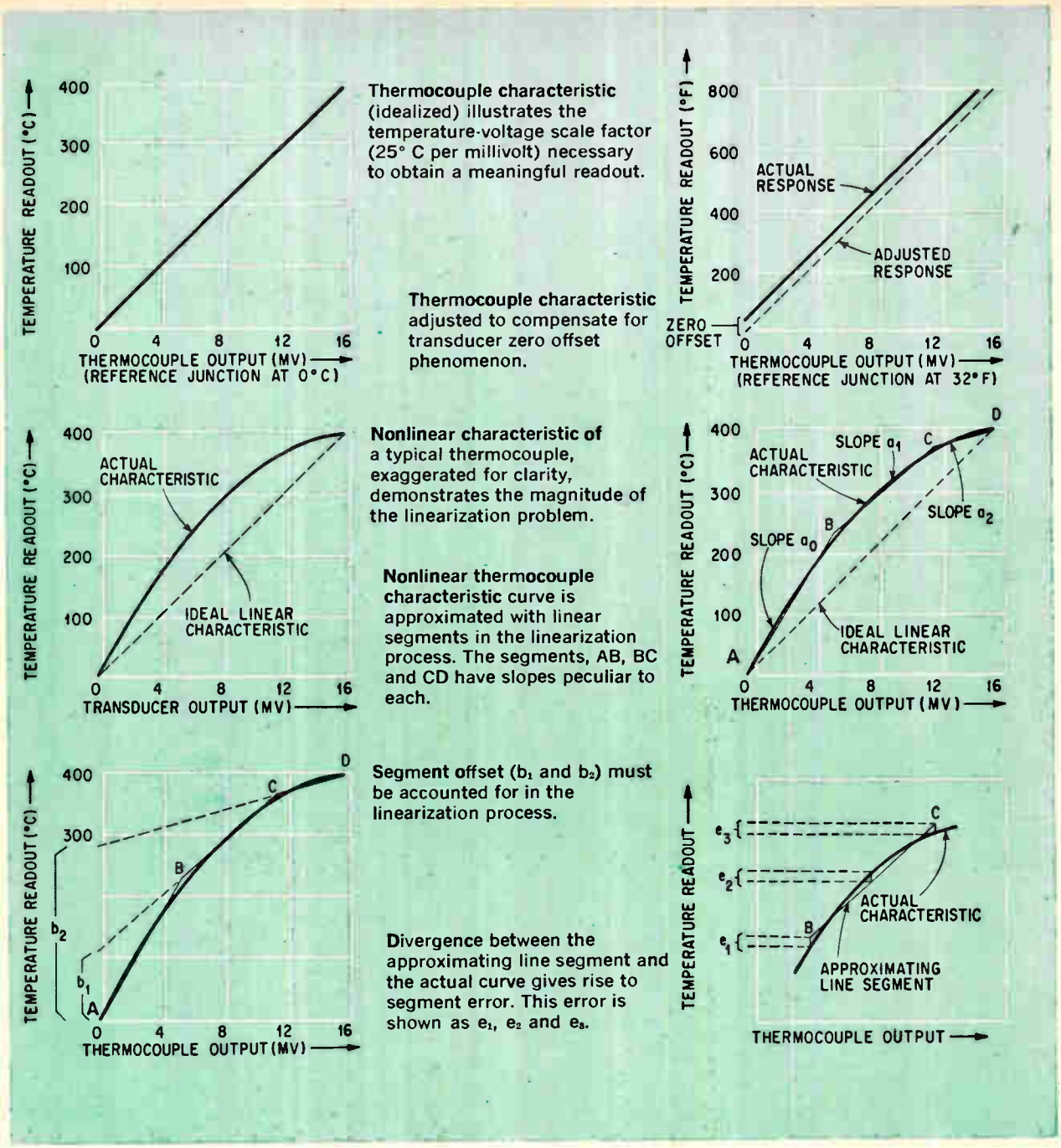
Peter Johnson, a native of England, taught electronics at the Royal Military College of Science prior to joining the Dymec division of the Hewlett-Packard Co. As publications manager, he is responsible for technical manuals, data sheets, field training and supervision of Hewlett-Packard's printing services in the Palo Alto, Calif. area.



100°C.

This method also works for tachometers and turbine flowmeters whose outputs are pulse rates proportional to an analog input; they can be applied directly to the counter portion of the digital voltmeter. Since the counter can handle frequencies up to 300 kilocycles, it can accommodate most types of pulse-producing transducers.

The digital voltmeter's counter uses display decades that can be preset. When the transducer has a zero offset, this can be compensated for by introducing a preset count that is equivalent to the offset. The decades are reversible, so the display can handle transducer offset of either polarity.

Digital linearizing is accomplished by making successive linear approximations to the characteristic curve (right center graph above).

The ideal situation is where one equation describes a straight line as shown in the graph, at the top left. Here a single equation, $y = ax$, relates the temperature readout y to the transducer voltage x. The coefficient a is the scale factor.

With the successive-approximation approach, each segment shown in the center graph above at the right has its own equation. These are

$$y_{AB} = a_0x, \quad y_{BC} = a_1x + b_1, \quad y_{CD} = a_2x + b_2$$

For all segments except the first, a segment offset is introduced. These offsets are b_1 and b_2. They are shown in the left bottom graph.

The length of each segment is determined by the degree of nonlinearity of the transducer characteristic and the accuracy required. In the graph above at the bottom right, the runout errors, e_1, e_2 and e_3 are kept within predetermined limits, say, for example, ±0.1°C. Therefore, to achieve a given measurement accuracy, the more nonlinear

the characteristic curve, the shorter and more numerous the segments must be.

The system can select the proper segment. The transducer voltage, and hence the operating point on the characteristic curve, is measured by sampling the output of the voltage-to-pulse rate converter. The voltage value is integrated to obtain a d-c voltage; this is compared with a series of preset voltage levels, each corresponding to a segment end point.

When the transducer voltage exceeds A but is less than B [see center figure, right, p. 103], a logic circuit selects the appropriate sample period for the slope a_0 of the segment AB. For a voltage between B and C, the logic circuit selects the sample period corresponding to the slope a_1 of segment BC. The offset of each segment is also corrected digitally by entering an appropriate initial count into the voltmeter. These initial counts correspond to b_1, b_2, etc. for each segment.

Although the number of segments, the segment end points, the related sample periods and the segment offset conditions are different for each type of transducer, they can be predetermined for any transducer, and have been for the most commonly used transducers with the aid of a computer. Thereafter, the change from one type of transducer to another only entails changing control settings and diode matrices.

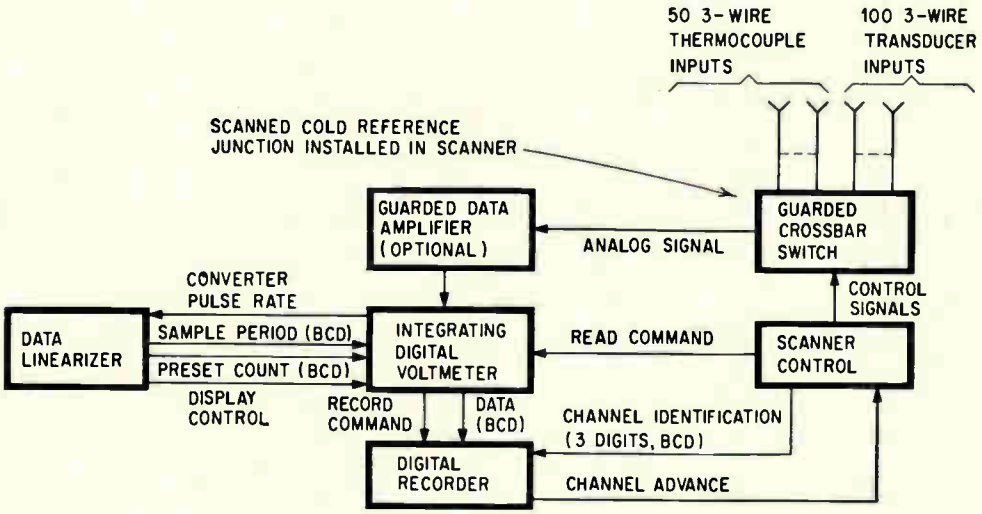
Guarded crossbar speeds scanning

The digital method of transducer measurement employs an input scanner, an integrating type of digital voltmeter, and a printer or other type of digital recorder. Speed and flexibility are greatly enhanced when a guarded crossbar scanner is used as the input scanning device. For direct-reading transducer measurements, some modification of the scanner and voltmeter and the addition of an accessory instrument are necessary to permit the scaling, transducer offset correction and linearization that may be required. In the Dymec system, the accessory is designated a data linearizer.

Full-scale input ranges for the basic system are ±100 millivolts, ±1 volt and ±10 volts. Valid over-ranging to ±300% of full scale extends these ranges to ±300 millivolts, ±3 volts and ±30 volts respectively. The most sensitive range is useful for strain-gage bridges, thermocouples and other transducers producing maximum outputs around 50 millivolts. The higher ranges can accommodate transducers whose maximum outputs are about three to five volts. A guarded data amplifier can be added if necessary to achieve maximum accuracy with low-level inputs. This amplifier provides a gain of 10 and results in a full scale input range of 10 millivolts, extended to 30 millivolts by valid over-ranging.

Data linearizer

Within the data linearizer are the converter rate detectors and the circuits necessary to provide the binary-coded-decimal commands for the voltmeter sample period (scale factor), and the preset count (transducer zero offset and segment offset). The linearizer also selects the decimal-point position and measurement-unit indication in the voltmeter display window. A functional diagram of the data linearizer is given on the facing page.



Data-acquisition system modified for direct-reading of transducer outputs by the incorporation of a digital voltmeter and data linearizer.

A transducer-output characteristic may be approximated by up to 10 segments with this instrument. However, if transducer characteristics are expected to be especially nonlinear, the system may be expanded to include more segments. The date linearizer can also be expanded to include 10 additional independent scale factors. These may be used to obtain direct readouts from transducers that do not require linearization.

Two or more data linearizers can also be used in a system for further expansion and increased capability.

The preset linearization characteristic or any one of the 10 independent scale factors can be selected by a front panel switch or by an external selector such as the system programer.

The segment end points, slopes and offsets for commonly used thermocouples are predetermined by computer. The end points are expressed in millivolts and degrees centigrade, offsets are in degrees centigrade and the slopes are given

in degrees per millivolt. No external equipment is needed for the linearization of a specific themocouple. A swingaway panel permits adjustments and setup changes to be made easily from the front of the instrument.

The rate detectors, which determine the segment end points, are mounted on plug-in cards, three to a card. The detector's trigger levels are adjusted by reference to a stable, variable voltage source in the linearizer. This source, consisting of a temperature-stabilized zener diode and a 10-turn potentiometer, is set in turn to each segment end point, the voltage of which is displayed directly on the voltmeter. The corresponding rate detector is then adjusted for triggering. An external indication of triggering is provided by a small lamp next to the adjustment point of each detector.

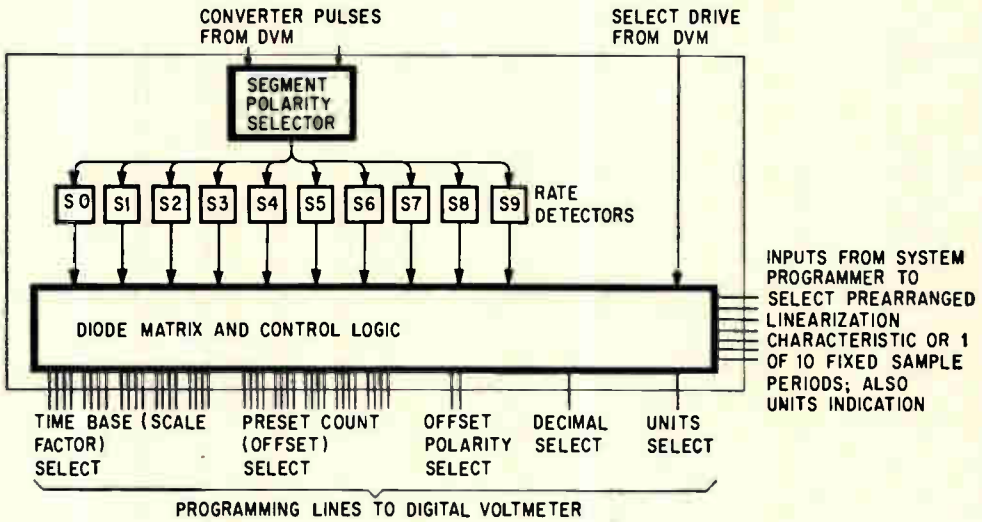
To select the voltmeter sample period, binary-coded-decimal commands are set up by inserting diode pins into a plug-in card. One card accommodates 12 segments, with five selectable decades per segment. This is equivalent to 20 binary-coded-decimal lines per segment.

also been included for positioning the decimal point by external command. In addition to such indications as voltage, frequency and resistance, provided by the standard voltmeter, the annunciator panel has been modified to display special measurement units such as degrees of temperature, revolutions per minute, pounds per square inch, foot-pounds, microinches per inch.

Thermocouple input scanner

A modified guarded crossbar switch is used for operation with thermocouples. Inside the guard shield is a thermocouple reference junction, designed for operation at ambient temperature and electrically compensated to simulate a reference temperature of 0°C. This junction is scanned together with the external thermocouples. Consequently, each thermocouple input occupies two 3-wire scanner channels. The 50 thermocouple inputs shown in the figure on the facing page leave 100 three-wire channels for use with other transducer inputs.

The proportion of input channels requiring a



Data linearizer showing how system can be programed externally.

A similar technique is used to set up the commands for entering the preset count for each segment. However, an additional pin per segment is necessary to indicate if the offset (y-axis intercept) is positive or negative. These settings can easily be checked by switching the voltmeter to its frequency mode and reading the offset, which is displayed in millivolts. Similarly, by switching the voltmeter to the check mode, the scale factor can also be validated.

Digital voltmeter

Special time-base decades are installed in the integrating voltmeter to permit selection of sample periods from 10 microseconds to one second, in 10 microsecond increments, by external binary-coded-decimal commands. The sample periods usually will be between 0.1 second and one second.

Although it has presettable, reversible decades as standard feature, the digital voltmeter has been modified to allow positive or negative preset counts to be entered by external commands. A means has

scanned reference junction can be tailored to suit any particular application. However, the number of thermocouple inputs must be a multiple of 10.

When a programer is used, the prearranged linearization characteristic or any of the 10 fixed scale factors from the data linearizer may be applied to any scanner input channel.

How accuracy is achieved

The convenience of direct readout is evident. The user will also want to know how accurate his final answer is. The following discussion is directed toward thermocouple transducers, because linearization and zero-offset correction are usually required for this type of transducer. The same reasoning applies to any type of transducer.

Inaccuracy of measurement can result from errors in the measurement conversion to direct readout, in the data-acquisition system itself and the individual transducers.

Errors during the conversion of a measurement can arise from scale factoring, transducer zero-

Sources of system errors

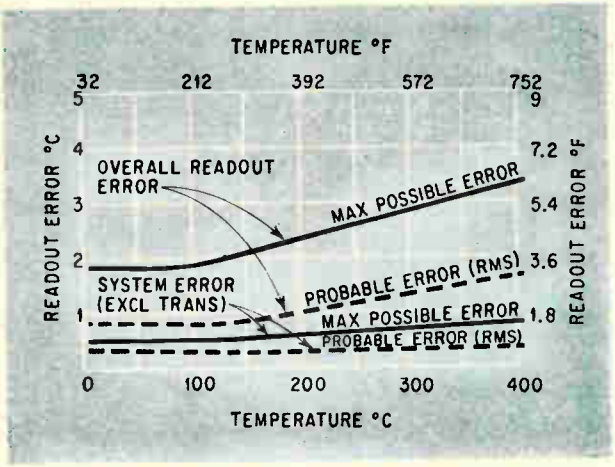
Error source		100 MV Range Without Amplifier		10 MV Range With Amplifier	
		% fs	% rdg.	% fs	% rdg.
Stability		.03	—	.04	—
Linearity		.005	—	.006	—
Noise		.019	—	.11	—
Attenuator		—	.005	—	.012
Internal reference		—	.01	—	.01
Arithmetic sum		.054	.015	.156	.022
RMS Sum		.036	.011	.117	.016
Error for	Max. possible	.55%		.18%	
10 MV Signal	Probable (rms)	.37%		.13%	
Error for	Max. possible	5.41%		1.58%	
1 MV Signal	Probable (rms)	3.61%		1.19%	

All errors are ±.

Sources of transducer errors

Error source		Temperature (°C) 0	100	200	300	400
Scale factor		.000	.005	.010	.015	.020
Offset, (tranducer zero & segment)		.005	.005	.005	.005	.005
Segment run-out		.100	.100	.200	.300	.400
Segment end-point		.000	.027	.023	.021	.022
Data acquisition system	(arith.)	.390	.412	.434	.488	.525
	(rms)	.293	.293	.294	.300	.327
Total system error	(arith.)	.495	.549	.672	.829	.972
	(rms)	.309	.311	.357	.425	.503
Transducer	(arith.)	1.300	1.300	1.700	2.100	2.500
	(rms)	.755	.755	1.050	1.360	1.720
Overall readout error	(arith.)	1.8	1.9	2.4	3.0	3.5
	(rms)	0.8	0.8	1.1	1.4	1.8

Figures apply to a copper-constantan thermocouple. All errors are ±.



Magnitudes of errors due to the transducer alone are compared with system without transducer in this graph of over-all readout accuracy. The most serious source of error in the final readout is due to the transducer.

offset compensation and linearization.

Errors in scale factor are determined by errors in the voltmeter's sample period. In the Dymec digital voltmeter this error is kept to a minimum by deriving the standard sample periods from a crystal oscillator. Compensation for the small error from this source is performed during the instrument's calibration. Only the resolution error of the sample-period selector circuits remains. The use of a five-decade preset divider keeps this to only ±½ count in 10^5, or ±0.005% of a reading.

Compensating for transducer zero offset may introduce an error into the voltmeter which is associated with the preset count. A five-decade preset counter is used, keeping the error to ±½ count in the voltmeter reading. The resultant measurement error is dependent on the scale factor used. For example, with a thermocouple whose scale factor is 25°C per millivolt. 1°C is displayed as 0001.0°C. The ±½ count error corresponds to ±0.05°C. This can be reduced further through the use of the guarded data amplifier. The 1°C is then displayed as 001.00°C; the count error now corresponds to ±0.005°C.

Inaccuracies during linearization are caused by errors associated with segment run-out, end-point selection, scale factor and offset.

Segment scale factor and offset errors have already been discussed.

Segment run-out is the maximum discrepancy between the National Bureau of Standards curve for the particular transducer and the linear approximation for each segment. For transducers with the same tolerance over their nominal response characteristic, segments are selected to achieve the same run-out for each segment. However, with thermocouples, the response tolerance is not uniform throughout the operating range. Therefore the segments must be chosen to adjust the run-out error proportional to the variation in the thermocouple tolerance. The 10-segment capacity of the data linearizer is sufficient to keep the run-out error of a copper-constantan thermocouple smaller than ±0.1°C. This is four times better than the Instrument Society of America's standard for special grade wire.

Variations in the rate detector's trigger levels, used to set the segment end points, result in a small additional error in segment run-out. These variations change with the operating point and are inversely proportional to the converter pulse rate. The magnitude of the resultant error in readout is a function of the slope divergence between adjoining segments. Using a 10-segment approximation for a copper-constantan thermocouple, the error is smaller than ±0.17°C, or within ±0.03°C if the data amplifier is used.

There are several possible sources of system error. These are tabulated at the top of this page. The contribution shown for each source is the worst-case condition. The noise specification refers to random internal noise with the shortest sample period used, 0.1 second. The temperature effects do not require consideration, because the system can be calibrated for use at any desired temperature.

Ambient temperature variations of ±5°C result in error less than ±0.05°C in the final readout.

The system is fully guarded; this eliminates errors from common-mode noise—spurious signals appearing from input to ground. Common-mode rejection specifications are the same for the standard crossbar scanner and voltmeter combination—110 decibels at 60 cycles per second and 130 decibels at d-c. The use of the optional amplifier will result in a reduction of common-mode rejection by only six decibels. The voltmeter provides additional superimposed noise rejection through averaging. The degree of rejection is a function of the noise frequency and the sample period. Even with a sample period as short as 0.1 second, as may be required in the scaling process, rejection of superimposed noise will be better than 20 decibels. The combination of shielding and averaging results in effective common-mode rejection of greater than 130 decibels at 60 cycles.

Transducer errors

The transducer itself is a contributor of errors. With a thermocouple, for example, wire error and reference-junction error must be considered.

Wire error is the deviation of a thermocouple output from its nominal characteristic curve. The characteristic curves for pairs of thermocouple materials are defined by the National Bureau of Standards. The permissible deviations are defined by the Instrument Society of America standards. For example, the wire error for copper-constantan, type T, special grade, is ±0.4°C from −60° to 100°C and ±0.4% of reading from 100° to 400°C.

Under operating conditions it is seldom possible to use the same wire for the sensor and reference junctions. The reference junction is usually built into the equipment, and may not match the sensor material perfectly. Therefore the wire errors of both the reference and sensor junctions contribute to system inaccuracies and are additive.

The difficulty of maintaining the reference junction at the true ice-point also must be taken into account. True ice-point junctions, held automatically at 0°C by refrigeration, are capable of maintaining a temperature of 0°C ± 0.05°. They create a shielding problem because they are too bulky to package within the scanner chassis. In addition, they are expensive.

This problem can be averted by using electrically compensated reference junctions. These provide reference temperatures of 0°C ± 0.5°. Although less accurate, they are small enough to be incorporated within the scanner's guard shield. The resulting large reduction in common-mode noise more than compensates for the additional error associated with the use of an electrically compensated reference junction. All of these transducer effects are additive and can produce a maximum error of ±1.3°C with a copper-constantan thermocouple over temperature from −60° to 100°C. The maximum probable error is ±0.75°C.

The system's accuracy

Final readout accuracy is influenced greatly by the type of transducer used, and it is not meaningful to quote a general figure accuracy. The bottom table on the facing page summarizes the pertinent data for a typical thermocouple, copper-constantan. This thermocouple provides an output of 0 to 16 millivolts over the temperature range of 0° to 400°C. The optional amplifier is employed to lower the full-scale input range. The maximum possible readout errors and the maximum probable readout errors are shown in the figure on the facing page. To facilitate a comparison the system error, excluding transducer error, is plotted on the same graph.

It can be seen that for a typical thermocouple, the maximum probable error—in measurement, conversion to engineering units and linearizing—is ±0.5°C, or ±1°F. This error is much smaller than that contributed by the thermocouple itself. Using matched thermocouples for all channels, or providing individual reference junctions for each channel, can reduce the thermocouple error to about ±0.5°C (1°F), giving an over-all readout error of ±1°C (2°F). However, reducing thermocouple error this way is expensive; it's feasible only in setting up an entirely new installation.

It is interesting to note that the use of platinum resistance probes instead of thermocouples does not significantly improve accuracy. Unmatched platinum probes are equivalent to unmatched special-grade thermocouples, and calibrated probes are comparable with matched or calibrated thermocouples.

This digital technique is valuable in a data-acquisition system. It allows a direct readout capability to be added to any data-acquisition system without affecting measurement accuracy and approximation for linearization to be made as close as desired. Measurement accuracy is principally determined by the errors inherent in the transducer.

A glossary of conversion terms

Scale factor is a multiplying factor that converts a transducer's electrical output into engineering units. For example, a thermocouple exhibits a change in output voltage for every change in temperature. The measuring device, therefore, must display a change in voltage as a change in temperature. Thus with a sensitivity of 40 microvolts per degree centigrade, a change of one millivolt in the thermocouple's output must be converted to a change of 25° in the displayed variable (top graph, left, p. 103). The millivolt output, therefore, must be multiplied by the scale factor of 25°C per millivolt. Similarly, for a strain-gage bridge, a typical scale factor would be 20 pounds per square inch per millivolt or, for a flowmeter, 10 gallons per minute per cycle per second.

Transducer zero offset represents the amount by which the transducer output differs from zero at the zero level of the measured variable. Consider a thermocouple that has no zero offset, as shown (top graph, left, p. 103). If the display were in degrees Fahrenheit instead of centigrade, an offset would occur since the transducer produces a finite negative voltage at 0°F. This offset must be compensated before scaling takes place (top graph, right, p. 103).

Maximum possible readout error is the system error figure, based upon the arithmetic sum of all contributory error sources under consideration, taking them at their worst cases.

Maximum probable readout error is the system error figure, based upon the root-mean-square sum of all contributory error sources under consideration, taking them at their worst cases.

Modernizing the missile range; Part 2

As our space program reaches farther from the earth, more precise tracking is needed. Engineers are improving existing gear. Plans include pulse radar for aircraft and satellites.

By John F. Mason

Military Electronics Editor

Not far from some of the most beautiful beaches in the Caribbean, on the island of Antigua halfway between Cape Kennedy and Ascension Island, a group of radar engineers spent many months repairing and revising the newest, most advanced pulse tracking radar on the Air Force's Eastern Test Range. After almost 500 modifications, the long-range sensor, designated the AN/FPQ-6, performed even better than the Radio Corp. of America's specifications had promised.

"The need for so much work didn't mean the radar was designed badly," said Antigua's radar manager, Ron Spears of RCA. "Modifications are always needed. All complex new systems have flaws. Techniques used for the first time usually need smoothing out. The results we've had with the radar are beyond anything we'd hoped for."

Within sight of the FPQ-6, right down by the sea, another group of engineers is putting the finishing touches on Glotrac, a system that uses continuous-wave and pulse radar information and has a range of 20,000 miles.

On the island of Eleuthera, about 280 miles from Cape Kennedy, a group of engineers headed by Bob Pickett is getting the final bugs out of the General Electric Co.'s Mistram 2, the most accurate continuous-wave radar in operation on the range and one that has been the most difficult to put into good operational form. Here again, the modifications don't reflect on the design. Like any complex system, Mistram 2 needs modification.

Work on these islands is typical of the activity on all the missile-range stations from Cape Kennedy to Pretoria, South Africa. Existing instrumentation must be vastly improved to support the 70 or more missile and space projects now scheduled. All the existing pulse and continuous-wave radar systems are being modified and improved, some c-w systems are being expanded, and pulse radars may be put into aircraft and even satellites.

Pulse radar

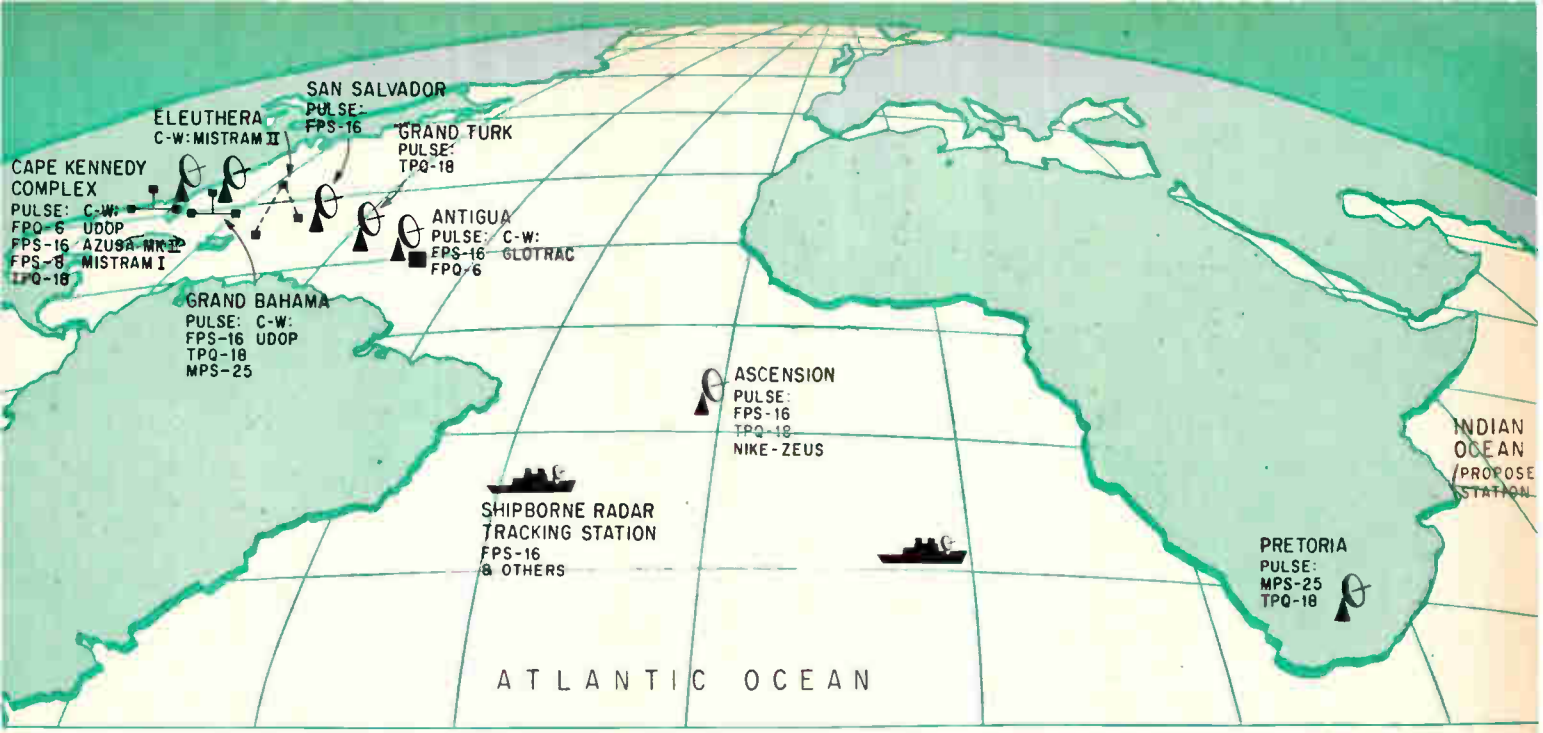
One important task of pulse radar is range safety. When a missile leaves Cape Kennedy, radars from the Cape to Antigua watch the vehicle to see if it's behaving as it should. If the missile is off course and threatens life or property, the range safety officer can blow it up.

After a missile's power is exhausted, the course cannot be changed; but the vehicle is monitored down the range, and finally it is tracked by ship radar as it reenters the atmosphere.

Unlike c-w radar, pulse radar can track a target with or without a cooperative beacon transponder. Last May, for example, the FPQ-6 at Antigua picked up the Soviet Cosmos satellite at 865 miles, an impressive distance. It tracked the 135-foot Echo II balloon satellite at 2,200 nautical miles, and followed Ranger 7 from horizon to horizon—a period of 500 seconds. Ranger was about 850 miles from the radar and 100 miles above the earth when it sank below the horizon. If Ranger had not been below the horizon when it went into its transfer orbit (when the vehicle leaves the earth orbit for its trip to the moon), the long-range FPQ-6 could easily have tracked the entire maneuver.

A transportable version of the FPQ-6, designated the TPQ-18, on Grand Turk tracked Ranger 7 for 371 seconds, and Saturn 6 for 500.

The Antigua radar had a definite role in the early portion of the Ranger 7 mission. It watched the restartable Agena vehicle during its first burn—the first period of powered flight. The data was used to determine the characteristics of the parking orbit, and this information was sent to Ascension, to Pretoria and to tracking ships for use in determining the transfer orbit. Data on that crucial portion of the mission was sent to the Jet Propulsion Lab-



Pulse and c-w radars. Most of those shown are already installed and operational; the others will be in by 1969.

oratory in California, which directed the flight.

The FPQ-6 and the transportable TPQ-18 [Electronics, Nov. 30, 1962, p. 20] are the newest pulse radars on the range and are considered to be so advanced that no new tracking pulse radars are being developed to replace them. The effort is going into debugging them, and devising new ways to get better performance.

The FPQ-6 evolved from the FPS-16, which is also still used on the range, along with its trailer-mounted version, the MPS-25.

All of these pulse radars operate in C-band and were developed and built by RCA. The FPS-16 can track a one-square-meter target without a beacon at up to 150 nautical miles; the FPQ-6, to 300 miles. With beacons, unambiguous range goes up for the FPS-16 to 1,000 miles, and for the FPQ-6 to 32,000 miles.

More metric data

Engineers are trying several ways to get more precise measurements of position and velocity for space shots from pulse radar. To date, c-w radar provides such information more accurately—particularly rate data, the target's speed in relation to the radar. But c-w radar has disadvantages: it requires a cooperative transponder, it must be installed with a long baseline (a precisely measured distance between two ground-based receivers), and it must function in conjunction with other remote stations. Pulse radar, installed in one spot, is simpler.

Range engineers plan to modify three pulse radar stations to measure vector velocity from three radial velocity components. This, they believe, would provide accuracy of velocity comparable with that of existing c-w systems.

Mike Wilson, of the Pulse Radar division at Patrick Air Force Base, Fla., says that precise velocity data and multiple target resolution could be obtained if the FPQ-6 were modified for coherent Doppler operation. This could be done by using a fine-line tracking technique to extract fine-grain information from the pulse signal spectrum. The Doppler information could be extracted by transmitting an ultra-stable frequency signal and using a fine-line (narrow-band) filter in an automatic-frequency-controlled servo loop.

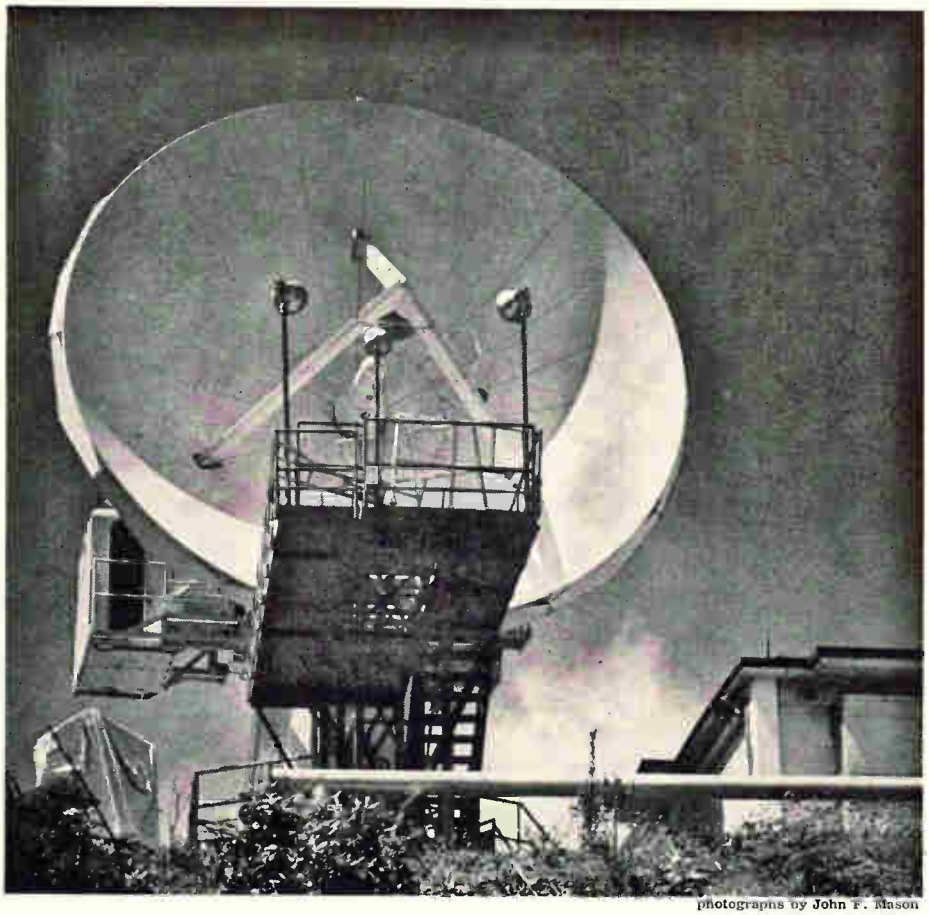
The filter would track the returned spectral line corresponding to the transmitted carrier frequency. In the fine-line tracking mode, the procedure is similar to a c-w system's.

With this technique, Wilson says, radial velocity measurements accurate to 0.1 foot per second have been demonstrated with a feasibility model. And greater tracking range is expected from the increased signal-to-noise performance obtained from the fine-line signal-processing technique.

Upgrading the radar

Though the narrow antenna beam-width (0.4°) of the FPQ-6 provided greater range and precision than the 1.2° of the FPS-16, it was slow in finding the target—especially if good acquisition information hadn't been passed on to the radar from another source.

This problem was solved by installing a beam spoiler—a waveguide switch that causes the transmitter to emit energy from all five horns of the Cassegrainian feed system rather than from only one. Usually, the center horn transmits and the four horns surrounding it act as receivers. Transmitting through all five decreases range and accuracy, but it does broaden the beam during the acquisition mode. Once the target is acquired, the operator switches back to the narrow beam. The radars at Grand Turk and Antigua are already equipped with beam spoilers. Although the technique is a good



photographs by John F. Mason

AN/FPQ-6 radar required almost 500 modifications after it was installed at Antigua. Now it performs beyond expectations. Last May it picked up the Soviet Cosmos satellite at a range of 865 miles.

one, it will ultimately be replaced by electronic scanning, which is better.

Electronic scanning

Acquisition and multitarget tracking capabilities of the C-band radars used on the two Atlantic range instrumentation ships will be improved in another way. These 30-foot dish radars are used to provide range, angle and amplitude information on ballistic missiles as they reenter the atmosphere. As the primary trackers on the ships, they are used to direct the L- and X-band radars also on board.

Both acquisition and multitarget tracking will be improved by modifying the radar to scan electronically. In November, the Air Force's Electronic Systems division at Hanscom Field, Mass. issued invitations for proposals to bid on feasibility studies of such a technique. The solution will probably involve an array of phase-shifting elements in front of the reflector or across the reflector. Exactly where they will be placed and what kind of elements they will be will come out of the contractor's report.

The engineers at Hanscom Field are also studying the whole reentry instrumentation problem. They are trying to identify the kinds of radar and optical gear that will be needed over the next five years.

Side-lobe lock-on

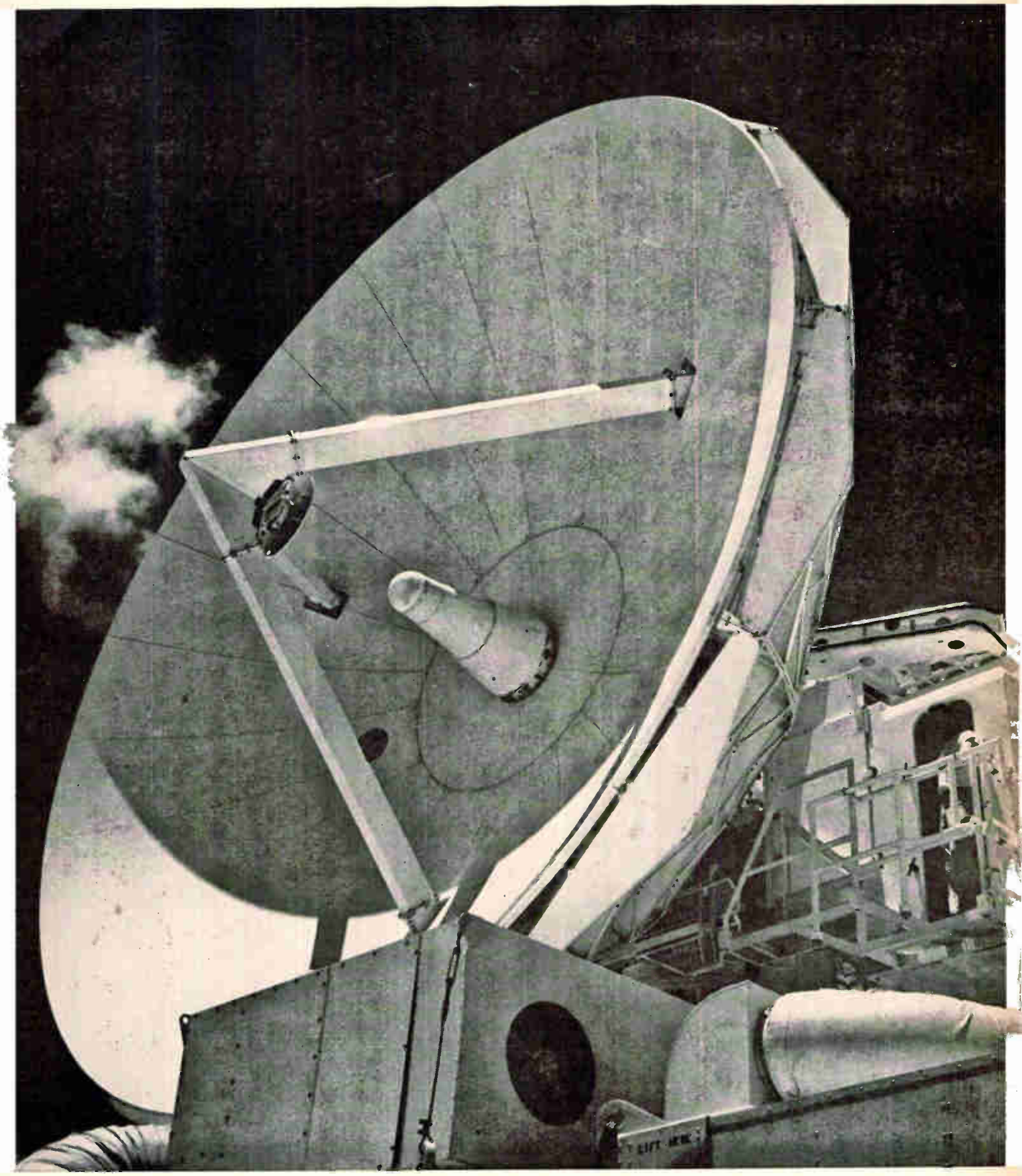
With the ground-based FPQ-6 and FPS-16 radars, it is possible for an operator to lock on to a target with the side lobe and think it is the main lobe. This would give him erroneous track information. To prevent such an error, the range is having side-lobe indicator and positioning (SLIP) systems built for all the FPQ-6's on the range.

SLIP will detect a side-lobe track condition and automatically reposition FPQ-6 antennas on the main beam. The SLIP modification adds a passive, conical scan system with a 36-inch parabolic antenna mounted on the present antenna mast. The system receives azimuth and elevation-angle error signals from a skin or beacon target independently of the main radar antenna.

Collimating radar with tv

Since the first AN/FPQ-6 became operational on the range 14 months ago, several independent studies have shown elevation errors that exceed specifications. Most of the errors indicate either feed-horn droop or dish distortion at various elevation angles, or poor calibration of the boresight tower.

In the attempt to isolate these errors, it became clear that existing methods of collimation with the boresight tower were inadequate. The Air Force now plans to buy a television-optical tracker that will provide the necessary optical alignment between the r-f axis and the mechanical axis of the radar system under dynamic as well as static conditions. The target will be a 12-inch reflectivity balloon.



Radar now going into downrange stations is six times more effective than its predecessor. This AN/TPQ-18 at Grand Bahama Island is the transportable version of AN/FPQ-6. The Atlantic range is getting four transportable and two permanent installations. RCA builds all of them.

The engineers also would like to improve the range of the FPQ-6 when the target is at low elevation and has low angular velocity. The Air Force is buying parametric amplifiers to increase the range approximately 30%.

Guard against false data

All the FPQ-6's will soon get pulse coders for their transponders as a guard against spurious signals or interference.

The coder is designed to be used with the FPQ-6 and the FPS-16. It will simultaneously generate three codes; the coding selected is determined by the transponder in the missile.

At present, all tracking systems are on land or aboard ship. Studies are under way at Hanscom Field, however, for an airborne instrumentation platform for precision tracking of cooperative targets (project 7817) and for a satellite-based tracking station (project 5930). Although aircraft are already used on the range, they are for telemetry and communications relay, not for tracking.

Easier tracking

The advantages of putting a tracking station in a plane are numerous. Tracking stations are often needed where there is no land or where the land is owned by a foreign government that may put restrictions on its use. Planes are more maneuverable than ships and cost less, they get above much of the earth's atmosphere, and they extend line-of-sight transmission. For tracking vehicles close to the earth, aircraft are expected to be about as accurate as ships.

The Mitre Corp. made a four-month study for Hanscom Field last year on the feasibility of using an aircraft for tracking purposes. The engineers simulated, on a computer, the entire problem and the performance of an airborne C-band radar. The results were promising; now the Air Force would like to breadboard the equipment and try it out.

A navigation system for a tracking aircraft has already been tested at Hanscom Field. Since any position error in the aircraft itself would compound an error in calculating the missile's velocity as well as create a big acquisition problem, the highly accurate GAM-87 navigator, used in the defunct Skybolt missile, was chosen.

System modified

The stellar-inertial-Doppler system, which was developed by the Nortronics division of the Northrop Corp., was modified to include a vidicon tube in place of the photomultiplier associated with the star tracker. The system was installed in a C-131 cargo plane. The star tracker was then used to acquire and track the Echo I balloon satellite to see how well it could generate azimuth and elevation angles from an aircraft. The aircraft's position was tracked accurately by several ground radars, and the position of Echo I is always accurately known.

The device tracked Echo I on six passes for a total of 17.6 minutes. Although the results have not yet been fully evaluated, the engineers believe they will be good.

Air Force engineers also tested the GAM-87 for two potential problems. They flew the C-131 over water to see how this affected the Doppler, and they operated the system in a gravitational anomaly area. The preliminary conclusion is that there was some degradation of the Doppler's efficiency over water, but not too much. There is no information yet on the gravitational anomaly test. The Air Force believes that the results will be good enough to proceed with the program.

Antenna bids sought

One problem in the proposed airborne platform is to get a good antenna. It must be a broad-band, three-aperture device, using C-, S- and vhf-band, though final specifications may eliminate the vhf-band requirement. It will be no bigger than 7½ feet in diameter, and will probably be a dish. Requests went out recently for proposals to bid on antenna study contracts. In addition to proposals for the antenna itself, contracts will be awarded to study the mounting problem, stabilization methods, propagation effects, radome positioning and materials.

The aircraft will use other tracking sensors, such as lasers and infrared detectors. These are good for angle determination, while radar provides good range and range-rate information. An airborne computer will also be needed.

Satellite tracker

The General Electric Co. and the Lockheed Corp. have been working since July on one-year study contracts to determine the practicability of tracking with pulse radar from a satellite. One such platform, strategically placed in synchronous orbit, could monitor the entire test flight of a long-range missile. The project is ambitious, but the potential in such a system is great. The satellite would also relay telemetry, command and communication signals between ground sites and space vehicles.

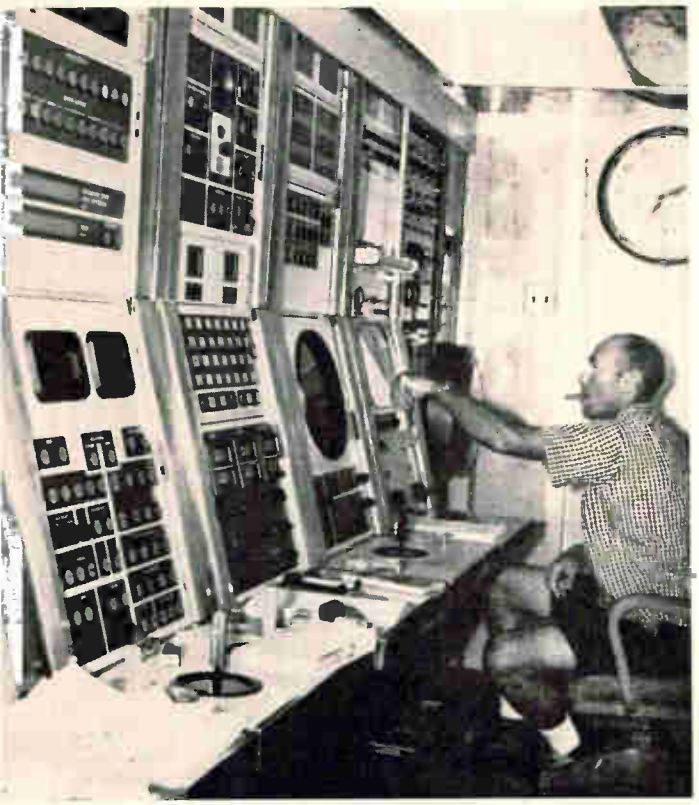
Early-launch tracking

There is a real need for equipment that will pick up a missile the moment it leaves the launch pad and continue to track up 60,000 feet, when Mistram (missile trajectory measurement) can take over. It is important to track the missile during this crucial lift-off stage to evaluate the performance of the engine and the guidance system.

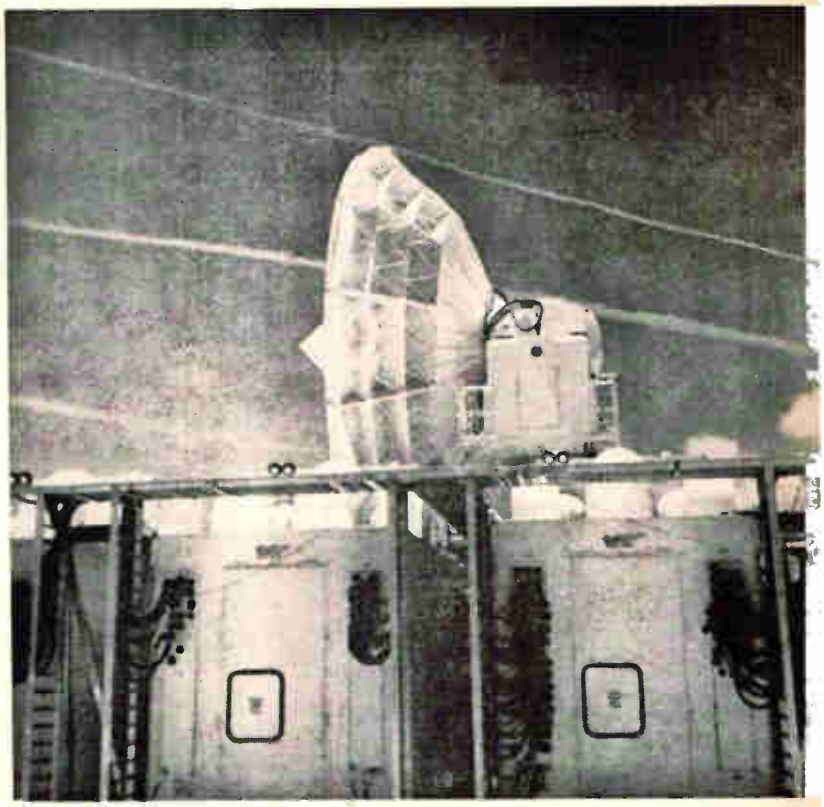
Three feasibility studies were carried out on early-launch tracking systems at Rome Air Development Center.

One technique calls for eight microwave radars installed in a V in front of the launch pad. The radars fanned out between points 100 and 25,000 feet from the pad. The missile carried a transponder. This approach was expensive and it took up a lot of space. At some sites, the line of radars would have to extend into the ocean.

Another technique used gamma radiation. This



Grand Bahama's chief radar engineer, R. S. Marchant, operates the AN/TPQ-18 tracking radar from a van.



TPQ-18's airconditioned vans look like big refrigerators. Nine of these shelters are needed at each site.

approach had no propagation problems or blackout by smoke, but its range was only about 1,000 feet and it caused a radiation hazard.

The third, and most promising, technique uses a laser. RCA is developing an active laser tracker [Electronics, Jan. 10, 1964, p. 10], and the Perkin-Elmer Corp., a c-w gas laser [Electronics, Apr. 20, p. 30].

Rome was working with a c-w gas laser. Funds ran out, however, and the program stopped, at least temporarily.

The problem of calibrating c-w and pulse radars precisely enough is so great that the Air Force plans to put up satellites that contain transponders to do the job. Since the exact position of an established satellite is always known, the slightest error in any ground-based measuring device will be revealed.

Two types of satellites

In Project 7818, the Electronic Systems division, in cooperation with the Space Systems division,

Lowest price wins

Although the missile ranges will continue to be a good electronics market, the Defense Department's cost-reduction program is a source of growing frustration to many contractors.

One industry official said: "The government's insistence on buying electronic hardware from the lowest bidder, the way they buy desks, chairs and wastebaskets, results in the government's often getting junk—which is never really a bargain. The procedure, in fact, is probably indirectly injuring our space effort."

That view is prevalent among suppliers and government and military officials. All sources asked to remain anonymous.

"In a fixed-price, invitation-to-bid procurement, the bidder simply submits a price, and low price wins the award. There is no consideration given to originality, creativity, improvements or genuine advances of any kind," the industry executive continued.

"The immediate result is to squelch any desire on the part of the potential contractor to risk proposing quality hardware. Then, once the contract is awarded, changes are difficult to make. For example, during the course of a long-term contract, it's very possible that the state of the art improves, or the government's requirements change. But due to the type of contract involved, it is not easy to change. The specs remain the way they were and the government loses the opportunity to take advantage of new technological developments.

"It would be much better to have a negotiated fixed price, or more fixed price plus incentive."

Of the first 383 contracts awarded by the Electronic Systems division in fiscal 1965, 75 were fixed price and only one was fixed price plus incentive.

Cost reimbursement accounted for 106 contracts; cost plus fixed fee 189; cost plus fixed fee plus incentive, 9; and cost sharing, 3.

will put up two kinds of satellites. Project 7818.02 will be a satellite equipped with four kinds of transponders: S-band and C-band to check the Verlort and Prelorp radars used by the National Aeronautics and Space Administration, and a vhf transponder and two uhf transponders to check the radars aboard the range ships. The satellites will also have a telemetry system and a command-and-control capability.

The Space Systems division will buy the booster, integrate it with the satellite, launch it, and control its operation once it is in orbit. The satellite will be launched into an orbit that is near-polar—80° to 95°, and near-circular, 300 to 500 nautical miles high. It will be spin-stabilized. Hanscom Field hopes to have three satellites launched, the first in December, 1965.

Project 7818.03 will consist of two satellites. Each will carry an X-band transponder for Mistram, a special transponder for Glotrac in the 5,000 megacycle range, and a C-band transponder for the pulse radars. The first of these satellites will go up in February, 1967. Its inclination will be 30° to 40° at launch, its orbit will be nearly circular at 300 to 500 miles altitude, and the satellite will be spin-stabilized.

Refraction work

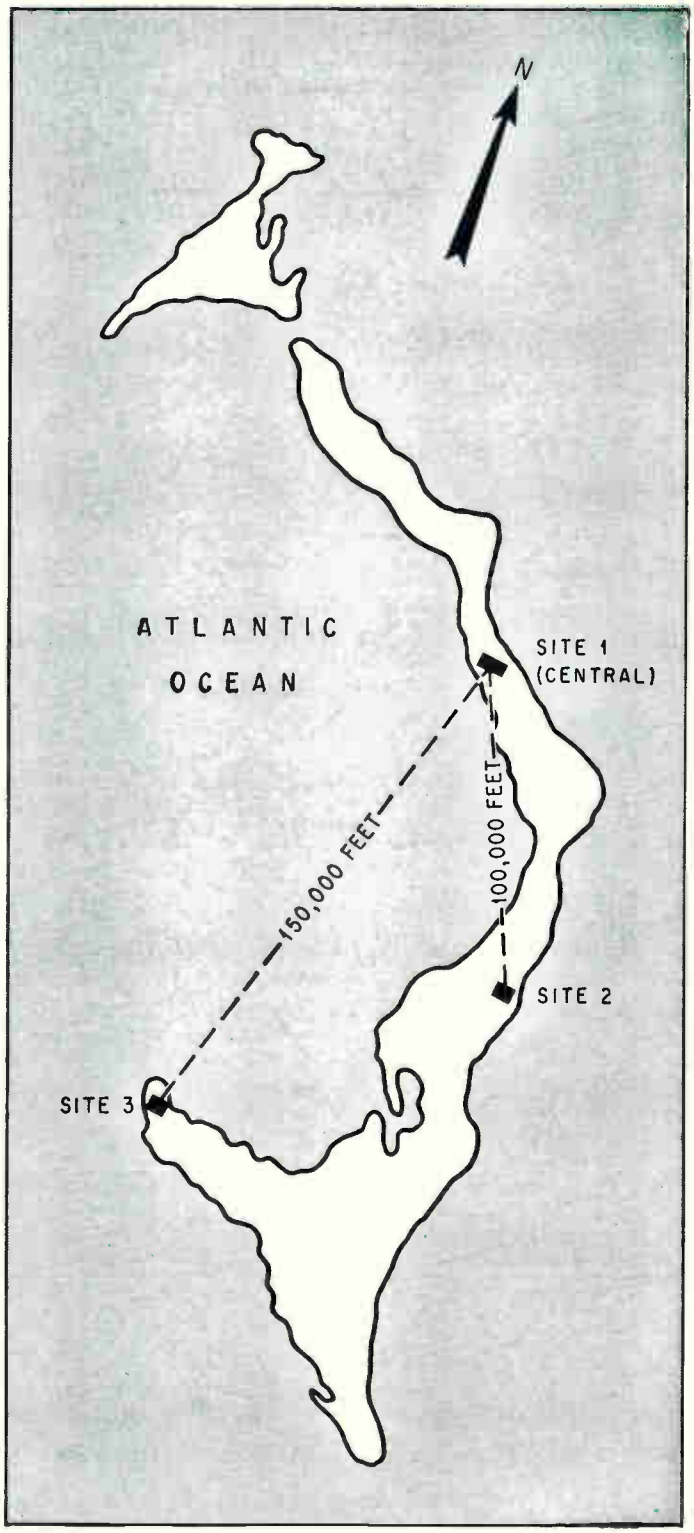
Errors in angle measurements due to refraction are a serious headache for both c-w and pulse radar trackers. In an attempt to correct them, Hanscom Field has three studies under way at the Air Force Cambridge Research Laboratory, the National Bureau of Standards and the Mitre Corp.

Cambridge is trying to come up with a system whereby the refractivity index of the atmosphere at any given time can be determined by measuring meteorological conditions. The lab has put meteorological equipment and an airborne refractometer into a C-130, which is flown through the clouds over Cape Kennedy at altitudes up to 20,000 feet. A U-2 flies above the C-130 and takes photographs of it and the cloud conditions. Later, the appearance of the clouds is matched with the refractometer readings taken in the C-130. It is hoped that enough comparisons will make possible a refractivity index based on cloud profiles.

The Bureau of Standards is taking a series of readings from which it hopes to make tables that will show the index when variables such as temperature, pressure, wind and moisture content are known.

On a mountain in Hawaii, 10,000 feet high, the bureau has a transmitter. About 15 miles away, at sea level, there is a receiver. The angle of elevation is about 5°. The bureau transmits continuously, measuring the refraction all the time, and matching it with the variables.

Mitre is attempting to develop a line integral refractometer to provide almost instantaneous readout of the refractivity index by determining the moisture content in the atmosphere, which is the biggest variable, and the oxygen content. The



Mistram 2, on the island of Eleuthera, has three sites. The central station (Site 1) equipment includes the tracking antenna and receiver, the transmitter and receiving antenna, ten receivers, data extraction circuits, communication and recording equipment, refractometer, optical tracker, simulator, operator and coordinator consoles and power equipment. Each remote station (Sites 2 and 3) houses a simple receiving antenna slaved to the central station antenna, a receiver for beacon signals, a receiver for phase stabilization, a refractometer, communication equipment and power. Communication between the central station and the remote stations is by microwave link.

method is to transmit radio signals at frequencies above and below the water absorption band (22 gigacycles) and the oxygen band (60 Gc). The differences in phase delay between the two signals are directly proportional to the moisture content and the amount of oxygen. With this information, a working approximation of the refractivity is figured out, almost in real time.

Continuous-wave radar

Continuous-wave radar systems on the range measure position and velocity more precisely than pulse radars do because c-w derives information from the easily measured Doppler shift. Pulse radar measures range accurately enough, but must depend on the mechanical changes in the antenna's azimuth and elevation to determine the velocity.

At present, four types of c-w systems are used on the test range: Azusa, Glotrac, Mistram, and Udop (ultra-high-frequency Doppler). The systems complement each other because of their locations and their particular capabilities.

Azusa Mark 2 is at Cape Kennedy and measures position and velocity up to about 400 nautical miles downrange. It can pick up the missile very quickly after it leaves the pad—at an altitude of about one mile—and the readout is in real time.

Glotrac has a range of up to 20,000 miles. When it becomes fully operational, it will be useful for space missions. Results are not in real time, but may be in the future. Glotrac depends on Azusa as one of its station inputs.

Mistram doesn't have the range of Glotrac, but it is the range's most accurate c-w system. It is capable of full accuracy up to 600 miles. Mistram picks up the missile when it is about 5° above the horizon. Data obtained from the system is available in real time and is used for range safety and for impact prediction.

Udop, a real-time system, has one complex in the launch area and one at Grand Bahama. Like Azusa, it picks up the target at low altitude. Udop is the only range system that has reliably tracked through staging events of solid-propellant vehicles.

All c-w systems require a cooperative beacon transponder in the target, a transmitter on the ground, and three or more receivers at separate, precisely located sites. The line between any two receivers is called a baseline.

Fundamentally, a c-w system transmits a signal from the ground station to the target, where the frequency is multiplied and transmitted back to the ground. The ground receivers compare the phase of the returned signal with a coherent phase reference.

The speed with which the target's range changes is measured at each receiver. This data is derived by comparing the received signal with a reference in a quadrature phase detector. The output produces one pulse for every 90° of phase rotation. Each pulse represents a discrete change in radial range. The digital recording system records at a sampling rate of 10 and 20 points a second. The pulses are stored in a computer which is capable of a readout speed of 10 pulses a second. The data is then processed to give the range rate.

Range difference, the difference in distance of the target from each receiver, is measured by comparing the signals received by the different receivers. The difference in phase of the signals is proportional to the difference in range.

The target's range is measured at the receiver by comparing the phase of the received signal with a reference. The phase difference is proportional to the electrical distance to the target.

All range systems use variations of this basic approach. The differences in system capabilities are due to the precision and speed of the techniques used. Accuracy is directly proportional to the baseline length, that is, the distance between receiving stations. However, as the baseline is lengthened, phase error and survey problems increase.

Azusa, the oldest c-w radar

The oldest c-w radar on the range is Azusa, a C-band short-baseline (1,500 feet) system consisting of nine receivers and one transmitter located along two crossed baselines. The length of the electrical baseline is maintained with precision by connecting the receivers by waveguides constructed in temperature-controlled trenches. The central conical-scan receiving antenna tracks the target and positions the other receiver and transmitter antennas. All the antennas are high-gain parabolic dishes.

Azusa determines position by continuous comparison of phase differences between microwave signals to and from the transponder. The frequency-controlled signals from the ground transmitter are beamed to the transponder, which retransmits them to the ground receivers, where they are converted to a form usable for phase comparison. These phase differences are a measure of two direction cosines and the slant range, three quantities that provide enough information to determine the position of the missile.

Glotrac—the newest

Glotrac is a new system on which a great deal of work is planned. It will go on new ground sites, and on at least one ship. The bulk of the work, however, will consist of services and equipment to improve system reliability and performance and reduce maintenance costs.

Originally, Glotrac was designed as a global tracking network for the military communications satellite Advent. It was to consist of several C-band pulse radars (FPS-16 or equivalent) integrated with the Mark 2 Azusa and several new portable c-w tracking systems compatible with Azusa. During the booster's flight, the pulse radars were to acquire position data and the c-w elements would receive rate data, all in a form suitable for postflight evaluation of launch vehicle guidance.

Although the Advent program was canceled, the Air Force decided to go on and install the c-w por-

When a Minuteman missile launched from Cape Kennedy reaches an altitude of 60,000 feet, RCA engineer Sam Lynch picks it up on Mistram 2 at Eleuthera. The entire Mistram 2 complex is operated at this console.

The countdown console (right) is positioned so that lead engineer Bob Pickett can watch it and the operator's console in front of him.

tions of Glotrac downrange for regular missile-range work.

Glotrac consists of several semitrailer vans and parabolic tracking antennas installed beside the vans. Each van contains a five-gigacycle receiving system fed by an external receiving antenna that automatically tracks the transponder in the missile by conical-scan techniques.

Atomic standards

One transmitter interrogates the bird at C-band with a signal referenced to an internal atomic standard. Remote vans compare the received signal with their own atomic standards. To synchronize the data at all vans for processing, timing modulation is also transmitted, and timing marks are recorded at each van. No common-reference or electrically-stable baselines are needed because of the ultra-stable references at each van, the extended baselines used, and the timing modulation.

The receiving system detects the Doppler present on the received signal, reads the Doppler cycle count ten times a second, and records the readings on magnetic tape. Each 60th reading may be transmitted in real time by teleprinter to the IBM 7094 at the Cape, if communication links are available.

Some vans also contain a five-kilowatt c-w transmitter capable of interrogating either an Azusa transponder or a specially developed Glotrac transponder.

Glotrac's accuracy is limited by the precision with which the timing modulation provides synchronization, the accuracy with which the initial vehicle position is known, and survey information. Large parabolic tracking antennas and parametric amplifiers are used to enhance sensitivity and ensure Glotrac's accuracy at space-probe ranges.

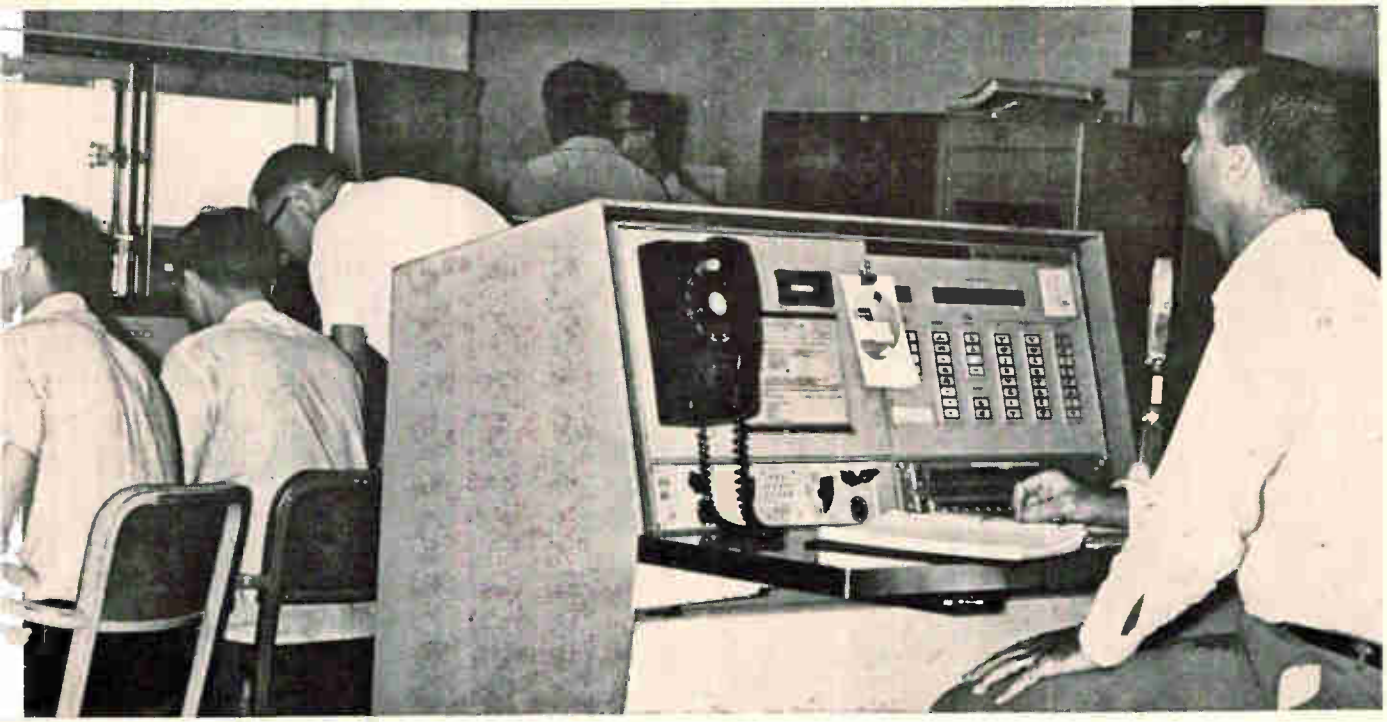
Various plans are being considered for extending Glotrac coverage. For instance, ships could be instrumented and moved out to solve tri-lateration solutions with existing Glotrac stations. At present, however, the test range is considering adding rate baselines to the existing transmitter stations at Bermuda and Antigua, and instrumenting one ship only. The ship could be moved about to reinforce the particular baseline being used, thereby extending coverage. A single-baseline system can operate accurately down to an elevation of 5° above the horizon. A reinforced baseline extends high-quality data coverage down to 2°. This could mean a range extension of 300 miles.

The new baseline system would be different from the one being installed at Pretoria, which uses an over-all automatic-frequency-control (AFC) technique for controlling the airborne transponder to keep the ground-received frequencies constant at 5,000 megacycles. A better approach would be to use an existing fixed-frequency ground transmitter and allow the computer to compensate for baseline electrical length changes which result from receiving variable frequencies.

Procurement for '65

A good deal of equipment will be bought this year for Glotrac.

- Very-low-frequency receivers will be used to correlate more closely each station's reference frequency to a common signal generated by the National Bureau of Standards. Each station can then set reference oscillators to the same atomic standard, and frequency correlation between stations can be improved by almost one order of magnitude.
- Severe heat within the synthesizer's power supply has caused repeated failure. A modular, solid-



state power supply is being considered to improve the system's reliability.

- Continued failure of parametric preamplifiers has made it necessary to provide a more reliable mixer-preamplifier assembly.
- Teletype converters will be bought to provide acquisition and system checkout aid for remote vans.
- Frequency conversion is needed to move Azusa and Glotrac out of the radio astronomy operating band. The new frequency will be 5,008 megacycles.
- The range will get an operational G transponder in 1965. The C transponder now used has limited Glotrac capabilities but is compatible with the Glotrac system. The G transponder would operate throughout the mission. The proposed G transponder will weigh 5.25 pounds; the C weighs 19 pounds.

Plans now call for Glotrac to be installed in the Pacific, the Indian Ocean and Alaska.

Mistram—brightest hope

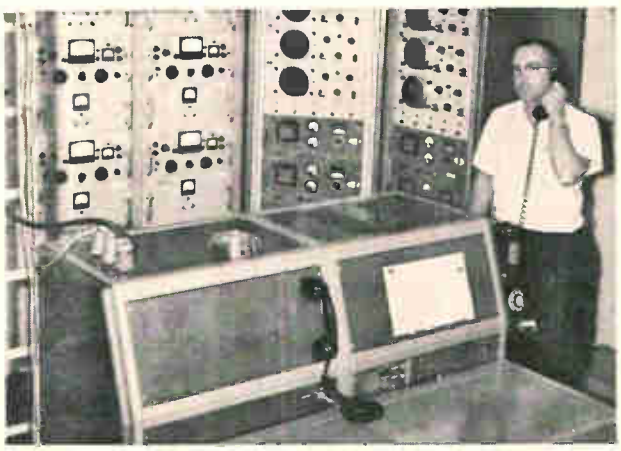
Mistram, the system with the greatest potential for accuracy—ten times that of any other electronic tracking system on the range—has required a great deal of debugging. Work continues to realize the system's real potential, however, at both Mistram sites—Mistram 1 at Valkaria, Fla., about 30 miles south of Cape Kennedy, and Mistram 2 at Eleuthera, about 280 miles downrange.

Mistram uses c-w phase comparison techniques to measure range from a central station, and range difference across orthogonal baselines. The two determine position, and the rate at which they change determines velocity. Range is measured by counting the number of wavelengths traveled by the signal to the missile and back to the central station. Range difference is found by counting the difference in the number of wavelengths traveled by the signals from the missile to each end of the baselines. A computer is used to compute trajectory.

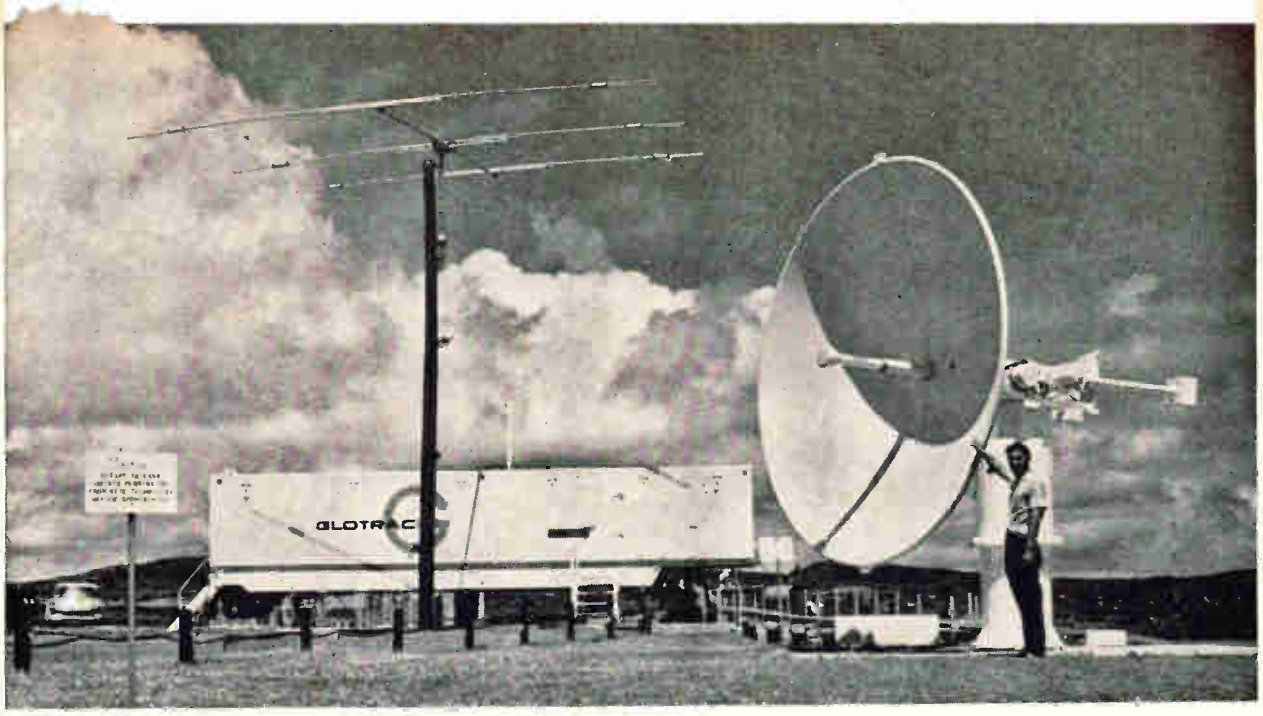
Mistram 1 and 2 can operate independently or cooperatively. One can operate as a receiver while the other is transmitting. In some programs, handover is accomplished: in the Saturn flights, Mistram 1 was active and Mistram 2 passive during the first 300 seconds, and then the systems switched roles. Together they tracked the big missile for more than 600 seconds.

Mistram has tracked Titans, Minuteman missiles, Saturns and Gemini.

Sometimes the Mistram signal is lost because of plasma sheath blackout. On a Minuteman test earlier this year, such an interruption occurred 60



Udop leader Gene Hillesland at Grand Bahama Island checks by telephone with remote sites of this c-w tracking system. Udop tracks missiles during engine burn.



Glotrac measures, with extreme accuracy, position and velocity of missiles as far out as 20,000 miles. The hybrid c-w pulse radar/computer system will be useful for deep space probes. This trailer and antenna station is at Antigua.

seconds after lift-off, the first stage event; at 80 seconds, when the skirt separated; and at 120 seconds, at the end of the second-stage burn. New techniques have cut the duration of signal loss to about one second.

Problems remain

There are still problems, however:

- Mistram 1 data printout. Checkout, maintenance and calibration results cannot now be read on-site. At present, adjustments are made in the equipment, a simulation is run, and the data is transmitted to the Cape, where it is recorded on magnetic tape. The tape is then printed out and analyzed to determine the adequacy of the adjustments. Because of these delays, the same problem could occur in a subsequent test. A high-speed printer will be bought to permit engineers at the site to determine the validity of the calibration and to diagnose possible troubles. Mistram 2 already has this capability.
- Analog recorders. The charter recorder system that came with the instrumentation was designed for installation and checkout only. It has been found deficient in the number of recordings it can make and in the way the data is organized.

These failings result in performance analysis reports being delayed and incomplete. A contract is currently being concluded to buy more recorders which would add event pens to existing recorders and regroup the data functions to provide a more logical organization.

- R-f leakage. Phase errors between the various signals occur in Mistram because of r-f leakage. This causes ambiguities in the data output. To identify the sources and effects of the r-f leakage, a coherent leakage detector is now being used.
- Airborne antennas. The range engineers have prepared criteria for airborne antennas and have requested that range users modify their antennas accordingly. Major problems exist with the Minuteman and Gemini antennas. Because Mistram uses two frequencies, side lobes in the antenna pattern result in phase errors between the continuous and calibration channels and introduce ambiguities in the data.

The Gemini program office has given range engineers an antenna for evaluation and testing in conjunction with Mistram 2.

- Transponder. The range is developing an improved space-rated Mistram transponder which will be lighter, require much less power input, have greater power output and more reliability. It is expected to be easier and cheaper to produce and easier to manufacture. This transponder should achieve a greater amount of passive data and increase the range of coverage. The Air Force plans to include NASA's Manned Space Flight Center's workmanship specifications, mounting requirements, and environmental specifications for support of NASA programs.

Udop

One system near the Cape is run by NASA. The second, operated by the range, is installed on Grand Bahama and four of the island's cays.

The transmitter is uhf and the transponder replies at double the transmitted frequency. Phase coherence and Doppler data is fed into a digital processor, which converts them to cycle counts. The precision of individual Udop receivers is approximately one-tenth of a Doppler cycle, or about 0.1 foot. Data is sent to the Cape in real time.

Acknowledgment

The author acknowledges the help of Robert B. Pickett, lead engineer for Mistram 2 at Eleuthera.

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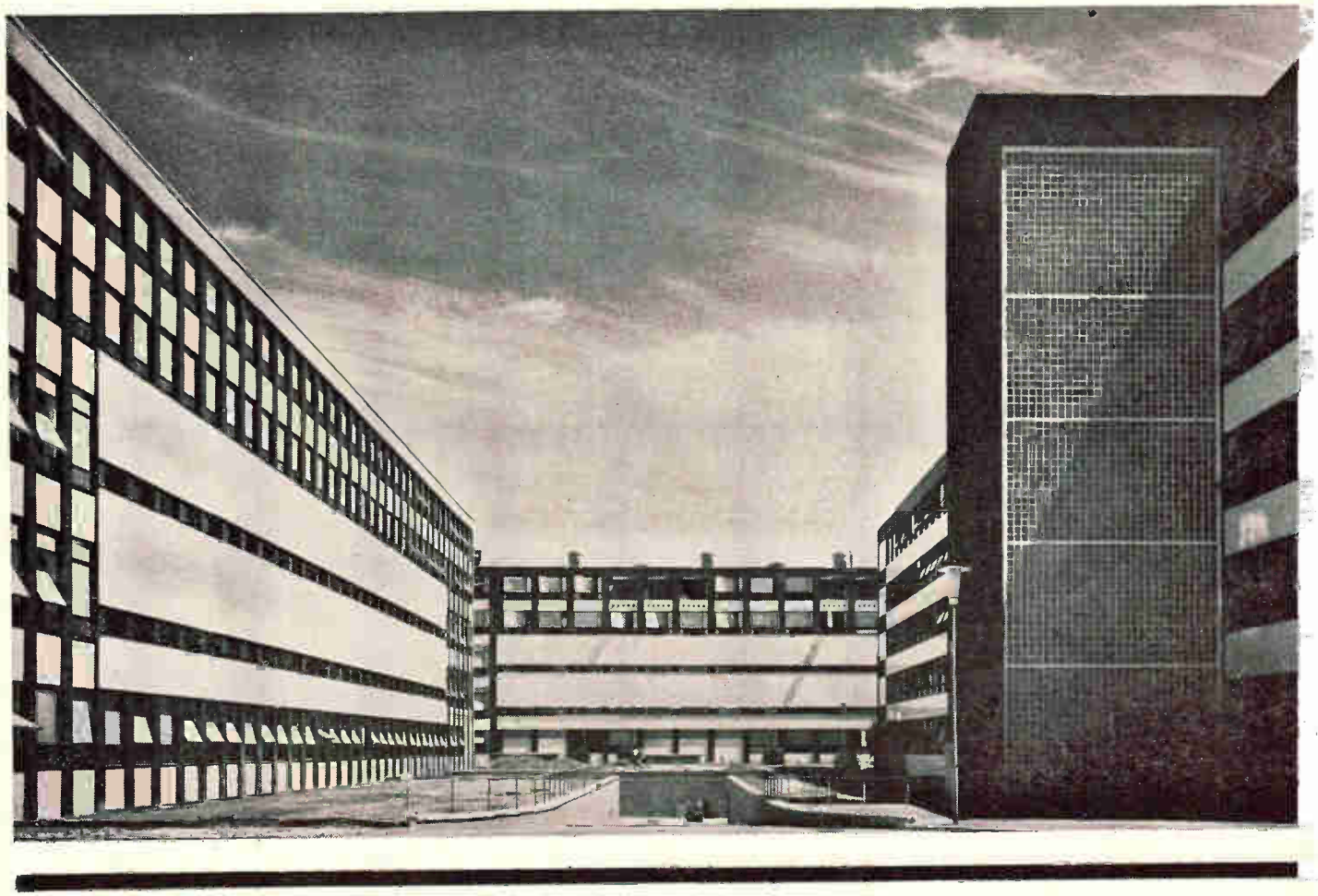

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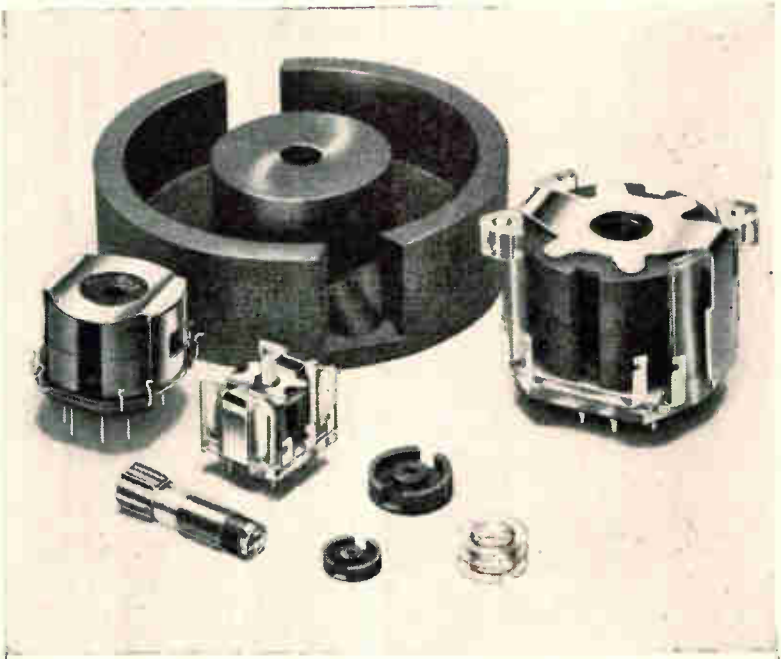

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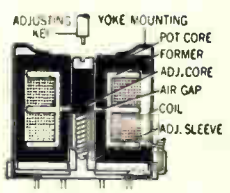

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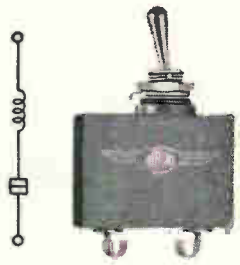
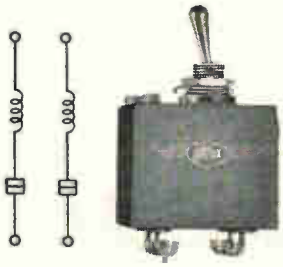
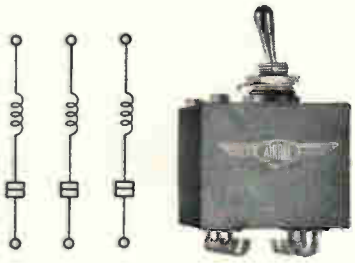


Series AP1 electromagnetic circuit protector provides positive protection in current ranges from 50 ma to 20 amps. It is obtainable with remote contacts to actuate a warning light or signal, when the main contacts open.



Two pole AP12 protectors guard two independent circuits which may be inter-active. Both circuits open simultaneously should an overload occur in either branch. Trip-free design prevents closing while the overload persists.



The three pole AP112 series protects three individual circuits. Each pole of the 2 and 3 pole protectors may have a different current rating and fast, medium or slow delay action. All AP protectors exceed MIL-C-39019 specs.

Airpax Types 175-13 and 300-13 electromechanical choppers (60 and 400 CPS respectively), are packaged for PC board mounting. Both have SPDT, BBM contact action with 10 V, 1 ma ratings. Noise is low, life is 5000 hours.

Model 36A is a micro-midget electromechanical chopper having a drive voltage of 6.3 V at 60 CPS. Noise is 6 uv max. into 1 meg. Weighing 21 gr., it occupies a space of only 0.455 cu. in. The 46A uses a 400 CPS drive.

Type 2557 (60 CPS) and Type 2757 (400 CPS) are DPDT high performance, low noise electromechanical choppers with drive leads out the top. Long life (5000 hours), high shock (100 G) and temp. range to 100°C.

The new Ugon relay is a sub-miniature, highly sensitive device suitable for transceivers, missile guiding heads, aircraft equipment and similar uses where fast response, light weight and small volume are demanded.

Airpax relay R40-1 has SPDT contact action, with an operate and release time of 2 milliseconds max. Life is in excess of 100,000 operations, dry circuit condition. Coil power dissipation is 350 milliwatts. Leads are spaced for PCB.

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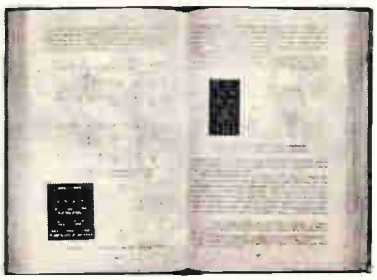

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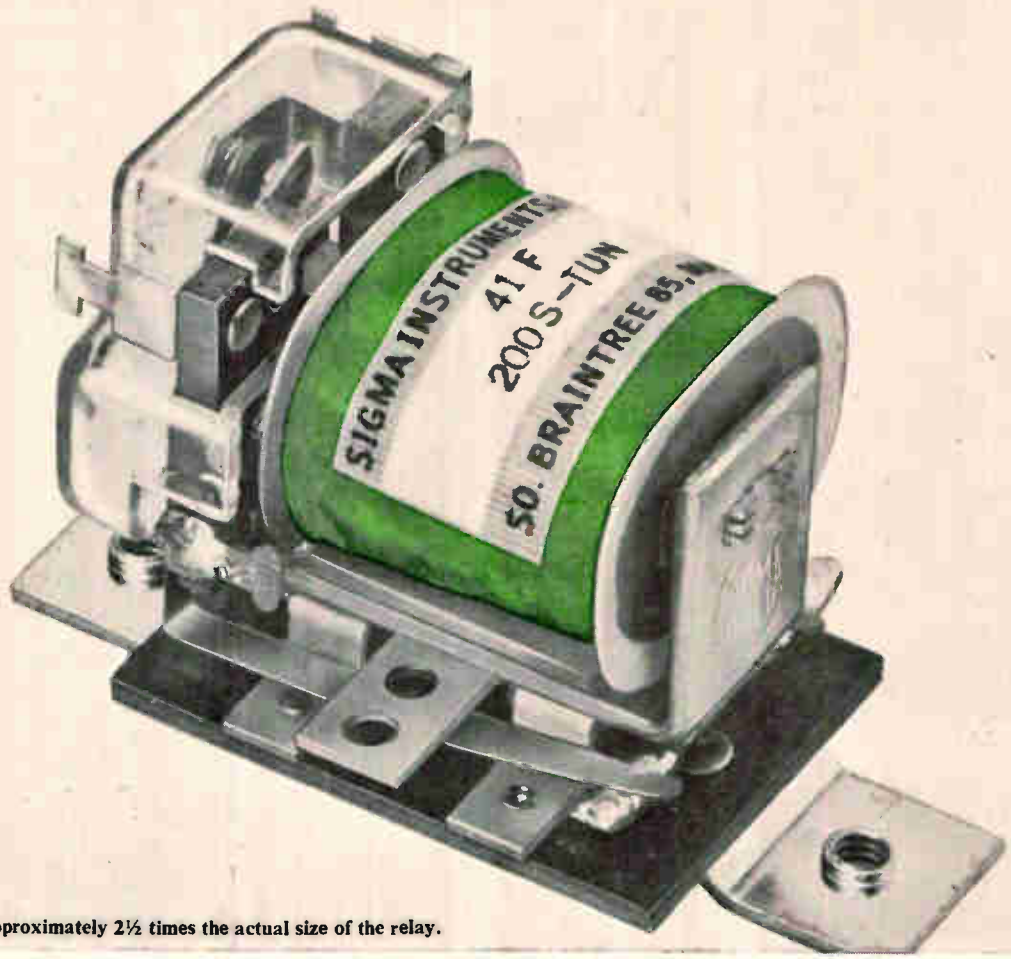
Insulation of MYLAR® on Sigma relay increases thermal range 50% ...costs remain the same



This photo is approximately 2½ times the actual size of the relay.

Sigma met the problem of increased thermal specifications by switching to insulation of MYLAR* polyester film. With its higher temperature rating, MYLAR upgraded the thermal range of Sigma's Series 41 relay by 50%. This surpassed the specifications required and broadened applications for the relay.

In addition, the switch from acetate film to MYLAR in other relays made by Sigma Instruments, Inc., of Braintree, Massachusetts, also meant:

- **a smaller coil,** since the high dielectric strength of MYLAR permits the use of thinner, more pliable film.
- **longer life** is designed into the coil by the use of MYLAR, which does not dry out or change characteristics with age.
- **insulation costs remain the same,** because less MYLAR is needed for equivalent dielectric strength, as compared with most other insulators.

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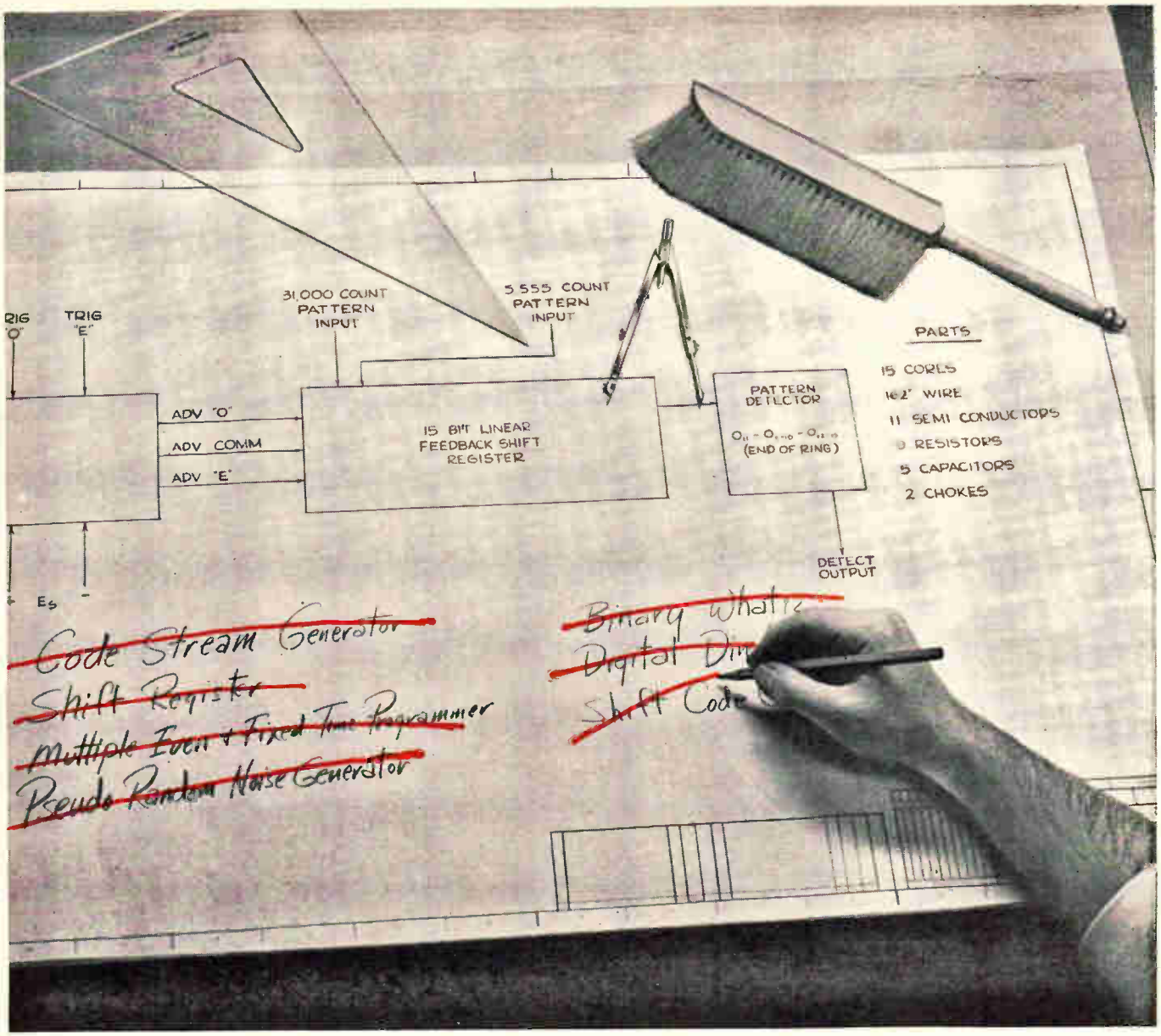

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Probing the News

Meeting report

Putting integrated circuits in their place

Users at the Solid State Circuits Conference weren't drawn into the hybrid-vs.-monolithic controversy. Cost and performance still determine their choices

The keynote session on "Hybrid vs. silicon monolithic circuits" at the Solid State Circuits Conference in Philadelphia last month was billed as controversial. It was—for manufacturers. Users didn't seem to take sides; their interest was more in how to put integrated circuits into systems than in what kind they were.

Peter B. Myers, director of research and development for the Defense Systems division of the Bunker Ramo Corp., summed it up for the users. He told an interviewer: "Hybrid and monolithic integrated circuits are supplementary, not opposing, technologies. It doesn't cost a user anything to stay uncommitted, but it can be very expensive if you lock yourself in with a choice."

I. The criteria

Though the conference management did its best to keep the pot boiling, most users indicated that their decision is still based on two age-old engineering criteria: cost and performance. Two rules of thumb emerged:

- Cost: In general, monolithics are preferred when large volumes are needed (unless the user can afford an expensive mechanization program). If volume requirements are low, hybrids usually have the edge when monolithics are not available as off-the-shelf components.
- Performance: Since monolithic integrated circuits cannot perform well enough for many of today's applications, either hybrid integrated or discrete circuits are sometimes mandatory.

Jobs for hybrids. Throughout the conference, the limitations of monolithic integrated circuits had speakers spotting specific applications for hybrid components.

- Item. "Hybrid integrated circuits are desirable in low power applications because they allow the use of the big capacitors and resistors that are needed"—in an informal evening session on micropower circuit technology.
- Item. "You have to use hybrid integrated circuits in a precision digital-to-analog converter because you need resistors held to tolerances of one-tenth of one percent."—Professor James B. Angell, Stanford Electronics Laboratories, Stanford University.
- Item. "Hybrid circuits look attractive in microwave applications because they are easier to package."—Jack Kilby, manager, Texas Instruments, Inc.
- Item. "At circuit speeds around one nanosecond, discretes are still favored because lead length and parasitics make packaging tricky."—Rex Rice, Semiconductor division of the Fairchild Camera & Instrument Corp.

Rice contends that the main reason hybrids are now favored for the difficult circuits—especially linear circuits—is "inadequacies in monolithic-circuit processing techniques."

"Integrated-circuit manufacturers have had to concentrate their

Comparing hybrids and monolithics . . .

Technology Parameter	Thick/Thin Film Hybrid	Monolithic Diffused	Monolithic Deposited
Resistivity (ohms per square)	10–100K	100–300 Also 2–3	50–400
Resistor Values (ohms)	10–500K	50–20K	10–100K
Tolerance	½–2%	10–30%	8–20%
Temp. Coeff. of Resistance. (ppm/°C)	10–300	1000–3000	40–150
Roll-Off Freq.	1–2 Gc	10–100MC	0.5–1Gc

Technology Parameter	Thick/Thin Film Hybrid	Monolithic Diffused	Monolithic Deposited
Capacitors (pf)	1–100,000	10–400	10–1,000
Cap. Tolerance	½–10%	15–20%	2–20%
Temp. Coeff. of Capacitance. (ppm/°C)	50–400	1000	50–200
Inductors (μh)	To 10	None	.....

Technology	1 Gate/Package Monolithic	1 Gate/Package Hybrid	3 Gates/Package Monolithic	3 Gates/Package Hybrid
"Chip Cost" (Unit cost)	1	3	2	9
Packaging Cost	15–20	6	24	7
Total Cost/per circuit	16–21	9	9	5

talent on high-volume digital circuits," Rice, an advocate of monolithic circuits, explains. "Now that these lines have been established, we can turn our engineers to linear circuit design and processing. You will now see a very drastic acceleration in the rate at which monolithics take over functions other than digital."

At one session on computer memories, engineers from Motorola, Inc., Norden division of the United Aircraft Corp., and Texas Instruments all reported that their companies were developing lines of monolithic memory drive and sense circuits—types of circuits that now use hybrid technology.

II. In defense of hybrids

Probably the most eloquent advocate of the hybrid integrated circuit was E. M. Davis, manager of component development at the International Business Machines Corp. Davis, who had made the first technical presentation describing the hybrid components in IBM's System 360 computer series last summer, said monolithics are so popular largely because of their potential for reducing the size of components and costs. But he insisted that such potential lies far in the future; today hybrids are superior. "Only hybrid techniques permit the economical production of many of the difficult circuits found in large systems," he said.

No other way. To prove his point, he compared the range of component values available today [see first two charts on p. 125]. Hybrid techniques allow a broad range of resistors and capacitors. Inductors to 10 microhenries are also possible.

He also cited two useful hybrid integrated circuits that cannot be built economically by monolithic techniques at present. One is a four-input gate which operates at 1½ nanosecond speed; the other a memory sense amplifier whose output of 40 milliamperes is controlled to 40 milliamperes. Hybrid circuits were responsible for the speed of the gate and the precise control of the amplifier, he claimed.

Cutting costs. Hybrid circuits can be less expensive than monolithics, primarily because they are easier to package [see third chart on p. 125]. The development of glass passivating techniques drastically cut the cost of packaging by eliminating the hermetic seal and header normally required. Both IBM and the Burroughs Corp. [see p. 75] can now coat active element chips with glass.

Packaging, almost everybody at the conference agreed, represents by far the biggest portion of costs. Davis pointed out, "Silicon chips which contain one, two or three transistors are so inexpensive, the cost of packaging a circuit is more than the cost of implementing it."

Because the ceramic substrate of the hybrid circuit is always bigger than the monolithic silicon chip, it is easier to connect leads. During the panel session, a member of the audience offered the opinion that IBM's packaging technique for System 360 components put hybrid integrated circuits far ahead of monolithics for practical applications.

Making a choice. Davis concluded his presentation with a rule of thumb for choosing hybrid or monolithic integrated circuits. The key, he said, is the ratio between the number of active and passive components. If the ratio is small, hybrid integrated circuits are probably preferred; if more active elements are needed, the choice is probably for monolithic.

III. The case for monolithics

Following Davis to the podium was E.A. Sack of the Westinghouse Electric Corp.'s Molecular Electronics division, speaking for monolithic integrated circuits. He started by attacking the high cost of automation required to build hybrid circuits in volume. After seeing the film Davis showed to illustrate how IBM System 360 components are built, Sack had quipped, "All of you who have $100 million for automation equipment don't have to hear any more."

Sack's argument was based on two predictions. He forecast early improvement of the four major batch processes by which most monolithic integrated circuits are produced; this will cut costs by increasing yields, he said.

And he predicted rapid acceleration of a trend to incorporate more devices on a single chip. Monolithic techniques are compatible with such a trend; hybrid circuits are not compatible. Sack thinks costs of

monolithic integrated circuits will be cut by 80%.

Wave of the future. To Sack, the wave of the future is the multigate functional block. He said, "In integrated circuits, we get transistors for less than one cent apiece . . . With active elements practically free, we'll see a lot of startling designs." One device he believes the industry is ready to offer is a 30-gate add-subtract on one chip in one package. Currently, several companies offer devices which have six gates on a single chip.

Though almost everybody agreed with Sack's thesis, the stumbling block may be packaging. Gordon Moore, director of research at Fairchild's Semiconductor division, one of the panelists who answered questions after Davis and Sack spoke, called packaging "about 90% of the cost."

IV. The supply problem

One questioner asked if much of the defense of hybrid circuits weren't academic; few companies supply them, he noted, and one of the biggest makers, IBM, won't sell them to outsiders. Although no panel member cared to rebut the statement, evidence is building up that the number of suppliers of hybrid circuits is about to increase.

At the IEEE show later this month, for example, both Burroughs and Varo, Inc., will introduce new lines of hybrid circuits. The General Instrument Corp. is preparing a line of hybrid components for consumer devices; only production problems will block its introduction at the show. These companies will join such concerns as the Sprague Electric Co., (which builds custom circuits by hybrid techniques), Digital Equipment Corp., CTS Corp., National Semiconductor Corp. and Hughes Aircraft Corp., which already supply hybrid circuits.

After the session, Prof. Stephen Angello of the University of California at Santa Barbara offered an opinion that the two technologies were slowly merging. He said, "Hybrid makers are using more monolithic techniques and the monolithic makers are going to have to use more hybrid interconnection techniques. Eventually, we'll have a difficult time distinguishing between what is a monolithic and what is a hybrid integrated circuit."

Direct digital control systems, biomedical engineering in spotlight

Both rapidly-emerging technologies will be subjects of conference symposia; DDC hardware to be described

The first experiment in direct digital control for industry was carried out at a Monsanto Co. plant in Texas City, Tex., only three years ago. Minnesota Mining and Manufacturing Co. offered the first commercial system a year and a half ago. Yet DDC has come of age; 18 firms will take part in a three-session symposium at this year's IEEE show and the emphasis will be on hardware currently on the market.

Biomedical engineering has also bloomed into an important field for electronics; but at present the field is at a plateau. Two sessions will be held in a Symposium on Artificial Organs, Prosthetic Devices, and Sensory Aids. The aim is to survey achievements and future needs in the hope of attracting new technicians to the field, which needs new ideas.

I. Turn to digits

Direct digital control systems replace analog systems with a digital computer. The computer can handle a number of control loops on a time-sharing basis; it provides both monitoring and closed-loop control ranging from simple on-off set point operations through the optimizing of an entire industrial complex.

Considering their scope, DDC systems are not expensive, which is one reason that they have gained acceptance so quickly. Another is that analog systems and digital supervisory optimizing systems have definite limitations. DDC is simpler and requires less-complicated programing than supervisory.

Telling the world. The DDC sessions are likely to provide most of the public information on the subject this year, because new users of the systems do not yet have much to say. Dr. Theodore J. Williams, senior engineering supervisor at Monsanto and the man who did more than anyone to develop DDC, told Electronics that potential users would find the systems already available impressive. Dr. Williams indicated that the user would have to match the

Program for direct digital control sessions

The Direct Digital Control symposium at the IEEE show will be held in three sessions. At the first:

Ferranti Ltd. will discuss its hardware and experience with DDC. The company recently sold six systems to Imperial Chemical Industries Ltd. in England.

Foxboro will report on DDC experiments. This company gets computers from the Digital Equipment Corp. and supplies complete systems; it has sold at least two, one of which is now being installed at a Standard Oil Co. of New Jersey plant.

Westinghouse, which has its own computer, will talk about its application to DDC. The company already has sold a two-computer system to Monsanto.

IBM will discuss its control system for DDC. It announced hardware last year.

Honeywell, which also has its own computer—and uses thin-film components in its system—will talk about what it feels is a new approach to DDC. The company recently sold a system to the Shell Oil Co.

Digital Equipment Corp. will provide information on closed-loop digital control of a nuclear reactor. This company uses a type of chip circuitry in its computer; it is supplying Foxboro as well as selling its own full system.

At the second session:

Bunker-Ramo will dicuss its system, which uses a computer built by Computer Control Corp. That company will sell the computer to any systems builder.

General Electric may introduce an integrated circuit computer for DDC. GE claims that its integrated software-hardware design provides a "total systems approach" to DDC.

Leeds & Northrup will discuss its system, which employs a computer built by Scientific Data Systems.

Control Data Corp. will give a paper on "The Heart of DDC."

Systems Engineering Laboratories will discuss preset and digital control of a steel mill. The company is expected to show a new DDC system.

At the third session:

E-A Industrial, which is linked to the British firm, Elliot Automation, will discuss its limited multi-level system, which uses a simple digital computer. The system cannot carry out some complex tasks, such as adaptive or feed-forward control. Its design permits strict replacement for analog controllers.

Fisher & Porter will talk about a new DDC system, of limited capability, to replace an analog system.

Minnesota Mining and Manufacturing will discuss a flexible DDC system.

Data Systems, which was recently acquired by Union Carbide, is expected to offer an integrated DDC system with attractive specifications at a low price. Union Carbide will use the equipment, and also make it available to other users.

Taylor Instruments will talk about a single-loop two-mode system which is a digital replacement, loop for loop, for an analog system, rather than a multiplexed system.

Allis-Chalmers and Electronic Associates, Inc. listed earlier as participants, have withdrawn.

speed and inventiveness of the manufacturer, who has come from nowhere in three years. "DDC gives both parties a chance for innovation and application which should revolutionize the field of process control," he added.

II. Four approaches

Essentially, the papers presented will deal with hardware and problem-solving. Companies presenting them divide into four groups:

- Those using DDC to enter new markets. Examples are Minnesota Mining and Manufacturing, Systems Engineering Laboratories, Inc., Union Carbide Corp. with Data Systems, Inc., and E-A Industrial Corp. All make complete systems.
- Those adding DDC to their line of process control systems. All offer complete systems, and most make their own computer main frames. Examples are Ferranti Ltd., of Britain, International Business Machines Corp., Bunker-Ramo Corp., General Electric Co., and Control Data Corp.
- Old-line industrial instrument makers, such as Leeds & Northrup Co., the Foxboro Co., Honeywell, Inc., Taylor Instrument Co., and Fisher & Porter Co.
- Companies building computer main frames, the heart of DDC systems, but staying away from end-use systems. These include Digital Equipment Corp., Computer Control Co., and Scientific Data Systems. The latter, for example, sells main frames to Leeds & Northrup. These companies consider input-output systems to be money-losing operations. Most are eager to supply more than one manufacturer.

III. Mixed disciplines

Biomedical engineering draws on a number of technologies other than electronics; among them are chemistry, hydraulics, pneumatics —and, of course, medicine. This interrelationship of many disciplines is shown very clearly in the papers to be given at the symposium on artificial organs, prosthetic devices, and sensory aids.

Among subjects of interest are:

- A booster heart that has been connected to conscious dogs for 41 hours continuously. Dr. Adrian Kantrowitz of the State University of New York College of Medicine will describe his device, which he calls an auxiliary ventricle. It provides long-term assistance to a failing heart. The booster is timed by an electrocardiogram wave which triggers an electronically-

Space electronics

Beefing up moon photos

Computer technique perfected on the Ranger 7 shot helped improve resolution of Ranger 8 pictures

By William B. Wallace

Los Angeles Regional Editor

When Ranger 8 swept across the face of the moon into the Sea of Tranquility Feb. 20, its low angle of descent (about 42°) caused blurring and reduced the resolution of the pictures it sent back to earth. Scientists were deliberately trading resolution quality for a gain in other factors—such as getting a better three-dimensional effect. That they were able to make the swap was due in part to Ranger 8's better cameras [Electronics, Feb. 22, p. 60] and in part to a computer technique of improving resolution developed by Robert N. Nathan of the Jet Propulsion Laboratory.

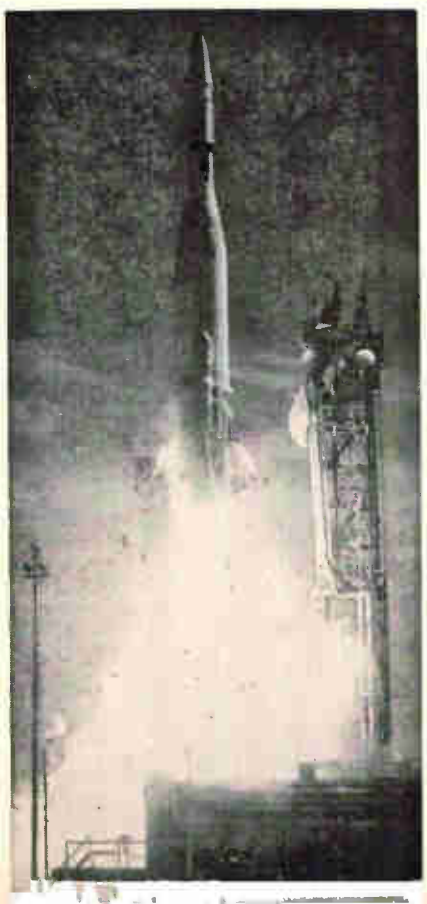
Rocket bearing Ranger lifts off from Cape Kennedy ▶

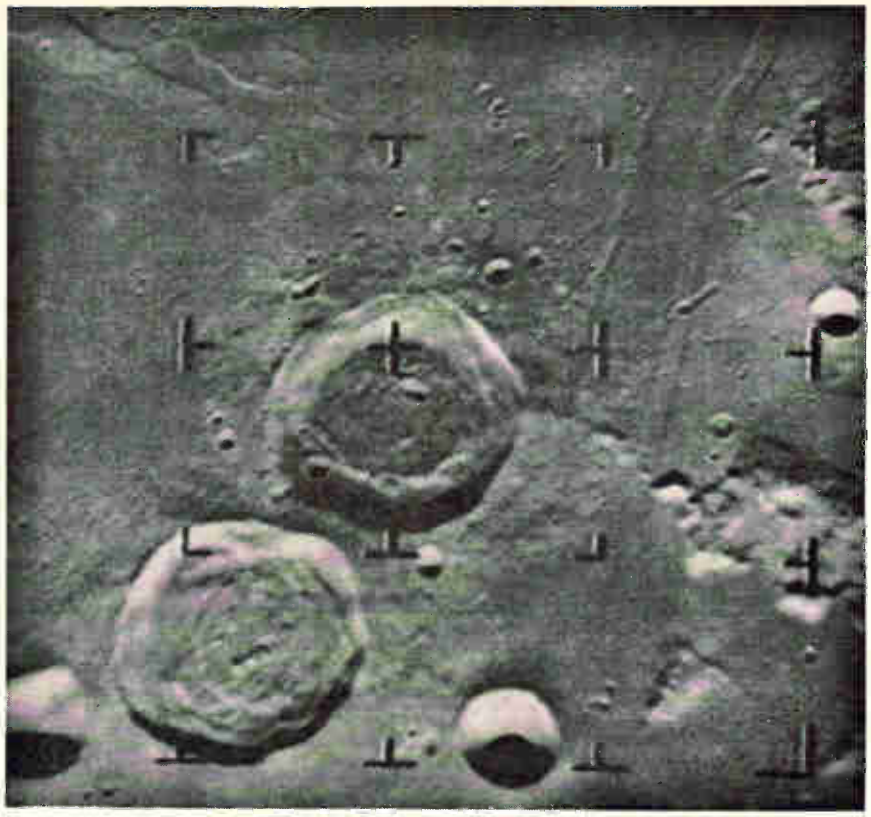
controlled solenoid valve on a compressed-air tank. A number of materials, such as Silastic 372 reinforced with Dacron, and polyurethane coated with other materials are being tested to prevent clotting problems. A battery-operated power unit has also been developed, to bypass the air tank, and is being evaluated.

▪ The cybernetic aspects of medical orthotic (assisting) and prosthetic (replacement) research will be discussed in a two-part paper by Dr. R. W. Cornell of the University of New Hampshire, and Dr. J. B. Reswick and Dr. L. Vodovnik of Case Institute of Technology. An overview of man and machine control theory will be followed by a detailed study of the Case Research Arm-Aid, a basic research tool that supplements arm muscles and has clinical applications far in the future.

This is the first time the cybernetic concepts of the arm-aid will be reviewed. It uses a numerical control system similar to some machine tool controls.

The paper will also discuss an artificial neural bypass system with which a patient who has lost limb control can use shoulder motions to provide information from useful to paralyzed muscles.





Ranger 8 moon photo was taken from 151 miles up.

Dr. Nathan is the man who wasn't satisfied with Ranger 7's pictures—even though they were five times better than any moon photos ever taken [Electronics, Aug. 10, 1964, p. 17]. After some setbacks, he proved his point by doubling the quality of those pictures. And when Ranger 8 came along, his techniques were good enough so that the new pictures could be computerized as they came in.

The project began 3½ years ago, when Nathan first saw the Russian pictures of the moon's far side. "I was certain we could do much better," he says. "It was quite clear that extraneous signal noises had distorted their pictures and severely handicapped analysis."

The problem was to attenuate the noise interference. The solution bore some additional advantages.

Ranger 7 carried six cameras: two full-scan, f-type and four partial scan, p-type. Both types contain a one-inch vidicon; but the f-type has 1152 scanning lines in an 0.44 square inch format and

Dr. Robert Nathan (left) and Robert Selzer of the Jet Propulsion Laboratory check computer output of moon photo resolution technique.

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the p-type cameras scan 300 lines in an 0.11 inch format. One f-type and two p-type cameras have 75 mm f:2.0 lenses; their light sensitivity was improved in Ranger 8 by increasing the signal intensity. The other lenses, 25 mm f:0.95, were unchanged in Ranger 8.

I. Point by point

The camera signals come directly from the tape in combined form. They are demodulated, and each channel is digitized. The computer sees a partial-scan picture as 300 lines with each line divided into 300 points so that the resultant computer view of the picture is similar to a newsprint half-tone engraving.

The big picture

Some scientists doubt that it will be possible to determine the nature of the moon's surface from any pictures—no matter how good. After studying Ranger 7 pictures, the consensus was that the surface would support a landing; with Ranger 8's 7,000 pictures as additional evidence, the experts aren't so sure. The initial consensus is that the surface may be volcanic—and therefore very dangerous—under a dust-like cover. Dr. Gerard P. Kuiper of the Lunar and Planetary Laboratories at the University of Arizona says, "Ranger 8 pictures indicate to me that the surface may be a frothy material; however, there is no way of determining if it is hard underneath. We will have to wait for the Surveyor mission—or even Apollo."

Surveyor is a soft-landing probe. Apollo will be manned.

The computer converts the 90,000 points that make the picture into 90,000 six-bit words. This provides 64 possible degrees of shades between dead white and black for each point. A new tape of the digitized signal is made and then processed through a link film recorder.

When the system was first used with Ranger 7 pictures, the results were disappointing; the quality of the picture appeared to decrease rather than increase. Close examination, however, revealed that an increase in picture resolution had brought up noise interference not discernible in the original cathode ray tube reproduction.

II. Noise problem

Nathan analyzed the interference pattern and determined that it was caused by an oscillator in the vidi-

con erasing system of an adjacent camera. Through computer analysis, he developed the noise pattern and was able to produce a picture of the noise alone. By nulling the pattern signal, he was able to remove the noise from the picture, and thus achieved the improvement he sought.

Other noise intereference that can be removed or greatly reduced includes the mesh noise that is detectable in calibration pictures, ghosting noise caused by retention of previous image on the vidicon, and clamp-error noise causing a shift of intensity for the whole video line. The distortion-correction crosses and other such fiducial marks can also be removed.

The digitized tape might save otherwise lost pictures. It will be much easier to find the line sync in a weak signal. If a picture should fall out of sync and be ripped into unintelligible confusion, it might be salvagable on the new tape. Correction for photometric distortion caused by nonuniformity in camera sensitivity will be possible, as will correction for geometric distortions caused by non-linear sweep deflection in the camera.

III. Photometric usage

Various photometric functions, such as enlargement of selected portions of the picture or correction of geometric distortion caused by a low angle of picture taking, are possible. A major advantage of computer enlargement over photometric enlargement is the quality of definition. In photometric enlargement, the film grain is enlarged along with the image, and there is a loss of definition. When enlarged by the computer, the beam size of the film recorder remains the same regardless of the enlargement factor.

Although the link recorder has a beam nearly twice the diameter of the RCA recorders from which the initial pictures come, a quadruple enlargement would have half the loss of definition since the enlargement from the RCA picture would have to be made from a photograph of the tube face and the beam width would be enlarged with the image.

Picture contrast can be adjusted if desired, and contrast control can be used to enhance the image if

the range of contrast causes some detail to drop out. By dropping out some of the shade values at either end of the spectrum, the lost details can be brought up at the other end by assigning binary word values to smaller increments of shade. As an example, using full contrast from white to black, seven degrees of shade may appear between two specific shades; with the shifted scale that never reaches full white or full black, 10 degrees of shade may occur between the same two shades.

Desert station tunes in

It's predawn in the Mojave Desert in California; chilly, dry, serene. An 85-foot dish stares silently at the moon, its tracking movement barely perceptible.

The quiet scene belies the electric tension that men feel as they await the moment when an historic threshold may be crossed. Inside a low building in the shadow of the antenna, more than 20 engineers and technicians turn dial and crowd around monitoring machines to await pictures scheduled to be made 240,000 miles away. The images will be sent by three transmitters situated inside a cone-shaped can about the size of a tv camera and tripod, weighing 808 pounds and speeding along a collision course with the moon.

A man wearing a colorful sport shirt yells: "Here comes the first one—it looks good!" It's the start of a 7,000-picture stream, closeup after closeup as the six cameras zoom in on their lunar subject. A cheer goes up; then the crew at the Goldstone Deep-Space Tracking Center settles down to the routine of recording pictures from tv screens.

Those pictures wouldn't have been possible without the down-to-earth engineering at that desert station.

I. Double redundancy

The receiving system, first used in July for Ranger 7's flight to the moon, uses two receivers to pick up the same f-m signal. According to the Radio Corp. of America, prime contractor for the equipment, it's a combination of the two analog signals being transmitted from the two types of cameras aboard the spacecraft.

The combined signal is received, amplified and fed into tape decks, each of which records the signals from both receivers on two different tracks. Thus the single, combined signal from Ranger is recorded in four different places.

In addition to being fed to the tape decks, the amplified signal is fed into a demodulator that separates the two video signals. The signals are processed

Initial experiments make it seem probable that contour maps of the lunar surface can be automatically drawn from the Ranger pictures. JPL experimenters reasoned that the varying shades of gray are related to the slope of the terrain. They hope to be able to establish provable correlation between specific shades and altitude. Several experimental contour maps have been made using this theory; they appear about as would be expected, though there are one or two deviations still unexplained.

n the moon

for framing and synchronization, and fed into two film recorders. Each film recorder consists of a cathode-ray tube, a 35-millimeter strip camera looking at the screen through an image divider, and a Polaroid camera looking at the screen from the other side of the divider. A viewing port is also provided; however, the picture trace on the screen is so slow that initial elements start to fade before the picture is fully traced, and the human eye is incapable of perceiving the complete picture. This is why the Polaroid camera is used to monitor the pictures on the screen.

II. Cameras synchronized

Two full-scan cameras on Ranger are full frame; each picture fills one frame and contains 1,152 lines. Each full-frame camera transmits a picture every 5.12 seconds. One camera erases its vidicon and prepares for the next picture while the other camera scans its vidicon and transmits the picture. Pictures from the four partial-scan cameras are quarter-frame—four pictures fill one frame—and contains 300 lines each. A picture is transmitted every 0.2 second from one of the four partial-frame cameras.

The signals from each partial-scan camera go to a specific quadrant of the cathode-ray screen. The 35-mm strip camera is sequenced to move a frame every fourth picture instead of for each picture, as with the camera on the full-scan recorder.

The main control and tracking site is backed up by a nearly identical installation a few miles away. Across the equator, two other stations in the deep-space network follow Ranger, but without video receivers. These are at Woomera, Australia, and Johannesburg, South Africa.

Ranger telemeters information on 15 variables, including temperature, altitude, power-supply level and positions of solar panels. Its trajectory, velocity, position and maneuver commands are determined at the Jet Propulsion Laboratory in Pasadena and relayed to the stations for transmission to Ranger.

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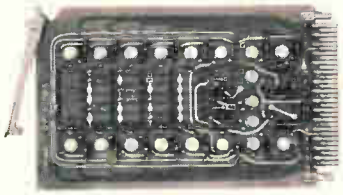

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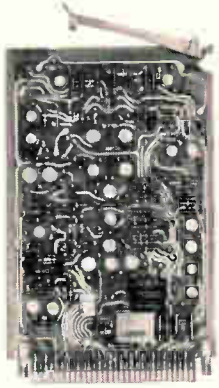

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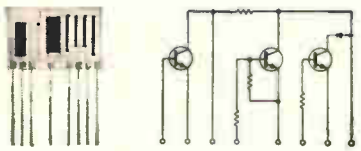

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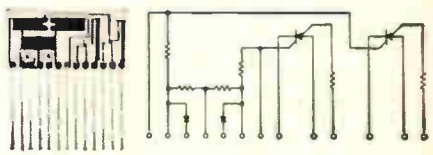
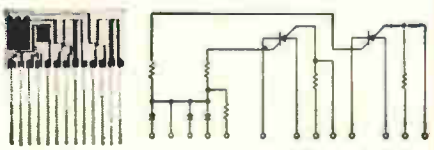
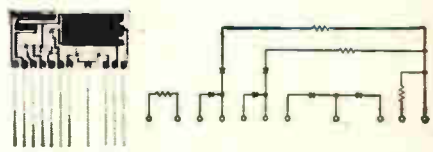


SCS FLIP-FLOP



DECODER LATCH



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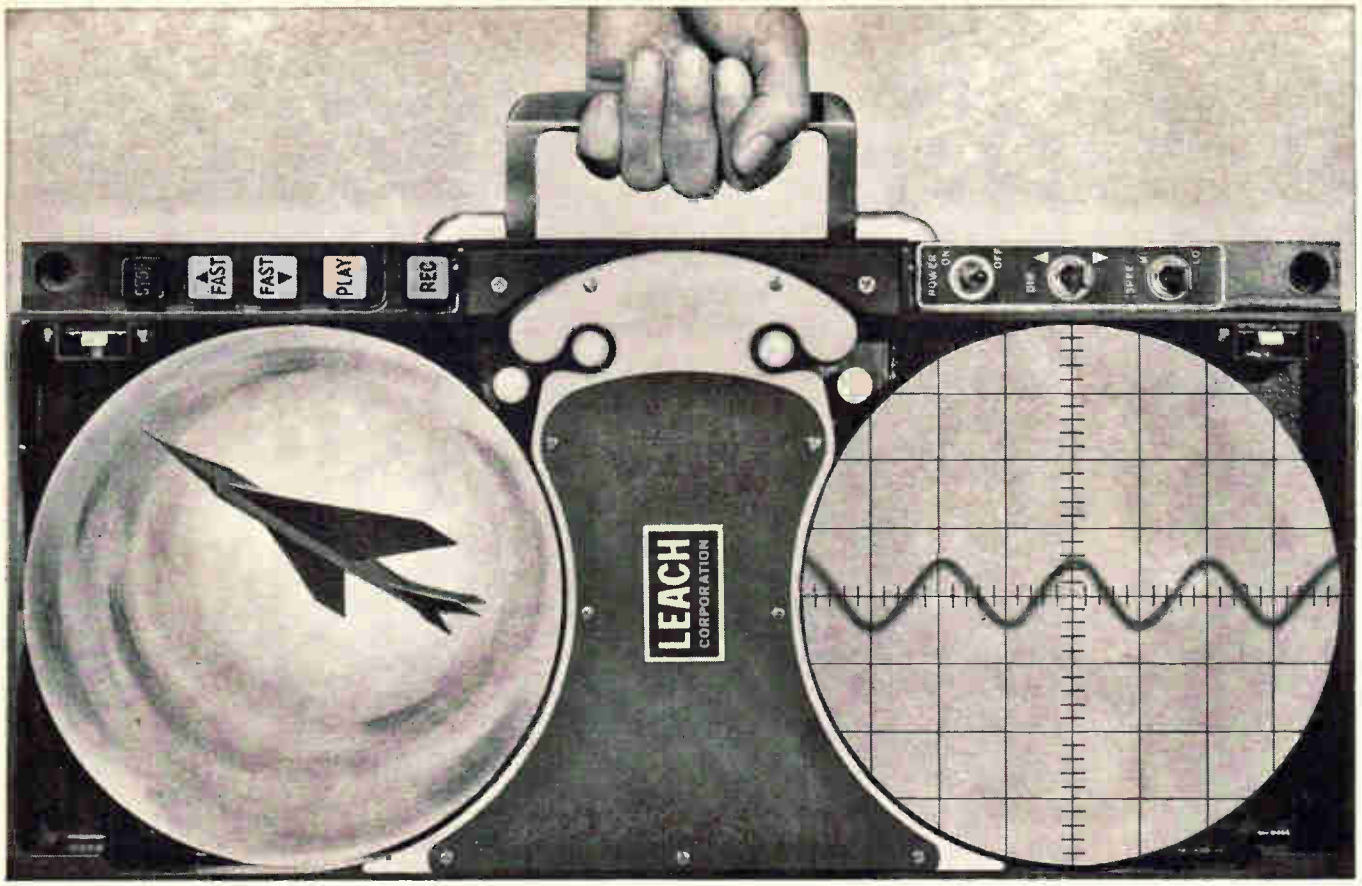

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In any critical application, and especially under extreme environments, the MTR-3200 provides precise recording, storage and reproduction of data. Mil-type components are used throughout the unit, and special features are incorporated such as the dual differential capstan drive to control tape tension. The unit's rugged construction insures overall reliability while providing precise instrumentation quality data. Environmental features: Shock, 10 g - 11 ms ½ sine - 3% p/p flutter; Vibration, 10 g rms random operating - 6% p/p flutter; Flutter, less than 0.5% peak-to-peak at 60 ips; Acceleration, 25 g operating; Temperature, –40°C to 70°C operating; Humidity, 95% operating; Altitude, 150,000 ft. (unlimited for 20 hours).

Versatility is as broad as any application. The unique instrumentation in the MTR-3200 provides up to 14 channels Analog and FM or 16 Digital channels which can be used in any combination. Seven tape speeds are available, and with a simple belt change, are electrically-selectable in speed pairs. Since minimum power is required for operation and it has local or remote control, the MTR-3200 is suitable for any test site. The entire unit is compatible with IRIG standard data reduction equipment.

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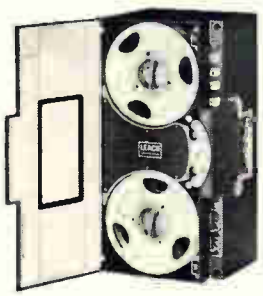
For further information on the MTR-3200 Tape Recorder/Reproducer write to:



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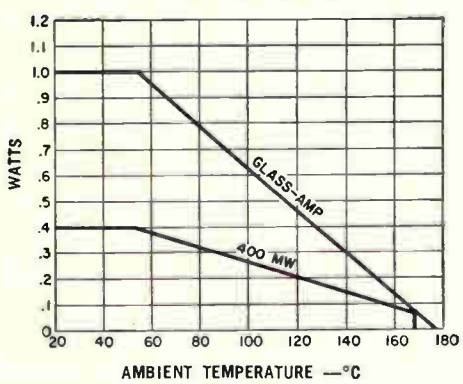

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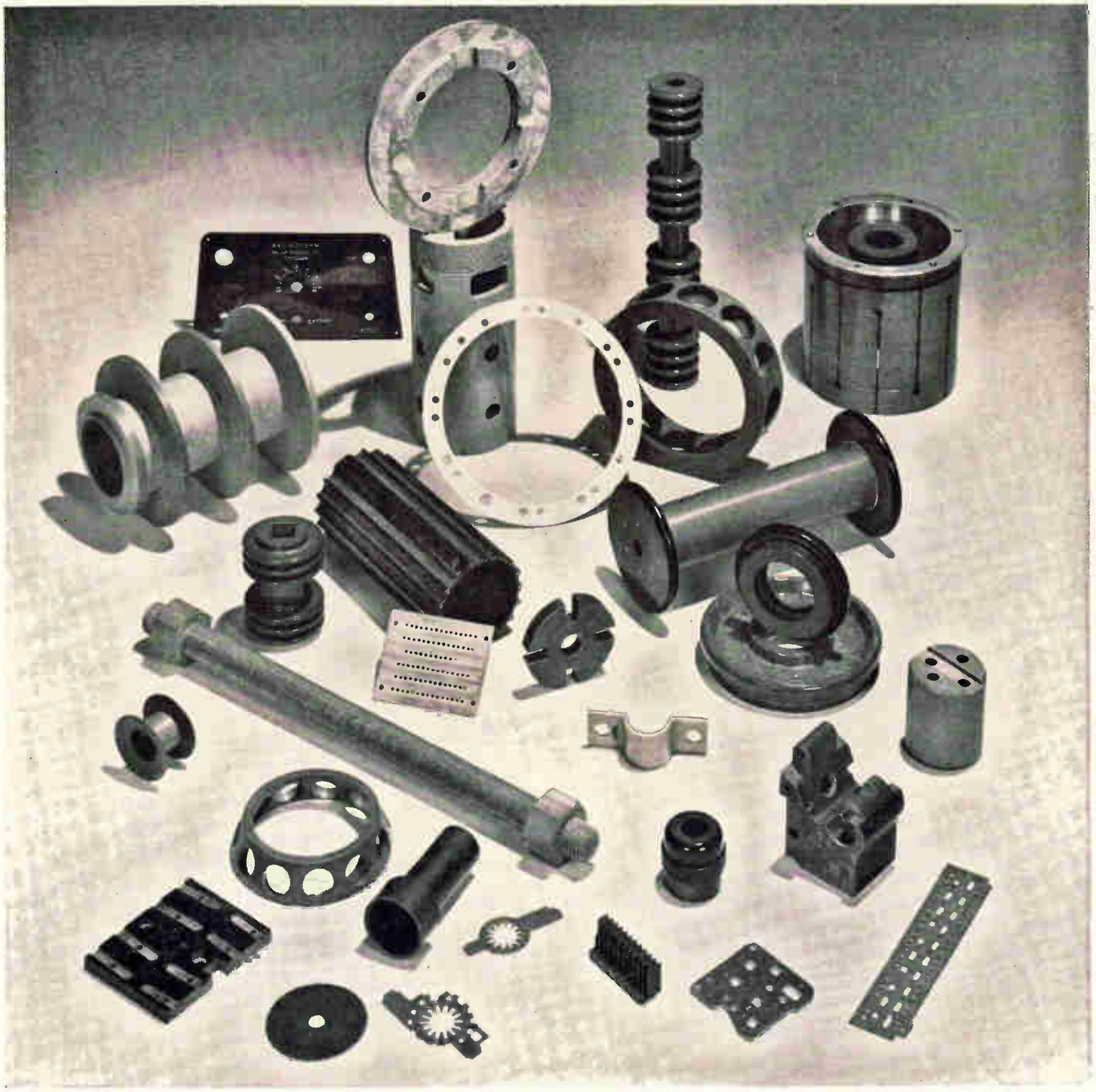

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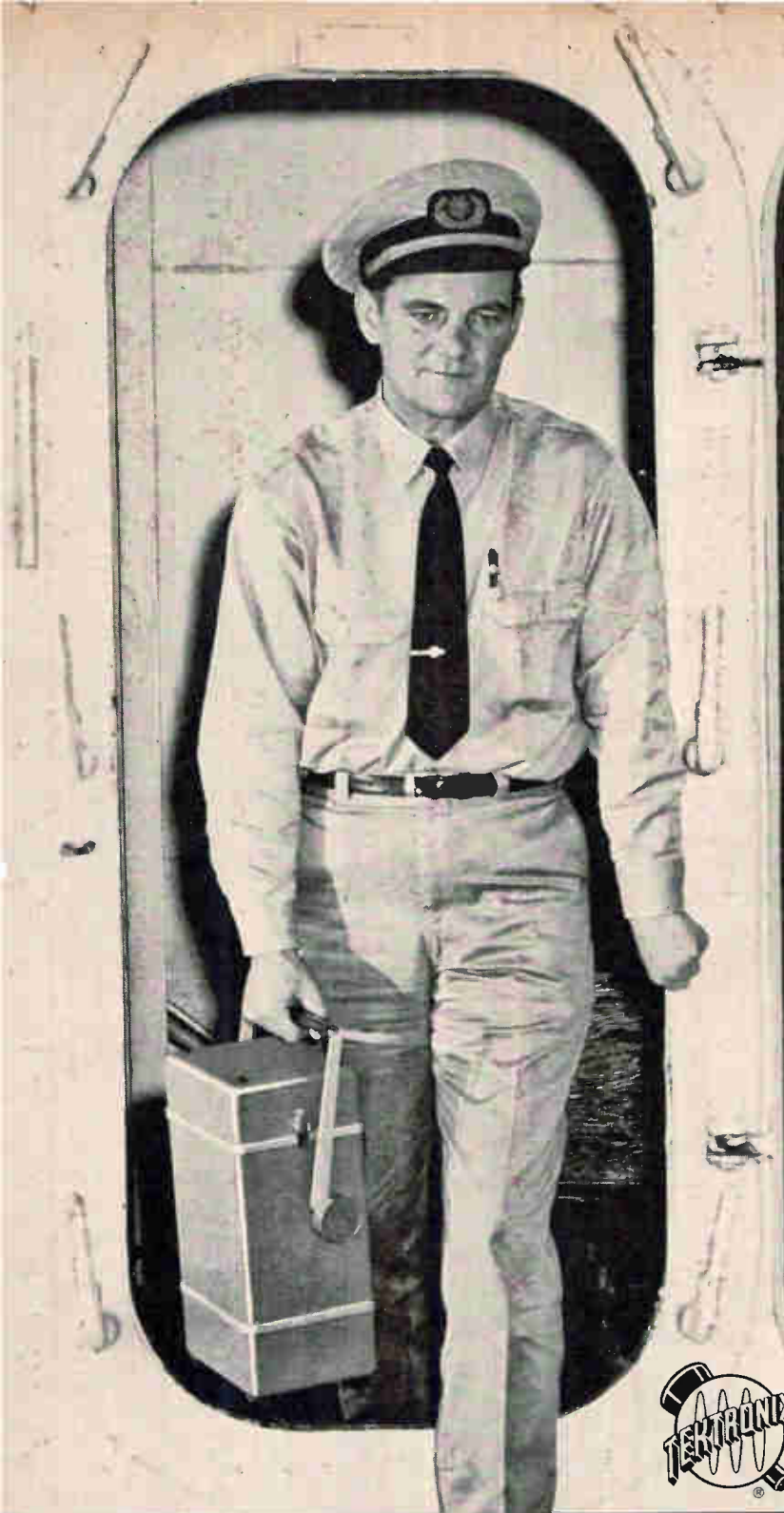

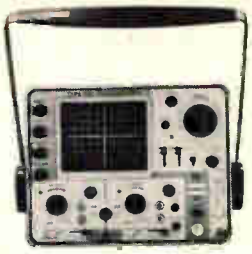

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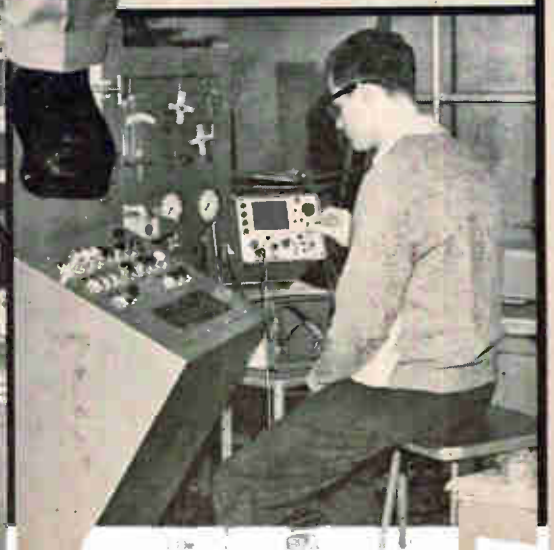

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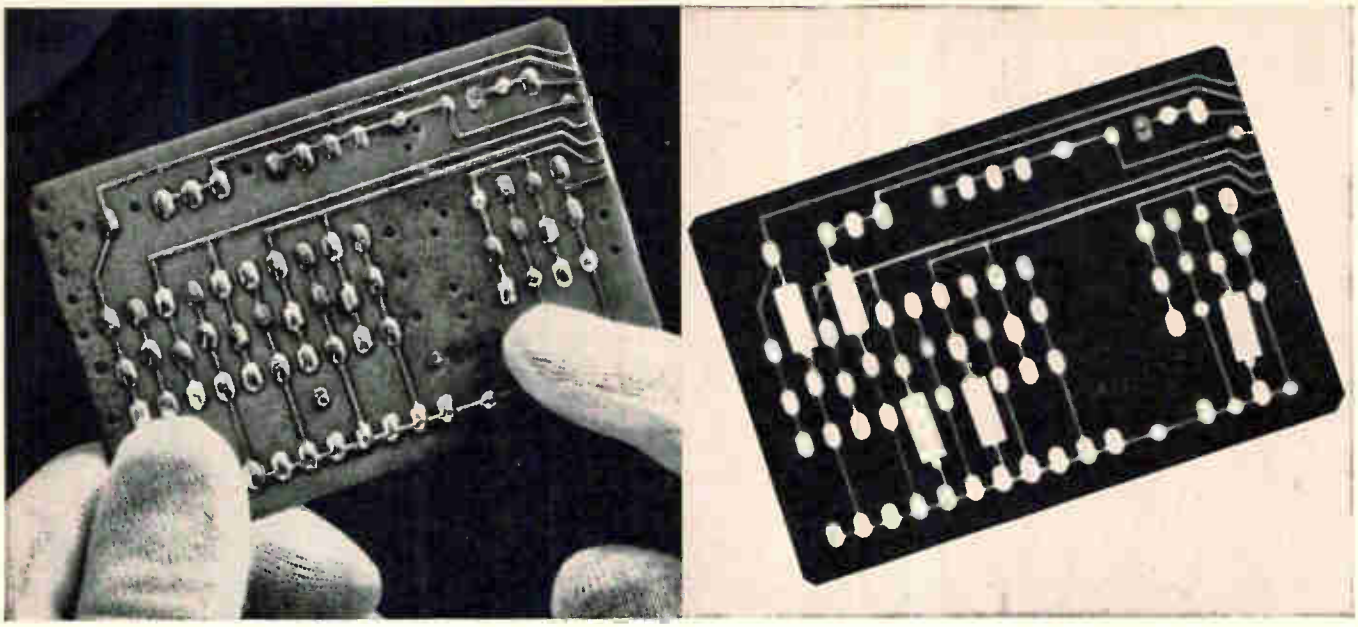

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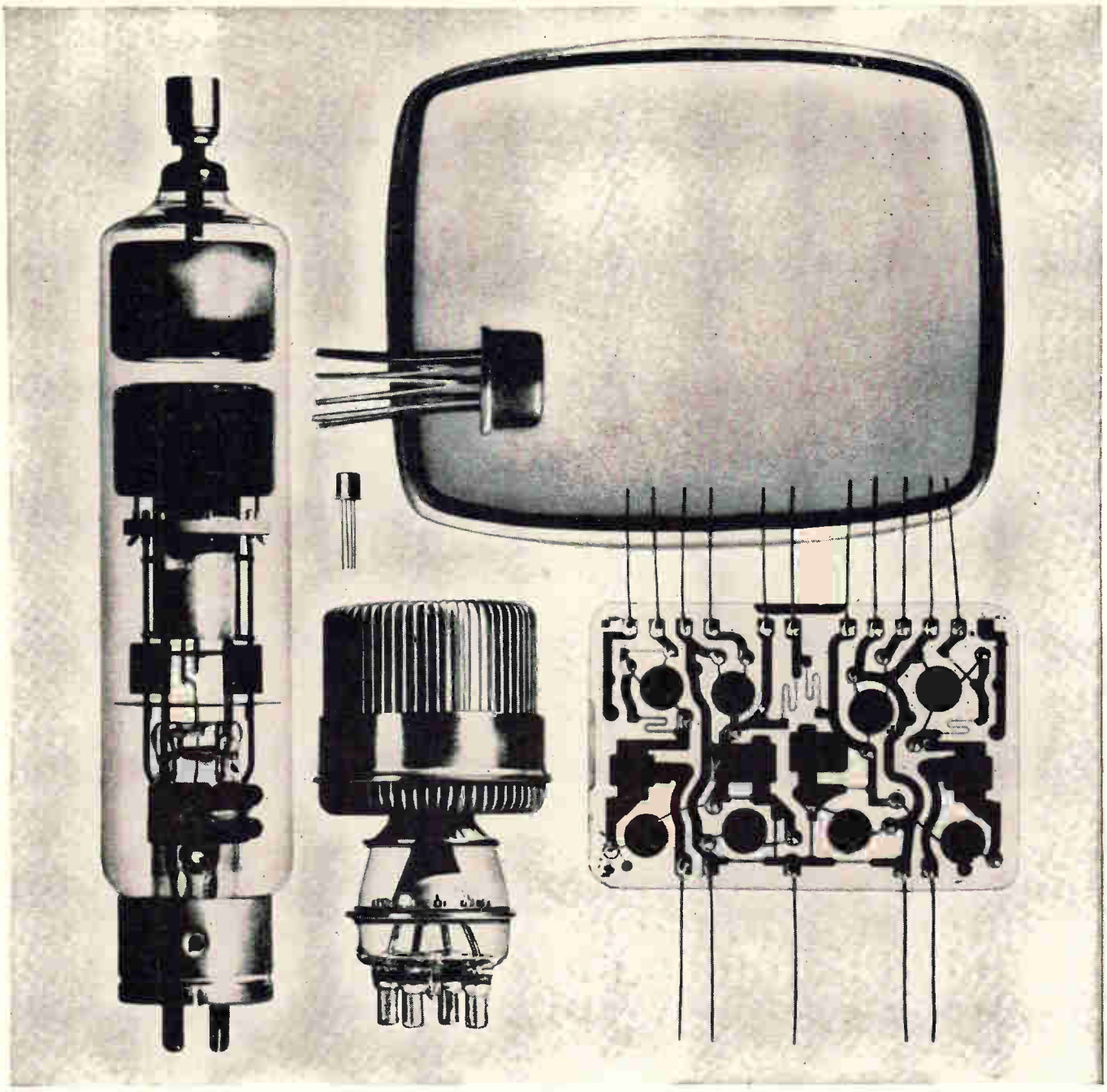

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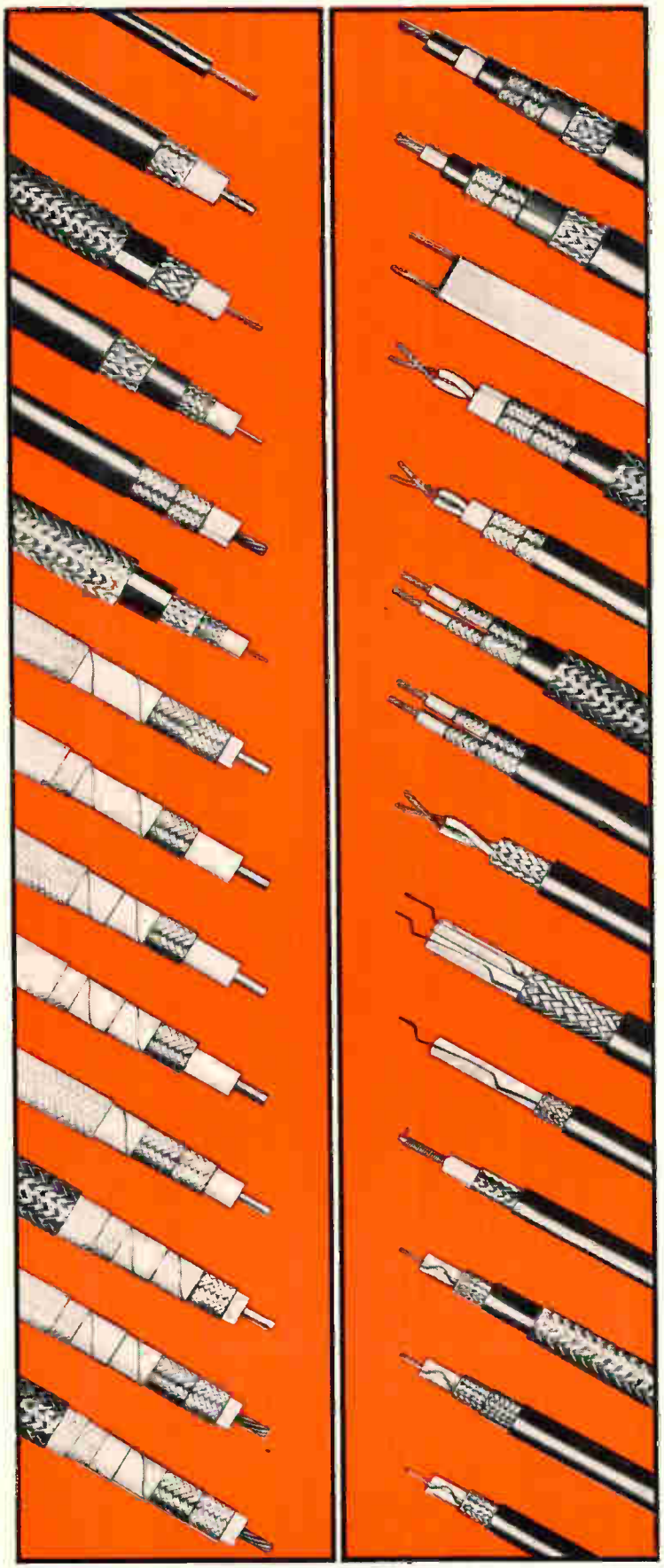

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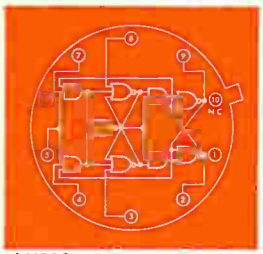

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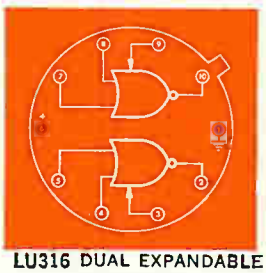

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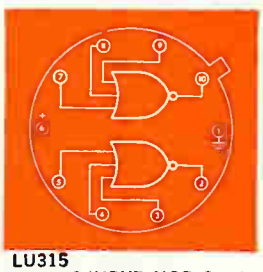

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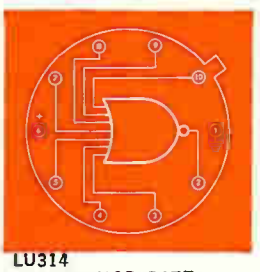

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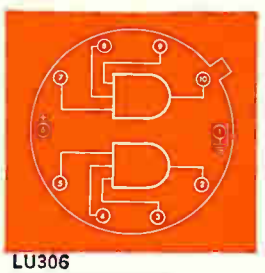

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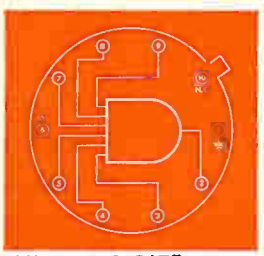

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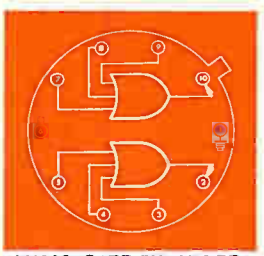

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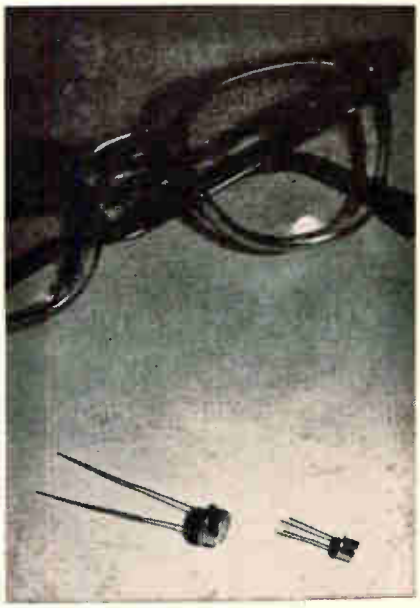
Devices use a new light-sensitive substance that combines CdS and CdSe to realize the best qualities of both

Not too long ago, design engineers wanting to use photocells were faced with a constant dilemma. They had a choice of devices with high response speeds and inadequate stability, or units with good stability and sluggish response. Today, however, the need to compromise between speed and stability for a growing number of applications no longer exists, due to the development of a new light-sensitive material known as 5H. This substance combines cadmium sulfide and cadmium selenide to realize the best features of both materials.

The resulting photocells have the high response speeds of CdSe and the stable memory and temperature characteristics of CdS, as shown in the accompanying comparison table. Identified as the CL705HL, CL905HL and CL905-HLL, the devices exhibit a virtually linear curve for resistance versus light level. Their speed is 1-2 msec (about 10 times that of CdS cells) and memory is 15 times better than CdSe cells.

One industrial example of what 5H cells can do is the case where a manufacturer of teletypewriter equipment is producing a line of teleprinters that use about 54 photocells (one to match each of the keys on the printer keyboard). Since the operation of this printer called for fairly high response speeds, the designers had a batch of cadmium selenide cells built into the equipment. These teleprinters, as they now function, require a warmup period of a half hour to 45 minutes at the start of each day. All of the cells must be brought out of the dark phase of their light history into the light phase before the equipment can start to function. With the use of 5H cells, however, the warmup period is no longer necessary. The manufacturer of the equipment described can build 5H cells into his production runs, and, in addition, could make up a changeover kit or provide some other means of letting purchasers of the units update them.



Another example is the case of a plastics manufacturer who uses a photocell to count the little plastic pieces as they travel from a molding machine into a hopper. The molding, mixing and other machinery has a faster warmup time than the photocells he was using. By changing over to 5H, his counter can keep pace with the rest of the machinery when it is started up each day.

Among the many applications which the company foresees for 5H photocells are included choppers, a-to-d converters and position servos.

The new units are offered in hermetically sealed, transistor-type metal cases of the TO-18 and TO-5 variety. Price range is 80 cents to $2. Delivery is immediate.

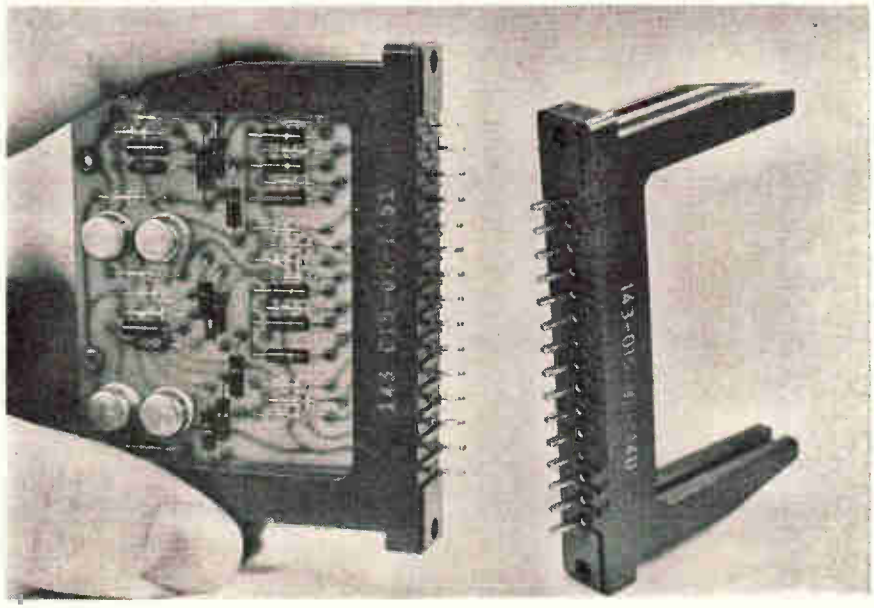
Clairex Corp., 8 West 30th St., New York 1, N.Y.

Circle 350 on reader service card

Representative photosensitive materials

Characteristic	5H	Material CdS (Type 5)	CdSe (Type 3)
General Characteristics	Fast, Stable	Very Stable	High Speed
Response speed @ 100 ft. candles			
Rise	0.002 sec.	0.007 sec.	0.001 sec.
Fall	0.001 sec.	0.014 sec.	0.002 sec.
Temp. coeff. @ 1 ft. can. from 0° to 75° C (100% conductance @ 25° C)	0.186%/°C	0.066%/°C	1.57%/°C
Light history effect @ 1 ft. can. (change in conductance between cell types measured from long exposure @ 30 ft. can., and long exposure to dark)	24%	9%	200%
Percent relative response (2854° K light source=100%)			
2250° K	101%	110%	132%
6500° K	106%	81%	34%
Resistance vs. light, linearity slope (0.1 fc to 100 fc)	0.92	0.74	varies from super linear to sub linear
Peak spectral response	5500 ang. (like human eye)	5500 ang. (like human eye)	7350 ang. (near infra-red)
Minimum ratio from 2 fc to dark within 5 seconds	1:1000	1:1000	1:10,000

New Components and Hardware



Connector offers more p-c board support

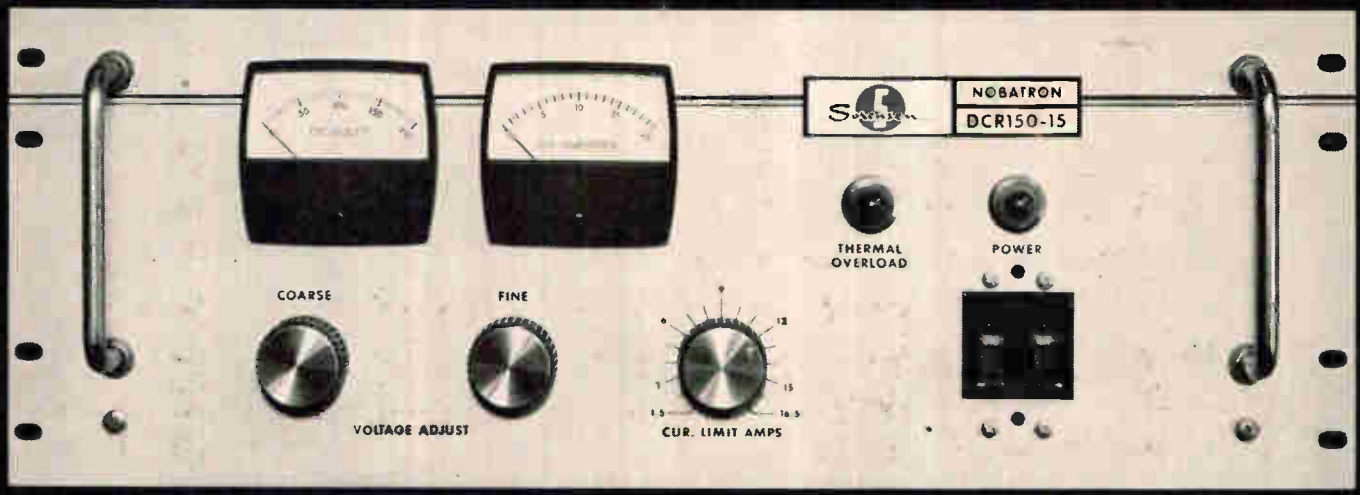
A new connector with integral molded card guides offers more p-c board support than is currently available from conventional board guides. Integral card guides extend 1⅜ inch above the main body of the new connector; conventional card guides, which must be attached mechanically, extend less than half an inch. The longer projections prevent board rocking and provide positive alignment in blind-spot installations. The series 143 connector is available in 15- and 22-contact models with slots between contacts for Delrin keys. This feature permits keying without loss of contacts. Both employ the manufacturer's tuning fork contacts, which tests show resist corrosion and changes in contact resistance even after 500 cycles of insertion and withdrawal during a 49-hour salt-spray bath. The dielectric material of the connectors is mineral-filled diallyl phthalate, according to MIL-M-14 Type MDG. The connectors themselves meet the performance requirements of MIL-C-21097B. However, since the connectors can be made to meet special requirements, virtually any thermosetting dielectric material is available, along with a wide variety of contact materials, platings and tail styles.

Amphenol Connector Division of Amphenol-Borg Electronics Corp., 1830 S. 54th Ave., Chicago, Ill., 60650. **[351]**

Capacitors feature precision dimensions

New form-mold encapsulated capacitors offer over-all size efficiencies and precision dimensions for greater spacing accuracy in printed circuits, plus welded leads for more reliable electrical contact. The BlackHawk capacitors are designed for test and measurement, control, communications and consumer product applications. Initial availability includes two case sizes with ratings from 0.001 to 1.0 μf and from 100 to 600 v d-c at 85° C. The units are noninductively wound, incorporating capacitor grade Mylar dielectric and high-purity aluminum foil. Operating temperature range is from −55° C to +125° C. Units are designed for continuous operation at rated voltage at 85° C. In addition to standard ±20% tolerance, the new ca-

New from Sorensen... 40 volts at 10 amps in a constant current power supply for $325.00



Now...19 DCR supplies from 0-400 to 0-2400 watts

1. 19 SILICON CONTROLLED RECTIFIER SUPPLIES AVAILABLE ... Delivery in 30 days or less.
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3. COMPACT PACKAGING...7" or 5¼" Rack Height
4. HIGH EFFICIENCY
5. CONSTANT VOLTAGE REGULATION...with continuously adjustable current limiting.
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11. VOLTAGE REGULATION...(as low as ±0.1% or 15 mv) Line and Load combined
12. CURRENT REGULATION ... As low as ±15 ma
13. LOW RIPPLE ... 0.5% + 50 mv (RMS)
14. UNITIZED CONTROL CIRCUITRY ... for easy maintenance
15. COARSE AND FINE CONTROLS...for Voltage Output

For complete data on the DCR series and other Sorensen products, send for the new, 140-page "Controlled Power Catalog and Handbook." Write to: Sorensen, Richards Avenue, South Norwalk, Connecticut. Or use Reader Service Card Number 200.

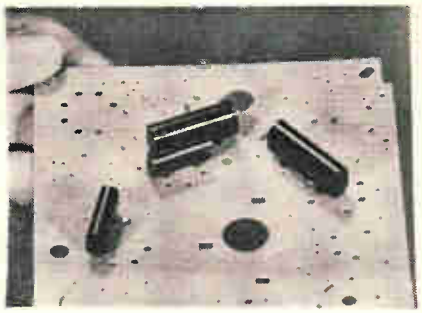
DCR ELECTRICAL AND MECHANICAL SPECIFICATIONS:

MODEL NUMBER	VOLTAGE RANGE (VDC)	VOLTAGE REG. (LINE & LOAD COMBINED)	OUTPUT CURRENT (AMPS.)	CONSTANT CURRENT RANGE (AMPS.)	CURRENT REG.	RMS RIPPLE	TRANSIENT RESPONSE	PACKAGE SIZE (INCHES) WIDTH	HEIGHT	DEPTH	WEIGHT (LBS.)	PRICE
DCR 300-1.25	0-300	±.1% or 60mv	0-1.25	0.125 to 1.37	±15ma	0.5% + 50mv	30msec	19	5¼	15	52	$325
DCR 150-2.5	0-150	±.1% or 30mv	0-2.5	0.25 to 2.75	±15ma	0.5% + 50mv	30msec	19	5¼	15	52	325
DCR 80-5	0-80	±.1% or 30mv	0-5	0.5 to 5.5	±15ma	0.5% + 50mv	30msec	19	5¼	15	56	325
DCR 40-10	0-40	±.1% or 15mv	0-10	1 to 11.0	±20ma	0.5% + 50mv	30msec	19	5¼	15	55	325
DCR 300-2.5	0-300	±.1% or 60mv	0-2.5	0.25 to 2.75	±15ma	0.5% + 50mv	30msec	19	5¼	18	77	525
DCR 150-5	0-150	±.1% or 30mv	0-5	0.5 to 5.5	±15ma	0.5% + 50mv	30msec	19	5¼	18	77	525
DCR 80-10	0-80	±.1% or 20mv	0-10	1.0 to 11.0	±20ma	0.5% + 50mv	30msec	19	5¼	18	77	525
DCR 60-13	0-60	±.1% or 15mv	0-13	1.3 to 14.3	±20ma	0.5% + 50mv	30msec	19	5¼	18	77	525
DCR 40-20	0-40	±.1% or 15mv	0-20	2.0 to 22.0	±25ma	0.5% + 50mv	30msec	19	5¼	18	77	525
DCR 300-5	0-300	±.1% or 60mv	0-5	0.5 to 5.5	±15ma	0.5% + 50mv	30msec	19	7	18	95	710
DCR 150-10	0-150	±.1% or 30mv	0-10	1.0 to 11.0	±20ma	0.5% + 50mv	30msec	19	7	18	95	710
DCR 80-18	0-80	±.1% or 20mv	0-18	1.8 to 19.8	±25ma	0.5% + 50mv	30msec	19	7	18	98	710
DCR 60-25	0-60	±.1% or 15mv	0-25	2.5 to 27.5	±25ma	0.5% + 50mv	30msec	19	7	18	100	710
DCR 40-35	0-40	±.1% or 15mv	0-35	3.5 to 38.5	±35ma	0.5% + 50mv	30msec	19	7	18	102	710
DCR 300-8	0-300	±.1% or 60mv	0-8	0.8 to 8.8	±20ma	0.5% + 50mv	30msec	19	7	18	115	825
DCR 150-15	0-150	±.1% or 30mv	0-15	1.5 to 16.5	±25ma	0.5% + 50mv	30msec	19	7	18	115	825
DCR 80-30	0-80	±.1% or 20mv	0-30	3.0 to 33.0	±30ma	0.5% + 50mv	30msec	19	7	18	120	875
DCR 60-40	0-60	±.1% or 15mv	0-40	4.0 to 44.0	±40ma	0.5% + 50mv	30msec	19	7	20	130	900
DCR 40-60	0-40	±.1% or 15mv	0-60	6.0 to 66.0	±60ma	0.5% + 50mv	30msec	19	7	20	131	925

Sorensen
A UNIT OF RAYTHEON COMPANY

Circle 151 on reader service card

New Components



pacitors are available with ±10% and ±5% tolerances. Dimension accuracy provided by form-mold encapsulation facilitates automatic insertion in circuit board designs, eliminating machine jam-ups that could result from less critically dimensional dip-encapsulated capacitor designs. The epoxy case also resists soldering damage that might occur during installation. The BlackHawk units incorporate radial leads that are welded to the foil. This fused metal-to-metal bond maintains positive low-resistance contact even at signal-level voltages and greatly reduces losses and rejects due to broken leads. Mounting feet molded into the base of the capacitor elevate the body of the unit above the circuit board, thus providing a natural escape route for soldering by-products, since circuit board holes are not blocked by gases during dipping and soldering operations. Extensive life tests demonstrate that the new units can withstand 500 hours at 85° C and 125% of the rated d-c voltage applied, with not more than one failure in 12. Price ranges from $53 to $305 for thousand-lot quantities.

General Electric Co., Schenectady, N.Y. **[352]**

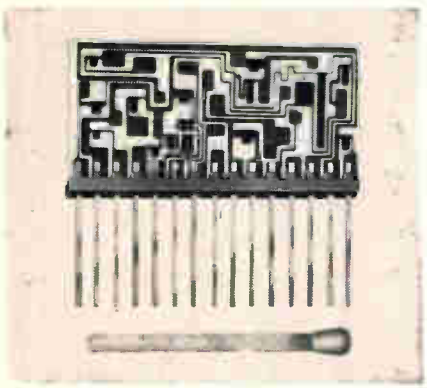
Wirewound trimmer rated at ¾ watt

A new ¾-w, 15-turn wirewound trimmer is designed with military stability, yet is economically priced. It measures 1 in. by 0.320 in. by 0.180 in. Series 160 is completely insulated and sealed in a diallyl phthalate housing with no metal parts outside. For maximum dielectric strength, the adjustment end

of the shaft is molded nylon. A simple positive clutch mechanism is built into the lead screw. Element terminations are free from mechanical strain because of a low resistance foil welded to the termination wire. All fixed electrical connections are welded into place. Maximum power dissipation is achieved by a high temperature epoxy insulated copper mandrel. For positive engagement with the lead screw, the metal drive block is threaded. A one-piece wiper welded directly to the drive block gives positive contact between the resistance element and the center collector. Bare solid wire on Teflon insulated stranded leads are available. Resistance range is 100 ohms to 20,000 ohms and temperature coefficient is 70 ppm maximum. Price is under $3 each in production quantities; delivery, 5 to 6 weeks.

CTS of Berne, Inc., Berne, Ind. [353]

Connector makes substrates pluggable

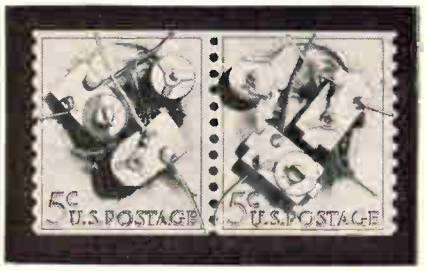


Several new microelectronic packaging techniques and connector applications are being introduced. One such approach will be a connector which makes substrates pluggable. A single row of contacts on 0.100 in. centers and a maximum width of 0.095 in. permits

New Components

stacking substrates with back panel wiring on an 0.100 in. square grid. The same model is also available with contacts in a single row on 0.050 in. centers. The plug shown on p. 153 is available up to 4 in. in length; 0.020 in. square male contacts can be supplied in lengths up to 0.600 in. for use with a variety of connection means such as plug and receptacle, welding, dip-soldering, solderless, wrapping, etc. Insulation is diallyl phthalate; contacts are brass with gold flash over nickel plating. Right angle mounting versions are also available.
Elco Corp., Willow Grove, Pa. **[354]**

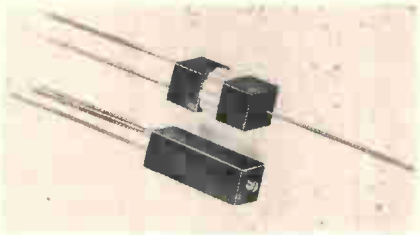
Tiny trimmers weigh under a gram



A line of tiny trimmer capacitors permits industrial and military users to pack circuits more densely than ever before, according to the manufacturer. The trimmers, ranging from 1.5 to 30 pf, measuring only $\frac{1}{32}$ in. in diameter and weighing less than a gram, operate from 1 to 70 Mc, from −15° C to +85° C. After 1,000 hours at 85° C, with applied voltage three times working voltage, capacitance is reported to drift no more than 5% of 0.5 pf. A proprietary technique of multilayer electrode metalizing permits low wattage soldering directly to electrodes, without fear of burnoff or amalgamation. The trimmers are available in three models. One is the DA813, where minimum size is most important. The DA814, packaged for horizontal or vertical mounting in p-c boards, has a slotted shaft for screwdriver adjustment. Preassembled connecting wires permit flexibility in positioning the trimmer within the layout. The DA815, mounted for cord-

wood packaging, also has a slotted shaft for screwdriver adjustment. Rotors are of temperature compensating ceramic, stators of high alumina ceramic. Insulation resistance after one minute is a minimum of 50 v d-c. Charge at 25° C is greater than 10,000 megohms.
Centralab, Electronics Division of Globe-Union, Inc., 998 E. Keefe Ave., Milwaukee 1, Wisc. **[355]**

Pot stresses high precision



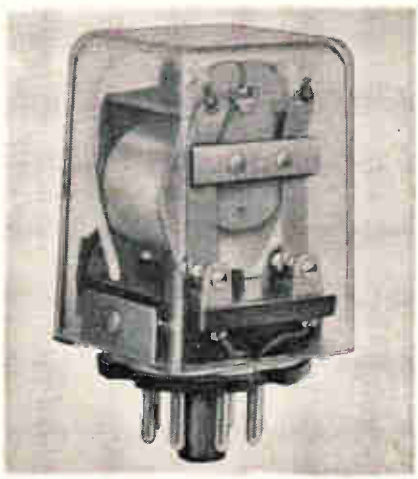
The new Verni-Trim potentiometer is said to offer an improvement of 10 to 100 times in resolution, resistance stability, resistance range and temperature coefficient over conventional design trimmers. The devices are suited for high precision applications which cannot be met by conventional design units as well as for general laboratory usage requiring precisely adjustable resistances. The resistance element is 5 to 20 in. long against the ¾ in. of conventional design trimmers. The extra length magnifies resolution and stability by several orders of magnitude. Resolution is infinite from 0.5 ohm through 200 ohms. In these values actual resistance or voltage adjustments can be made through 0.005% as against approximately 1% in conventional finite resolution trimmers. Resolution is finite from 100 ohms through 200,000 ohms. Although the resolution is determined by the number of wire turns, it is still 10 to 50 times better than that of conventional design pots of the same resistance value. A fixed resistor of any specified value can be embedded optionally within Verni-Trim's case and connected in series or shunt with the adjustable element. This feature expands Verni-

New Components

Trim's resolution to anything one may wish to specify while limiting proportionately the range of adjustment. Range is 0.5 ohm through 1 megohm wirewound. Temperature coefficient is as low as 2.5 ppm/° C between pot terminals. Stability is 0.01% either short or long term. Sizes vary from 0.312 in. diameter by 1.0 in. long to 0.500 by 0.406 by 2.0 in.

Verni-Trim Corp., 44 Prospect St., Yonkers, N.Y. **[356]**

Relay lives clean, lasts longer

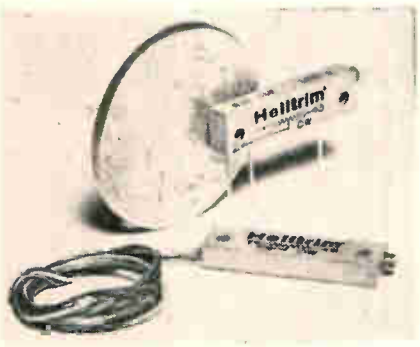


A new general purpose relay is available with an 8- or 11-pin octal type plug-in base. With the 22AP relay, dust covers of butyrate plastic or aluminum provide longer life with less maintenance by protecting the mechanism against dirt and other contaminants. In addition, the relays have been designed with fewer parts than most in their price range. Lower pull-in voltages are claimed as another advantage (d-c: 70% of nominal voltage; a-c: 75% of nominal voltage). Designed for heavy-duty spdt, dpdt or 3 pdt switching on a-c or d-c inputs, the relays are rated at loads of 5 or 10 amps at 115 v a-c. They weigh only 3½ oz. Standard contact material is gold-plated silver cadmium oxide, with other materials available on request. The a-c version of the 22AP has operating

voltages of 0.5 to 250; current range is 0.005 amp to 10 amps; and temperature range is —55° C to +72° C. The d-c version has operating voltages of 0.2 to 130. Current range is 0.005 amp to 10 amps and temperature range is —55° C to +85° C. Coil voltages on the a-c range from 6 to 230, and on the d-c from 6 to 110.

E.W. Bliss Co., Eagle Signal Division, Davenport, Iowa. [357]

Thin pot licks space problem



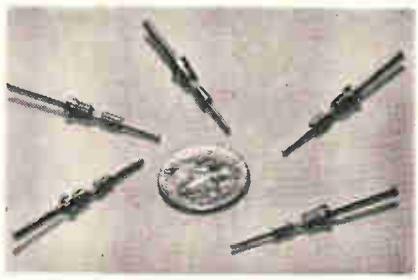
A new mil-spec style RJ12 trimming potentiometer is designed for applications where mounting space is limited. The model 56 Helitrim trimmer is less than 0.200 in. thick and requires only about ⅔ the board space of a conventional style RJ11 trimmer. It has plastic housing and is available with either pins or leads. An improved epoxy method was used to guarantee sealing of the unit far beyond the requirements of most environmental specifications. In addition, the model 56 offers a cermet resistance element with essentially infinite resolution and standard resistances from 10 ohms to 2 megohms. Power rating is 1 w at 85° C. and the ambient temperature range is —65° to 175° C.

Helipot Division of Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif., 92634. [358]

Fuse designed for small spaces

A series of special purpose Picofuses, for fusing terminal strips and connectors, is announced. The subminiature Picofuse is designed for multipurpose applications in

New Components

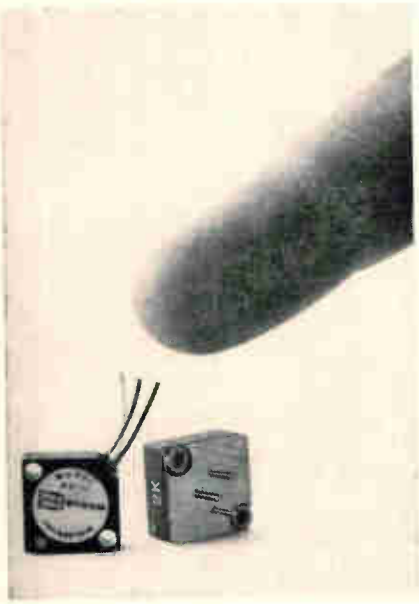


single and multipin connectors, rack and panel connectors, p-c connectors, terminal strips, and terminal boards. They are ideal where conventional fuse posts or holders are too big. For most applications, the tiny Picofuse is terminated with pins that simply plug into a terminal strip or board, or connector. Threaded pins are also available for positive hold-down. Picofuses are easily replaced if blown, and all fuses are readily accessible since they are right at the connection junction for easy servicing. In addition, such fused connectors prevent tampering by unqualified service personnel. The fuse is available in a wide range of amperage ratings from ⅛ through 5 amps at 125 v. All models have short circuit interrupting capacity of 300 amps at 130 v d-c. The ceramic body fuse couples low resistance with high speed action. It provides extreme accuracy in blowing time at a minimum of 300% of rating. The body, not including terminals which may vary in length, is approximately 8/32 in. length by 0.078 in. diameter. The fuse weighs ⅕ gram and offers high reliability with excellent shock and vibration characteristics.
Littelfuse, Inc., 800 E. Northwest Highway, Des Plaines, Ill. [359]

Flatpack holds circuit chip

The flatpack is designed to accommodate or hold an integrated circuit chip (die). It consists of a substrate holder (shown on p. 162), cover, and solder preform. All are procured separately. One of its more distinctive characteristics is the flatpack's superior glass-to-

A wide range of Daystrom Precision Trimming Potentiometers to fill all your needs. Typical examples include...



1. For Military Applications

Daystrom Squaretrim® Potentiometers Style RT-22 are made and tested in complete compliance with MIL-R-27208A and have additional features too.

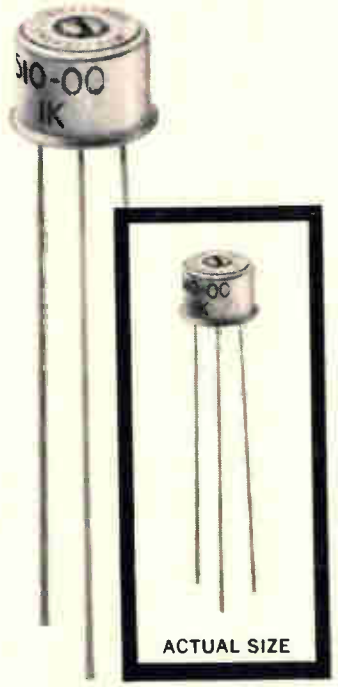
The black anodized aluminum case provides maximum heat dissipation, maximum rigidity and effective electrical shielding. The resistance elements are wound by the unique wire-in-the-groove process which assures locked-in linearity and resolution. A gear ratio of 45:1 permits the user to take full advantage of the available electrical resolution for precise pick-off values.

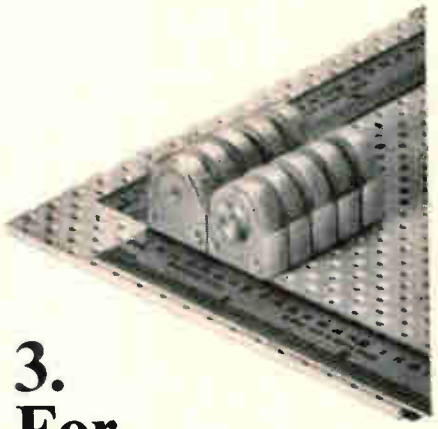
Models 313-118 HS, Style RT 22 L with flexible leads and Models 318-105 HS, Style RT-22P with base pins are available.

2. For Precision Instruments

Daystrom Series 510 Transitrim is closer to being completely hermetically sealed than any available potentiometer. It is designed with a vacuum-tight glass-to-metal seal header, in addition to an O ring under compression on the adjustment screw.

The series 510 employs the compact TO-5 configuration with an all-metal housing .335" Dia. (flange .360" Dia.). Power rating is 1.25 watts in *still air* at 50°C with an operating temperature range from −55 C to 175°C. Available resistance range is from 10Ω to 30K, with or without stops.





3. For Commercial Applications

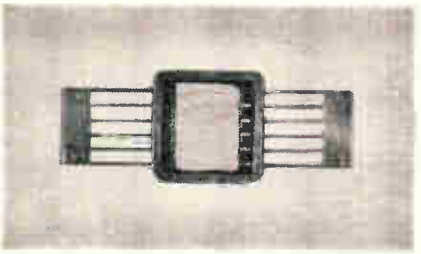
Daystrom Series 333 Trimming Potentiometers are *low in cost* ($1.45 each in 100 lot quantities) and *compact* (10 units can be fitted into ½ cubic inch of space on a PC board).

The resistance element is made by the same unique wire-in-the-groove method used in high reliability MIL-type Daystrom Squaretrim Potentiometers. The Series 333 offers dual adjustment–single turn finger tip on the knurled knob or fine adjustment (4 to 1 ratio nominal) with an Allen wrench. It dissipates 0.2 watt in *still air* at 40°C. Available with resistance values from 50Ω to 10K, (Lower and higher values on special order).

Write for complete data and samples for evaluation on these "Quality by Design" potentiometers or see your Weston salesman. In Canada, Daystrom Ltd., Cooksville, Ont.

DAYSTROM POTENTIOMETERS ARE ANOTHER PRODUCT OF
WESTON INSTRUMENTS, INC.
ARCHBALD, PENNSYLVANIA 18403

Circle 161 on reader service card 161

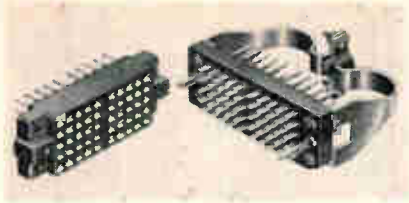


metal seal, which provides an excellent temperature coefficient. The final sealing process utilizes a solder preform. Three types can be supplied; a tin-antimony preform with a eutectic of 252° C, a gold-tin preform with a eutectic of 280° C and a gold-germanium preform with a eutectic of 356° C. The gold-tin preform offers a gold-to-gold junction in the solder as well as a relatively small grain structure for sealing capability. The eutectic point of the gold-tin preform also provides a large temperature differential from that of the 372° C gold-silicon eutectic of the integrated circuit die, which insures package/circuit integrity during final sealing. The flatpack utilizes two materials to provide a matched glass-to-Kovar sealing. A proprietary glass is used which provides excellent thermal tracking over the temperature range of 0° C to +300° C. Glass flow external to the package is kept to a minimum, thereby easing the requirements for final lidding. Plating is 100 μ in. minimum. Initial offering, 10-299100-1 (substrate holder), 10-299198-1 (cover), and 10-299175-1 (preform) is a $\frac{3}{8}$ in. by $\frac{3}{8}$ in. square flatpack.

Bendix Scintilla Division, Sidney, N.Y. [360]

Gold button contacts cut connector cost

Welded gold buttons preserve high reliability with only 5% of the gold needed to plate wire-wrap and other automated connectors. Limiting coverage to the actual contact area inside female receptacles can cut connector costs 15 to 20%, depending on the size of the connector, according to the company. The plated gold buttons are in-

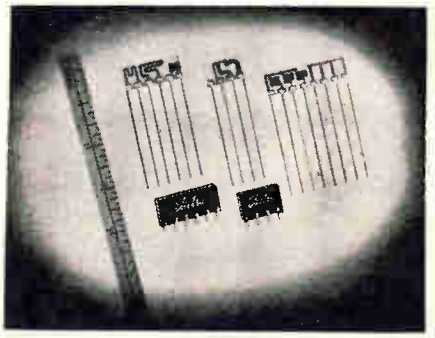


serted in a pre-formed seating area on the contacts and welded into place with a proprietary technique which bonds the button without affecting its plated gold. Costs for the new contact are higher than for overall plating, but savings in the amount of gold required result in lower over-all connector costs. Gold button contacts, developed in collaboration with Western Electric, are currently used with wrap post terminations. The technique is also applicable to a broad range of connector and termination styles, for p-c boards as well as rack and panel types. Assemblies including 50 of the new contacts are available from company stock. Additional assemblies of 60 and 72 contacts, or special sizes of 12, 18 and 26 contacts, can be made up to suit customer requirements.
Cinch Mfg. Co., 1026 S. Homan Ave., Chicago 24, Ill. [361]

Resistor network is stable, rugged

A new line of cermet resistor networks has superior load life stability. The passive networks, initially available in 4, 6 and 8-lead configurations, can be adjusted to 0.25% tolerance after firing and still retain better than a 1.0% change in resistance load life. Within a single network, the cermet is capable of maintaining temperature coefficient tracking from resistor path to path within 25 parts per million per degree centigrade, linearly, from low to high temperature range. The networks feature a consistent positive temperature coefficient of 200 ppm/° C (nominal). Resistance range is from 10 ohms to 500,000 ohms, and dissipation is 12 w per sq in. Environmental and life characteristics exceed the requirements of MIL-R-10509. Tolerances offered are from 0.25% to 5%. The maximum number of resistors on the 4-lead substrate is 3; for the 6-lead

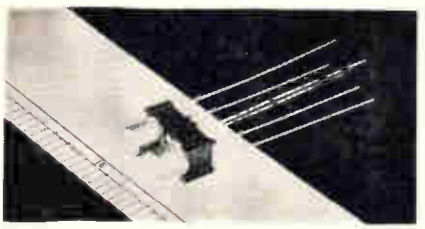
New Components



network it is 5 and for the 8-lead device 7. A precise orientation index is cast into the body of the epoxy encapsulation to simplify accurate manual or mechanized insertion. The module is rugged enough to be stapled into circuit boards by conventional assembly machines. Prices vary according to configurations and operating characteristics.

Electra Mfg. Co., Independence, Kan., 67301. **[362]**

Pads team up to save space

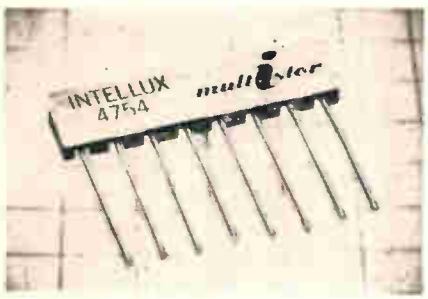


Originally developed for use in the Gemini space capsule, Transipad models 10054 and 10055 team up for maximum space utilization wherever TO-18 transistors are mounted on an 0.125-in. grid board. Company figures show a 12½% increase in packaging efficiency on board surface with this combination. With a maximum square dimension of 0.240 in., this assembly allows full use of each grid intersection of the 0.125 pattern. Space is saved by rotating the emitter tab into the grid area of the transistor itself. The transistor first enters Transipad 10055, which firmly seats it and provides strain relief. Leads then inserted into the 10054 are spread from 0.100 diameter to the 0.125 grid pattern. As the assembly

is pressed together, the transistor and Transipad 10055 automatically rotate 45° to place the emitter tab directly over the emitter wire, preventing its projection into the adjacent grid area. With an overall height of 0.185 in., this assembly has 0.035-in. spacer feet which raise it from the board for thorough wash-out of solder-flux residue and prevent moisture trap. Because of above-board space required for other components, the manufacturer points out, this area between assembly and board may be "free" and not evaluated as a "trade-off". The two Transipads are molded from glass filled diallyl phthalate meeting MIL-M-14F type SDG specifications. The company makes no charge for small quantities to be used for experimental design research.

Milton Ross Co., Southampton, Pa. [363]

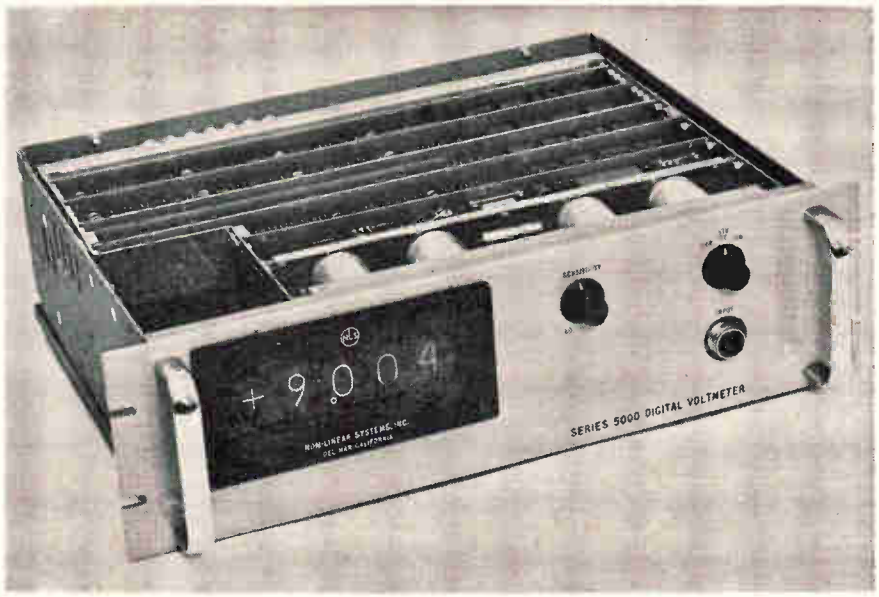
Resistor networks meet MIL-R-10509D



The Multistor is a thin-film, passive device wherein tin oxide is deposited on a high resistivity glass substrate, photo etched, terminated with fired ceramic silver and hermetically sealed with a fused glass superstrate. Individual resistors are interconnected with an electroplated copper cross-over pattern. The company says it is able to provide a network with precisely controlled temperature coefficient tracking, negligible interelement capacitance and low noise. Resistivity range is 40 to 120 ohms/square standard, and 20 to 400 ohms/square special, with tolerances of 10%, 5% and 2½%. Multistors are in full compliance with performance requirements of MIL-R-10509D and are available on short notice.

Intellux Inc., 30 S. Salsipuedes St., Santa Barbara, Calif. [364]

New Instruments



Dvm gives top performance at low cost

A digital voltmeter that the manufacturer represents as a breakthrough in the low-price field is being introduced. It is expected to bring the time- and moneysaving benefits of highly accurate, automatic, digital voltage measuring to many users who formerly could not make the necessary initial investment for automatic equipment. Model 5005 dvm offers features previously available only in instruments costing 40% more, according to the manufacturer. It supplies four-digit display of d-c voltages from ±0.001 to ±999.9 v in ranges of ±9.999/99.99/999.9 v. Accuracy is ±0.01% of reading + 1 digit. High common mode noise rejection reduces the effect of spurious noise by 106 db at 60 cps, even when the noise has 1,000 ohms unbalance. (Noise from a balanced noise source is easier to reject, but a balanced source is rarely encountered in practice.) The instrument contains an input filter to reduce signal mode noise. Input impedance is 10 to 1,000 megohms. Circuitry is all-transistor. The highest grade instrument construction is employed throughout; circuits are mounted on highest quality, interchangeable, plug-in, etched circuit, epoxy-fiberglass boards. The dvm has been life-tested to an equivalent of 20 years' use for eight hours a day at one reading every two seconds. The design was proven by operation at an ambient temperature of 150°F, much too hot to handle without gloves. Price of the model 5005 is only $985.

Non-Linear Systems, Inc., Del Mar Airport, Del Mar, Calif. [381]

Sweep oscillator covers wide range

A new sweep oscillator, model VR-50M, represents a state-of-the-art improvement in sweep generator technique, according to the manufacturer, because it can cover from 500 to 1,000 Mc using hybrid solid state and nuvistor circuitry, eliminating the need for expensive backward-wave oscillators or heterodyned output. The oscillator, plugged into the basic SM-2000 chassis, provides a sweep generator designed for production, inspection or laboratory testing. The wide sweep width of the VR-50M makes it particularly useful in test-

500 kc-1300 mc WIDE SWEEP and MARKER GENERATOR

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121-B 121-A

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- **Extended Narrow Sweep Operation over the Full Frequency Range.**
- **Ruggedized Layout with Standard "Plug-in" Simplicity.**
- **P-123A Plug-in Head, Sweeps an Octave, 100 to 1000 mc.**
- **Optional Added 0-10 db, 1 db step Attenuator.**

The 121-C delivers 0.5 volts rms into load—after a built-in attenuator—with excellent flatness and waveshape. Provides flat, wide sweeps and stable narrow sweeps; linear frequency output, agc'd rf level, and a frequency marker system. Harmonic marks at 1, 10 and 100 mc and circuits for an external variable marker are provided. A direct-reading 0-300 mc digital frequency dial provides smooth center frequency control and remarkable vernier adjustment for narrow sweep operation.

The electronic frequency modulation eliminates the microphonics, instability and frequent breakdowns of mechanical sweeps.

SPECIFICATIONS

Frequency Range: 500 kc to 1300 mc
Sweep Width: 5 kc to 500 mc
VHF (0.5 to 300 mc): 50 kc to 300 mc
UHF (200 mc to 1050 mc):
@ 220 mc, 5 kc to 50 mc;
@ 500 mc, 25 kc to 225 mc;
@ 800 mc, 35 kc to 350 mc.
P-122A (900-1300 mc): 200 kc to 400 mc
P-123A (100-1000): any octave, 100 to 200 mc, 200 to 400, 300 to 600, etc.

RF Output: .5 volt rms into 50 ohms, metered.
Flatness: ±.25 db to 800 mc.
±.5 db to 1300 mc.
Markers: crystal-controlled harmonics of 1, 10, 100 mc, or as specified.
Attenuation: 60 db in 10 db steps.
Sweep Rate: 10 to 60 cps, external from dc to 20 kc.
Price: $1295. P-122A head: $335.
P-123A head: $335.
Markers: $145.

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Circle 167 on reader service card 167

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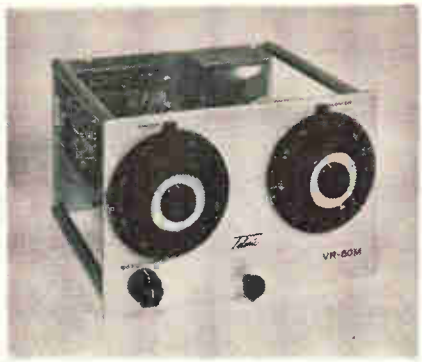


ing broadband equipment, such as parametric amplifiers and multiplexer equipment. General laboratory applications may also be fulfilled, because of the variable sweep width, center frequency and repetition-rate features. The VR-50M can be operated in four modes: sweep, c-w, modulated sweep and modulated c-w. The amplitude-modulated sweep or c-w mode generates a square wave with frequency variable from 800 to 1,200 cps. The unit can sweep manually (to scan any portion of the display), internally, externally, or internally variable from 0.01 to 100 cps. The sweep to retrace ratio can be switched from 1 to 1 or 10 to 1 for oscilloscope display. A built-in variable marker covers the entire 500 to 1,000 Mc range. Plug-in crystal-controlled harmonic and single frequency markers, at customer specified frequencies, allow infinite marking capabilities. Sweep width is continually variable from 5 to 500 Mc with a leveled output of 0.3 v rms. Nuvistor and transistor hybrid circuitry provide the VR-50M sweeper with the optimum in reliable performance. Price is $695; delivery is 60 to 90 days. The basic SM-2000 control chassis ($775) accepts 19 plug-in oscillator heads covering the frequency range of audio to 3 Gc.

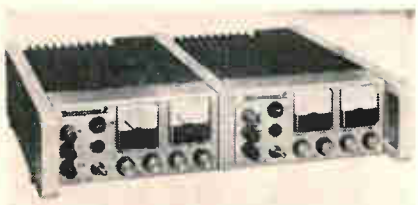
Telonic Industries, Inc., 60 N. First Ave., Beech Grove, Ind. **[382]**

True rms ammeters in 2 configurations

Two multirange true rms ammeters are announced. They feature a maximum current range of 1,000

amperes with full scale accuracy over the entire range of 0.5% at frequencies from 50 cps to 10 kc. The first is a model 500 CTE which consists of a model 500 Transquare meter used in conjunction with an external current transformer for all ranges. It has the ranges 10/20/50/100/200/500 and 1,000 amps. The other configuration is designated model 560CT. This meter has self-contained ranges of 1/2/5/10/20/50/ and 100 amps. The additional ranges of 200, 500 and 1,000 amps are provided by means of a compact, external current transformer. A unique feature, according to the manufacturer, is the ability to change ranges by means of a small integral switch mounted on the meter panel. The high-current circuit is left undisturbed, and the necessity for changing the number of turns around the transformer in order to switch ranges has been eliminated. Prices range from $925 for the model 500 CTE (including transformer) and $725 for the 560 CT. The 1,000-amp current transformer is an additional $350.
Greibach Instruments Corp., 315 North Ave., New Rochelle, N.Y. [383]

Laboratory-type power supplies



Solid state, laboratory-type power supplies are available in two series, LS and L, comprising 76 different models. A result of more than 18 months of development, these all-silicon, modular-construction supplies unlock hidden power capabilities, the company says, by means of state-of-the-art switching circuits. They double voltage or current rating without adding the usual penalties of size, weight and cost. The user receives essentially the same performance as with a competitive supply of twice the power rating, according to the manufacturer. Efficiency is in the order of 80% to 90%, combined with regulation ac-

New Instruments

curacy up to 0.01%, and stability up to 0.01% 1 mv. Panel heights have been reduced below most accepted industry sizes, and reliability objectives in excess of 25,000 hours mean time between failure have been achieved. The LS series illustrated is available in 38 models up to 160 v d-c and 25 amps. They provide 0.01% line and 0.03% load regulation, and include as a standard feature overvoltage load protection, using automatic semiconductor circuitry. Operation up to 80°C is permissible, and all units have provisions for adjustable current limiting, programming, tracking, constant voltage/constant current with automatic crossover, and power limiting. Parallel operation is possible with unique proportional sharing of the load current in accordance with power rating. The L series is also available in 38 models up to 160 v d-c and 25 amps. They provide 0.1% line and 0.3% load regulation, and operation up to 80°C is permissible. These units provide adjustable current limiting, programing, remote sensing, and series operation. Prices of the LS series range from $295 to $995; the L series, $175 to $620.

Technipower, Inc, a subsidiary of Benrus, 18 Marshall St., Norwalk, Conn. [384]

Bridge/analyzer features versatility

A professional-grade instrument has been announced for precision measurements of resistance and capacitance, also for diode reverse and transistor quiescent current measurements, insulation testing and resistance-capacitance-inductance comparison with external

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DESIGN AUTOMATION PROGRAMMERS / Requires previous experience in programming for design automation, good understanding of engineering and hardware problems, BS degree in math, engineering or related field.

PRODUCT ENGINEERING

POWER SUPPLY DESIGN / Intermediate and senior level positions are available for circuit designers experienced in worst-case design of solid-state power supplies. BS or MS in EE required.

PACKAGING / These positions entail layout and design of packaging for computer systems. Applicants must have previous experience with electronic computers or electromechanical devices. Background in miniaturization utilizing thin films and integrated circuits is desirable. BSEE required.

VALUE ANALYSIS / These intermediate and senior level positions entail organizing and conducting value-analysis projects on company products. Work also involves assisting in locating new products and services, and participation in design and producibility review. Requires BS in engineering and three years' experience with electronic computers or electromechanical devices.

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CIRCUIT DESIGN / Openings are available at all levels for design of advanced integrated-circuit computers. Must have good knowledge of transistors and worst-case circuit design techniques. BS or MS in EE required.

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standards. Model 965 Faradohm bridge/analyzer does not damage capacitors. It offers instant vtvm zeroing. The unit includes a 6-range vtvm, full overload protection, variable polarizing voltage, and an 11-range micro/milliammeter. Capacitance ranges are 5 to 10,000 pf, 500 pf to 1 μf, 0.5 μf to 100 μf, 50 μf to 5,000 μf. Power factor is 0 to 80% at 60 cps. Resistance ranges are 0.5 to 1,000, 50 to 100,000 ohms, 5,000 ohms to 10 megohms, 5 to 500 megohms directly and up to 200,000 megohms using a metered variable d-c supply. D-c voltages are 1.5, 5, 15, 50, 150 and 500 v full scale into a 10-megohm input. D-c current ranges are 0.15, 0.5, 1.5, 5, 50 μa, 0.15, 0.5, 1.5, 5, 15 ma (75 mv drop across terminals). Accuracy is ±5% on all except power factor when reading below 30%. The resistance - capacitance - inductance comparator range is 0.025 to 50 (ratio). Bridge supply potential is less than 0.5 v rms, 60 cps, except 10 v rms on lowest capacitance and highest resistance ranges. Variable d-c is 0.4 to 1.5, 1.4 to 5, 4 to 15, 14 to 50, 40 to 150, 140 to 500 v at 10 ma max. Power requirements are 32 to 45 w at 115 v a-c. 60 cps. The unit is 8½ in. high by 12½ in. wide by 9 in. deep. Weight is 15 lb. Price is $129.95.

EICO Electronic Instrument Co., 131-01 39th Ave., Flushing, N.Y. [385]

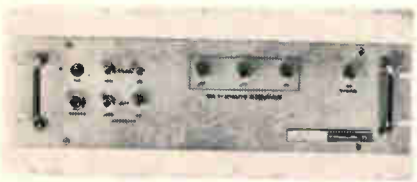
Portable oscilloscope covers d-c to 15 Mc

This portable oscilloscope, type 422, weighs approximately 20 lbs.

with A supply, including power cord and panel cover. It combines easy portability with high performance, even under rugged field conditions. The scope can be used for testing and servicing high-speed computers, telemetering equipment and other modern instrumentation where space for test instrumentation is limited. Type 422 is 6.75 in. high, 8.5 in. wide and 16 in. deep. Bandwidth of d-c to 15 Mc, sensitivity to 10 mv/div, dual-trace operation, and sharp, bright displays provide laboratory oscilloscope performance for field-site applications. The unit is said to be ideal for aerospace studies and geophysical research. Type 422, with the d-c power supply option, operates four hours or more on self-contained rechargeable batteries, recharging them through its own circuitry, or can operate from any common a-c or d-c source. Low power drain makes it very useful for the installation and maintenance of equipment in remote locations. A 4-in. rectangular crt, with illuminated, internal graticule, provides 8.2 sq. in. of display area, with bright sharp traces even under high ambient light conditions. Four operating modes include each channel singly, alternate or chopped electronic switching between channels, or both channels added algebraically. In the added algebraically mode, channel 2 can be inverted for differential operation. Other features include sweep range from 0.5 μsec/div to 0.5 sec/div, a 10 $\times$ sweep magnifier and a highly adaptable triggering system which includes automatic and channel 1 only. Price is $1,325.

Tektronix, Inc., P.O. Box 500, Beaverton, Ore., 97005. [386]

Fast and accurate frequency comparator



A new frequency-error expander provides frequency comparisons between a test signal and a stable frequency reference to a resolu-

tion of 10^9 in one second, 10^{10} in 10 seconds, and 10^{11} in 100 seconds. The unit uses a single connector to handle eight test inputs ranging from 100 kc to 5 Mc. Eliminating the need for external dividers and multipliers, the test instrument achieves fast, accurate measurement of short and long term frequency stabilities and the calibration of frequency instruments, electronic counters and oscillators. The frequency error expander provides up to 10,000 times greater resolution in the same count period than can be obtained using a digital counter directly. In operation, the frequency error expander converts the test input signal to a common 1-Mc signal and mixes it with 900 kc synthesized from the 1-Mc or 100-kc reference. The output of 100 kc is then multiplied 10 times to provide a 10 times error expanded signal at 1 Mc. This process is repeated to achieve error expanded outputs up to 10,000 times, always at an output frequency of 1 Mc. Output levels are 1 v rms into 3,000 ohm load for the error expanded outputs and 1.5 v rms into 3,000 ohm load for the reference outputs. Price of the error expander is $1,495. Delivery is in four weeks.
Motorola Inc., Communications Division, 4501 Augusta Blvd., Chicago, Ill., 60651. [387]

Function generator uses plug-in principle

Extending the plug-in idea to function generators, the model 3300A is a compact, convenient, multipurpose source of test waveforms. It provides two simultaneous outputs that may be any two of three waveforms. These are of common frequency and constant amplitude. Frequency is controllable either by

New Instruments

a front-panel dial or by an external voltage to a rear-terminal connector, useful for controlled sweeps or programed frequency. The basic instrument produces sine, square or triangular waves ranging from 0.01 cps to 100 kc. With the model 3302A plug-in, the generator will deliver a single cycle on demand, in known phase with an outside signal, or multiple-cycle operation with variable start/stop phase. A phase-lock loop makes it possible to synchronize the 3300A to any periodic signal with a frequency from 10 cps to 100 kc. An exclusive front-panel meter positively displays achievement of lock. The loop also provides 360° of phase variability. Two output amplifiers are integral; either may be balanced or single-ended, and floating. Each will deliver 36 v peak-to-peak open circuit (4 v p-to-p into 50 ohms). The output system is d-c coupled and fully floating with respect to power line ground. Model 3300A will add convenience to the design and test of servo systems, for electrical simulation of mechanical phenomena, for sweeping filters, amplifiers, and other frequency-dependent devices. It may be programed to deliver frequencies for production testing. The solid state instrument is housed in a rack-convertible modular cabinet 5 in. high. The basic model 3300A generator is $570; model 3301A basic plug-in, $20; and model 3302A, $190. First deliveries are expected to begin in June.

Hewlett-Packard Co., 1501 Page Mill Rd, Palo Alto, Calif. **[388]**

Price breakthrough claimed for dvm

A price breakthrough is claimed for the model 5005 digital voltmeter. The unit offers features previously available only in instruments costing 40% more. Major features are: four-digit display of d-c voltages from ±0.001 to ±999.9 v in ranges of ±9.999/99.99/999.9 v; accuracy of ±(0.01% of full scale +1 digit); high com-

mon mode noise rejection achieved by guard shielding; fully floating input circuit; a life expectancy of 20 years at one reading every 2 seconds for 8 hours a day; automatic range and polarity changing; built-in input filter; 10 to 1,000 megohms input resistance; minimum speed of 2 sec/reading; transistor circuitry throughout; interchangeable plug-in epoxy fiberglass circuit boards; and operation over a wide ambient temperature range (0° to 140° F.) Some applications are: testing electronic and electrical components and circuits, strain gage and thermocouple readout (in conjunction with a preamplifier), environmental testing, gyro and accelerometer testing, medical electronics, nuclear research, and industrial process monitoring. The 5005 can measure length, pressure, temperature, stress, strain, velocity, acceleration, frequency, flow rate, light intensity, weight or any other quantity that can be converted into voltage by an external transducer. Price is $985.

Non-Linear Systems, Inc., Del Mar Airport, Del Mar, Calif. **[389]**

Interference analyzer for 14 kc to 1 Gc

A solid state instrument for measuring radio frequency interference has been developed for the range 14 kc to 1 Gc. Model EMC-25 interference analyzer meets the latest military and commercial requirements for automated rfi data acquisition. The unit is capable of being electronically scanned over the entire frequency range and has remotely controllable band selection. It incorporates an internal battery supply in addition to capability for a-c operation. Besides being small and light, the EMC-25 offers sensitivity and operational simplicity. A choice of two bandwidths in each of 15 bands from 50 cps to 500 kc is standard

New Instruments

in the unit. Detector functions provided are carrier, peak, 60-db scan, slideback and f-m deviation. In 60-db scan, a full 60-db range can be read on the meter without changing input attenuator settings. Outputs for phones, external meter, X-Y recorder, i-f and video are incorporated in the instrument. Price is $8,200.

Electro-Metrics Corp., 88 Church St., Amsterdam, N.Y., 12011. [390]

Temperature controllers are read directly

New laboratory-style proportional temperature controllers feature cabinet-type construction and a new direct-reading dial. The CU-300 series uses a high-precision proportional controller capable of regulating temperature to a fraction of a degree. A thermal loop compensates for the effects of time lags in the system being controlled. This compensation, including both rate and reset actions, is made adjustable to allow maximum flexibility in controlling a wide variety of thermal loads. The controllers are thus ideal for a precision temperature control of ovens, furnaces, test fixtures, plastic molding machinery, extruders and a wide variety of similar industrial and laboratory equipment. A 10-turn potentiometer is used to obtain maximum accuracy and repeatability in setting the temperature. The temperature is read on a 4½-in. direct-reading dial that can be set quickly to the desired tem-

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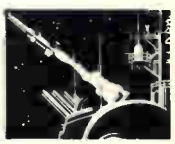
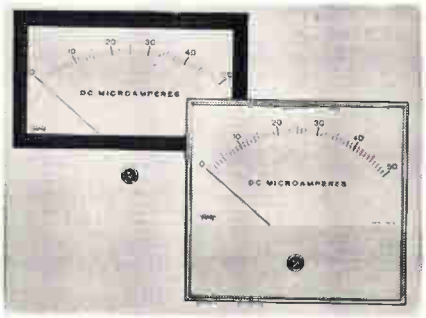


New Instruments

perature without the need for a calibration chart. The controller is mounted in a cabinet, complete with deviation indicator, on-off switch, pilot light, fuse, line cord and connection plug. Any temperature range can be furnished between −200° and +1,100° C. Standard forms have power outputs up to 6 kw. The controller can also be furnished with temperature-alarm circuits that are activated whenever the temperature is not at the desired set point. Harrel, Inc., 16 Fitch St., E. Norwalk, Conn. **[391]**

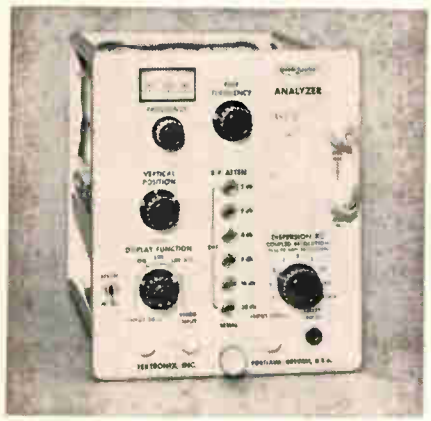
Panel instruments offered in 3 sizes



A new panel instrument features flexibility and interchangeability, with an optional mounting bezel for behind-the-panel mounting and dramatic picture-window effect. The G-series is available in three sizes: 2½ 3½ and 4½ in. providing selection opportunities for the user. The instruments also feature the company's Bar-Ring d-c movements that provide exact, reliable readings and are self-shielded from stray magnetic fields. The Bar-Ring design also allows more torque, faster response and more ruggedness. A long dominant scale has a large dial area for multiple scales and other applications. In addition, a flat insert for the masked portion of the meter front may be painted any color and can be imprinted with company logos, instructions, etc., subject to special handling fees. The G-series panel instruments are available in a-c ranges from 10 ma, and d-c ranges from 5 μa. Prices are from $11.60 and up. Deliveries

are made in 45 to 60 days.
The Triplett Electrical Instrument Co., Bluffton, Ohio. [392]

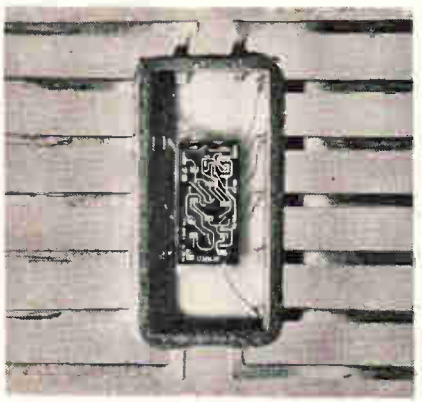
Spectrum analyzer augments scope



Type L-10A spectrum analyzer plug-in unit covers the frequency range of 1 Mc to 36 Mc. It fits all the company's oscilloscopes that accept letter-series or 1-series plug-ins. The combination provides calibrated dispersion with optimized cross-coupled resolution to simplify operation—yet each control can be operated independently. Calibrated sweeps of the oscilloscope permit measurements such as pulse repetition rates—not possible with ordinary analyzers, according to the manufacturer. Oscilloscope usefulness is doubled, since it can be used for either spectrum analysis or video displays without changing plug-in units. Versatile triggering facilities of the oscilloscope are said to allow unique applications. The first i-f amplifier of the L-10A is at 60 Mc. Thus, the image and other spurious responses are well outside the frequency range of this instrument. Basic characteristics of the L-10A include a dial accuracy of ±(100 kc + 1% of dial reading); sensitivity, −100 dbm at 10 cps resolution; dispersion, 100 cps to 20 kc calibrated in eight steps plus uncalibrated search position; resolution, 10 cps to 1 kc; display—log, linear, linear × 10, video, 100 mv/cm variable, 10 cps to oscilloscope vertical bandwidth approximately equal to 50-ohm input resistance. Price is $1,200. Available during the second quarter of 1965.
Tektronix, Inc, P.O. Box 500, Beaverton, Ore., 97005. [393]

New Semiconductors

Integrated circuit low-level switch



A monolithic integrated-circuit, low-level switch, available in models 4JP345 and 4JP358, offers a typical "on" resistance of 10 ohms at 160 kc. Such a low resistance, the manufacturer says, is difficult to achieve in integrated circuits. The reduction in resistance is attributed to epitaxial deposition and a unique construction feature in which N^+ deposition islands are placed under the transistor collector-base junction. This results in low resistance paths and relatively high inverse small H_{FE} (beta) of the output transistors. Another primary feature is the low offset voltage in the "on" state: 5 mv. This new circuit is designed primarily for shunt switching applications. Possible uses are in industrial and military digital-to-analog converters, time-sharing circuits, displays and other applications in which an element is to be shorted out for a time and then placed back on the line. Each package contains two switches which are operated independently through internal diode resistor networks. The 14-lead network flatpack measures 0.135 by 0.260 by 0.045 in. Other ratings: output current, 1 ma; power dissipation, 50 mw at 85°C output; and input breakdown voltage, 5 v. Price for the 345 type is $19.90 in quantities of 100, while the 358 version sells for $17.50.

General Electric Co., Schenectady, N.Y. [371]

Diode limits charging voltage

The Amp-Gate diodes, to be introduced publicly at the IEEE show, are designed for battery recharging or other voltage-limiting applications. Advantages claimed include two-hour recharge times, extension of battery life, and overvoltage protection. Amp-Gate diodes consist of one or more series-connected, forward biased p-n junctions, available in combinations of 0.4 and 0.7 v per junction. The diodes equalize voltages applied to series-connected cells by providing a shunting path which prevents overcharging. The company developed the circuit to control charge on nickel cadmium cells, up to 5 ampere-hours capacity. It now can produce diodes handling up to 25 amps. Diodes are connected in parallel with rechargeable cells, so the anode of each diode is common with that of a cell. When a cell reaches full charge, its voltage triggers the diode; which then prevents overcharging by shunting the charging current around the cell. In the circuit, it functions much as a low-voltage zener diode—drawing only slight amounts of current until the cell reaches the clamping voltage—at which point it passes abruptly into high conduction. Simultaneously, charging current through the cell decreases sharply. Ability of the device to clamp the voltage and reduce the charge rate through the cell at the end of the charge assures safe, reliable operation under continuous unattended charge conditions, according to the company. Amp-Gate diodes make it possible to recharge low cells in less than two hours—reducing the charge-to-discharge time ratio from 20:1 to nearly 1:1. The device's ability to prolong cell life was

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New Semiconductors

demonstrated in cycle tests subjecting nickel cadmium cells to two-hour charges at 1.2 amp, and 39 minute discharges at 0.5 amp. Unprotected cells showed 100% loss in capacity, compared with 3% losses after 345 cycles and 7% after 615 cycles by diode-protected cells. Delivery on sample Amp-Gate diodes is 30 days, according to the company. Unit cost for sampling lots is $25, in groups of three to five units.
P.R. Mallory & Co. Inc., Burlington, Mass., 01801. **[372]**

Advance claimed for p-channel FET's

Two new field effect transistors are being introduced. Both are enhancement mode, p-channel, insulated gate devices. The FN-1034 is said to outperform significantly any other device for chopping, switching, analog-to-digital and digital-to-analog converting, and multiplexing applications. It features zero offset voltage, low-turn-on voltage, low ON resistance and unconditional stability. Typical specifications for critical characteristics are: gate threshold voltage of 1.5 v, claimed to be a three-fold improvement over competitive units; channel resistance of only 200 ohms at —10 v applied gate voltage, said to be half that previously offered; and gate-to-source capacitance of only 2.8 pf. The FN-1024 FET is offered for applications requiring high input impedance, low noise, high gain, and excellent stability. Typical uses include vhf amplifiers, frequency mixing, or initial stages following pressure, temperature or strain transducers. Transconductance,

measured at −1 ma, is 1600 μmhos. Noise figure at 10 kc does not exceed 2 db. Gain-bandwidth product, at −10 ma, is 160 Mc. Input resistance and capacitance are 10^{15} ohms and 4.0 pf, respectively. Both FET's are packaged in TO-18 cases with four loads: drain, gate, source, and substrate. Maximum voltage for each device is 50 v; total device dissipation, 300 mw; and thermal resistance, 2 mw/°C. Price is $27.50 each for quantities of 1 to 99.

Raytheon Co., Semiconductor Operation, 350 Ellis St., Mountain View, Calif. **[373]**

Silicon diodes are radiation-tolerant

A series of radiation-tolerant diodes, with ratings up to 2 amps at 300 v, will be exhibited at the IEEE show. According to the manufacturer, demand for radiation-tolerant semiconductors is increasing from customers who have radiation-resistant specifications on their total equipment and systems. Industry interest is said to be focused particularly on diodes that have radiation tolerance and can switch sizable amounts of power. The new diffused silicon epitaxial diodes will switch up to 2 amps in speeds ranging from 100 to 300 nsec, switching from 10 mils forward to 10 mils reverse and recovering to 5 mils. The radiation tolerance is inherent in the junction design. The diodes will tolerate neutron levels of 1×10^{15} neutrons versus time; electron radiation of 1×10^{16} electrons per sq cm. They will be unaffected by gamma radiation. Temperature range, −195°C

New Semiconductors

to +175°C, is inherent in design of the whiskerless, void-free package. The silicon die is metallurgically bonded to the two pins, and over that assembly is a glass sleeve fused directly to the silicon and to the two pins.

Unitrode Transistor Products Inc., Waltham, Mass. [374]

Diffused silicon npn transistor

A new diffused silicon, epitaxial npn transistor is made by planar techniques. Model 3TE240 is intended for high-gain, Class B and C, r-f amplifiers up to 250 Mc. It utilizes a new mounting arrangement with the emitter connected to the case. The device is ideally suited for grounded emitter amplifier use where high power gain is needed. It features up to 10 w output at 40 v and 250 Mc; greater than 15 w output at 40 v, 13 db typical gain, 150 Mc. Maximum ratings (at 25°C case temperature unless specified) are: collector-base voltage, 80 v; collector-emitter voltage, 80 v; emitter-base voltage, 4.0 v; collector current d-c, 3 amps; total power dissipation, 25 w; derating above 25°C, 0.167 w/°C; storage temperature, —65 to +200°C; junction temperature, 175°C.

Clevite Semiconductor, 1801 Page Mill Road, Palo Alto, Calif. [375]

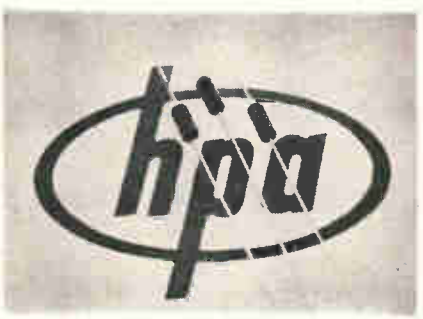
Building blocks for high-level logic

A manufacturer will debut in integrated circuitry at the IEEE show by introducing three building blocks for high-level logic. A single

eight-input nand/nor gate, dual four-input nand/nor gate, and dual four-input nand/or gate are announced. Each will be available in two temperature ranges— —55° C to 125° C and 0° C to 75° C. The three integrated circuits are basic elements of a planar epitaxial high-speed logic family with a propagation delay range of 8 to 20 nsec. Another feature is high capacitive driving capability. According to the company, the output design of the circuits enables them to drive 300 pf with ease. Short-circuit protection is also built into the output. Each of the three basic logic elements is available in a TO-5 can or a flat package. Each element is also available for either of two fan-out requirements. One type is designed for a fan-out of 1 to 20 to similar units; the other for 1 to 7 to similar units. Production quantities will be available from inventory.

Transitron Electronic Corp., Wakefield, Mass. [376]

Reliability enhanced in hot carrier diode

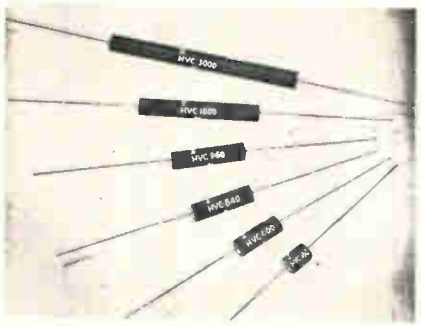


A hot carrier diode incorporates advances in metal-silicon technology, the company reports. The 2200-series diodes have higher forward current and breakdown voltage, and broader temperature range. Minority carrier charge storage and low internal noise generation have been practically eliminated. Type 2201 features $B_V > 30$ v; $I_R < 300$ na at $V_R = -15$ v; $I_F > 50$ ma at $V_F = 1.0$ v; and $C_O < 1.0$ pf at $V_R = 0$. The 2202 differs only in $B_V > 20$ v and $I_R < 500$ na at $V_R = -15$ v from the 2201 specifica-

tion. The 2203 specification features $B_V > 20$ v; $I_R < 500$ na at $V_R = -15$; $I_F > 50$ ma at $V_F = 1.0$ v; and $C_O < 1.2$ pf at $V_R = 0$. All devices in this series have minority carrier lifetime of less than 200 picoseconds. The operating and storage temperature range extends from −60° to +150°C. Power dissipation at 25°C is rated at 100 mw and peak pulse power exceeds 5 ergs. The 2200-series hot carrier diodes are said to meet the requirements of MIL-S-19500 C. They are suitable for use in ultrafast logic switching and pulse shaping. Low internal noise generation, due to the negligible charge storage, enhances the operation of mixer and detector circuits in uhf and vhf design. Prices for 1 to 99 range from $8.70 to $9.60 each; for 100 to 999, from $5.80 to $6.40.

HP Associates, 620 Page Mill Rd, Palo Alto, Calif., 94304. [377]

Cartridge-type silicon rectifiers



High-voltage silicon rectifiers of the cartridge type are available with avalanche characteristics. They are said to be comparable in performance to units that cost substantially more yet that do not have avalanche characteristics. The avalanche characteristics provide built-in protection against transient overvoltages. The new line consists of 17 units ranging in piv rating from 1,800 to 30,000 v. The units have a d-c ma rating from 250 to 50, depending on the voltage. Maximum forward voltage drop at rated current ranges from 4 v for the smaller units to 50 v d-c for the largest type. The HVC silicon rectifiers are all ⅜ in. in diameter and are contained in epoxy-sealed phenolic tubes. The tube lengths range from $\frac{9}{16}$ in. to $4\frac{1}{16}$ in. depending

upon the voltage. They are supplied with 2-in. leads of 0.032-in.-diameter goldplated wire.

Sarkes Tarzian, Inc., 415 College Ave., Bloomington, Ind. [378]

Germanium transistors in plastic packages

A new line of germanium epitaxial transistors is announced for consumer and industrial circuit applications. The company says their use will give with no price premium, much lower noise figure, better gain and improved automatic gain control performance than older devices. Designated the TIXMO1 through MO8, they are the first of the manufacturer's new line of pnp germainium epitaxial planar transistors in plastic packages. The MO1 through MO4 units are designed for service in the r-f and i-f sections of a-m and f-m receivers. High receiver sensitivity is possible using these transistors because of their extremely low noise figure (3.0 db typical at 100 Mc) and high gain (calculated maximum available gain is 28 db at 100 Mc). The TIXMO5-8 are said to be outstanding for vhf-tv tuners and tv i-f strips. Their use allows circuit designs which give good picture quality in both fringe and strong signal areas. This is due to their forward age characteristics (20.5 db minimum gain reduction through small signal current transfer ratio fall-off alone). Typical noise figure for the TIXMO5 is 2.8 db at 200 Mc, giving superior tuner performance. All eight transistors are in a new plastic package. Standard TO-18 pin circle lead configuration is used. The package is capable of withstanding the heat of all normal soldering operations without damage, and it gives excellent stability under high-humidity conditions. The transistors have been tested to the requirements of MIL-S-202C, method 103A, without failures. Prices range from 25 to 35 cents in production quantities.

Texas Instruments Inc., 13500 North Central Expressway, Dallas, Texas. [379]

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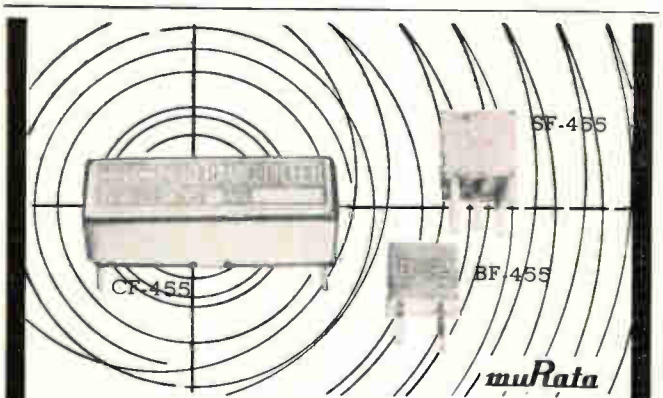

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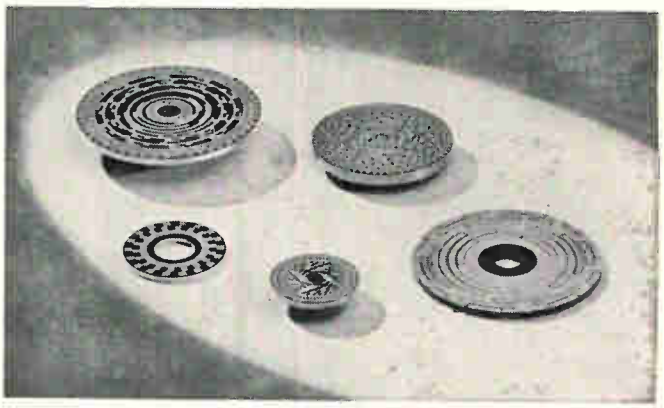

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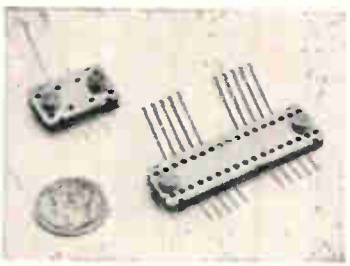

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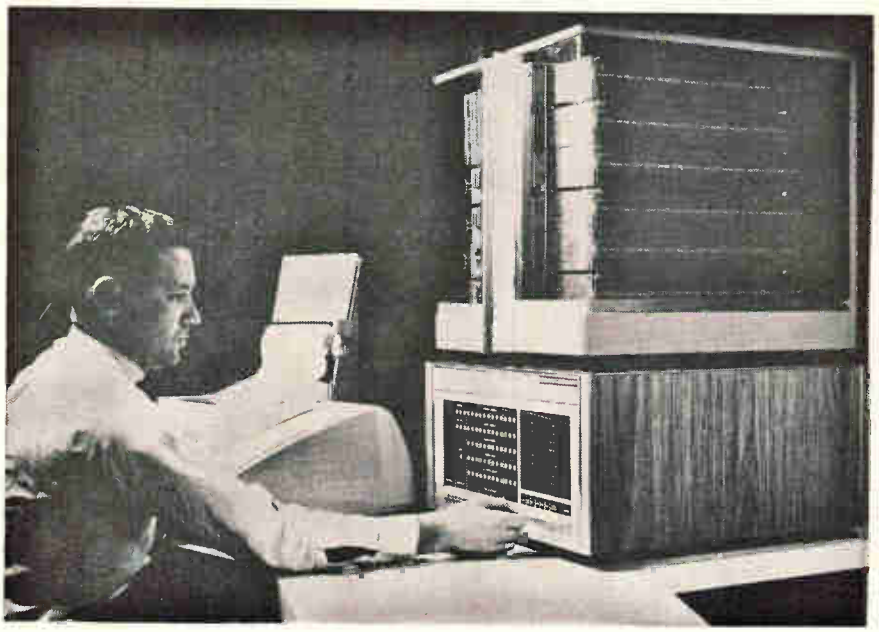


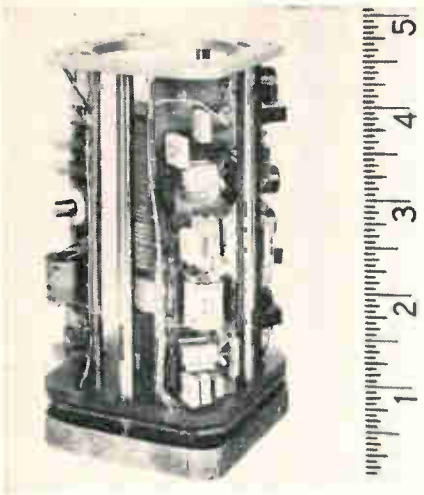
Digital computer at lower cost

The Programmed Data Processor-8 will be exhibited for the first time at the IEEE show this year. Low price of the computer is made possible through the use of integrated circuits, according to the manufacturer. The PDP-8 is intended for high-speed data handling and processing in computation centers, laboratories, and process control systems. All processing circuits in the computer use silicon semiconductors, many in the company's new 10-Mc Flip Chip integrated circuit modules. Wiring of the central processor is done with a wire-wrap machine under automatic control. The basic PDP-8 will sell for $18,000 with 4,096 words of 12-bit core memory. Is has a 1.6-μsec memory cycle, adds in 3.2 μsec, and transfers data at rates up to 625,000 words per second. The basic system will be a console teleprinter with a 10-character-per-second paper tape reader and punch, and complete software package including Fortran, macro assembler, and on-line debugger. The programming system also contains symbolic editing programs, standard Fortran libraries, input/ouput programs, single and multiple precision and fixed and floating point arithmetic routines, and utility and maintenance routines. Because of the low price, compactness, speed, ease of use, and simplified programming systems, the manufacturer predicts that many smaller laboratories and industrial processors will be able to use the PDP-8 to take advantage for the first time of modern computation and control techniques.

Digital Equipment Corp., Maynard, Mass. [401]

Crystal oscillator warms up fast

The highest stability packaged crystal oscillator currently available is the FFO-160, according to the manufacturer. This unit measures only 4½ in. by 2¼ in. by 2¼ in. and provides a long term stability better than five parts in 10^{10} per day and one part in 10^{8} per month. Output frequency is 1 Mc; output level, 1 v rms into 500 ohms. Operating ambient temperature is −40°C to +65°C. The new crystal oscillator was designed specifically to supply a signal of very high sta-



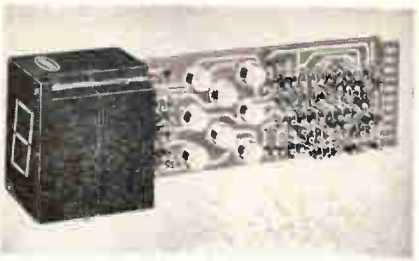
bility over a broad range of environmental conditions. Its fast warm-up capability and outstanding operational characteristics over extremes of temperature, humidity, shock and vibration well suit the FFO-160 to airborne, shipboard, mobile and space, as well as fixed station, applications. A proportionally controlled oven maintains the crystal's temperature constant within a few millidegrees over the unit's operating ambient temperature range. The oscillator stage employs automatic gain control to maintain constant crystal current. Low impedance buffer amplifiers protect the oscillator from load variations while an internal regulation system virtually eliminates the effects of power supply fluctuations.

Manson Laboratories Division, the Hallicrafters Co., 77 Danbury Road, Wilton, Conn., 06897. [402]

Display module for binary input

Highly legible bar matrix display modules are available in a new form adaptable directly to logic circuits. The new products provide translator-drivers as an integral part of each module. An inherent advantage of the seven-lamp display is the reduction in the drivers required from the usual 10 to seven. A diode matrix converts from BCD to the display code directly, avoiding any costly double conversion to decimal and then to the seven-line input to the lamps. Models are offered for power from 14 and 28 v d-c and for 120 v, 60 cps (rectified). All logic levels and polarities are

New Subassemblies



provided for and memory is optional. One-inch digits are displayed while panel area and depth projection are small. Punctuation—decimal, comma and colon—is optional in every module. An auxiliary module displays descriptive captions.

Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y., 11237. [403]

Digital printer solves decoding problems

The Accudata 200 oscillograph digital printer converts electrical data into printed digits on the left-hand margin of Visicorder oscillograph records, printing up to four digits per line at a maximum rate of 200 lines per second. This system makes possible the direct recording of digital data in precise time coincidence with analog traces on oscillograms. Until the introduction of the Accudata 200, real time or range time codes recorded on oscillographs by galvanometers required visual decoding, and actual digital equivalents had to be manually annotated on the record. The Accudata 200 solves these problems through the use of a new high-speed recording technique. The system uses a matrix of tiny light sources (as illustrated on p. 196) encapsulated in a recording head which is mounted within the Visicorder oscillograph. The numbers are formed by turning on remotely the appropriate combination of light sources in the matrix. The cycle time of these light sources is measured in nanoseconds, permitting extremely high printing rates at fast paper speeds. Time coincidence with analog data is achieved by mounting the recording head in the same plane as the galvanometer recording spots. The

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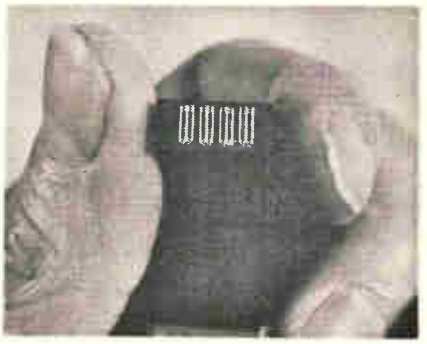
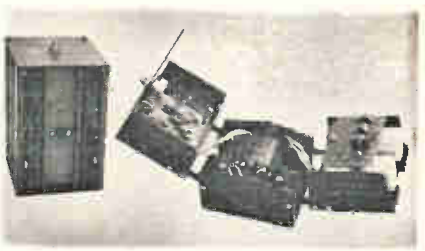


Accudata 200 may be programed to print any number of different data information blocks in any sequence. Simple programing can also provide time coincident event marks and data identification codes. Digital data can be recorded in time sequence or in any sequence on command, such as during a predetermined incremental change in value, or during an excursion beyond a predetermined level.

Honeywell, Denver Division, 4800 E. Dry Creek Road, Denver 10, Colo. [404]

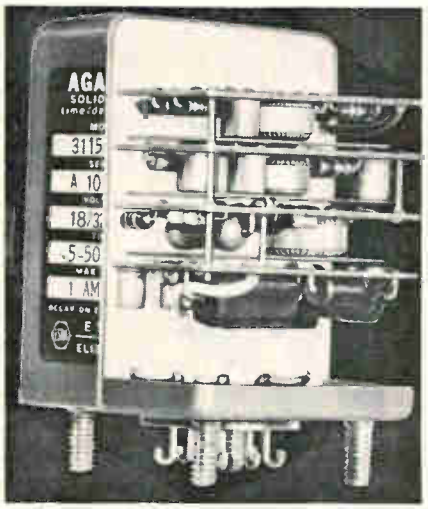
All-silicon, plug-in modular power supply



A line of ½-¼ amp, plug-in modular power supplies are announced for military and precision industrial application. The GS series of all-silicon units have outputs of 3 to 90 v at 500 ma in 5 voltage ranges. Electronic automatic short-circuit protection is built in and mean-time-before-failure is over 20,000 hours. Input is 105 to 125 v a-c, 50 to 400 cps, single phase. Regulation is ±0.02% line, ±0.05% load or ±5 mv; ripple, 200 μv; ambient, −20° to +65°C; stability, ±0.005% per °C typical; transient response, 50 μsec or less; size 5¾ in. high by 3⅝ in. wide

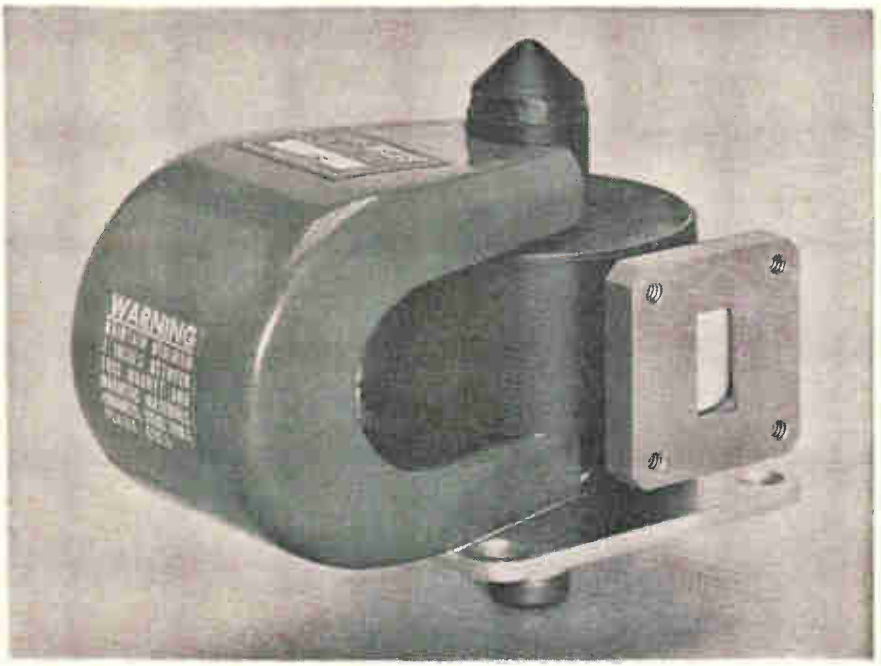
by 4¼ in. deep. These supplies are intended for use in systems designed to MIL-E-4158, MIL-E-5400, MIL-E-16400, and FAA 777.
Transistor Devices Inc., Route 53, Mt. Tabor, N.J., 07878. [405]

Magnetic timer offers extended delay



A series of precision electronic timing instruments uses the magnetic core counter principle. Principal features are high repeat accuracies, extended delay periods, and outstanding reliability, according to the manufacturer. The 3100 series delay-on-energizing timers offer ranges from milliseconds to months or years, with stock models providing 100:1 adjustment ratios. Typical accuracies are ±0.25% at fixed voltage and ambients, with 0.05% attainable in some models. Operating at 18-32 v d-c, they will switch up to 4 amps when supplied with static output, or up to 3 amps resistive at 32 v d-c with relay outputs. Two basic models are offered, designed for ambients of −55°C to 85°C or −55°C to 125°C. Standard delay ranges cover a total span from 0.05 to 500,000 seconds, with others supplied on special order. Timing is set at the factory, or may be externally adjusted, depending on type selected. All standard units measure 1½ in. square at the base, with height governed by timing range. Typical height for a 5,000 second timer is 3 in. A variety of mounting styles is available.
Agastat Timing Instruments, Elastic Stop Nut Corp. of America, 1027 Newark Ave., Elizabeth, N.J. [406]

New Microwave

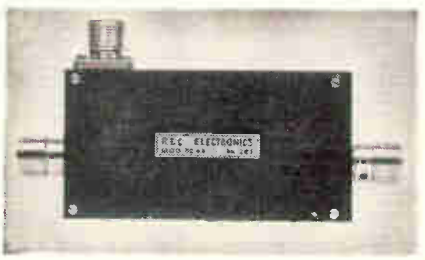


Coaxial magnetrons operate at Ku band

A new family of metal-ceramic coaxial pulse magnetrons operates at 16 to 17 Gc. The most important tube in the line is the L-3958, rated at 10 kw peak power with fixed frequency at 15.5 Gc. This is claimed to be the highest power ever produced in so small a package (maximum weight is 3.0 lb). The highly-efficient tubes feature low-frequency pushing and pulling, resulting in excellent spectrum coverage. Longer life is anticipated, since the tubes are designed with large emitting areas. The devices may be used in weather and surveillance radar, airborne and missile systems and pulse doppler systems. Operating conditions are: heater voltage, 6.3 v; heater current, 1.6 amps; preheat time, 60 seconds minimum; pulse voltage, 5.0 kv d-c nominal; pulse current, 5.0 amps. Pulse length is 2.0 μsec; duty cycle, 0.002; anode temperature, 150°C; cathode temperature, 175°C; vswr, 1.3:1; altitude, 25,000 ft.

Litton Industries, Electron Tube Division, San Carlos, Calif. **[421]**

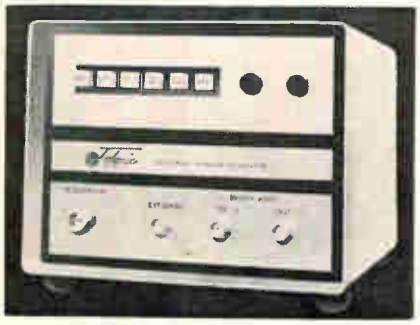
Directional couplers feature low vswr



A series of 18 standard precision coaxial directional couplers is announced. It covers the frequency range of from 120-245 Mc to 4-10 Gc with a coupling accuracy of ±1.0 db over the specified range. In each range, couplers are available with 10, 100 or 1,000 w power ratings. In addition to low vswr, the couplers offer high directivity. This makes them specially useful in reflectometer systems, in measuring antenna efficiency or in any laboratory application where there is a requirement to measure the power in one direction without disrupting the line. The vswr in coupling output is only 1.2 to 1

maximum and coupling can be specified for 10, 20 or 30 db. The units are made with lightweight aluminum and Teflon with silver plate finish. The type N or TNC female connectors are silver-plated brass. Prices start at $100 and range up to $225, depending on the frequency range, coupling and power rating.
RLC Electronics, Port Chester, N.Y. [422]

Marker generator spans 5 Mc to 12.4 Gc



The TMS-1 microwave marker generator provides sharply defined trace excursions on an oscilloscope or X-Y recorder to give precise indication of frequency intervals during a trace. Generally used with a swept frequency generator, the all solid state instrument enables the user to evaluate rapidly a frequency response curve by providing marks every 5, 10, 50 or 100 Mc over a range of 5 Mc to 12.4 Gc. In operation, the generator samples an unknown r-f from the swept source and mixes this sample with harmonics produced by its own internal crystal oscillator. The mixer output is then channeled to a low noise video amplifier and combined with the vertical input to an oscilloscope or X-Y recorder. Accuracy of the resulting markers is 0.001%. Marker frequency intervals are determined by a convenient push-button system allowing rapid selection or changing of marker spacing. If intervals other than standard are desired, an r-f connection on the front panel permits use of an external oscillator for any frequency, from 2 Mc to 200 Mc. This circuit is also activated by push button. Other controls include size and bias adjustment to regulate height of the

New Microwave

marks, an extremely convenient feature when working on steep slopes of the response curve. All controls and connections are made at the front panel of the instrument. Price is $1,485.

Telonic Engineering Co., a division of Telonic Industries, Inc., 480 Mermaid St., Laguna Beach, Calif. **[423]**

Peak power meter spans 3 to 300 mw

The Microline 66A3 peak power meter has been developed. Accurate, direct readout of peak power can be taken continuously and instantly with this high precision, completely-transistorized instrument. Microwave peak power measurements over the range of 3 mw to 300 mw can be made directly with unparalleled ease and accuracy, the company says. The Microline 66A3 requires no special skill to operate or additional equipment other than a bolometer mount with a calibrated barretter. The completely portable operation, and the small size and weight, permit simple field measurements. Four full scale ranges of 10, 30, 100 and 300 mw peak power are provided; accuracy is ±5% of full scale. Repetition rate is 50 to 10,000 pps, and pulse width is 0.25 to 10 μsec. Price is $890.

Sperry Microwave Electronics Co., P.O. Box 1828, Clearwater, Fla. **[424]**

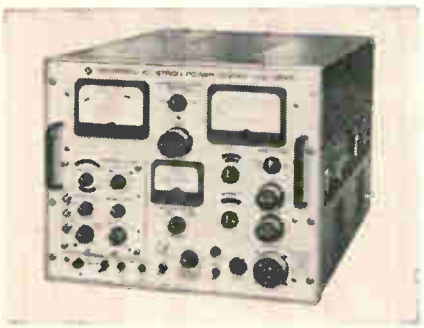
Miniature oscillator delivers 10 watts

The BETO oscillator, designated BTO-20, is one of a family of volt-

age-tunable magnetrons now available. It is a low noise, magnetically shielded tube delivering at least 10 w over any 600-Mc range specified between 2.6 and 3.7 Gc. Power flatness is ±1 db. Said to be the smallest 10-w package available, it weighs only 19 oz with heat sink. This rugged, miniature oscillator is ideal for applications requiring compact, lightweight packaging. The magnetic circuit configuration results in a negligible external magnetic field and permits the tube to contact other ferromagnetic materials without degrading performance. The integral heat sink allows the BETO oscillator to operate within specifications for more than two minutes without auxiliary cooling, starting from an ambient temperature as high as 160°F. Other characteristics include: noise power, below carrier, greater than or equal to 1 Mc from carrier is 80 db/Mc; modulation sensitivity, 1.8 ± 0.1 Mc/v; maximum anode voltage, 2300 v d-c; injection electrode voltage, 525 ± 50 v d-c.

Varian Associates, Bomac Division, Beverly, Mass. [425]

Klystron power supply for exacting lab use



A new universal klystron power supply, Model Z815C, has been designed for laboratory operation of most reflex klystrons, as well as many other microwave tubes. It features a digital readout dial for accurate presetting of the 4,200 v, 360 w beam supply and two separate reflector outputs. The unit offers a grid supply for positive or negative grid operation, and a 0.15 v d-c filament supply. All supplies have excellent line and load regulation and extremely low ripple. For example, the regulation of the beam supply is 0.005% for line and load;

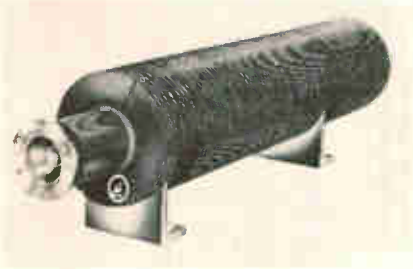
New Microwave

maximum ripple is 2.5 mv rms. A modulator section provides square wave, pulse, sawtooth and sine wave modulation which can be applied to reflector I or the grid. Counters or dials are provided for very accurate presetting of d-c voltages. The filament voltage is continuously monitored with an accurate voltmeter. The controls of the other supplies can be calibrated through a switchable metering circuit to an accuracy of ±0.25%. Metering of beam, grid and filament current is also included. The supply is available on eight weeks delivery and is priced at $1,975.
Microlab/FXR, Livingston, N.J. [426]

Phase-lock synchronizer and sweeper marker

A microwave phase-lock synchronizer and sweeper marker is being introduced. The synchronizer, model 244, is designed for the control of microwave frequency sources. It uses an i-f of 25 Mc and provides both discrete lock-point frequencies and continuous tunable coverage in the 2-to-15 Gc band. The 244 will phase-lock klystrons, backward-wave oscillators and other voltage tunable sources to an internal crystal reference or to an external reference. An external 5-Mc crystal-controlled reference oscillator can be used with the 244 for coherent control of microwave frequencies to crystal reference accuracies. When used with sweepers, the 244 can utilize its internal 10 Mc and 50 Mc precision marking points throughout the band with an accuracy of 0.001%. The 10 and 50-Mc increments can be used to extend the frequency range down to 35 Mc or up to 15,025 Mc. It is capable of controlling microwave frequencies to quartz reference accuracies; for example, a 10,000-Mc source to an f-m drift stability of 50 cps, and a long-term drift to 1,000 cps. Model 244 measures 3½ in. by 17 in. by 19 in. and weighs 30 lb. Price is $1,750 per unit; delivery, 30 to 60 days.
LFE Electronics, 1601 Trapelo Road, Waltham, Mass. [427]

Co-ax dummy loads for 0.2 to 10 Gc



Three new series of coaxial dummy loads are announced. They operate in the 0.2 to 10 Gc region and employ high temperature refractory material as the load elements. They are available with maximum power ratings up to 15 kw average and 40 Mw peak, and are supplied with EIA or JAN flanges or type N connectors. Maximum vswr is 1.20. The unfinned TT series and the transverse finned TV series are designed for free air convection cooling. The TW series loads are high power, liquid-cooled units. Each series is available in 14 combinations of connector series and frequency ranges. All three series are priced from $400, with availability set at 4 weeks. Special units can be custom designed to meet specific requirements.

Microlab/FXR, Livingston, N.J. [428]

Ultraminiature mixer-preamplifiers

A line of ultraminiature integrated mixer-preamplifiers is designed to be compatible with the manufacturer's microminiature i-f amplifiers. The units find applications in missile and aerospace systems where small size and weight are needed and extremes of environment are present. Featuring low noise performance, rfi construction, a calculated mean-time-between-failure of over 200,000 hours, and very low power drain, these units are available from vhf to Ka band. Typical of this series is model MMP34/2B. Its r-f is 34 to 36 Gc; i-f, 60 Mc; i-f bandwidth, 20 Mc; noise figure, 11db; gain, 20 db.

RHG Electronics Laboratory, Inc., 94 Milbar Blvd., Farmingdale, L.I., N.Y. [429]

New Production Equipment

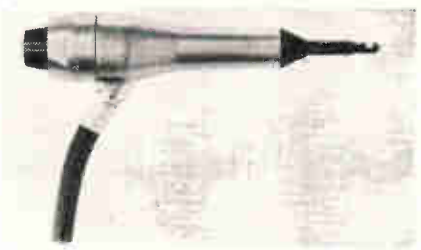
Fast-recovery diffusion furnace

Design of the model DKT ceramic element diffusion furnace, featuring a high thermal mass heat sink, is said to set new performance standards in the semiconductor industry. A 200 gram load of wafers inserted into this furnace has no more effect on thermal load than a drop of cold water falling into a pan of boiling water. The furnace has extremely high oxidation resistance both in the heat sink and in the heating elements, and thus can operate hundreds of degrees above normal diffusion operating temperatures. It is capable of continuous operation at temperatures up to 1,400°C. This leads to high thermal safety and extremely long equipment life. Model DKT provides extremely high thermal conductivity by means of the heat sink; this feature evens out temperature ripples and greatly simplifies instrumentation by permitting complete temperature control through a single instrument system.

It maintains flat zones of ±0.5° over the entire length of the heat sink. The sink design provides high thermal mass, so that work can be placed in the furnace and brought to operating temperature with no overshoot. The DKT sells for less than $4,000 per unit.

C.I. Hayes, Inc., Cranston, R.I. [451]

Single-action air guns punch, drive and cut



A line of single-action air guns for cutting and driving has been introduced. They are offered initially in eight different configurations for driving taper pin terminals, setting plastic rivets, driving retainer clips, center punching, and for cutting, crimping or bending nonferrous wire. Each gun is a single-purpose tool. A light squeeze on the throttle button triggers a piston blow with a maximum force of 65 lb. The piston action produces no kick and very little noise. The guns are designed to operate on an exclusive, patented "exploding air" principle, and are said to be the first of their kind ever offered to industry. Driving and punching guns, weighing 9¼ oz, are made of steel. Cutting guns weigh 6½ oz and are made of aluminum. The company reports that field tests in electronics manufacturing applications have proven the capabilities of the new single-action guns to achieve significant savings in time and labor. The cutting guns are used for quick trimming of wires on circuit boards. The driving guns can set captivated or non-captivating taper pin terminals with uniform pressure through any number of cycles. They are said to offer advantages over the hammer-and-punch method when used for setting rivets.

The Aro Corp., Industrial Division, Bryan, Ohio.[452]

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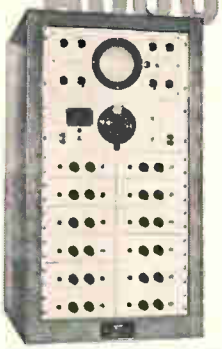
±0.03° ACCURACY



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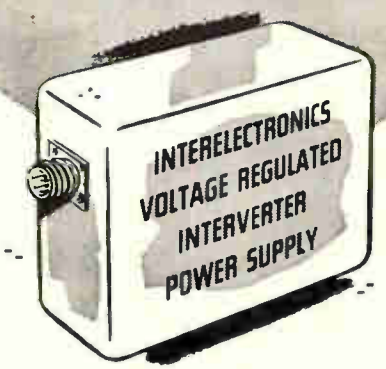

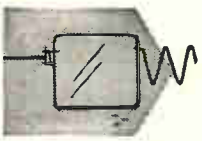

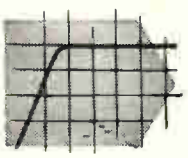

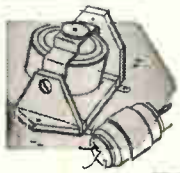

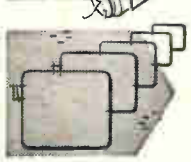

Interelectronics all-silicon thyratron-like gating elements and cubic-grain toroidal magnetic components convert DC to any desired number of AC or DC outputs from 1 to 10,000 watts.

Ultra-reliable in operation (over 260,000 logged hours), no moving parts, unharmed by shorting output or reversing input polarity. High conversion efficiency (to 92%, including voltage regulation by Interelectronics patented reflex high-efficiency magnetic amplifier circuitry.)

Light weight (to 6 watts/oz.), compact (to 8 watts/cu. in.), low ripple (to 0.01 mv. p-p), excellent voltage regulation (to 0.1%), precise frequency control (to 0.2% with Interelectronics extreme environment magnetostrictive standards or to 0.0001% with fork or piezoelectric standards.)

Complies with MIL specs. for shock (100G 11 mlsc.), acceleration (100G 15 min.), vibration (100G 5 to 5,000 cps.), temperature (to 150 degrees C), RF noise (I-26600).

AC single and polyphase units supply sine waveform output (to 2% harmonics), will deliver up to ten times rated line current into a short circuit or actuate MIL type magnetic circuit breakers or fuses, will start gyros and motors with starting current surges up to ten times normal operating line current.

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Interelectronics—first and most experienced in the solid-state power supply field produces its own all-silicon solid-state gating elements, all high flux density magnetic components, high temperature ultra-reliable film capacitors and components, has complete facilities and know how—has designed and delivered more working KVA than any other firm!

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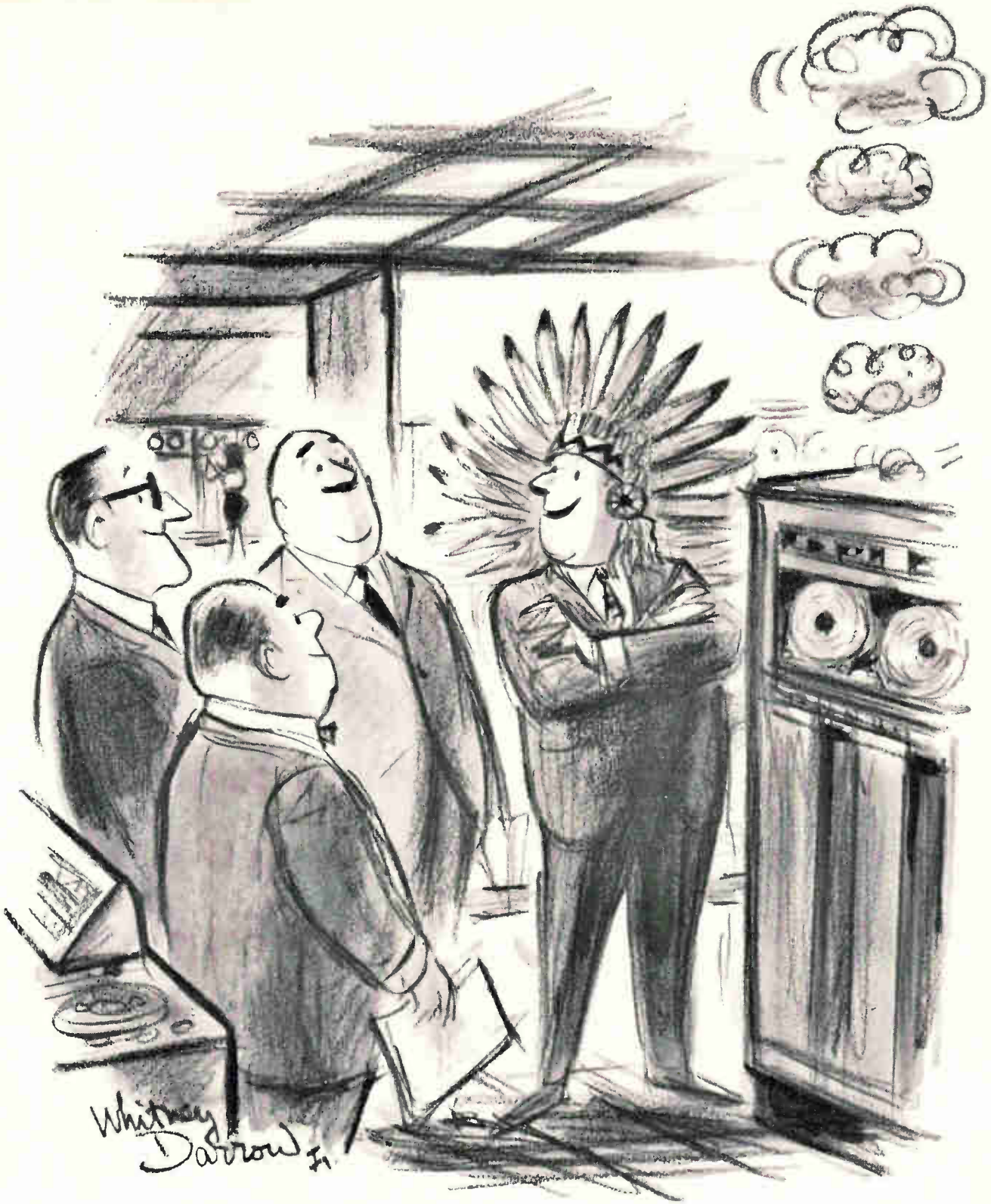

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Silicon carbide fibers in quantity

Single crystal silicon carbide whiskers are now in large quantity production. Previously, the making of whiskers has been confined to the laboratory where only a few grams at a time have been available for research purposes. The whiskers (shown magnified in the photo) are needle-like single crystals of from 0.5 to 3 microns in diameter and 10 to 300 microns in length. Tensile strength of the fibers is from 3 to 10 million psi. Fiber purity is 99.5% SiC. They are corrosion resistant to acids and aqueous alkalies, and retain strength of 2 to 3 psi up to 3,200°F. The company says there is no limit as to the quantities that can be produced. Twenty-five pounds can be supplied off the shelf. In small quantities, the whiskers would cost $100 per gram; large-quantity production has reduced this price to $100 an ounce, when supplied in 25-lb quantities. The crystals have potential as a structural reinforcement of plastics, metals and ceramics. Because silicon carbide is

opaque to infrared radiation, the fibers may be extremely useful for both cryogenic and high temperature insulation. Principal high volume application is for NASA and defense, as a high temperature resistance material for space applications.

The Carborundum Co., P.O. Box 337, Niagara Falls, N.Y. [441]

Two-part, heat-curing potting compound

A high-temperature resisting, elastomeric cable molding and potting compound is said to offer many advantages over conventional materials (including the polysulphides, polyurethanes and silicones). Designated EC-2273 B/A, it approaches or exceeds the requirements of Mil Spec 8516-C for sealing compounds used with electric connectors and electric systems. The potting compound has good low temperature properties at −60°F and is outstanding for applications where temperatures as high as 375°F will be maintained for 1,000 hours. It will also withstand temperatures of 500°F for four hours and 600°F for short periods of time without deterioration. The compound has the added advantage of weight reduction since its density is only 1.17 grams/cc. It provides excellent and consistent adhesion to many materials including primed metals, neoprene, PVC, etched Teflon, nylon and other wire insulation materials. EC-2273 B/A is a two-part, heat curing material which can be mixed in an open container at normal room temperatures. It is characterized by a long, 24 hour room temperature, non-moisture sensitive pot life and a relative fast cure of about 2½ hours at 225°F. The long pot life permits interruption in the application and curing operations when necessary. The material does not generate heat during cure and shrinkage is minimal. The new potting compound has a Rex durometer hardness of 60, and a Shore durometer hardness of 55.

Adhesives, Coatings and Sealers Division, 3M Co., 2501 Hudson Road, St. Paul, Minn., 55119. [442]

New Books

Measurements

Electronic Precision Measurement Techniques and Experiments
Members of the Staff, Philco Technological Center
Edited by John E. Remich
Prentice-Hall, Inc.
1964, 336 pp., $13

This is a general-purpose reference and training text which will be valuable to engineers and technicians interested in accurate tests and measurements. For example, the chapter on "Mathematic Evaluation of Errors" makes a clear distinction between the terms "accuracy" and "precision," something which is not always well understood by many engineers. The book's dominant theme of accuracy is skillfully interwoven with a second theme—the use and calibration of electrical and electronic instruments.

Although the major emphasis of the book is on electrical and electronic instrumentation, three of the thirteen chapters deal with other related subjects. Dimension measurements and calibrations are covered, as well as physical measurements and calibrations for force, pressure, temperature, optics, shock, vibration, and radioactivity.

An important aspect of the book is its attention to calibration—something which should make it of real interest to personnel doing standard laboratory and calibration laboratory work. For example, in addition to the chapter on errors, there are three other chapters dealing with "Introduction to Standardized Calibration," "Systems and Units of Measurement," and "Basic Standards and Measurements." Also, all of the remaining nine chapters of the book discuss calibration techniques in their respective equipment or measurement categories. Ten calibration procedures are given as training exercises at the end of some of the chapters.

The book is valuable for reference, although it does not have too much indexing in depth. However, the information is grouped logically in the various chapters and therefore is relatively easy to find. Forty-four pages of the book

are devoted to appendix material for reference use.

From the training point of view, this book is well suited for classroom use by groups, for on-the-job training, or for self-improvement study by an individual. Fundamental principles of measurement and instrumentation are covered well. In addition, there are numerous questions, problems and exercises at the conclusion of many chapters. Answers to problems are given on a separate page at the end of the book.

An earlier edition was published in 1962 by the TechRep division of the Philco Corp. under the title "Precision Measurement Techniques." The major change in the new edition appears to be the addition of the training material in the form of questions, problems, and exercises.

In spite of the fact that the type was entirely reset for this edition, some errors have been carried over from the 1962 edition. For example, on pages 227 and 228, the value of microwave attenuation obtained by the audio substitution method is incorrectly described as being the average of two values, A_1 and A_2, instead of one-half of the distance of the values A_1 and A_2. The book is not excessively mathematical, but basic equations are given.

The book is not a completely up-to-date text, because some of the material dates back five or more years prior to the 1962 Philco edition. However, this is incidental to the fundamental principles of measurements, calibrations, and instrumentation which are so well covered by this book. Also, this is one of the few books of its kind in this important field of accurate measurements and tests.

Lloyd B. Wilson
Sperry Gyroscope Co.
Great Neck, N.Y.

Recently published

Handbook of Electron Tube and Vacuum Techniques, Fred Rosebury, Addison-Wesley Publishing Co., 598 pp., $17.50

Engineering Systems Analysis, A.G.J. MacFarlane, Addison-Wesley Publishing Co., 272 pp., $8.50

Understanding Lasers and Masers Stanley Leinwoll, John F. Rider Publisher, 88 pp., $1.95

Technical Abstracts

Mechanical modulator

Frequency modulation of a GaAs diode laser
C.S. Kim, H. Raillard, J. M. Smith, S.W. Tehon and R. Vuilleumier
Electronics Laboratory, General Electric Co., Syracuse, N.Y.

Hydrostatic pressure, applied by a piezoelectric transducer, appears to be the most precise technique yet devised for directly modulating the frequency of gallium-arsenide diode lasers. The technique enables the diode to be operated at a constant power level, which avoids the temperature changes induced in the laser by the more conventional method of modulating the diode input current. Such temperature changes cause linearity in emission intensity, wavelength and radiation pattern and make it difficult to obtain coherent optical transmission.

Current modulation can result in frequency variations of several hundred gigacycles, while hydrostatic modulation gives a frequency stability of around 5 megacycles, or about 10^{-4} angstrom units in wavelength. A hydrostatic pressure of 50 atmospheres will change the wavelength of a gallium arsenide laser by 1 angstrom.

The feasibility of hydrostatic modulation is demonstrated by the following structure: a diode laser is mounted between two tungsten disks which provide electrical and thermal contact. This structure is placed on a copper heat sink. To the top disk is coupled a copper plate over which the lead-zirconate-titanate transducer is located. The diode electrodes are soldered to the heat sink and plate, and the transducer electrodes to the plate and transducer.

For convenience the laser is operated in a pulse mode at a temperature of 77° K (it can be lased continuously at 3° K). The transducer's ultrasonic resonance frequency is 2.5 megacycles. The compression and extension of the transducer is applied in phase with the diode current pulses by inserting a delay-line and 13-stage binary countdown circuit between the 2.5-mc oscillator and the diode pulse supply. The diode is pulsed for 1½ microseconds, 300 times a second.

Analysis of the diode's spectral response shows that the wavelength shifted by about 1.4 angstroms during alternating voltage cycles, including a thermal shift of about 0.1 angstrom. The wavelength shift is 0.01 angstroms per volt, for a transducer voltage swing of 130 volts. Modulation is 500 megacycles per volt. An optical phase shifter is required to detect modulation.

The technique is less complex and requires considerably less power than laser modulators which depend upon the birefringent effect in crystals such as KDP (potassium dihydrogen phosphate).

The hydrostatic-pressure effect was previously noted by G. E. Fenner in the Journal of Applied Physics, p. 2955, 34/1963. (During discussion of the paper, J. P. Vasseur, of CSF Laboratories, France, said that a similar experiment had been carried out there.)

Presented at the International Solid-State Circuits Conference, Philadelphia, Feb. 17-19.

Laser logic

GaAs laser inverter
W.F. Kosonocky, R.H. Cornely and F.J. Marlowe
RCA Laboratories, Radio Corp. of America, Princeton, N.J.

Because the decay times of diode lasers are 10^{-11} or 10^{-12} seconds, digital logic elements made with such lasers may operate 10 to 100 times faster than transistor-type logic. Laser logic devices may provide signal gains of 100 to 1,000 and delay times around 10 nanoseconds.

Several types of laser logic devices have already been reported by Kosonocky and other experimenters. This paper reports early tests of a laser inverter that can perform logic functions such as OR-NOT and AND-NOT.

The basic inverter is a gallium-arsenide crystal 10 mils wide, 30 mils long and 4 mils high, with the junction a horizontal plane 10 by 30 mils. The rear 26 mils of the two long sides are roughened with abrasive and the opposite end is lapped to a 15-degree angle. This, in effect, creates two lasers, one an amplifier along the long axis and the other

an oscillator whose axis is between the unroughened ends of the long sides.

If the beam of another diode laser enters this laser along the amplifier axis, it quenches the oscillations in the oscillator section, turning off the normal output through the two unroughened portions of the long sides of the laser. The amplified input beam then exists through the angled end of the laser and can be used as an input to another inverter.

The same crystal has been converted into a dual laser-oscillator by sawing a groove into the top surface, at the back edge of the oscillator portion, and providing separate electrical inputs to each portion. The large section then provides the quenching signal directly to the oscillator.

The measured quenching time of the dual laser is 1 nanosecond, but it is probably actually in the picosecond range, since a photodiode with limited response was used for signal detection. Also, gain must be more than 10 for quenching.

Among the problems still to be solved before such devices become practical are signal coupling and the necessity for operation at cryogenic temperatures.

Presented at the International Solid-State Circuits Conference, Philadelphia, Feb. 17-19.

Semiconductors vs. ferrites

Isolators using semiconductors
J. Gremillet
Compagnie Generale de Telegraphie Sans Fils, Puteaux (Seine), France

The electromagnetic helicon effect can be used to make semiconductor devices, such as isolators, circulators and phase shifters, at frequencies impractical for gyromagnetic devices made of ferrites. The helicon effect is useful at any frequency between a few cycles per second to 10 gigacycles.

The helicon effect refers to the corkscrew-like motion of an electron in the presence of d-c magnetic induction and a pulsating electric field. It was first reported by P. Aigran in 1960.

Details are given for an 80-megacycle isolator with a power rating of 10 watts when cooled by air. It is made of indium antimonide semiconductor crystal and built into a coaxial cable. The operating frequency is too low for a practical

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Technical Abstracts

ferrite device. The insertion losses of such circulators are typically less than 1 decibel at frequencies between 30 and 1,000 megacycles.

Presented at the International Solid-State Circuits Conference, Philadelphia, Feb. 17-19.

Optoelectronic coupling

An optically-coupled digital integrated circuit
J.D. Merryman, Texas Instruments, Inc., Dallas

Optoelectronic techniques can achieve circuit functions previously difficult or impossible to reduce in microelectronic form. The electrical isolation provided by optical coupling permits a considerable common-mode rejection between input and output.

An optoelectronic pulse amplifier (OPA) is a digital integrated circuit which performs the function of a broadband pulse transformer with response extending to zero frequency. It uses optical coupling internally to provide an electrically isolated input. It has applications in transmitting either a-c or d-c signals across computer subsystem interfaces, where circulating currents make it undesirable or impossible to interconnect subsystem grounds. The devices can also be used to reject common-mode noise at the receiving end of long transmission lines. Transformers customarily used have limited bandwidth and do not transmit d-c.

The OPA is packaged in a standard semiconductor flatpack and operates from a single power supply of 3-6 volts.

The input terminals are connected to a thin flat gallium arsenide injection-luminescent diode which may be driven by 5-ma pulses at 1.2 volts. The optical output is coupled by a thin layer of a ternary selenium glass to a silicon photodiode built in a p-type substrate. The diode output feeds an amplifier circuit in the same substrate. The amplifier produces 5-volt output pulses of 300 nanosecond rise time when operated from a 6-volt power supply. Smaller amplitudes and longer rise times are obtained with a three-volt power supply.

Presented at the International Solid-State Circuits Conference, Philadelphia, Feb. 17-19.

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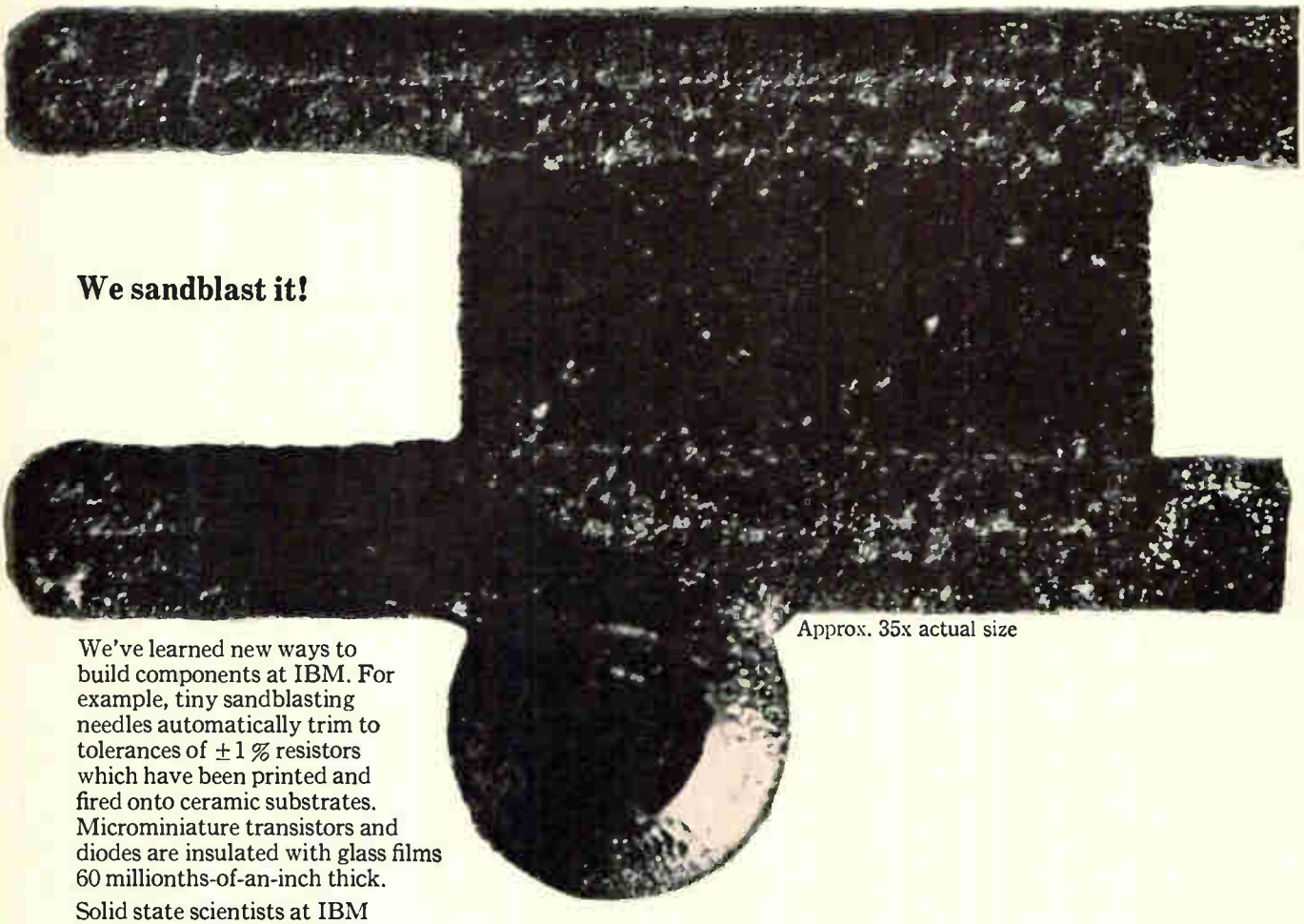

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Output 22kv at 28 amp. Rep. rates: 2.25 microsec. 300 pps, 1.75 msec 550 pps, .4 msec 2500 pps. Uses 5C22 hydrogen thyratron. Complete with driver and high voltage power supply. Input 115v 60 cy AC.

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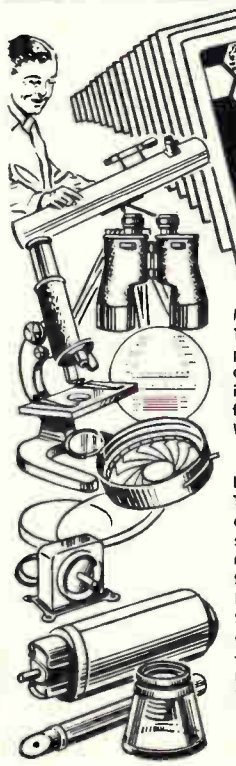

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New Literature

Relays. Eagle Signal, a division of The E.W. Bliss Co., 736 Federal St., Davenport, Iowa. A 16-page brochure describes and illustrates a line of general purpose and medium power relays. Circle **461** on reader service card

Soldering gun. Wen Products, Inc., 5810 Northwest Highway, Chicago, Ill., offers a bulletin on the model 450 All soldering gun that features automatic thermal regulation, said to provide heat to the tip 36 times faster than a comparable 500-w soldering iron. **[462]**

Microwave radio. Lenkurt Electric Co., Inc., 1105 County Road, San Carlos, Calif., has issued a brochure describing its type 76E microwave radio system for use in the industrial and auxiliary broadcast frequency bands between 12.2 and 13.25 Gc. **[463]**

Pressure transducers. Computer Instruments Corp., 92 Madison Ave., Hempstead, L.I., N.Y., has available a completely revised 24-page catalog featuring precision-film potentiometer pressure transducers. **[464]**

Nickel cadmium cells. Gulton Industries, 212 Durham Ave., Metuchen, N.J. New D-size Adhydrode, sealed nickel cadmium cells with substantially reduced charging time are described in bulletin VO120a. **[465]**

Analog multipliers. American Aerospace Controls, Inc., 123 Milbar Blvd., Farmingdale, N.Y., has available a four-page bulletin describing its 0.1% accurate, feedback controlled series 3050 analog multipliers. **[466]**

X-Y recorders. Houston Instrument Corp., 4950 Terminal Ave., Bellaire, Texas. 77401. A new short-form bulletin gives essential specifications, features and prices of a complete line of X-Y recorders. **[467]**

High density packaging. Magnetic Shield Division Perfection Mica Co., 1322 No. Elston Ave., Chicago, Ill., 60622. Data sheet 175 shows how higher density packaging can be achieved by enclosing magnetically sensitive components of any size or shape in shields that are easily, quickly cut to shape from permanently preannealed Netic and/or Co-Netic foil alloys. **[468]**

Industrial laminates. General Electric Co., Laminated Products Dept., Coshocton, Ohio. A 16-page booklet describes Textolite copper-clad laminates, thin glass laminates for multilayer circuitry, sheets, tubes and rods. **[469]**

Dual directional couplers. Adams-Russell Co., Inc., 280 Bear Hill Road, Waltham, Mass., 02154. A technical data sheet describes two dual directional couplers that provide constant coupling over the frequency range from 2 to 100 Mc. **[470]**

Porous anode capacitors. General Electric Co., Schenectady, 5, N.Y. GET-2993A is a 20-page bulletin describing polar, tantalum porous anode capacitors with thixotropic liquid electrolyte. **[471]**

Hardware. Atlee Corp., 2 Lowell Ave., Winchester, Mass., offers a general catalog covering its line of component holders and clips, tube shields and inserts for industry. [472]

Thermistor terminology. Victory Engineering Corp., 136 Springfield Ave., Springfield, N.J. Bulletin MTD131 defines 22 terms commonly used in connection with thermistors, and explains the significant parameters pertinent to these temperature-sensitive resistive components. [473]

Trimming potentiometers. Helipot Division of Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif., 92634, has available a data sheet covering commercially priced Helitrim model 75 trimming pots. [474]

Photocells. Clairex Corp., 8 W. 30th St, New York 1, N.Y., has available a 16-page photocell designers manual. [475]

Frequency response tracer. B&K Instruments, Inc., 3044 W. 106th St., Cleveland 11, Ohio. A four-page specification booklet has been released on the new model 4709 frequency response tracer with 14-in. crt. [476]

Digital sequence controllers. Emerson Electric Co., 8100 Florissant Ave., St. Louis, Mo., 63136. A two-color specification sheet covers Accra-count direct digital controllers for sequential operations. [477]

Solder and flux kit. Alpha Metals, Inc., 56 Water St., Jersey City, 4, N.J., has issued a bulletin describing the new solder and flux kit for pre-soldering in research and development and for solving pre- and post-soldering production problems. [478]

X-Y recorders. Houston Omnigraphic Corp., 4950 Terminal Ave., Bellaire, Texas, 77401. A single-sheet bulletin contains complete specifications, features and prices covering the company's newest X-Y recorders. [479]

Passive networks. Electra Mfg. Co., 800 North 21st St., Independence, Kansas, 67301. Bulletin 864101 tells how, why and when to design with Microelectron thin-film passive networks. [480]

Nickel cadmium batteries. Gulton Industries, Inc., 212 Durham Ave., Metuchen, N.J., has issued an illustrated brochure describing its expanded KO series of rechargeable, pressure-vented, nickel cadmium batteries. [481]

Capacitor specifications. Union Carbide Corp., Kemet Department, 11901 Madison Ave., Cleveland, Ohio, 44101. Two bulletins now available relate the benefits of Kemet solid tantalum capacitors to the new high reliability MIL specifications. [482]

Voltage reference source. Epsco, Inc., Data System Products Division, 411 Providence Highway, Westwood, Mass. Technical bulletin 96401 describes the model VRS-611 portable voltage reference source. [483]

Semiconductors. Amperex Electronic Corp., Slatersville, R.I., 02876, has announced the latest edition of its condensed semiconductor catalog. Copies may be obtained by writing to the manufacturer on company letterhead.

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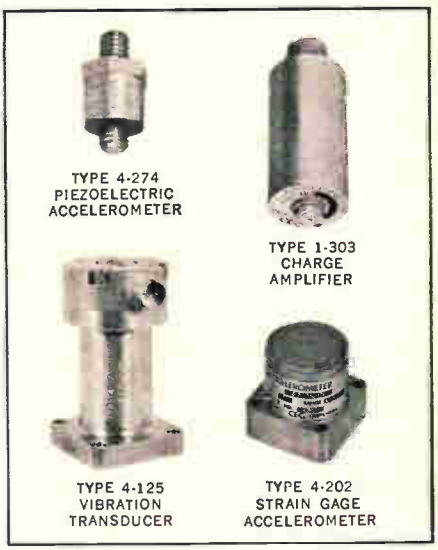

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March 8, 1965

Electronics Abroad

Volume 38
Number 5

Germany

Along the wall

Ever since its construction by East Germans on Aug. 13, 1961, the seven-mile-long Berlin Wall has been a formidable barrier to travel between East and West Berlin. But it's a puny obstacle to modern electronics.

Radio and telephone communication across the wall is simple, frequent—and dangerous.

Families who find themselves separated by the cold war, although in waving distance of each other, often maintain contact via ordinary telephones connected by a beam of infrared light shining between their apartments. Some enterprising tinkerers have refined their systems with multiplexers and amplifiers. Others, with more money and daring, sometimes use small f-m sets of 1 or 2 watts.

Sinister aspects. A report on Aunt Helga's health isn't the only kind of information smuggled across the wall. A few years ago an East German spy who lived next door to United States Army Headquarters in West Berlin was arrested while posing as a press photographer. He had converted his camera into a Morse-code transmitter, using an infrared light beam to carry his messages over the wall.

The battle of wits and watts is carried on below ground, too. East German security police are said to use deep metal probes and highly sensitive microphones to detect digging, as for tunnels. The probes go down to about 300 feet and are connected in groups to central consoles, where operators switch in and listen for unusual noises.

The East Germans still remember the U. S. Central Intelligence Agency's feat of tunneling into East Berlin and tapping the central telephone exchange for a year before being discovered.

The wall, seen from West Berlin.

Bugging the Reichstag. Listening equipment, for tapping into official telephone lines in West Berlin, is reported to be installed in an abandoned railway tunnel connecting the Reichstag to the former Reichs-Chancellery in East Berlin.

Committees of the West German Parliament meet regularly in the old Reichstag building. During the past month, several officials meeting in the south wing have noticed extraordinary activity in a five-story office building about 140 feet to the east—across the wall. The West Berlin police are convinced that East German cameramen were filming the committees' proceedings, using telescopic lenses.

West German officials believe that several other rooms in the Reichstag, those with eastern exposure, are regularly monitored by sensitive "big ear" microphones set up just east of the wall. Meetings dealing with security matters are held in the far end of the building. But the foreign relations committee, still insecure, has moved out of the Reichstag entirely, into quarters in a federally owned building far from the wall.

War of the airwaves. At longer range, the electronic war is waged across the Berlin Wall by radio and television. West Berlin has six radio stations, including the Free Berlin Transmitter (SFB), which also operates a tv transmitter. East Berlin has four radio stations, including the Volga transmitter operated by the Soviet Union.

Western tv programs seem to be popular in the East. A foreign guest, in an East Berlin hotel used chiefly by Communist party functionaries, switched on the tv set in his room recently and was surprised that the only program he could get was from SFB in West Berlin. When he asked why, a party official explained. "I'm sorry, but our antenna is fixed to only point west."

About 48% of East German homes have tv sets, and 70% of these are believed to tune in occasionally to programs that originate in the West. For the highly industrialized southern part of East Germany, the West operates transmitters in northern Bavaria and along the Iron Curtain.

Despite the constant propaganda barrage by airwave, little jamming is practiced. Technicians are even reported to exchange news over the air when things are slow.

Electronic wall? A steady trickle of clues indicate that East Germany is seeking an electrical and electronic substitute for the ugly wall covered with barbed wire. Border guards who escaped to the West in recent weeks say engineers are trying to develop "a per-

fect national border" by 1970.

In January, the East Berlin police erected a short stretch of trip-wire fence of low voltage, possibly as a test installation.

Silent Spectra

The most likely challenger of the International Business Machines Corp.'s preeminence in the European computer field would seem to be the quiet combination of two giants—the Radio Corp. of America and Siemens & Halske AG of West Germany.

Last month the Siemens 4004 system was introduced. The accompanying fanfare omitted one significant fact: the central processors are RCA's new Spectra 70. The only Siemens equipment is in peripherals — printer, punched-tape unit and typewriters.

Fast action. It's the first large-scale introduction of Spectra 70 equipment in Europe, although customers must wait until late this year for delivery. The move stems from a long-discussed agreement the two companies signed in December, by which they share licenses and sales facilities [Electronics, Sept. 21, p. 100].

Siemens is secretive about its new computer. It even refuses to tell who's buying it, but some customers are known to be companies that had considered buying the Siemens 3003, a transistorized unit in the microsecond class. The 4004 is rated in nanoseconds.

New generation. Siemens says all components for the Spectra 70 are already in production in Germany, but units for the first customers will be imported, almost in toto, from the U. S. The company concedes it's still a year away from assembling them into a third-generation system that will probably be named Siemens 5005. A company official says Siemens labs have developed thin-film techniques and solid-state circuits comparable with RCA's and with those of other concerns in the United States.

Programing is a different matter. Industry observers believe this may be RCA's biggest contribution in the Siemens transaction.

The Reichstag: is it bugged?

Punched-card equipment for the 4004 comes from IBM.

Counterattack. Siemens' new push into microcircuitry and nanosecond speeds seems to be a reaction to two American companies' moves into the German market: IBM, a perennial power made stronger with the new System 360; and the General Electric Co., which invested $43 million last summer in Compagnie des Machines Bull in France.

Although it's one of Western Europe's top 10 industrial concerns, Siemens is a relative newcomer in the computer field. Its first commercial unit, the 2002, was introduced about six years ago. The 2002 was able to compete technically, but was considered too expensive. The 3003, introduced last spring, has been somewhat more successful.

Siemens has installed about 70 computer systems in West Germany, accounting for 3% of the market. IBM dominates the field with about 65% of all installations and Machines Bull has about 5%.

Fierce competition. The European computer market is expected to be rich and cutthroat. Market analysts see a 25% annual climb in sales—double that in the U. S. By 1970, new installations in Germany are forecast at 6,000 to 7,000, compared with 1,274 installed now; in Western Europe, 15,000 computers will be added to the present 3,920.

But of 17 companies now selling computers in West Germany, only half a dozen are expected to still be in the race five years from now.

Mideast muddle

When Gamal Abdel Nasser invited East Germany's Communist Party leader to visit Cairo, the West German government offered Egypt's president a sop. Bonn announced that it was halting further arms shipments to Israel.

The announcement produced surprise in many world capitals. West Germany had disclosed a well-kept secret. Since 1961, Bonn has sent about $64 million worth of arms to Israel, fulfilling 80% of a commitment made by former Chancellor Konrad Adenauer. German exports of electrical and electronic equipment to Israel in 1963—the last full year for which figures are available —totaled $6.5 million, with more going via Italy and, presumably, other countries.

When Walter Ulbricht arrived in Cairo on Feb. 24, Bonn considered it an indication that Egypt might recognize East Germany. West Germany halted all economic aid and hinted at a break in diplomatic relations.

Loser all around. The news of West Germany's private deal with Israel spotlighted a program of military sales and aid that the government had been conducting in the Middle East and Africa with little publicity and almost no controversy. The program is valued unofficially at $200 million over the last three years, much of it in electronics equipment. This is in addition to commercial exports. Now both military and commercial exports to that portion of the world are in jeopardy.

Israel imposed a counterboycott on the German companies that halted military shipments.

For West German companies the commercial stakes are large. The United Arab Republic's imports from West Germany total $100 million a year, including about $10.5 million worth of electrical and electronic equipment. Egypt's partners

in the Arab League account for more business: Syria, $2.3 million worth of electrical and electronic gear; Iraq, $3.6 million; Jordan, $700,000.

No comment. West Germany's two biggest electronics companies —Telefunken AG and Siemens & Halske AG—have refused to answer any questions about the effect of the threatened break with Egypt. Another company, Imperial Rundfunk und Fernwerk, says it has a $5 million contract with Cairo to supply 20,000 portable Astronaut television sets in knocked-down form for reassembly in Egypt.

In the past nine months, Imperial Rundfunk says it has shipped 5,000 of the 19-inch, battery-powered sets at $250 apiece. The company expects to complete the transaction, its largest order from abroad.

If East Germany succeeds in gaining recognition in Cairo, it could use this as a wedge elsewhere. Besides Israel, nine other countries have received or negotiated for military aid from Bonn.

Tanzania, composed of the former countries of Tanganyika and Zanzibar, already has accepted an East German consulate general in Dar es Salaam, the capital, and probably will be stricken from Bonn's aid list. East Germany has official representatives in 36 noncommunist countries.

Chile

Party line

President Eduardo Frei calls his economic reform program "revolution with liberty." In the past month he has broadened its scope with moves toward nationalization of Chile's telephone and electric power systems.

The actions are designed to step up expansion of communications and power in this ribbon-like country that extends along the Andes Mountains, 2,600 miles north to south with an average width of only 100 miles. They're aimed, too, at Chilean control of public utilities. If the moves on the eve of the March 7 congressional elections also increase the popularity of Frei's Christian Democratic Party, he figures so much the better.

President Frei moves toward nationalization of Chile's telephone industry.

More phones. The government arranged for the acquisition of 49% of the shares of the Chilean Telephone Co. from the International Telephone and Telegraph Corp. The shares will be owned by the government and by private investors. Ultimately Frei hopes to nationalize the telephone industry.

Chile now has 251,000 phones—about 2.8 per 100 residents. Under a five-year expansion plan, the government expects that number to rise to 436,000. The purchase and expansion will cost $125 million.

More jobs. ITT also has agreed to manufacture in Chile 88% of the equipment necessary for the expansion. Frei expects this to result in more industrial investment and in more jobs—about 1,300—for Chilean workers.

When the power agreement is completed, Chile will own 90.5% of the Chilean Electric Co.'s shares, with the rest held by private Chilean citizens. The company is a subsidiary of the American & Foreign Power Co. Chile also owns Chile's Electric Enterprise, Inc., a power complex that produces 69% of the country's electricity.

Great Britain

Fadeproof phones

High-frequency telephone circuits between London and New Delhi are field-testing a system designed to overcome heavy noise and fading. The new electronic link combines a-m and f-m transmission.

The Post Office, which operates Britain's telephone network, designed the system, called Lincompex. It says Lincompex is providing satisfactory reception under conditions that would block conventional two-way phone communication entirely. Lincompex is said to set a new standard of reliability under changing conditions of radio propagation.

Control signal. The compression and expansion functions at the transmitter and receiver are linked by a separately transmitted control signal. At the transmitting end, the speech input is applied to a compressor, which gives a constant output irrespective of the speech-input level. The compressor's response eliminates even syllable-to-syllable changes in amplitude. The compressor always fully modulates the radio transmitter to assure optimum signal-to-noise ratio. The compressor also produces a separate control signal proportional to the speech level at the input.

The control signal is transmitted over the radio link by frequency modulation of a subcarrier. The f-m system makes the signal relatively immune to fading.

At the receiving station the compressed speech and control signal are separated by filters. The control signal is demodulated in a discriminator. Meanwhile the compressed speech is applied to a variable-gain expander amplifier. Amplification in the expander is controlled by the demodulated control signal, which restores the original amplitude variations of the speech.

No singing. This linked system eliminates the need for singing suppressors, which are commonly used in international telephony to prevent instability due to high net gain around the circuit in the go and return pattern. The suppressors, acting as voice-controlled switches, insure that only one direction of transmission is connected at any time. Under poor propagation conditions, lock-out can occur where noise operates one of the suppressors, preventing one subscriber

from breaking in to switch the circuit over. In the Lincompex system, the circuit has constant loss, and singing suppressors are unnecessary.

In addition, the control signal is used between words to mute the expander so that radio noise from the link is muted during silence intervals.

India

Status symbol

New Delhi, which is still struggling to stamp out vestiges of India's ancient caste system, has a new status symbol: the television antenna.

The capital of the second most populous country on earth has exactly 551 registered tv receivers. Nearly one-third of these are in government-owned tv clubs, a few dozen others are in schools, and a handful more are communally owned. That leaves precious few in private residences in this city of 2.5 million residents.

The picture may change drastically when the government launches its five-year plan for a $210-million network to serve most of the country's 450 million inhabitants.

Why the hurry. There's a sense of urgency in government offices where tv plans are being drawn. Television is considered vital in reducing illiteracy from its present 76%, encouraging family planning, improving hygiene, spreading agricultural information, and generally bringing 20th-century technology to this backward nation.

There's another, less altruistic reason: politics. National elections are scheduled in the spring of 1967. The ruling Congress Party would like to use tv as a campaign medium. Party leaders are trying to lure foreign capital and technicians to India long before the campaign begins.

High hurdles. The obstacles are formidable: 14 recognized languages and hundreds of dialects, and a critical shortage of foreign exchange, to name a couple.

India's only tv station is a five-kilowatt transmitter in New Delhi, financed by the Ford Foundation in 1959 and operated as a test station by the state-owned All-India Radio Broadcasting Co. It now broadcasts two hours a week in addition to a few hours of special school programs. Immediate plans call for boosting this to 2½ hours a day.

Government leaders say high priority will have to be given to receiver production.

The first phase of tv development would be the construction of high-power transmitters in New Delhi, Bombay, Calcutta and Madras. Later, transmitters would be built in smaller cities and all stations would be linked by a network of relay stations.

Who'll pay. One obstacle to financing is the anti-advertising stand taken by Mrs. Indira Gandhi, India's minister for information and broadcasting, and by other government leaders. Without commercials, Indian tv would have no chance of becoming self-supporting.

Communist East Germany has engaged in some hard selling to persuade India to let East German technicians install the tv system. The Germans have offered a $50-million credit, much of it to go toward tv development. There's one string: India must recognize East Germany. So far, India has rejected that condition.

West Germany says it has offered no foreign aid for India's tv. Two companies—Telefunken AG and Siemens & Halske AG—have shown interest in doing business with India, but they're not talking about credit.

A British-led consortium also is said to have offered to supply equipment.

Propaganda. There's also pressure in Parliament for building a radio network to counteract anti-Indian propaganda from Communist China. The government plans to establish one high-power, medium-wave transmitter in Calcutta in December, strong enough to reach most of Northeast and South-

east Asia. It will also build two 250-kilowatt stations and one 100-kilowatt unit in New Delhi. These will begin operation this year.

The government is trying to obtain these transmitters from Communist countries and to pay for them in rupees.

Around the world

Hong Kong. A cable-laying vessel sailed into Hong Kong harbor one day recently after a stormy voyage through the typhoon-infested South China Sea, and completed the first phase of a round-the-world telephone cable. The system is called Seacom—for Southeast Asian sector, British Commonwealth telecommunications project—now links Hong Kong with the Malaysian cities of Singapore and Jesselton. The next phase will extend the link to Australia.

Seacom will provide 80 high-quality telephone circuits or their equivalent in teleprinter or data circuits. Equipment is supplied by Standard Telephones and Cables, Ltd., the British subsidiary of the International Telephone and Telegraph Corp. So far, STC has received orders totaling more than $61 million.

Italy. Pleasure craft cruising in the Mediterranean may soon have bright-display radars—at least those owned by dolce vita sailors who are willing to pay $3,150 for the luxury. The transistorized device was shown at the fourth International Nautical Show in Genoa by Selenia, the Italian subsidiary of the Raytheon Co.

Its antenna uses a two-inch-thick horizontal blade that spins at 80 revolutions per minute. The antenna is a slotted-waveguide array, providing a 1.6° horizontal and 23° vertical beamwidth.

Trinidad & Tobago. The Caribbean will have its first television plant when Sylvania Electric Products, Inc., opens an assembly line in Port of Spain early this spring. Sylvania, a subsidiary of the General Telephone & Electronics Corp., will produce a full line of tv sets, radios, stereophonic phonographs, and telephone and telecommunications equipment.

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3	22	41	60	79	98	117	136	155	174	193	212	231	250	269	288	307	326	345	364	383	402	421	440	459	478	497	516	964
4	23	42	61	80	99	118	137	156	175	194	213	232	251	270	289	308	327	346	365	384	403	422	441	460	479	498	517	965
5	24	43	62	81	100	119	138	157	176	195	214	233	252	271	290	309	328	347	366	385	404	423	442	461	480	499	518	966
6	25	44	63	82	101	120	139	158	177	196	215	234	253	272	291	310	329	348	367	386	405	424	443	462	481	500	900	967
7	26	45	64	83	102	121	140	159	178	197	216	235	254	273	292	311	330	349	368	387	406	425	444	463	482	501	901	968
8	27	46	65	84	103	122	141	160	179	198	217	236	255	274	293	312	331	350	369	388	407	426	445	464	483	502	902	969
9	28	47	66	85	104	123	142	161	180	199	218	237	256	275	294	313	332	351	370	389	408	427	446	465	484	503	951	970
10	29	48	67	86	105	124	143	162	181	200	219	238	257	276	295	314	333	352	371	390	409	428	447	466	485	504	952	971
11	30	49	68	87	106	125	144	163	182	201	220	239	258	277	296	315	334	353	372	391	410	429	448	467	486	505	953	972
12	31	50	69	88	107	126	145	164	183	202	221	240	259	278	297	316	335	354	373	392	411	430	449	468	487	506	954	973
13	32	51	70	89	108	127	146	165	184	203	222	241	260	279	298	317	336	355	374	393	412	431	450	469	488	507	955	974
14	33	52	71	90	109	128	147	166	185	204	223	242	261	280	299	318	337	356	375	394	413	432	451	470	489	508	956	975
15	34	53	72	91	110	129	148	167	186	205	224	243	262	281	300	319	338	357	376	395	414	433	452	471	490	509	957	976
16	35	54	73	92	111	130	149	168	187	206	225	244	263	282	301	320	339	358	377	396	415	434	453	472	491	510	958	977
17	36	55	74	93	112	131	150	169	188	207	226	245	264	283	302	321	340	359	378	397	416	435	454	473	492	511	959	978
18	37	56	75	94	113	132	151	170	189	208	227	246	265	284	303	322	341	360	379	398	417	436	455	474	493	512	960	979
19	38	57	76	95	114	133	152	171	190	209	228	247	266	285	304	323	342	361	380	399	418	437	456	475	494	513	961	980

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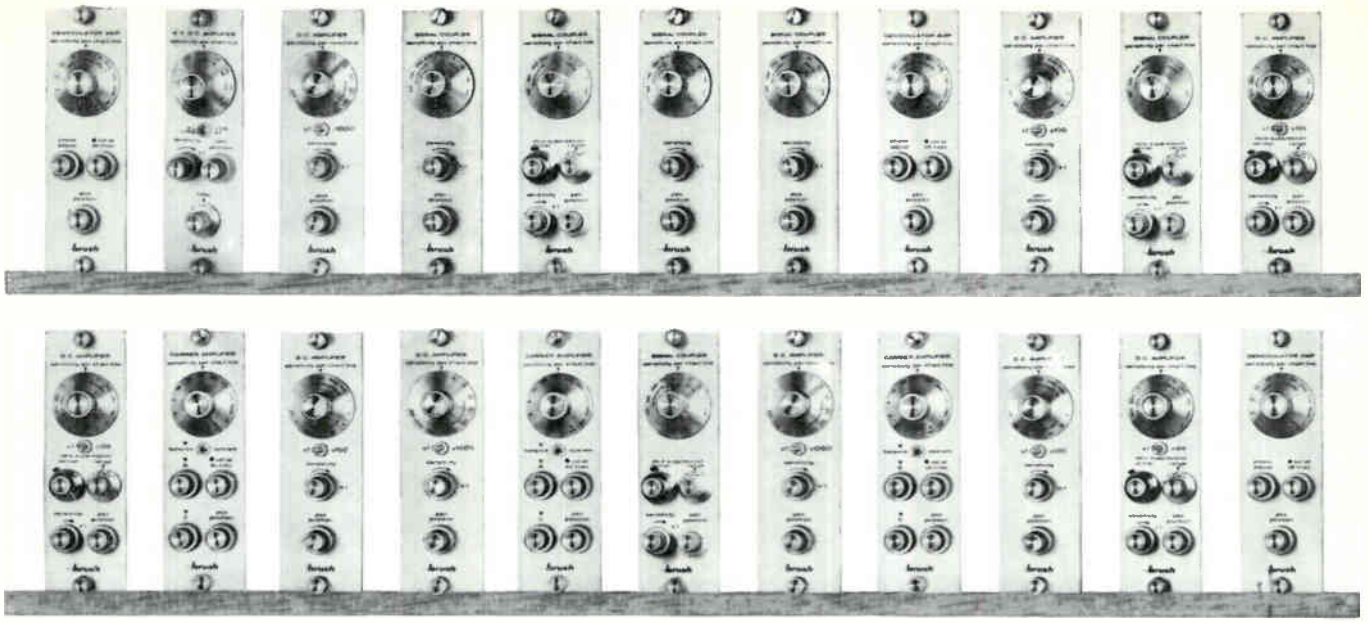
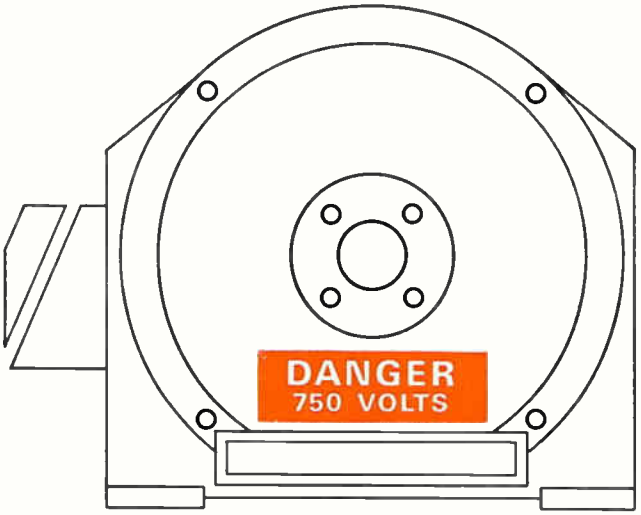


Brush has an "off-the-shelf" preamplifier for almost any recording requirement that comes to mind.



Take high voltage motors for instance.

Recording *their* electrical performance is especially tough. But thanks to a new free-floating, high gain Brush preamplifier, (second from left, top row) it's just another job. This newest addition to the Brush line of 22 different preamplifiers accepts signals up to 1000 volts DC OFF-GROUND, potential differences to 1000 volts DC; plugs into any advanced model Brush Direct Writing Recorder; eliminates possibility of damaged equipment, disruptive downtime and danger to personnel. Surprised that Brush *stocks* such a highly specialized preamplifier? Don't be. And don't be surprised either, when the folks at Brush promise to meet *your* direct-writing recording requirements with an optimum-performance system of "off-the-shelf" modular sub-systems. They can . . . better and faster than anyone else in the business. See for yourself. Write: Brush Instruments Division, Clevite Corporation, 37th & Perkins, Cleveland, Ohio 44114.

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Take Two...RCA-A15487 and -A15488

THEY'RE SMALLER

Oscillator, 4⅜" x ⅞"
Amplifier, 4⅜" x ⅞"
Combined Total Weight, 7 oz.

THEY'RE BETTER

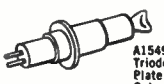
2.5 Kw Peak Plate Input (at 0.001 Duty)
500 Watts (Min.) Peak Power Output
Duty Factor: 0.01 to 0.001. Meets All FAA (AIMS) Requirements Even Under Worst Combinations

Reflecting a new total capability for precision control of both tube and cavity, RCA introduces its new L-Band A15487 and A15488. These two developmental units are a pulsed pencil tube–cavity oscillator and a grounded-grid amplifier, respectively. Designed to transmit automatic traffic-control identification and altitude information for aircraft at 1090 Mc, the A15487 and A15488 demonstrate important system advantages. For example:

- They meet frequency stability requirements for antenna VSWR specifications with a mismatch up to a VSWR of 4.0:1.
- With a total weight of only 7 ounces, they are from 45% to 75% lighter than similar transponder cavities.
- They achieve their performance levels without exceeding a 1000-volt dc supply voltage. And they do so with greater efficiency over a wider temperature range–from –54° to +95°C (equipment ambient).
- Their integral design approach permits improved efficiencies as well as better life and stability at less weight and small size. In addition, this approach greatly simplifies maintenance and logistic requirements.

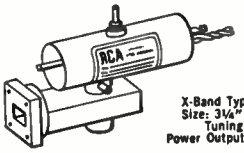
For more detailed information on the RCA-A15487 and RCA-A15488, see your RCA Representative. Also ask him about other RCA Microwave devices, such as the A15481, A15499, A15501, and A15511. Or write: Manager, Microwave Marketing, RCA Electronic Components & Devices, Harrison, N.J.

S-Band Type A15481
Size: 1¾" x ¾"
Tuning: ±15 Mc
Power Output: 105 Watts



A15499 Ceramic-Metal Pencil Triode. High Power Grid and Plate Pulse Service. Power Output: 1.8 Kw at 3300 Mc.

X-Band Type A15501
Size: 2½" x 1½" x 1"
Tuning: ±75 Mc
Power Output: 5 mw



X-Band Type A15511
Size: 3¼" x 2" x 1"
Tuning: ±50 Mc
Power Output: 100 mw

RCA

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