Electronics®

Graph processing speeds network design: page 112

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A pulser for laser diodes: page 137

November 14, 1966

75 cents

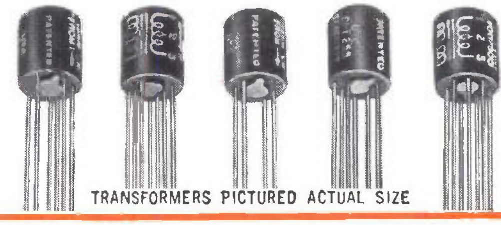
A McGraw-Hill Publication

Below: Sony's products compete around the world: page 155

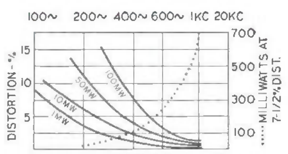
PIONEERS IN MINIATURIZATION

NEW

DI-T200™ SERIES



ULTRAMINIATURE TRANSISTOR TRANSFORMERS & INDUCTORS



TYPICAL DI-T200 PERFORMANCE
SOURCE: RATED PRI. IMP. AND D.C.
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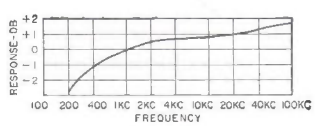

- **DUMET LEADS** (gold plated, weldable and solderable)
- **STRAIGHT PIN TERMINALS** (printed circuit application)
- **HIGHEST PERFORMANCE** for size in the industry
- **METAL ENCASED** (Grade 4, Ruggedized)

Type No.	Pri. Imp.	DCma‡ in Pri.	Sec. Imp.	Pri. Res.	Mw Level	Application
DI-T225	80 CT 100 CT	12 10	32 split 40 split	10	500	Interstage
DI-T230	300 CT	7	600 CT	20	500	Output or line to line
DI-T235	400 CT 500 CT	8 6	40 split 50 Split	50	500	Interstage
DI-T240	400 CT 500 CT	8 6	400 split 500 split	50	500	Interstage or output (Ratio 2:1:1)
DI-T245	500 CT 600 CT	3 3	50 CT 60 CT	65	500	Output or matching
DI-T250	500 CT	5.5	600 CT	35	500	Output or line to line or mixing
DI-T255	1,000 CT 1,200 CT	3 3	50 CT 60 CT	110	500	Output or matching
DI-T260	1,500 CT	3	600 CT	90	500	Output to line
DI-T265	2,000 CT 2,500 CT	3 3	8,000 split 10,000 split	180	100	Isol. or interstage (Ratio 1:1:1)
DI-T270	10,000 CT 12,000 CT	1 1	500 CT 600 CT	870	100	Output or driver
DI-T273	10,000 CT 12,500 CT	1 1	1,200 CT 1,500 CT	870	100	Output or driver
DI-T276	10,000 CT 12,000 CT	1 1	2,000 CT 2,400 CT	870	100	Interstage or driver
DI-T278	10,000 CT 12,500 CT	1 1	2,000 split 2,500 split	620	100	Interstage or driver
DI-T283	10,000 CT 12,000 CT	1 1	10,000 CT 12,000 CT	970	100	Isol. or interstage (Ratio 1:1)
DI-T288	20,000 CT 30,000 CT	.5 .5	800 CT 1,200 CT	870	50	Interstage or driver
DI-T204	Split Inductor (2 wdgs)	§ .1 Hy @ 4 maDC, .08 Hys @ 10 maDC, DCR 25Ω §§ .025 Hys @ 8 maDC, .02 Hys @ 20 maDC, DCR 6Ω				
DI-T208	Split Inductor (2 wdgs)	§ .9 Hys @ 2 maDC, .5 Hys @ 6 maDC, DCR 105Ω §§ .2 Hys @ 4 maDC, .1 Hys @ 12 maDC, DCR 26Ω				
DI-T212	Split Inductor (2 wdgs)	§ 2.5 Hys @ 2 maDC, .9 Hys @ 4 maDC, DCR 630Ω §§ .6 Hys @ 4 maDC, .2 Hys @ 8 maDC, DCR 157Ω				
DI-T216	Split Inductor (2 wdgs)	§ 4.5 Hys @ 2 maDC, 1.2 Hys @ 4 maDC, DCR 2300Ω §§ 1.1 Hys @ 4 maDC, .3 Hys @ 8 maDC, DCR 575Ω				

‡DCma shown is for single ended useage (under 5% distortion—100mw—1 KC)... for push pull, DCma can be any balanced value taken by 5W transistors (under 5% distortion—500mw—1 KC) DI-T200 units have been designed for transistor application only... not for vacuum tube service. U.S. Pat. No. 2,949,591 other pending.
Where windings are listed as split, ¼ of the listed impedance is available by paralleling the winding.
§Series connected; §§Parallel connected.

ALL STOCK UNITS MIL TYPE TF4RX
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High Power Rating	up to 100 times greater.
Excellent Response	twice as good at low end.
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High Efficiency	up to 30% better . . . compare DCR.
Moisture Proof	hermetically sealed to MIL-T-27B.
Ultraminiature Size	5/16 Dia. x ⅜" H, 1/15 Oz.

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The leads are uninsulated 1" long, .016 D Dumet wire, spaced on a .1" radius circle to conform to terminal spacing techniques of the "TO-5" case semiconductors and micrologic elements.

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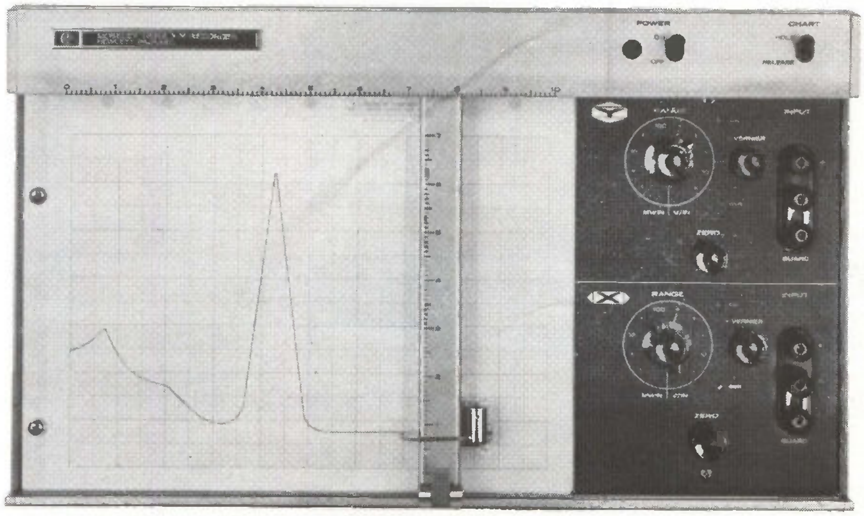

THE MOSELEY 7035A

This is a high-performance, low-cost solid-state recorder for everyday applications not requiring high dynamic performance. Five fixed calibrated ranges 1 mv/inch to 10 v/inch. High input impedance, floating guarded input, 0.2% accuracy at full scale. Adjustable zero set.

Each axis of the 7035A has an independent servo system with no interaction between channels. Maintenance-free AUTOGRIP* electric paper holddown and electric pen lift are standard. Options available include locks for zero and variable range controls, rear input, and retransmitting potentiometer for X axis.

For general-purpose applications, you can't beat the Moseley Division 7035A. Ask your Hewlett-Packard field engineer for a demonstration. Or write for complete specifications to Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

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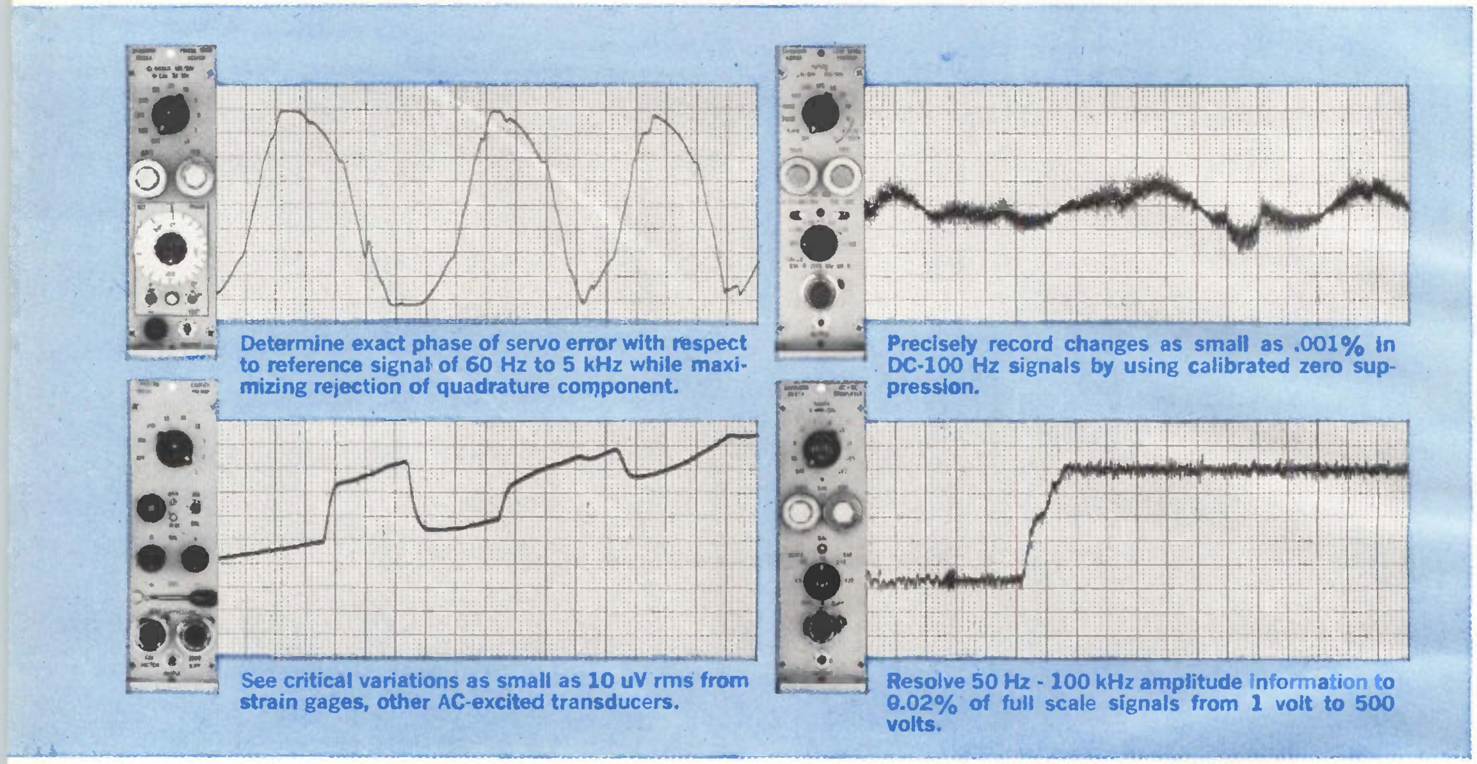

When you need the greatest possible degree of signal-conditioning precision and operational control, Sanborn 7700 Series oscillographs with solid-state "8800" plug-ins will give you chart recordings of *maximum resolution and intelligibility.*

Seven highly versatile signal conditioners offer unique performance capabilities: three DC types with a 1 uV - 250 V dynamic range, floating differential input and calibrated zero suppression . . . an AC-DC Converter with calibrated zero suppression and scale expansion permitting resolution better than 0.1%, 10 ms response and isolated, 1 meg. input . . . a phase-sensitive demodulator with calibrated reference phase shift, 90° calibrated dial with four quadrant selections, and a frequency range of 60 Hz to 5 kHz . . . a carrier preamp with 2400 Hz internal transducer excitation supply, calibrated zero suppression, cal. factor control and conversion gain of 10,000 . . . and a general-purpose DC preamp particularly useful for 100 mm wide chart recording.

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For a new brochure describing the advantages and wide choice of Sanborn thermal writing oscillographs, write Hewlett-Packard Company, Sanborn Division, 175 Wyman Street, Waltham, Mass. 02154.

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Electronics

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Readers Comment

Embarrassment

To the Editor:

In the well-researched article on the IWCS program [Oct. 3, p. 167], your caption writer has embarrassed me. I am responsible for Page's engineering effort in Vietnam and Southeast Asia; over-all management responsibility is vested in Page's vice president, Lincoln Brown, with all field work under direction of vice president Loren Bailey who is resident in Saigon.

W.D. Carter
Ass't. Director, Engineering
Page Communications Engineers, Inc.
Washington, D.C.

Changed equation

To the Editor:

It has come to my attention that there is an error in my article "FET's call the tune in active filter design" [Oct. 3, p. 98]. Equation 3 for the damping factor, p. 99, should read:

$$p = \frac{1}{M} + \frac{2}{M}(1 - K_2),$$

instead of

$$p = \frac{1}{M} + \frac{M}{2}\left(\frac{1}{1 - K_2}\right)$$

J.M. Loe
Project Engineer
Philco-Ford Corp.
Blue Bell, Pa.

Adequate feedback

To the Editor:

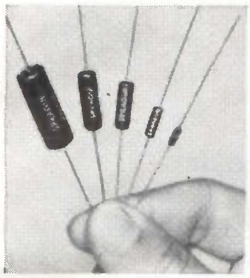
I agree most wholeheartedly with William Perzley's letter concerning power supply reliability guidelines [Sept. 19, p. 7].

He has trouble finding power supply reliability guidelines because power supply customers have not demanded adequate reliability in the past. Needless to say, any company will not perform any unnecessary task.

It is with great pleasure that I hear a top management man acknowledging the importance of reliability as applied to any system. Far too often in the last five years, I have seen reliability treated as

RESISTORS FOR PERSPICACIOUS DESIGN ENGINEERS

FILMISTOR® PRECISION METAL-FILM RESISTORS



Extended-range Filmistor Resistors now give you dramatic space savings in all wattage ratings — 1/20, 1/10, 1/8, 1/4, 1/2, and 1 watt — with absolutely *no sacrifice in stability!*

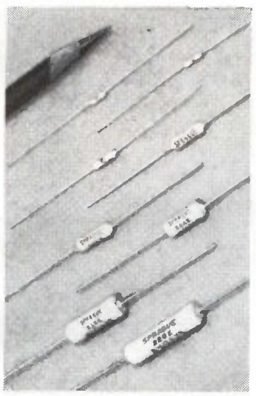
Filmistors offer extended resistance values in size reductions previously unobtainable. For example, you can get a 4.5MΩ resistor in the standard 1/4 watt size, which had conventionally been limited to 1 MΩ. Filmistor Metal-Film Resistors are now the ideal selection for "tight-spot" applications in high-impedance circuits, field-effect transistor circuits, etc.

Other key features are ±1% resistance tolerance, low and controlled temperature coefficients, low inherent noise level, negligible coefficient of resistance, and rugged molded case.

Filmistors *surpass* the performance requirements of MIL-R-10509E.

Write for Engineering Bulletin 7025C

ACRASIL® PRECISION/POWER WIREWOUND RESISTORS



These silicone-encapsulated resistors combine the best features of both precision and power wirewound types, giving them unusual stability and reliability.

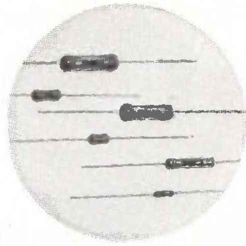
Acrasil Resistors are available with tolerances as close as .05%, in power ratings from 1 to 10 watts. Resistance values range from 0.5 ohm to 66,000 ohms.

Their tough silicone coating, with closely matched expansion coefficient, protects against shock, vibration, moisture, and fungus.

Acrasil Resistors meet or exceed the requirements of MIL-R-26C.

Write for Engineering Bulletin 7450

BLUE JACKET® VITREOUS ENAMEL PRECISION/POWER WIREWOUND RESISTORS



Axial-lead resistors available in ratings from 1 to 11 watts, with resistance tolerances to ±1%. Non-inductive windings available to ±2% tolerance.

All welded end-cap construction securely anchors leads to resistor body. Vitreous coating and ceramic base have closely matched expansion coefficients.

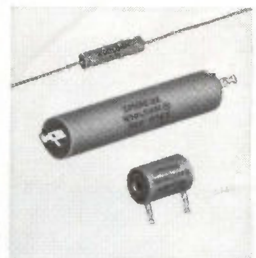
Write for Engineering Bulletins 7410D, 7411A

Tab-terminal Blue Jacket Resistors can be had in a wide selection of ratings from 5 to 218 watts, with several terminal styles to meet specific needs.

Tab-terminal as well as axial-lead Blue Jackets can be furnished to meet the requirements of MIL-R-26C.

Write for Engineering Bulletins 7400B, 7401

KOOLOHM® CERAMIC-SHELL POWER WIREWOUND RESISTORS



Koolohm Resistors are furnished in axial-lead, axial-tab, and radial-tab styles, in a broad range of ratings from 2 to 120 watts. Both standard and non-inductive windings are available.

Exclusive ceramic-insulated resistance wire permits "short-proof" multilayer windings on a special ceramic center core for higher resistance values. The tough non-porous ceramic shell provides complete moisture protection and electrical insulation. Koolohms can be mounted in direct contact with chassis or "live" components.

Axial-lead Koolohm Resistors to MIL-R-26C are available in MIL styles RW55 and RW56.

Write for Bulletins 7300, 7305, 7310

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Sprague Stackohm Resistors are especially designed for equipment which requires power wirewound resistors of minimum height. Their flat silhouette permits stacking of resistor banks in close quarters.

Aluminum thru-bars with integral spacers act as mounting means and also conduct heat from within the resistance element. Resistance windings are welded to end terminations for maximum reliability. An outstanding vitreous coating protects the assembly against mechanical damage and moisture. Ceramic core, end terminations, and vitreous enamel are closely matched for coefficient of expansion.

Stackohm Resistors are available in both 10-watt and 20-watt ratings, and can be furnished with resistance tolerances as close as ±1%. Resistance values range from 1 ohm to 6000 ohms.

Both 10- and 20-watt types meet the stringent requirements of MIL-R-26C.

Write for Engineering Bulletin 7430

Send your request to Technical Literature Service, Sprague Electric Co., 35 Marshall St., North Adams, Mass. 01247, indicating the engineering bulletins in which you are interested.

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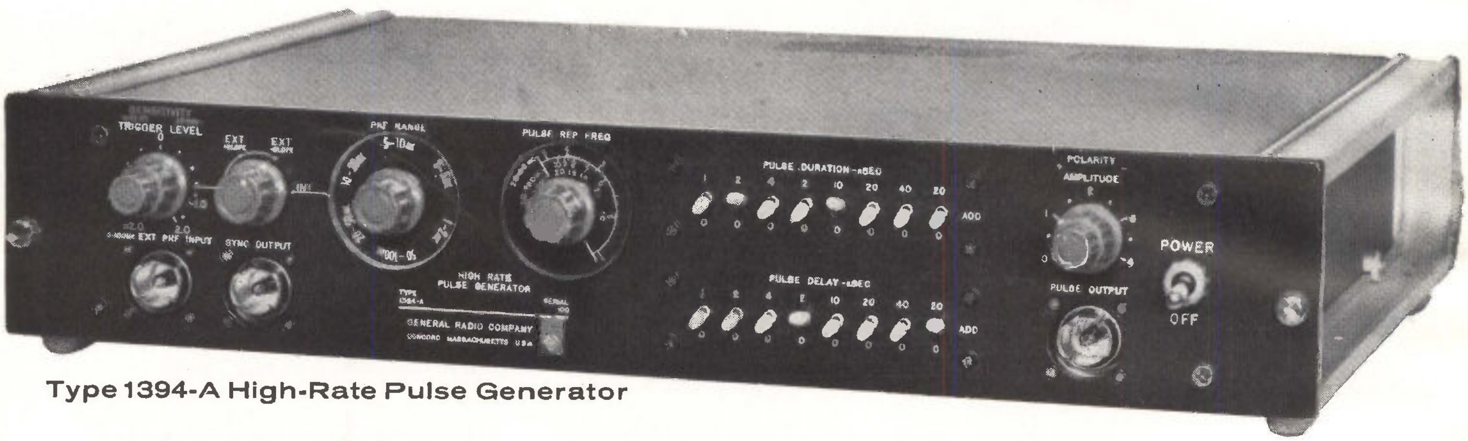

Type 1394-A High-Rate Pulse Generator

The development and testing of today's high-frequency digital circuitry call for a pulse generator whose output pulses have:

1. High repetition rate.
2. Fast rise and fall times.
3. Sufficient voltage to switch circuits.

GR's new pulse generator meets these requirements, and it has many other useful features for testing high-speed computers, radar systems, digital-communication systems, and other sophisticated equipment. It has, for instance, calibrated controls for pulse duration, delay, amplitude, and repetition frequency, and pulses of either polarity are available at the output. The fast-rise-time capability of the 1394-A makes it also well suited for the study of component characteristics, such as semiconductor switching speed and pulse-transformer rise time. Add to these features a price that is substantially less than that of comparable instruments and you have a pulse generator that has an unusually high performance/price index.

An accessory unit, the Type 1394-P1 Pulse-Offset Control, is available for applications requiring a dc-coupled output. This unit fixes the base line of the output pulses to any reference voltage from −2 to +2 volts and is continuously adjustable. Price: $255 in USA.

Other Pulse Instruments

Type 1217-C Unit Pulse Generator
... high performance at minimum cost, prf up to 1.2 MHz. Price: $275 in USA.

Type 1398-A Pulse Generator
... rise and fall times less than 5 ns, 60-V output pulses, prf up to 1.2 MHz. Price: $595 in USA.

Type 1395-A Modular Pulse Generator
... produces practically any pulse shape or train you may want, five different modules available, main frame accommodates up to 7 modules. Price: Main Frame, $575; Modules, $160 to $400 in USA.

Type 1397-A Pulse Amplifier
... linear amplifier with 1.2-ampere output for use with Types 1217-C and 1398-A or any other pulse generator with negative output pulses. Price: $495 in USA.

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Circle 6 on reader service card

a fringe benefit rather than an integral part of a system.

Reliability is fine, as long as it doesn't cost much, otherwise reliability is the first to suffer from contract cutbacks. This action seems to be inconsistent when the Department of Defense allocates approximately 10% of the procurement dollar for reliability.

This does not mean that proposals should be unrealistic. A top reliability program should not be an indirect function, but should provide adequate rapid feedback to the designers, etc. I know of two semiconductor manufacturers that have made the physics of failure aspect of reliability a direct economical benefit to their respective industries by providing adequate feedback to designers and process engineers.

E.V. Chamberlain
Reliability engineer
Indialantic, Florida

Too optimistic

To the Editor:

During editing, my article "Holography's practical dimension," [July 25, p. 88] acquired a decidedly more optimistic view on holographic television than had been my original intent. I must concede, however, that the readability of the paper was improved.

In my original manuscript, the section on holographic television opened with the following paragraph:

"Perhaps the ultimate bequest of holography will be holographic motion pictures and television; recently there has been again some talk in this direction. Our assessment of this possibility is decidedly pessimistic, at least for the next few decades. However, we can engage in some speculation along these lines."

For the closing section, I wrote: "But recall that this discussion is in the realm of the speculative. Holographic television is not yet in sight, nor did anything transpire at the recent (March, 1966) Optical Society Meeting to bring its realization any closer."

Holographic home television, of course, is an intriguing subject for speculation, but is decidedly in the realm of the "way far out."

Emmett N. Leith
Institute of Science and Technology
University of Michigan
Ann Arbor

Credit due

To the Editor:

In my article, "Scattering parameters speed design of high-frequency transistor circuits," [Sept. 5, p. 78] it inadvertently appeared that I was assuming credit for developing some of the new concepts which were presented.

I wish to acknowledge the correct source. The charts on pages 83 and 84 are derived from equations 20 through 25 on page 87. These scattering parameter design concepts were originated by George E. Bodway, who kindly made available to me his as-yet unpublished paper, "Two-port power flow analysis of linear active circuits using the generalized scattering parameters."

In this paper, Bodway derives these important new equations. Their development was entirely his, and I am eager that the credit be his.

Fritz K. Weinert
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Palo Alto, Calif.

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People

Many semiconductor companies, content to produce conventional integrated circuits, avoid multichip devices and large-scale arrays because in their opinion the first is too old and the second too new. But the General Instrument Corp. is investing heavily in both technologies.


Jerome Fishel

Business is so good that the company—based in Newark, N.J. —has constructed a plant in Syosset, N.Y., to house the hybrid circuit department while the metal oxide semiconductor (MOS) department has taken over the old Hicksville, N.Y., plant completely.

The reorganization has pushed two young men into the limelight. **Jerome Fishel**, 38, was named director of operation for the hybrid circuit section and **J. Leland Seely**, 34, was put in charge of the MOS department. Each will have responsibility for development, engineering, production and marketing in his own field.


J. Leland Seely

Teacher, too. Fishel, an electrical engineer, has a varied background. He taught transistor electronics for five years at Adelphi University and was a vice president at the General Transistor Corp. before it merged with General Instrument in 1960.

"There's been a resurgence in hybrid circuits and many companies are now entering the field," Fishel says. He predicts sales will double this year. The new facility expands floor space and the department has been put on a two-shift basis.

Fishel claims General Instrument has a head start in the military hybrid circuits market. "We've been at it longer than anyone else," he says.

Fishel also believes the reorganization will help his section attain its goals faster. "The reorganiza-

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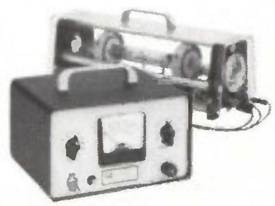
LAS-101 LASER for school and laboratory

Output 0.25 mW at 6328 Å, TEM_{00n} mode, 1 mW multimode (optional), guaranteed one year. Optional 1.15 and 3.39 μ mirrors in quick-interchange mounts. Single-isotope, double-walled tube, heated cathodes. $660

P-102 LASER POWER SUPPLY



For the LAS-101, provides required 300 volts dc, 60 mA, and 6.3 volts ac, 1.5 A. Fully adjustable control of the discharge current. Operates from 117 volts ac ± 15%, 50-65 c/s. $165

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Output 0.50 mW at 6328 Å, TEM_{00n} mode, 2 mW multimode (optional); one year warranty. Optional 1.15 and 3.39 μ mirrors in quick-interchange mounts. Single-isotope, double-walled tube, heated cathode. Integral high-voltage supply operates from line voltage. $980

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Output 125 μW near 6328 Å, TEM_{00n} mode, single frequency. Temperature compensated for frequency stability. Integral photodetector, electro-magnetic tuning control. Single-isotope, double-walled tube, heated cathode. Compact size, modular construction. $1800

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Finesse of 30 over range of 4250 to 6500 Å; 10 GHz (1/3 wave-number) free spectral range. Tilt-tunable through x-y adjustable mount. Ranges of .65 to .95 μ and narrow-band 6943 Å optional. $425

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Operates from 4250 to 7000 Å, or (optional) from .7 to .95 μ or narrow-band at 6328 Å. Finesse of 30 or better, free spectral range of 1.5 GHz in standard model, variable by simple slide adjustment of reflector end plates. Electro-magnetic reflector drive. $655

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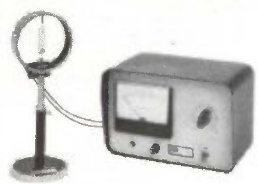

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People

tion will give us independent operation and more control, making things easier to manage by eliminating a lot of red tape."

Off the shelf. The hybrid department currently is producing approximately 25 standard hybrid circuits and a wide variety of custom circuits. Fishel explained that his department manufactures circuits in cans and flatpacks. "We use a variety of transistors, both npn and pnp, junction field-effect transistors and MOS FET's," he added. Techniques employed include thermal pairing and voltage trimming of cermet resistors. Under development are flip chip and beam lead devices and complex hybrid circuits compatible with large-scale MOS arrays.

Seely earned a Ph.D. in physics from the University of Utah in 1962 and then went to work for the General Motors Corp.'s defense research laboratory in Santa Barbara, Calif. There he worked with Arnold Nordsieck, inventor of the electric vacuum gyro. Seely directed development and design of levitation and readout systems for the gyro.

His interest in solid state physics led him to semiconductor technology. "I felt there was a bright future for MOS and I wanted to get in on the beginning," Seely said of his decision to join General Instrument in late 1964 as a member of its original MOS group.

More R&D. Seely expects to place increased emphasis on the research and development aspects of MOS technology and to work toward development of bigger and more complicated modules. One area of work centers on analog to digital and digital to analog converters.

The MOS section currently produces a wide range of MOS circuits, including shift registers, MOS FET's, digital differential analyzers, multiplexers, gates and other devices.

Seely said General Instrument does not use discretionary wiring techniques but concentrates on custom design of each component—a process he calls individual tailoring.

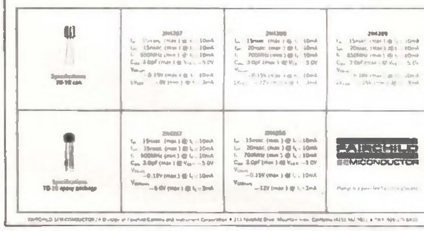
Circle 11 on reader service card

Recap Three:

Here are eight of our latest new product announcements. (You may have missed one in the past month or so—we've all been busy.) If you have a question about any of these new products, mark the corresponding number on the bingo card. Or call any Fairchild Distributor.

PNP 15nsec. SWITCH

Five new silicon PNP transistors are now available from Fairchild, the first of a new series of ultra fast PNP switching devices. They offer the fastest switching speed, the highest frequencies, and the lowest capacitance. These transistors are gold-doped to make possible extremely fast switching speeds and provide lifetime control. Use them as reliable Planar II epitaxial replacements for the germanium 2N960 series. Use them for high speed computer switching circuits, or other military, industrial, and commercial applications. They're available now from distributor stocks, in TO-18 cans or TO-18 epoxy packages. Get samples from your distributors or write for our data sheets. Stop giving up speed to design with silicon PNP. Switch to Fairchild.



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12nsec. SWITCH 24¢

Fairchild 2N4274 and 2N4275 are the fastest epoxy saturated switching devices you can get. These epoxy NPN switches are similar to the 2N2369A, and are available now from depth-stocked distributor shelves, or from Fairchild. No other devices at this price (24¢ in lots of 10,000) can come close to the performance characteristics of these transistors. Get them now from Fairchild Distributors or get our data sheets for complete information.

FAIRCHILD SEMICONDUCTOR

Specifications: (2N4275)

t_r	13nsec. (max.) @ 10mA
t_{on}	12nsec. (max.) @ 10mA
t_{off}	12nsec. (max.) @ 10mA
V_{EBO}	15V (min.)
$V_{CE(sat)}$	0.2V (max.) @ 10mA
f_T	400MHz (min.) @ 10mA
C_{obo}	4.0pF (max.)

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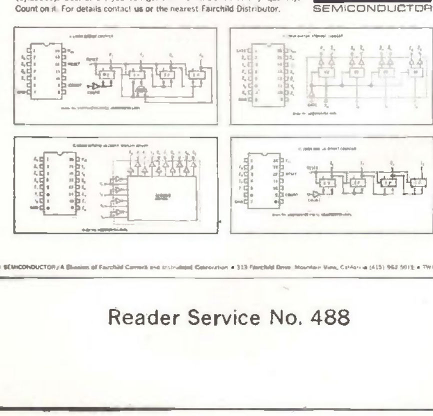

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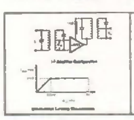

Specifications (T_A = 25°C, f = 10.7MHz)

Operating Voltage Range	[illegible]
Stability Limited Gain	41db
Reverse Transadmittance	[illegible]
Forward Transadmittance	35mmhos
Output Conductance	0.02mmhos
Input Conductance	[illegible]
Output Voltage Swing	10v
Power Gain @ f = 100MHz	20db

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Meetings

Electric Welding Conference, IEEE, American Welding Society, Industrial Electrical Engineering Society; Park Shelton Hotel, Detroit, **Nov. 15-17.**

Aircraft Design and Technology Meeting, American Institute of Aeronautics and Astronautics; International Hotel, Los Angeles, Calif., **Nov. 15-18.**

Ceramic/'66 Exhibit and Seminar, Technical & Electronic Manufacturer's Association; Trade Show Building, New York City, **Nov. 15-17.**

Conference on Magnetic & Magnetics Materials, IEEE; Sheraton Park Hotel, Washington, D.C., **Nov. 15-18.**

Mid-Atlantic Engineering Conference and Tool Exposition, American Society of Tool and Manufacturing Engineers; Baltimore Civic Center, Baltimore, Md., **Nov. 15-17.**

National Conference on the Management of Aerospace Programs, American Astronautical Society; University of Missouri, Columbia, Mo., **Nov. 16-18.**

Engineering and Maintenance Conference, Air Transport Association; Century Plaza Hotel, Century City, Los Angeles, Calif., **Nov. 17-18.**

Symposium on Oceanography and Oceanology, Institute of Environmental Sciences; Henry Hudson Hotel, New York, **Nov. 17.**

Energy Conversion Exposition, American Society of Mechanical Engineers; Statler Hilton, New York City, **Nov. 27-Dec. 1.**

Meeting and Technical Display of American Institute of Aeronautics and Astronautics; War Memorial Auditorium, Prudential Center, Boston **Nov. 29-Dec. 2.***

Vehicular Communications Conference, IEEE; Montreal, Quebec, **Dec. 1-2.**

Meeting of the National Committee of the International Scientific Radio Union; Cabana Motor Hotel, Palo Alto, Calif., **Dec. 7-9.**

Electronics Industry Plating Symposium, American Electroplaters' Society; Robert Treat Hotel, Newark, N. J., **Dec. 8-9.**

Electrical and Electronic Measurement and Test Instrument Conference, IEEE; Talisman Motor Inn, Ottawa, Canada, **Jan. 9-11.**

Symposium on Reliability, American Society for Quality Control, IEEE; Sheraton-Park Hotel, Washington, **Jan. 10-12.**

American Society for Quality Control Meeting, American Society for Quality Control; California State Polytechnic College, Kellogg Campus, Pomona, Calif., **Jan. 21.**

Midwest Welding Conference, Illinois Institute of Technology Research Institute; Illinois Institue of Technology, Chicago, **Jan. 24-25.**

Ultrasonic Manufacturers Association Technical Symposium and Meeting, Ultrasonic Manufacturers Association; New York, **Jan. 25.**

Symposium on Nondestructive Testing of Welds, Illinois Institute of Technology Research Institute; Illinois Institute of Technology, Chicago, **Jan. 30-Feb. 2.**

Call for papers

International Conference on Communications, IEEE; Minneapolis, Minn., June 12-14. **Dec. 1** is deadline for submission of a 50-word abstract and a 300-word summary to Robert J. Collins, technical program chairman, 1967 ComTech Meeting, department of electrical engineering, University of Minnesota, Minneapolis, Minn. 55455.

International Conference on Electronics and Space, organized by the French Institute of Electrical and Electronic Engineers and sponsored by the Electronic Industries Association of France, April 10-15. **Dec. 1** is the deadline for submitting abstracts of papers to Secretariat, Colloque International sur l'Electronique et l'Espace, 16 rue de Presles, Paris 15, France.

Joint Automatic Control Conference, sponsored by the Instrument Society of America, at the University of Pennsylvania, June 28-30. **Dec. 1** is deadline for submitting papers to Donald A. Rodgers, general chairman, Consolidated Electrodynamics Corp., Pasadena, Calif.

International Conference on Magnetics, magnetics group of IEEE, Shoreham Hotel, Washington, April 5-7. **Dec. 7** is deadline for submission of two-page abstracts to Dr. R. F. Elfant, IBM, Thomas J. Watson Research Center, P.O. Box 218, Yorktown Heights, N.Y.

* Meeting preview on page 16

The connector Thing

A periodical periodical designed, quite frankly, to further the sales of Microdot connectors and cables. Published entirely in the interest of profit.

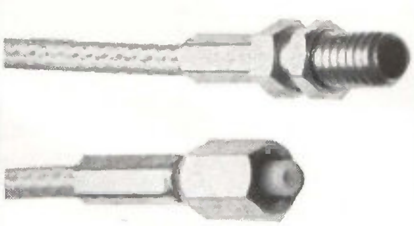
WIN

a pot of gold!

Lepra/Cons Unite!

In celebration of the introduction of the highest density coax rack and panel and multi-pin connectors on the market today (the broadened Lepra/Con line), Microdot is awarding to five lucky winners (see contest rules below) five simulated gold pots (of the chamber variety) with your, repeat your, name emblazoned thereon. Perfect for desk top decoration.

First, let's talk Lepra/Con.

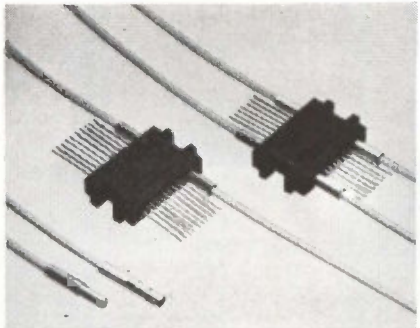


Through its stringent policy—"Never Look Back, They May Be Gaining On You"—Microdot has expanded its Lepra/Con line of ultraminiature connectors ... tiny little coax jobs with an OD of only ⅛ inch and a mated length of only one inch.

But why stop there.

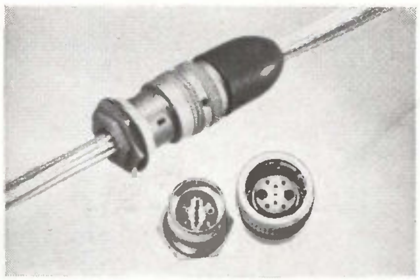
Now there's the Lepra/Con multi-pin ... all crimp, no solder; high density; uses Twist/Con pin contacts; low cost; and it's the smallest full 50 ohm coax available today.

Now there's the Lepra/Con Twist/Con /say it fast fifty times) which combines all of the above advantages in a rack and panel coax connector.



Now there's the slide-on Lepra/Con for singular ease of installation.

And, of course, there is still the old Lepra/Con (if you can call six months old).



HOW TO WIN YOUR POT OF GOLD

1. First, of course, decide whether you actually want a pot of gold. In all likelihood, your place of employment has far more up-to-date facilities. However, if you decide a pot is for you, go to step two.

2. Write down all the applications you can think of for the Lepra/Con line *on your job*. And think about it. There are probably more than the twelve you can jot down immediately without hardly thinking at all.

3. Call your Microdot representative directly or drop him a note giving him all your suggested applications, your name, company, title, address and telephone number. Do not call or write Microdot. We only make connectors. Our reps sell them. Hopefully.

4. A jury of six will judge all entries for originality, number of applications and neatness. The five best will each be awarded the simulated gold pot (of the chamber variety).

5. All entrants will win a free picture of our beloved Candy inscribed passionately and personally to you.

6. This whole shoddy affair draws to an end on December 31, 1966. Happy New Year!

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Meeting preview

On all fronts

The American Institute of Aeronautics and Astronautics, traditionally concerned with the lofty concepts of space, will also consider the more mundane problems of high-speed air and ground transportation. The institute's third annual meeting will take place in Boston's War Memorial Auditorium, Nov. 29 to Dec. 2.

Retired Air Force Maj. J.C. Maxwell, whose word on the supersonic transport development program will count heavily, will describe how the Federal Aviation Agency is handling the ticklish task of selecting the winner in the SST competition.

On the final day of the meeting, members will hear arguments on both high-speed air and surface transportation in the Boston-to-Washington corridor.

William Seifert of the Massachusetts Institute of Technology will present a paper on the technical problems of a ground transportation system capable of speeds of 300 miles per hour. Seifert will analyze such problems as propulsion, guideway, communications and control.

Rapid transit. Edwin R. Wisner of the Budd Co. will report on development of a 160-mile-per-hour passenger train running from Washington to Boston. Wisner will compare this design with the San Francisco Bay Area Rapid Transit Authority system. He will also show how the railroads are adopting systems developed for planes.

To be sure, the meeting will not ignore space. Topics such as space science experiments, propulsion systems and the application of aerospace technology in other fields will be examined.

Sessions are scheduled for those who specialize in reliability, marine systems and management. In addition, four panel discussions will bring together the nation's top men in the fields of space policy and launch and propulsion systems. The propulsion panel will debate whether new propulsion systems are needed for lunar and planetary flight.

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Advantages:

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Provides data directly in impedance and phase angle, 1 ohm to 100K ohms 0 to 360°

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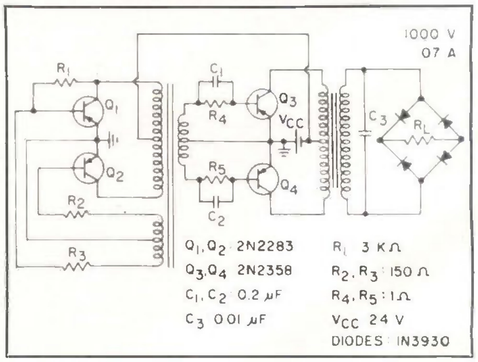

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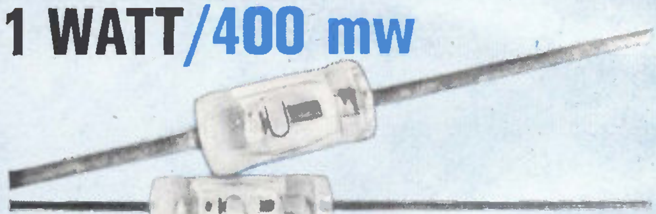

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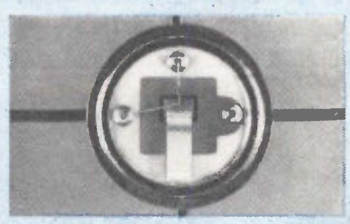
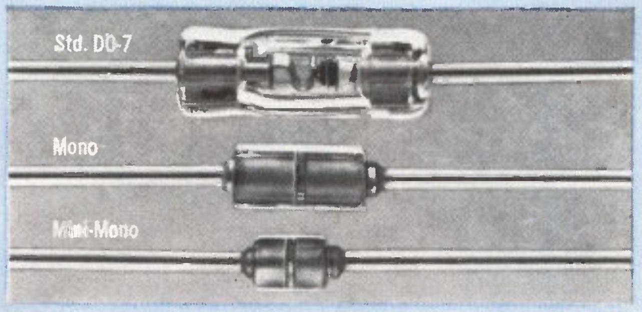
FAST SWITCHING INTEGRATED POWER DARLINGTON CIRCUIT



This device is an epitaxial integrated power circuit with all aluminum ultra-sonic bonded leads. This circuit is usable as a commutating diode, high speed power switch, regulator, high gain power gate and inverter, and linear or servo amplifier. Packaged for 20 watts rated power. Minimum gain of 1000 at 1 ampere.

	1-99	100-999
2N998	$12.00	$ 8.05
2N999	24.00	16.00

SIZE UP YOUR NEEDS
MINI-MONO/Mono Diode



CDC's subminiature dual stud hermetic glass packaged unit is an extremely sophisticated device. Considerable dimensional and electrical flexibility exists. Units are available in O.D.'s from .060 to .100 and overall lengths from .090 to .265. Electrically, the range is from 1N457 to 1N3600.

DEVICE	STANDARD DO7		MONO-DIODE EQUIVALENT		MINI-MONO EQUIVALENT	
	1-99	100-999	1-99	100-999	1-99	100-999
JAN 1N914	$ .35	$ .24	$ .40	$ .27	$ .70	$ .57
1N916	.52	.35	.65	.43	.95	.73

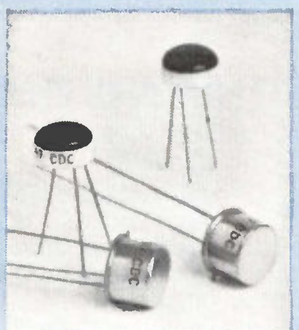
RTL
Mono Circuit

Continental Device Corporation's RTL family of monolithic circuits is really an extension of CDC's proven ability in the manufacture of hi-rel volume components. And when it comes to prices, CDC wins the game.

OPERATING RANGE:		
	−55°C to +125°C	To-5 metal can
	0 to +100°C	To-5 metal can
	+15°C to +55°C	Epoxy equivalent

DEVICE	PART NO.	PACKAGE	1-99	100-999	1,000
Buffer	CMC219001	Epoxy TO-5	$ .80	$ .54	$ .36
Dual 2-Input Gate	CMC219141	Epoxy TO-5	.80	.54	.36
JK Flip-Flop	CMC219231	Epoxy TO-5	1.50	1.00	.67

EPOXY/METAL CAN
TRANSISTOR



With CDC the chip's the thing! Only the package changes. CDC uses the same stringent process controls in manufacturing dice for epoxy transistors as are used for all military and high reliability metal packaged devices.

METAL CAN TRANSISTOR			EPOXY EQUIVALENT			
Device	1-99	100-999	Device	1-99	100-999	1000
JAN 2N697	$1.00	$ .67	CS 697	$ .60	$ .40	$ .28
JAN 2N1613	1.50	1.00	CS 1613	.70	.47	.30

PORTABLE IC TESTER...$995.00

Model 9522 tests *all* DC E&I characteristics for any 2 to 14 lead integrated circuit. It is a solid state, short circuit protected device. It measures from 0-30V and from 1nA to 100mA. Also, it is adaptable for measuring switching characteristics. Has four 0 to ±15V power supplies with vernier control and two fixed 24V power supplies. Small, compact, easy to carry. Weighs a mere 25 lbs. Immediate delivery. $995.00.

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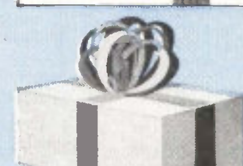
FREE sample devices sent on request.



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Editorial

Forcing the airlines' hand

In September, the announcement by the Boeing Corp. of its determination to build the 489-passenger 747 jet aircraft obsoleted the electronic reservation system of every airline that will put the jumbo aircraft into operation. And the prospect of such huge passenger loads spotlighted the shoddiness and inadequacies of the passenger check-in and ticketing procedures of most airlines.

An editorial decrying these procedures [Sept. 19, p. 23] brought an icy protest from the Air Transport Association, an industry group that defends airlines. It also brought a flood of air-travel horror stories from fellow passengers. By horseback survey, if all the stories are true, as many as two out of every three passengers have trouble with reservations, checking in, buying a ticket or reclaiming luggage. It will be many times worse when the 747 starts flying in 1970, and even sooner because the stretched version of the DC-8 will start flying at the end of 1966 with 165-passengers and next year with more than 200 passengers.

The electronics experts who have been working to solve the passenger check-in problem—and the work has been pitifully limited primarily because the airlines have had little interest in speeding up procedures—agree that there is no technical reason for passengers to have so much difficulty when checking in for a flight. Electronics could have solved the problem three years ago. The rub has been economic feasibility. The airlines attach no monetary value to a passenger's feelings of frustration and irritation nor do they concern themselves with the time a passenger loses when he has to wait for a ticket agent or his luggage.

Happily, from the passengers' standpoint, the new 747 will force a change in the airlines' apathetic attitude. If they don't change, loading so many passengers could cause such long delays in departure that it would cost the carriers a fortune and destroy schedules. In fact, they would run so late they might even wake up the sleeping members of the Civil Aeronautics Board, the moribund, incompetent and ineffective government agency charged with protecting passengers' rights. (As an example of the CAB's current disdain for passengers, some airlines regularly run as many as 40% of their flights late without as much as a raised eyebrow from the members of the CAB.)

The first step the airlines will have to take is to think in terms of an integrated system that uses electronics to tie the reservation system into the check-in and ticketing procedure. In almost every case so far, the airlines have tried to solve the problem piecemeal. They want to buy a piece of hardware here to do one part of the job and a piece there to do another. And the two pieces are never connected.

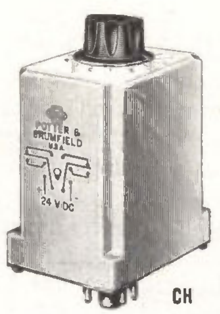
Secondly, the airlines will have to change some of their systems, procedures, accounting forms, rituals and checks. What has to happen can be compared almost exactly to the changes required when data processing first went into industrial companies. The financial men tried to use computers merely to mechanize bookkeeping procedures. Electronic data processing didn't really prove its worth until management recognized that a company's entire systems, procedures and forms had to be changed because of the character of the computer.

Without making a single technological development, a computer company could design a system that would make it possible for a regular traveler to telephone for a reservation, arrive at the airport and check in by inserting his credit card—with a magnetic strip—into a terminal device that would check his reservation, print out his ticket, charge his account, issue him a boarding pass, make a seat selection and provide a baggage tag for his luggage. With his boarding pass, he could get on the aircraft quickly and with a minimum of trouble. At the same time, the system would keep a running count of how many passengers had checked into that flight so the airlines could plan the handling of standby travelers in advance. The same system could work with other passengers too—the traveler making several consecutive flights on the same ticket, the no-reservation traveler, or the traveler who has to alter his ticket—by adding an agent to the loop. But the system would do most of the work of ticketing and check-in.

Unfortunately, it takes about three years to design such a system. Not because of any hardware lag but because it will take that long to understand the system and tailor hardware for it. For example, neither the airline nor the hardware people know how many passengers fly "two-leg" tickets—say New York to Chicago and return; how many arrive at the airport with no reservation; how many have consecutive flights on a single ticket, or how many passengers arrive at the airport to make a change (say from tourist to first-class service). One computer company hopes to start such a study next year if it can persuade an airline to cooperate.

With a clear assurance that electronics can simplify the check-in, ticketing and reservations, and an understanding that there will be a three-year design delay, passengers want the airlines to get on with the job of serving them.

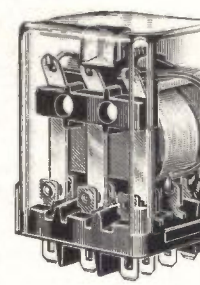
NEW! *Four problem-solving P&B relays . . . all immediately available at factory prices from leading electronic parts distributors*



CH

Solid State Time Delay Relays for as little as $17.50

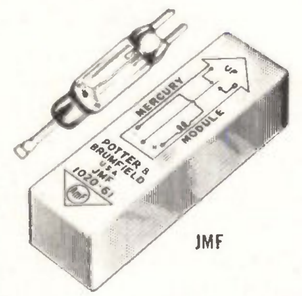
Here is a practical cost saving answer to many timing applications in the range of 1.0 to 180 seconds. You can save up to 60% on relay cost. They're available for AC or DC, knob adjustable, and accuracy is +10% over a −10°C to +55°C temperature range and include an internal 10 amp DPDT relay.



KUP

Versatile KUP relay can be a cost-saving answer to your plug-in relay problem

Save up to $2.00 each over similar relays with octal-type plugs. Get greater reliability, too. Relay has quick connect/solder terminals. Nylon socket (sold separately) rated for 10 amperes. One to three poles. Cover is heat and shock resistant lexan. For DC or AC operation.



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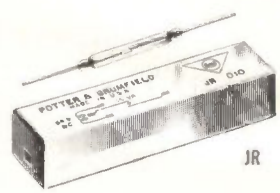
Mercury-wetted contact relay modules give you fast response, reliability, high sensitivity and extremely long life. Designed for printed-circuit mounting. Has SPDT, break-before-make (Form C) contact arrangement for single-side-stable or bi-stable operation.



JR

Reed Relays may replace expensive solid state devices

In many applications JR reed relays may be used in place of more expensive solid state devices over which they have one basic advantage . . . they are not subject to inadvertent switching by line transients.

For applications where fast operate time, low power and long life are required. Their high sensitivity and compact size recommend them for data processing, computer equipment, logic circuitry, for voltage or current sensing and various other types of control circuits.

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Electronics Newsletter

November 14, 1966

NASA pulls Voyager program out of JPL

In a surprise move the National Aeronautics and Space Administration is quietly transferring responsibilities for the Voyager unmanned planetary program from contractor-operated Jet Propulsion Laboratory to two NASA centers. Reasons reportedly involve both technical dissatisfaction and a need to keep the centers busy in the current period of declining space budgets. The action will shock industry, which had been expecting to get a large share of the Voyager program. Under the new arrangement it's expected that more of the work will be done in-house at the Marshall Space Flight Center, Huntsville, Ala., for the spacecraft, and at the Langley Research Center, Hampton, Va., for the landing capsule.

Honeywell shifts to electrically alterable read-only memories

Honeywell, Inc., is taking a new tack in logical controls.

When it delivers its first H-8200 computer next year, the control for the big machine will be an electrically alterable read-only memory. Presumably interlocks in the memory's drive circuits will make it inaccessible to programers, thereby preserving its control function.

Several other recently announced computers have read-only memories as their principal means of control, but the machines must be dismantled and all or part of the memory must be replaced when any part of the stored data is being changed. Such changes are sometimes required when design improvements are made or when the computer's application requires a special set of instructions.

Honeywell spokesmen will not disclose details of the new design, beyond saying that it used conventional ferrite cores with one hole, not multiaperture cores. Because of the memory's electrical alterability, its specifications will be less stringent than those of other read-only memories. Therefore, says Honeywell, it will be cheaper and easier to maintain. Also, it will be twice as fast as any other announced read-only memory, putting it in the 100- to 200-nanosecond range.

High power at uhf with transistors

Solid state components may soon be invading one of the few remaining territories hitherto served exclusively by vacuum tubes: the generation of high-power ultrahigh frequency signals. In an experiment engineers at the Radio Corp. of America's Industrial and Power Tube division in Lancaster, Pa., have successfully combined the outputs of 64 overlay transistors to produce 1,200 watts of uhf power.

Photovoltaic detector appears compatible with CO_2 lasers

The carbon dioxide laser, which at 850 watts of continuous-wave power holds the laser power record, may have found its match—a photovoltaic diode detector.

The detector, made of lead tin telluride (PbSnTe), is believed to be the first photovoltaic detector of infrared radiation in the 8- to 14-micron range. It's in this wavelength range that the CO_2 laser operates and, conveniently, it's in this range that transmission through the earth's atmosphere is attenuated least.

The PbSnTe work is being directed by Ivars Melngailis, head of the applied physics group at the Massachusetts Institute of Technology's Lincoln Laboratory.

Electronics Newsletter

In a photovoltaic detector a change in the light signal produces a change in the device's output voltage. Virtually all of the previously developed detectors that were sensitive in the 8- to 14-micron range are photoconductors, that is, a change in the light signal produces a change in the device's resistance. Photovoltaic devices offer considerable advantages in some applications—such as speed of response and sensitivity.

In preliminary work photovoltaic response was observed up to 11 microns at liquid nitrogen temperature and up to 14 microns at liquid helium temperature. "This means that at 12°K we are covering the atmospheric window, and at 77°K we are able to detect the 10.6-micron radiation of a CO_2 laser," says Melngailis.

Although the Lincoln Lab scientist didn't say so, the development raises the possibility of tuning the detectors by varying their composition.

Computer-controlled test gear for planes gains in industry

Computer-controlled test equipment for aircraft, already firmly established in the military field, is now moving into a civilian area.

Next week the Boeing Co. of Seattle expects to receive bids from 12 United States and British electronics companies for a four-station test and checkout system for jet aircraft production lines.

Although Boeing is the first, it's not alone in moving toward such computer-controlled gear. It's understood that Trans World Airlines, Eastern Air Lines and United Air Lines have started drawing up specifications for similar test gear, and bids for the equipment are expected to go out to industry next year. The company that wins the Boeing contract is expected to gain a lead for the airlines' contracts.

Image-dissector gives computer eyes

Information International, Inc., of Cambridge, Mass., has developed what amounts to an eye for computers. The device, called an Eye, is an image-dissector camera similar to a low-sensitivity television camera. With it, the computer gets its input from its environment by viewing it directly instead of by the usual methods of punched cards, magnetic tape or optical readers.

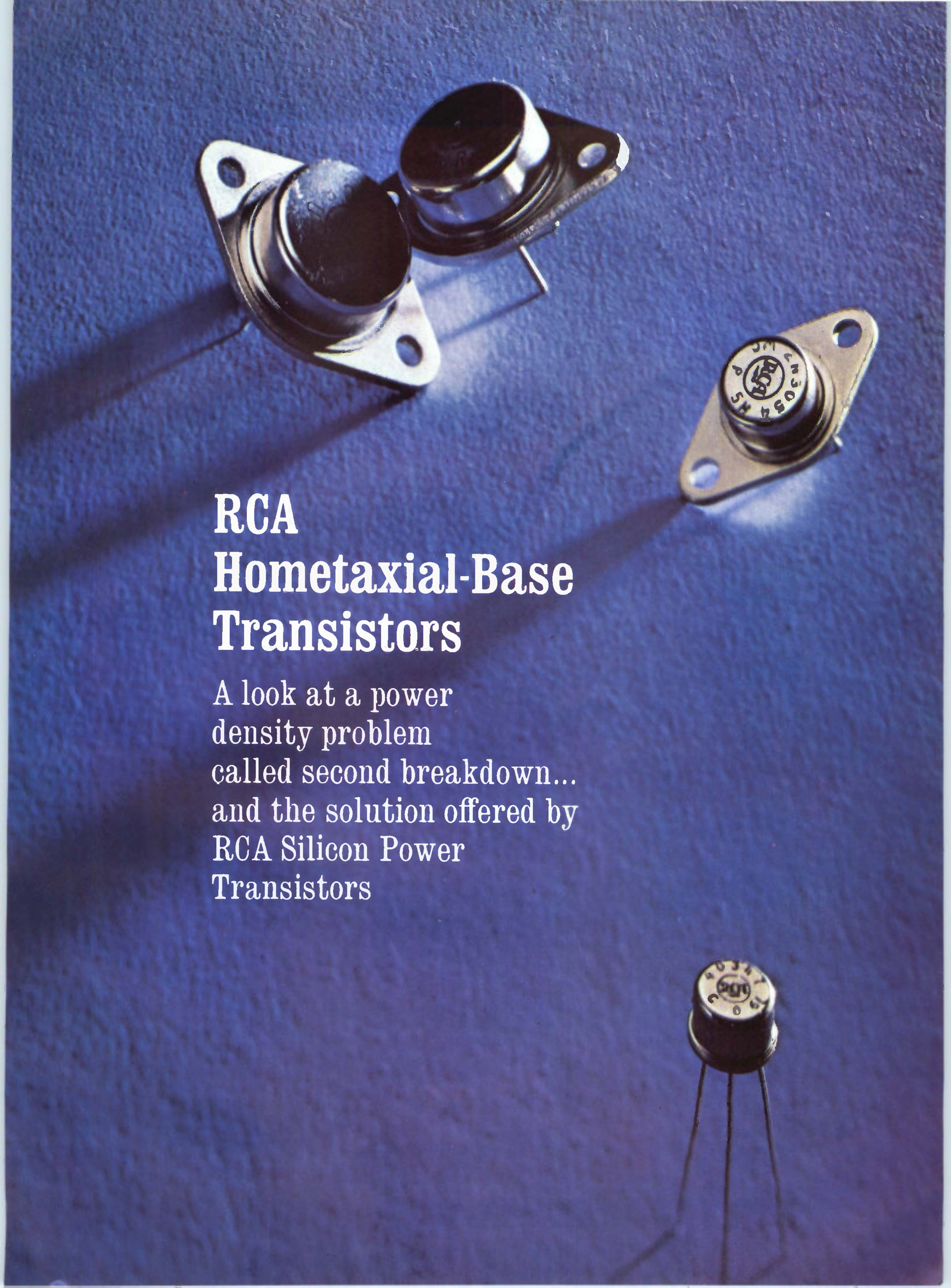
Unlike a tv camera, which makes a raster scan over its entire field of view 30 times a second, the Eye has a conditional scan. It seeks out some significant part of the image, concentrates on it and then moves to other parts on order from the computer.

Controlling the Eye is a pattern recognition program with a certain degree of artificial intelligence. For example, the Eye may look at a drawing on a blackboard. First it looks at the whole blackboard, then it settles on part of a chalk line and finally it follows the line and analyzes the path to discover what kind of pattern was drawn.

Instrument makers: IC's in-house or not

Edgerton, Germeshausen & Grier, Inc., of Bedford, Mass., a manufacturer of nuclear electro-optical and oceanographic instrumentation joins the Hewlett-Packard Co., Tektronix, Inc., and other instrument companies that have decided on in-house development and production of integrated circuits. But the General Radio Co. of West Concord, Mass., one of the oldest instrument makers in the business, hasn't yet decided on the IC path, concedes Ivan G. Easton, senior vice president.

Circle 27 on reader service card→



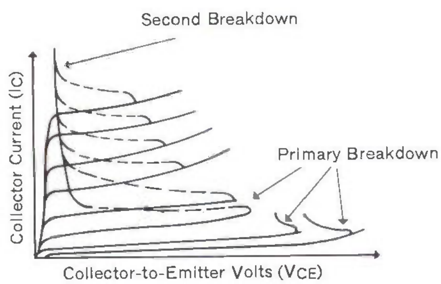
RCA Hometaxial-Base Transistors

A look at a power
density problem
called second breakdown...
and the solution offered by
RCA Silicon Power
Transistors

PROBLEM:
Second Breakdown

WHAT IS SECOND BREAKDOWN?

Second breakdown is a potentially destructive phenomenon resulting from the formation of localized "hot spots" induced by high-current concentrations. It is so named because it is the secondary voltage breakdown as opposed to predicted or primary breakdown. Second breakdown is characterized by an abrupt collapse in V_{CE} with a simultaneous increase in I_C. The resulting combination of high current and voltage destroys the transistor unless adequate current-limiting techniques are used. While second breakdown can occur in all transistors, it is of particular significance in power devices where high currents and voltage are encountered.

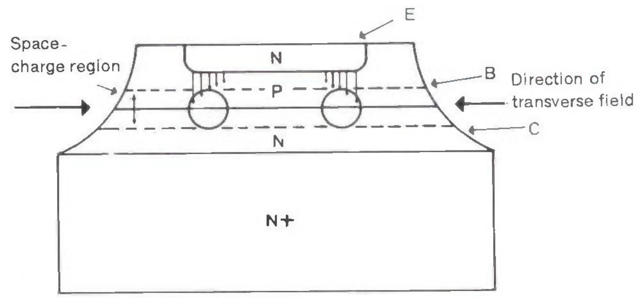


IN WHAT MODES OF CIRCUIT OPERATION IS SECOND BREAKDOWN ENCOUNTERED?

Second breakdown can occur in both forward- and reverse-bias modes of operation of the emitter-base junction. The operating principle differs in each mode, as does the amount of energy or voltage initiating the effect. Forward-bias second breakdown occurs most often in linear circuits using power transistors. Reverse-bias second breakdown usually occurs in inductive power-switching circuits.

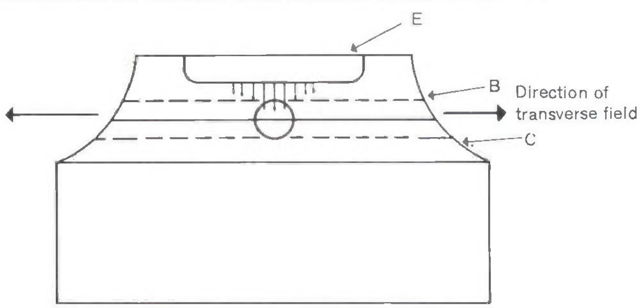
WHAT HAPPENS IN FORWARD-BIAS SECOND BREAKDOWN?

During forward-bias operation, a transverse electric field is set up in the base region, and a "space-charge" layer is formed at the base-collector-junction. As current flows from the emitter to the collector, the transverse field focuses the current flow into a narrow region under the emitter edge. When the current flows through the "space-charge" layer, a significant amount of heat is generated by the combined product of current and voltage. With current flow focused into a small area, the heating effect is localized and the formation of hot spots (circled areas in diagram) may result. If unchecked, these hot spots initiate a regeneration cycle of highly focused current which may destroy the transistor.



WHAT HAPPENS IN REVERSE-BIAS SECOND BREAKDOWN?

During reverse-bias operation of the emitter, the direction of the transverse field is reversed by the polarity change. As a result, the emitter current is focused into a small region at or near the center of the emitter. Because of the crowding of current flow into a region smaller than that under forward-bias conditions, reverse-bias second breakdown can be encountered at substantially lower power levels. The resistance of a transistor to reverse-bias second breakdown is reduced



by any design alteration which increases current density or prevents emitter current from fanning out. Power transistor designs which have (1) narrow base width, (2) an accelerating base field, or (3) insufficient emitter size for their operating current generally exhibit reverse-bias second breakdown at lower power levels than transistors without these factors.

WHAT IS THE RELATIONSHIP BETWEEN ENERGY REQUIRED FOR SECOND BREAKDOWN AND FREQUENCY CAPABILITY?

In the design of high-frequency transistors, the base width is minimized to reduce the transit time of emitter current through the device. The resulting short path does not permit significant current spreading or fan out. As a result, focused current flows across the collector junction with a resultant increase in power density and localized heating. Also, because of the narrower base region, this heating effect is more closely coupled to the emitter junction, promoting thermal regeneration and second breakdown. Designers should note that the selection of devices having higher frequency capability than needed for a given design greatly compromises circuit reliability and resistance to second breakdown.

SOLUTION:

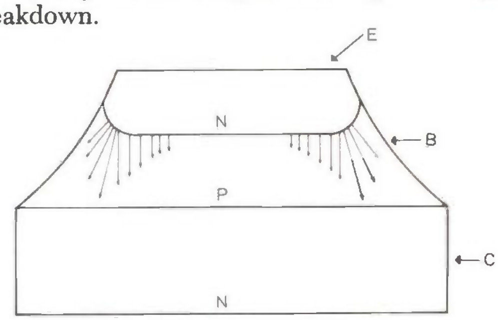
RCA Hometaxial-Base Transistors

WHAT IS RCA HOMETAXIAL-BASE TECHNOLOGY?

Hometaxial-Base technology is an RCA-developed process which has proved to be effective in preventing second breakdown. In this technology, a single-diffusion process is used to form both emitter and collector junctions in a uniformly doped silicon slice. The result is a *homogenously* doped base region free from accelerating fields in the *axial* (collector-to-emitter) direction—hence the name Hometaxial. The Hometaxial-Base transistor is also characterized by a wide base region, further enhancing the ability of the device to resist second breakdown. The attendant simplicity of this technology has resulted in a family of reliable, low-cost power transistors.

HOW DOES HOMETAXIAL-BASE TECHNOLOGY IMPROVE SECOND BREAKDOWN CHARACTERISTICS IN THE FORWARD-BIAS MODE?

Hometaxial-Base technology greatly minimizes the risk of second breakdown in the forward-bias mode by allowing the emitter current to fan out before it enters the collector region. Because uniform doping levels are employed, there is no field to accelerate the current. And because of the wide base width, the current fans out by electron diffusion before reaching the collector junction. Although these two factors limit somewhat the high-frequency performance of Hometaxial-Base transistors, they are most significant in preventing second breakdown.

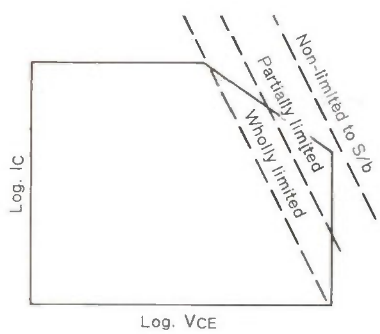


HOW DOES HOMETAXIAL-BASE TECHNOLOGY IMPROVE SECOND BREAKDOWN CHARACTERISTICS IN THE REVERSE-BIAS MODE?

Because of the high-current densities under reverse-bias conditions, wide base structure and uniform doping are even more important than in the forward-bias mode. In addition, the collector of the Hometaxial-Base unit is designed to prevent "localized widening" of the base region into the collector layer. This "localized widening" occurs in multiple-diffused designs when the emitter current density increases beyond a value consistent with the fixed impurity doping level of the collector. The collector region of Hometaxial-Base transistors is designed to minimize this widening and the degradation of breakdown voltage which accompanies it in multiple-diffused structures.

WHAT DEVICE RATINGS ARE AVAILABLE TO ASSURE MAXIMUM SAFE OPERATION IN THE FORWARD-BIAS MODE?

Every transistor is subject to second breakdown at some combination of voltage and current in the forward-bias mode. Accordingly, RCA has developed a series of "Safe Area of Operation" curves for both dc and pulse conditions. These curves show at what point a given transistor may be wholly limited, partially limited, or non-limited in terms of second breakdown. Such curves are now included in all recently published data for RCA Hometaxial-Base devices and are being added to the earlier published data sheets.



ARE COMPARABLE DESIGN CURVES AVAILABLE TO ASSURE MAXIMUM SAFE OPERATION IN THE REVERSE-BIAS MODE?

Specifying devices for maximum safe operation in the reverse-bias mode is somewhat more complex than for forward-bias conditions. As a result, RCA supplies a series of three curves which relate source voltage, source resistance, and output inductance to the power required for second breakdown. With such a rating system, the designer can determine whether circuit operation conditions fall within the safe-operating region indicated. Again, RCA is adding such design curves to its new data sheets and is revising existing sheets to include them.

SUMMARY

RCA's family of low-cost Hometaxial-Base transistors offers the user of silicon power devices two distinct benefits. First, it provides him with a proved transistor structure which, because of its wide-base, uniform doping, and special collector design, is inherently superior in eliminating second breakdown. Second, it provides him with a complete system of ratings curves which specify maximum safe operation in both forward- and reverse-bias modes. This combination of device design and application assistance equips the designer with a unique solution to the problem of second breakdown.

RCA HOMETAXIAL-BASE TRANSISTORS...

a family of low-cost reliable silicon power transistors offering you freedom from the problems of second breakdown

FOR POWER APPLICATIONS UP TO 50 KHz, FROM 1A TO 30A			
TO–5 I_C (Max) TO 1A P_T (Max) TO 5W	TO–66 I_C (Max) TO 4A P_T (Max) TO 29W	TO–3 I_C (Max) TO 15A P_T (Max) TO 117W	TO–3 I_C (Max) TO 30A P_T (Max) TO 150W
40347 h_{FE} = 20-80 @ I_C = 450 mA V_{CEV} (Max) = 60V	**40250** h_{FE} = 25-100 @ I_C = 1.5A V_{CEV} (Max) = 50V	**40251** h_{FE} = 15-60 @ I_C = 8A V_{CEV} (Max) = 50V	**2N3771** h_{FE} = 15-60 @ I_C = 15A V_{CEV} (Max) = 50V
40348 h_{FE} = 30-100 @ I_C = 300 mA V_{CEV} (Max) = 90V	**2N3054** h_{FE} = 25-100 @ I_C = 0.5A V_{CEV} (Max) = 90V	**2N3055** h_{FE} = 20-70 @ I_C = 4A V_{CEV} (Max) = 100V	**2N3772** h_{FE} = 15-60 @ I_C = 10A V_{CEV} (Max) = 100V
40349 h_{FE} = 25-100 @ I_C = 150 mA V_{CEV} (Max) = 160V	**2N3441** h_{FE} = 20-80 @ I_C = 0.5A V_{CEV} (Max) = 160V	**2N3442** h_{FE} = 20-70 @ I_C = 3A V_{CEV} (Max) = 160V	**2N3773** h_{FE} = 15-60 @ I_C = 8A V_{CEO} (sus) (Min) = 160V
		2N4347 h_{FE} = 20-70 @ I_C = 2A V_{CEV} (Max) = 140V	**2N4348** h_{FE} = 15-60 @ I_C = 5A V_{CEV} (Max) = 140V

For more information on Hometaxial-Base transistors and how they help you solve the problems of second breakdown, see your local RCA representative. For technical bulletins on specific types, write Commercial Engineering, RCA Electronic Components and Devices, Harrison, N. J.

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- ☐ It operates on *either* ac or dc.
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The package combines MEC's proven miniature low noise TWT with an advanced power supply design. For precise, efficient, and stable performance, the all-silicon, solid-state supply features integrated circuitry and micrologic networks.

The unique primary input circuit allows you to operate from either 115 volt, 48 to 420 cycles ac, or 150 volt dc at efficiencies greater than 70%. That'll really simplify your flight line or service area testing!

Compare the specifications of integrated TWT amplifiers – then let's hear from you.

Model	Freq. (GHz)	Gain min (db)	N. F. max (db)	P sat min (dbm)
M9071	2 - 4	35	10	10
M9072	4 - 8	35	10	10
M9073	8-12.4	35	10	10
M9080	7-11	35	10	10

Please write for complete specifications.

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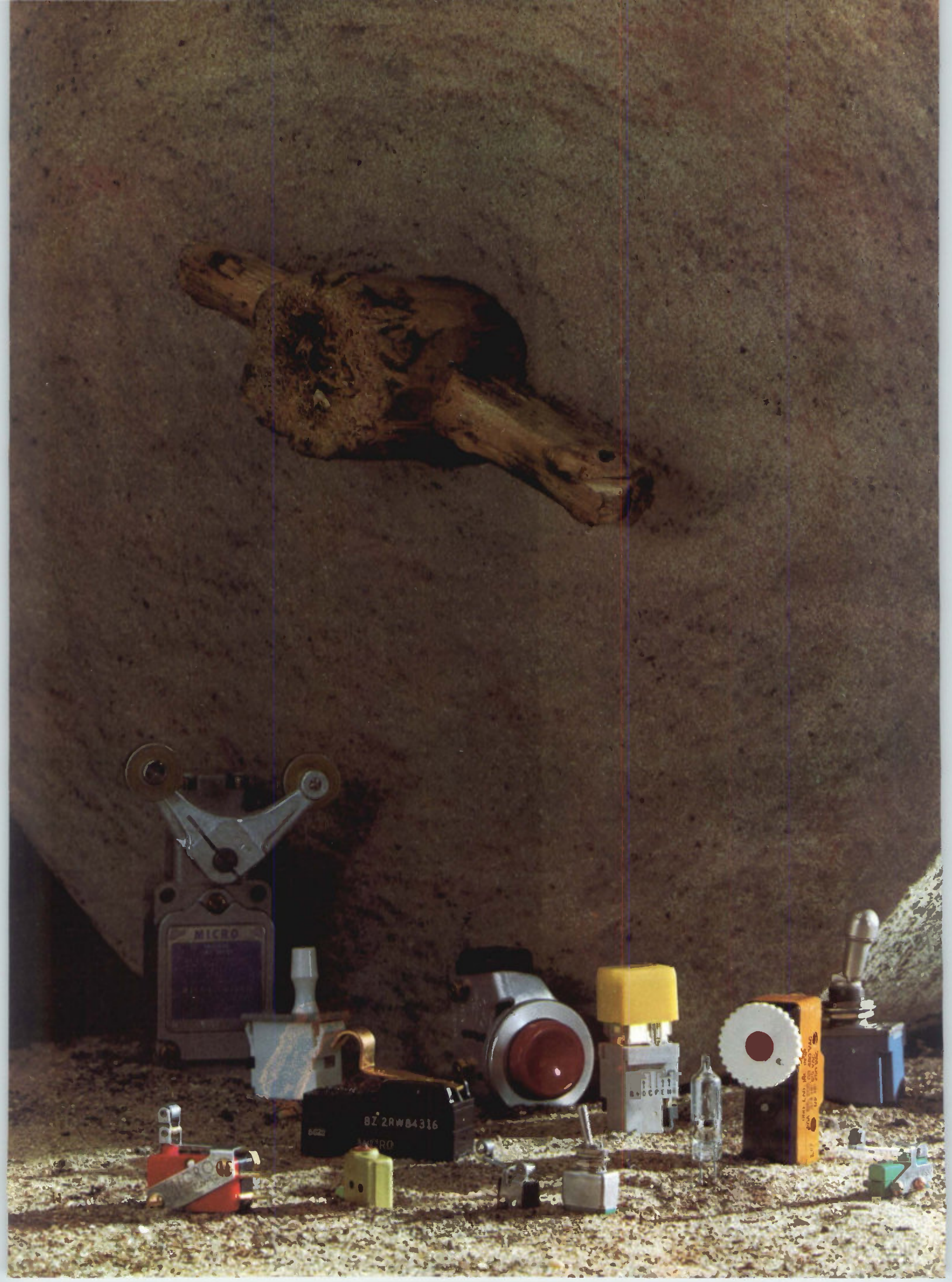
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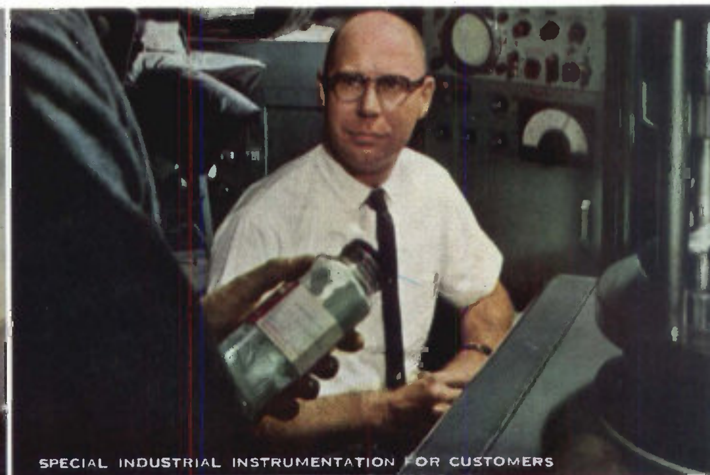
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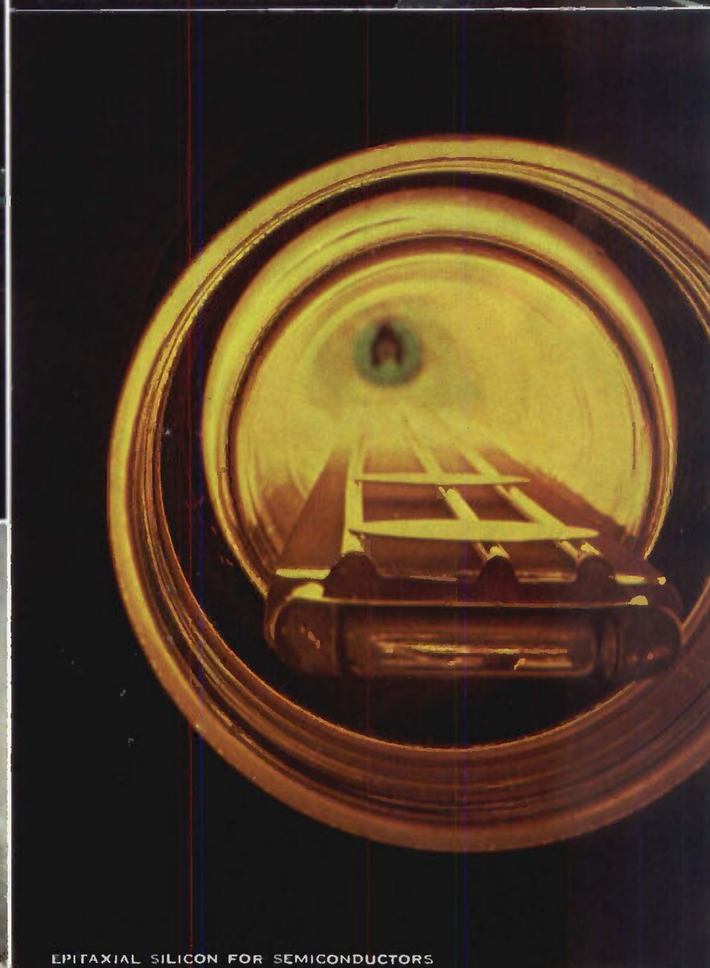
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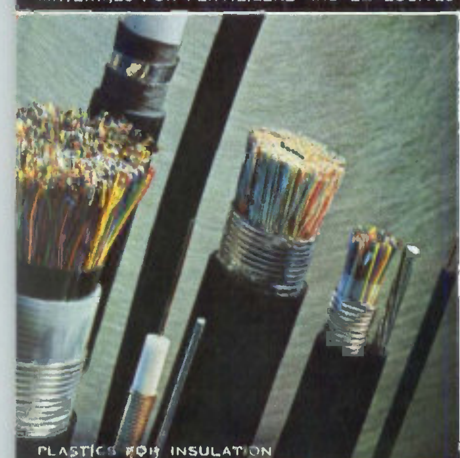
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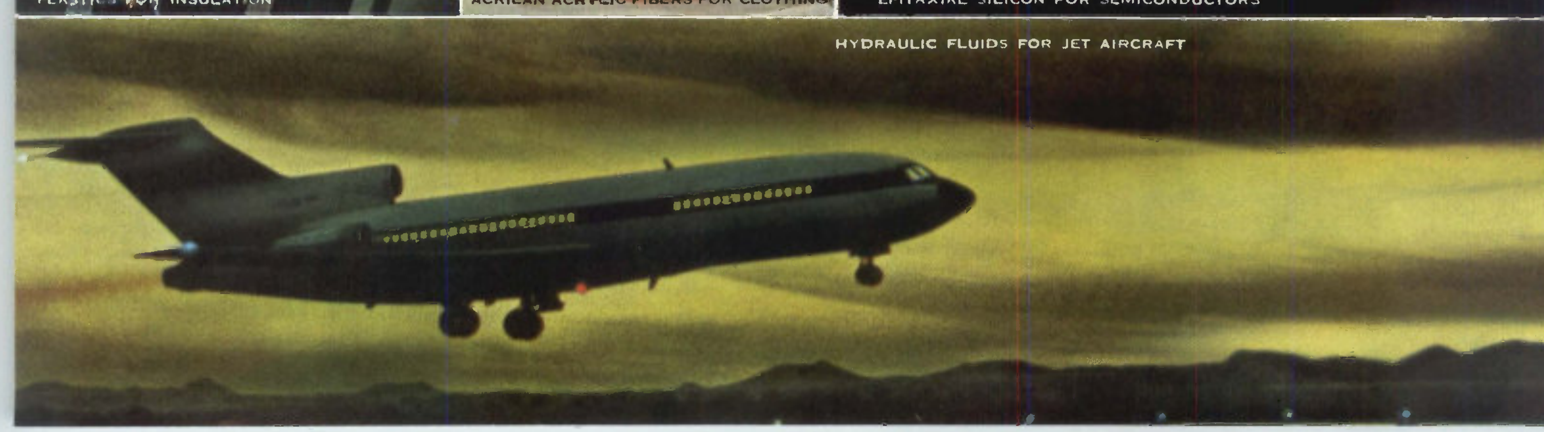
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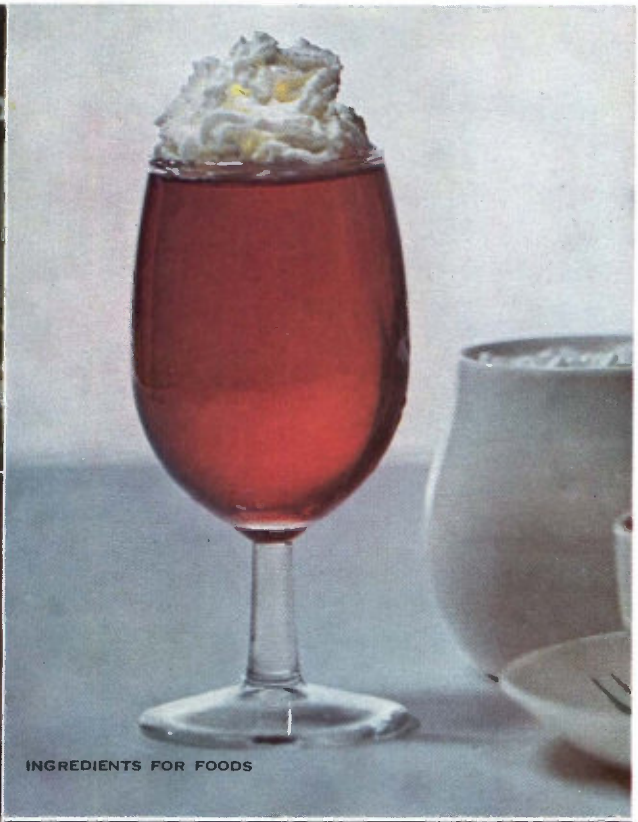

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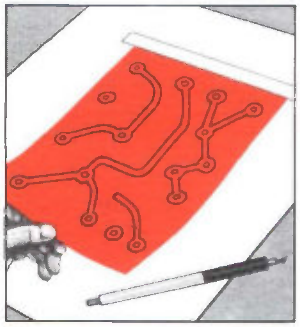
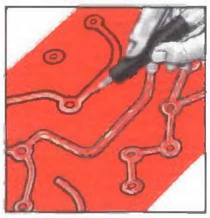
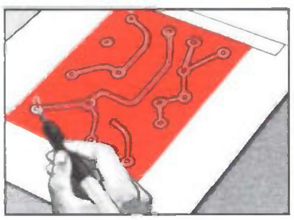


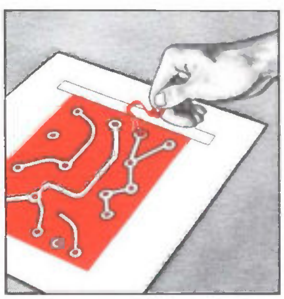
Cut a piece of the desired film large enough to cover area to be masked. Tape it down firmly at the top *with dull-side up*.



With sharp blade, outline the areas to be masked. *Do not cut through the backing sheet*. The Ulano Swivel Knife does the job quickly, easily.



Using the tip of the blade, lift up a corner of the film thus separating it from the backing sheet.



Now carefully peel off the film as outlined leaving a completed mask, positive or negative, that corresponds exactly to the desired pattern.

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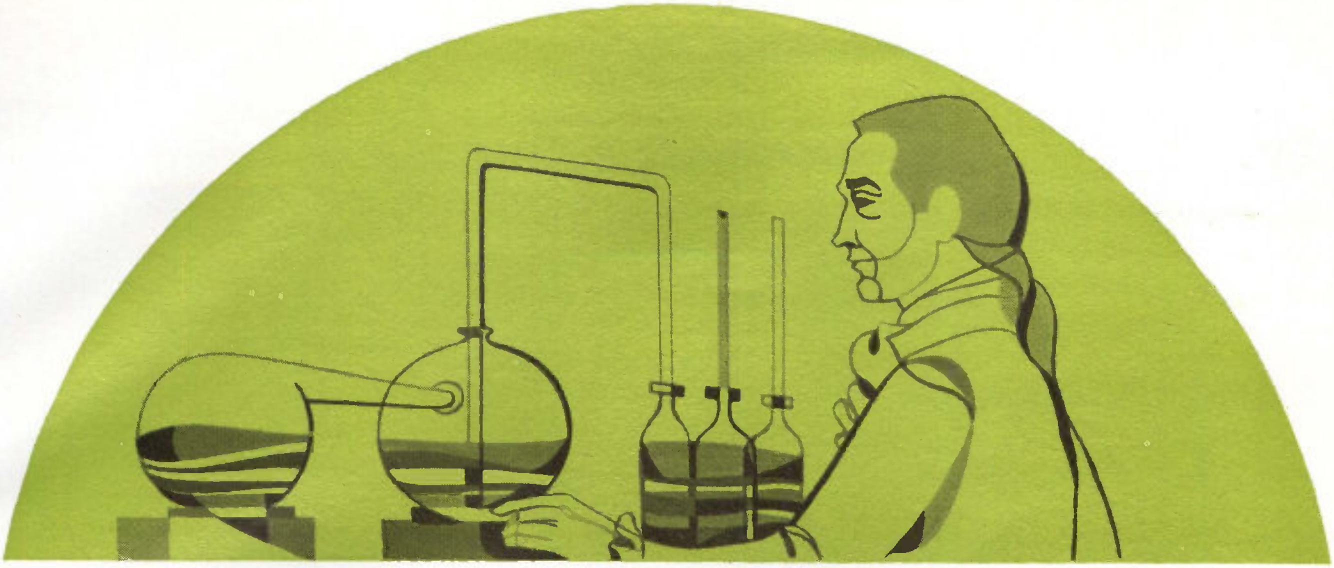

INNOVATION IS THE PULSE OF PROGRESS

In 1757, the French chemist, Antoine Lavoisier, showed that when oxygen combines slowly with iron or certain other metals, rusting takes place and a precise increase in weight occurs. He also demonstrated that certain metal oxides, such as mercuric oxide, lose oxygen and become lighter when heated. By such novel studies, he established the existence of oxidation processes and, more importantly, the existence of discrete elements. A genius of his time, Lavoisier pointed out that matter is neither lost nor gained in a chemical change and that as much heat is required to decompose a compound as is given off when the compound is formed. He introduced the first rational nomenclature and quantitative methods of chemistry. Lavoisier was truly one of the great chemists and is often called the founder of modern chemistry.

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[2]U.S. Pat. No. 3,243,211

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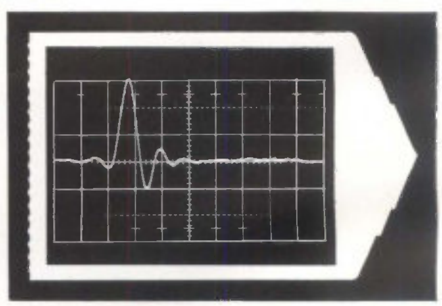

Typical Photograph of Crosscorrelation Function of Input and Output Signals of Complex Passive Network Driven by White Noise.

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PRINCETON APPLIED RESEARCH CORP.

November 14, 1966

Electronics Review

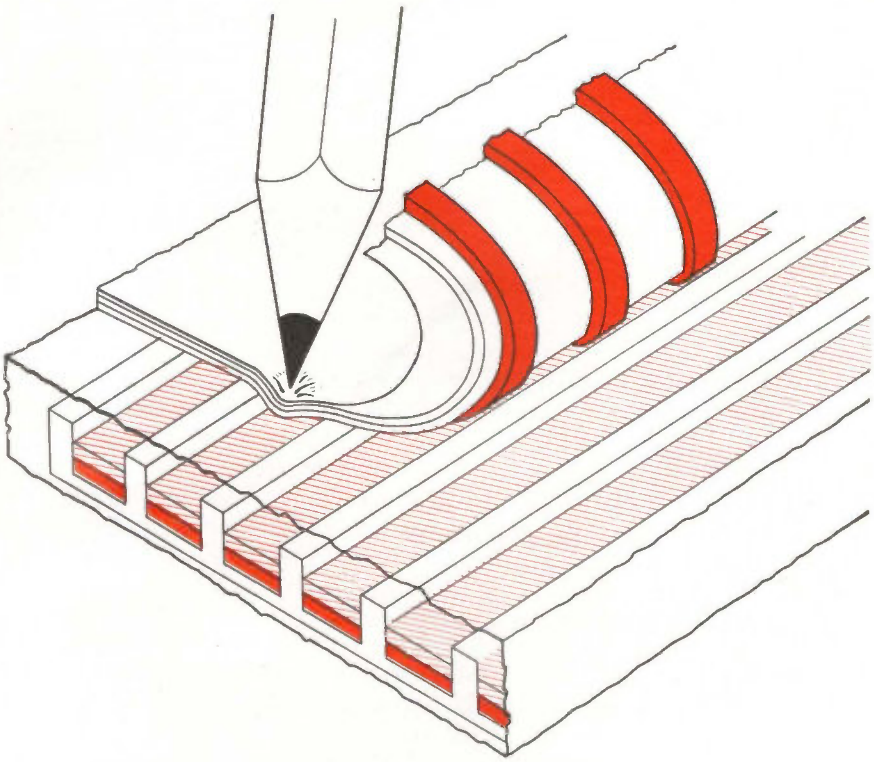
Volume 39
Number 23

Computers

Copy writing

Up to now an engineer using a computer writing tablet, such as the Rand tablet, had to be endowed with what amounted to split vision. He had to draw on the tablet with a special stylus, and at the same time watch a display of what he was drawing on a cathode-ray screen—a procedure that's both distracting and tiring. But a new computer writing tablet enables the engineer to write on a piece of paper with a pencil and the pencil's pressure on the paper enters the handwritten data directly into the computer.

Proves technique. Designer John Simek of the International Business Machines Corp.'s engineering laboratory at Endicott, N.Y., has built one model of the tablet for an adaptive learning project to prove that the technique works.



Pressure of a pencil point on IBM tablet generates computer data.

In some respects the IBM unit resembles the Rand tablet, a graphic input device developed by the Rand Corp. [Electronics, June 14, 1965, p. 42]. But the Rand tablet uses a stylus that's wired to the computer to transmit the signals, and it makes no hard copy.

The IBM tablet has a 2-by-5 inch writing surface made of a Mylar film lying on a copper-clad glass-epoxy board; a set of parallel conducting lines is etched on top of the board and a perpendicular set is printed with conductive ink on the bottom of the film. Both sets of lines are spaced 32 to the inch. A binary counter applies voltage pulses to each of the first set of lines in order; and sense amplifiers detect which of the second set is in contact with one of the first set. The sequence of pulses transfers the pattern into the computer's memory. The computer can then execute a pattern-recognition program, display the pattern on a screen or process it.

Smooth. Both sets of lines are gold-plated to establish a low-resistance contact. The lines on the glass-epoxy board are depressed 0.0005 inch beneath the surface to avoid spurious contacts by hand pressure or wrinkles in the Mylar. The depressions are not so deep that the writing feels bumpy.

Simek uses his transducer to handprint letters into a computer, which was programed to recognize different characters entered by different people. He divided the writing surface into 40 half-inch squares with a 16-by-16 matrix of grid lines in each square; corresponding lines in each matrix were electrically connected. Thus, patterns drawn in any square look like patterns drawn in any other square. This is sufficient for his project and reduced considerably the amount of electronics needed to drive and sense the transducer. In its present form, the transducer doesn't tell the computer where on the tablet the letter is being written. However, says Simek, it wouldn't be too difficult to add electronics to give the system this capability.

The transducer is similar to IBM's elastic diaphragm switch announced about a year ago. That device established contact through holes in a plastic sheet, defining the path of a pencil or stylus and providing signals that could be used by a computer. Neither the elastic diaphragm switch nor the new transducer has reached IBM's commercial production line.

Timely program

People count by tens and computers by twos. But the passage of time is counted by a complicated mixture of tens, twelves and sixties—satisfying neither man nor computer.

Frank Cilino and several engineer colleagues at the Western Electric Co.'s laboratory at Princeton, N.J., have worked out a calendar scheme that should satisfy both man and machine. Their plan is to divide time into what they call millidays; one milliday is one thousandth of a day and as a unit of time it retains the advantage of the day—the cycle of human activity.

Work-a-day. The computation of the milliday was not meant as an idle exercise to amuse puzzle buffs. It offers a real advantage for both commercial and scientific users of computers. Consider this: a payroll program computes the pay for a workman who punched in at 8:22 a.m. and punched out at 4:08 p.m. —a mixed-modulus calculation. Or this: a data-communications computer calculates the duration of all incoming and outgoing messages to determine proper charges for telephone service; messages originating in different time zones where night rates may be in effect must be charged differently from local messages.

Cilino's choice of a milliday is sufficient to provide enough resolution—corresponding to 1.44 conventional minutes or 86.4 seconds —for most commercial needs and many scientific needs. Where finer resolution is necessary, millidays are easily divided into still smaller units.

Under the system days are numbered sequentially from 1 to 365 (366 in leap years). Then, Feb. 18 becomes day 49, and June 4 becomes day 155 (day 156 in a leap year). With this system, leap years are of no consequence except on day 366. Furthermore, 9:00 a.m. on June 4 becomes day 155.375, and 6:00 p.m. of Feb. 18 becomes day 049.750. Direct subtraction of two purely decimal numbers gives the elapsed time in decimal fractions.

Clock puncher. This method of measurement affords two bonuses. First, a computer can treat time and date as arithmetical quantities, without requiring special routines to change the base—except for changes between binary and decimal, which it has to do quite often anyhow. Second, an ordinary six-place decimal counter becomes a clock-calendar if it is tripped once each milliday. Such counters can be driven by standard one-revolution-per-minute clock motors through 36-to-25 reduction gears, or by special one-revolution-per-milliday clock motors that are commercially available.

The measurement in millidays has some disadvantages, too. A milliday clock must be reset to 001.000 at midnight on New Year's Eve—exactly at midnight if it is to retain its accuracy. Conventional decimal counters reset to zero, not 001.000. And elapsed time from one year to the next must take this resetting into account. Furthermore, if the computer's measurement of time is to be included in outputs for human consumption, the days and millidays must be reconverted into standard form—at least until such time as people can be persuaded to tell time in millidays, too. This reconversion would require another special computer routine.

Then there's the old bugaboo of time zones—an important consideration for computer systems that transmit and receive data over long distances. The correction is to add or subtract about 41.667 millidays for each time zone change; the exact correction is not expressible in decimal notation, so that if this is done several times, a cumulative error can build up.

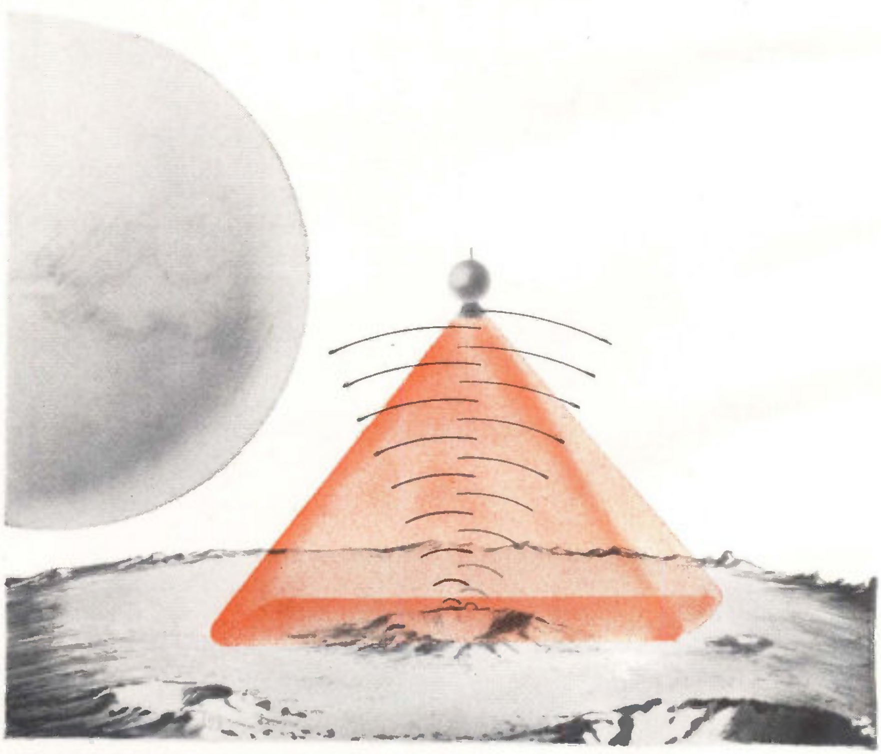
Avionics

Scattered view

Because the terrain-mapping radar on unmanned spacecraft flying over lunar surfaces can only measure a single angle of incidence at a time, many passes are required—a procedure that takes hours. Now, a new radar, called a Scatterometer, reduces those hours to minutes by eliminating the need to repeatedly reorient the radar antenna. One pass by the spacecraft is sufficient to measure all angles of incidence simultaneously.

The system was developed by the Ryan Aeronautical Co.'s Electronic and Space Systems division for the National Aeronautics and Space Administration.

High and wide. The Scatterometer—called that because it receives and records profile signals even when they are scattered by terrain—emits a 120° fan-shaped



A spacecraft, using a Scatterometer, has to fly over a pock-marked area of the lunar surface only once to get a detailed profile of the terrain.

beam that simultaneously detects detailed signatures at many angles of incidence. For example, at an altitude of 30,000 feet the beam could map an area 20 miles long and 2 miles wide. By comparison, the conventional radar's pencil beam can scan an area of about 1/10 of a mile square and can detect signals returned at a single angle of incidence in a single plane.

The Ryan radar measures the backscattering cross section of the return signal by relating its amplitude at a given doppler frequency to its angle of incidence. Filters separate the reflected energy into discrete doppler frequency intervals; altitude and surface reflectivity characteristics determine signal amplitude in each frequency interval.

The doppler signals are converted into audio signals which are then stored on a wideband f-m tape recorder. After the flight, the tape is played back through a spectrum analyzer. A computer then synthesizes a topographical map by combining all the various data.

Signature search. Ryan engineers have mounted the system in a Douglas DC-3 flying laboratory and are making recordings of radar signatures of heavily forested land, rocky hills and deserts that are well known. These signatures will eventually be compared with radar responses from unexplored regions to prepare profile maps of these areas.

In addition, the military is considering adapting the wide-sweep radar to some down-to-earth applications. In battle areas like Vietnam, pilotless drones and manned aircraft would have to make only one pass over an area to get detailed maps of even the roughest topography.

Electron devices meeting

Sealing vacuum's fate

By combining the beam lead technique with a silicon nitride seal, engineers at Bell Telephone Laboratories believe they have found a way to encapsulate transistors and integrated circuits in a batch process. The new technique makes it possible to seal thousands of devices simultaneously while they are still on a single silicon slice. Transistors made by the new sealing technique have already exhibited longer life under accelerated aging tests than hermetically sealed devices.

Potentially, the process could eliminate vacuum sealed systems, like TO-5 cans, which require that the slice be cut into individual chips that are then assembled on a header and sealed to a cover by a costly process.

The seal is formed by heating the silicon slice to 875°C in a closed chamber containing pure hydrogen. Then a mixture of silicon hydride and ammonia is introduced. On contact with the slice, the gases react to form silicon nitride, which adheres to the slice, forming a protective barrier against sodium ions and other forms of contamination.

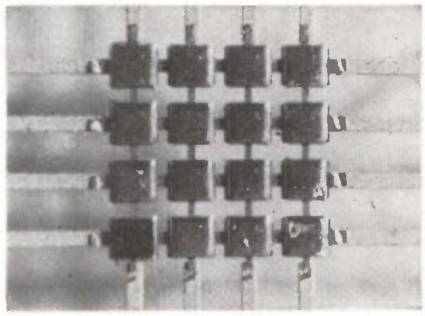
Window opener. Beam lead contacts are also applied to the devices while they are on the slice. The contacts, made from multilayer combinations of titanium-platinum alloy and platinum silicide, form a strong chemical bond with the silicon nitride and seal the contact areas. To make electrical contact to the devices, windows are opened in the silicon nitride by etching.

The new process is highly effective in protecting semiconductor devices against penetration and contamination by metallic ions in the atmosphere. Sodium ions, because of their small size, are especially troublesome. Epitaxial silicon transistors sealed with the new method were exposed to sodium ions and then subjected to accelerated aging tests at normal bias but at a power level that raised the junction temperature to 300°C. Their median life exceeded the 1,000-hours of hermetically sealed transistors aged under the same conditions, but without exposure to sodium ions.

The sealing technique was described at the International Electron Devices Meeting in Washington by G.H. Scheer, W. Van Gelder, V.E. Hauser and P.F. Schmidt.

Light on the beam

Another first for the beam lead technique was reported at the meeting in Washington. By combining planar and beam lead technologies, Bell Labs engineers W.T. Lynch and R.A. Furnange have been able to batch fabricate 4-by-4 matrix arrays of gallium arsenide



Beam leads support matrix of light-emitting diodes on 10-mil centers.

(GaAs) light-emitting diodes. This is the first time beam lead techniques have been successfully applied to gallium arsenide devices.

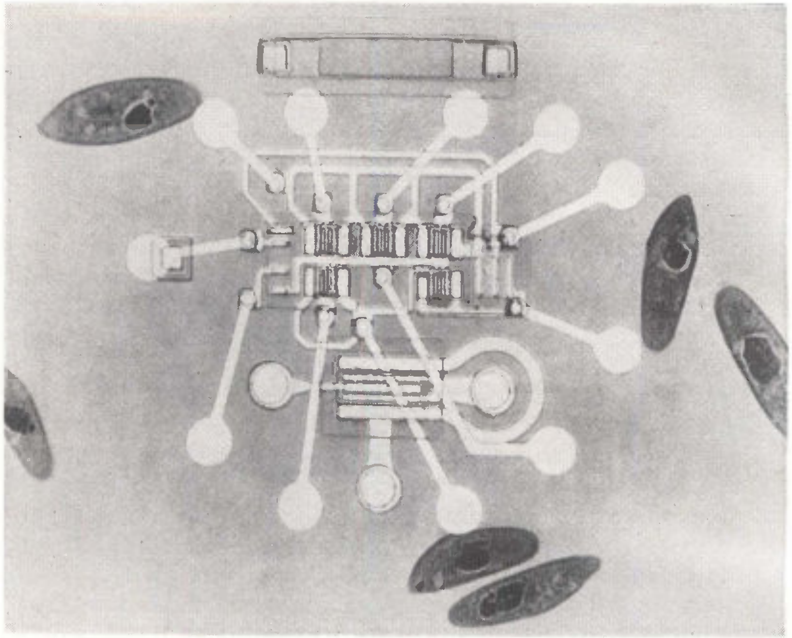
The diodes are arranged on 10-mil centers in a 40-mils square area. The devices are made by diffusing zinc into the GaAs after masking with alternating layers of silicon oxide (SiO_2) and phosphosilicate glass. A continuous layer of SiO_2, deposited after the pattern has been defined but before the diffusion step, minimizes lateral diffusion and reduces reverse current leakage to 10^{-11} amperes or better, according to Lynch.

Polishing the slice. Beam leads make contact to the n and p regions of the diodes on the same side of the slices. The back of the slice is polished to a final thickness of less than 2 mils and the excess material between devices is etched away, leaving the diodes connected electrically and structurally by the heavy leads.

The process results in diode arrays of exceptional uniformity—at yields of about 90%—which indicates potentially low cost for the arrays. Lynch and Furnange anticipate that the process can be successfully applied to matrixes as large as 10 by 10, with yields as high as 50%.

Light is emitted through the backs of the diodes. Typical quantum efficiencies are about 0.2% at excitation currents up to 100 milliamperes.

Because the spacing of the array can be closely controlled during fabrication, Lynch points out that alignment in optical systems can be made much more accurately than with individual diodes. He sees the arrays being applied as coupling interfaces with high isolation between computer subsystems and in memories.

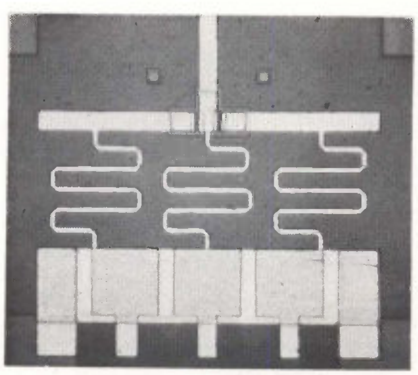


The highest speed for an integrated circuit is claimed by IBM for this 400-picosecond current mode switch. Oblong shapes are paramecia (for size comparison) not defects.

A monolithic first

The invasion of the microwave component field by integrated circuits continued at the International Electron Devices Meeting with the announcement of the first all monolithic microwave IC. Alfred Ertel, an engineer at Texas Instruments Incorporated, described a silicon antenna transmit-receive switch designed to operate at 9 gigahertz. The switch was developed as part of the contract TI has with the Air Force Systems Command for the investigation of molecular electronics for radar applications.

On the substrate. The circuit is contained on a single silicon chip 100 mils square. The active switching elements are p-i-n diodes integrated with microstrip transmission lines and thin-film capacitors on a silicon substrate. Bias to the diodes is supplied through quarter wavelength meander line chokes which are bypassed to ground by the capacitors.



Components of first monolithic microwave IC include diodes, strip line chokes and thin-film capacitors.

An important function of a transmit-receive switch is to isolate a receiver from a transmitter during transmission, thus preventing overloading of the receiver and possible burnout. The monolithic switch is capable of from 25 to 27 decibels of isolation with continuous-wave input of 1 watt, or a peak of 50 watts. The insertion loss over the frequency range of 8 to 9 Ghz was 1.5 to 2 db. Voltage standing wave ratio was better than 1.5 to 1 over the range.

Smallest, fastest

Development of a 400-picosecond current mode logic circuit in a single silicon chip that's less than 0.01 square inches, [Electronics, Oct. 17, p. 25] prompted the International Business Machines Corp. to claim a record for the smallest, fastest monolithic integrated circuit. IBM engineers at the International Electron Devices Meeting attributed the device's record performance to sharpened photolithography and masking techniques.

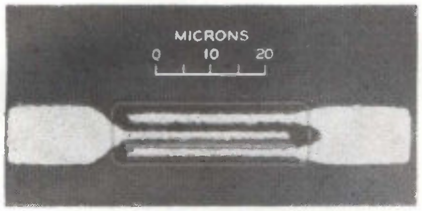
The circuit contains five transistors and three diffused resistors. Each transistor is about 0.001 inch square and has emitter widths and emitter-to-base spacings of 0.000075 inch. The collector and emitter junction depths of the double-diffused transistors are 3,200 and 2,000 angstroms, respectively. Junction isolation and two levels of metalization are used in the IC.

Developers of the high-speed circuit, A. Dhaka and Kenneth West of IBM's Components division, reported that computer-aided transistor design techniques were used to optimize the transistors. Chief factors, they said, that affected the design were emitter area, mobile charge storage in the forward-biased emitter base junction, current crowding under the emitter and depth of the junction.

About 100 picoseconds of the new unit's 400-picosecond propagation delay, is package delay.

Barriers pushed. Bell Telephone Laboratories claimed two records with a 12-gigahertz oscillator diode and a 7-Ghz transistor. The experimental silicon diode generates continuous-wave power double that reported for silicon pn diodes and eight times that reported for Gunn effect devices. The silicon transistor has a cutoff frequency above 7 Ghz—the highest reported—and a power gain of greater than 4 decibels at 4 Ghz.

The microwave oscillator diode, developed by Toshio Misawa, was said to provide 1.1 watts of c-w power at 12 Ghz with 8% efficiency. Misawa attributed the higher output to better mounting and bonding, improved heat dissipation and closer control of processing. A big gain, he said, was made by mounting the diode upside down in its housing. This puts the pn junction near the metal mount and fosters better heat flow.



Very thin base layer and micron-wide emitter stripes are key to performance of 7-Ghz transistor.

Processing improvements lie chiefly in controlling the impurities or doping profile of the silicon semiconductor. Misawa has experimented only with simple pn junction diodes, which are easy to fabricate because they need only one diffusion.

Shorts possible. Improved fabrication techniques were also credited with bettering the performance of high-frequency transistors by allowing the internal dimensions of the devices to be cut down. A key to very high frequency transistor operation is a thin base—about 0.01 microns—and a narrow emitter stripe—about a micron wide. Thin base layers, however, encourage emitter collector shorts, which result from dislocations and impurities in the silicon that are introduced during diffusions.

The developer of the transistor, Rudolf Schmidt, avoided the shorts by making both base and emitter diffusions shallow—the base is 0.3 micron and the emitter 0.2 micron, for a net active base thickness of only 0.1 micron. The shallow diffusions, Schmidt says, makes the number of defects negligible.

The emitter stripe was held to a micron by improved masks and by depositing a thin metal layer between the silicon dioxide and photoresist layers. The metal serves to prevent interference between reflected light from the silicon surface and the incident light which causes nonuniform exposure of the photoresist and poor resolution of the pattern. Another way to cut the reflections would be to use a high optical density photoresist.

Film transistor. Hope looms for the much discussed all thin-film integrated circuit—in the form of an indium arsenide (InAs) high-frequency transistor. Scientists at the Westinghouse Electric Corp.'s research laboratories described the fabrication of devices made with ultra thin (only a few millionths of an inch thick) films of InAs. The experimental transistors are still comparatively crude, T.P. Brody, one of the developers, reported. The first models operate up to 8 Mhz, Brody said, but this response will be extended 100 times. The transistor's ultimate performance, he said, should reach well into the microwave region—up to several gigahertz. His prediction is based on the high mobility of the charge carriers in the InAs material—100 times greater than that of cadmium sulfide, the material traditionally used for thin-film transistors.

Indium arsenide has another notable advantage—its temperature stability over a wide range, from near absolute zero to 300°F.

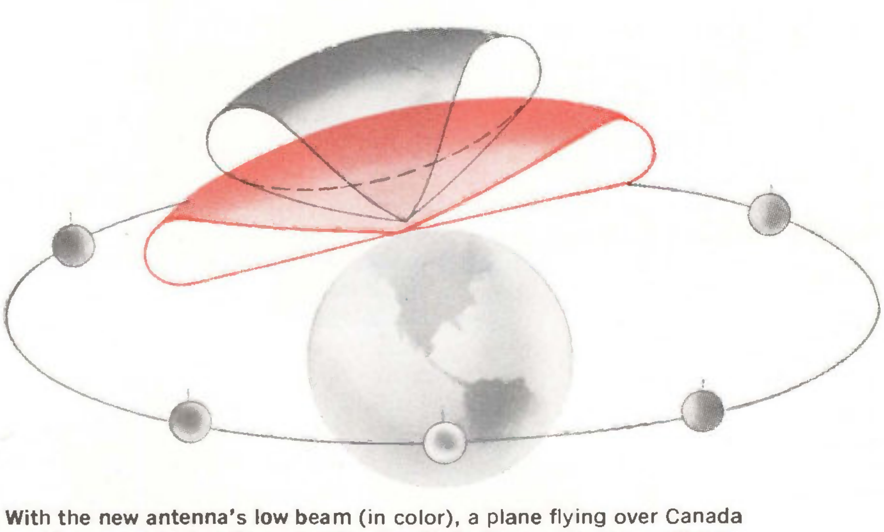
The arsenide films are made by evaporating indium and arsenic inside a vacuum chamber; vapors of the two metals combine chemically and a thin layer of InAs deposits on a glass or quartz substrate. The transistors are formed by successive depositions of InAs, metal, insulation material and metal in layers that are typically 5 to 10 millionths of an inch thick.

Antennas

Hugging the horizon

The day is fast approaching when airplanes will routinely transmit radio messages through communication satellites for relay to the earth or other airplanes. At present a combination of economic and technical barriers stand in the way. A solution to one technical obstacle has been devised by Electronic Communications, Inc., of St. Petersburg, Fla. The company has developed an antenna that allows a plane, say flying over North America, to communicate with a relay satellite orbiting about the equator —without having to aim the antenna at the satellite.

Conventional omnidirectional antennas produce lobes that are



With the new antenna's low beam (in color), a plane flying over Canada could communicate with a satellite directly to the south. Conventional omnidirectional antennas produce a high-angle beam (shaded area) and could not intersect the satellite without flying farther south.

Pop art antenna, to be mounted on an aircraft's fuselage, was specifically designed to operate with satellites.

angled too high above the horizon of the earth. But the Electronic Communications antenna produces lobes that nearly hug the horizontal plane.

A bonus. The antenna provides a secondary advantage: its beam is circularly polarized. Hence, if because of a fault on the transmitting satellite one polarization is lost, the antenna will still pick up a loud and clear signal.

Electronic Communications designed the antenna under an Air Force contract that calls for the company to build ground, air and shipboard terminal equipment for a classified experimental satellite communications system. There is a possibility the system will be tested with a tactical satellite to be launched in 1967.

George Petrick, a project engineer at Electronic Communications ground system engineering section, said the company examined available antennas, found them unsuitable and decided to design its own. He said other companies had come up with similar antennas but these were basically linearly polarized. Helixes perpendicular to the antenna's axis and conical spirals were also considered, but these designs lacked either the bandwidth or the low beam pattern.

Compromise. The antenna's peak pattern reaches 30° above the horizontal, but the beam width stretches 40° above the horizontal. Its frequency capacity ranges from 225 to 300 megahertz. Although the designers wanted a lower peak angle, they had to compromise to keep the antenna's height low. Asked to indicate the factors that influence the choice of beam angle, Petrick would only say that it depends on two factors—the satellite and the geographical area the plane must cover.

The diagram on page 47 illustrates this. If the plane were over Canada, the new antenna would have a beam (in color) that could intersect with a satellite directly south of it. But an antenna lacking the low-angle coverage (shaded area) would not be able to communicate with the satellite unless the plane flew farther south.

To be circularly polarized the antenna must possess horizontal and vertical components of polarization. The loop formed by the four curved sections at the top of the antenna constitutes the horizontally polarized portion. The four tapered stubs that link the loops and the central hub act as a vertically polarized array. The horizontal and vertical polarization components must also be 90° apart in time phase. This is accomplished by using the stubs as the feed for the loop. Since the stub sections are a quarter wavelength long (90 electrical degrees) the loops have the proper phase relationship for cross polarization. Because of the antenna's symmetry the beam pattern is omnidirectional.

Useful design. The tube at the bottom of the antenna is a quarter-wavelength transformer section that matches the 50-ohm impedance of the receiver or transmitter to the 125-ohm impedance of the antenna. Filled with Teflon, the transformer section acts as a coaxial line that feeds the stubs. Radial spokes protruding from the transformer shape the beam pattern at high frequencies.

Prototype antennas have been tested on KC-135 flying tankers. Production units will also be tried out on cargo transports, bombers and other aircraft.

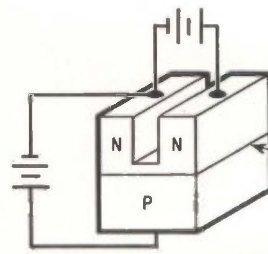
A radome compatible with mach 1 aircraft fits over the antenna. Although designed specifically for satellite-to-plane communications, the company says the antenna could provide communications between planes, too.

Communications

Tuning Gunn?

Two technicians at the Radio Corp. of America's Princeton, N.J., research laboratories have developed a tunable microwave source that is believed to oscillate by the Gunn effect. If this is the case, it holds out the hope of electronically tuning the higher-power Gunn effect oscillator.

The experimental microwave source is a modified gallium arsenide diode that oscillates at frequencies of 60 megahertz to 2.5 gigahertz and is tunable over a 10% frequency range. Implicit in the tuning capability is the ability to frequency modulate the oscillation. By comparison, conventional Gunn devices must be mechanically tuned—generally too slow for modulating audio or other communications signals. The two developers are Arthur Hahn and Arnold Matzelle.



Experimental oscillator developed by RCA is a GaAs diode in which the **n** terminal has been divided in two. The voltage between the two resultant n terminals makes the device oscillate. The other voltage tunes the device.

Although the ouput with the modified diodes is only a milliwatt and efficiencies are 0.5%, it's believed that the principle can be applied to conventional Gunn effect devices to get higher power outputs while at the same time retaining

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the tuning capability.

Possible applications. Although RCA researchers believe that it's too early to say that a practical device is possible, the voltage-tuning feature has already aroused the interest of RCA's Defense Electronics division, where the applications would be obvious: wideband, rapidly tuned receivers required in radars, electronic counter-measure equipment and field communication gear.

It could also serve as a low-power transmitter. The Princeton group has frequency modulated the diode's oscillation with music and has received the signal on a standard f-m receiver. It has also modulated the device with digital information at a rate of 200,000 bits per second.

Joseph Dienst, a member of RCA's technical staff in the microwave research laboratory, explains that the device was fabricated by first cementing the p terminal of a GaAs diode to a transistor header. Then a fine saw cut a slot into the n material to a depth of 10 to 15 microns above the diode's pn junction. The cut forms two separate n terminals and transforms the diode into a three-terminal device.

If the n junctions are connected in series with a coaxial line's center conductor, the device will oscillate when a 6-volt potential is applied between the two n terminals. This oscillation is believed to be a Gunn effect mechanism.

In addition, if the p terminal is made more negative than the n terminal, the device's oscillation can be tuned by controlling the pn voltage.

Simpler yet. However, the p type material only serves to form a junction whose capacitance can be varied by an external voltage. It is possible to make the device with a Schottky barrier junction, which is just a metal electrode attached to the n material. "At the junction between the metal and the n material we get an effective capacitance just as we do in the depletion region of a GaAs diode," says Dienst. It is this structure that more closely suggests the possible application to a regular Gunn device.

RCA says that two electronic mechanisms appear to control the diode's operation—the Gunn effect and the field effect. However, the researchers point out that this is only a tentative conclusion and that the exact operating mechanisms are still to be determined. However, indications are promising.

When biased for oscillation, the electric field in the vicinity of the cut and above the diode junction is about 4,000 volts per centimeter. This value is the Gunn threshold for oscillation. In addition, Dienst says, "If we cut into the p type junction, no oscillations occur." Similiarly, Gunn effect devices cannot be made with p material. Both facts give credence to the possibility that a Gunn mechanism is involved.

Modify the field. Tuning is controlled by the field effect, which in turn is related to the junction capacitance. Dienst explains that the traveling electric field produced by the Gunn effect propagates very close to the junction capacitance. "By modifying the junction capacitance with an external voltage, we modify the traveling field, which allows us to tune electronically," he adds. With a combination of mechanical and electronic tuning, RCA's devices can be tuned over more than a 2 to 1 band.

The theory of the device was advanced by Kenneth Petzinger, who is now at the University of Pennsylvania.

Advanced technology

On tap

Air Force experiments with an unused class of semiconductors known as tap crystals may lead to such optoelectronic devices as a diode laser for each color in the rainbow, computer memories and yes-no decision elements, accelerometers, tuned oscillators, image intensifiers for infrared target detectors and ballistic camera triggers.

These are a few possibilities cited by Cole W. Litton and Yoon Soo Park of the aerospace research laboratories at Wright-Patterson Air Force Base, Ohio.

Tap crystals—compound semiconductors that store current when they are stimulated by light—give up energy as flashes of light when they are physically tapped. The effect was first observed about six years ago in cadmium sulfide crystals that were cooled by liquid nitrogen to 77°K. After they were exposed to light and tapped the crystals flashed bright green, but the causes were unknown. Now, enough is known to produce variations of the effect in a family of crystals.

Infrared trigger. Impurity elements from Group I in the periodic table were found in the cadmium sulfide; this discovery led the researchers to the reproduction of the tap effect in other semiconductors compounded from Group II and Group VI elements. Some tap crystals can now be stimulated by heat, instead of light, and some will flash when excited by infrared energy, rather than tapping.

For example, zinc oxide doped with sodium is stimulated by exposure to light whose wavelength is shorter than 3,680 angstroms. It will flash blue-green several hundred times when mechanically excited—once for each tap. If the zinc oxide is doped with lithium, light no longer stimulates it, but raising its temperature from 77°K to about 200°K will cause it to emit light when cooled again and tapped.

After optical stimulation, emission is directional and localized. Thermally stimulated crystals glow more uniformly but give up their energy after only a few taps, Litton and Park report.

The explanations for the effects are complex—and still incomplete. In the optically stimulated crystals, holes are apparently trapped during the formation of hole-electron pairs. Energy stored by the trapping is freed during excitation by an involved sequence of effects when the holes recombine with free electrons. At room temperature, the crystals have high resistivity and are photoconductive. In the dark, at 77°K, the conductivity

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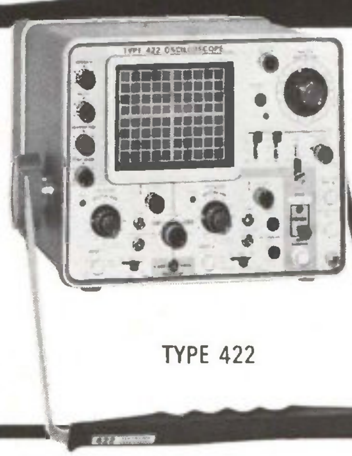

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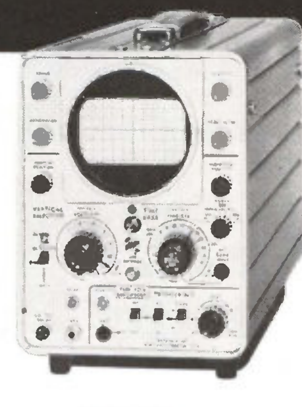

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almost disappears. Exposure to light raises the conductivity and the crystal remains conductive when the light is removed, indicating current storage. The amount of current varies with the amount of optical stimulation.

The mechanism is different in the thermally stimulated crystals. The energy seems to be released when holes become freed and recombine with trapped electrons.

After optical stimulation, emission is directional and localized. Thermally stimulated crystals glow more uniformly but give up their energy after only a few taps, Litton and Park report.

Pick a color. The researchers think that injection laser diodes could be made to emit any color, from infrared to ultraviolet, by making the lasers of II-VI semiconductor crystals doped with various alkali metals. A negative-resistance characteristic—the property that helps lasing in gallium arsenide—has been observed in cadmium sulfide crystals doped with both sodium and lithium and is expected in sodium-doped zinc oxide.

Negative-resistance crystals can also be made to oscillate at predetermined frequencies in tuned circuits, they add, and so could be used to fabricate oscillators.

Since the energy stored in the optically stimulated type of crystal can be converted into light by infrared energy, Litton and Park believe a mosaic of crystals could serve as an infrared target detector and image intensifier for the military.

Optoelectronics

Storage on a chip

To be sure, books have their place. But to libraries, Government agencies and virtually anybody who deals with massive amounts of printed data, the place that books take up is just too much. The Army has decided to do something about it: it's awarded a $191,000 contract to a small Bristol, Conn., company that has developed a technique for storing many holographic images on a slice of potassium bromide no bigger or thicker than a 35-millimeter piece of film.

If the experimental program is a success, the crystals may compete strongly with microfilm gear, which is widely used in many data-storage systems.

Picture on command. The contract calls for the company, Carson Laboratories, to deliver by next June a system that can store some 1,020 pages of detailed drawings and engineering tables on a single crystal, and on command search for and display the information, in sharp detail, and reproduce hard copies of any of the pictures. What, in fact, the Army is looking for is to replace a massive library with a helium-neon laser, a handful of thin potassium bromide crystals, a small real-time, random-access mechanism for hunting out the desired pages and a conventional dry photographic system.

The system will be built around a concept unveiled by Carson last spring [Electronics, May 30, p. 35]. That system was based on Bragg angle holography in which an image-carrying laser beam is fired at a potassium bromide crystal. The crystal, of a class of alkali halides that can be bleached by a red laser, stores the holographic imprint of the image on an infinitesimally thin layer of the crystal. The angle the laser hits the surface of the four-millimeter thick crystal determines at what layer in its structure the picture is stored. Thus, multiple images can be stored simply by shifting the angle of incidence. The crystal can only be bleached—hence store images—if it's warmed to about 80°C. When the crystal is cooled to 0°C, and an unmodulated laser beam is fired into it, the stored image is reconstructed, with hardly a detail of the original lost.

Hard copy. The military contract, from the Army Missile Command at Huntsville, Ala., calls for the system to be able to store images of pictures as large as 18 by 24 inches. And for the production of hard copy, Carson will project the holographic image on light-sensitive silver paper, a conventional dry photographic process, explains Richard F. Weeks, Carson's project engineer.

The speed of the unit, says Weeks, will be limited by the indexing scheme for searching out the desired information. But generally, he adds, it will take only a matter of seconds to fish out and display the correct engineering table or diagram.

Another requirement in the Army contract is development of a technique to reproduce the entire image-laden crystal. Weeks is coy about disclosing how Carson will reproduce the crystal—either by bleaching the images into the crystal one at a time or by some mass-production process.

For positioning the critical laser angle, Weeks explains, Carson will use a mechanical positioning approach. But eventually, he notes, "we'll have to seek a faster, more accurate electronic positioning technique.

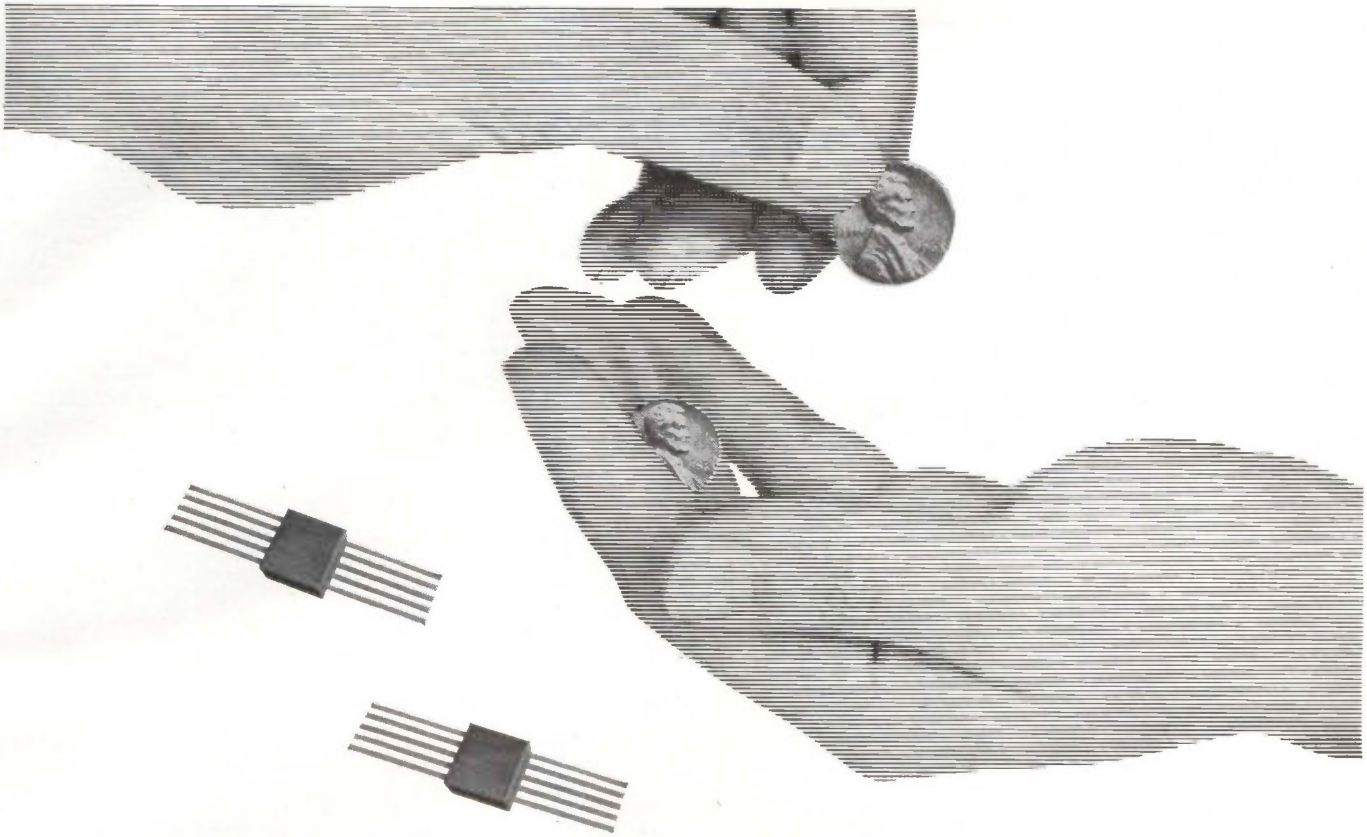
Resolution of the reproduced picture, he says, is no problem. "We've already achieved a resolution of 10 line pairs per millimeter—which is better than that produced from commercial microfilm—and we expect to improve on that."

Industrial electronics

Light switch

Switching many thousands of volts with 1,000-volt silicon controlled rectifiers connected in series is, to say the least, tricky. If a current surge doesn't zap them, reverse overvoltage will, especially if each rectifier in the string isn't triggered on at precisely the same time.

To overcome the triggering problem, the Westinghouse Electric Corp.'s research development center in Pittsburgh has developed a silicon switch that is fired not by an electric signal applied to a gate, as with a conventional silicon controlled rectifier, but by a beam of light. The light is guided to the switch through fiber-optic light



pipes, resulting not only in the elimination of complex triggering circuitry, but also complete isolation between the trigger and load circuits.

Only two terminals. The light-activated switch—essentially a two-terminal device—was developed by D.R. Muss, Westinghouse's manager of silicon device development, and H.E. Suarez, an engineer in the section. Their switch differs from ordinary light-activated scr's which still use a third gate terminal.

Three-terminal devices have been around for more than five years. However, they've been limited to low current ratings—less than an ampere—and voltage ratings of only several hundred volts. These ratings are much too low for the applications—radar modulators and high-power multikilovolt power system switching—Westinghouse has in mind.

Muss and Suarez report they have built a prototype array of three of the new switches which, connected in series, has been able to carry 40 amperes. Each unit has withstood anywhere from 600 to 800 volts. Equally interesting is the fact that the Westinghouse researchers are using a gallium arsenide diode laser, emitting in the infrared, as their source of light. The fiber optics connect the light to the sensitive areas of the switches.

Match for a switch. Long-term reliability is a major reason for using a diode laser, instead of, for example, a xenon flash tube. Another reason is that the infrared wavelengths—around 0.9 micron—lie in the most sensitive, current-producing range of the silicon. The combination of the two is almost an ideal match.

Thus, despite the low light-producing efficiency of the diode source, the over-all efficiency of the gallium arsenide-silicon system is about the same as if the high-intensity light from a xenon flash tube were used instead; this is because the xenon lamp emits most of its light at wavelengths to which the silicon does not respond.

The unit is able to carry its high current because, according to Muss and Suarez, the light illuminates a relatively large area of the silicon under the cathode. The illuminated area is roughly 10 times greater than in a normal light-activated scr. This reduces current density in the silicon, allowing the unit to withstand surge currents of 400 amps/microsecond, again about 10 times the safe rating of a conventional scr. Turn-on time is in hundreds of nanoseconds.

More possible. In the future, it may be possible to raise the current-carrying capacity of the switch to 250 amperes. A single gallium arsenide diode may even be able to trigger as many as 100 switches. This should certainly make them suitable for converters on high-voltage d-c power transmission lines. D-c transmission systems are coming into increasing prominence because it actually costs less to send d-c power over long distances than a-c. There are no losses comparable to the inductive and capacitance losses on an a-c line.

Right now, converters for raising and lowering the voltage levels use mercury-vapor tubes. Solid-state devices, such as scr's or light-activated silicon switches could offer faster control-speed response and take up considerably less room in the power station—all at a sharply lower cost.

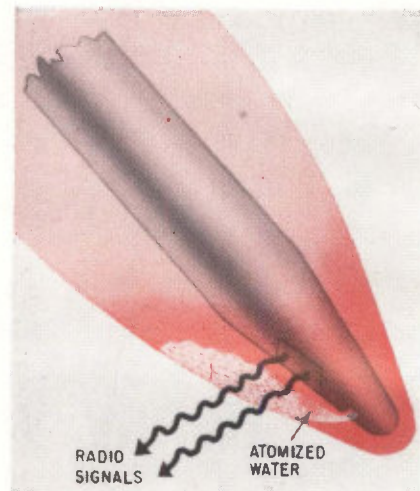
Space electronics

Dampening the problem

Reentry blackout has plagued every flight in the Mercury and Gemini series. The problem has been tolerated for these flights, but as NASA comes closer to the manned Apollo mission, blackout becomes increasingly serious.

Of all the proposed techniques to solve the problem, a rather unsophisticated approach that dates back to the early 1960's appears to hold the greatest chance of immediate success. The technique: spraying water into the hot sheath of ions that envelopes the craft and blocks radio signals.

A new series of detailed tests will begin in March, when the National Aeronautics and Space Administration will fire a Scout rocket down the Eastern Test Range. The project is called RAM, for radio attenuation measurements. The missile will be tipped with a specially designed nose cone that will contain, among other things, a tank of water and a 10-gigahertz antenna. As the nose cone reenters the atmosphere at 28,000 feet per second the water will be sprayed



Spray of water reduces blackout encountered by spacecraft reentering the atmosphere

out, clearing a swath through the sheath.

The nose cone is being assembled at the space agency's Langley Research Center, Va., with the help of the LTV Aerospace Corp., a subsidiary of Ling-Temco-Vought, Inc. A second payload will be fired next October; it will carry such sensors as a Langmuir probe and a microwave impedance probe to take more detailed measurements of the sheath.

Silence. Blackout occurs when the great heat radiated by a reentering spacecraft turns the atmosphere around it into ionized gases, which is called the plasma sheath. For the recent Gemini flights, reentry was at 24,000 feet per second and the blackouts lasted only about three or four minutes. But Apollo spacecraft will be coming back from the moon at 36,000 feet per second, so it

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No easy answer. Laurence F. Gilchrist, deputy director of NASA's electronics and control division, doubts that the communications blackout will ever be completely eliminated. But early tests indicate the water spray technique may ease the problem.

Tests with the technique were held in the early 1960's, when ballistic flights of water-carrying rockets were test fired from Wallops Island, Va. Those flights, with the nose cone returning through the atmosphere at 18,000 feet per second, buoyed space scientists' hopes that they were on the right track. Later, similar experiments were tried on some of the Gemini flights, with equally optimistic but inconclusive success.

Preventive medicine. Once the RAM project is completed Gilchrist wants to get attenuation experiments on the Apollo Applications Program, a proposed follow-on to the manned lunar landing. Thus Apollo application flights could test ways of preventing the longer blackouts expected when manned spacecraft return from other planets.

The Air Force is also interested in learning more about the plasma sheath and is conducting experiments with missile reentry bodies using the smaller Trailblazer rocket. The program consists of six launches from Wallops Island to measure the blackout at 17,600 feet per second. The experiments are being conducted by the Ohio State University Research Foundation under an $80,000 contract from the Air Force's avionics laboratory, Wright-Patterson Air Force Base, Ohio.

To be sure, other attacks on the blackout problem are being made. The one that holds the greatest promise over the long run is a plan to use a tracking frequency of 35 gigahertz [Electronics, April 18, p. 37]. Signals at that frequency are better able to pierce the ion sheath than lower-frequency signals. But the technique faces a major obstacle. NASA has nearly completed its conversion to S band (1,550 to 5,200 megahertz) from C band (5,000 to 10,900 Mhz). The major investment in this equipment leaves NASA reluctant to make yet another switch.

Military electronics

Backseat driver

It's hardly a secret among companies designing and building satellite communications systems that their efforts are handicapped by conflict and lack of cooperation within the Government agencies responsible for particular projects.

Congressional critics have not been unaware of the growing problem. As far back as 1962, hearings conducted by lawmakers produced urgent pleas for the agencies to work together more closely. The most recent hearings, concluded only two months ago, resulted in another long list of recommendations.

The advice of the panel—the House Military Operations subcommittee—was most pointed.

It urged a speedup in the application of satellites by the Pentagon and demanded improved organization of the various programs, as well as the expenditure of more money to facilitate these recommendations. The House group also pointed out an immediate source of the troubles, namely equipment deficiencies, especially at ground terminals, that are causing delays in the program.

Hurry it up. The Defense Department was urged to make its Initial Defense Communications Satellite system operational as speedily as possible. The committee described the situation as "awkward" since the Government has already spent $112 million for the beginnings of such a limited system, which provides only two voice circuits or a handful of Teletype channels.

The committee is convinced that the Initial system's capacity can be increased 10 to 20 times with "very modest cost increases," and said this expansion should be implemented "as soon as is practicable." The Army already has begun an improvement program on ground station antennas that will boost the Initial system's capacity from 2 to 11 voice channels by mid-1967.

Because of the Aug. 26 failure to launch a second batch of Initial satellites, the third launching in the program has been moved up from March, 1967 to January, 1967. It will attempt to add eight satellites to the seven communication repeaters now in near-synchronous orbit. A fourth launch, also scheduled for early 1967, hopefully will add three more.

Advancement. The Initial system should be expanded by additional satellite launches and upgraded by improved hardware so that it can be used as an operational system until it is replaced in 1970 by the Advanced Defense Communications Satellite system now under study, the committee asserted. Since the original order for satellites from Philco-Ford Corp., a subsidiary of the Ford Motor Co., will be exhausted by the next two shots, more satellites are needed. And the Air Force currently is determining how many more will be procured for the Initial system.

The committee felt that the Advanced system should have capacity of at least 100 to 200 voice-grade circuits. Planning for the Advanced system has been completed, and once it is approved by Defense Secretary Robert McNamara and the Joint Chiefs of Staff, the Pentagon expects to let contracts to industry in fiscal 1967.

Troubles. Transportable ground terminal problems are plaguing the Initial system [Electronics, Sept. 5, p. 30]. The committee called these deficiencies the "most immediate, pressing problem" of the Initial system. The terminals will not be fully operational until the beginning of next year and preliminary system testing will take months. Some of the technical problems in Hughes Aircraft Co.'s AN/MSC-46 station were so consistent that they indicated the possibility of design defects, the Army said. Fourteen of the 40-foot antenna stations are being built.

And a 23,000-pound, 18-foot cloverleaf antenna terminal, the AN/TSC-54, is also being built for the Initial system by Radiation, Inc. The ground station, which was publicly introduced Nov. 10 in Melbourne, Fla., is also behind schedule and running 40% over cost expectations. The first model of the 13 stations ordered will be delivered in April 1967, four months behind schedule.

Reversing the fallout

Generally the direction of technological fallout is one way; first the military or the National Aeronautics and Space Administration develops a process or a concept and then industry picks it up for civilian application. But an electronic atomizer, recently developed, is an exception.

The American Petroleum Institute funded a research program aimed at replacing the not-too-reliable motor-driven pressure nozzles on home oil heaters that spray a thin film of oil into the furnace. The result was an ultrasonic device. The institute and the developer, Arthur D. Little, Inc., of Cambridge, Mass., claim the device is far superior to the old-fashioned pressure nozzle.

No sale. But oil furnace producers haven't exactly beaten a path to the institute's door for the product. Robert R. Perron, research staff member at Little, who directed the work explains: "You can sell reliability to a consumer, but it's tough to sell reliability to a builder if it costs him a half-dollar more." And it's the builders who buy most furnaces.

However, the nonprofit Battelle Memorial Institute of Columbus, Ohio, took a look at the product and decided that if home builders weren't interested, maybe the Army was.

The military was most interested, and it was especially attracted by the way the atomizer sprayed the oil into a furnace—silently. The atomizer was then redesigned for use in a portable power supply whose sound wouldn't give its location away.

What's being delivered to the Army Electronic Command at Fort Monmouth, N.J., is an atomizer, operated by piezoelectric elements that vibrates at 100 kilohertz and produces a flow rate of one-tenth gallon of fuel oil per hour. The heat from the burning oil is applied to thermoelectric materials to produce 100 watts.

On the home front. The developers haven't given up hope of selling the ultrasonic device to the civilian market and some oil burner manufacturers still have it under evaluation.

Perron describes the unit as remarkably reliable. For example, in the test it worked for more than two years, with unfiltered No. 2 fuel oil going through it at one-half gallon per hour. The atomizer tips were cycled 4 x 10^{12} times at a stress of 11,000 pounds per square inch and still were performing satisfactorily at the end of 19,636 hours. In contrast, oil burner nozzles burn out every few years and replacement generally costs $15.

The ultrasonic nozzle feeds oil to a furnace like this:

A fluid film is spread over the surface of a piston. The film is vibrated in a direction normal to the surface and this causes a grid of intersecting capillary wavelets to arise on the surface. The oscillatory vibration of the fluid surface causes the wavelets to increase in height and steepness until the wave tips break off and droplets escape.

The atomizer's piezoelectric transducers are driven by a vacuum tube or solid-state phase shift oscillator in which the transducer capacitance is part of the feedback circuit. Once the feedback has been adjusted, the oscillator is locked to the resonant frequency of the transducer. Two watts delivered to the transducer achieves satisfactory atomization.

Solid state

Satellite transistors

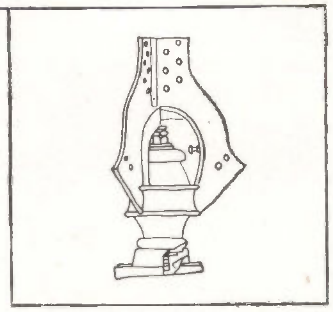
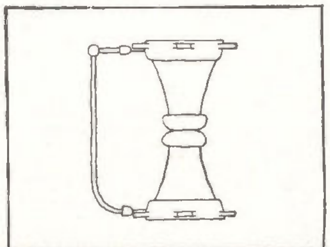
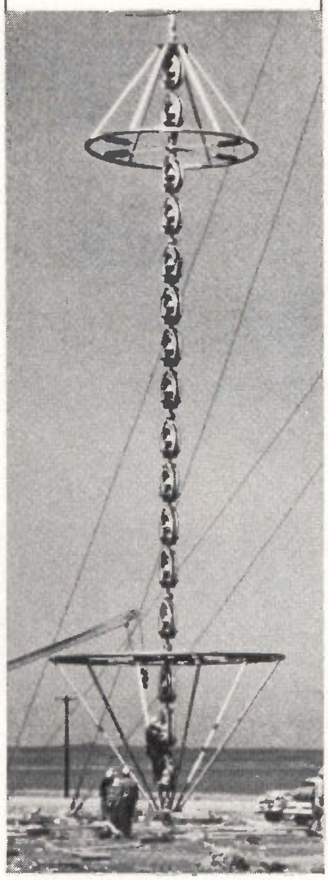
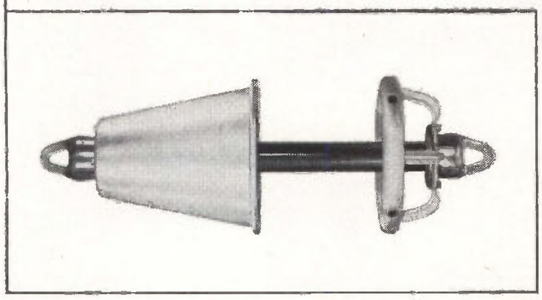
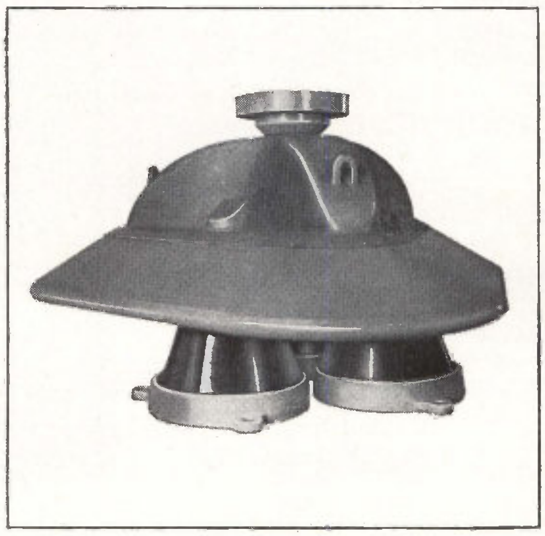
Designers of digital telemetry and sensing circuits for communication satellites face a dilemma. They must keep power dissipation to an absolute minimum and so require circuits that operate on microamps or even nanoamps. Yet circuits operating at very low current levels are sensitive to surface ionization effects. Such effects occur when a satellite passes through the outer Van Allen belt. Unwanted leakage currents result and shifts in other device parameters—such as turn-on voltage of a field-effect transistor (FET)—may occur.

Limited to two. At the Northeast Electronic Research Engineering Meeting this month A.G. Stanley of the Massachusetts Institute of Technology's Lincoln Laboratory compared available transistors with respect to performance under ionizing radiation. He concluded that the designer is restricted to microamp circuits using bipolar transistors that have a gain below 10, and the p-channel junction FET's in the nanoamp range.

Metal oxide semiconductor (MOS) FET's are not as radiation resistant as initially supposed. Under positive gate bias, Stanley noted electron irradiation up to a total dose of 10^{14} electrons/centimeter^2 may shift the gate turn-on voltage by as much as 90 volts in the negative direction. Positive space charge generated by the radiation in the oxide induces a negative charge at the semiconductor surface which tends to keep a p-channel device in the off state and an n-channel device in the on state, he said.

The effect is enhanced by the large drift field across the insulating layer of the MOS device, causing major shifts in gate turn-on voltage at total doses as low as 10^{12} e/cm^2.

The metal nitride semiconductor (MNS) FET, was discounted by Stanley because it is not yet available. But he said it may sharply reduce the shift in gate turn-on voltage and reduce the source-

drain leakage below a nanoamp.

High tolerance. Junction field-effect transistors have a higher tolerance to radiation induced bulk damage than bipolar transistors since they are majority carrier devices, Stanley said. However, n-channel FET's are not immune from surface ionization effects. Upon irradiation, with the gate junction back biased, the gate current increases well above 1 microamp and the drain current shifts, too. The gate leakage currents of most p-channel FET's are less than 1 nanoamp. In n-channel FET's the positive space charge generated in the oxide induces an n-type inversion layer on the surface of the p-type gate region which generates the leakage current when the junction is back biased.

Electronics notes

- **Multifunction kick.** Five additions to Texas Instruments Incorporated's line of complex function digital integrated circuits were announced last week at the Fall Joint Computer Conference. The circuits are even more complex than the four brought out at the IEEE Show last spring—emphasizing a trend that many observers had predicted. The big advantage of cramming more functions into one package is cost savings, with reliability an important bonus. TI estimates a saving of anywhere from 20% to 40% over simpler IC's that would be required to perform the same functions. One of the new IC's is a quadruple fuel adder that adds four 2-bit numbers. TI says that systems designers can slash costs by 41% by using this circuit instead of four single IC adders. Other devices in the line include counters and a decoder-driver.
- **Money for SRAM.** The Air Force has awarded the Boeing Co. a contract to develop and build a short-range missile system. SRAM, a nuclear missile, will have a range of about 100 miles. Boeing is receiving $142.3 million to develop the system and $93.5 million for production.

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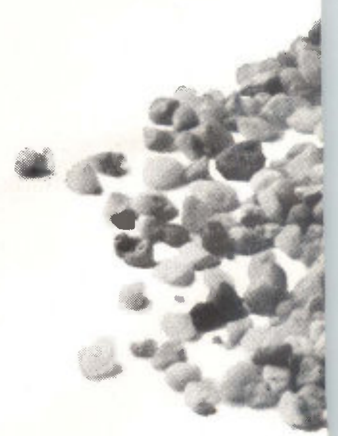

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are roughly 1/100 the size and weight of their conventional counterparts. With about 20 times the power overload capacity. And capable of handling as much energy in the avalanche as in the forward direction.

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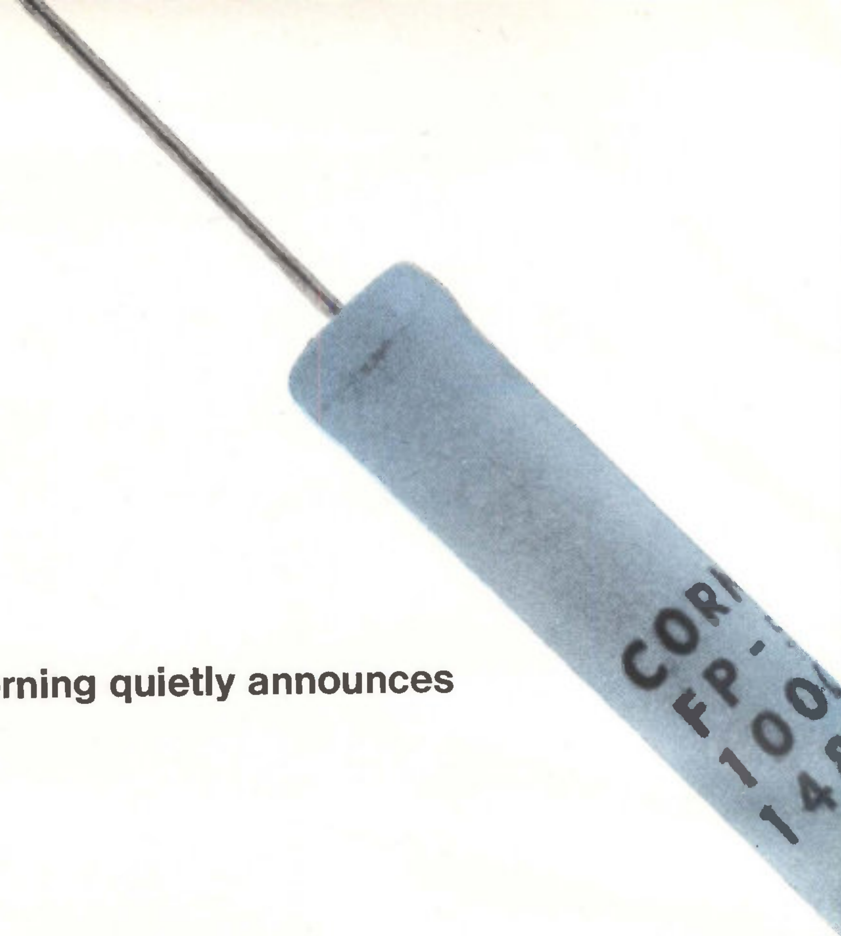
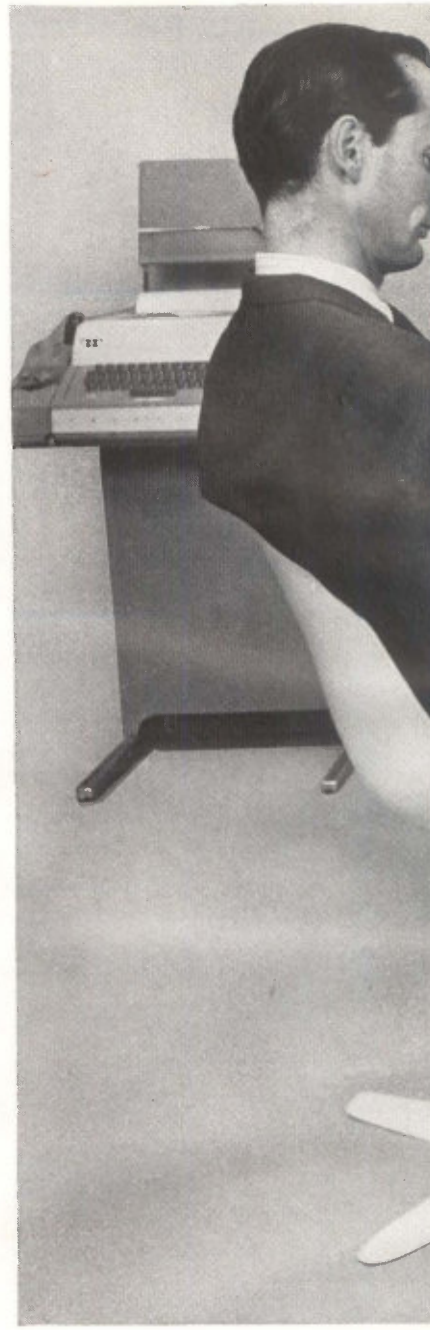


Corning quietly announces



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THE μ-COMP DDP-516

SPECIFICATION SUMMARY

Type	16-bit parallel binary
Console	Movable
Addressing	Indirect/indexing
Memory Size	Up to 32,768 words
Cycle Time	960 nanoseconds
Add	1.92 μsecs
Single Word I/O Transfer	1.92 μsecs
Automatic (Cycle Stealing) I/O Transfer	Over 1 mc (16-bit words)
Weight	250 lbs.
Temperature	0°-45°C
Hardware Index Register	

THE NEW μ-COMP DDP-516 . . . is being manufactured and delivered today — complete with an extensive software package.

It's no surprise that the DDP-516 from Honeywell, Computer Control Division is the most advanced commercial I/C compact computer you can find today . . . a natural third generation machine from the house that built the first 16-bit compact and the first I/C computer.

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Above: DDP-516 with 16K I/C core memory.

memory used in the DDP-124 I/C general purpose computer . . . the same memory unit that's the favorite of many systems' builders.

And that's not all . . . the DDP-516 is ideal for on-line real-time applications because of its unusually flexible I/O. Priority interrupt (individually maskable) is standard. DMC allows economical multiplexing of up to 16 devices, all simultaneously time sharing the I/O bus. Megacycle I/O rates are duck-soup for cycle stealing DMA.

DDP-516 HIGH PERFORMANCE HARDWARE IS ALL I/C. μ-PAC logic modules are used throughout. They are packaged in a 24" x 24" x 38" mainframe that features front access to both modules and interwiring. You'll also find that field expansion and plug-in option additions are easy because of basic hardware modular construction.

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PRICE: $25,000 including total software package.

DELIVERY: software immediately, hardware in as few as 90 days. Units are now being built for use in control applications, data acquisition, message communications and laboratory work.

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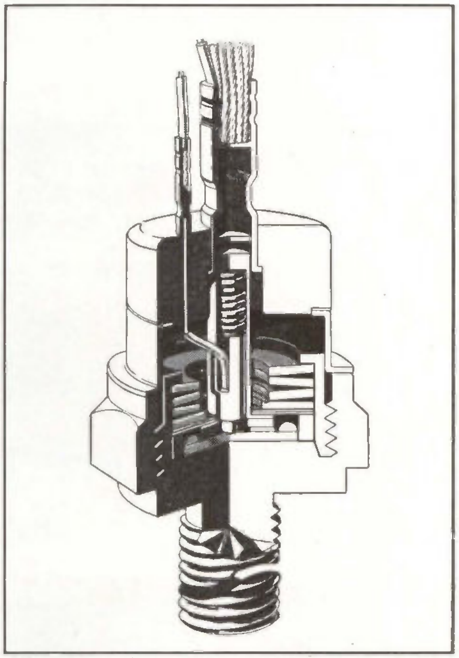
There's a concrete, sensible reason behind the higher capabilities of Westinghouse thyristors. Exclusive CBE design (Compression-Bonded Encapsulation) eliminates solder joints. Washer-type springs join semiconductor elements by compression alone. With conventional solder joints gone, the prime cause of thermal fatigue is eliminated. And thermal impedance is reduced 30% to 40%. This gives you the increased surge and current ratings.

Your Westinghouse distributor has CBE-design thyristors in both standard and fast-switching types. And all have the unique Westinghouse Lifetime Guarantee.* Call your distributor for immediate delivery. Or write Westinghouse for complete technical data. Westinghouse Semiconductor Division, Youngwood, Pennsylvania.

Ⓦ DEVICE TYPE	UNITS COMPARED HAVE SAME CASE SIZE	SURGE CURRENT AMPS	FORWARD CURRENT AMPS @ CASE TEMP. SHOWN	THERMAL IMPEDANCE	MAX. V_{FB}	MIN. DV/DT Exp. to V_{FB}	SWITCHING④ SPEED T_{OFF}
219	CBE Rating Prior Rating	1200 700	35 @ 97°C. 28 @ 97°C.	.35°C/W .5 °C/W	1400 1000	100V/μsec No Rating	40μsec typ. No Rating
254 (2N4361-2N4378)	CBE Rating Prior Rating	1600 1000	70 @ 82°C. 57 @ 82°C.	.28°C/W .5 °C/W	1400 1000	100V/μsec No Rating	40μsec typ. No Rating
218	CBE Rating No comp. unit	3300 None	125 @ 88°C. None	.15°C/W None	1400 None	100V/μsec① None	40μsec typ. None
220 (2N3884-2N3894)	CBE Rating Prior Rating	4500 3500	175 @ 83°C. 150 @ 76°C.	.13°C/W .20°C/W	1200 600	50V/μsec No Rating	50μsec typ. No Rating
223	CBE Rating Prior Rating	5000 5000	300② 250②	.18°C/W .22°C/W	1200 1000	50V/μsec No Rating	50μsec typ. No Rating
2191 & 2192	CBE Rating Prior Rating	1200 500	35 @ 97°C. 23 @ 97°C.	.35°C/W .5 °C/W	1000 600	100V/μsec 100V/μsec③	15 & 20μsec max. 15μsec max.
2541 & 2542	CBE Rating Prior Rating	1400 750	70 @ 67°C. 70 @ 50°C.	.28°C/W .4 °C/W	1000 600	100V/μsec 100V/μsec③	15 & 20μsec max. 15μsec max.
2181	CBE Rating No comp. unit	3200 None	125 @ 88°C. None	.15°C/W None	1000 None	100V/μsec① None	20μsec max. None
2201	CBE Rating No comp. unit	4000 None	175 @ 80°C. None	.13°C/W None	1000 None	50V/μsec None	25μsec max. None
2231	CBE Rating No comp. unit	4500 None	300② None	.18°C/W None	1000 None	50V/μsec None	30μsec max. None

① Exponential to .8 V_{FB} ② Has integral heat sink for forced air cooling ③ Linear to .8 V_{FB}
④ Those devices above line—standard speed, those below—fast

Westinghouse CBE-design thyristors have surge ratings up to 70% higher than previous conventional types.



CBE design eliminates solder, uses spring washers to join thyristor elements by compression. Result: higher surge, current and I^2t ratings.

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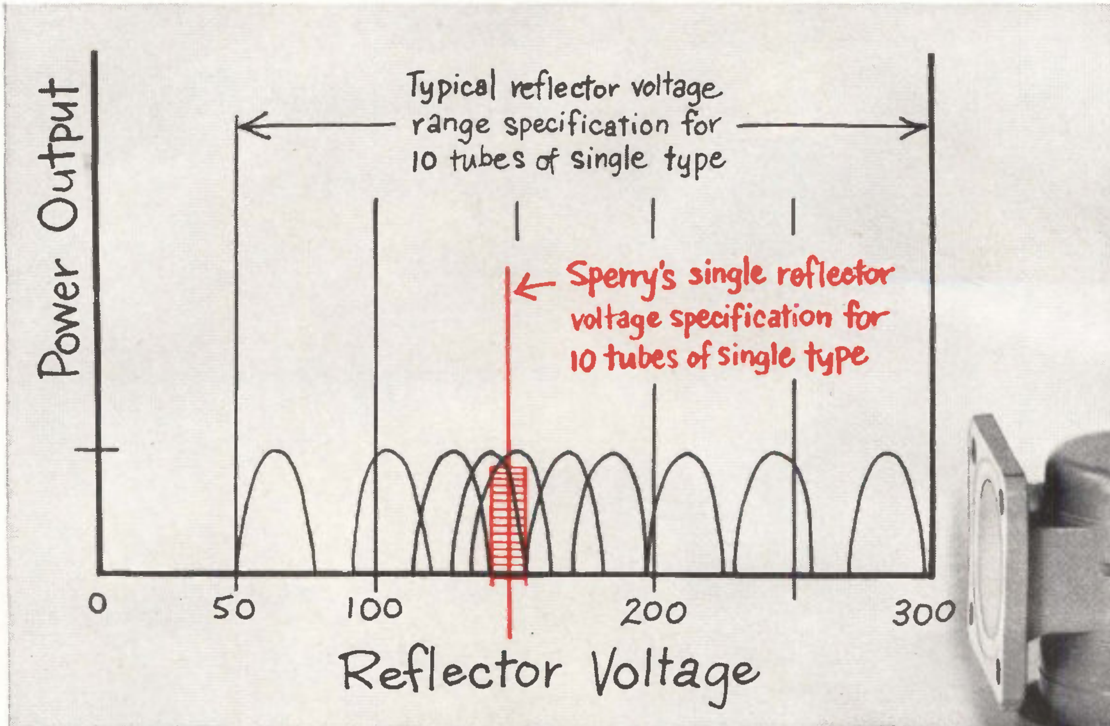
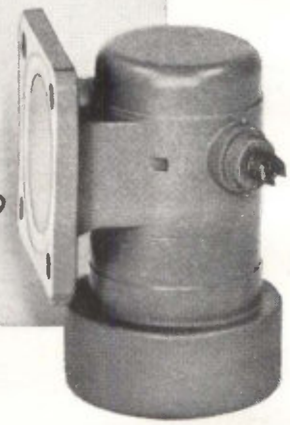
THE DEATH OF AN AGGRAVATION

(An encouraging note for those concerned with the application of reflex klystrons.)





All the reflex klystrons in your next order can have the same reflector voltage! A remarkable new development from Sperry has eliminated the familiar problem of searching a wide reflector voltage range for proper tuning. Tube replacements can be made in the field with no adjustments to either tube or system.

You no longer need a power supply that can allow for large and unpredictable reflector voltage variations. You no longer need a potentiometer to adjust the reflector voltage, or the test gear required for tuning the tube in the field.

Now you simply decide what reflector voltage you want and tell us. As the chart above indicates, we can put the center frequency right where you want it and deliver the tube either fixed-tuned or mechanically tunable.

There's other beneficial fallout from this concept. Many characteristics, such as modulation sensitivity, are more uniform from tube to tube. And, as far as shock and vibration are concerned, our tubes are state-of-the-art.

Sperry technology has now perfected reflex klystrons that offer the new single reflector voltage principle for a variety of applications in X, U, K and V bands.

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Evaluate Sperry for Value! This new development comes from the Sperry Storehouse of Knowledge . . . for more than 25 years the outstanding source of improvements in microwave tubes. Our inventory is technology. Draw on it whenever you need outstanding performance from klystrons, traveling wave tubes, or backward wave oscillators.

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Washington Newsletter

November 14, 1966

Cable may replace ailing tropo link in Southeast Asia

Technical problems with a 450-mile troposcatter communications link in Southeast Asia reportedly is the reason for the current urgency in laying an undersea cable between Saigon, South Vietnam and Bangkok, Thailand. Neither the Philco-Ford Corp., a subsidiary of the Ford Motor Co., the tropo system builder, nor the military agencies involved would confirm that the Air Force cable—439L—would replace the Army-operated tropo link when the cable is completed in April. **But officials acknowledge that the tropo link, operating with parabolic antennas at 2 gigahertz, had been out of service for as much as 10% of the time earlier this year.**

The troposcatter system—longest in Southeast Asia—is a recently upgraded part of the Integrated Wideband Communications System [Electronics, Oct. 3, p. 167]. The addition of high-efficiency feed horns, improved receivers and new low-noise amplifiers should solve the outage problem, maintains the Philco-Ford Corp. The $26.3 million contract for building 439L was awarded in March to Page Communications Engineers Inc., a Northrop Corp. subsidiary.

Navy gets 'no' on additional A-6A aircraft

In testimony still classified, Defense Secretary Robert S. McNamara reportedly told a House Armed Services special investigations subcommittee that the Navy's request for additional A-6A all-weather aircraft had to be turned down **because avionics producers were too busy to take on the job.**

Although McNamara didn't name the companies, the major suppliers of A-6A avionics now include Litton Industries Inc. for the digital computer and inertial navigation system; the Norden division of United Aircraft Corp. for the Ku-band radar; and the GPL division of General Precision Inc. for the doppler system. **McNamara said the Navy would have to be satisfied with the A-4F, a plane in which the pilot must make a visual sighting of the target before dropping his bombs.**

NASA seeks funds for space workshop and telescope

The National Aeronautics and Space Administration, pushing ahead to get the Apollo Applications Program moving, will ask Congress for funds for initial hardware. **The agency is now evaluating some 20 proposals and will seek money in 1967 for two:** a telescope using sophisticated electronics to be mounted on the Apollo spacecraft to observe the sun, and an airlock so astronauts can enter a spent stage of the Saturn launch vehicle to conduct experiments requiring zero gravity. One of the two, probably the workshop, could fly as early as the fourth manned Apollo mission late next year.

Airlines' satellite faces delay

Despite the enthusiastic response from airlines and the Federal Aviation Agency for a demonstration satellite to relay very high frequency communications from transoceanic airliners [Electronics, Oct. 3, p. 171], **the current target launch date of late 1968 is beginning to look overly optimistic.**

The early operational use of such a satellite was not supported by any other nation at the recent Montreal meeting of the International Civil Aviation Organization. Additionally, a cautious attitude to the Communications Satellite Corp.'s timetable for putting up Aerocom was urged by the House Government Operations Committee in a recent report. It recommended that the FAA work closely with the National Aeronautics and Space Administration to gain more knowledge and information before contracting for the prototype system.

Vhf tests will be conducted next year on the space agency's Applications Technology Satellite.

Second Apollo crew will search stars in key experiment

Space agency officials call one of the 16 experiments scheduled for the second Apollo flight the most complicated electronics test ever flown in a manned United States spacecraft.

The astronauts who fly the mission, planned for next summer, will have aboard four proportional counters to measure low-energy X-rays from stellar sources. The crew will have to maneuver the spacecraft to align the counters with the desired stars. The first Apollo launch, recently rescheduled from early December to mid-January, will have 11 experiments on board.

Antimissile system still a Chinese puzzle

Despite China's successful test of a medium-range nuclear missile last month, the outlook remains dim that the fiscal 1968 budget will include funds to deploy the Nike-X antimissile system [Electronics, Oct. 3, p. 76]. Pentagon planners are examining a stripped-down version of Nike-X to counter any Red Chinese threat. It would be much less expensive than a full-scale antimissile system.

1967 launch date likely for second in Intelsat 2 series

Failure of the apogee motor to put the Communications Satellite Corp.'s Intelsat 2 satellite into stationary orbit over the Pacific Ocean last month has caused the postponement of the second satellite launch in the series from Nov. 23 until early next year. But Comsat is hopeful that the satellite launched Oct. 26, and now in a 12-hour elliptical orbit, will be able to relay eight to 10 hours of commercial traffic daily between Hawaii and the United States.

The satellite's primary job was to provide six channels for the space agency's Apollo communications network—something it won't be able to do. Comsat's delay in providing these circuits, however, is not expected to affect any Apollo mission schedules.

Preliminary data on last month's launch indicates the satellite's apogee engine was subjected to much colder temperatures than the design specifications called for. If this is confirmed in ground tests to be conducted at Hughes Aircraft Co., the satellite builder, protective shielding will be installed on the remaining three satellites.

Competition coming from Comsat center

It won't be operating until 1968, but producers of satellite equipment are already worrying about competition from the Communications Satellite Corp.'s $10-million research center. Comsat recently picked a site in Maryland, about 30 miles from Washington, and announced that it was seeking a top man from industry to head the new center.

A highly placed Comsat official gave the industry cause for concern when he said that the corporation will build some flight hardware and that he wouldn't rule out satellites. The center will work on ground station equipment and may build terminals for operational use.

What solvent meets "white room" standards for rocket fuel systems?

Liquidometer says: FREON® Precision Cleaning Agent.

Liquidometer Aerospace Division of Simmonds Precision Products, Inc., in Long Island City, N. Y., maintains one of the world's most efficient "white rooms" to insure the microscopic cleanliness of their rocket fuel sensing devices. That's because the slightest particle of metal, organic residue or other contaminant could endanger the success of space missions. And that's why the solvent used to clean these critical components is FREON Precision Cleaning Agent.

FREON is a selective solvent—it cleans without affecting commonly used materials of construction. Its low surface tension penetrates the smallest pores and crevices. Its high density floats away all particulate matter. Its excellent stability permits reuse after recovery by simple distillation and filtration. FREON is nonflammable, and unlike many other solvents, relatively nontoxic. Special exhaust systems are rarely needed.

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	HGSR		HGSM				HGM
	Series 10000	Series 50000	Series 10000	Series 50000	Series 1000	Series 5000	
Dimensions (l x w x h)	1 9/16" x 17/32" x .400"		2 1/16" x 5/8" x .625"				3 13/64" x 3/4" x 3/4"
Contacts (Note 1) Action (spdt)	1 Form D	1 Form C	1 Form D	1 Form C	1&2 Form D	1&2 Form C	1&2 Form D
Ratings Switched load (max)	2 amp, 500 v, 100 va		2 amp, 500 v, 100 va				5 amp, 500 v, 250 va
Carry load (max)	5 amp, not switched		5 amp, not switched				10 amp, not switched
Inrush load (avg) 10 ms / 10 sec / 100 sec	20 amp / 4 amp / 2 amp		20 amp / 4 amp / 2 amp				50 amp / 10 amp / 5 amp
Circuit resistance (max) (Note 2)	20 milliohms		20 milliohms				35 milliohms
	Variation less than ± 2 milliohms from initial value over 20 x 10^9 operations (Independent of current or voltage)						
Operating voltage	Up to 90 vdc		Up to 90 vdc				Up to 90 vdc
Operate time (nom) at max coil power	1.0 ms		1.0 ms		1.2 ms single side stable 1.0 ms bi-stable (Note 3)		As low as 2.4 ms (Note 3)
Sensitivity Bi-stable	20 mw either winding of double wound coil		20 mw either winding of double wound coil		25 mw (Note 3)		As low as 550 mw (Note 3)
Single Side Stable	40 mw single wound coil, 80 mw either winding of double wound coil		40 mw single wound coil, 80 mw either winding of double wound coil		115 mw (Note 3)		
NOTES:	1. Except for very light loads such as thermocouples and strain gauges, contacts must be protected by a resistor-capacitor suppression circuit. 2. Measured at 6 vdc, 100 ma. 3. Depending on number of contacts.						

Clare also offers Mercury-Wetted Contact Relays for wired assemblies... as well as in printed circuit board assemblies, combined with other components mounted on pcb's supplied by Clare or customer. See Clare Manual 201D.

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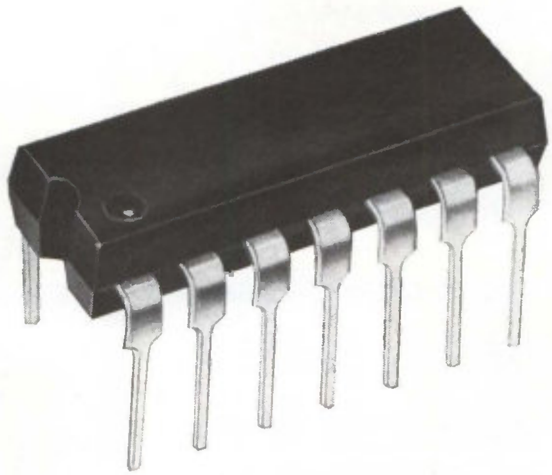

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Dual 4-Input Gate (MC725P)	1.08	.81
Dual Buffer (Non/inverting) (MC788P)	1.35	1.00
Hex Inverter (MC789P)	1.08	.81
Dual J-K Flip-Flop (MC790P)	2.00	1.50
Triple 3-Input Gate (MC792P)	1.20	.90
Triple 3-Input Gate (MC793P)	1.20	.90
Dual Buffer (MC798P)	1.35	1.00
Dual Buffer (MC799P)	1.08	.81

MDTL* – MC830P Series		
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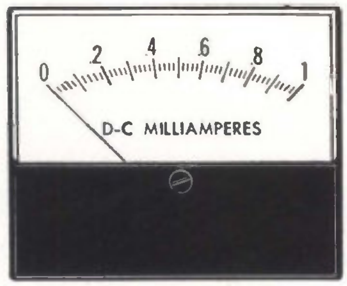

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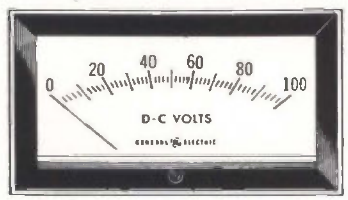

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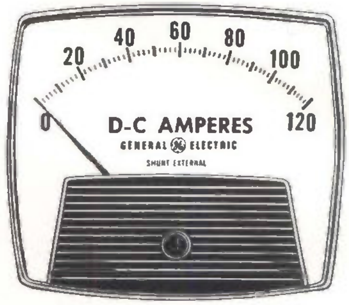

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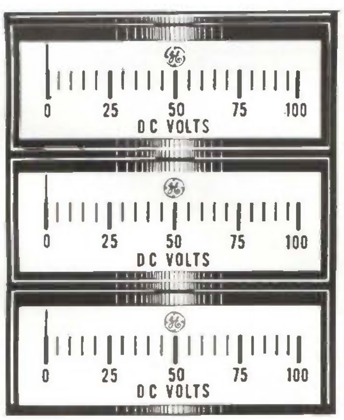

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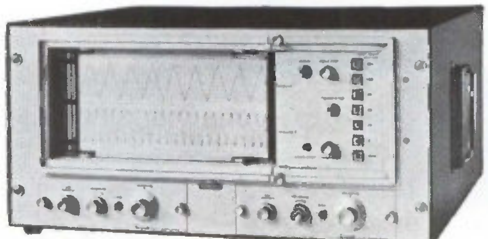


Mark 842 Hi-torque Penmotor Recorder

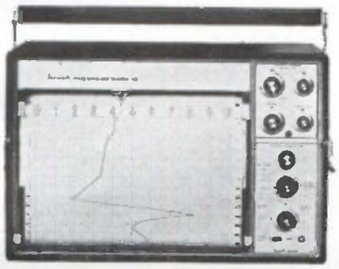
Highly versatile pressure-thermal rectilinear writing system. See list of "plug-in" preamplifiers on facing page.

Mark II Portable Recorder

Lightweight, highly versatile—a complete dual channel recording system. Anyone can plug it in, put it in writing anywhere!

Mark 2300 Lightbeam Oscillograph

Application possibilities of this versatile portable recorder are almost unlimited. Simple incandescent light-source is fail-safe. ▶



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No. Channels Analog Event	2 2 standard	2 1 standard	2 2 standard	1 1 (accessory)	1 to 16
Channel width	80mm	40mm	40mm	10"	6"*
Penmotor type	Position feedback	Hi-torque d'Arsonval	d'Arsonval	Potentiometric	Lightbeam galvo
Writing method	Pressurized ink‡	Pressure-thermal	Capillary ink	"Solid-state" wax-base	Tungsten† lightbeam
Trace presentation	Rectilinear	Rectilinear	Curvilinear	Rectilinear	Rectilinear
Chart speeds	0.05, 0.1, 0.2 0.5, 1, 2, 5, 10, 20, 50, 100, 200mm/sec	0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200mm/sec	1, 5, 25, 125mm/sec	1, 2, 5, 10, 20 in./min. 1, 2, 5, 10, 20 in./hr.	0.2, 0.4, 1, 2, 5, 10, 25 and 50 ips, plus above speeds ÷ 100
Frequency response	35cps full scale (80mm)	75cps full scale (40mm)	35cps full scale (40mm)	1cps full scale (10 inches)	Depends on galvo selected—to 2500 cps
Linearity	½% full scale	½% full scale	2% full scale	0.2% full scale	2% full scale
Input characteristics	0.5mv/div; 1 meg constant; floating	Interchangeable preamps (see listing at left)	10mv/div; 5 meg single-ended; 10 meg balanced	50 microvolts/div; 1 meg, constant; also potentiometric	Varies with galvo selected; impedance 100K floating with Brush galvo amplifier

*Total chart width
†Patent pending

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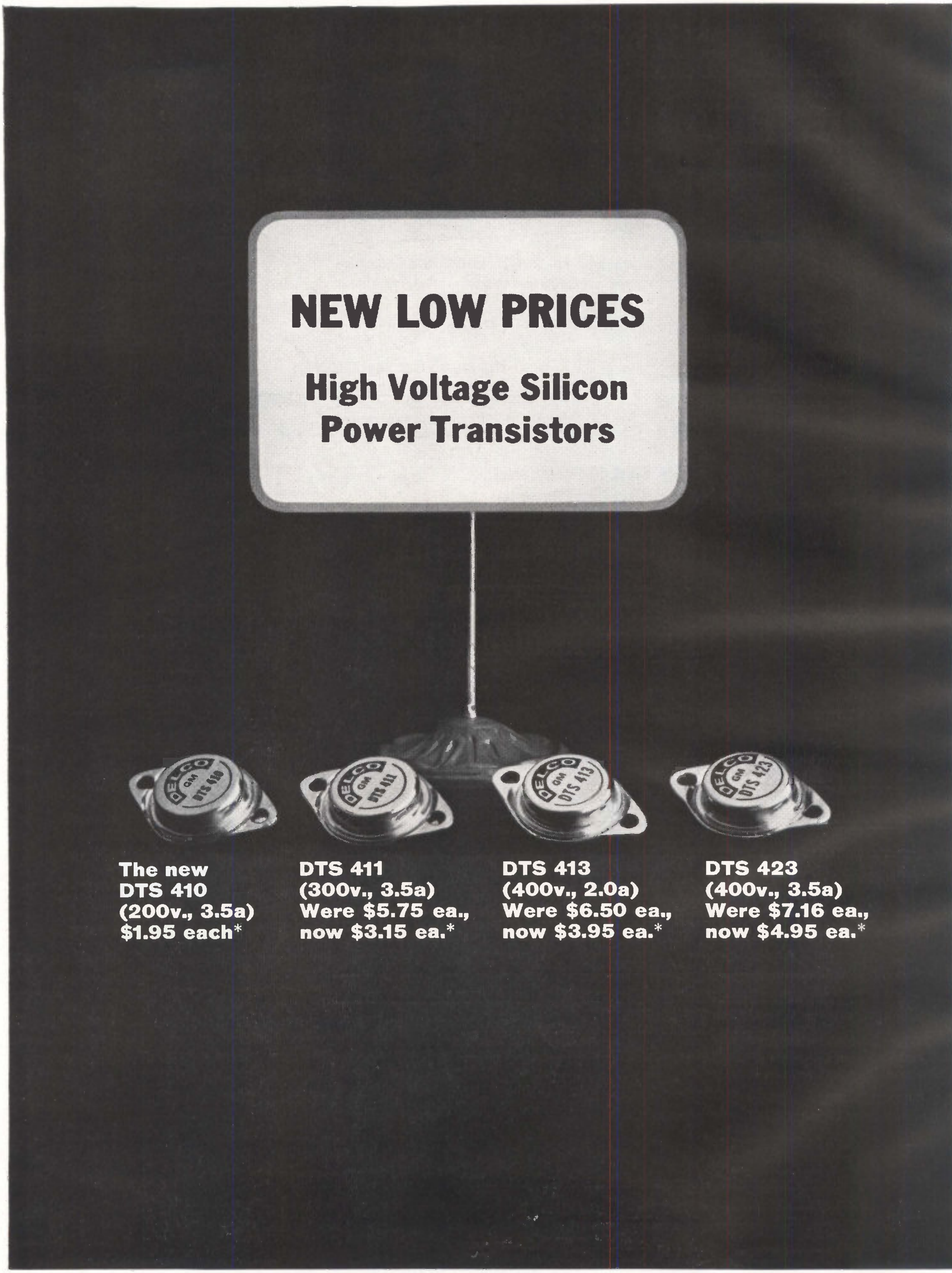

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From now on, the cost-cutting advantages of Delco NPN high voltage silicon power transistors cost even less. Look over the new low prices on the opposite page.

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DTS 411	300V	300V (min)	3.5A	10 @ 2.5A	100W
DTS 413	400V	325V (min)	2.0A	15 @ 1.0A	75W
DTS 423	400V	325V (min)	3.5A	10 @ 2.5A	100W

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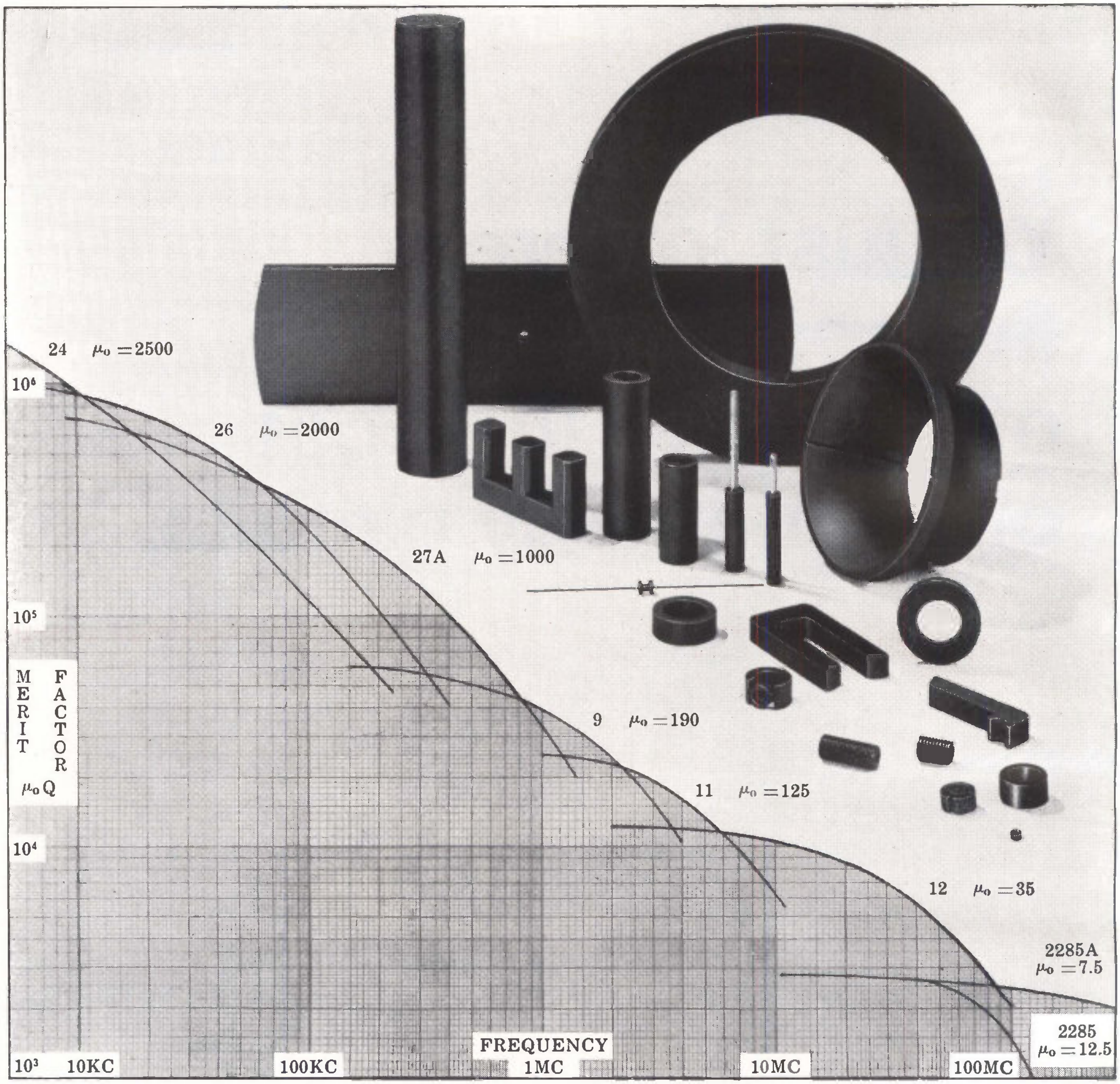

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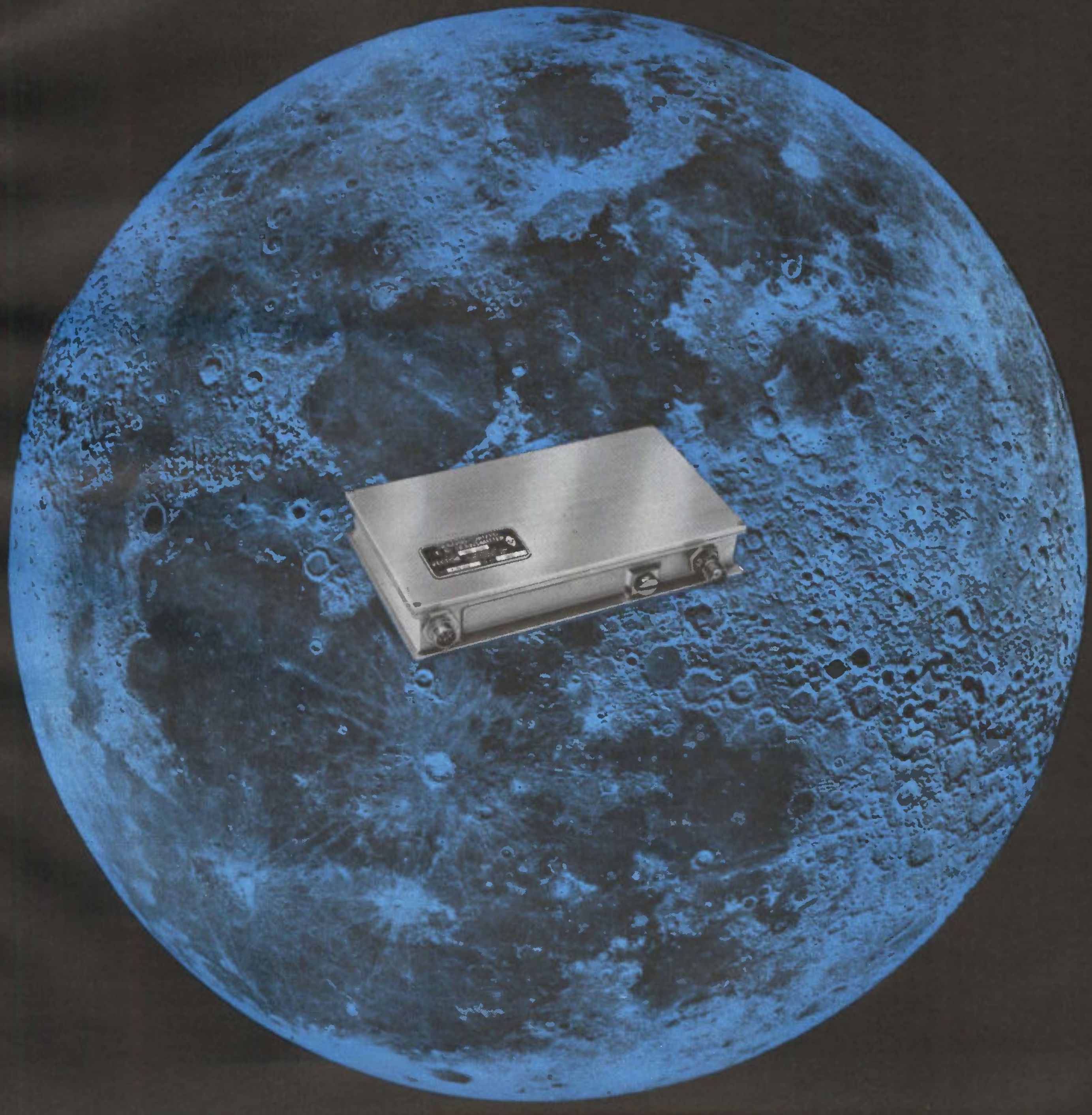

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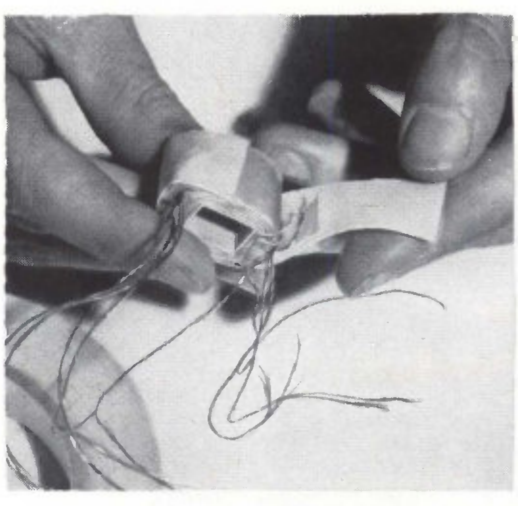

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When specifications call for a new core, or stack configuration, nobody can match Indiana General's design, development, and production capabilities. We make and sell more ferrite memory cores than anyone in the world. In fact, we invented them. Many of our competitors are licensees.

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These two unretouched photographs of rectifier stud mounting bases made of conventional electrolytic tough pitch copper (ETP) on the left and OFHC® brand copper on the right, both of which were heated in hydrogen to simulate brazing, tell the story of hydrogen embrittlement at a glance. The ETP stud shows blistering, symptomatic of a disrupted, brittle structure. The smoothness of the stud made of OFHC is evidence of its sound structure.

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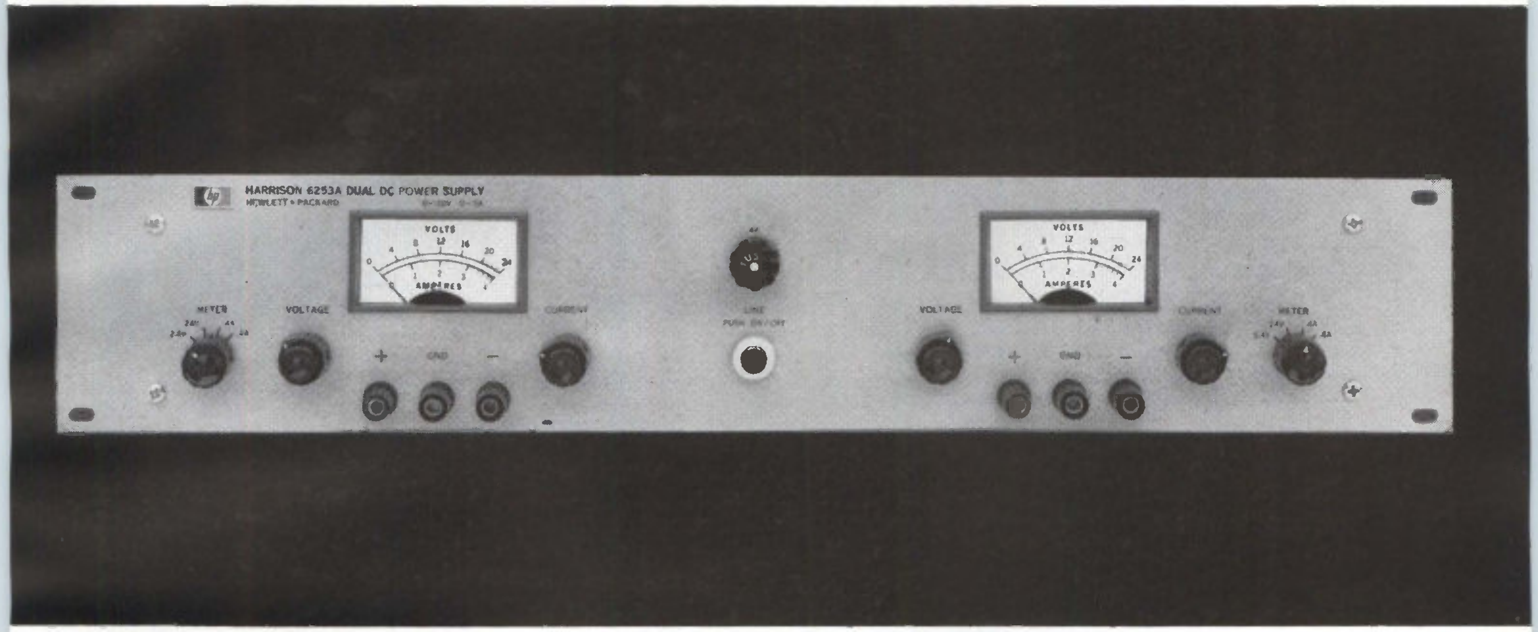

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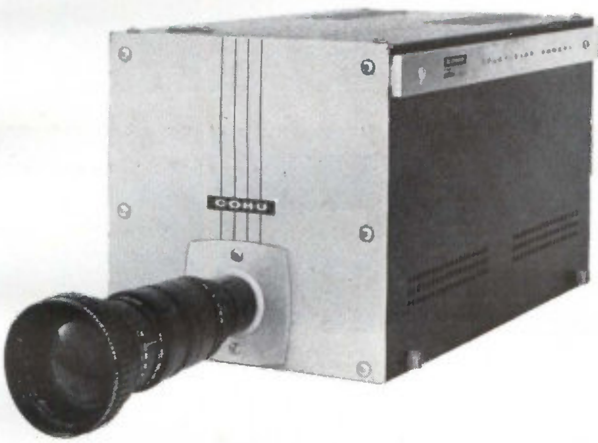

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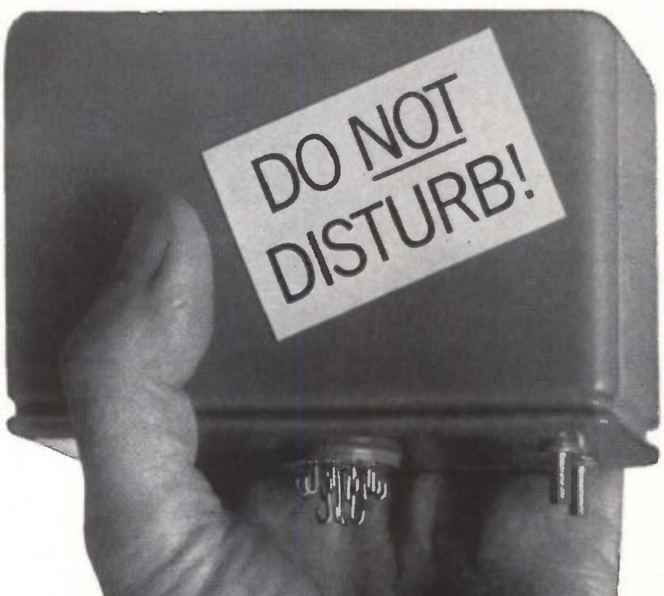

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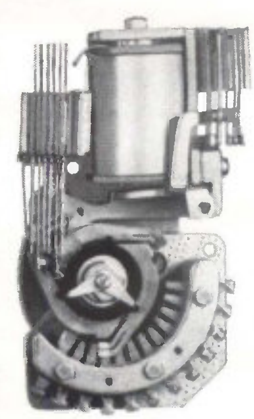

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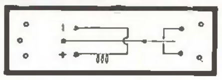
Adlake Mercury Wetted Relay — Application Data

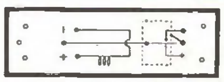
Capacitance of Adlake Mercury Wetted Contact Relays Applicable for Low Signal Applications

Typical Capacitance in Picofarads — Graphs illustrate typical capacitance values for Adlake AWCA-16000 series relays. Fig. I is for unshielded relays. Fig. 2: Electro-statically shielded switch brought out to a separate pin. Fig. 3: Electro-statically shielded switch with case and shield tied together at a common pin. Interelectrode capacitance across contacts of a bare switch, without external wires, is less than 1.0 picofarad.

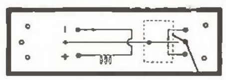
Abbreviation COMM. stands for the Combination of the Armature and Normally Closed Contact. N.O. is the abbreviation for Normally Open Contact; whereas the symbol # is the mean average for the 5 relays. Graphs are available on other styles of Adlake Mercury Wetted Contact Relays upon request. (Please state wiring configuration.)



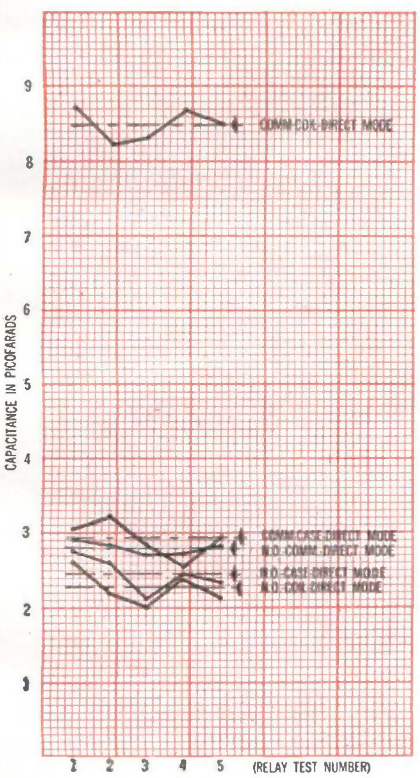
AWCA 16011-S
Fig. 1

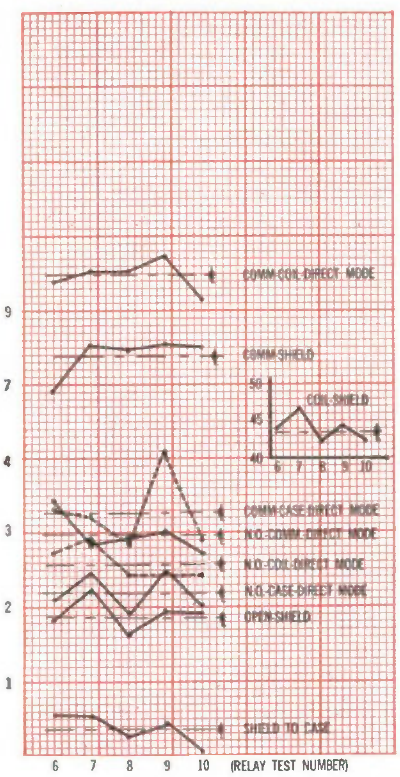


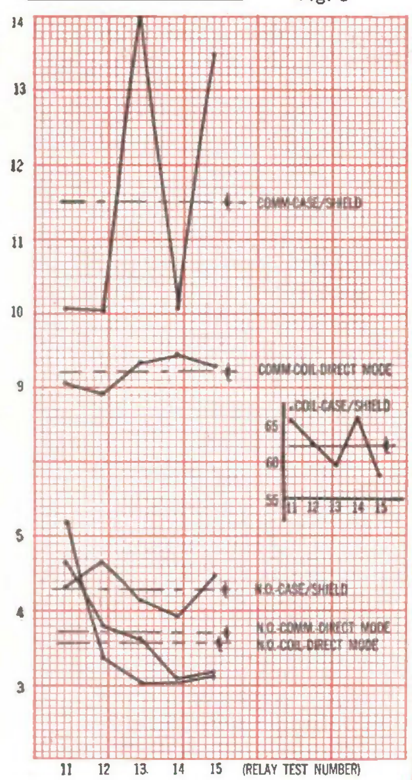
AWCA 16016
Fig. 2



AWCA 16018
Fig. 3







Data was obtained using a Booton Electronics Corporation Capacitance Bridge, Model 75-A-S8 at 1MHz

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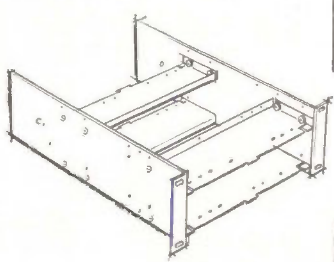

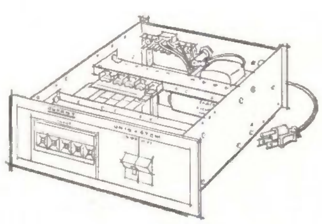

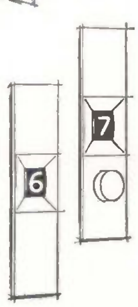

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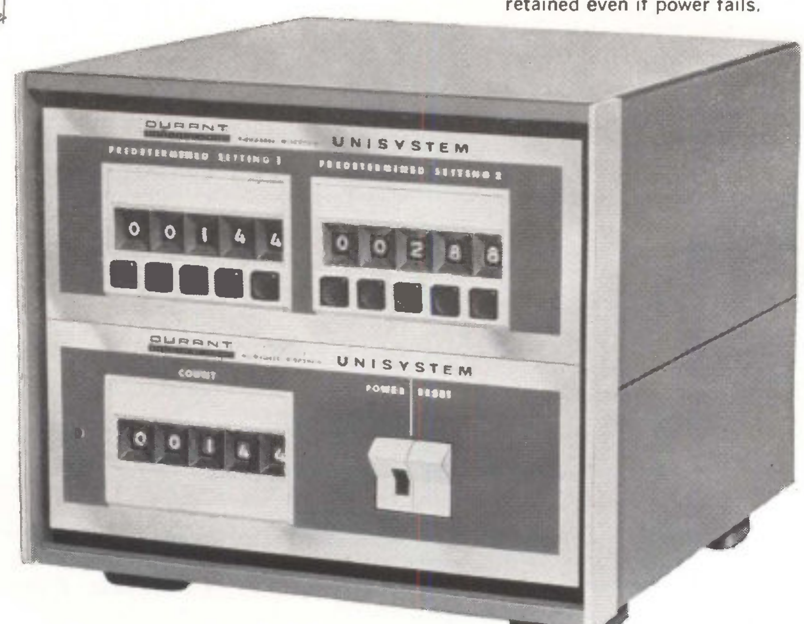

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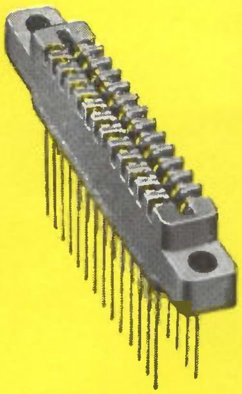
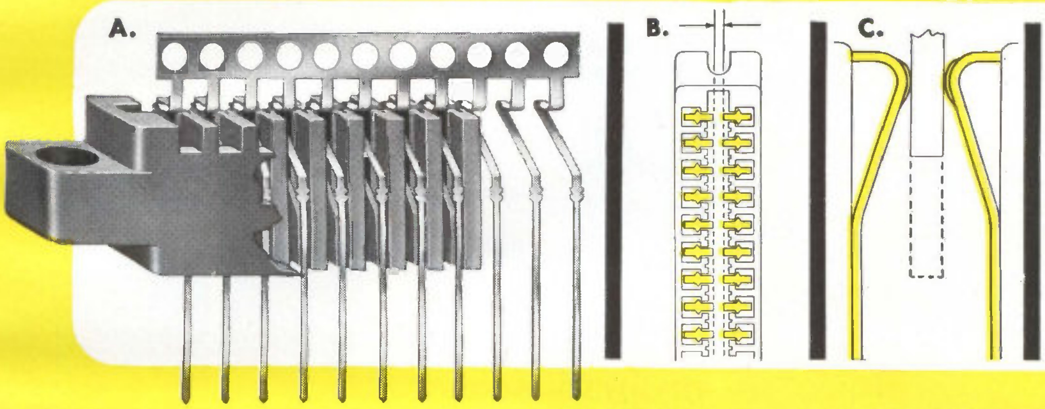


Cinch gives you the tail stability you need for programmed wire wrapping— in a miniature p.c. connector



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These precision tooled comb contacts are precisely and automatically preloaded with insertion of the comb into the insulator. The true tip location in the required position for automatic wrapping equipment is assured by the comb assembly technique. This technique employs a force fit to the insulator, assuring rigid, exact positioning. Cinch also manufactures .045″ square tail rectangular terminal and other wire wrap terminated printed circuit board connectors suitable for use with the automatic wire wrap equipment manufactured by Gardner-Denver.

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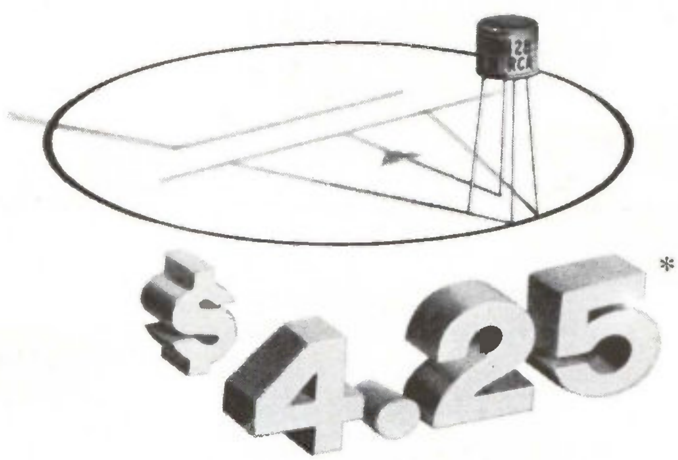

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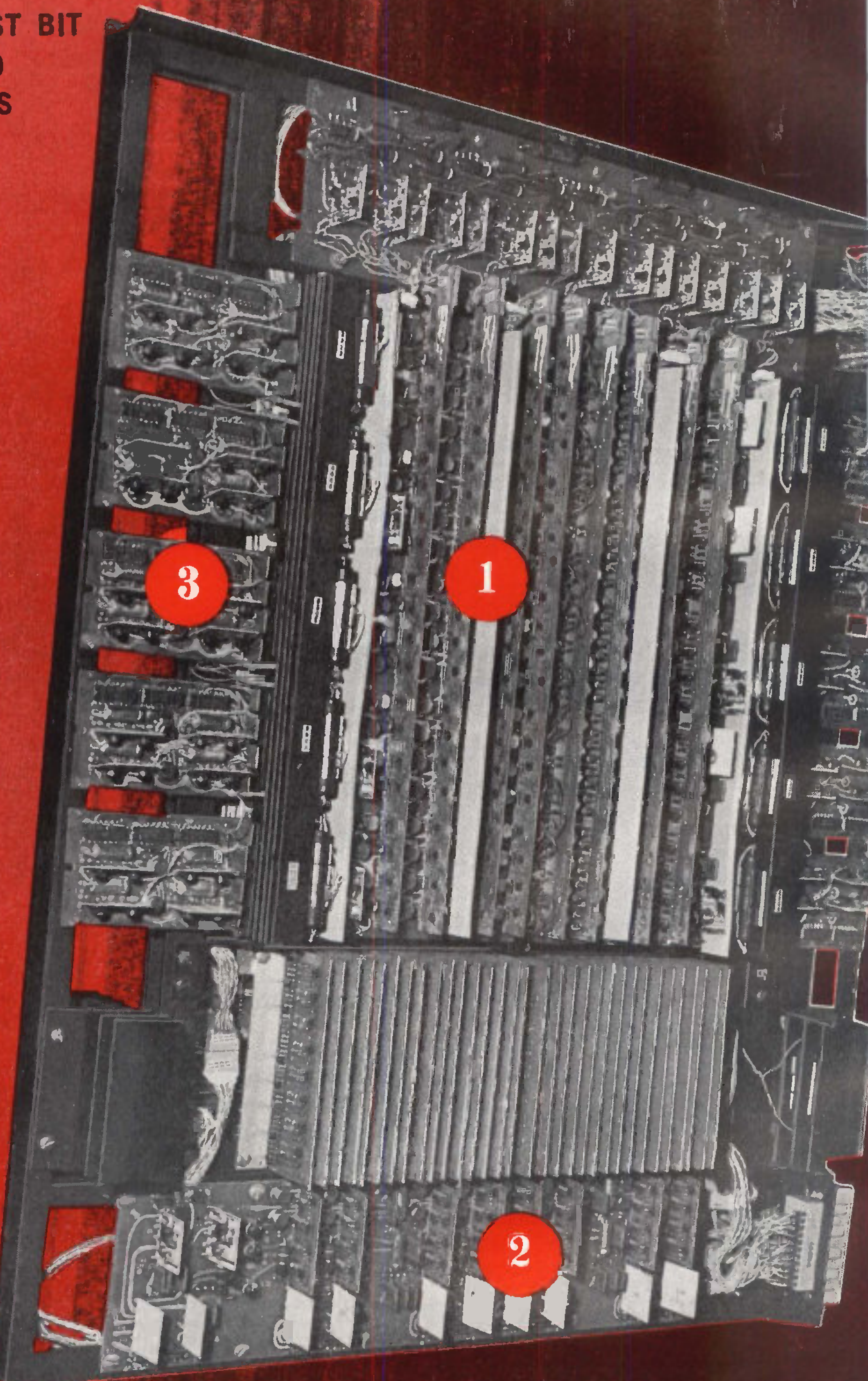

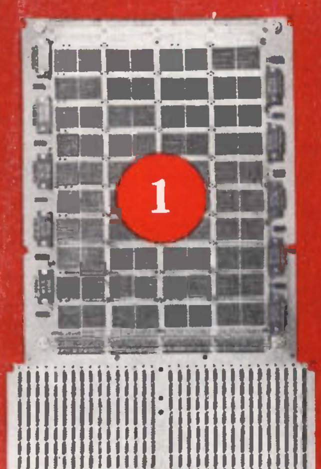

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November 14, 1966 | **Highlights of this issue**

Technical Articles

Topology reduces design drudgery: page 112

In theory, complex computations for the analysis of passive networks are fine, but in practice they can tie up engineers for days, particularly if there are more than three independent loops in the network. With a graphic approach, the engineer does not have to calculate the determinants and cofactors. Instead, he uses graphs, edges, vertices and trees to determine these elements by inspection.

IC's in action, part 2 Trends and trade offs: page 128

In the second part of this series, written for the user of integrated circuits, the compromises that must be made between design goals and practical realities are examined. The engineer finds that he must temper his design not only by the performance limitations of the circuits but also by such factors as realistic lead times for new circuits.

Avalanche transistors drive laser diodes hard and fast: page 137

One weakness of injection laser rangefinders has been the circuit to drive the laser. What's needed, of course, is a circuit that produces pulses of extremely short duration and fast rise time. Using the driving circuit described in this article, an engineer can design a rangefinder that is more accurate than conventional radar equipment.

Sony tries to be first, or at least different: page 155

Among Japanese electronics companies—and electronics firms elsewhere in the world too—Sony has the reputation for building good electronic consumer products and for aggressively developing unusual new products. Its product development philosophy is simple: the product is the thing. Some of Sony's more interesting designs are examined closely in this article. For the cover, photographer Richard Saunders lined up a variety of Sony's products from the home video tape recorder to tiny tv.

Coming November 28

- **Design automation series**
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Topology cuts design drudgery

Graphs, edges, vertices and trees are some of the terms of the new language of a topological technique of network analysis that eliminates time-consuming mesh and node calculations

By S.P. Chan

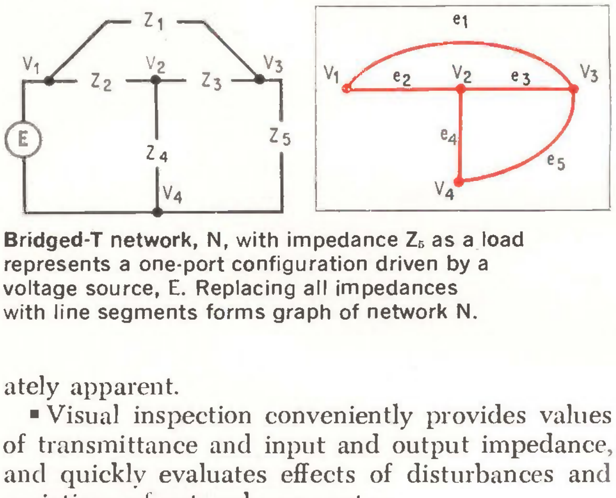
University of Santa Clara, Santa Clara, Calif.

In theory, complex calculations for the analysis of passive networks are fine, but what works in the classroom often is impractical on the job—particularly when more than three independent loops or nodes are involved. As the circuit grows more complex, calculations for the determinants and cofactors in mesh or node analysis become tedious, time-consuming and more prone to human error. It makes sense to try something less cumbersome in the engineering department. Now the engineer can turn to topological or graphic techniques as a shortcut in analyzing networks.

With the graphic approach, the engineer does not have to calculate the determinants and cofactors; instead he obtains them by inspection. He merely replaces all impedance elements in a network by line segments and then obtains a complete analysis of the network by following a simple sequence of steps.

Compared with conventional methods, the topological technique is faster, simpler and includes a simple check to tell the engineer if he is on the right track. The results are the same but topological methods offer some bonuses:

- The analysis results in a graphic display of the admittances at various parts of the network.
- All existing feedback loops become immediately apparent.
- Visual inspection conveniently provides values of transmittance and input and output impedance, and quickly evaluates effects of disturbances and variations of network parameters.
- The method adapts easily to computer-aided analysis of simple or complex networks.



Bridged-T network, N, with impedance Z_5 as a load represents a one-port configuration driven by a voltage source, E. Replacing all impedances with line segments forms graph of network N.

Defining topology terms

Before demonstrating an actual topological analysis, it is necessary to define the terms in the technique with the help of bridged-T network shown above. The network is loaded by impedance Z_5, and has four nodes (V_1, V_2, V_3, and V_4) and five branches (Z_1, Z_2, Z_3, Z_4 and Z_5). The voltage E represents the source.

If each of the five branches is replaced by a line segment while retaining the four nodes, a graph, G, of the network results as shown above. Such a representation is known as a graph of the network, N, and each of the five line segments is called an edge of the graph. Each edge corresponds to a branch in the network. For the graph shown, the edges are e_1, e_2, e_3, e_4, and e_5. Each of the nodes in the network, N, corresponds to a vertex in the

The author

Since receiving his Ph.D from the University of Illinois in 1963, S. Park Chan has been teaching at the University of Santa Clara. Chan was the principal investigator of a National Science Foundation research project on the topological applications to switching networks.

graph, G. Thus, V_1, V_2, V_3, and V_4 are the vertices of the graph. The number of edges connected to a given vertex is called the degree of the vertex. For example, vertex V_3 has a degree of 3 since three edges connect to it. Likewise, vertex V_1 has a degree of 2, V_2 has a degree of 3 and V_4 has a degree of 2.

The graph can be divided into a number of subgraphs, G_i. If G_i does not contain all the edges of the graph, G, it is called a proper subgraph of G. In the diagram, edges e_3, e_4 and e_5 would be one subgraph, in this case called a loop-set because it forms a closed loop. Two other types of subgraphs are the path-set and the tree. A path-set consists of a group of edges that link one vertex to another without repeating an edge; e_5, e_1 and e_2 represents one path-set because it connects vertex V_4 to V_2. A tree is a connected subgraph that contains all the vertices of G but does not form any closed loops. One possible tree contains edges e_1, e_2 and e_4. Two other trees of G are e_2, e_3 and e_4 and e_1, e_3 and e_5.

By subdividing the graph further it is possible to form a 2-tree. A 2-tree of G consists of two unconnected subgraphs that do not contain loops, but when connected contain all the vertices of G. Such a 2-tree can be formed with edges e_1 and e_4 or e_2 and e_5. Note that a 2-tree is obtained by removing one of the edges from the tree. The tree-admittance product for the tree e_1, e_3 and e_5 is $Y_1Y_3Y_5$, and is obtained by multiplying the admittances of the tree edges. The 2-tree admittance product of the 2-tree e_2 and e_5 is Y_2Y_5.

Network functions

Before the topological technique can be demonstrated a few basic network formulas must be established. To explore the relationships, the engineer should consider the representation of a network, N, with n independent nodes as shown at top. Node 1′ is the reference or datum node. Voltages $V_1, V_2, \ldots V_n$ (which are functions of the complex frequency variable s) are the node voltages, $v_1, v_2, \ldots v_n$ (which are functions of time, t) between the n nodes and the reference node 1′ with the plus polarity at the n nodes. Nodal analysis yields the n-independent current equations, written here in matrix form:

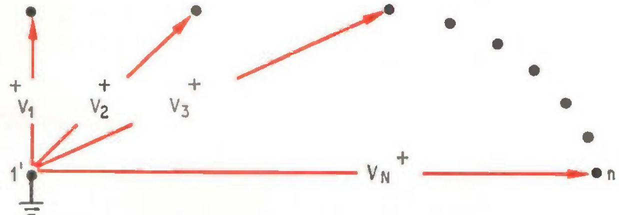
$$\begin{vmatrix} Y_{11} & Y_{12} \ldots Y_{1n} \\ Y_{21} & Y_{22} \ldots Y_{2n} \\ & \ldots \\ Y_{n1} & Y_{n2} \ldots Y_{nn} \end{vmatrix} \begin{vmatrix} V_1 \\ V_2 \\ V_n \end{vmatrix} = \begin{vmatrix} I_1 \\ I_2 \\ I_n \end{vmatrix} \quad (1)$$

or, in abbreviated matrix notation,

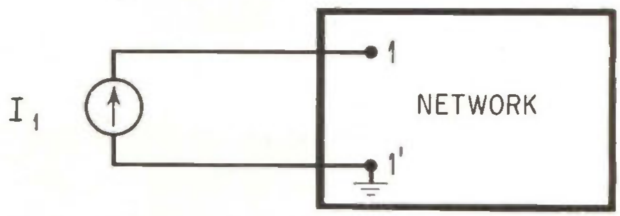
$$|Y_n| \; |V_n| = |I_n| \quad (2)$$

where $[Y_n]$ is the node admittance matrix, $[V_n]$ the n-vector (defined as a column matrix of order $n \times 1$) of the node voltage transforms, and $[I_n]$ the n-vector of the transforms of the known current sources.

The engineer usually is concerned with two types of networks, the one-port and two-port. For



Independent nodes, n in all, schematically represents a general network N. Node 1′ represents the reference or datum node.



Passive one-port network with zero-initial conditions and a current source driver helps derive the driving-point impedance and admittance functions.

the one-port network he generally wants to know the input impedance, $Z_d(s)$ or input admittance $Y_d(s)$. From the matrix of equation 1 expressions for $Z_d(s)$ and $Y_d(s)$ result in

$$Z_d(s) = \frac{V_1}{I_1} = \frac{\Delta_{11}}{\Delta} \quad (3)$$

and

$$Y_d(s) = \frac{1}{Z_d(s)} = \frac{\Delta}{\Delta_{11}} \quad (4)$$

respectively.

Equations 3 and 4 show that both $Z_d(s)$ and $Y_d(s)$ can be expressed in terms of the determinant of Y_n, Δ, and its (1,1) cofactor, Δ_{11}. The engineer will recall that the cofactor Δ_{jk} is obtained by striking out the jth column and kth row of the determinant, Δ, and solving for the remaining determinant. Thus, Δ_{11} is determined by striking out column one and row one from Δ and solving the remainder.

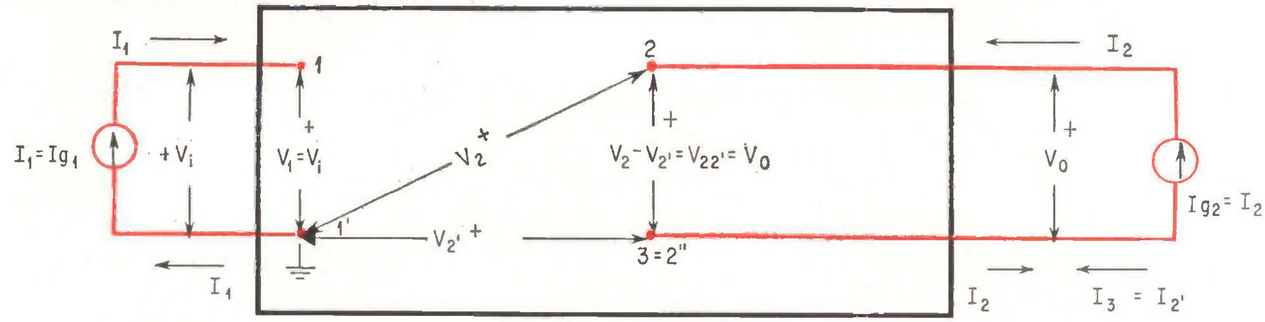
Next, consider a passive two-port network driven by two current generators I_{g1} and I_{g2} at ports 1 and 2 respectively [see top p. 114]. Here the engineer is usually concerned with the Z open-circuit or Y short-circuit parameters. These are defined from a two-port analysis as follows:

$$z_{11} = \left.\frac{V_i}{I_1}\right|_{I_2=0} = \frac{\Delta_{11}}{\Delta} \quad (5a)$$

$$z_{21} = \left.\frac{V_0}{I_1}\right|_{I_2=0} = \frac{\Delta_{12} - \Delta_{12'}}{\Delta} \quad (5b)$$

$$z_{12} = \left.\frac{V_i}{I_2}\right|_{I_1=0} = \frac{\Delta_{21} - \Delta_{2'1}}{\Delta} \quad (5c)$$

$$z_{22} = \left.\frac{V_0}{I_2}\right|_{I_1=0} = \frac{\Delta_{22} + \Delta_{2'2'} - 2\Delta_{22'}}{\Delta} \quad (5d)$$



Passive two-port network, driven by two current generators derives expressions for the Z and Y parameters.

$$y_{11} = \left.\frac{I_1}{V_1}\right|_{V_0=0} = \frac{z_{22}}{\Delta_z} \quad (5e)$$

$$y_{21} = \left.\frac{I_2}{V_i}\right|_{V_0=0} = \frac{-z_{21}}{\Delta_z} \quad (5f)$$

$$y_{12} = \left.\frac{I_1}{V_0}\right|_{V_i=0} = \frac{-z_{12}}{\Delta_z} \quad (5g)$$

$$y_{22} = \left.\frac{I_2}{V_0}\right|_{V_i=0} = \frac{z_{11}}{\Delta_z} \quad (5h)$$

where

$\Delta_z = Z_{11} Z_{22} - Z_{12} Z_{21}$

The preceeding nodal equations can be related to the topological definitions by the following:

Δ = the sum of all the tree admittance products for a network, N, where a tree admittance product is defined as the product of the admittances of all the branches of the tree.

Δ_{jj} = the sum of all the 2-tree admittance products of a network, N, with each 2-tree term formed from a two-part subgraph containing node j in one subgraph and node 1′ in the other.

Δ_{ij} = the sum of all 2-tree admittance products of a network N with each 2-tree term formed from a two-part subgraph containing nodes i and j in one connected subgraph and the reference node 1′ in the other.

For convenience, equations 3 and 4 can be rewritten as:

$$Z_d(s) = \frac{W_{1,1'}(Y)}{V(Y)} \quad (6)$$

and,

$$Y_d(s) = \frac{V(Y)}{W_{1,1'}(Y)} \quad (7)$$

Similarly, equations 5a through 5g can be rewritten to express the open-circuit parameters of a passive two-port network without mutual inductances. These are:

$$z_{11} = \frac{W_{1,1'}(Y)}{V(Y)} \quad (8a)$$

$$z_{12} = z_{21} = \frac{W_{12,1'2'}(Y) - W_{12',1'2}(Y)}{V(Y)} \quad (8b)$$

$$z_{22} = \frac{W_{2,2'}(Y)}{V(Y)} \quad (8c)$$

And, the short-circuit parameters for a passive two-port network without mutual inductances are:

$$y_{11} = \frac{W_{2,2'}}{\Sigma u} \quad (8d)$$

$$y_{12} = y_{21} = \frac{W_{12',1'2} - W_{12,1'2'}}{\Sigma u} \quad (8e)$$

$$y_{22} = \frac{W_{1,1'}}{\Sigma u} \quad (8f)$$

where,

$V(Y)$ = sum of all tree admittance products of all the trees of a network, N.

$W_{1,1'}(Y)$ = sum of the 2-tree admittance products of all the 2-trees with node 1 in one part and node 1′ in the other part. These 2-trees are the same as the set of all the trees of a modified network obtained by shorting node 1 to node 1′ of the original network.

$W_{2,2'}(Y)$ = sum of the 2-tree admittance products of all the 2-trees with node 2 in one part and node 2′ in the other part. These 2-trees are the same as the set of all the trees of a modified network obtained by shorting node 2 to node 2′ of the original network.

$W_{12,1'2'}(Y)$ = sum of the 2-tree admittance products of all the 2-trees of the network with each 2-tree having one part containing vertices 1 and 2, and the other part containing vertices 1′ and 2′.

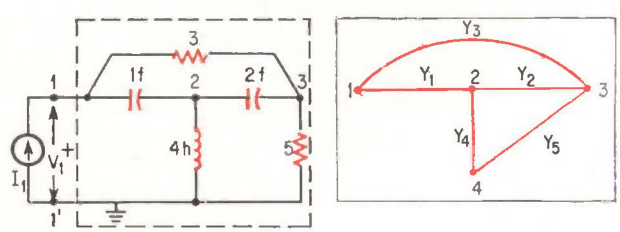


Illustration of the topological technique shows passive one-port network with zero-initial conditions used in example 1. Graph of the one-port network is formed by replacing the impedance values with line segments and their appropriate admittance values.

$W_{12',1'2}(Y)$ = sum of the 2-tree admittance products of all the 2-trees of the network, N, with each 2-tree having one part containing vertices 1 and 2′, and the other part containing vertices 1′ and 2.

ΣU = sum of all 3-tree admittance products of the network, N, for the following four combinations of 3-trees:

- A subgraph with vertices 1 and 2′ in one part, vertex 2 in a second part and vertex 1′ in a third.
- A subgraph with vertices 1′ and 2′ in one part, vertex 1 in a second part and vertex 2 in a third.
- A subgraph with vertices 1 and 2 in one part, vertex 2′ in a second part and vertex 1′ in a third.
- A subgraph with vertices 1′ and 2 in one part, vertex 1 in a second part, and vertex 2′ in a third.

A 3-tree of a graph G is a proper subgraph of G consisting of three unconnected subgraphs without loops that, when the subgraphs are connected, contain all vertices of G.

Analyzing networks by topology

With the basic relationships and definitions established, the examples that follow will help explain how to analyze networks by topology:

Example 1. Obtain the driving-point impedance $Z_d(s)$ and its reciprocal $Y_d(s)$ for the passive one-port shown at bottom left of page 114.

In accordance with equations 3 and 4 or 6 and 7, the problem is to determine both Δ and Δ_{11}.

Step 1. To find Δ, draw the graph of the network by replacing each element with an appropriate line segment that represents the admittance of that branch as shown at bottom right of page 114.

Step 2. Form all tree admittance products for the network by inspecting the trees of the graph. These are shown in table 1.

Step 3. Form Δ by summing all the tree admittance products. Thus,

$$\Delta = s/2+2s^2/5+1/12+s/15+1/20+1/6+2s/15+1/60s = 2s^2/5+7s/10+3/10+1/60s$$

Step 4. To find Δ_{11} short vertex 1 to 1′ and obtain a new graph of the network, called G_{11}' as shown in table 2 on page 116.

Step 5. Form all 2-tree admittance products of N by obtaining the set of all tree admittance products of G_{11}' as shown in table 2.

Step 6. Form Δ_{11} by summing all the 2-tree admittance products. Thus,

$$\Delta_{11} = 2s^2+s/3+s/5+2s/3+1/2+2s/5+1/12s+1/20s = 2s^2+8s/5+1/2+2/15s$$

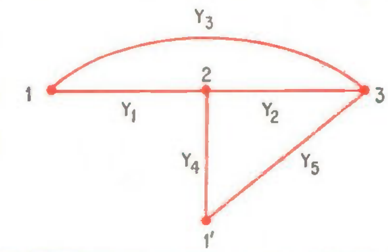
Step 7. Form $Y_d(s)$ and $Z_d(s)$ as defined in equations 3 and 4. Hence,

$$Y_d(s) = \frac{\Delta}{\Delta_{11}} = \frac{(2s^2/5+7s/10+3/10+1/60s)}{(2s^2+8s/5+1/2+2/15s)} = \frac{(24s^3+42s^2+18s+1)}{(120s^3+96s^2+30s+8)}$$

and $Z_d(s) = 1/Y_d(s)$.

When the same example is done by the conven-

Table 1: Graph of network N in example 1



$Y_1 = j\omega C_1 = s$

$Y_2 = 2s$

$Y_3 = 1/R = 1/3$

$Y_4 = 1/j\omega L = 1/4s$

$Y_5 = 1/5$

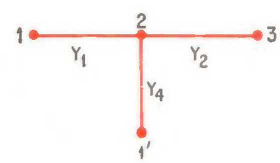
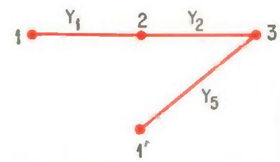
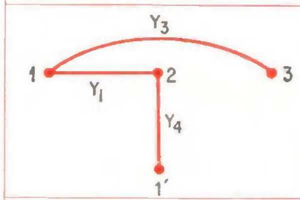
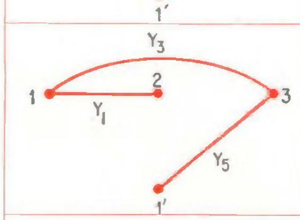
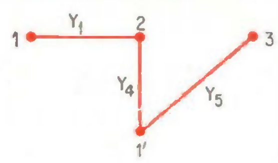
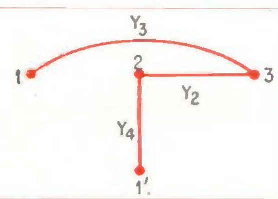
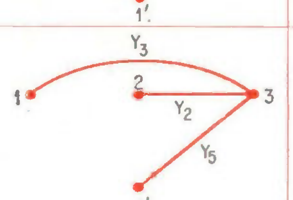
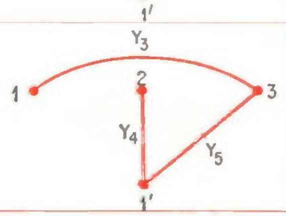
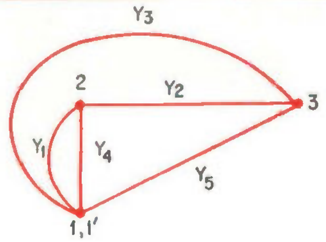
TREES OF NETWORK N	TREE – ADMITTANCE PRODUCTS
	$Y_1Y_2Y_4 = (s)(2s)(1/4s) = s/2$
	$Y_1Y_2Y_5 = (s)(2s)(1/5) = 2s^2/5$
	$Y_1Y_3Y_4 = (s)(1/3)(1/4s) = 1/12$
	$Y_1Y_3Y_5 = (s)(1/3)(1/5) = s/15$
	$Y_1Y_4Y_5 = (s)(1/4s)(1/5) = 1/20$
	$Y_2Y_3Y_4 = (2s)(1/3)(1/4s) = 1/6$
	$Y_2Y_3Y_5 = (2s)(1/3)(1/5) = 2s/15$
	$Y_3Y_4Y_5 = (1/3)(1/4s)(1/5) = 1/60s$

Table 2: $G_{11'}$ formed by shorting vertices 1 and 1′



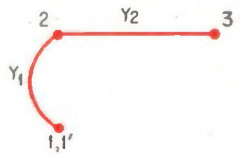
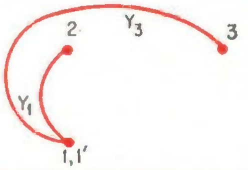
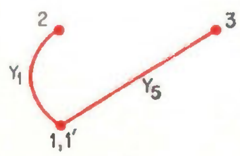
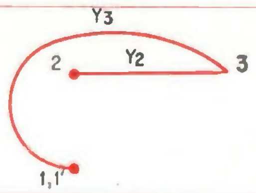
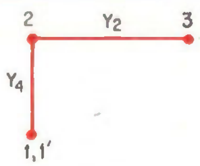
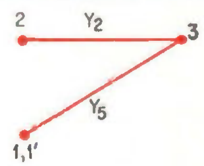
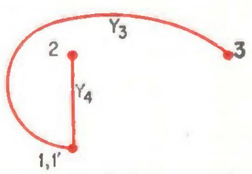
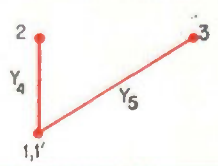
$Y_1 = j\omega C_1 = s$

$Y_2 = 2s$

$Y_3 = 1/3$

$Y_4 = \frac{1}{j\omega L} = 1/4s$

$Y_5 = 1/5$

2-TREES OF NETWORK	2-TREE ADMITTANCE PRODUCTS
	$Y_1Y_2 = (s)(2s) = 2s^2$
	$Y_1Y_3 = (s)(1/3) = s/3$
	$Y_1Y_5 = (s)(1/5) = s/5$
	$Y_2Y_3 = (2s)(1/3) = 2s/3$
	$Y_2Y_4 = (2s)(1/4s) = 1/2$
	$Y_2Y_5 = (2s)(1/5) = 2s/5$
	$Y_3Y_4 = (1/3)(1/4s) = 1/12s$
	$Y_4Y_5 = (1/4s)(1/5) = 1/20s$

tional mesh or node technique, a set of equations must be formed for each loop or node. Then a matrix is formed for the network and much mathematical calculation is required to obtain the result for $Z_d(s)$ and $Y_d(s)$. As a comparison to the topological approach consider the same network analyzed by node equations. Thus,

Step 1. Form the node equation for the network.

$$I_1 = \left(\frac{3s+1}{3}\right)V_1 - s\,V_2 - \frac{1}{3}V_3$$

$$0 = -s\,V_1 + \left(\frac{12s^2+1}{4s}\right)V_2 - 2s\,V_3$$

$$0 = -\frac{1}{3}V_1 - 2s\,V_2 + \left(\frac{30s+8}{15}\right)V_3$$

Step 2. Form the matrix equation for the results of step 1. Hence,

$$\begin{bmatrix} \left(\frac{3s+1}{3}\right) & -s & -\frac{1}{3} \\ -s & \left(\frac{12s^2+1}{4s}\right) & -2s \\ -\frac{1}{3} & -2s & \left(\frac{30s+8}{15}\right) \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} I_1 \\ 0 \\ 0 \end{bmatrix}$$

And,

$$\Delta = \begin{array}{c} \begin{matrix} \quad 1 & \qquad 2 & \qquad 3 \end{matrix} \\ \begin{bmatrix} \left(\frac{3s+1}{3}\right) & -s & -\frac{1}{3} \\ -s & \left(\frac{12s^2+1}{4s}\right) & -2s \\ -\frac{1}{3} & -2s & \left(\frac{30s+8}{15}\right) \end{bmatrix} \begin{matrix} 1' \\ 2' \\ 3' \end{matrix} \end{array}$$

Step 3. Expanding and simplifying,

$$\Delta = \frac{(24s^3 + 42s^2 + 18s + 1)}{60s}$$

Step 4. Evaluate the (1,1′)cofactor of Δ_{11} by expanding the Δ determinant with column 1 and row 1′ deleted. Thus,

$$\Delta_{11} = \begin{bmatrix} \left(\frac{12s^2+1}{4s}\right) & -2s \\ -2s & \frac{30s+8}{15} \end{bmatrix}$$

$$= \frac{120s^3 + 96s^2 + 30s + 8}{60s}$$

Step 5. Form $Z_d(s)$ and $Y_d(s)$ from equations 3 and 4. Hence,

$$Z_d(s) = \frac{\Delta_{11}'}{\Delta} = \frac{120s^3 + 96s^2 + 30s + 8}{24s^3 + 42s^2 + 18s + 1}$$

and

$$Y_d(s) = \frac{\Delta}{\Delta_{11}} = \frac{24s^3 + 42s^2 + 18s + 1}{120s^3 + 96s^2 + 30s + 8}$$

which agrees with the result obtained previously.

For a network of more than three loops or nodes expansion by minors would have been required for the matrix. This would require an enormous amount of tedious calculation.

Example 2. Obtain the Z-impedance parameters for the two-port ladder network shown below with topological techniques. The Z-impedance parameters are defined by equations 5a through 5d or equations 8a through 8c.

Step 1. Draw graph G for the two-port network as shown below.

Step 2. Form all tree combinations for the graph as in table 3.

Step 3. Form V(Y) by summing all tree admittance products of the graph G. Thus,

$$V(Y) = Y_1Y_2Y_3Y_4Y_6 + Y_1Y_2Y_3Y_5Y_6 + Y_1Y_2Y_4Y_5Y_6 + Y_1Y_3Y_4Y_5Y_6$$
$$= s\,G_1G_3G_4G_6\,(C_2 + C_5) + s^2\,G_1G_6C_2C_5\,(G_3 + G_4)$$

Step 4. Short vertex 1 to 1′ to obtain the graph $G_{11'}$ shown in table 4 on page 118.

Step 5. Form $W_{1,1'}(Y)$ by summing all the tree admittance products for the trees of graph $G_{11'}$. Thus,

$$W_{1,1'}(Y) = Y_1Y_3Y_4Y_6 + Y_1Y_3Y_5Y_6 + Y_1Y_4Y_5Y_6 + Y_2Y_3Y_4Y_6 + Y_2Y_4Y_5Y_6 + Y_3Y_4Y_5Y_6 + Y_2Y_3Y_5Y_6$$
$$= G_1G_3G_4G_6 + s\,[C_5G_6\,(G_1G_3 + G_1G_4 + G_3G_4) + G_3G_4G_6C_2] + s^2\,C_2C_5G_6\,(G_3 + G_4)$$

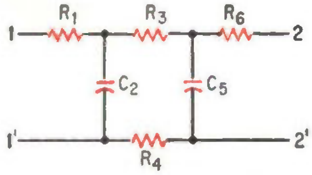
Step 6. Short vertex 2 to 2′ of graph G to form graph $G_{22'}$, as shown in table 5 on page 118.

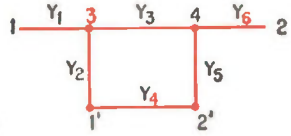
Step 7. Form $W_{2,2'}(Y)$ by summing all tree admittance products for the trees of graph $G_{22'}$. Thus.

$$W_{2,2'}(Y) = Y_1Y_2Y_3Y_4 + Y_1Y_2Y_3Y_5 + Y_1Y_2Y_3Y_6 + Y_1Y_2Y_4Y_5 + Y_1Y_2Y_4Y_6 + Y_1Y_3Y_4Y_5 + Y_1Y_3Y_4Y_6$$
$$= s\,[G_1G_3\,(G_4C_2 + G_6C_2 + G_4C_5) + (G_1G_4G_6C_2)] + s^2\,G_1C_2C_5\,(G_3 + G_4) + G_1G_3G_4G_6$$

Step 8. To obtain $W_{12,1'2'}(Y)$ form the set of all 2-trees of G that includes vertices 1 and 2 in one subgraph, and 1′ and 2′ in another as shown at top page 118. The only such set for the graph G contains edges e_1, e_3 and e_6 in one subgraph and e_4 in the other. Thus, $W_{12,1'2'} = Y_1Y_3Y_4Y_6$

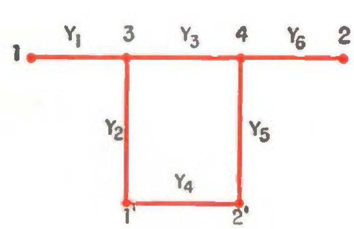
Step 9. To obtain $W_{12',1'2}(Y)$ form the set of all 2-trees of graph G that contain vertices 1 and 2′ in one subgraph and 1′ and 2 in another subgraph.

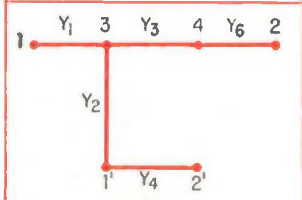
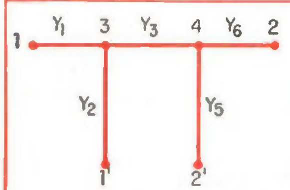
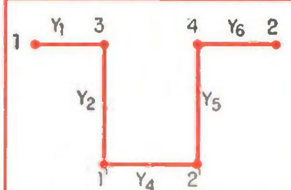
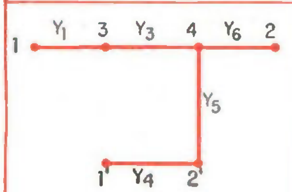




Passive two-port network and its graph aid examination of the ladder network. Graph is formed by replacing all impedance values with line segments and appropriate admittance values.

Table 3: G of the two-port network in example 2



TREES OF G	TREE-ADMITTANCE PRODUCTS
	$Y_1Y_2Y_3Y_4Y_6 = s\,G_1G_3G_4G_6C_2$
	$Y_1Y_2Y_3Y_5Y_6 = s^2G_1G_3G_6C_2C_5$
	$Y_1Y_2Y_4Y_5Y_6 = s^2G_1G_4G_6C_2C_5$
	$Y_1Y_3Y_4Y_5Y_6 = s\,G_1G_3G_4G_6C_5$

For this example such a set does not exist. Thus, $W_{12',1'2} = 0$.

Step 10. Form the Z-impedance parameters as defined by equations 8a through 8c and substitute their admittance value. Hence,

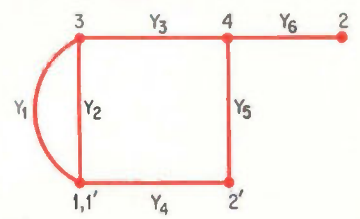
$$z_{11} = \frac{G_1G_3G_4G_6 + s\,[C_5G_6\,(G_1G_3 + G_1G_4 + G_3G_4) + G_3G_4G_6C_2] + s^2\,C_2C_5G_6\,(G_3 + G_4)}{s\,G_1G_3G_4G_6\,(C_2+C_5) + s^2\,G_1G_6C_2C_5\,(G_3+G_4)}$$

$$z_{12} = z_{21} = \frac{G_1G_3G_4G_6}{s\,G_1G_3G_4G_6\,(C_2+C_5) + s^2\,G_1G_6C_2C_5\,(G_3+G_4)}$$

$$z_{22} = \frac{s\,[G_1G_3\,(G_4C_2+G_6C_2+G_4C_5) + (G_1G_4G_6C_2)] + s^2\,G_1C_2C_5\,(G_3+G_4) + G_1G_3G_4G_6}{s\,G_1G_3G_4G_6\,(C_2+C_5) + s^2\,G_1G_6C_2C_5\,(G_3+G_4)}$$

Example 3. For the two-port ladder network of

Table 4: New graph $G_{11'}$ formed by shorting 1 to 1′



$Y_1 = G_1$
$Y_2 = sC_2$
$Y_3 = G_3$
$Y_4 = G_4$
$Y_5 = sC_5$
$Y_6 = G_6$

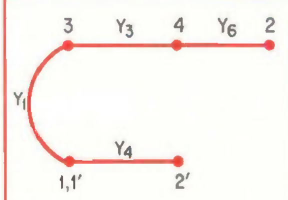
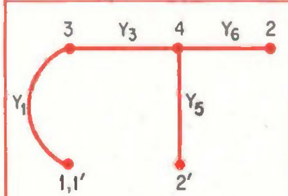
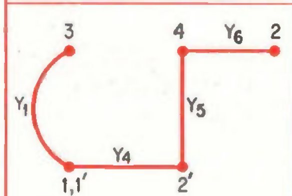
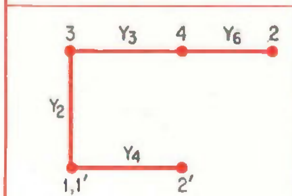
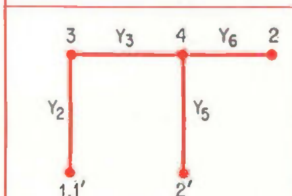
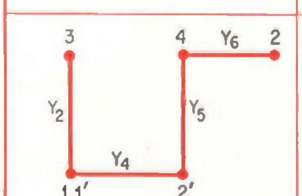
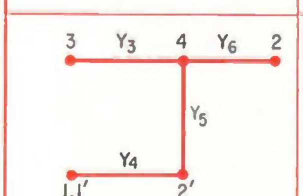
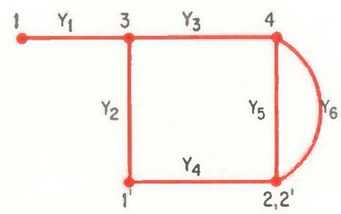
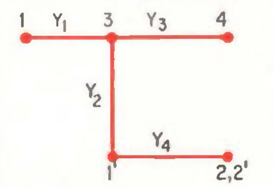
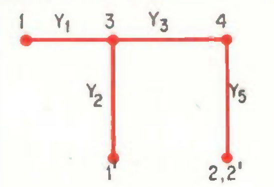
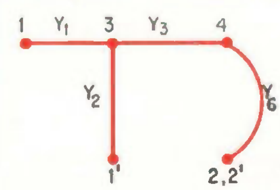
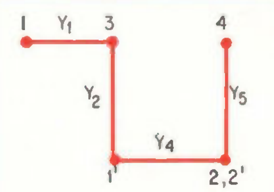
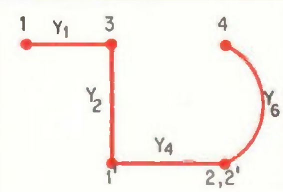
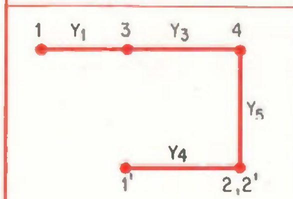
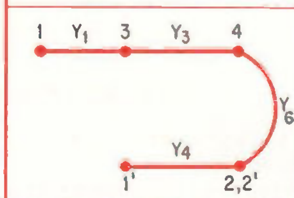
TREES OF $G_{11'}$	TREE-ADMITTANCE PRODUCTS
	$Y_1 Y_3 Y_4 Y_6 = G_1 G_3 G_4 G_6$
	$Y_1 Y_3 Y_5 Y_6 = s\, G_1 G_3 G_6 C_5$
	$Y_1 Y_4 Y_5 Y_6 = s\, G_1 G_4 G_6 C_5$
	$Y_2 Y_3 Y_4 Y_6 = s\, G_3 G_4 G_6 C_2$
	$Y_2 Y_3 Y_5 Y_6 = s^2 G_3 G_6 C_2 C_5$
	$Y_2 Y_4 Y_5 Y_6 = s^2 G_4 G_6 C_2 C_5$
	$Y_3 Y_4 Y_5 Y_6 = s\, G_3 G_4 G_6 C_5$

Table 5: $G_{22'}$ formed by shorting vertices 2 to 2′



$Y_1 = G_1$
$Y_2 = sC_2$
$Y_3 = G_3$
$Y_4 = G_4$
$Y_5 = sC_5$
$Y_6 = G_6$

TREES OF $G_{22'}$	TREE-ADMITTANCE PRODUCTS
	$Y_1 Y_2 Y_3 Y_4 = s\, G_1 G_3 G_4 C_2$
	$Y_1 Y_2 Y_3 Y_5 = s^2 G_1 G_3 C_2 C_5$
	$Y_1 Y_2 Y_3 Y_6 = s\, G_1 G_3 G_6 C_2$
	$Y_1 Y_2 Y_4 Y_5 = s^2 G_1 G_4 C_2 C_5$
	$Y_1 Y_2 Y_4 Y_6 = s\, G_1 G_4 G_6 C_2$
	$Y_1 Y_3 Y_4 Y_5 = s\, G_1 G_3 G_4 C_5$
	$Y_1 Y_3 Y_4 Y_6 = G_1 G_3 G_4 G_6$

example 2 calculate the Y short-circuit parameters.

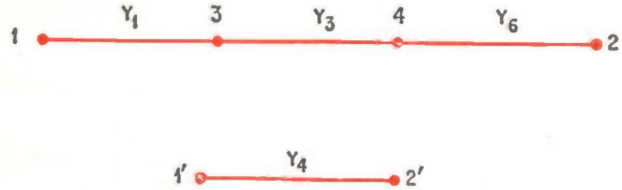
Since the Y parameters are defined by equations 8d through 8f, the only term remaining uncalculated is Σ U.

Step 1. To calculate Σ U the engineer must form the 3-tree admittance products of the network by forming the following subgraph combinations:

- All three-part subgraphs with vertices 1 and 2′ in one part, vertex 2 in a second part and vertex 1′ in a third part. For this example there is only one such subgraph.
- All three-part subgraphs with vertices 1 and 2 in one part, vertex 2′ in a second part and vertex 1′ in the third part. For this example there is only one such subgraph.
- All three-part subgraphs with vertex 1 in one part, vertex 2′ in a second part and vertices 1′ and 2 in a third part. For this example there is only one such subgraph.
- All three-part subgraphs with vertex 1 in one part, vertex 2 in a second part and vertices 2′ and 1′ in a third part. For this example there are nine such subgraphs.

All four groups are illustrated in table 6.

Step 2. Form ΣU by summing all 3-tree admittance products. Thus,



The only 2-tree of the two-port network with one part containing nodes 1 and 2, and the other nodes 1′ and 2′.

$$\Sigma U = Y_1Y_3Y_4 + Y_1Y_3Y_5 + Y_1Y_3Y_6 + Y_1Y_4Y_5 + Y_1Y_4Y_6 + Y_2Y_3Y_4 + Y_2Y_3Y_5 + Y_2Y_3Y_6 + Y_2Y_4Y_5 + Y_2Y_4Y_6 + Y_3Y_4Y_5 + Y_3Y_4Y_6$$

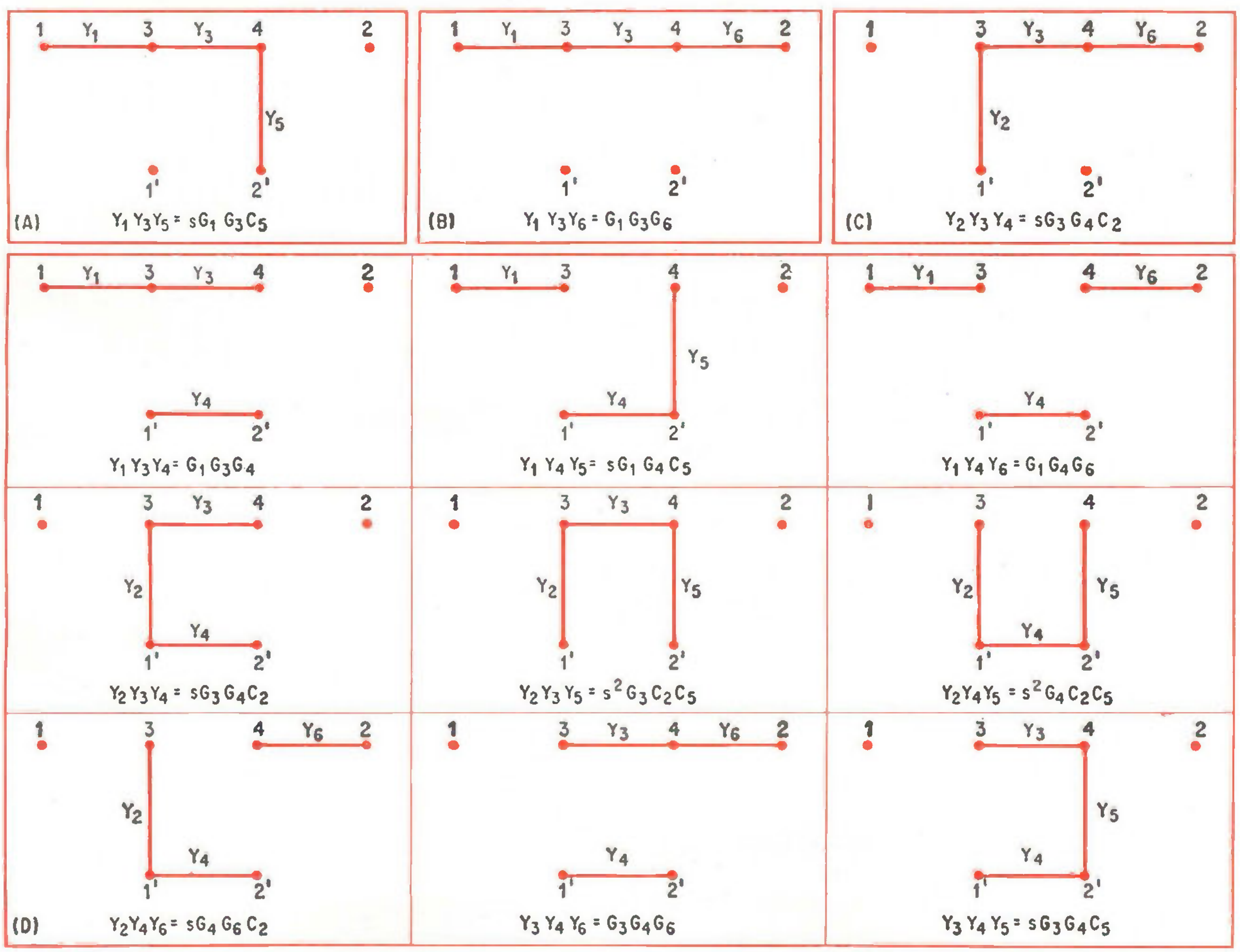
Step 3. Form the Y parameters using equations 8d through 8f—which can easily be performed.

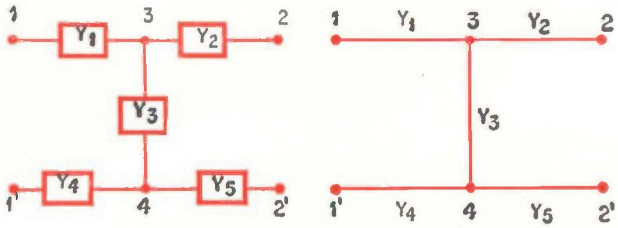
Example 4. For the network shown at top page 120 find V(Y), $W_{1,1'}$ (Y), $W_{12,1'2'}$ (Y), $W_{12',1'2}$ (Y), $W_{2,2'}$ (Y), and ΣU, with topological techniques.

Step 1. Draw the graph of the network, by replacing each element with a line segment that represents the admittance of the element as shown at top page 120.

Step 2. To calculate V(Y), obtain the set of all tree admittance products for the network by inspecting the trees of the graph. For this network

Table 6: The 3-trees of the two-port ladder network of example 2





A passive two-port network and its graph used for example 4.

only one tree exists. It is formed with edges e_1, e_2, e_3, e_4 and e_5. Thus, the tree admittance product is the product of all admittances for these edges,

$V(Y) = Y_1Y_2Y_3Y_4Y_5$

Step 3. To find $W_{1,1'}(Y)$ short circuit vertex 1 to 1′ and obtain a new graph of the network, called $G_{11'}$ as shown in table 7.

Step 4. To evaluate $W_{1,1'}(Y)$ sum all of the tree admittance products found in table 7. Thus,

$W_{1,1'}(Y) = Y_1Y_2Y_3Y_5 + Y_1Y_2Y_4Y_5 + Y_2Y_3Y_4Y_5$

Step 5. To find $W_{2,2'}(Y)$, short circuit vertex 2 to 2′ and obtain a new graph $G_{22'}$ as shown in table 8.

Step 6. To evaluate $W_{2,2'}(Y)$ sum all of the tree admittance products found in table 8. Thus,

$W_{2,2'}(Y) = Y_1Y_2Y_3Y_4 + Y_1Y_2Y_4Y_5 + Y_1Y_3Y_4Y_5$

Step 7. To obtain $W_{12,1'2'}(Y)$ form the set of all 2-trees of G that includes vertices 1 and 2 in one subgraph, and 1′ and 2′ in another subgraph. Thus,

$W_{12,1'2'}(Y) = Y_1Y_2Y_4Y_5$

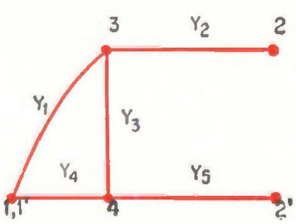
Step 8. To obtain $W_{12',1'2}(Y)$ form the set of all 2-trees of G that includes vertices 1 and 2′ in one subgraph, and 1′ and 2 in another subgraph. For this example there is no such subgraph. Thus,

$W_{12',1'2}(Y) = 0$

Step 9. To find ΣU, examine the 3-trees of G for the combinations:

- All three-part subgraphs with vertices 1 and 2′ in one part, vertex 2 in a second part and vertex 1′ in a third part. There is one such set for this example.
- All three-part subgraphs with vertices 1′ and 2′ in one part, vertex 1 in a second part and vertex 2 in the third part. There are two such sets for this example.
- All three-part subgraphs with vertex 1 and 2 in one part, vertex 2′ in a second part and vertex 1′ in a third part. There are two such sets for this example.
- All three-part subgraphs with vertex 1′ and 2 in one part, vertex 1 in a second part and vertex 2′ in a third part. There is one such set for this example.

Table 7: Graph $G_{11'}$ for the network of example 4



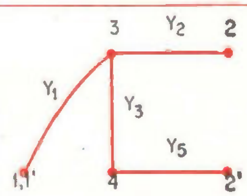
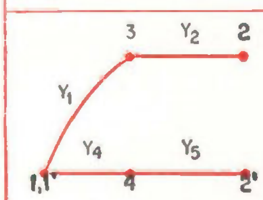
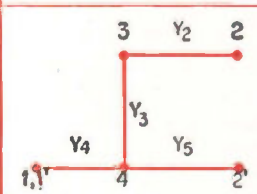
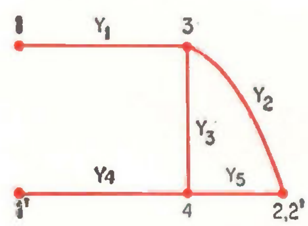
TREES OF $G_{11'}$	TREE-ADMITTANCE PRODUCTS
	$Y_1\ Y_2\ Y_3\ Y_5$
	$Y_1\ Y_2\ Y_4\ Y_5$
	$Y_2\ Y_3\ Y_4\ Y_5$

Table 8: Graph $G_{22'}$ for the network of example 4



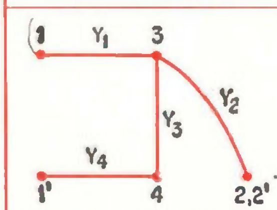
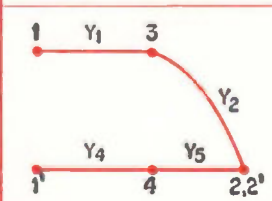
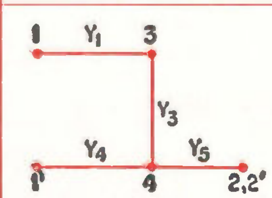
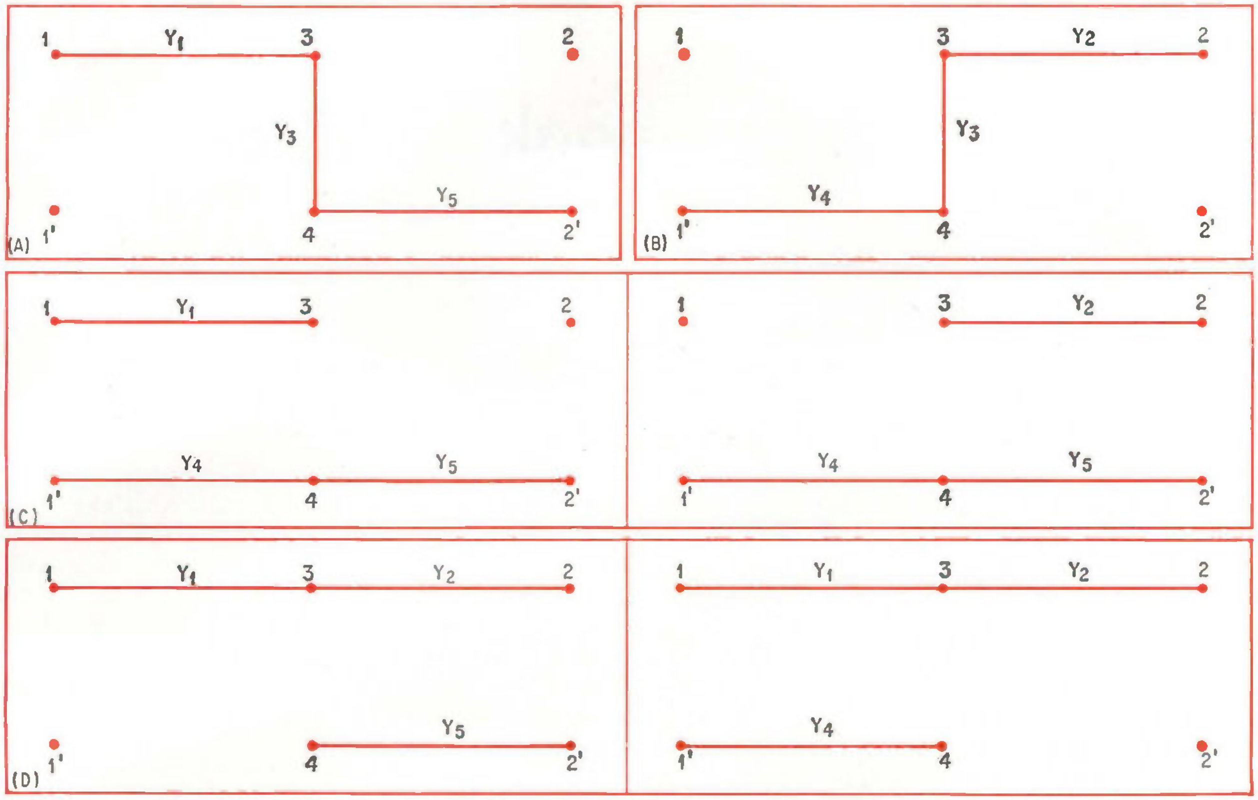
TREES OF $G_{22'}$	TREE-ADMITTANCE PRODUCTS
	$Y_1\ Y_2\ Y_3\ Y_4$
	$Y_1\ Y_2\ Y_4\ Y_5$
	$Y_1\ Y_3\ Y_4\ Y_5$

Table 9: All 3-tree combinations for the network of example 4



These are shown in table 9. Thus, ΣU is formed by summing all 3-tree admittance products of G.

$$\Sigma U = Y_1Y_3Y_5 + Y_1Y_4Y_5 + Y_2Y_4Y_5 + Y_1Y_2Y_5 + Y_1Y_2Y_4 + Y_2Y_3Y_4$$

With the data thus obtained, both the Z and Y parameters can be formed.

Making sure you're right

Since each tree, or 2-tree, is obtained by inspection, it is quite possible that a tree may be omitted simply because of an oversight. How can the engineer be sure that all the trees, or 2-trees, have been included? The answer: by a systematic method of listing the trees and 2-trees when topological formulas are applied. One such method follows:

Since the number of edges, e, in a tree of a connected graph with v vertices is v—1, the upper boundary of the total number of trees T_t, can be determined with C(e, v—1), where C(e, v—1) is the combination of e objects taken v—1 at a time. Thus, $T_t = C(e, v - 1)$ But, from algebra,

$$C\,(e, v - 1) = \frac{e\,!}{(v - 1)\,!\,(e - v + 1)\,!}$$

where, for any positive integer k,

$$k\,! = k\,(k - 1)\,(k - 2)\,\ldots\,2 \cdot 1$$

Thus, if all the C(e, v—1) terms are listed by forming all the possible combinations of e edges taken v—1 at a time and all loops of the graph are subtracted from these C(e, v—1) terms,

T_t=C(e, v—1) minus all loop combinations

For example, consider the one-port network and its graph on page 114. This graph has five edges and three vertices. There are 10 possible combinations of edges since

$$C\,(5, 3) = \frac{5\,!}{3\,!\,(5 - 3)\,!} = \frac{5 \cdot 4 \cdot 3 \cdot 2 \cdot 1}{3 \cdot 2 \cdot 1 \cdot 2 \cdot 1} = 10$$

Listing the edge combinations systematically yields: 123, 124, 125, 134, 135, 145, 234, 235, 245 and 345. But, by inspection of the graph, the combinations 123 and 245 form loops and therefore are not trees. Subtracting these two from the 10 possible combinations leaves eight trees of G.

The ability to check the topological analysis can be programed into a computer. Computers are used in topological network analysis, but the future success of the technique depends on cutting the time below that required by conventional techniques. This, in turn depends on having a simple tree-finding algorithm. And many investigators have, in recent years, conducted much successful research in developing network algorithms for the computer. Their contributions have been in finding topological formulas for active networks.

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Circuit design

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.

Frequency-modulated output from low-cost unijunction

By Gary M. Nickus
RDF West, Westminster, Calif.

A frequency-modulated pulse generator that has many applications in industrial control can be built for less than $3 with a unijunction transistor. The generator is designed for synchronizing two processes or test instruments.

Operation of the generator depends on the intrinsic standoff ratio, n, of the unijunction. When the voltage on the emitter of the unijunction transistor reaches a value of nV_{BB}, a negative resistance is established between the emitter and base of Q_1, causing capacitor C_1 to discharge through resistor R_1. Thus, a positive pulse is produced.

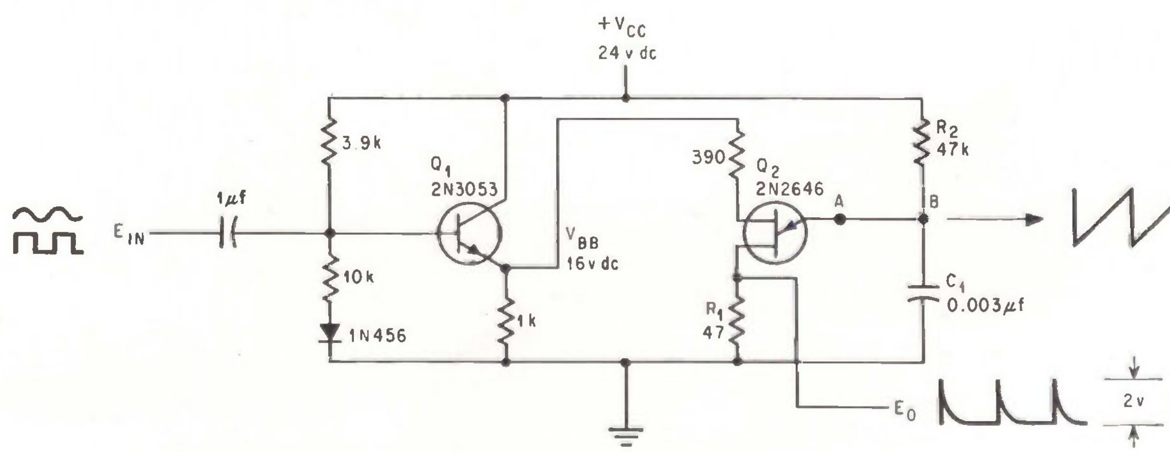
Transistor Q_1 is an emitter follower that supplies a potential V_{BB} to transistor Q_2. Without an input signal, V_{BB} is 16 volts d-c. With an input signal, E_{in}, however, V_{BB} is amplitude modulated, centered around 16 volts d-c; and V_{BB} causes the output signal, E_o, to be frequency modulated. An increase in the voltage at the base of Q_1 raises V_{BB}, and as V_{BB} goes up, the period between pulses at R_1 also increases. The modulating signal E_{in} can have any waveshape. The amplitude of E_{in} determines the amount that the period of E_o changes; the modulation frequency sets the rate at which E_o changes.

The period T between pulses with no input signal can be varied by changing the values of R_2 and C_1. The period may be calculated from

$$T = [V_{BB}/V_{CC}]\ RC \ln (1/1-n)$$

With the values shown, the period is 10^{-4} seconds. Periods longer than 1 second can be obtained by increasing C_2, but for values greater than 10 microfarads, additional resistance of 1 ohm per μf should be inserted between points A and B to protect the emitter of the unijunction transistor.

The amplitude of E_o will vary with the size of C_1, ranging from 2 volts peak to peak when C_1 equals 0.001 μf to 10 volts at 3 μf.

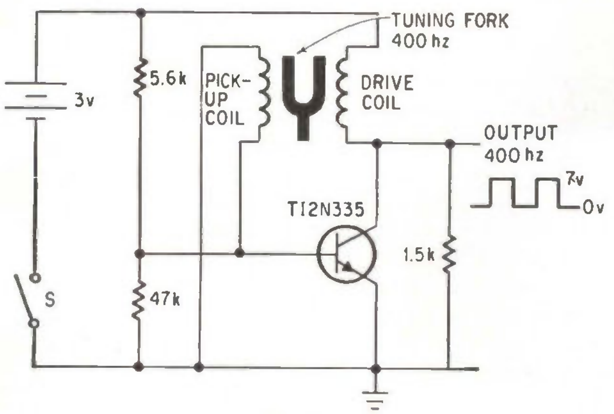


Frequency-modulated output voltage results when modulated waveshape V_{BB} is produced by Q_1. The period of the output is controlled by V_{BB} and is directly proportional to it.

Tuning fork drives portable frequency standard

By Stuart V. Scheffel
Scheffel Electronics, Santa Barbara, Calif.

Replacing the pulse transformer in a blocking oscillator with a tuning fork produces an accurate 400-hertz portable frequency standard. The simple, bat-



Tuning fork replaces the pulse transformer in a blocking oscillator and converts the circuit into a portable frequency standard that generates a square wave at the resonant frequency of the fork.

tery-powered circuit is ideal for checking out servo control systems in military equipment.

When switch S is closed, the transistor conducts and current flows through the drive coil of the tuning fork. The drive coil is a small electromagnet located near the top of the space between the wide steel tines. Once energized, the drive coil attracts both tines, starting fork vibration.

Another small electromagnet, the pickup coil, is mounted directly beneath the drive coil. As the tines vibrate they alternately increase and decrease the magnetic permeability of the pickup coil's core, increasing the permeability to a maximum when the tines are closest together and decreasing it to a minimum when the tines are farthest apart. The changes in permeability cause the magnetic field to expand and contract. When the field cuts across the windings of the pickup coil, a voltage is generated. An expanding flux field generates a positive voltage, a contracting flux field induces a negative signal.

At the start the positive signals increase the forward bias of the transistor when applied to the base. A larger surge of current flows through the drive coil, causing a larger deflection of the tines. The longer excursion of the tines brings them closer to the core of the pickup coil on their inward swing. When the tines are close to the core wider variations in the extent of the flux field are developed, inducing voltages of greater positive amplitude. These voltages are again applied to the base. This regenerative cycle quickly drives the transistor into saturation on positive swings of the pickup coil signal.

When the fork reaches mechanical resonance—about 15 seconds after the switch closes—the pickup coil signal is a slightly clipped sine wave with an amplitude of 1.2 volts peak to peak. The 47-kilohm resistor is placed in parallel with the pickup coil to improve the shape of the negative half-cycle of the sine wave, insuring a symmetrical output signal. The 1.2-volt peak-to-peak pickup coil voltage is larger than the base bias of 0.54 volt: therefore, the transistor is driven into saturation on positive voltage swings and is cut off on negative excursions. The resulting output signal is a crisp square-wave with a peak-to-peak amplitude of 7 volts with a frequency stabilized at 400 hz.

Because the circuit is self-contained and built with rugged components it is well suited for use in a portable field instrument. A breadboard version of the circuit oscillated for 39 hours on two AA cells. The tuning fork is a Varo Model 6250L-400.

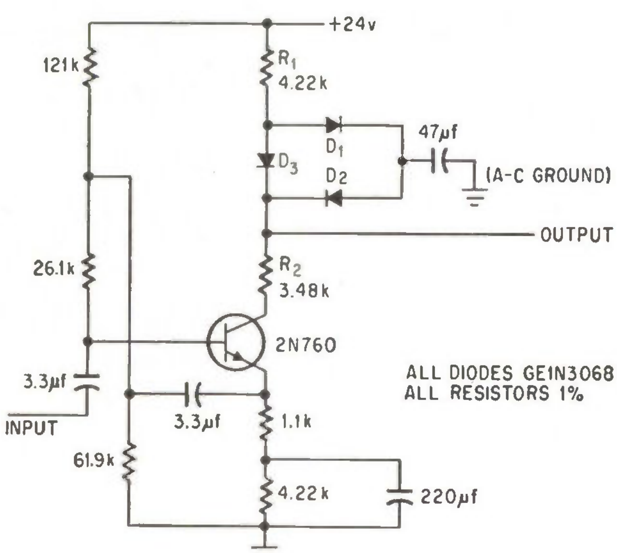
Diode bias replaces batteries in logarithmic converter

By R.K. Nisbett

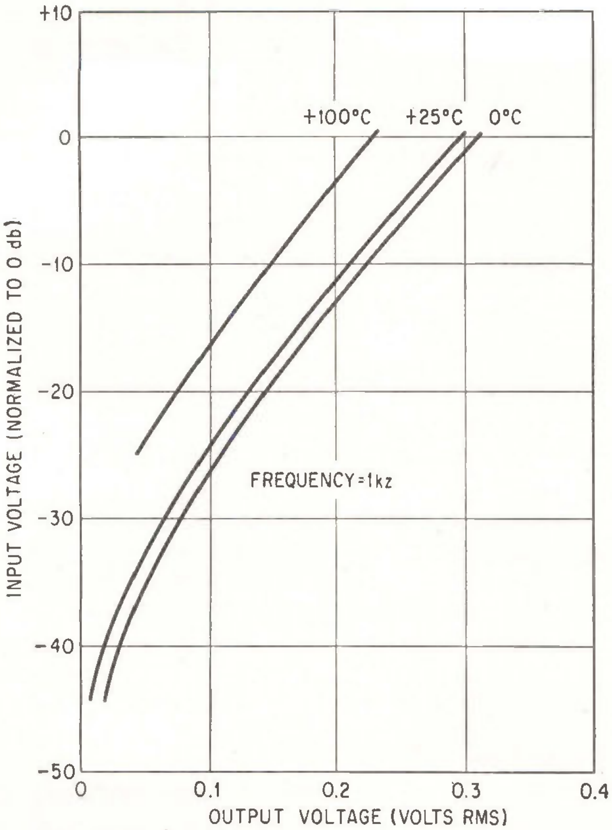
ITT Federal Laboratories,
San Fernando, Calif.

A converter circuit designed for data compression produces an output voltage proportional to the logarithm of an a-c input over a 36-decibel range. Bias provided by a single diode replaces the bias batteries usually needed in an a-c logarithmic converter.

In all logarithmic conversion amplifiers, the logarithm is obtained by passing the signal through a diode biased in the region where its impedance



Diode D_3 biases converting diodes D_1 and D_2 whose impedances vary logarithmically with a-c current.



Input (normalized to O db) as plotted against the output voltage is linear to within ±1 db over a 36-db range of input voltages.

is proportional to the logarithm of its current. This circuit has two converting diodes of opposite polarities. So, logarithmic compression of both the positive and negative portions of the amplified a-c waveform takes place as they pass through the 47-microfarad capacitor to a-c ground.

Diode D_3 shunts nearly all of the quiescent collector current past diodes D_1 and D_2. In addition, it provides each of them with the required 0.15-volt forward bias, keeping them in the logarithmic portion of the operating curve. Ordinarily this bias is supplied by a floating battery and a network of adjustable resistors. The rest of the circuit operates as a conventional common emitter amplifier. The range of input signals that the circuit can handle is limited only by the linear operating range of the converting diodes. The curves shown above are a plot of the input (normalized to O db) against the output voltage and show that the circuit is linear within ±1 db over an input range of 36 db. The range can be increased to 40 db by increasing the d-c supply voltage and the size of shunting resistor R_1. This reduces the effect of a-c impedance to ground of the d-c power supply.

Compensation is required to reduce changes in voltage across the junctions of diodes D_1 and D_2 at elevated temperatures. Resistor R_2 has a negative temperature coefficient which increases the current flow through D_1 and D_2. To force more current through the diodes at higher temperatures, R_1 has a positive temperature coefficient. If an additional diode voltage boost is needed, a positive thermal coefficient resistor of 10 ohms may be placed in the a-c ground circuit between the conversion diodes and the 47-μf capacitor. Without compensation, the output voltage was found to decrease at a rate of 0.8 millivolt root mean square per degree centigrade.

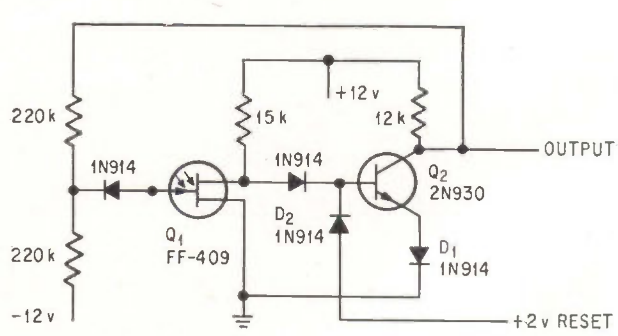
Light-sensitive FET

By Bruce R. Smith

Marshall Laboratories, Burlington, Mass.

Incident light saturates field effect transistor Q_1, shown below, and turns off npn transistor Q_2 to provide a positive output voltage. When the light source is removed, Q_1 remains on due to a gate circuit which feeds back the positive output to Q_1. Thus, a latching function is provided which is useful for such applications as an electronic garage-door opener, a smoke or fume detector or a warning mechanism in a paper or steel mill where a break in the sheets might require stoppage of the flow operation. The circuit is also suitable in star trackers, because of its high voltage gain (more than 100,000) and sensitivity (as great as 0.1 foot-candle).

The circuit has good noise immunity because of the diodes in the emitter and base of Q_2. Additional diodes in the emitter circuit will increase the noise immunity in the reset and turn-on lines. Reset is accomplished by a positive pulse at the reset terminal greater than the combined voltage drops of diode D_2, the base-to-emitter junction of Q_2 and



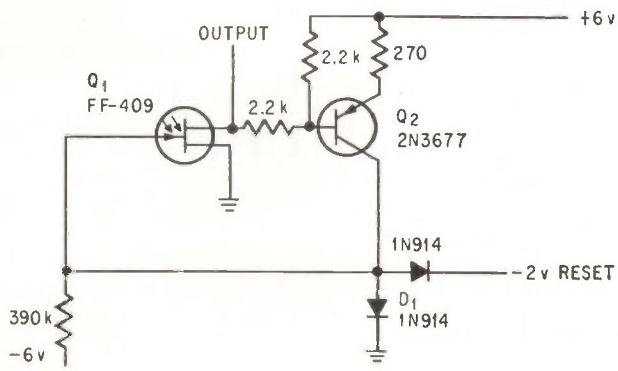
High voltage gain, good noise immunity and sensitivity are available from this arrangement. Transistor Q_1 is a light-sensitive field effect that triggers a positive output voltage when light is applied.

that produced across diode D_1.

A modified version of the circuit appears at the right. Here, Q_2 has been replaced by a pnp transistor. In this configuration, both Q_1 and Q_2 are normally off, and thus the circuit will not draw power until activated.

When light is applied, Q_1 saturates Q_2 and provides a positive potential, as before. This potential is fed back to the gate circuit of Q_1 to provide the hold potential.

Note that the anode of diode D_1 is connected directly to the gate to couple to the reset pulse and prevent positive excursions greater than 0.7 volt from appearing in the gate circuit. This version does not have as much noise immunity as the npn circuit.



By using a pnp transistor for Q_2 instead of an npn, the circuit remains in an off state until activated by the light source. Thus, no power is dissipated by the circuit. Noise immunity for this arrangement is poor.

Unijunction memory stores until readout

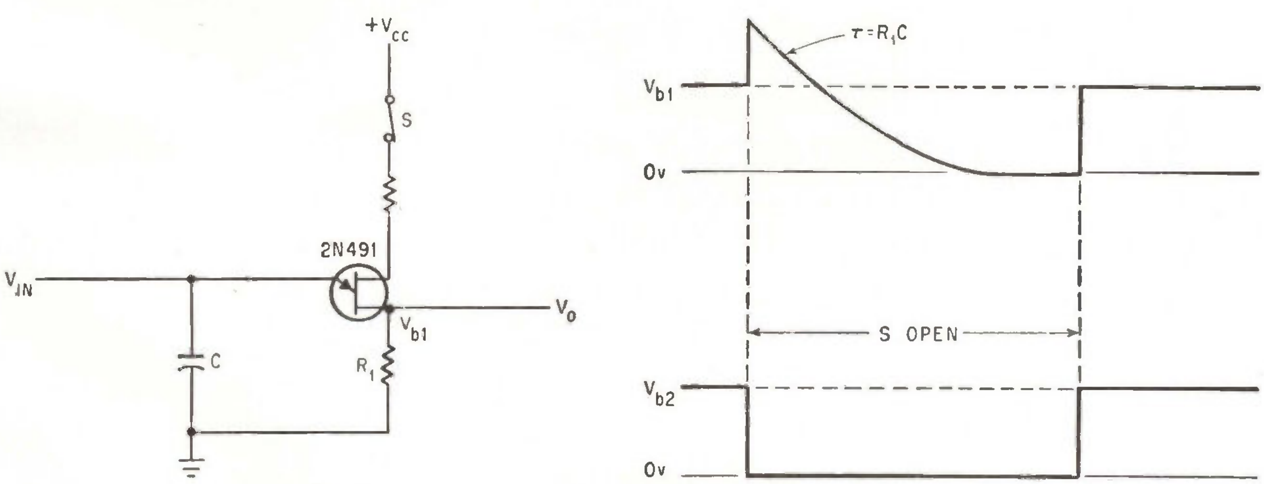
By R.G. Malm

Westinghouse Electric Corp., Baltimore

A unijunction transistor can provide a simple and inexpensive memory circuit if destruction of information during readout is permitted. Storage times from 5 to 10 minutes can be readily obtained if the quality of the storage capacitor is high and the leakage of the transistor is low.

To store the information, a voltage greater than V_{b1} but less than $V_{b1} + \eta V_{bb}$ is applied to capacitor C. The intrinsic ratio η is a parameter of the transistor and varies from 0.56 to 0.68 for this unijunction. Thus, the emitter-base junction remains reverse biased. When switch S is opened, V_{b1} drops until the emitter-base junction is forward biased; at which time the voltage across C, which is the negative of the normal work-function voltage, appears across resistor R_1. Capacitor C then discharges through R_1 and switch S can then be closed, resetting the memory.

To detect the presence of a voltage on C, the d-c component, V_{b1}, must be subtracted from the output V_0. Without a voltage on C no output is produced, as shown in the accompanying waveforms.



Several minutes of storage time can be obtained with the unijunction transistor in this circuit. Waveforms are a plot of output voltage, V_o, versus time. In the top waveform, with switch closed, the spike above V_{b1} initiates storage action. Bottom waveform, with switch open, shows O volts across C and no output voltage is produced.

Reference sheet

Nomograph finds output voltage error

Chart quickly evaluates performance of operational amplifiers from specified gain and offset parameters

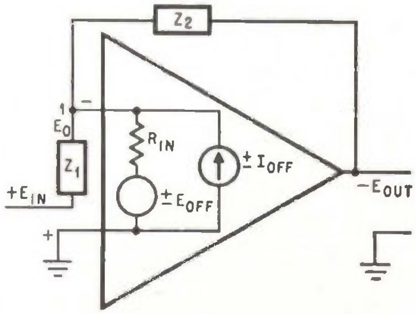
By Ed Schuck

Rosemount Engineering Co., Minneapolis, Minn.

The design and performance of operational amplifiers can be conveniently evaluated with the nomograph on the facing page. It relates voltage gain, offset voltage and current and input impedance to output error. Although based on a simple voltage amplifier, its application can be extended to integrators, differentiators or other specific types of operational amplifiers by appropriate characterization of impedances Z_1 and Z_2, as shown in the equivalent circuit below.

The standard parameters shown in the equivalent circuit are the input impedance R_{in}, offset voltage $\pm E_{off}$, offset current I_{off} and voltage gain A_v. They are usually specified by the manufacturer.

Offset voltage and current represent small, undesired signals generated externally by the amplifier and appear at its input. They can never be perfectly biased away, except at one moment in time, under one particular set of conditions. Output error represents the amount of deviation between expected and actual output.



Equivalent circuit for an operational amplifier including internal impedence R_{in} and offset voltage and current, E_{off} and I_{off}, respectively. For a specific operational circuit, such as a voltage amplifier or integrator, substitute the proper values for impedances Z_1 and Z_2.

By summing the currents that enter or leave node 1, using Kirchhoff's current law, an expression for the output voltage can be found in terms of the circuit parameters. Thus:

$$\frac{(E_{in} - E_o)}{Z_1} + \frac{(\pm E_{off} - E_o)}{R_{in}} \pm I_{off} = \frac{(-E_{out} + E_o)}{Z_2} \quad (1)$$

But,

$$E_{out} = E_o A_v \quad (2)$$

And, when equation 2 is substituted into equation 1 an expression for E_{out} is derived. Hence:

$$E_{out} = \frac{-E_{in} Z_2}{Z_1} \frac{\left[1 \pm \frac{Z_1}{R_{in}} \frac{E_{off}}{E_{in}} \pm \frac{I_{off} Z_1}{E_{in}}\right]}{\left[1 - \frac{1}{A_v}\left[\frac{Z_2}{Z_1} + \frac{Z_2}{R_{in}} + 1\right]\right]} \quad (3)$$

Equation 3 is in the form that relates E_{out} to the constants A, B and C and the external impedances Z_1 and Z_2.

$$E_{out} = \frac{-E_{in} Z_2}{Z_1}\left[\frac{(1 \pm C)}{(1 - \frac{1}{AB})}\right] \quad (4)$$

where,

C = the offset term =

$$\pm \frac{E_{off} Z_1}{R_{in} E_{in}} \pm \frac{I_{off} Z_1}{E_{in}}$$

A = the voltage gain = A_v

B = the feedback gain =

$$\frac{1}{\left[\frac{Z_2}{Z_1} + \frac{Z_2}{R_{in}} + 1\right]}$$

Therefore, the error equation may be represented as:

Percent of reading error = 100

$$\left[1 - \left[\frac{(1 \pm C)}{(1 - 1/AB)}\right]\right] \quad (5)$$

A nomograph based on equation 5 evaluates the performance of an operational amplifier quickly and accurately.

Using the nomograph

For this example the impedances of Z_1 and Z_2 were chosen as resistances R_1 and R_2 respectively. The values were chosen so that $R_2 = 10\ R_1$, thus, if no error were present E_{out} would be 10 volts for an E_{in} of 1 volt. The manufacturer's data provided the following information regarding the internal parameters of the operational amplifier:

$R_{in} = 100{,}000$
$E_{off} = +1$ millivolt
$I_{off} = +0.01$ microampere
$A_v = 50{,}000$

It is desired to design an operational amplifier that has a percent error of 0.02. It is first necessary to evaluate the percent error for the given parameter values.

Step 1: Calculate the values for C and AB.

$$C = \left[\frac{\pm E_{off} Z_1}{R_{in} E_{in}} \pm \frac{I_{off} Z_1}{E_{in}}\right]$$

$$= \left[\frac{1 \times 10^{-3} \times 10^4}{100 \times 10^3 \times 1} + \frac{0.01 \times 10^{-6} \times 10 \times 10^3}{1}\right]$$

$$= 2 \times 10^{-4}$$

$$A = A_v = 50{,}000$$

$$B = \frac{1}{\left[\frac{Z_2}{Z_1} + \frac{Z_2}{R_{in}} + 1\right]}$$

$$= \frac{1}{\left[1 + \frac{100 \times 10^3}{100 \times 10^3} + \frac{100 \times 10^3}{10 \times 10^3}\right]}$$

$$= 1/12$$

$$AB = 50{,}000 \times 1/12 = 4.5 \times 10^3$$

Step 2: Locate the point 2 x 10^{-4} on the C scale of the nomograph.

Step 3: Locate the point 4.15 x 10^3 on the AB scale.

Step 4: With a straight edge connect the points selected in steps 2 and 3.

Step 5: Read the percent error on the center scale. For this example the percent output error is 0.045%. Therefore, if $E_{in} = 1$ volt, $E_{out} = 10.0045$ volts. Note that this percent error is not within the desired range.

Step 6: To determine the range, magnitude and sign of the offset term that would provide the required accuracy of 0.02%, connect the point 4.15 x 10^3 on the AB scale to the point +0.02% on the center scale by a line extending to the C scale and read the resulting offset term, which is —0.4 x 10^{-4}. This is the upper limit of the offset range.

Step 7: To determine the lower limit, connect the point 4.15 x 10^3 on the AB scale to the point of —0.02% on the center scale and read the resulting offset term on the C scale, which is —4.4 x 10^{-4}. Thus, the offset term C must be within the range

$$-0.4 \times 10^{-4} \leqq C \leqq -4.4 \times 10^{-4}$$

The amount of offset correction required is obtained by solving the following equation for E_{off} using the limits of C found from the nomograph:

$$C = \frac{Z_1}{E_{in}}\left[\frac{\pm E_{off}}{R_{in}} \pm I_{off}\right]$$

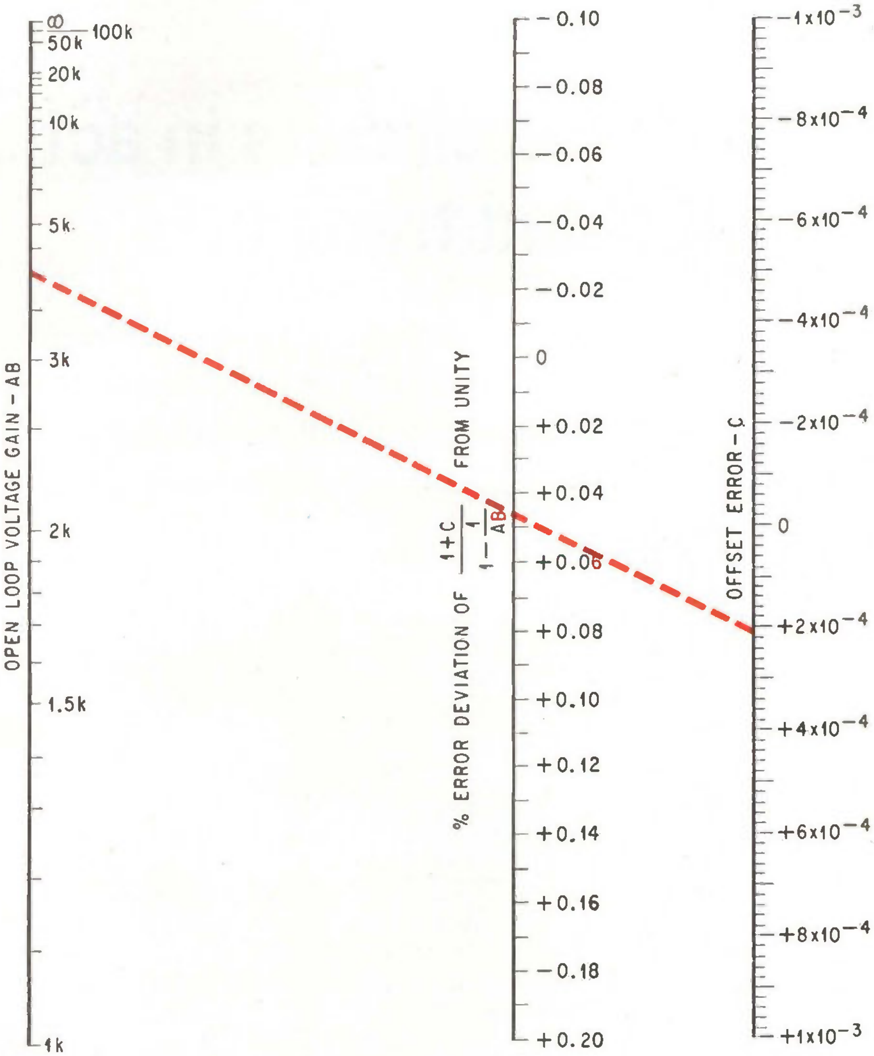
Substitution of the C values yields:

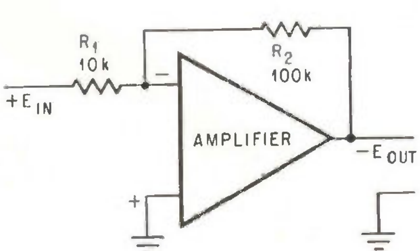
$$-1.4 \leqq E_{off} \leqq -5.4 \text{ millivolts}$$

Thus, if E_{off} is compensated between these values while maintaining the same offset current as before, the required accuracy of 0.02% can be achieved. Note that the nomograph scales may be changed if necessary by multiplying scale, AB, by a constant N and dividing the other two scales by the same constant.

Since the offset current and voltage are inherent in the manufacturer's design, the user has no control over them. If he cannot find another operational amplifier with the values desired, the designer must adjust the values of Z_1 and Z_2 to achieve the required accuracy.

Nomograph relating gain, offset and percent of reading error





When impedances Z_1 and Z_2 are resistances of 10 and 100 kilohms, respectively, this circuit functions as a straightforward voltage amplifier.

Integrated circuits in action: part II Trends and trade offs

While the designer of integrated circuit equipment is attempting to pick an approach and develop guidelines for using IC's, the ground rules covering costs and performance continue to change

By Donald Christiansen
Senior associate editor

The single factor in the design of integrated circuit equipment that can be varied without affecting others has yet to be pinned down. Perhaps it is the color one paints the cabinet. The designer attempting to refine the performance of his IC equipment by seeking a little more gain, a little more speed or a little less volume often feels he's got hold of a wineskin—when he presses in one spot it bulges in several others.

Furthermore, since the demarcation between the IC and the equipment in which it is used is shifting, the development of rules and relationships to guide designers is a difficult task. Among those factors that affect the big picture are availability and logistics as well as performance demands imposed by the equipment specifications.

Meeting the trade off challenge thus poses some of the most difficult questions the IC user will face.

Typical of the trends generated by the use of IC's are those illustrated on page 131: decreased material and labor costs, reduced bulk, simplified maintenance and shifting engineering work loads. Frequently encountered trade offs are illustrated on page 133: power vs frequency, spares requirements vs module complexity, numbers of pins vs equipment reliability, package size and packaging techniques vs volume, and system partitioning vs cost.

When, where and how many?

Foremost in the selection of IC's for a piece of electronic gear is the number of circuits required. Engineers at the Sperry Information and Communications division of the Sperry Rand Corp. examine what they term a yield-to-cost ratio, a figure of merit that is particularly sensitive to the number of ICs needed but previously unavailable.

In the yield are savings resulting from reduced cost of materials, size, weight and power requirements. Also considered to be part of the yield are increases in value of the system that result from increased reliability and performance. On the debit side of the ledger, Sperry lists additional engineering labor and vendor start-up costs.

Equipment delivery date can be a strong factor in the choice of IC concept. History, if not reason, teaches that schedules always deteriorate and Sperry engineers say that long lead times needed for special IC's are no exception. Therefore, probable delivery delays must be chalked up as a cost in the yield-cost ratio.

Sperry used the yield-cost ratio as a guide in selecting both digital and linear IC's for the microelectronic conversion of its passive-active detection and location (Padloc) sonar system (passive search and active echo ranging). For the logic in the bulk-delay and shift-register correlator the engineers chose a modified form of standard direct coupled transistor logic (DCTL). Only 3 different IC's were required: a dual NOR gate, a J-K flip-flop, and a buffer element.

In the linear data processing subsystem, a basic monolithic differential amplifier was chosen. It is used with thin film feedback circuits. A low noise version was required for the preamplifier circuit, and that was achieved through a minor masking change.

Buffer and clipper functions are accomplished using a single IC and appropriate separate feedback components. Sperry elected to go with discrete component voltage regulators, since only 10 regulator cards were required in the entire system.

I. How trends affect decisions

Switching to IC's is more like trying to jump aboard a fast train than onto the proverbial bandwagon. One IC user complains that the art will not hold still. Decisions valid today are obsolete tomorrow and one often must guess and gamble.

When Interstate Electronics Corp., a subsidiary of the Interstate Engineering Corp., Anaheim, Calif., considered the design for its 1010 medium scale computer, it decided to use monolithic IC's wherever possible. But since the 1010 is a commercial general purpose computer that must compete with machines like the IBM 1800, SDC 1700 and the Sigma 2—now dominating the market—cost is a major factor. One way Interstate trimmed costs was to specify standard circuits.

Although some of the circuits were not standard at the time of design, the firm had assurances from the vendor that they would become standard and that Interstate would benefit from a price reduction. Designers at Interstate took the gamble and won.

Engineers at Sperry were vexed by similar uncertainties in the linear or analog area, which they note is even more fluid than the digital area. The display console for the Padloc system houses conventional crt electronics and unique analog functions such as servo and write amplifiers.

Although most of these circuits could be realized in IC form, Sperry elected to forego that route in favor of conventional electronics. Present costs, they noted, could not justify IC's at the time of design. The need for designing one-of-a-kind circuits would tie up too many engineers for too long and leave small hope for an immediate return on the investment.

Another course that was considered and rejected was to digitalize as many circuits as possible, but since the microelectronic Padloc was a conversion from a discrete component version, the engineering was already done for those portions of the equipment that would not be converted to IC's. Finally, any gamble on devices that were not on the immediate horizon was impractical for one-of-a-kind applications in a system destined for shipboard use, where a purchase of more than 200 systems is rare.

Designers who pick a winner from the wide choice of standard IC's may benefit from reduced prices "down the road," brought about by volume purchasing of the devices by competitors, too. For example, one large IC maker estimates that 80% of new logic designs are being implemented in transistor-transistor logic (TTL), which suggests that price and performance competition among vendors of TTL will become bitter.

Can it be had?

Availability is unquestionably one of the most important influences on the designer's choice of IC's and IC packages, says Ralph Baer, chief engineer, equipment design, of Sanders Associates, Nashua, N.H. Five years ago the choice was simple, he notes. "It was either resistor-capacitor-transistor logic (Texas Instruments Incorporated Series 51) or direct coupled transistor logic (Fairchild's Micrologic)—there were no other serious contenders." And IC packages and packaging techniques were, he recalls, in "just about the same aboriginal state." Today the designer can select from among a variety of logic schemes—both saturating and nonsaturating—and packages.

How design decisions are tempered by time can be seen in this example: In 1963 Sanders undertook to redesign and repackage a rack-size airborne digital computer that had been built with discrete components. The computer had to be shrunk to a volume of less than 1.5 cubic feet. Sanders' engineers leaned on their previous experience with DTL and RTL, then opted for DTL for a number of reasons—among them better noise margins, lower can-count, and good availability.

Sanders' packaging engineers then decided to mount no more than 14 DTL flatpacks on one small plug-in multilayer printed circuit card. Each flatpack had 10 leads. The small p-c card was selected for reasons that in 1963 were entirely valid: parallel-gap welded IC's were not easily replaceable, making the card throwaway, and cost for a mil spec IC averaged $15-$20, yielding the required throwaway cost of under several hundred dollars.

Modules of this small size are usually best organized into general purpose categories such as shift registers, multiple gate cards and line driver cards—much like their predecessor discrete component cards. Advantages of this arrangement are well known: standardization and off-the-shelf availability. The chief disadvantage stems from the complexity of the back panel wiring. Since airborne equipment cannot accept the weight and volume of a complex harness, multilayer p-c boards were used. Twenty plug-in cards were interconnected by a 5-layer p-c board.

Today's approach

The small card approach, Sanders' engineers note, puts the burden on interconnections, and motherboard costs go up disproportionately with the number of layers. If the redesign of the airborne computer were to be attempted by Sanders today, an alternate approach based on a large subsystem, special purpose card would be used.

The large subsystem card would mount, say, 30 to 200 IC's. The approach is made feasible by the availability of 14-lead flatpacks and the reflow solder technique of attaching IC's so they can be replaced if necessary. Also, IC prices have dropped so that an entire board can be replaced at small cost.

Sanders sums up benefits of the large cards as follows: complete subsystems on one card mean fewer input-output connections—cards do not become pin-limited. In contrast, the smaller general-purpose cards often carry just a few IC's since they use up all the available pins. This is particularly serious in the case of multiple gate cards. With large cards, system reliability, a function of total pin interconnections, is boosted. Motherboard wiring is simplified; costs are reduced and reliability improved. Most systems in Sanders' experience can be interconnected using 2 or, at the most, 3-layer motherboards. Special 2-layer boards developed by Sanders (and for sale to competitors) permit unrestricted throughboard connections, and are easier and less expensive to lay out than conventional 2-sided boards. Finally, when connections are made all on one board the wiring runs can be made very short. Combined with higher speed IC's, system speeds can be boosted.

Most military and commercial digital systems now being designed by Sanders use the large card concept. A typical card from a second generation data processor has 50 flatpacks per card, pretinned land areas and solder pads for IC lead attachment and card connector attachment, respectively. As the number of IC's per card increases, the likelihood of repeating cards within a system decreases, and as a result the percentage of the total system represented by spare cards increases, as shown in the curve on page 133.

Not all systems designers have settled on the large card concept. The Martin Co., a division of the Martin Marietta Corp., for one, has elected to produce computers with a versatile single integrated circuit plug-in module [Electronics, Oct. 17, p. 68]. How the module approach selected affects system reliability is shown in the table on page 133, compiled by Jack Staller of Sylvania Electronic Systems division.

Hidden factors

Repercussions from the use of IC's are sometimes unexpected. Often overlooked in the cost of owning equipment containing large quantities of IC's is the logistic advantage of simpler maintenance and troubleshooting procedures, and the cost saving resulting from the need to order, stock, and release and keep records on fewer parts. Indeed, the system manufacturer benefits in the same way from simplified parts bookkeeping.

Higher parts densities in IC equipment virtually exclude the performance of maintenance at simple levels of system complexity. Larger modules are replaced in order to keep equipment operating. And these modules are often so complex that they are truly throwaway—field repair is virtually impossible, and maintenance depot repair is difficult and costly. With the improvement in module reliability afforded by the use of IC's, the maintenance organization as we know it today may atrophy; good maintenance technicians may become hard to find. On the other hand, even the high reliability levels achieved thus far in IC gear (0.0007%/1,000 hours for Minuteman) are insufficient for some applications, such as longtime deep space probes, and observers believe that the best answer is self-diagnosis and self-repair of this equipment.

II. The trade off tightrope

The alternative devices available to the designer are well known. Among them are monolithic semiconductor integrated circuits, thick film circuits with semiconductor chips added, thin film circuits with chips added, and modifications and combinations of all. One difficulty in selecting an approach is that as the art is refined in each area, some phases progress more rapidly than others. Techniques that once held an advantage, say in cost or in tolerances, may be downgraded. The objective designer must be ready to switch his allegiance; standing by a favorite method on an emotional basis can be disastrous.

A case in point, notes film-circuit expert Jerry Selvin, of Sylvania's Electronic Systems division, Waltham, Mass., is the changing picture in thin versus thick films. Sylvania, a subsidiary of General Telephone & Electronics Corp., has jettisoned most of the thin film equipment used over the past several years in favor of semiautomatic and automatic methods for production of screened ceramic IC's. Such circuits, Selvin says, can be produced by Sylvania at costs as low as one-fifth that of the cost of vacuum deposited thin film circuits—and, he emphasizes, with fabrication equipment considerably less complex and costly than that used by IBM for its thick film System 360 computer circuits.

No ideal technique

At this point in integrated electronics history, purists who say that the best integrated circuit is one produced by a single technique must be reluctantly labeled dreamers. A practical all-thin film, all-thick film or all semiconductor IC has not been developed. The monolithic IC perhaps comes closest, but even it requires a technique such as aluminum deposition to make appropriate interconnections between elements.

The battle of the techniques, most realists admit, is largely an artificial one and was born of the prejudices of device manufacturers and nourished by technical publicists and trade press writers seeking to glamorize a technology that does not require glamorizing.

Nevertheless, it can be recognized that films are more appropriate than monolithic IC's for some applications, and vice versa. It must also be recognized that, largely because the silicon monolithic IC is essentially self-contained, it is often looked at first when the designer considers IC's. He thinks of films and hybrid techniques as auxiliary methods when the silicon IC cannot do the job.

Monolithic silicon circuits

Many industry observers rank the semiconductor IC with the tube and the transistor in importance to the electronics industry. The National Aeronautics and Space administration is backing its belief that 80% of space systems electronics will consist of IC's by 1972, and that most will be

Production and engineering costs are shifting

IC's pare costs of discrete component equipment

Discrete components	Quantity	Unit cost	Total cost
Diodes	1512	$ 0.25	$ 378.00
Transistors	336	1.05	352.80
Capacitors	420	0.05	21.00
Resistors	1428	0.044	62.83
Printed-circuit boards	28	5.00	140.00
Connectors and hardware	29	2.75	79.75
Driver card	1	16.68	16.68
		Subtotal	1051.06
Labor			
Assembly			87.00
Back-panel wiring			149.40
Testing			43.50
		Subtotal	279.90
		Total	$1330.96

I-C Components	Quantity	Unit cost	Total cost
Dual input NOR	84	$ 2.65	$ 222.60
Dual 3-input NOR	42	3.20	134.40
J-K flip-flop	42	6.35	266.70
Buffer	14	2.55	35.70
Printed-circuit board	7	10.00	70.00
Connectors	7	2.75	19.25
		Subtotal	748.65
Labor			
Assembly			21.00
Back-panel wiring			29.40
Testing			10.50
		Subtotal	60.90
		Total	$ 809.55

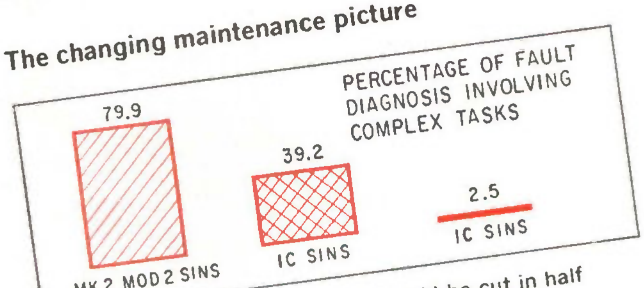
Costs for materials and labor required to produce a data processing system with integrated circuits are almost 30% and 40% lower, respectively, than estimated costs for a similar discrete-component system.

IC's reduce bulk of guidance computer

Equipment	No. of parts	Volume (cu. ft.)	Weight (lbs.)
Minuteman I (discrete components)	14,711	1.55	70
Minuteman II (integrated circuits)	5,510	0.39	32

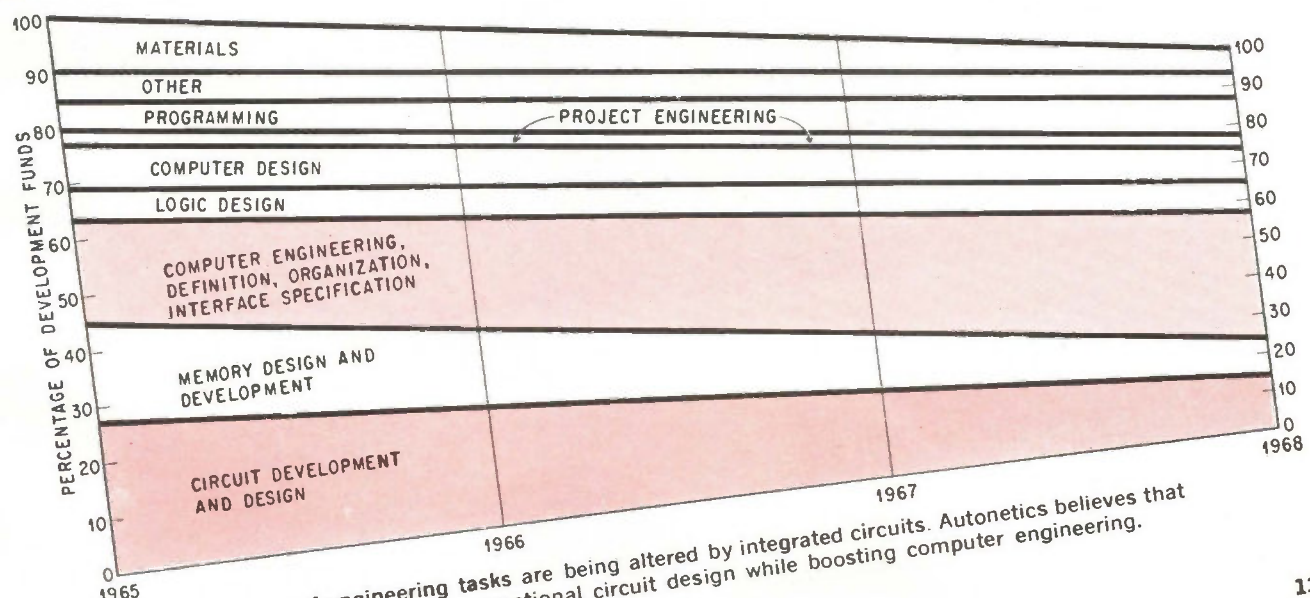
Changeover from discrete components to integrated circuits in the Minuteman missile guidance computer cut the computer's weight in half and reduced the volume by almost four times.

The changing maintenance picture



Maintenance aboard submarines could be cut in half (center) by IC version of Polaris ship's inertial navigation system (SINS), Autonetics estimates, and depot repair of modules would slash cost (right).

Shifting the work load



Relative proportions of engineering tasks are being altered by integrated circuits. Autonetics believes that large scale integration will reduce conventional circuit design while boosting computer engineering.

The name game: a clarification of terms

The label "integrated circuit" has been criticized as ambiguous while "microcircuit" and "microelectronics" have been called inapt as terms for integrated circuits and the IC art.

Recently the Institute of Electrical and Electronics Engineers approved "integrated electronics" as a generic term, defining it as "that portion of electronic art and technology in which the interdependence of material, device, circuit and system-design consideration is especially significant; more specifically, that portion of the art dealing with integrated circuits."

The rationale for discarding "microelectronics" and "microcircuits" is that they imply small size, which may be of only secondary importance in some cases. Nevertheless, "microelectronics" will probably die hard since it has gained wide acceptance. As a descriptive term to blanket the broad art that sometimes includes very small—but not integrated—devices, as well as IC's, it seems hard to beat.

Electronics magazine will generally use the IEEE terminology, reserving "microelectronics" as an exception to the rule when it seems appropriate.

Definitions for IC's . . .

Two or more elements inseparably associated on, or within, a substrate to form an electrical network or circuit is a broad definition for an integrated circuit. But more exact definitions of IC's and their parts avoid ambiguity.

- Monolithic IC has a single semiconductor body, such as silicon crystal as its substrate.
- Thin film IC is composed of elements formed by thin films— usually less than a micron thick— deposited on a substrate by techniques such as vacuum evaporation. The elements aren't necessarily passive.
- Thick film IC is similar to thin film IC except that the films are formed by a process such as screen printing and are much thicker than deposited films.
- Hybrid thin film or thick film IC has devices— typically transistors, diodes or monolithic IC's— added to the basic film IC.
- Multichip IC is an assembly of semiconductor device chips joined within a common package by jumper wires or by an interconnection pattern on the substrate or header. Strictly speaking, a device that also has passive elements formed directly on the substrate is not a multichip IC, but rather a hybrid IC.
- Functional electronic block has often been used as another way of saying monolithic IC, but it should be reserved for monolithic IC's whose elements are difficult or impossible to identify, or whose functions can't be pinpointed to a specific area of the device.

. . . and for IC elements

- Element is the smallest identifiable part of an IC, such as a single transistor, diode, resistor, capacitor or inductor.
- Device is a unit that can't function if its parts are separated. Integrated circuits, as well as components like transistors, are devices.
- Active element or device is one that exhibits gain. Strictly speaking, transistors—and sometimes tubes—are the active elements of IC's, but diodes are traditionally classified as active devices.
- Passive elements and devices are those that aren't active; for example a film resistor in a hybrid IC or a diffused resistor in a monolithic IC.

monolithic silicon devices, with a major study project.

At its Electronics Research Center, Cambridge, Mass., NASA is building and equipping a facility called Predict which will be used to fabricate silicon integrated circuits for its studies.

As NASA sums it up, the attributes of silicon IC's are low cost as a result of batch processing, reliability stemming from processing simplicity, and the ability to fabricate a variety of integrated devices merely by varying photographic patterns. Also, NASA cites the relatively small number of different materials required; fewer materials suggest higher reliability. Some circuits, for example, need only silicon, silicon oxide, aluminum and gold.

Many of the interconnections which were the system designer's responsibility in the days of discrete component systems have been absorbed by the integrated circuit—resulting in a system's greater inherent reliability. According to one engineer at Sperry, it becomes the designer's task to retain within the system the improvements in performance and reliability that the IC offers him.

Today, many IC's, particularly those in flatpacks, require exotic packaging technology. The density of interconnections has reached the point where manual handling is difficult, if not impossible. Also, power density is higher even though power dissipation is less per element, Sperry designers point out. The incompatibility of achievable element densities and present interconnection technology is spotlighted by the knowledge that Sperry's Univac designers could build a complex thin film memory in an inch-cube, but they wouldn't be able to make the one million connections to the cube that would be needed—and the problem of heat removal has not even been considered.

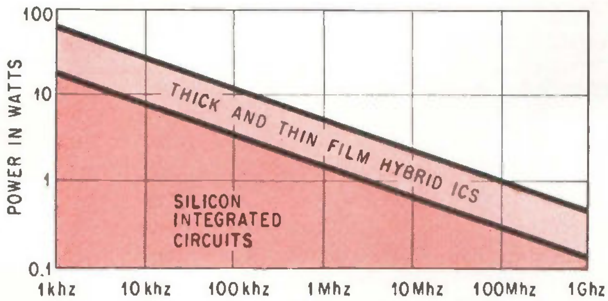
The limitations of monolithic circuits are pretty well known. Tolerances on individual elements better than 20% are difficult to achieve, and sometimes tolerances are much worse. It is possible to fabricate diffused resistors above 100 kilohms, but device manufacturers are reluctant to include resistors having a total value of 50 kilohms in standard IC's; they'd prefer to do without them altogether if possible. Likewise, IC makers feel reasonably comfortable with capacitors of about 25 picofarads, but they begin to rebel at 50 picofarads and insist that 100 picofarads is a shameful waste of valuable silicon into which several transistors could have been built.

Metal oxide semiconductor

Metal oxide semiconductors (MOS) will compete with monolithic silicon IC's in some areas, but are expected by the experts to offer cost rather than performance advantages. Present speeds are in the 1-2 Mhz range, two or three orders of magnitude below the theoretical limit. Chief advantages are expected to be in medium speed, large, complex arrays. The MOS transistor can be used as a resistor having values up to 200 kilohms. Since resistivities are as high as 200,000 ohms per square, MOS

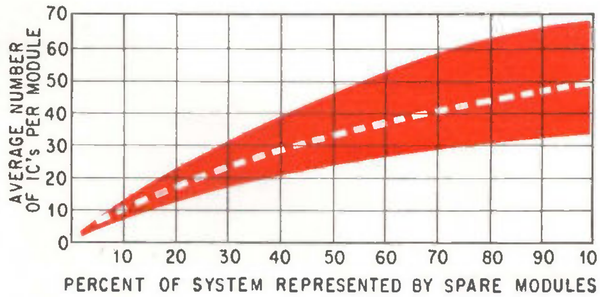
Power and packaging determine IC choices

Power-frequency trade off



Approximate performance envelopes for monolithic integrated circuits and thick film and thin film hybrid circuits show that hybrid IC's with attached active devices are needed for higher power and frequency.

Spares are a function of module complexity



As more IC's are crammed in a module, the types of spare modules needed rises. Dotted line represents a general purpose computer containing about 3,600 IC's. Curve reflects experience at Sylvania Electronic Systems.

How partitioning affects equipment reliability

Module approach	Smallest replaceable unit (SRU) size in no. of IC's	No. of SRU's	No. of SRU types	Total connecting pins	Failure rates Per SRU	In back wiring	% in back wiring	System MTBF Hours	System failures per year
Single assembly	3689	1	1	580	14.904	0.000	—	6710	1,306
Large card	119	31	26	5,199	0.4867	0.070	0.46	6598	1.328
Small card	9	410	15	21,900	0.0388	1.1385	6.7	5865	1.494
Individually pluggable	1	3689	15	44,848	0.0040	4.558	23.6	5178	1.692

Larger modules and fewer friction-type connector pins increase system reliability. The large, 119-IC card represents Sylvania's MSP-24 computer. Values for other sizes are extrapolated. Minuteman device and interconnection reliability is assumed.

The impact of IC packages and packaging

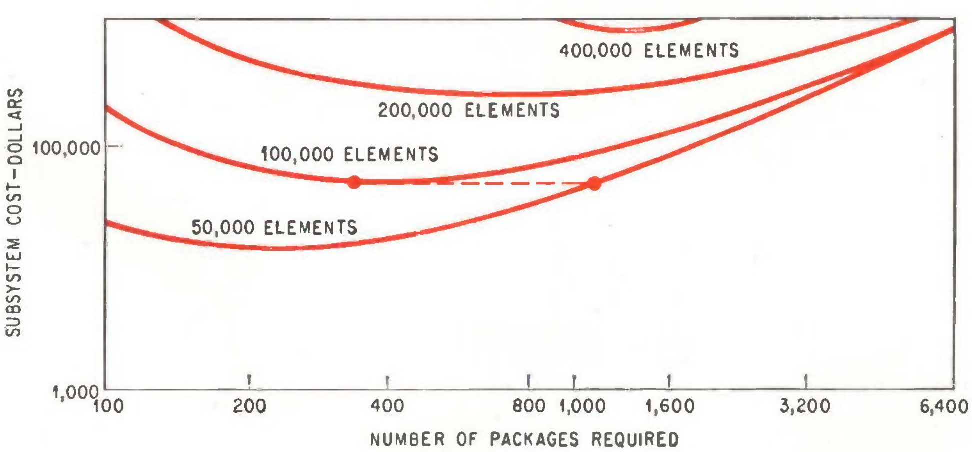
Type of package	Packages per sq. in.	Packages per cu. in.
Dual in-line	3.2	12
TO-5	6.3	23
1/4 x 1/4 Flatpack	7.0	47*-107**
1/4 x 1/8 Flatpack	10.3	69*-154**

*Plugged in **Stacked arrays

Type of packaging	Volume of IC's as a percentage of total volume*
1-Sided PC Board	1-3
2-Sided PC Board	2-6
Volumetric (3-D)	5-25

*At the subsystem level

Best-case packaging densities for four types of IC packages, assuming clearances are minimum and flatpacks in stacked arrays are in contact. Sylvania's findings on volumetric efficiencies are shown at the right.



Poor computer subsystem partitioning can wipe out cost advantages gained at the logic engineering stage. In Autonetics study, based on IC's containing similar repetitive elements, subsystem cost bottoms at about 250 elements. If the 50,000-element system were partitioned at a 40 element per module level, (dotted line) it would match cost of the optimized 100,000-element system.

Selection of integrated circuit types is guided by process capability

	Monolithic		Thin film		Thick film
Integrated circuits	Bipolar Silicon	Metal oxide Silicon	Evaporated thin film	Sputtered tantalum thin film	Screen printed thick film
Advantages	Reliability and long life low cost high density low weight standardization amenable to high production	low cost simple design high density resistivities to 20 kilohm/□ amenable to redundant design direct coupling avoids capacitors symmetrical switching capabilities	Good line definition high reliability high precision wide choice of materials permit 1:1 translation from discrete component design amenable to production of interconnections	good line definition high reliability high precision by anodizing	low cost simple production techniques amenable to production of interconnections resistivities of 1-20 kilohm/□ capacitance of 500-500,000 pf/sq. in. high power capability
Limitations	Power-frequency product high development cost loose tolerances diffused resistivities are 100-200 ohms/□	limited frequency capability	active devices must be added exhibit unique failure modes low sheet resistivity production procedures can be complex	active devices must be added specialized production processes needed	active devices must be added trimming required for close tolerances high voltage coefficient nonlinear temperature characteristic

resistors can offer savings in area usage over diffused resistors.

Multichips

A compromise art used early in the history of IC's was the so-called chip and wire technique. This concept, in which several silicon chips, each containing relatively few elements, are connected within a single package, got around the problem of low IC yields. It helped get equipment built with IC's fast, and familiarized designers with IC's.

In some cases, the better isolation between elements that this multichip technique afforded resulted in higher circuit performance. Though fewer simple multichip circuits are built today, the concept has not necessarily reached the end of its lifespan. For example, C.F. O'Donnell, vice-president of Autonetics, points out that even with large-scale integration, the multichip approach can be used. Autonetics is a division of North American Aviation, Inc. As a monolithic array of IC's gets bigger, O'Donnell notes, yields decrease. One way around low yield is to use discretionary wiring in which only the good circuits in a wafer are connected by a unique wiring pattern. But in O'Donnell's view, discretionary wiring is the wrong way to go. He suggests that arrays should contain only those devices that represent economical yields. In other words, if X number of devices cannot be sawed from a single wafer with a high probability that they'll all be good, then the designer is trying to get too many devices in the single chip. If necessary, smaller arrays can be joined as multichips.

The multichip approach has already been scaled up and refined for military avionics projects.

Thick films and thin films

While the silicon IC versus film circuit controversy may be a battle of paper tigers, the thick versus thin film contest has drawn real blood. In many cases the two techniques can do the same job, albeit by different routes.

S.M. Stuhlbarg, manager of Raytheon's microelectronics facility at Bedford Laboratories, Bedford, Mass., gives some rules of thumb. Stuhlbarg says highly complex, close tolerance analog applications requiring extremely good resistor stability call for thin film hybrid IC's. On the other hand, he notes, when hybrid IC's are needed in high production quantities, and when a large number of different circuit types are required, thick films may be the better route. Furthermore, Stuhlbarg indicates, the major need of a systems manufacturer may determine which facility he sets up; if he requires just a few complex analog IC's it may not pay to set up a thin film lab—he can buy them from outside suppliers.

Proponents of the thick film process emphasize its applicability to high volume use at relatively low cost. Several years ago, when rumors leaked through IBM's tight security that the computer giant was experimenting with thick films, sceptics scoffed at the suggestion that a "gross" technique used to put decorative designs on china could also be used to produce circuits accurate enough to compete with thin films. Yet the technique had already been used to make resistor networks and micromodule components, and IBM turned it into a highly accurate automated process for building hybrid IC's with the power required by high-speed computers, at a time when IC's were still a risk in terms of performance and availability.

Today IBM and others are building circuits that contain components as accurate as 1% achieved by trimming them after they're formed. Thick film circuits contain screened-on conductors, resistors and capacitors atop a ceramic substrate. Selvin of Sylvania boasts of resistors in the megohm range, and of power-handling capability of 20 watts per square inch at 125 degrees C. Capacitors in the hundreds of picofarads are possible, he says, and capacitance per square inch exceeds that of tantalum thin film circuits [Electronics, Oct. 17, 1966, p. 72] which is generally given as 1.0 microfarad per square inch. Breakdown voltage of capacitors can exceed 4 times that of tantalum film capacitors, which are rated at about 25 volts, Selvin claims.

Objectors to thick films suggest that circuits just as small and reliable can be made using microminiature discrete components. Yet the appeal of thick films is quite obviously that they avoid many of the one-by-one interconnections needed with discrete components. And it seems likely that thick film hybrid IC's in the near future will contain just as many silicon IC's as transistors.

Thin films smaller

Thin film boosters claim that thin film hybrid IC's can be significantly smaller than their discrete component counterparts, though they might cost more, particularly in moderate quantities.

Resistances up to a megohm can be fabricated by vacuum deposition and up to 1.5 megohms by sputtered tantalum methods. Yet makers of vacuum deposited circuits are likely to suggest that the line be held at 20 kilohms. A 50-kilohm resistor gobbles up a lot of area. Tolerances on resistors before trimming are about ±20%, and on capacitors are about ±10%.

In the case of tantalum circuits, resistors are adjusted and stabilized by anodizing at above 300 degrees C. Resistance is monitored during anodizing; when high precision is needed, values can be brought to within ±0.02%. Sheet resistivity for the tantalum circuitry ranges from about 50 to 500 ohms per square. Power dissipation for the tantalum film circuits is above 4.5 watts per square centimeter.

Both thick and thin films offer the possibility of a one-to-one conversion from discrete component circuits—and therefore may be favored by designers faced with short equipment delivery times or beginners who have little experience with monolithic silicon IC's. Films have an obvious role in circuits requiring high value, high power resistors.

The table at the left compares IC's. The values given are a cross section of industry opinion, not the maximum values that can be achieved by exotic processes or at the expense of another parameter, such as temperature stability or reliability.

Guidelines for selection of IC's

While cost and performance are widely recognized as criteria for evaluating alternative equipment designs, they are not much good to the designer who has to pick the best IC's for his project. They are too general. Instead, suggests C.F. O'Donnell, vice-president of research and engineering for the Autonetics division of North American Aviation, Inc., the designer can assess the suitability of IC's by examining three areas—design, fabrication and field use—and asking himself the following questions:

Design

- How good is the basic IC?
- Does it provide the wanted function (minimum volume, weight, power, cost)?
- Is there a good possibility that it can be produced more cheaply and that performance can be improved with time and usage?
- Is it versatile—can it be used many times or in a variety of ways in the equipment?
- Will it survive in operating environments?
- Will it function over the required temperature range and meet shock, vibration and radiation requirements?
- Will it satisfy interface tolerances (input and output signal levels and impedance matching).

Fabrication

- Does the IC lend itself to automated handling and package assembly?
- Does it facilitate easy testing at both subsystem and system levels?
- Is the cost of related tooling and special test equipment prohibitive?
- Is availability and delivery of the IC's good?
- Can the devices be easily and reliably interconnected?
- Can meaningful, manageable specifications be written to characterize the IC?
- Are the IC's interchangeable with similar devices from alternate sources?

Field use

- Can faults be easily located?
- How simple is the maintenance problem—particularly from the standpoint of stocking and handling spares?
- How good is operating reliability?
- Is operation availability (low down time) of equipment adequate?
- Does the IC approach considered lend itself to the use of redundancy, self-diagnosis and/or self repair of the equipment?

Avalanche transistors drive laser diodes hard and fast

Pulser circuit in injection lasers produces short, high-current pulses for high resolution radar

By Herman E. Brown and Robert A. Bond,
University of Texas, Austin

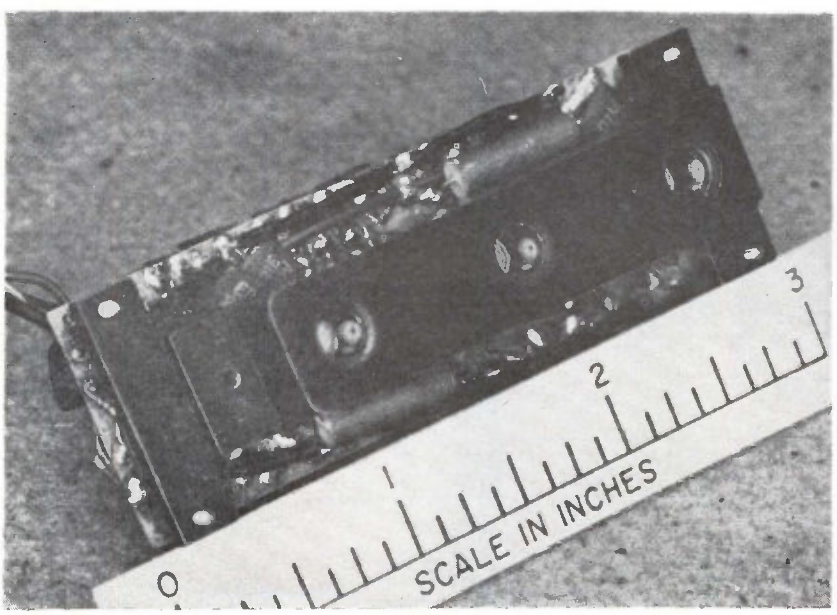
and James C. Bloomquist,
Eglin Air Force Base, Fla.

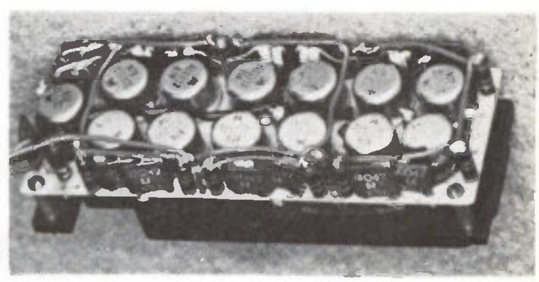
Among the men who experiment with lasers, the high-intensity, extremely narrow light beam emitted by the injection laser offers great promise in ranging applications. In fact, they reason, ranging equipment built with the laser diode ought to be more accurate than a conventional radar. So far, realizing such a range finder has been slowed by the lack of a suitable driving circuit for the laser. The resolution of a laser range finder depends on the maximum repetition rate, the rise time and the length of the laser driving pulses and these, in turn, depend on how efficiently excess heat is removed from the laser diode.

A pulser circuit, specifically designed to drive gallium-arsenide laser diodes, produces high-current pulses of extremely short duration and fast rise time. Its secret: using the avalanche mode of operation in silicon epitaxial annular transistors.

If high enough voltage is applied to the collector, avalanche multiplication of carriers will occur in the depletion region.[1] The transistor becomes a low-resistance, fast electronic switch, capable of providing short duration, high-current pulses.

Good quality laser diodes operating at room temperature require about 75 to 100 amperes of driving current to exceed the lasing threshold.





An array of three laser diodes with lenses and pulsers seen from the front (left) and back. Each section of the array, clearly indicated in the front view, generates 10 to 15 watts peak power through the entire system. The unit is less than 3 inches in length and 1 inch in depth and width.

Typically, the better diodes will radiate about 10 to 15 watts of peak power when pulsed with 150 to 200 amperes.

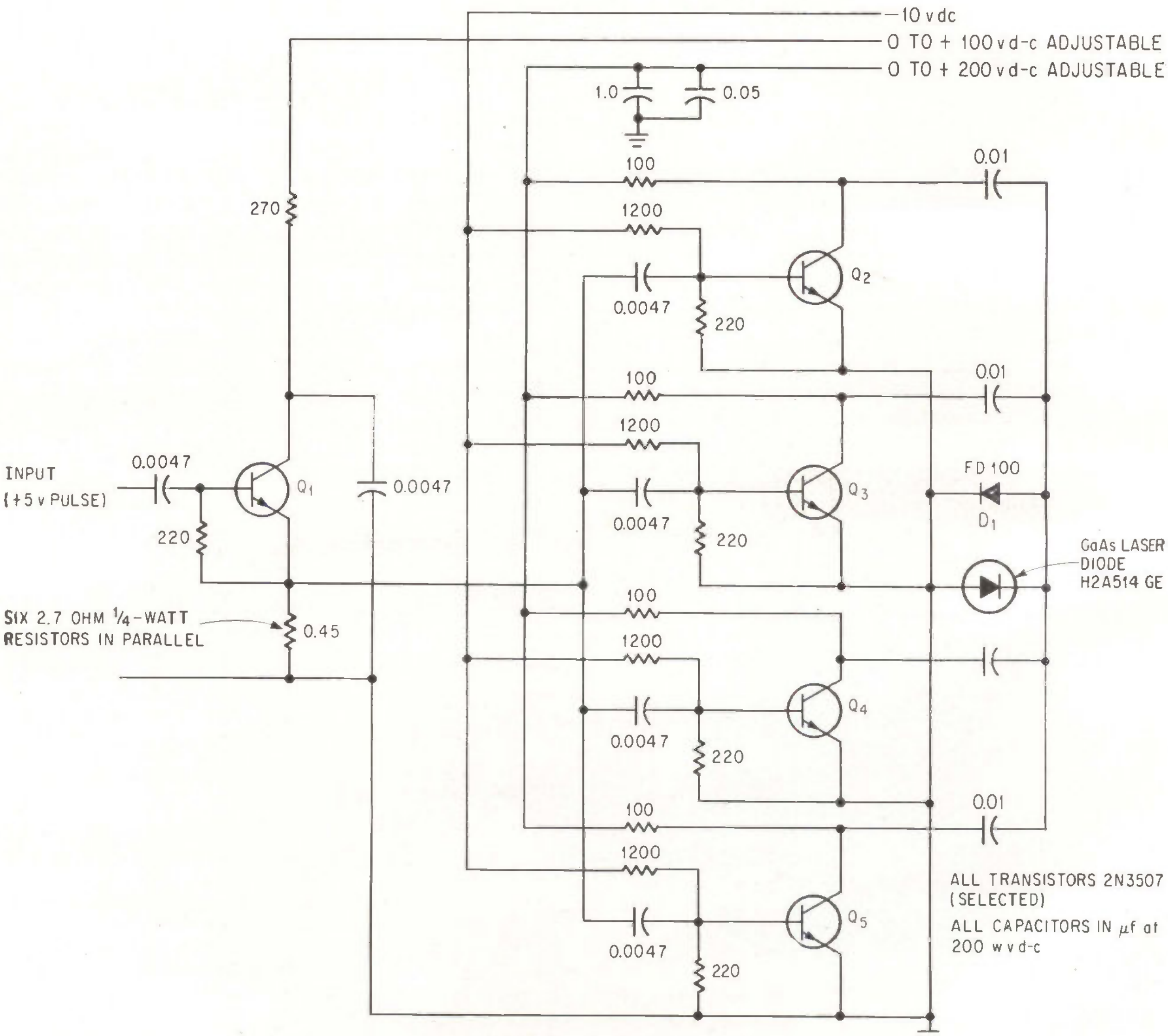
Since the diodes do not have sufficient area to dissipate the heat, to prevent burnout of the diode the lasing device must be pulsed instead of run continuously. At the same time, pulsing has to be carefully regulated or the power rating of the diode will be exceeded, destroying the semiconductor. Current pulses are kept as short as 50 to 100 nanoseconds to prevent such damage.

How pulse length affects resolution can be determined by the rule of thumb that a 2-nsec duration is equivalent to about 1 foot in range. In a standard radar system, rise times are in the order of 50 to 100 nsec. In the laser system, by contrast, rise times are only about 10 nsec and measurements are to within ±2.5 feet.

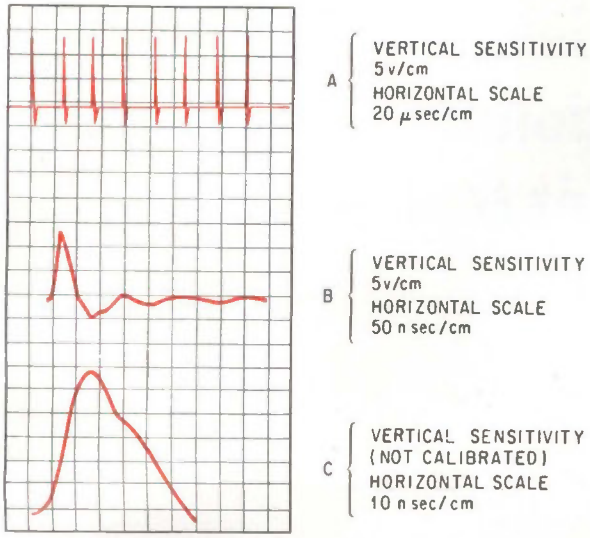
The circuit below pulses room-temperature GaAs laser diodes continuously at rates up to 10 kilohertz, or up to 100 khz provided the duty cycle (ratio of on-time to total cycle time) does not exceed that for continuous operation. Pulse length is about 60 nsec with peak currents approaching 200 amperes, depending upon the circuit's inductance and the potential that charges the collector capacitors.

Transistors act as switches

In operation, the 0.01-microfarad capacitors are charged to the applied potential through the 100-ohm resistors and the charging diode D_1. The four parallel npn transistors operate in the avalanche mode and act as switches, opening and closing at the applied trigger rate. When a 5-volt trigger pulse is applied to each transistor base, the base-to-emitter and base-to-collector junctions break down, producing a collector-to-emitter short circuit. When breakdown occurs, the collector capacitors discharge their stored energy through the laser diode. With the transistors in the avalanche mode, the total circuit impedance is less than 1 ohm.



Laser diode pulser circuit with 0.01-microfarad collector capacitors are charged to potential of 150 volts through the 100-ohm load resistances and the charging diode, D_1. Collector capacitors discharge their stored energy through the laser diode during the avalanche breakdown of transistors Q_2 through Q_5.



Typical current pulses reach a peak within 10 nanoseconds and last 50 nsec at a pulse rate of 45 khz. Expanded waveforms B and C show pulse in detail.

In each collector capacitor the stored energy $E = 1/2CV^2$, where V is the applied voltage. If the applied voltage is 150 volts, the energy will be approximately 10^{-4} joules. Dissipation of this energy in 10^{-7} second produces a peak power of about 1,000 watts. Since there are four parallel circuits, the total peak power will be about 4,000 watts. Efficiency of high-quality laser diodes at room temperature is about 0.3% and the beam output is about 12 watts.

The laser diode must be protected from damage caused by a shorted transistor or collector capacitor. This is accomplished by placing the laser diode in series with the collector capacitors and by paralleling it with a fast charging diode, D_1. If one or more of the pulser transistors are shorted, the d-c supply current does not pass through the laser diode. If any collector capacitors become shorted, the charging diode, which is forward biased, protects the laser diode.

Emitter follower, Q_1, is also operated in the avalanche mode to obtain the desirable fast rise time of 10 nsec and the low driving impedance for the laser pulser.

Q_1 is placed in the avalanche mode by applying a positive 5-volt input pulse and adjusting the collector potential until a stable avalanche condition is obtained. The emitter load resistance is adjusted by paralleling 2.7-ohm, ¼-watt resistors until the required 5-volt trigger pulse is obtained.

D-c breakdown key parameter

Since high peak current requires relatively high collector voltage, the most important transistor parameter for Q_2 through Q_5 is the d-c breakdown voltage from the collector to emitter (BV_{CEX}). A 10% larger breakdown voltage can be obtained with the Motorola 2N3507 transistor by reverse biasing the emitter-to-base junction. After considerable study this transistor was selected for three reasons:

- It avalanches at a relatively high voltage—usually 140 volts, but can be as high as 190 volts.
- It has a low failure rate under maximum operating conditions.
- And it requires no heat sink when operated below 10 khz because the TO-5 transistor case dissipates heat adequately.

The pulse circuit is difficult to construct primarily because inductance must be minimized. A small amount of wire in the circuit contributes a fairly large amount of inductive reactances when 50- to 100-nsec pulses with 10-nsec rise times are generated. The best way to reduce the inductance and still obtain up to 200 amperes peak current is to keep the current path very short. A complete pulser can be constructed with a volume less than ½-cubic inch. Careful location of the components restricts the effective current path to less than ½ inch. Typical current pulses generated by the pulser are shown at the left.

The photo on page 137 shows an array of three laser diodes assembled with collimating lenses and a pulser circuit for each diode. The three diodes are aligned so that their beams are parallel; however, they can be spread into a divergent beam for less intensity but wider coverage.

Reference

1. Lloyd C. Hunter, "Handbook of Semiconductor Electronics," Second edition McGraw-Hill Book Co., 1962, pp. 14-26.

Acknowledgment

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The authors

Herman E. Brown, heads the Electro-Optic Development Section of the Defense Research Laboratory at the University of Texas. His principal duties are the design, development and analysis of electro-optical systems.

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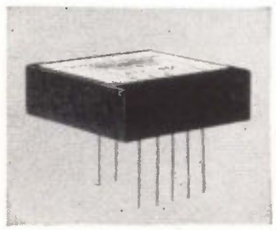
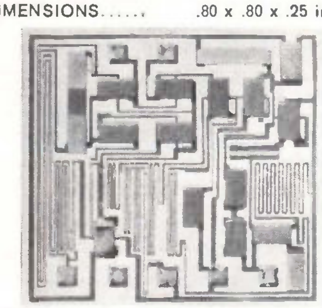
James C. Bloomquist is with the Missiles Branch of the Air Force Armament Laboratory, Eglin Air Force Base, Fla. He has long been interested in advancing the state of the art of laser technology.

Amperex announces the ATF-401... the operational amplifier made possible by our special production-line methods and thin film/LID circuit technology...

IF THIS  DOESN'T HYBRID LINEAR IC'S,

ATF-401 OP AMP QUICK REFERENCE DATA

VOLTAGE GAIN	
(open loop, $R_L = 5k$)	50,000 min
FREQUENCY FOR UNITY GAIN	2 MHz min
RATED OUTPUT	± 11V @ ± 2.2 mA min
INPUT NOISE ($R_{in} = 1k$)	5 μV max
INPUT VOLTAGE	
OFFSET	10 mV max
(externally adjustable to zero)	
TEMPERATURE DRIFT	10 μV/°c max
INPUT CURRENT	
OFFSET	50 nA max
TEMPERATURE DRIFT	2 nA/°c max
INPUT IMPEDANCE	
DIFFERENTIAL	200 kilohms min
COMMON MODE	10 megohms min
POWER REQUIREMENTS	
OPERATING (under load)	±15V, ±7 mA max
SHORT CIRCUIT CURRENT	± 20 mA max
DIMENSIONS	.80 x .80 x .25 inches



ATF-401 OP AMP BEFORE ENCAPSULATION

MAKE THE CASE FOR NOTHING WILL!

The ATF-401 is a thin film, linear, hybrid IC offering the best combination of price, size and performance of any monolithic, discrete or hybrid op amp now available

Hybrid circuit technology, given its biggest boost in years by the introduction of Amperex LIDS last March, takes another leap forward with the introduction of the solid state ATF-401, the first commercially available linear hybrid integrated circuit employing LID technology.

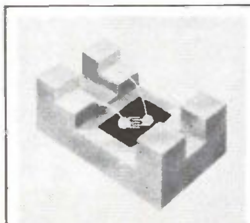
Using LIDS and the advanced micro-circuit design and production technology developed at Amperex during the past several years, we are now able to produce large volume runs of all kinds of hybrid IC devices, both as off-the-shelf items and as custom production circuits to meet your special system requirements. Combining the advantage of discrete-component circuitry (performance) with the advantage of monolithic IC's (low cost), Amperex hybrids, made with Amperex LIDS offer high performance at low cost, plus the third big bonus—small size.

The ATF-401 at $29.00 each, in hundred lots, outperforms many discrete op amps and without exception any monolithic op amp available. Further, since the ATF-401 is fully frequency-compensated it requires no external circuitry which would increase its effective size.

Take a look at these specifications:

- Open loop gain 50,000 (min)
- Full output to 10 KHz
- Gain bandwidth product of 2 mHz
- Temperature drift of only 10μV/°C and 2 nA/°C
- Long term stability of 25 μV/day
- Maximum noise contribution of 5 μV referred to input
- Common mode rejection ratio of 80 db (min)
- Complete short-circuit protection of all terminals
- All this in a small package less than 0.15 cubic inches

The ATF-401 is ideally suited for signal conditioning amplifiers, test equipment, control systems, AC and DC comparators, servo amplifiers and all instrumentation, computing and control applications where low-cost, small size, long life and low power consumption are of prime importance.



LIDS (Leadless Inverted Devices) are the micro-electronic packages for semiconductors that permit mechanized production of hybrid integrated circuits.

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TOMORROW'S THINKING IN TODAY'S PRODUCTS

Current dividers convert digital signals into analog voltages

A constant current repeatedly halved according to the digits of a binary number drives an amplifier whose output analog voltage is proportional to the input digital signal

By Herman Schmid

General Electric Co., Johnson City, N.Y.

A digital-to-analog converter in a single integrated circuit package is now feasible. The new technique employs active current dividers and does not depend on precision resistors as do conventional digital-to-analog conversion techniques.

A 10-bit prototype, built with discrete components, provides an accuracy of better than $\pm 0.05\%$ of full scale at room temperature and better than $\pm 0.125\%$ from 0 to 75°C. It will also work, at reduced accuracy, over the full military temperature range of $-55°$ to $+125°$C.

The new device also exhibits superior dynamic performance, offers significant reductions in size and weight, and will cost much less when built in quantities. The new converter thus helps to satisfy a growing need for simpler and smaller interface circuits between integrated digital control circuits and analog sensors and controls.

With present technology, a six-bit converter can be built as a single monolithic device. Converters with higher resolution can be made by putting the additional divider stages on a separate chip, with provision for external trimming resistors. As the technology improves, more stages in a single monolithic package should be possible.

Most digital-to-analog converters now in use employ either the weighted resistor technique at top right or the resistor ladder technique at center right.[1] The performance of both designs depends directly on the resistors' precision and on the accuracy of the transistor voltage switches. Building good transistor voltage switches as monolithic integrated circuits is difficult, and building monolithic IC's that incorporate precision resistors is not practical at present.

Conventional converters present several problems, even when built with discrete components. For example, a 10-bit weighted-resistor converter requires resistors with magnitudes ranging from 1 kilohm to 1 megohm. The higher-value resistors are bulky and expensive, and the lower values present an intolerable load to the analog voltage switch. The resistor ladder network overcomes these problems, but it requires twice the number of switches like the one at bottom right; this causes a significant increase in complexity and cost. Finally, the reference voltage supply must not only produce precise voltages, but must also drive half the number of switching transistors. This heavy load cannot be underestimated, especially when several converters share the same reference supply.

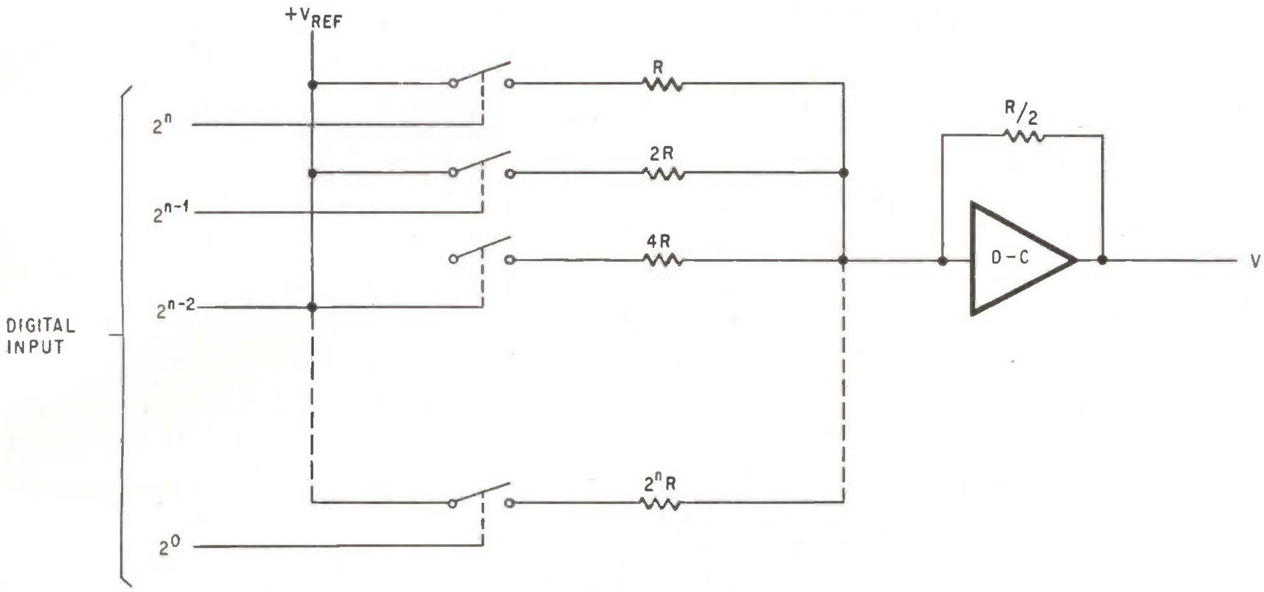
Dividing the current

The new design for a digital-to-analog converter is basically a series of cascaded current dividers each of which has two outputs as shown on page 144. One output is the current source for the next divider in the cascade; the other is gated to the output amplifier or to ground, depending on the state of a switch controlled by the binary digit to

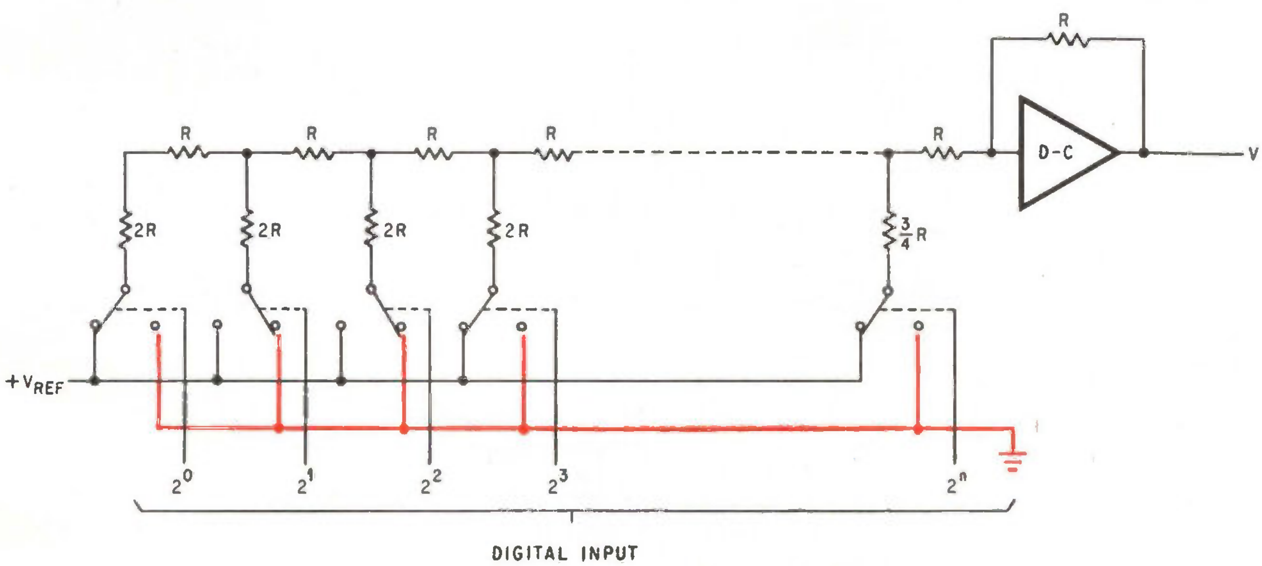
The author

Herman Schmid, of GE's avionics control business section, has applied for a patent on the new digital-to-analog converter. He has designed analog computing circuits since receiving his bachelor's degree in Germany in 1950. He also has a master's degree from Syracuse University.

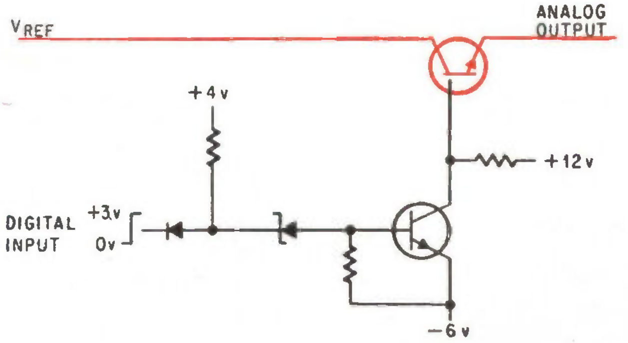
Conventional Converters



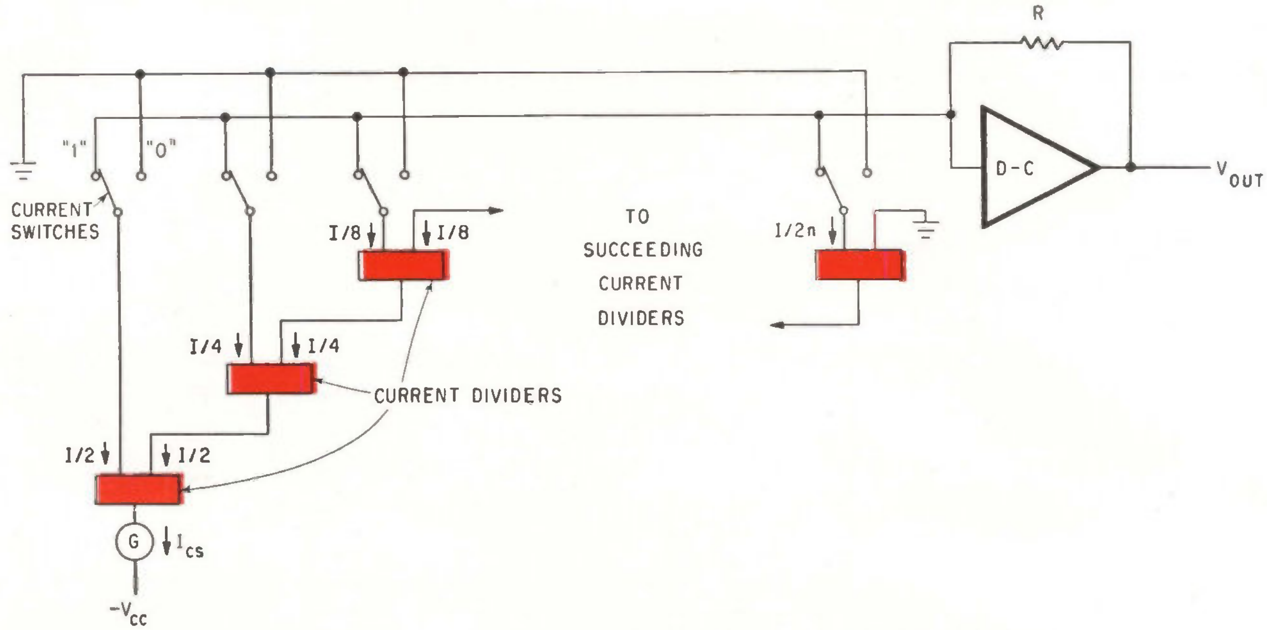
Weighted resistor digital-to-analog converter is a conventional design that requires precision resistors with a wide range of values.



Resistor ladder network, another conventional converter, requires precision resistors and an extra set of solid state voltage switches, shown in color.



Series analog voltage switch used in some conventional digital-to-analog converters. The two transistors and the multiplicity of power supplies make it expensive and inconvenient for systems using IC's. The circuitry in black merely switches the transistor shown in color.



Cascaded current dividers, shown in color, provide a series of successively halved currents that are added at the input of an amplifier in accordance with the digits of a binary number. The amplifier's analog output is then proportional to the digital input.

be converted. Cascading a number of these current dividers repeatedly halves the constant current into a number of currents having magnitudes proportional to ½, ¼, ⅛, . . .½ⁿ.

If any one of these currents were connected separately to the summing point, the output of the operational amplifier would generate a voltage proportional to that current which, in turn, would produce a current of the same magnitude but with opposite sign through the feedback resistor R. Thus the sum of the currents flowing to the summing point would be zero. Likewise when combinations of these binary current components are connected to the summing point, according to the digits of a binary number, an output voltage will be produced which is directly proportional to that number.

The key to the design is an emitter-coupled differential amplifier, whose transistors are closely matched, and whose base electrodes are returned to the same potential, thus making the collector currents equal. If in addition the ratio of collector current to base current—the β—is very high, then the collector currents are very nearly equal to the individual emitter currents.

The amplifier becomes a binary current divider, shown on the opposite page, if the two emitters are connected to a constant current source, the two bases to a single bias voltage source, and the two collectors through resistors to current sinks.

The ratio of the collector currents of the basic current divider is:

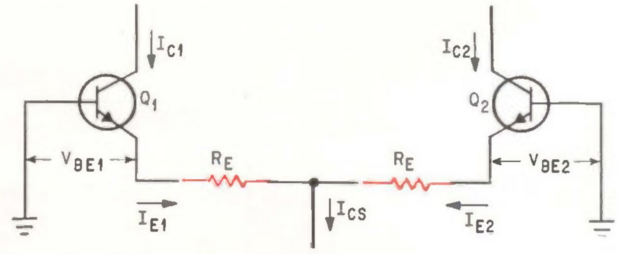
$$\frac{I_{C1}}{I_{C2}} \approx \epsilon^{k\Delta V_{BE}}$$

ΔV_{BE} is the difference between the two base-emitter voltages and k is a semiconductor constant; 1/k equals 26 millivolts. If ΔV_{BE} is 2.6 millivolts, the ratio I_{C1}/I_{C2} is 1.11, which means that one of the collector currents is 11% greater than the other, or the two currents vary ±5.5% with respect to a nominal value and ±2.75% with respect to the constant-current generator, which puts out twice the nominal current. Actually the maximum experimental mismatch between I_{C1} and I_{C2} with respect to the constant-current source is less than ±2% measured in 12 differential amplifiers.

In the panel opposite, the ratio of the d-c amplification factor α_1/α_2 is shown to be close to unity for a 10% difference in β, and therefore, does not significantly affect the collector current match.

Better division

The simple differential amplifier's basic division capability can be improved in various ways. The simplest way is to insert two matched resistors into the emitter leads, as shown below, thus correcting any initial difference in I_c. Experimenting with the



Resistors added to the emitter leads in the basic current divider improve its accuracy.

Analyzing the current divider

The relationship between the collector currents I_{C1} and I_{C2}, as a function of the amplification factors α_1, α_2, and the base-to-emitter voltages V_{BE1}, V_{BE2} for the circuit below, can be derived from the basic equation relating the emitter diode voltage and diode current:

$$I_E = I_o \epsilon^{(qV_{BE}/kt)} \quad (1)$$

and

$$V_{BE} = \frac{kt}{q} \log \frac{I_E}{I_o} \quad (2)$$

where I_E = the emitter current
I_o = the diode reverse-saturation current
q = the electron charge in coulombs
k = the Boltzmann constant
t = the temperature in degrees Kelvin

$\frac{kt}{q}$ is about 0.026 volts at room temperature.

Equation 1 may be written for the emitter currents I_{E1} and I_{E2} of both transistors of the differential amplifier. Then, dividing I_{E1} by I_{E2} gives the ratio:

$$\frac{I_{E1}}{I_{E2}} = \frac{I_{01} \epsilon^{(qV_{BE}/k_1t)}}{I_{02} \epsilon^{(qV_{BE}/k_2t)}} \quad (3)$$

If the transistors are identical and on one chip, then $k_1 = k_2$ approximately; equation 3 reduces to:

$$\frac{I_{E1}}{I_{E2}} \approx \frac{I_{01}}{I_{02}} \quad (4)$$

This means that the ratio of the emitter currents in the differential amplifier equals the ratio of the diode reverse-saturation currents.

The latter can be expressed in terms of $\Delta V_{BE} = V_{BE1} - V_{BE2}$ by writing equation 2 for two transistors and subtracting V_{BE2} from V_{BE1}:

$$V_{BE1} - V_{BE2} = \frac{k_1t}{q} \log \frac{I_{E1}}{I_{01}} - \frac{k_1t}{q} \log \frac{I_{E2}}{I_{02}} \quad (5)$$

If $k_1 = k_2$, equation 5 reduces to:

$$\Delta V_{BE} = (kt/q) \log \frac{I_{E1}}{I_{E2}} \bullet \frac{I_{02}}{I_{01}} \quad (6)$$

However, V_{BE} is always defined in terms of a fixed emitter current; therefore in equations 1 and 2, I_E can be considered constant. Therefore $I_{E1} = I_{E2}$ and:

$$V_{BE} = (kt/q) \log \frac{I_{02}}{I_{01}} \quad (7)$$

Solving equation 7 for I_{02}/I_{01} gives:

$$\frac{I_{02}}{I_{01}} = \epsilon^{(q\Delta V_{BE}/kt)} \quad (8)$$

Substituting equation 8 into equation 4 gives

$$\frac{I_{E2}}{I_{E1}} \approx \epsilon^{(q\Delta V_{BE}/kt)} \quad (9)$$

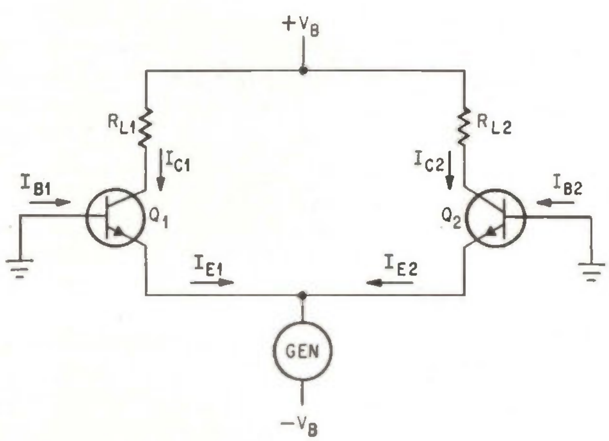
The relation between the collector currents I_{C1} and I_{C2} can be expressed with equation 9 by using the approximation $I_C = \alpha I_E$

$$I_{C2}/I_{C1} = (\alpha_1/\alpha_2) \bullet \epsilon^{(q\Delta V_{BE}/kt)} \quad (10)$$

However, if both transistors in a pair have a ratio of collector to base current (β) over 100, and equal within 10%, the α will be matched to better than 1%. Then α_1/α_2 is approximately unity, so that equation 10 reduces to

$$I_{C2}/I_{C1} \approx \epsilon^{(q\Delta V_{BE}/kt)} \quad (11)$$

The ratio of I_{C2}/I_{C1} is thus an exponential function of the difference in V_{BE}. If V_{BE} = 2.6 mv and kt/q = 26 mv then $I_{C2}/I_{C1} = e^{0.1} \approx 1.11$. (12)



Current-divider circuit that forms the basis of the new digital-to-analog converter. An improvement on this circuit is shown on page 144.

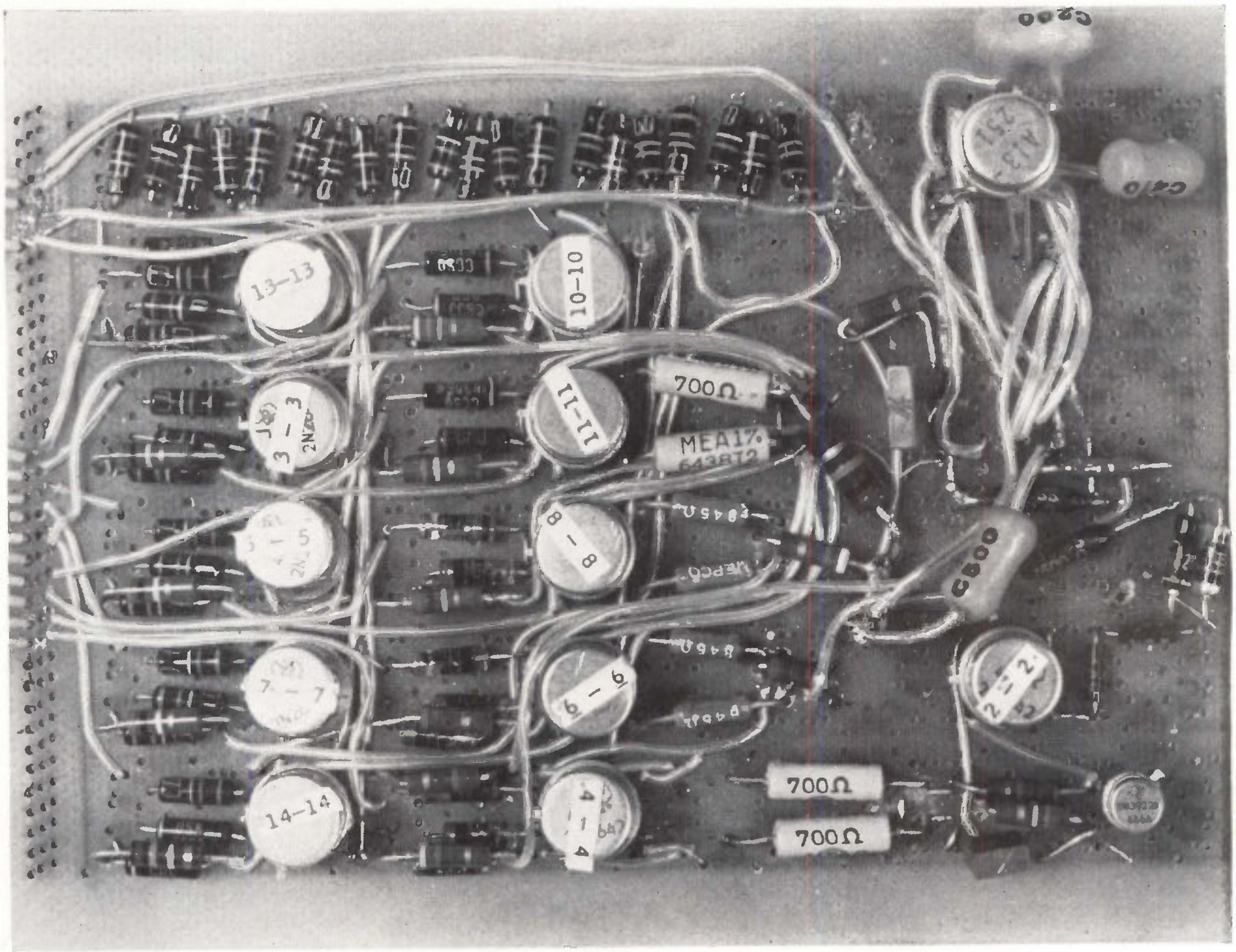
circuit in the figure showed that resistors of 500 to 800 ohms in the emitter leads corrected collector-current differences to within 0.01% of full scale.

The magnitude of the collector current is also important. With transistor d-c gains less than infinite, the base current will have a finite value that contributes to the emitter current. Transistors with β greater than 500 at 25°C and greater than 100 at lower temperature are now available. Since β is the ratio of collector current to base current, the base current is between 0.2% and 1% of the collector current, or the collector current is 0.2% to 1% less than the emitter current.

The loss of current to the base can be overcome in several ways. One way is to replace the individual transistors with Darlington transistor pairs. A simpler approach, less desirable in quantity production, is to increase the collector currents by connecting a large resistance between the collector and the negative bias.

A discrete prototype

A 10-bit prototype digital-to-analog converter was built from discrete components to verify the



Prototype converter built with discrete components. Except for a few of the resistors, all components can be duplicated in a monolithic integrated circuit.

design. The schematic of the prototype is shown on the opposite page and a photograph is above. The device comprises one operational amplifier, 10 current switches, 10 current dividers (in the tinted area), a constant-current generator, and a bias voltage supply.

A μA 709 integrated-circuit amplifier made by the Fairchild Semiconductor division of the Fairchild Camera & Instrument Corp. adds the currents and converts the sum to voltage. The feedback resistor of 2.5 kilohms provides a maximum output of 10 volts with a maximum input of 4 milliamperes. This low feedback impedance prevents excessive drift over the large temperature range.

The current switches are simple diode gates as shown on page 148. The anode of diode D_1 is connected to the summing point, the potential of which is always zero, and the anode of diode D_2 brings in the digital signal. The input signal swing is between —1 volt for a logical 1 and +1 volt for a logical 0.

When the input is at —1 volt, diode D_1 is forward-biased, diode D_2 is reverse-biased, and the current from the divider flows into the amplifier summing point.

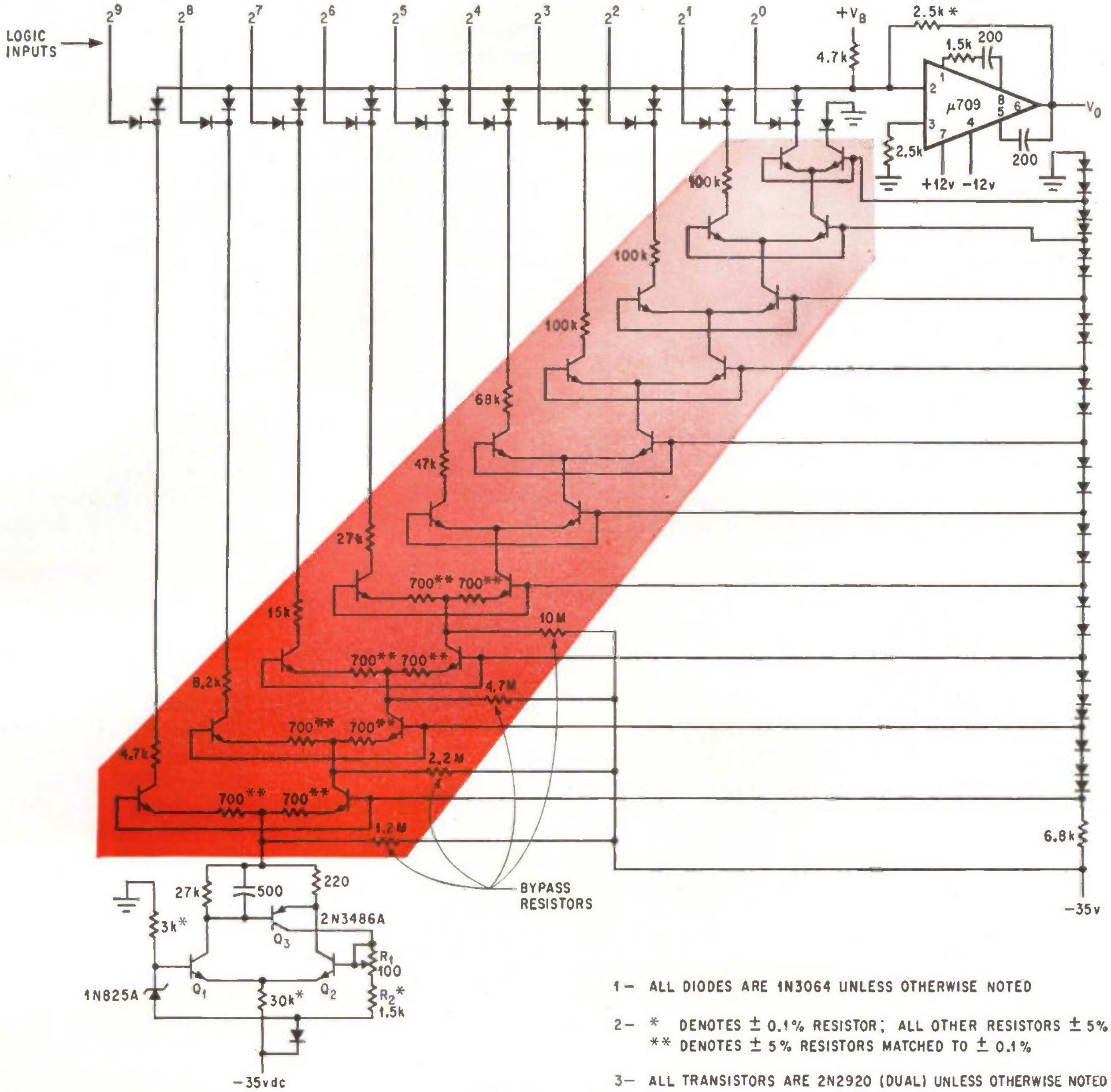
When the input is at +1 volt, diode D_2 is forward-biased, diode D_1 is reverse-biased, and the current from the divider flows into the source of the digital input.

Switching problems

Although this switch is simple, it has certain drawbacks. One hindrance is that one diode or the other is always reverse-biased. The leakage current, which flows in this reverse-biased condition, subtracts from the signal current. Therefore, the circuit requires diodes that have low leakage, especially at high temperature.

A second drawback is that conventional logic circuits do not necessarily swing between —1 volt and +1 volt. Either the input signals must pass through level shifters, or the summing point potential must somehow be established between the logical 1 and 0 levels.

The transistor base electrodes of each differential amplifier must be connected to a low-impedance voltage source whose potential is halfway between the collector and the emitter potential. A string of diodes provides these bias voltages conveniently. Two diodes are placed between successive differential transistors in the lower significant stages, providing a potential drop of about 1.4 volts; three diodes, giving 2.1 volts, are placed in the two most significant stages. The current



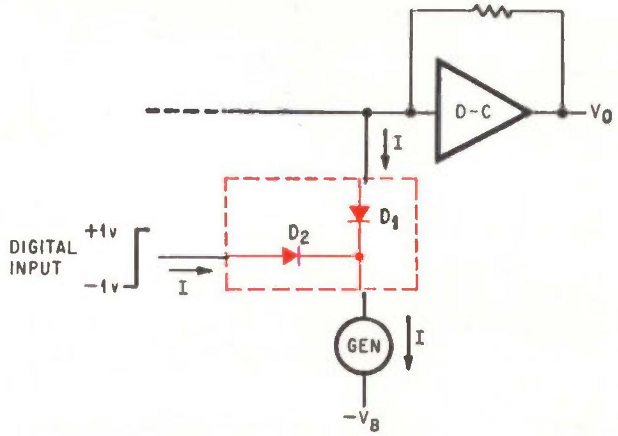
Ten-bit digital-to-analog converter uses cascaded current dividers (tinted area). The trim resistors compensate for current drawn off by the transistor bases. The string of diodes at the right provide bias voltages for the successive bases.

through the diodes can vary widely, because the value of the bias voltages provided by the diodes is not critical.

Compensating resistors

As shown above in the schematic of the prototype, only the four highest-order dividers of the ten need emitter resistors to make them more accurate, and bypass resistors to compensate for the base currents. These emitter resistors would have to be mounted externally for a monolithic converter. However, as better current dividers are built, fewer stages will require emitter resistors. Instead of the base-current compensating resistors in the discrete-component prototype, Darlington pairs would be used in a monolithic converter, since transistors are easier to implement than large resistors. Lower values of emitter resistors could have been used in the third and fourth divider stages, since they need not be as accurate as the high-order stages.

However, it was more convenient to make all emitter resistors the same. The actual value of these resistors is not critical, but they should be matched within the precision of the respective divider stage. That is, if the over-all precision of the converter is 0.1%, then the first stage must be precise to within 0.05%, the second stage to 0.1%, the third stage to 0.2%, and so on, doubling the percentage each time. After the first few stages



Series-shunt analog current switch that steers current toward or away from the summing node at the input to the amplifier. Only the two diodes are necessary; there are no transistors or extra power connections.

the precision can be very low without affecting the output appreciably.

The resistors in the collector circuits of the differential amplifiers make the voltage on the left-hand collectors approximately equal to that on the right-hand collectors. The tolerance of these resistors is very broad. The prototype contains ±5% discrete resistors, only because they were readily available. The right-hand collector voltage is, except in the least significant stage, the voltage on the emitter of the previous stage, which is 0.7 volt—the potential drop across one diode—below the bias voltage connected to the base electrodes.

The constant current generator in the prototype has another differential amplifier to amplify the difference between the voltage across the zener diode and the voltage across the resistors R_1 and R_2. This amplified difference, which is the voltage between the two collectors of transistors Q_1 and Q_2, is connected across the base-emitter junction of Q_3, which operates as a series regulator in the main current path. In an IC the constant-current generator could be built either as a separate hybrid circuit or together with the most significant converter stages. The constant-current generator replaces the constant-voltage source that conventional digital-to-analog converters require.

The digital-to-analog converter can be used in either unipolar or bipolar mode. In unipolar mode, a digital input of all 0's gives an analog output of 0 volts; an all 1's input gives an output of +10 volts; and an input 1000. . .000 corresponds to a +5 volt output. In bipolar mode, these inputs would provide outputs of —5, +5 and 0 volts respectively.

For bipolar outputs, a 5K resistor connected between the summing point and a +10 volt reference will provide a 2 milliampere bias current. This bias current will maintain the output swing between —5 and +5 volts.

High score in test

The performance of the new digital-to-analog converter depends on the quality of the differential amplifiers and other components or on the number of compensations or corrections provided.

All static accuracy tests have been performed on the laboratory model on page 146, which is a complete digital-to-analog converter.

In the single-digit test, where each digit is actuated separately, the static accuracy for any of the 10 digits was better than ±0.02% of full scale at 250°C, +0.06% from 0°C to 125°C, and —0.25% from 0°C to —55°C.

For any arbitrary combination of digital inputs, the static accuracy was ±0.05% of full scale at 25°C, ±0.125% from 0°C to 75°C, +0.5% from +25°C to +125°C, and —1% from 0°C to —55°C.

The largest error occurs at the lowest temperature, where the transistor amplification factors are the lowest. A significant error also occurs at high temperatures, where the leakage of the current-switching diodes is severe. Darlington pairs in the higher significant stages and low-leakage diodes in all the current switches would reduce these large errors at the extreme temperatures. At room temperature, the repeatability of the device is excellent —within +0.02% of full scale.

The constant current generator, the bias voltage supply, and the current dividers operate only statically—that is, they do not vary when the digital signal changes. Therefore they do not require the capability of fast switching. Since fast-switching diodes are readily available, the operational amplifier is the only speed-limiting device.

While dynamic tests so far have not been performed, the dynamic performance of this digital-to-analog converter is undoubtedly greatly superior to that of conventional converters.

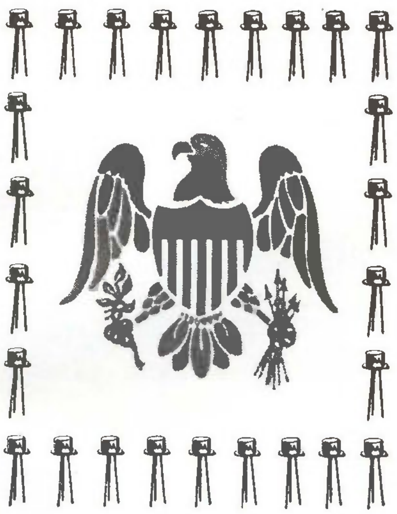
A single-chip package?

The degree to which implementation with monolithic circuits is possible is still questionable. With the present state of the art, a 6-bit digital-to-analog converter in a single monolithic package is possible. A 10-bit converter could be made with a second integrated circuit containing four additional converter stages, connected between the current generator and the most significant stage of the 6-bit device. The transistor emitter leads of these additional current dividers must be accessible to permit connecting precisely matched resistors into the emitter circuits of each differential amplifier for improved accuracy. The chips can merely be put into a film-resistor network, resulting in a hybrid integrated circuit.

As the technique of manufacturing matched monolithic differential amplifiers improves, and as fewer stages require compensation by external resistors, more current divider stages can be included on a single chip.

Reference

1. A.K. Susskind, Notes on analog-digital conversion techniques, The Technology Press, Massachusetts Institute of Technology, 1957.



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		I_C Collector Current			
		500 µA	10 mA	30 mA	150 mA
BV_{CEO} (min)	15 V		2N706 JAN (NPN) 2N918 JAN (NPN) 2N2481 USN/JAN ((NPN)		
	30 V				2N2218 JAN (PNP) 2N2219 JAN (PNP) 2N2221 JAN (NPN) 2N2222 JAN (NPN)
	35 V		2N1132 USN/JAN (PNP)	2N1131 USN/JAN (PNP)	
	40 V				2N2218A JAN (NPN) 2N2219A JAN (NPN) 2N2221A JAN (NPN) 2N2222A JAN (NPN) 2N2904 USN/JAN (PNP) 2N2905 USN/JAN (PNP) 2N2906 USN/JAN (PNP) 2N2907 USN/JAN (PNP)
	45 V	2N929 2N930			
	60 V		2N2904A JAN (PNP) 2N2905A JAN (PNP) 2N2906A JAN (PNP) 2N2907A JAN (PNP) 2N3250A JAN (PNP) 2N3251A JAN (PNP)		

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Circle 149 on reader service card

DESIGNER'S

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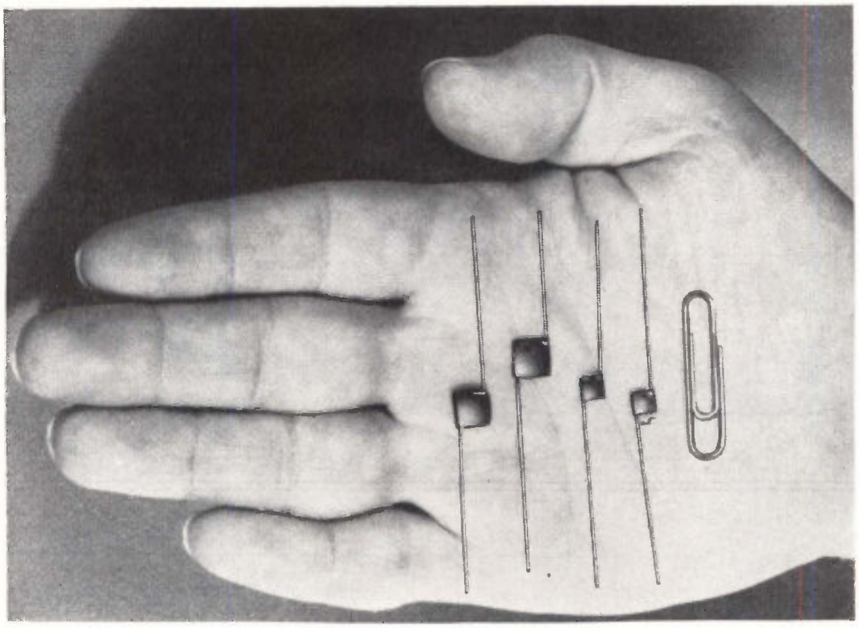
New miniature tantalum capacitor for microcircuits



The Mallory TUR is a miniature solid electrolyte tantalum capacitor designed for use with integrated circuits, thin film and other microelectronic circuits. It is supplied unencapsulated to provide extremely small size per rating. It is intended for use with microcircuits where it will be encapsulated after assembly.

The TUR has a new configuration which provides maximum capacity per unit volume. It's a square chip, only .225" to .325" square, and .04" to .170" thick depending on rating. It is supplied with an electrically insulating coating on the positive side of the case, so it can be stacked or placed directly on the circuit chip or board prior to encapsulation. When properly predried and encapsulated, it withstands MIL environments.

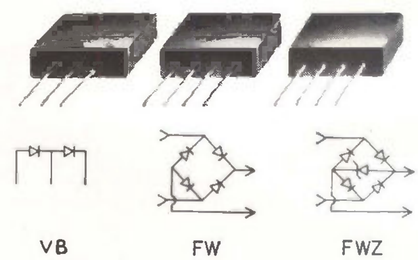
CV (capacity x voltage) product is extremely high. Ratings range from 47 mfd., 6 VDC to 15 mfd., 50 VDC. Temperature rating is —55°C to +85°C, de-rated linearly to $\frac{2}{3}$ voltage at 125°C. DC leakage is low. Three configurations keyed to lead position are available. Standard units are polarized; non-polarized units on special order. Leads are gold-plated ribbons, can be welded or soldered.

DIMENSIONS

Case Size	A Max.	B Max.	C Max.
A	.225	.225	.040
B	.225	.225	.050
C	.225	.225	.060
D	.225	.225	.075
E	.225	.225	.110
F	.325	.325	.060
G	.325	.325	.075
H	.325	.325	.110
J	.325	.325	.125
K	.325	.325	.170

CIRCLE 511 ON READER SERVICE CARD

Reducing costs with Mallory packaged rectifier circuits



You can save both on component costs and on assembly costs, with Mallory rectifier packages. Each of these factory-connected circuits costs less than what you would pay for an equivalent number of separate rectifiers. The four-rectifier bridge package costs less than four separate rectifiers, and the full-wave and doubler packages cost less than a pair of rectifiers.

Savings in assembly come from reduction in number of soldered connections which you need to make . . . one less on a doubler or full-wave circuit, two less on a bridge. You can figure it out for your own conditions, but here's a typical analysis. At a labor rate of $1.60 per hour, the saving is about $300 per 25,000 doubler packages, or $600 per 25,000 bridge packages. Extra reliability due to fewer solder joints is a plus value.

Cold-case encapsulated circuits include Type FW full wave bridge, Type VB voltage doubler, Type CT full-wave center tap with either positive or negative polarity . . . all rated for 100°C, in PRV values from 50 to 600 volts. Bridge circuits, Type FWZ, are also supplied with an integral, factory-connected zener diode across DC output terminals; all standard zener voltage ratings are available in this configuration.

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FILE

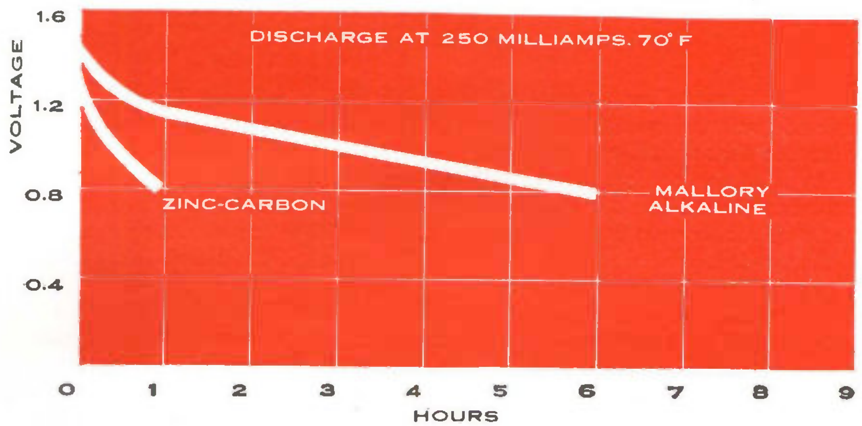
MALLORY

50th ANNIVERSARY

Improved heavy-duty performance now provided by Mallory Alkaline Batteries

Recent refinements in Mallory Alkaline Batteries increase their ability to deliver long life at higher values of current drain, and further improve their advantage over conventional zinc-carbon batteries both in service dependability and cost per hour.

This added capability is the result of new internal construction which increases the effective anode area in relation to cell volume. Internal impedance of the cell is reduced, particularly at low temperatures. At 70°F ambient, the Mallory alkaline system delivers up to 7 times more hours of service on continuous heavy drain than ordinary batteries (see chart). At 32°F, the improvement in performance is even better.



Added refinements in case and seal construction have also been made to insure reliability of the seal under even the most severe vibration.

Mallory Alkaline Batteries with the new construction are available in a broad range of standard cell configurations.

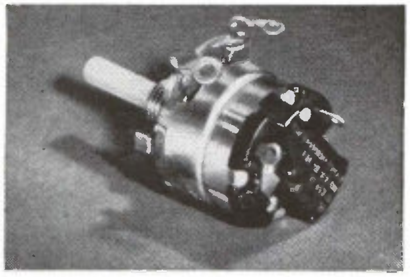
CIRCLE 513 ON READER SERVICE CARD

Circuit breaker-switch now available on Mallory controls

The OCB breaker-switch eliminates the need for a separate circuit breaker by combining overload protection and line switch into a single, compact unit. It's an extra convenience idea for television and stereo equipment, for instruments and any products which require overload breakers under 5 amperes.

To reset the breaker after it trips, you simply turn the switch back to OFF, then to ON. You cannot hold the breaker closed against an overload.

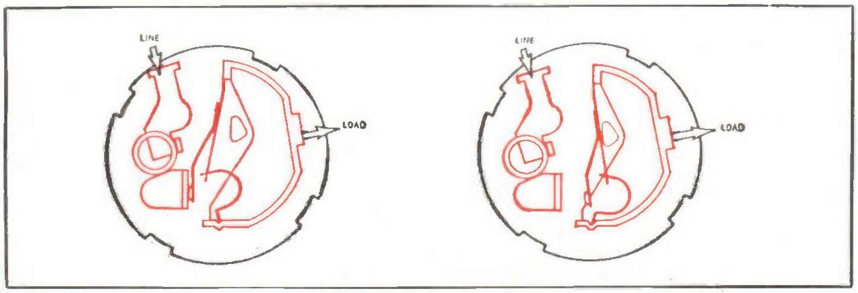
Holding current is factory-set to your specifications; standard range is 1.25 to 1.9 amperes, with special models available up to 5 amperes.



OCB breaker switch attached to volume control.

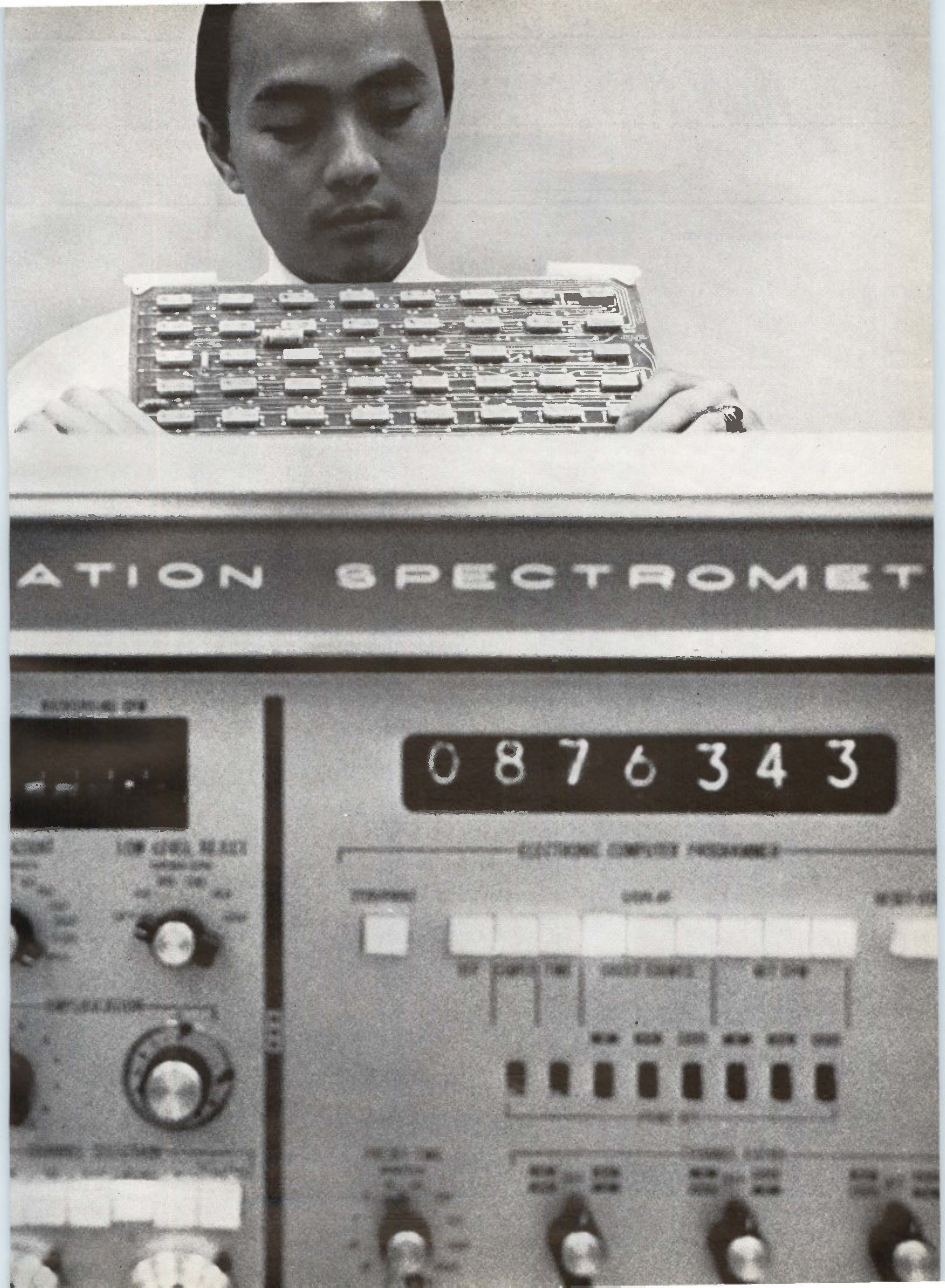
Break current is 50% higher than holding current. The OCB switch will withstand a 10% overload for 4 hours at 65°C ambient. It will take a 50 ampere surge, peaking in 1.6 millisec and decaying to normal in 3 millisec, without opening or being damaged.

The OCB is supplied attached to standard Mallory volume controls as a rotary on-off switch, or can be supplied as a separate breaker switch. As a combination control-switch-breaker, it offers savings in total component and assembly cost.



Diagrams show operation of breaker mechanism: at left, in MAKE position; at right, in BREAK position.

CIRCLE 514 ON READER SERVICE CARD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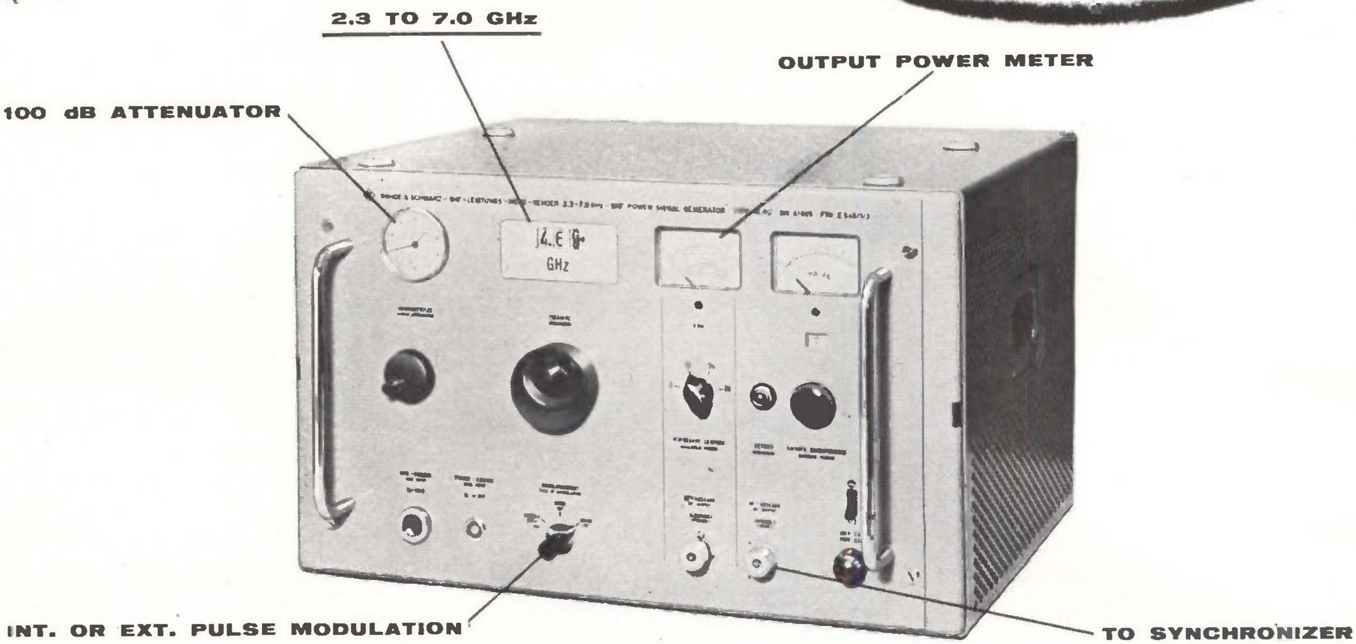

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- Can Be Synchronized
- Built-In Output Attenuator: 0 to 100 dB
- Built-In Power Meter: −3 to +36 dBm in 4 ranges
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APPLICATIONS

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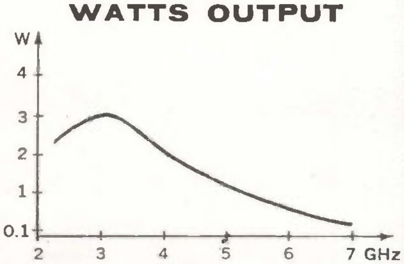

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Simpler circuits trace Sony's path to innovation

Though not first with the transistor, the Japanese have applied it to consumer electronics with a persistence and ingenuity that has improved entertainment products. Circuits and components have been simplified and made more reliable. Apparently simple circuits perform complex and sophisticated operations with a minimum of components. New functions have increased the versatility of products without adding substantially to their price

By the Products Planning division,
Sony Corp., Tokyo, Japan

and Charles L. Cohen
Tokyo regional editor, Electronics

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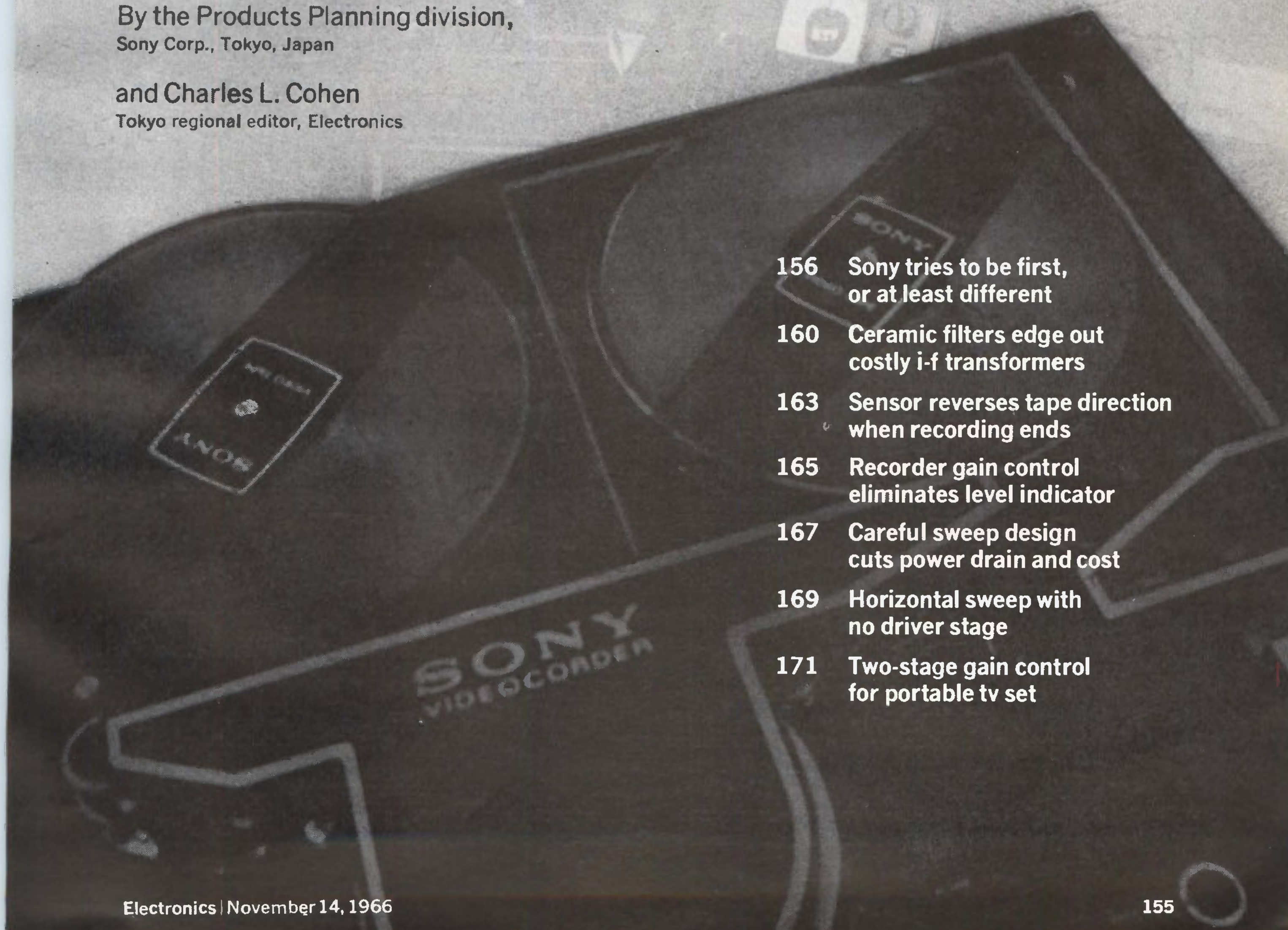

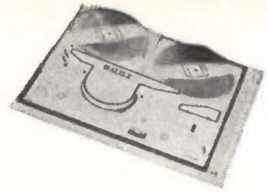

Sony tries to be first, or at least different

The Japanese company will scrap a consumer product that's only second best; it seeks to pioneer while husbanding its limited technical resources

By Charles L. Cohen
Tokyo regional editor

In 1964, engineers at the Sony Corp. of Tokyo built a prototype of an electronic calculator, but the machine still sits on a laboratory shelf. It never went into production because its performance was not superior to electronic calculators produced by other manufacturers.

Sony's harsh rejection of the calculator illustrates how the company's demanding product development program works. If a product is not unique or better, the company will not market it. Masaru Ibuka, the diminutive engineer who founded Sony in 1946 and is now its president, insists that Sony be first with a product—at least in Japan—or offer one that is radically different from any other on the market.

His philosophy has kept the company out of some lucrative markets like the radio battery business and plunged it into some unnecessarily difficult development. For example Sony chose to market color television with a Chromatron picture tube instead of the usual shadow-mask tube so its sets would be different. But mass producing the Chromatron turned out to be far more difficult than Sony expected. In setting up the manufacture of Chromatron Sony could not match the hundreds of millions of dollars others had put into perfecting the manufacture of the shadow-mask tube.

The product is success

To founder Ibuka, the product is the thing. He believes astute product development has been behind the company's explosive rise from a tiny instrument manufacturer operating in a burned-out store to a major consumer electronics producer whose radios, tape recorders and television sets are sold all over the world.

Although Sony boasts a handsome research and development budget, the major share of the money goes for development. Sony does little research, leaving that activity to Japanese government laboratories and universities.

When World War 2 ended, Ibuka set up a small company to exploit the development talents of a few engineers. He called his company the Tokyo Telecommunication Laboratories and started with one product, a vacuum-tube voltmeter. The company thrived and branched into professional electronic equipment for Japan's broadcasters.

In the early 1950's, Ibuka recognized that his still-small company would always be limited so long as it stayed in the instrument and professional broadcasting equipment fields. So he decided to gamble and move into consumer electronics where the markets were gargantuan and the competition fierce.

New name and new goals

About the same time Ibuka noticed something else: the transistor was being exploited widely in the United States in military applications but nobody was applying it to consumer products with the same fervor. Ibuki's engineers learned semiconductor technology and the company became the first in Japan to mass produce transistors. The first germanium units went into a transistor radio and Sony was on its way.

Once in the consumer business, the company changed its name to Sony because those four letters are written and pronounced the same everywhere in the world.

With its new name and an aggressive product-planning program, the company has broadened its line to include television, audio tape recorders and a video tape recorder priced for the home. At the same time it maintained its line of studio broadcast equipment, expanding it to include a video tape recorder and electronic dubbing equipment for movies. In fact, Sony has become synonymous with Japanese consumer products and product planning.

For many years the chief product planner was president Ibuka. Now Sony has grown so large that one man can no longer create all the company's products. Today much of the advanced planning is done by committee, though on that committee, Ibuka and executive vice president Akio Morita exert a greater weight than the other members.

Sony's top management consists of a nine-man board. On it are the president, the executive vice-president, two senior managing directors and five managing directors. Ibuka still does much of the long-range planning; Morita heads up marketing; one senior managing director directs project planning and the other production. These nine men and about 30 department heads lunch together daily, discussing company problems and reaching decisions informally as they eat.

Routine product planning is performed by the product planning division, which decides how many items to make and the type of product needed in each line. But its work is subject to regular review by the nine-man executive board and the luncheon group.

Something new

It is important to what Sony does in product planning that its vice president, Morita, a physicist who joined Ibuka in the early days, heads marketing and sales promotion. Morita uses technology to help sell the company's image and products. He tries to create the impression among customers that Sony is one step ahead today and will be even farther ahead tomorrow. He also wants customers to feel that a Sony product has something new in it.

With these concepts in mind Sony has introduced some products that were intended to do more for the company's image than its bankroll.

For example, Sony leapfrogged tubed tv when it introduced transistorized black-and-white receivers because it built its own semiconductors but not tubes. Sony did not expect the sale of many sets because at the time its transistorized set was too expensive. But many customers looked at the Sony tv and, impressed, bought a Sony radio.

More recently, when Sony decided to bring out a new small screen tv receiver, it decided to produce a 7-inch set with a black picture tube that would look different. Then Sony advertised it as the first transistorized 7-inch set in the world and its black face emphasized the difference. Although Sony capitalized on the promotional effect of the new design, there were good engineering considerations behind it. Designers had determined that from a cost standpoint the 7-inch size was almost optimum to build. Assembly of smaller sets was harder because of the size and because the miniaturized components required were more expensive. Larger sets cost more because material costs rise with set size.

Right now Sony is proudest of the home video tape recorder it introduced last year to sell for around $1,000 in the United States. The history of that development illustrates the philosophy that Sony tries to follow in product development.

Work first started on audio tape recorders at the company that was to become Sony in 1949. Ibuka thought that if audio recording was possible, then video recording should also be possible. The company's engineers proceeded with brute force methods: they increased tape speed and improved recording head characteristics. By 1953 they recorded a low-grade picture.

Ibuka knew others were working on video recording for broadcasting too: the Radio Corp. of America, the British Broadcasting Corp. and the Crosby Research Foundation. But he felt he was ahead. Then the Ampex Corp. caused a bombshell by introducing a perfected recorder, the Ampex VR 1000.

A look homeward

Sony was as stunned as anybody. A shocked Ibuka had to admit that his company was behind in video recording and had failed to introduce the world's first video tape recorder. It was at this time, however, that the company had decided to put a new emphasis on consumer goods, so Ibuka began to think about a video tape recorder for the home. Since the Ampex machine cost about $50,000, Ibuka felt a home recorder would require a radically different approach. His goal was a machine that was easier to buy and easier to run, cheaper, smaller and requiring less maintenance than the Ampex VR 1000.

The first result was the Sony SV-201, labeled an industrial video tape recorder because its price was still well above what Ibuka thought a consumer might pay. Six or seven were built and one was shown at the 1962 IRE show. Because it used mostly orthodox recording techniques—helical track recording and frequency modulation of the recording signal—the company president felt the machine was not good enough. He wanted one smaller, more compact and cheaper. So, like the electronic calculator of 1964, it's still sitting on a shelf.

But the SV-201 had one Sony innovation that was to mark all the company's future professional recorders: Sony's 1½-head recording. One head records all picture material and a second records the blanking periods which contain synchronization information. In the usual 2-head system, each head records both a picture period and a blanking period. The advantage of Sony's system is that the same head always records and plays back the picture so the heads needn't be matched closely.

At the 1963 IRE show, Sony was back with a new video tape recorder, the PV 100. Deliveries started in July of that year.

Although the machine was sold to industrial, medical and education institutions, the price of

From a ramshackle shed . . .

It was 1947 when Masuru Ibuka, second from left, proudly posed for this picture with three coworkers in front of the dilapidated building into which he had just moved his fledgling Tokyo Telecommunications Laboratories. Ibuka had set up the firm a year earlier on the fifth floor of a burned-out department store called Shirokiya. There, his group was separated from other tenants by a board fence. When the department store owners decided to reopen their retailing business Ibuka moved to this location.

$11,500 was far beyond a consumer's reach. But Sony decided that the machine's performance specifications exceeded the needs of home use. Turning to motion pictures for an analogy, Sony noted that theaters used 35-mm film because of the high quality but that consumers used 16-mm or even 8-mm happily even though the quality of reproduction was not as good as with the large size.

For its home recorder, Sony simplified the signal processing to cut down on electronic components. It also simplified mechanical construction. The result was the CV-2000 model which sells for about $1,000 in the United States. Although the quality is not as good as obtained with a studio recorder, or even with the industrial PV 100, it is satisfactory for the home.

Study in depth

Once committed to developing a product, Sony digs deeply. To perfect its video tape recorder for the home, the company's engineers delved into the metallurgy of magnetic materials to develop the company's own tape, probed the chemistry of coatings, binders, pigments and paints, studied the physics of magnetization and electromagnetic induction to produce a unique recording head and dissected the field of video recording so they could evolve a system of skipped fields that is primarily responsible for the reduction in electronic components compared with the number used in studio equipment.

Another phase of Sony's product development can be seen in the company's progress with semiconductor technology. Sony has introduced a few products primarily to improve its semiconductor manufacturing skills. It was the first company to mass produce transistors commercially in Japan. It was the first in Japan to put germanium mesa transistors in consumer products and it was the first to use silicon transistors the same way. Still, Sony won't sell its semiconductors to others. Its capability is used solely to keep the company's products at the forefront of technology and to insure its manufacturing divisions a supply of advanced devices. Sony thinks the company gets a competitive edge because it can develop products without tipping its hand on a new design through outside orders for special semiconductors.

That means the cost of all the processing development is borne by Sony alone. To afford it Sony sometimes spreads costs broadly over several products and attributes some of the expense to advertising. When the company introduced its 8-inch transistorized tv set, the high-voltage devices in the video output circuit cost $20 to $30 each. Sony probably lost at least a quarter of a million dollars on the set. But the company believes advertising the first transistorized television set brought in more than enough Sony radio sales to offset the loss.

Later, when Sony was ready to introduce its 5-inch screen set, which went into mass production, it could produce silicon transistors at a low cost

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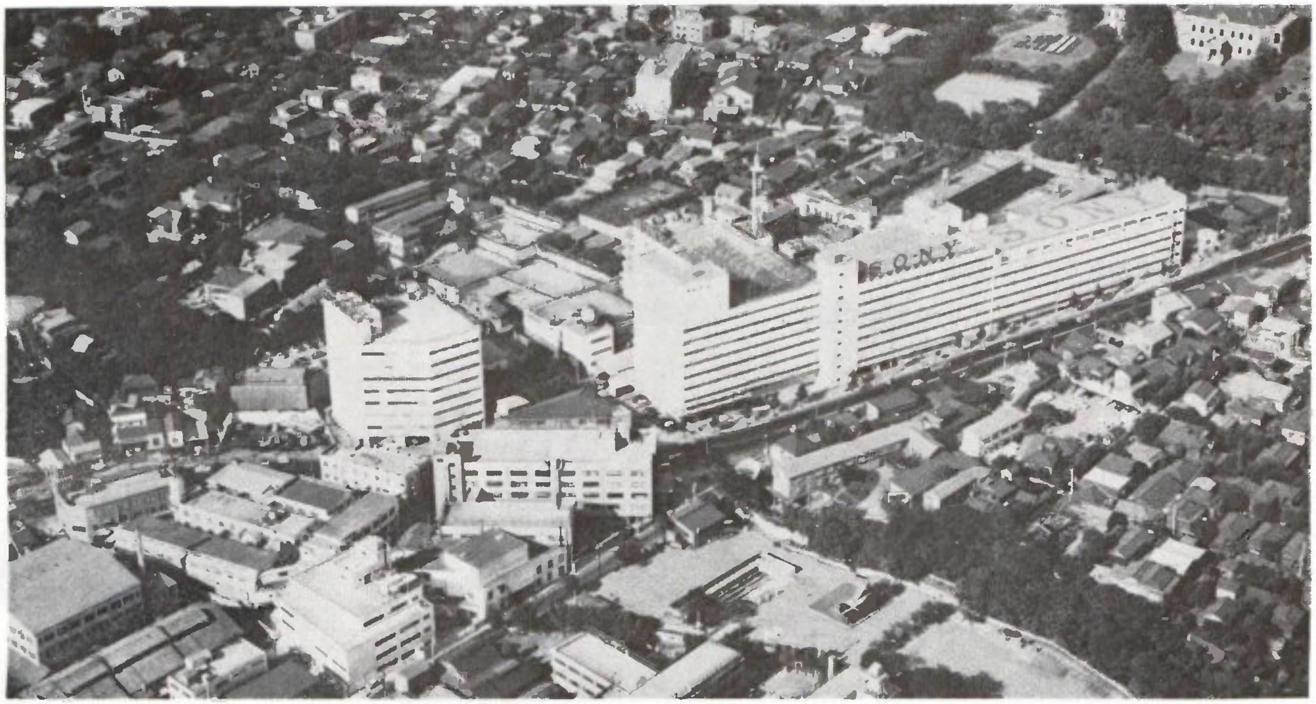


Today, on the same site, Ibuka's company, now renamed the Sony Corp., occupies several huge white-faced buildings in the heart of rebuilt Tokyo. Executive offices are on the top floor; equipment manufacturing and assembly are on the lower floors of the eight-story buildings. Semiconductor manufacturing is carried on in another plant at a different location. Sony's executives can see Mt. Fuji on a clear day, a reminder they represent a Japanese firm even though their constant aim is a world market.

because of its experience making them for the 8-inch set. At the same time other Japanese manufacturers could not compete with Sony because they did not have Sony's experience with silicon transistors.

Germanium still performs

Sony is using more and more silicon devices in its consumer products, but not to the exclusion of germanium devices. Its portable radios still have germanium output transistors even though silicon ones are used in other stages. That's because Sony's epoxy package cannot dissipate enough heat. In radios that have direct-coupled audio amplifiers a germanium transistor is used even in a low-level stage because Sony does not have a suitable pnp silicon transistor.

Sometimes the company will stay with older devices to husband its limited engineering resources. Thus Sony f-m sets have a germanium mesa transistor even though a silicon device could be designed and produced for less cost. Instead, the company designed an improved pnp driver transistor which has the high degree of linearity required in high-fidelity amplifiers.

The company's activity in semiconductor technology has helped it broaden its product line. For example, what was learned designing transistors for deflection circuits in tv sets has led to the development of linear transistors for high-fidelity phonographs. The linear amplifier in the vertical output stage of a tv set requires transistors with very linear performance. Similarly the higher power transistor in the horizontal output stage must have linear characteristics even though it is operated as a switch. When turned on, the transistor in the horizontal output stage is normally saturated with a high collector current and low collector voltage. The d-c forward current gain, h_{fe}, must stay high or the driving power becomes inconveniently high. It turned out that a transistor that keeps h_{fe} from slumping during saturated operation provides highly linear current gain throughout the operating range.

Right after it switched to consumer products, Sony built its consumer goods to lower quality standards than its professional gear. This caused the company considerable grief. The formula, Sony finally discovered, was to manufacture goods to the same high quality but to design them to lower specifications, such as lower frequency response.

On pages 160 to 172, are descriptions of some of the circuits Sony engineers have designed as they've worked to carry forward the company's unusual product development program.

Presented here are some of the interesting circuits developed by the Sony Corp. None are technological breakthroughs but all represent innovation. Three are for radios, two for tape recorders and four for television sets. Each involves at least one of the design aims of consumer electronic products: miniaturization, reduction of cost without sacrifice of performance or improved performance with no increase in cost.

Ceramic filters edge out costly i-f transformers

New piezoelectric elements eliminate i-f alignment in production; selectivity is maintained as costs drop

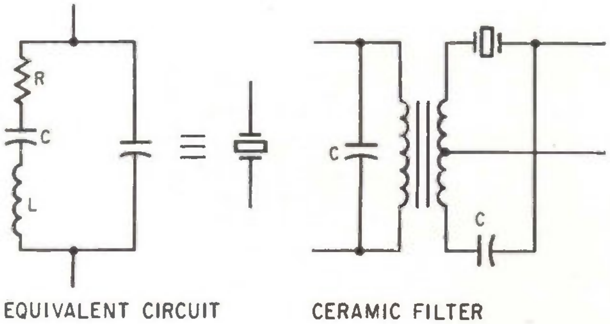
Reducing costs by reducing components is always a goal in consumer electronics. In intermediate-frequency sections of several radios, Sony is turning to ceramic filters instead of tuned-transformer stages. The result is equivalent, if not superior, selectivity with a savings in parts of as much as 10%. For example:

- Two ceramic filters—one a double-tuned, three-terminal element—are used in the model TR-1000, a 10-transistor multiband portable, list-priced in the United States at $69.50.
- A single fixed-tuned ceramic filter provides selectivity equivalent to three transformer-tuned stages in the $12.95 model 2R-27, an eight-transistor a-m portable.

The ceramic filters not only reduce the parts cost of the radios but the assembly cost as well. What's more, the radio in production needs no i-f alignment because the filters are supplied already fixed-tuned to their i-f frequency.

In the model TR-1000 the i-f amplifier consists of two stages, as in the schematic on page 162. One filter, tuned at 455 kilohertz, provides emitter-to-ground bypassing for the first i-f transistor, Q_1. The other filter, double-tuned at 455 khz, provides coupling between the two i-f stages. The over-all selectivity characteristic of the i-f section of the radio essentially is the product of the two filter characteristics. It is equivalent to the selectivity of an amplifier using two conventional double-tuned transformers, but at 6% less cost.

Transformer T_1 between Q_2 and the second detector diode D_1 is a small, fixed-tuned unit with an operating Q of about 10. It is used more for increasing gain by impedance matching than for improving selectivity.



Classical circuit for a crystal filter is a single-section lattice with four resonant elements—equivalent to the Jaumann-connected filter. Selectivity of i-f stage is obtained with a single Jaumann ceramic filter. Equivalent circuit of the ceramic filter element is also shown.

Piezoelectric elements

The ceramic filters use piezoelectric elements made of lead-zirconate-titanate, $PbZrO_3$-PbT_1O_3. Both are made by Murata Manufacturing Co. from a new material mass produced with a temperature coefficient and long-term stability of the same order of magnitude as in crystal filters.

Both filters are guaranteed within ±2 khz of their center design frequency. Though a maximum difference of 4 khz is possible between the two center frequencies, the much higher selectivity of the double-tuned filter prevents degrading of the over-all bandpass characteristic. Differences in center frequencies also have little effect on the broadband input and coupling transformers.

The emitter bypass filter, type BF-455A, is a two-terminal unit with a single, square ceramic resonator. Enclosed in a small resin case measuring only 0.14 by 0.28 by 0.28 inch, it can be used as an emitter bypass capacitor because its impedance falls sharply to a minimum at series resonance. The filter provides approximately the same amount of selectivity as a conventional single-tuned i-f transformer.

The coupling filter, type SF-455D, is also enclosed in a resin case 0.30 by 0.24 by 0.28 inch. Selectivity is equivalent to the total provided by a double-tuned and a single-tuned transformer.

The filter consists of two square resonating elements, each with an inner and an outer portion. An external capacitor of about 68 picofarads couples inner portions to form a double-tuned filter.

The outer portion of one element connects to the input terminal; the outer portion of the other element connects to the output. The third terminal is a common connecion to the reverse sides of both of the elements.

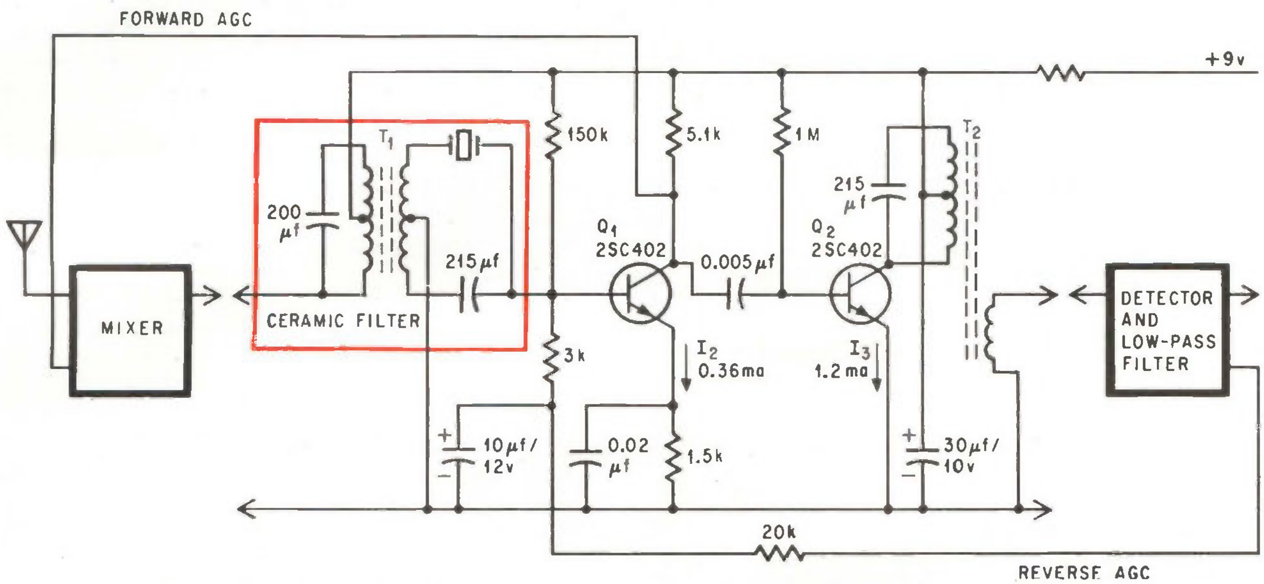
Spurious responses are usually a serious problem in ceramic filters. However, the responses of the individual elements in the double-tuned filter are not at integral multiples of the fundamental frequency. Nor are the elements completely uniform or symmetrical. And because the spurious response frequencies of the elements do not coincide, even though their fundamental frequencies are equal, the spurious responses of the over-all filter are greatly reduced.

Low-price portable

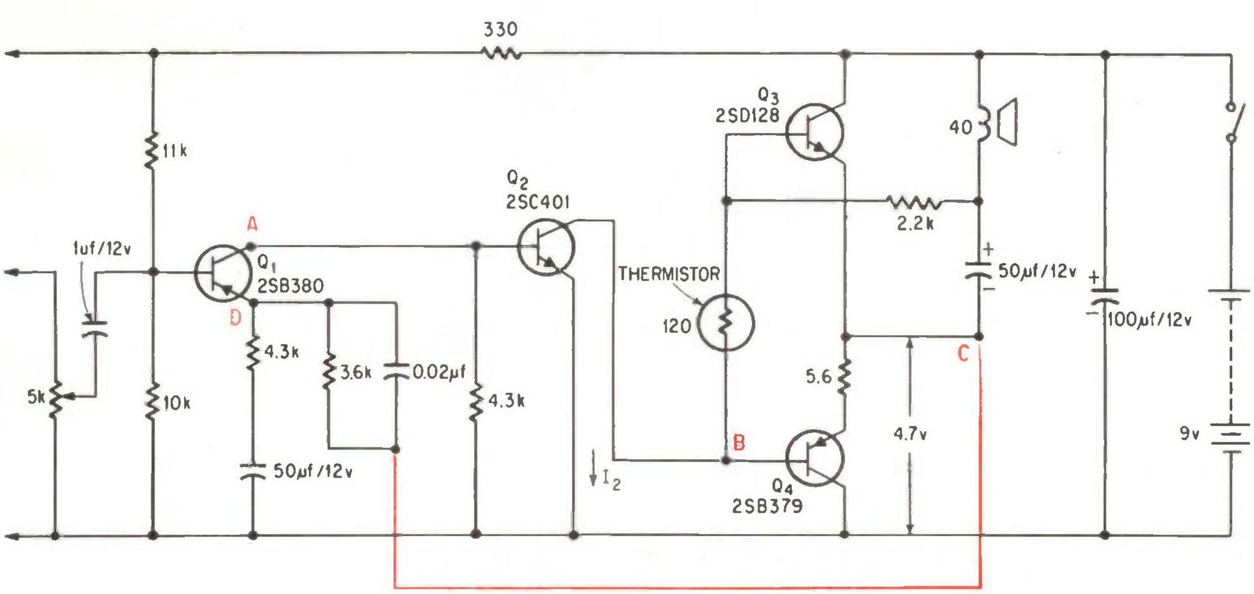
In the model 2R-27, the 455-khz ceramic filter, part of a two-stage i-f amplifier, is connected between the converter and the first i-f transistor, Q_1, as diagramed below. The Matsushita Electric Industrial Co. manufactures the lead-zirconate-titanate filter.

Resistance-capacitance coupling is used between the two i-f transistors. However, a small, fixed-tuned transformer, T_2, with the low operating Q of 5 provides the proper impedance transformation between the i-f stage and the second detector.

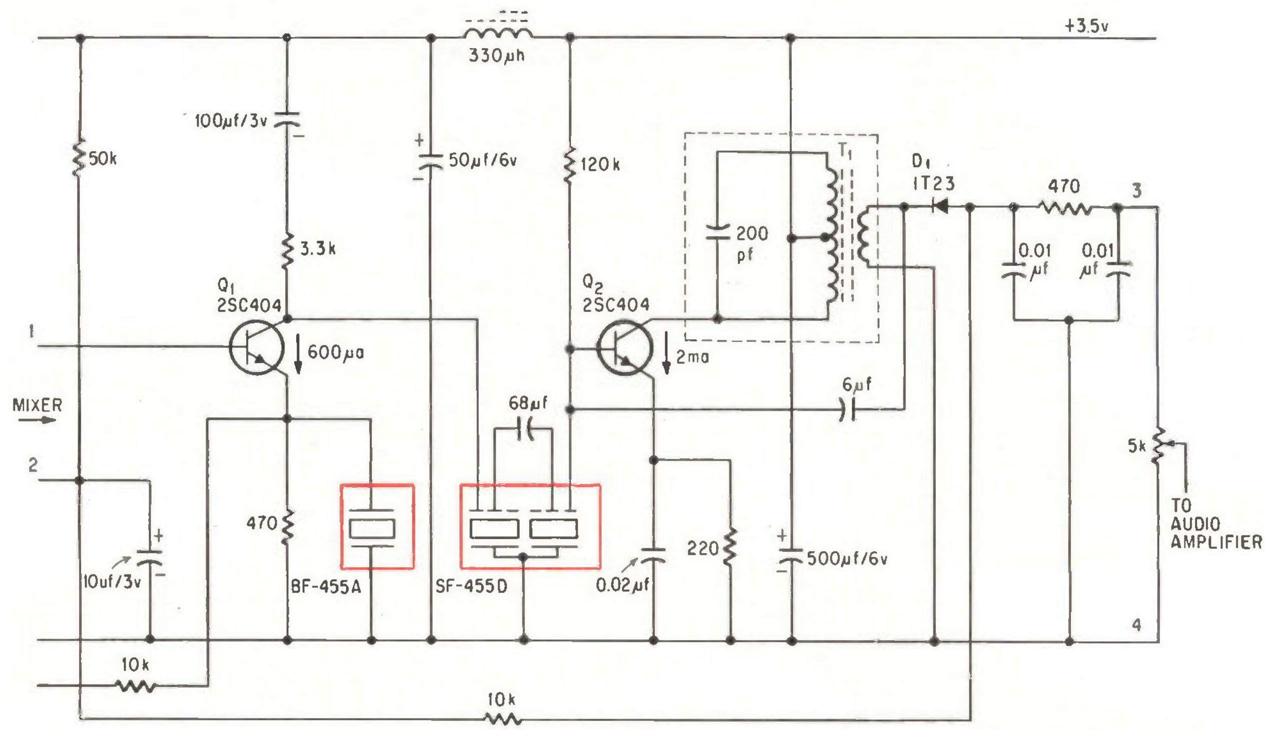
The classical circuit for crystal filters is a single-section lattice, shown on page 160, which can



Ceramic filter in the intermediate-frequency stage of a low-cost radio provides selectivity equivalent to three single-tuned transformer stages. Use of the filter eliminates need for alignment when the radio is in production, cuts down on the number of components and the assembly time.



Direct coupling of the audio output stages reduces the zero-signal battery to 5.5 milliamperes, eliminates two coupling transformers. Audio stages now cost 15% less than when transformers are used.



Intermediate-frequency amplifier of multiband portable uses single-tuned ceramic filters for emitter-to-ground bypassing of first i-f transistor, Q_1, and double-tuned ceramic filter to couple the stages. The amplifier is designed so that the input transformer is part of the converter module.

also be used with ceramic filters. But for such a simple radio a circuit with four ceramic resonant elements would be too expensive. Fortunately, the four-element lattice can be replaced with an equivalent circuit consisting of a center-tapped transformer and just two impedance elements. The circuit is known as the Jaumann connection, first developed in Germany in 1932. Sony modifies this connection still further in its i-f stage, using the ceramic material as one of the resonating elements in a Jaumann-connected filter.

The two-terminal ceramic element is in the form of a 0.2-inch diameter disk contained in a metal can measuring less than a half inch on a side. It is combined with a fixed-tuned transformer, T_1, and external capacitors to form the selective circuit. The resonant frequency of the filter is maintained within ±2 khz of the 455-khz i-f. The difference between the resonant frequency of T_1 and that of the ceramic element is less than 1.7 khz. This close control means that the selectivity characteristic of the i-f section is quite symmetrical and distortion at the second detector caused by unequal cutting of the sidebands is kept very small. Sufficient adjacent channel attenuation is obtained with no i-f alignment.

Sony feels that in the future ceramic filters of this kind, designed with integrated circuits, will be used in most small radios. A single ceramic element, with a minimum of external connections to the integrated-circuit chip, will yield the selectivity required. There will be no need for the coupling transformer T_2 because sufficient gain will be obtained merely by adding an extra amplifying transistor to the chip.

Direct-coupled audio

To cut down on the number of parts in the audio output stages of this small portable, Sony has coupled them directly. This not only eliminates two coupling transformers but also reduces the zero-signal battery drain to only 5.5 milliamperes. Life of the 9-volt, multilayer battery is increased by about 30% over earlier Sony radios. Also, the transformerless stages cost about 15% less.

The first two stages of the three-stage audio amplifier, shown on page 161, use a complementary-symmetry cascade connection and operate class A. The output stage has a push-pull complementary-symmetry connection and operates class B.

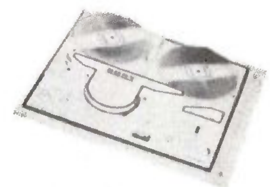
High stability is achieved by 100% d-c negative feedback through the 3.6-kilohm resistor from the output stage to the input stage transistor Q_1. Approximately 12 db of a-c negative feedback adds to the stability. With the second stage transistor Q_2 within the feedback loop, the stabilizing resistor usually needed in the emitter circuit can be removed. The bypass capacitor is also unnecessary.

The combination of pnp and npn transistors for Q_1 and Q_2 receives sufficient d-c negative feedback so that variations in the d-c current-amplification gains of the transistors have little effect on the over-all performance. The 2SC401 silicon transistor used for Q_2 has the advantage of amplifying the audio signal linearly with a zero-signal emitter current of only 2 milliamperes. This current flows through the speaker voice coil, which was specially designed to carry more than 12 milliamperes d-c without distortion.

The feedback loop stabilizes the d-c operating point of the audio output stage.

If a disturbance causes current at D to increase, the voltage at point A will rise and current I_2 will increase. This will cause a drop in voltage at points B, C and D—which suppresses the initial increase. A variation of this basic circuit is used in many of Sony's television sets.

Sensor reverses tape direction when the recording ends



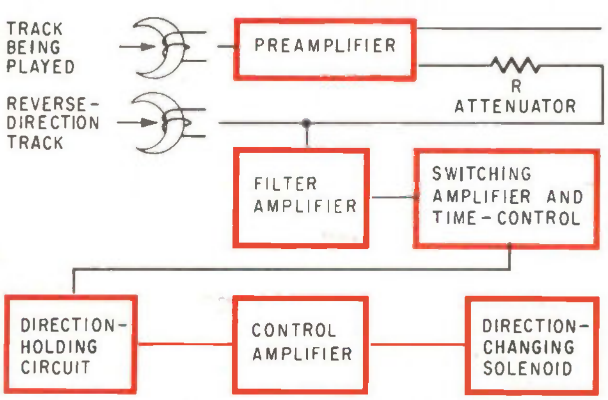
Automatic reversing circuit monitors recorded tracks, eliminating the need to modify tape

With what Sony calls its electronic sensory perception system, the direction of tape travel on a tape recorder is reversed automatically after the recorded portion has ended. In the system, designed for four-track stereo recorders, a triggering signal need not be added to the tape; in fact no modification of the tape is required at all.

Conventional tape-reversing systems either modify the tape physically or record on it in some way. Not only does this involve extra steps in tape production, but there is always the chance that the recording or the tape may be damaged.

Well-known reversing techniques include:

- Adhesive-backed aluminum-foil contacts fastened to the tape to operate a reversing switch.
- Special signals recorded on the tape and additional circuits in the recorder to reverse the tape automatically when the signal is sensed.
- Devices to sense the end of the tape when tension suddenly increases near the end of the reel.



"Electronic sensory perception" system in four-track tape recorders reverses direction of tape travel automatically by detecting signals in tracks one and four. When recording on tape ends, direction-changing solenoid is triggered.

Instead of these, Sony's system uses the actual recording on the tape tracks as its input and automatically reverses the tape when the recording signal ceases. An obvious danger in this elementary approach is that the tape may reverse automatically between musical phrases or in the unrecorded spaces between different selections on the same tape—which average 5 or 6 seconds. Two precautions are taken.

Recordings from tracks one and four are mixed to provide a signal whose dropout reverses the tape automatically. Since the two recordings are independent—track one is recorded for forward travel and track four recorded for return travel and there is no correlation between them—the statistical probability that both signals will drop out simultaneously is quite small.

In addition, a fixed time delay, T_1, of 6 to 10 seconds between the time when the recording ends and automatic reversal begins virtually eliminates the danger of reversal during the pause between recorded parts of the tape.

Another possible source of difficulty is the unrecorded portion at the beginning of each tape which averages 10 seconds but may run as long as 15 seconds. This is longer than T_1 and the recorder would automatically reverse if the T_1 delay was the only protection. So, a direction-holding circuit with a time delay, T_2, of about 10 seconds is provided.

This circuit, which is coupled to a manual stop switch, operates before the T_1 delay circuit becomes effective after the tape is started. Total direction-holding time, T_S, during which the recorder will not reverse after start, is about 20 seconds ($T_S = T_1 + T_2$).

The direction-holding circuit also operates when the tape is stopped in the middle. After the tape starts again the circuit maintains the same tape direction as before the tape was stopped.

A block diagram of the electronic sensory perception system is shown in the figure on page 163. The input signal is a composite of the signals from tracks one and four of the four-track tape. During mixing, crosstalk to the channel being reproduced must be kept more than 50 decibels below the program material. To achieve this, the track being reproduced is amplified to 0 db in the preamplifier and then attenuated in a resistive divider to the level of the reverse-direction playback head. This signal is then combined with that from the reverse track to form the composite signal.

A filter amplifier is used to boost the signal to the level required by the switching amplifier. It increases the signal-to-noise ratio by cutting all frequencies below 200 hz and all frequencies above 2,000 hz with an attenuation of 12 decibels per octave.

The switching amplifier converts the presence or absence of recorded signals, that is the presence or absence of an a-c signal, into a d-c voltage for controlling direction reversal. After the recorder has been started, the direction-holding circuit disables the switching amplifier and prevents it from producing a direction-reversing signal. However, when a direction-reversing condition is detected, the switching amplifier feeds the control amplifier which operates the reversing solenoid. This control amplifier may also be operated manually from a panel switch.

The switching amplifier is composed of transistor Q_1, resistor R_1, and capacitor C_1, as shown in the figure just below. This circuit has three time constants. The period of the recorded signal is T_{AC}. The time constant of R_1 and C_1 is T_1, corresponding to the delay in automatic reversal when the recording ends; the time constant of the collector-to-emitter on resistance of transistor Q_1 and capacitor C_1 is T_1'. For proper operation of the recorder, T_1 should be between 6 and 10 seconds. It is very much greater than both T_{AC} and T_1'.

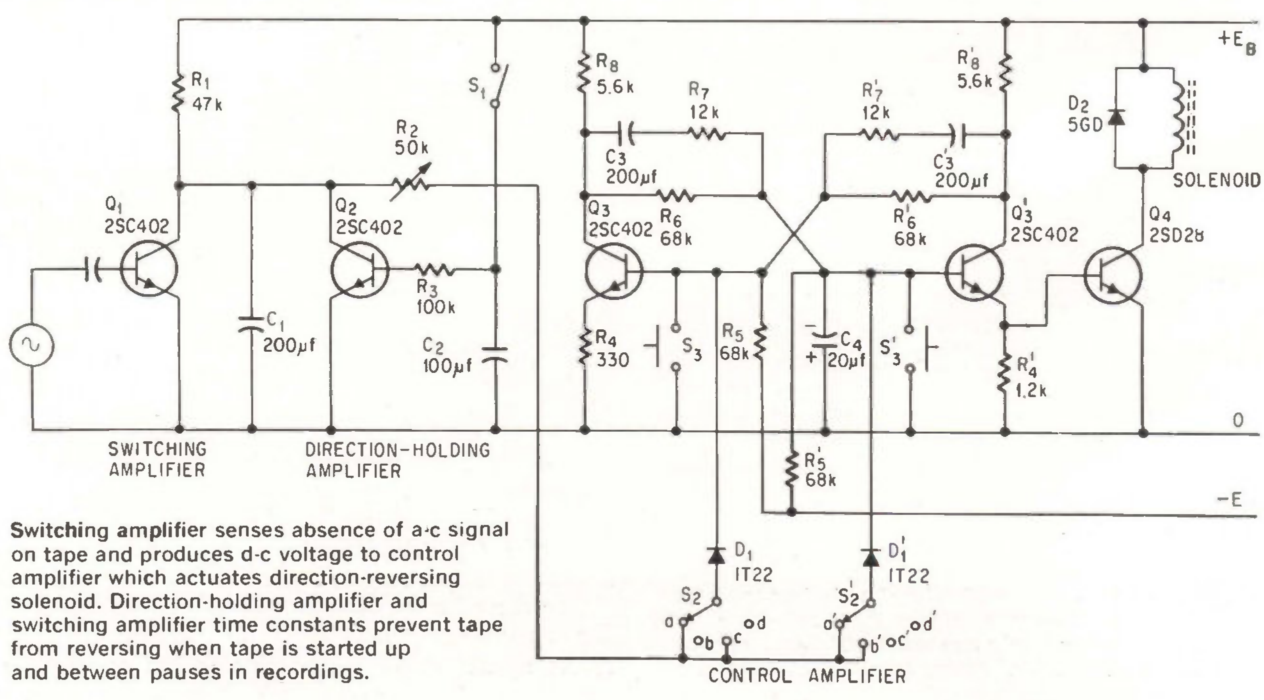
When an a-c signal is impressed on the base of Q_1, the transistor conducts during positive half cycles, discharging C_1. On succeeding half cycles the transistor is cut off and C_1 starts to charge. But since T_1 is much greater than T_{AC}, the rise in terminal voltage across C_1 is imperceptible. Also, since T_1' is much smaller than T_1, the capacitor is completely discharged on the following half cycle. Consequently the collector voltage of transistor Q_1 remains at 0 volts as long as there is an a-c signal impressed upon its base.

At the instant the a-c signal ceases, voltage on the collector of Q_1 rises to a predetermined value during the time interval T_1. Trimming resistor R_2 adjusts the operating voltage level of the control amplifier for fine adjustment.

The control amplifier is composed of a bistable flip-flop made up of transistors Q_3, Q_3', and an output transistor Q_4.

When Q_3' is off, Q_4 is also off and no current flows through the direction-changing solenoid. Under these conditions tape feeds in the forward direction. If the d-c control signal from the switching amplifier reaches a high enough level, the stage of the flip-flop changes so that Q_3' and Q_4 are on. Current flows in the solenoid and the direction of the tape reverses.

The flip-flop differs from most others in that the time constant of C_3, R_6, and R_7 is long—20 seconds—and an additional capacitor, C_4, is in the circuit. The long time constant is there so that after the recorder reverses automatically, it won't almost immediately reverse again. This precaution is necessary because the time delay before reversal is 6



Switching amplifier senses absence of a-c signal on tape and produces d-c voltage to control amplifier which actuates direction-reversing solenoid. Direction-holding amplifier and switching amplifier time constants prevent tape from reversing when tape is started up and between pauses in recordings.

to 10 seconds. Thus, after the tape starts going in the other direction there would still be no signal.

Capacitor C_4 is added so that when the recorder is first turned on transistor Q_3' will always be off and tape feed will be in the forward direction.

Transistor Q_2, with C_2, R_3 and switch S_1, make up the direction-holding circuit. Switch S_1 is coupled to the stop mechanism of the tape deck and is closed when the tape is stopped. This connects the base of Q_2 to the positive power supply through R_3. Transistor Q_2 is turned fully on, and capacitor C_2 is charged.

When the tape is started, S_1 is opened. However, Q_2 continues conducting during the interval T_2, the time constant of C_2 and R_3. After Q_2 turns off, the collector voltage of Q_1 can rise to a predetermined value during the interval of the time constant determined by R_1 and C_1.

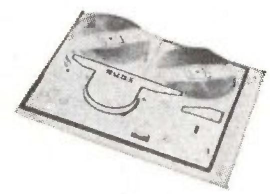
During this period of about 20 seconds, the direction-holding feature keeps the system from reversing the direction of tape travel even if there is no recorded signal.

Switches S_3 and S_3' control direction manually. S_3' sets the recorder for forward travel, S_3 for reverse. Whether the recorder is set for stop or play, these switches have the highest priority on operation. Switches S_2 and S_2' set the mode of automatic-reverse in this way:

- Position a-a'—forward, reverse, forward, reverse—repeated indefinitely.
- Position b-b'—single cycle of forward and reverse.
- Position c-c'—single cycle of reverse and forward.
- Position d-d'—automatic reverse off.

Regardless of the position of switches S_2 and S_2' manual reversal of the recorder by switches S_3 and S_3' is always possible.

Recorder gain control eliminates level indicator



No manual adjustment is required to hold recording level within 10 decibels for input level changes as high as 30 db

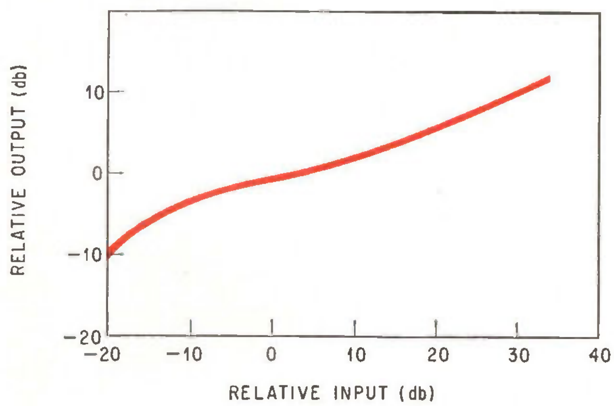
An automatic gain control amplifier used in a tape recorder maintains the proper recording level automatically without any kind of manual adjustment. It holds the gain without introducing distortion or noise and without seriously degrading the dynamic range of the signal.

The circuit has been kept deliberately simple so that it can be built into even inexpensive recorders. In the Sonymatic TC-900, which lists in the United States for $69.50, both the recording-level indicator and recording level control have been eliminated. Amplifiers with similar agc circuits are used in other Sony recorders.

The circuit for a typical automatic recording amplifier, next page, can keep the recording level constant within 10 db for an input level change of 30 db. The amplifier output is shown as a function of the input in the figure at the right.

Transistors Q_1 through Q_5 in the circuit are amplifiers. Diode D_1 is an agc detector. Transistor Q_6 is the agc control transistor.

Collector current of Q_6, a Sony 2SB381, is a linear function of its collector voltage for small signal amplitudes. Impedance between collector and emitter, Z_{CE}, of the transistor is thus an approximately ohmic resistance that can be expressed by the equation:

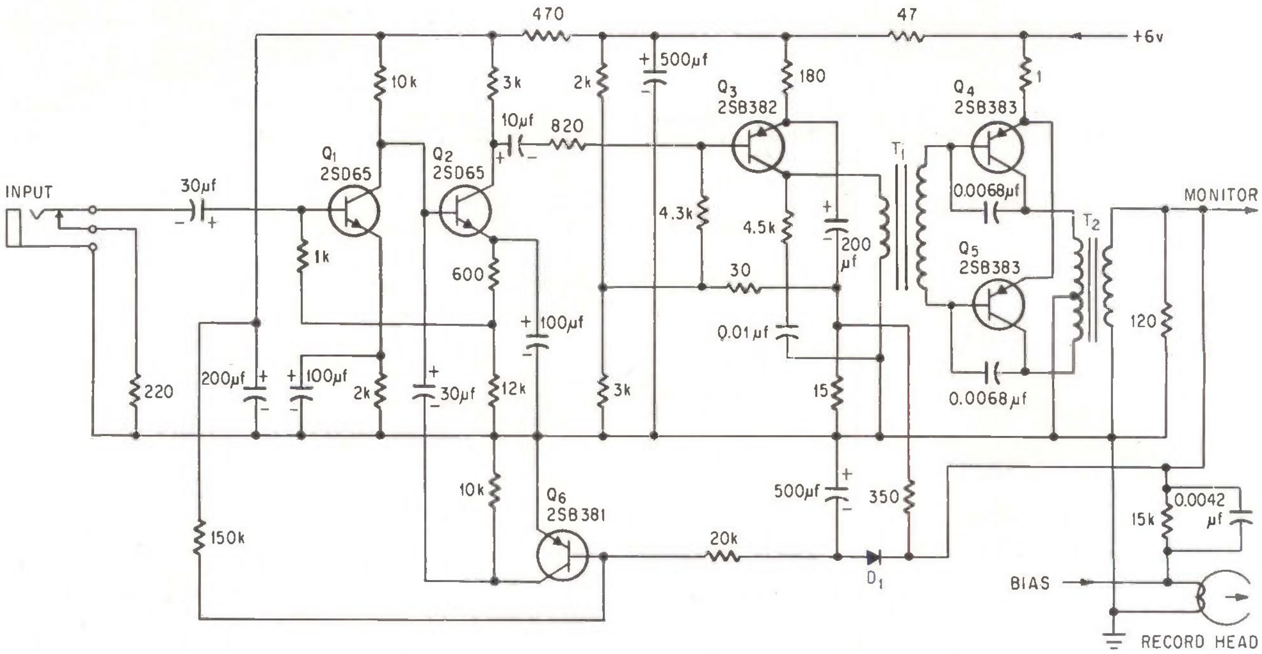


Output of automatic gain control amplifier is held to less than a 10-db change when input level changes as much as 30 db.

$Z_{CE} = \Delta V_{CE}/\Delta I_C$

The value of this impedance is controlled by varying I_b, the base current of the transistor. Z_{CE} is inversely proportional to I_b.

As the input signal to the recording amplifier increases, the output also increases. The gain-control signal, derived by rectifying a portion of the output signal with D_1, also increases. An increased

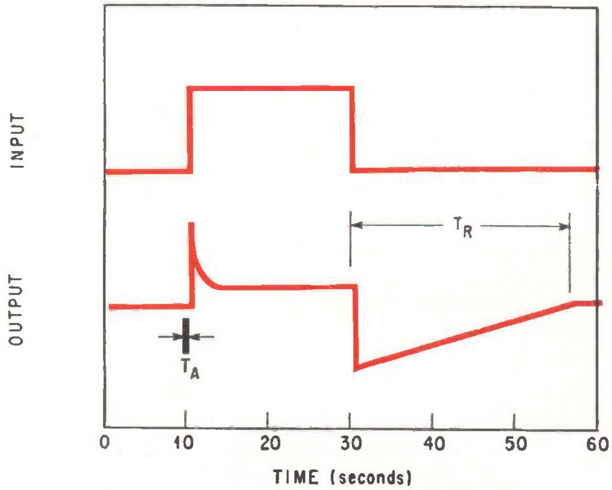


No manual gain adjustment of any kind is needed in Sonymatic TC-900 tape recorder which uses this automatic gain-controlled amplifier. Agc control transistor Q_6 acts as variable shunt impedance at output of amplifier Q_1 to modify gain of over-all recording amplifier.

control signal impressed on the base of Q_6 decreases its collector impedance Z_{CE}. More of the signal current at the output of Q_1 is shunted through Q_6 and the gain of the recording amplifier goes down. The output is thus held to a value close to what it was before the increase in input signal.

Attack and recovery

Attack time, T_A, and recovery time, T_R, both illustrated below, are important parameters in these amplifiers. Attack time is the lag between the instant the input signal level increases and the time the agc circuit has completed gain control. Recovery time is the lag between the instant the input signal decreases and the time the agc circuit has completed adjustment of gain.



Pulse response characteristics of recording amplifier determine how it will react to input level changes. Attack time, T_A—the time it takes the amplifier to resume gain control after the input signal increases sharply—is about 0.2 second. Recovery time, T_R—response time to sharp negative input change—is about 30 seconds.

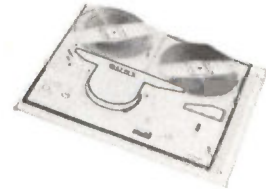
Attack time T_A is determined by the output resistance of the amplifier and the 500-microfarad electrolytic capacitor in the base of Q_6. A short attack time prevents distortion on initial syllables when the signal level changes abruptly. It must not be too fast, however, or short noises and electrical transients may cut the gain too much. T_A, which varies somewhat with the size of the level change, is about 0.2 second for an input level change of 20 db.

Recovery time T_R, determined by the RC components in the base of Q_6, is comparatively long, about 30 seconds for a level change of 20 db. When T_R is long, the agc circuit cannot follow a low-level signal coming immediately after a large one. Sudden gain changes do not occur and variations in amplitude of the input signal are reproduced with good fidelity. On the other hand, if T_R is too long, the agc circuit cannot follow long-period variations in input level.

The agc circuit has several other advantages:

- Its fast attack time and relatively slow recovery time almost completely eliminate audio-frequency signal components in the agc control signal, removing a source of distortion and noise.
- Comparatively long values of recovery time prevent a marked decrease in the dynamic range of the output signal.
- With the long recovery time, periodic microphone noise between phrases—when the input is zero—is blocked and the noise level of the amplifier itself does not increase.

Careful sweep design cuts power drain and cost



Several variations of vertical-sweep circuits reduce power consumption and number of parts in portable tv sets

The vertical-deflection circuits in several of Sony's portable television sets have been redesigned, reducing the number of components in one circuit and in another cutting down on the power consumption.

In the 7-inch 700U portable a two-transistor circuit, shown in the schematic below, is used for vertical deflection. It saves one transistor and its circuitry compared with the conventional three-transistor circuit used, for example, in Sony's 9-inch 9-51 portable.

In the 4-inch 4-20UW battery-operated portable, however, more important than cutting the number of components was reducing the power drain. The answer was a four-transistor vertical-deflection circuit shown on the next page. The class B output stage consists of two complementary transistors in a single-ended push-pull connection.

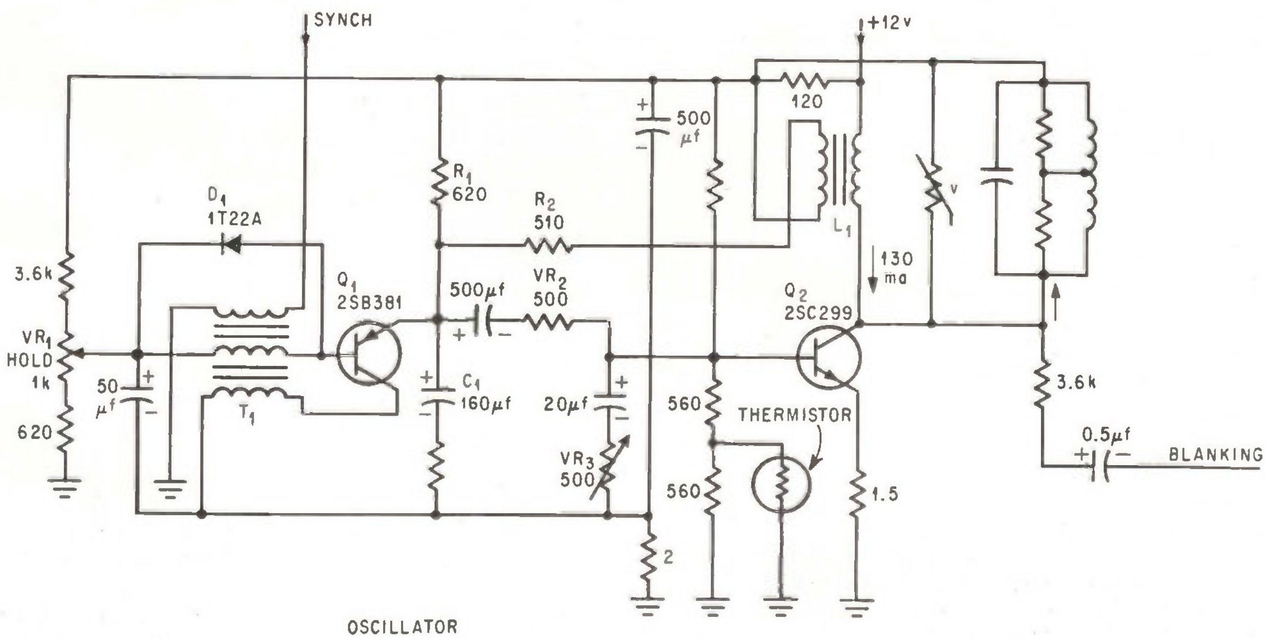
In general, vertical-deflection circuitry provides a repetitive 60-hertz sawtooth current through the vertical-deflection coil to sweep the electron beam vertically across the face of the picture tube. Because the frequency is low, the vertical deflection coil acts almost as a resistive load. Thus, the output amplifier driving the coil is linear, usually operating in class A.

The inductance of the vertical coil cannot be entirely neglected, however. Because of the inductive component, a peak voltage of 6 to 10 times the power supply voltage is generated during the vertical-retrace interval. This means that a transistor with a high reverse-voltage rating is needed in the output stage.

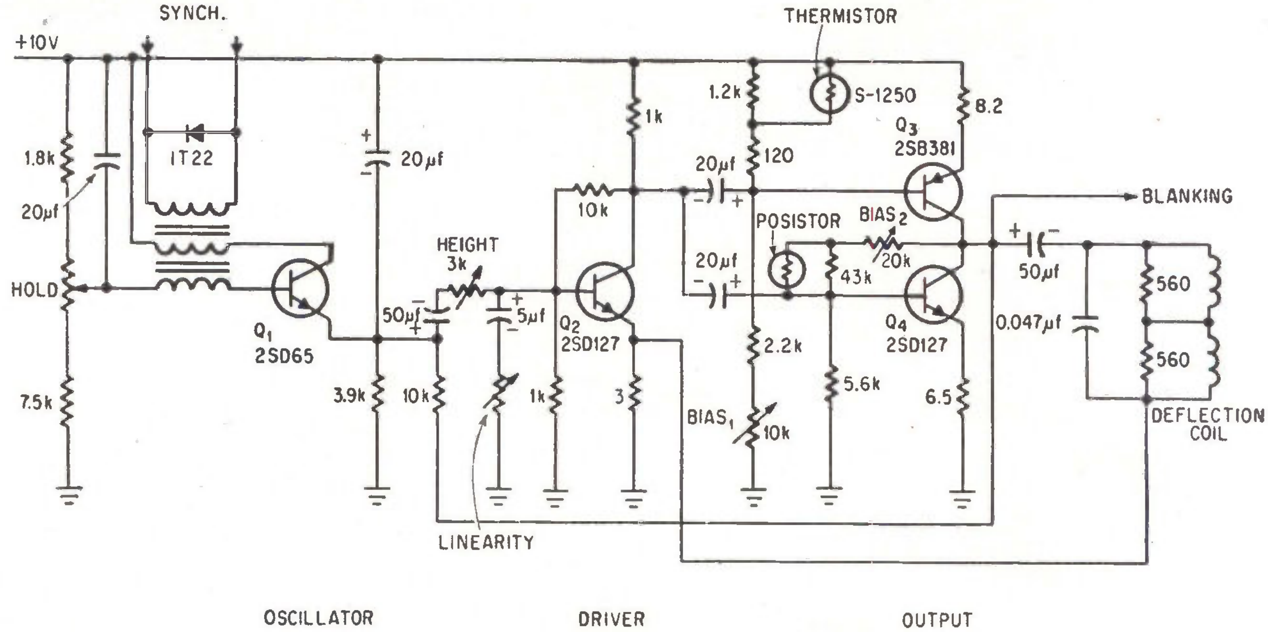
Blocking oscillator

Transistor Q_1 in the two-transistor circuit is part of an emitter-time-constant-type of blocking oscillator. Its switching action periodically discharges capacitor C_1, which is charged through resistor R_1, to generate the vertical-sawtooth voltage. Output across C_1 is approximately 2 volts peak-to-peak. Vertical hold potentiometer VR_1 adjusts the base voltage of Q_1.

The vertical synchronizing signal is injected into the tertiary winding of the vertical blocking transformer, T_1. Diode D_1, connected in parallel with



Two-transistor vertical deflection circuit in Sony's 7-inch 700U portable tv set. A design goal was to reduce the number of components.



Reduced power drain desired in 4-inch 4-204UW portable, led to design of four-transistor, vertical-deflection circuit. Output stage has two transistors operated in class B, complementary-symmetry in single-ended push-pull connection. Peak-to-peak deflection current is 134 ma but d-c current is only 20 ma.

the base winding of T_1, absorbs the pulse generated when Q_1 switches off.

As the value of the time constant of C_1 and R_1 is increased with respect to the vertical sweep period, the linearity of the generated sawtooth voltage improves. But, at the same time, the output voltage decreases so that the time constant cannot be made arbitrarily large. Values are usually between 30 and 100 milliseconds.

The sawtooth wave across C_1 passes through a passive network, which includes vertical height adjustment, VR_2, and vertical linearity adjustment, VR_3, on its way to the base of the vertical output transistor, Q_2.

This transistor operates class A and requires accurate temperature compensation because its output swing is almost equal to the power supply voltage. Without compensation, the operating point of the transistor would vary, reducing its linear operating range. Compensation is provided by physically attaching a thermistor to the transistor as a heat sensor. The thermistor compensates both for changes in ambient and in transistor-junction temperature.

The linearity of the vertical-deflection current is increased by negative feedback of a signal derived from the deflection current at the base of transistor Q_2. Complete correction cannot be obtained with negative feedback without excessive reduction in gain. Additional correction is provided with a positive-feedback signal, derived from a secondary winding on the vertical-deflection choke, L_1, and fed to the sawtooth-generating circuit. The total correction provided by the two feedback circuits provides a satisfactory linear sawtooth.

If the positive feedback is increased excessively by making R_2 too small, banding results. Banding is the failure of the interlaced scanning lines of successive fields to fall midway between each other. Adjacent pairs of lines, one from each field, overlap to produce a loss of detail in the overlapped region.

The voltage-dependent resistor connected in parallel with the deflection coil protects the vertical-output transistor by limiting the vertical-retrace pulse to 50 volts. If the retrace pulse were clamped at a lower voltage, the retrace interval would be excessive. Fifty volts is about the lower limit.

Four-transistor circuit

The output stage of the four-transistor vertical deflection circuit in the 4-inch set uses a pnp and an npn transistor in a class-B, single-ended push-pull output circuit, instead of class A as in the 7-inch set. This circuit was designed expressly for a small set powered by a battery. Although an extra transistor is needed, power drain is held to less than half that of the class A circuit, and the heavy coupling choke is eliminated.

Output transistors Q_3 and Q_4 are biased for class B operation so that collector current is less than 2 milliamperes in the absence of an input signal. When a sawtooth from the driver stage is impressed on the output stage, Q_3 is driven on during the negative portion of the input cycle. Transistor Q_4 is off. During the positive portion of the input cycle transistor Q_4 operates and transistor Q_3 is off. The sum of the two currents is the sawtooth current in the deflection coil.

The circuit must be adjusted so that the two sawtooths join smoothly if the linearity of the sweep is to be preserved. During production the two vertical bias potentiometers are adjusted alternately in a manner similar to the tracking adjustment of a radio. This must be done several times because the two adjustments interact. Both a thermistor and a positor (a thermistor with a positive temperature coefficient) are used to maintain the adjustment over a wide range of temperatures.

Reverse pulse voltage generated during the retrace interval of the deflection current appears as a forward bias across the collector-base diode of Q_3. The pulse is thus clipped at the 10-volt power supply level.

The value of the coupling capacitor to the deflection coil is empirically chosen to adjust the dissipation of the two transistors in proportion to their power ratings. This is necessary because the peak currents are not equal and because the two complementary transistors are not equal in power dissipating abilities: the pnp transistor can dissipate more power.

With a small enough capacitor, the ratio of voltage across the two transistors can be varied and the ratio of dissipations can be adjusted. Average current to the output stage of the vertical deflection amplifier is equal to the average collector current of Q_3. The waveform is approximately triangular, with the on interval about 8 milliseconds and its average value, including a slight additional bias of less than 2 ma, ranges from 20 to 22 ma.

Although the 4-inch set requires a peak-to-peak deflection current of 134 ma, a d-c current of only about 20 ma is sufficient with this circuit. Power drain of the output stage is about 20 ma at 10 volts, or 0.2 watt. If a standard class-A circuit were used instead of this single-ended push-pull circuit an average current of about 70 to 75 ma would be necessary.

Yoke circuit variations

Sony has developed variations in its vertical deflection amplifiers to permit, where possible, use of fewer components. Normally the deflection yoke is coupled to the output transistor by connecting one end of the yoke to ground and coupling the other end through a capacitor to the collector. Shunt feed prevents variations in the average current from affecting performance.

The circuit shown on page 167 evolved from this standard method. It has the advantage of eliminating the coupling capacitor.

In the three-transistor circuit Sony uses, for example, in its 9-inch set, one end of the deflection yoke connects directly to the collector of the vertical output transistor. The other end connects to the emitter of the vertical driver. Resistive voltage drops in the collector-emitter circuit balance the voltage drop through the shunt-feed choke. No coupling capacitor is needed. However, a 500-microfarad capacitor serves as both ground return for the yoke and as a decoupling capacitor between the output and preceding stages.

A variation of this circuit is used in the two-transistor configuration. The voltage drop across the 120-ohm resistor balances the voltage drop in the shunt-feed choke. Again, the 500-microfarad capacitor serves as both ground return and decoupling capacitor and the 2-ohm resistor in series with the capacitor provides a slight amount of negative feedback.

Sweep eliminates driver stage

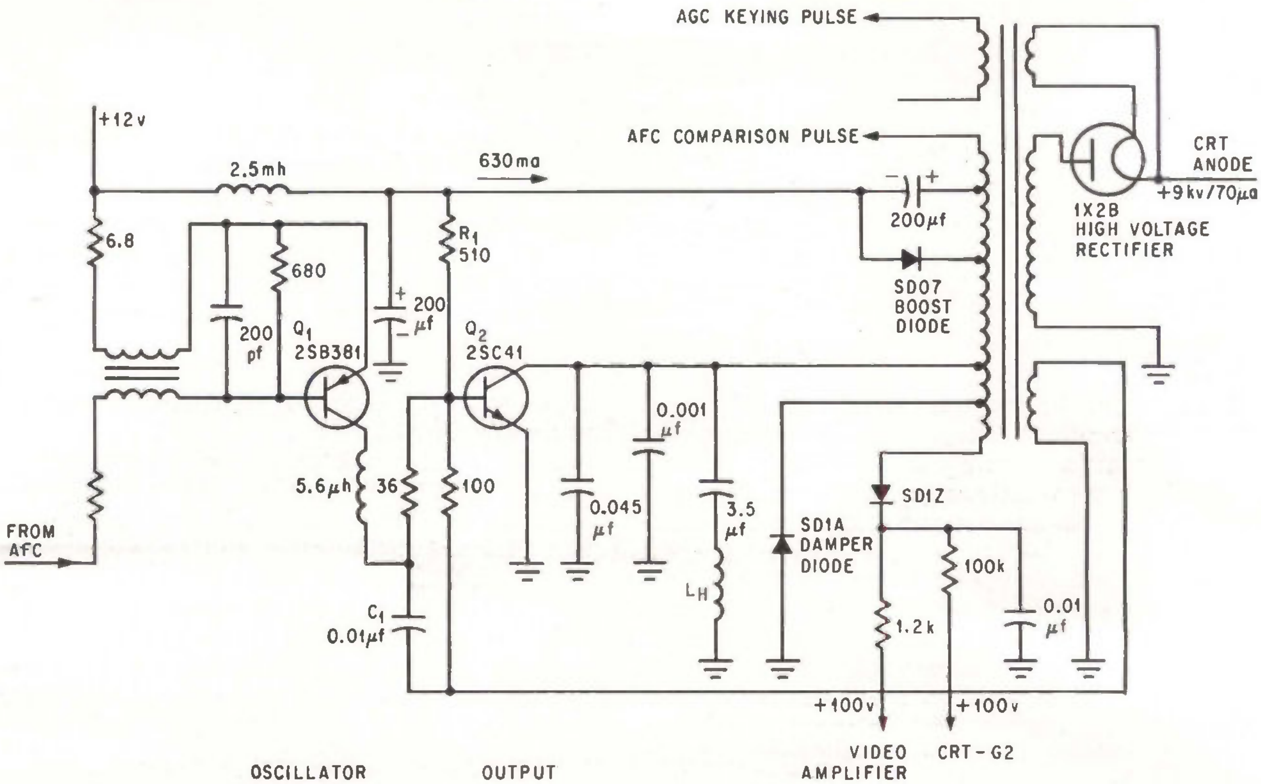
Two-transistor horizontal deflection circuit in 7-inch portable television set does the job of three transistors

For its low-priced portable television sets, Sony has redesigned the horizontal deflection circuitry, as shown on page 170, to use only two transistors, eliminating the driver stage. This economical circuit is used in the 7-inch 700U portable.

A three-transistor circuit normally is used in the horizontal deflection circuitry of a television set to sweep the electron beam across the tube's face. A blocking oscillator generates the initial sweep signal. It then goes to a driver stage where it is amplified and applied to the horizontal output stage. There it is boosted to the power level required for driving the horizontal deflection coil.

To restore the gain lost by eliminating the driver stage, Sony engineers added a tertiary winding to the flyback transformer which feeds a positive signal to the base of transistor Q_2 through capacitor C_1. In addition, a small forward bias is applied to the base of transistor Q_2 through resistor R_1. Because positive feedback is applied, Q_2 must have short hole-storage time to avoid introducing undesirable delay into the feedback loop.

The flyback transformer is not designed to match the impedance of the yoke as it usually does in the tube sets. During the portion of the sweep when Q_2 is conducting, the flyback transformer is essentially a choke for parallel feed of collector current to the transistor. It acts as a transformer



Driver stage is eliminated in two-transistor horizontal deflection circuit in Sony's 7-inch 700U tv set. A tertiary winding on flyback transformer provides a positive feedback signal to base of the output transistor Q_2, making up for the lost gain.

during flyback and while the damper diode, SD1A, handles sweep power. This use of the flyback transformer minimizes losses.

Boost circuit

Added to the primary winding of the flyback transformer is a boost diode, shown in the schematic, which helps to increase the supply voltage to the horizontal output circuit from 12 to 18 volts. This diode rectifies the a-c derived from the tap on the flyback transformer, charging the 200 microfarad capacitor and increasing the apparent supply voltage.

Boost is important in battery-operated sets—normally limited to 12-volt supplies—because the horizontal output transistor is running close to its maximum current rating but usually not at its maximum collector voltage rating.

For a given power-switching capacity, the transistor price decreases with increasing voltage rating up to about 300 volts with present Sony production techniques. For example, Sony uses 300-volt transistors in line-operated sets which have 24-volt power supplies, boosted to 36 volts. Peak voltage on the output transistor, operating from a 12-volt battery, boosted to 18 volts, is about 110 volts.

Another reason for operating at a boosted voltage is that as the supply voltage goes up, the collector-to-emitter voltage drop—about 1 volt in the circuit here—becomes a smaller fraction of the supply voltage and efficiency of the circuit goes up.

Peak horizontal deflection energy, P_H, in joules, required by the CT 480 picture tube in the 7-inch tv set is approximately 1.8—with units of millihenries-peak-to-peak amperes squared—at an anode potential of 9 kilovolts. L_H is the deflection yoke inductance in millihenries and I_{pp} is the peak-to-peak deflection current in amperes. This power expression is an empirical one, obtained by driving a deflection coil and measuring the energy needed for the slight overscan generally built into tv receivers. Actual inductance and current can be calculated from the equations:

$$P_H = 1/2\, L_H\, I^2_{pp}$$

$$I_{pp} = (T_H - T_R)\frac{E_o}{L_H}$$

where: L_H = yoke inductance in henries
I_{pp} = peak-to-peak deflection current in amperes
T_H = time of one horizontal line in seconds
T_R = horizontal retrace interval in seconds
E_o = power supply voltage (including boost)

In the 525-line television system used in the United States, the horizontal sweep period T_H is 63.5 microseconds, the reciprocal of the 15,750-hertz horizontal line frequency. The horizontal blanking interval is about 10 microseconds and it is usual to keep the retrace interval, T_R, less than this.

However, in transistor television the horizontal output circuit efficiency can be increased by lengthening the retrace interval within limits that do not degrade the picture. Efficiency is increased because, with the longer retrace time, the peak-to-peak sweep current required is decreased.

Thus, with a boosted power supply voltage, E_0, of 18 volts and a 12-microsecond retrace interval (T_R), the calculated deflection coil inductance L_H is 240 microhenries and deflection current I_{pp} is 3.8 amperes. In the actual circuit, inclusion of the flyback transformer as well as circuit resistive loss requires that the values be adjusted to $L_H = 220$ microhenries and $I_{pp} = 4$ amps.

Collector peak inverse voltage is calculated from the equation:

$$E_p = \frac{\pi}{2}\left(\frac{T_H - T_R}{T_R}\right)$$

Value of E_p calculated from the equation is 122 v peak-to-peak; measured voltage is 110 v.

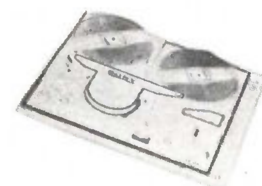
Switching power requirements in the horizontal output circuit is consequently $I_{pp} \times E_p = 440$ VA peak-to-peak. Approximately 60% to 70% of this power is handled by the output transistor, with a damper diode handling the remainder.

The flyback transformer also delivers:

- Anode high-voltage power supply for the 7-inch picture tube. Anode voltage is +9 kv, current 80 μamps (0.72 w).
- Heater power supply for the 1X2B high-voltage rectifier. Heater voltage is 1.25 v, heater current is 200 ma (0.25 w).
- Grid-two power supply for the picture tube and collector power for the video-output amplifier. Supply voltage is +100 v, total current drain is 6 ma (0.6 w).
- Keying pulse for agc (—21 v, peak-to-peak).
- Positive feedback pulse to the horizontal output circuit (—71 v, peak-to-peak).
- Comparison pulse for horizontal afc circuit (—68 v, peak-to-peak).

These power requirements are all developed by the horizontal output transistor so that the power consumption of the horizontal output stage is approximately 9.5 watts.

Two-stage gain control for portable tv set



Two transistors handle 50-db range of input signals without distortion or overload

Sony has devised a two-transistor automatic gain control for its portable television receivers with a control range exceeding 50 decibels, far greater than obtained in a single stage of conventional gain-control circuitry. Large input signals are handled without distortion or overload.

One of the transistors, Q_2, shown on page 172, amplifies while the other, Q_1, forms a variable impedance in the emitter circuit of Q_2 and also controls its bias.

The control signal for Q_1 is derived from the agc keyer circuit, which is indicated in the schematic. It is a positive-going signal fed to the base of Q_1 through a network consisting of resistor R_1 and bypass-capacitor C_1.

The equivalent parallel-resistance component, R_p, of the collector-to-emitter impedance of Q_1 is very sensitive to changes in collector to emitter voltage V_{CE1}. In the graph of R_p as a function of V_{CE1}, with I_{E1} as a parameter, shown on page 172, if I_{E1} is held constant and V_{CE} is reduced, R_p falls to a very low value.

At the agc start point, R_p is less than 70 ohms and Q_1 is operating in the saturation region. Collector voltage V_{CE1} is —0.15 volts and base voltage V_{BE1} is —0.3 volts. Since $V_{CE1} = V_{CB1} + V_{BE1}$, collector-to-base V_{CB1} is +0.15 volts. Forward collector-to-base voltage brings the very low value of R_p.

Combined transconductance

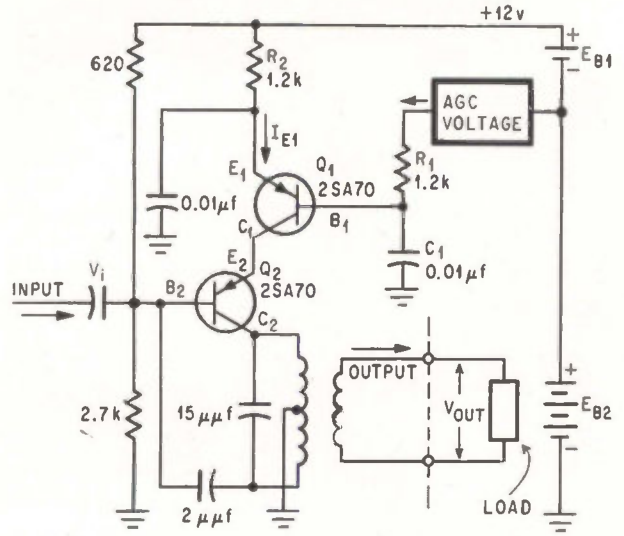
Resistance component R_p increases with increasing negative voltage bias on the collector-to-base junction and decreasing emitter current. In operation the collector voltage becomes more negative and the emitter current decreases as the bias point of Q_1 shifts from the agc start point, A, to the agc stop point, D. Collector impedance R_p increases from less than 70 ohms at A to 35,000 ohms at D. Transistors Q_1 and Q_2 can be viewed as a single transistor with a combined transconductance, $|G_m|$, given by:

$$|G_m| = \frac{\alpha_0}{|Z_e|}\,\frac{1}{\sqrt{1+\left(\frac{r_{bb}'}{Z_e}\right)^2\left(\frac{f}{f\alpha_b}\right)^2}}$$

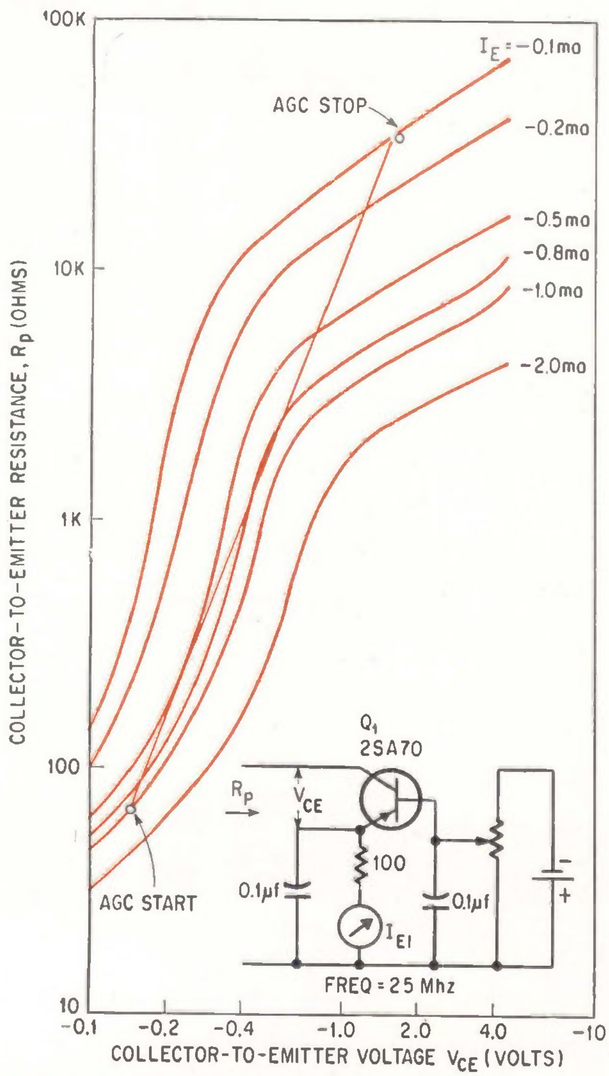
where: r_{bb}' = base-spreading resistance (100 ohms for the 2SA70)

$|Z_e|$ = impedance in emitter circuit of Q_2. It depends almost completely on V_{CE} and I_E of Q_1.

f = frequency of measurement, usually



Two-transistor gain controller in portable television receivers applies positive-going agc voltage to base of Q_1, which acts a variable emitter-circuit impedance for 26.75-Mhz i-f amplifier Q_2.



Collector-to-emitter resistance, R_p, plotted with the help of the circuit in the lower right, is very sensitive to changes in collector-to-emitter voltage, V_{CE}. Resistance varies from about 70 ohms to 35,000 ohms.

25 Mhz for i-f amplifiers in Japan.

$f\alpha b$ = alpha cutoff frequency for common base connection, typically 100 Mhz for the 2SA70.

α_o = value of α at low frequency. It can be taken as unity.

When I_{E1} is -1 ma and $|Z_e|$ is 100 ohms, the value of $|G_m|$ is 10 millimhos. This is the approximate transconductance at point A. When I_{E1} is -0.1 ma and $|Z_e|$ is 35 kilohms then the value of transconductance has decreased to 28.6 micromhos. This is the approximate value at point D. This large decrease in transconductance gives a correspondingly large decrease in gain. The attenuation ratio can be calculated from the formula for gain:

$$A_v = (V_o/V_i) \approx (|G_m| \times R_L)$$

As the operating point of the two-transistor circuit moves from agc start to agc stop, gain attenuation is about 50 decibels.

Distortion is reduced and overload prevented by having the bias on the amplifier vary with the level of the input signal, that is, the bias follows along the load line of emitter resistor R_2.

The peak value of the input voltage, V_i, is:

$$e_p = \sqrt{2}\,(1 + m) \times V_i \text{ (in volts)}$$

where m = the degree of modulation (in per cent)

V_i = root-mean-square input voltage.

If the degree of modulation is taken as 0.4 (40%), and V_i as 600 millivolts, then e_p is 1.2 volts by substitution in the equation.

The resistance of R_2 is calculated from:

$$R_2 = e_p/\Delta I_{E1}$$

where ΔI_{E1} is the difference between I_{E1} at the agc start point, A, and agc stop point, D.

Emitter current I_{E1} for point A is chosen as 1 ma, and for point D it is 0.1 ma. Substitution of $e_p = 1.2$ volts gives a calculated R_2 of 1,333 ohms. Since current gain α_0 of both transistors is at least 0.99, I_{E1} and I_{C2} are approximately equal. The collector current of Q_2 at point A is $I_{C2} = \alpha_0 2I_E \approx 0.98$ ma. At point D it is 0.098 ma. Bias, V_{BEA}, measured from the emitter of Q_1 to the base of Q_2 on the composite transistor consisting of Q_1 and Q_2 is 0.38 volts when there is no input signal. This bias corresponds to the condition existing at point A on the curves of R_p versus V_{CE}.

At point D on these curves, where the collector current of Q_2 is about equal to the emitter current of Q_1 at 0.1 milliamperes, the bias V_{BED} has increased to 1.58 volts.

Therefore, even if an input signal V_i of 600 mv rms is applied to Q_2 at point D, the transistor has a high input impedance because of the expanded linearization and little distortion of the controlled signal occurs. In production sets, R_2 is 1,200 ohms, the nearest standard value to the 1,333 ohms calculated, a value large enough to give the linearization desired.

Reprints of this report are available. Use the reader service card at the back of this issue.

AMELCO's new 807BE OP AMP has a total input offset voltage of only 3.0 mV! (−55°C to +125°C)

The 807 is the newest addition to Amelco's successful line of monolithic operational amplifiers—unsurpassed in drift performance and now available from stock at only $45.00 in TO-5s or flat packs.*

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PARAMETER	CIRCUIT TYPE			UNITS
Input Offset	807BE	709A	1533	
Voltage (25°C)	2.5	5.0	5.0	mV
Voltage (−55°C to +125°C)	3.0	6.0	6.0	mV
Voltage Drift (untrimmed)	10	note	note	μV/°C
Voltage Drift (trimmed)	5.0	note	note	μV/°C
Current	50	200	150	nA

Note: Both 709A and 1533 list no guaranteed value for this parameter. Worst case calculations of $\frac{11mV}{180^\circ C}$ show that devices with Drift of 60 μV/°C would be in spec.

$45.00 isn't much to pay for the world's best monolithic op amp. You'll pay three to four times that much for an equivalent module-type op amp—hardly what we'd call a bargain! Your best buy is really our 807 data sheet. It's free.

*QUANTITIES 100 AND UP

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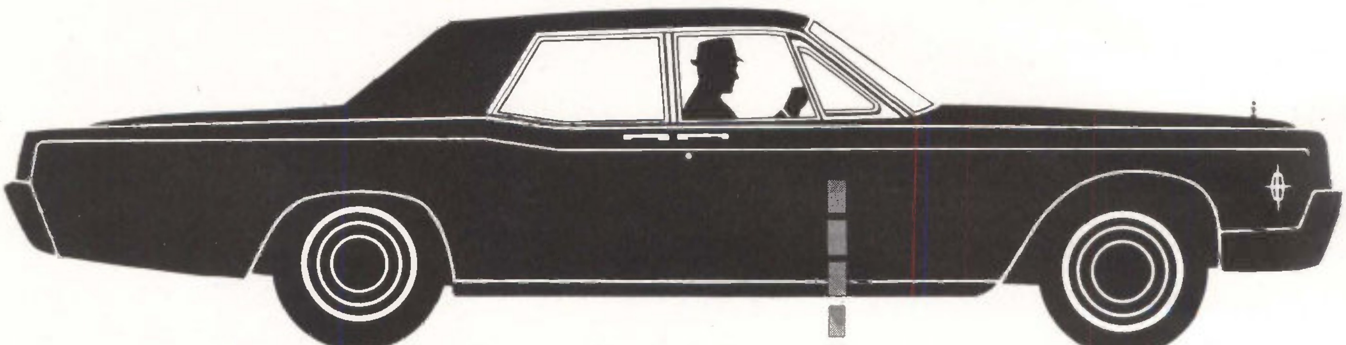
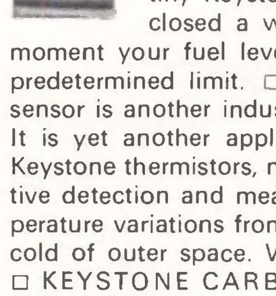
Circle 173 on reader service card

Low fuel warning



another first for Ford Motor Company —the key is KEYSTONE



A red light glows suddenly on your Continental's instrument panel. It warns you *"Low fuel,"* and stays bright to keep reminding. Back in the fuel tank a tiny Keystone thermistor had closed a warning circuit the moment your fuel level dropped past a predetermined limit. □ This liquid level sensor is another industry first for Ford*. It is yet another application for quality Keystone thermistors, made for the sensitive detection and measurement of temperature variations from oven heat to the cold of outer space. Write for literature. □ KEYSTONE CARBON COMPANY, St. Marys, Pennsylvania 15857

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Keystone *leads*
in versatile Thermistor design

 Circle 174 on reader service card

Circle 175 on reader service card→

NAND logic is old hat.

We've invented SDS Natural Logic for our T Series integrated-circuit modules. It's a comprehensive set of gating structures that permit the terms of any Boolean logic equation to be converted directly into hardware.

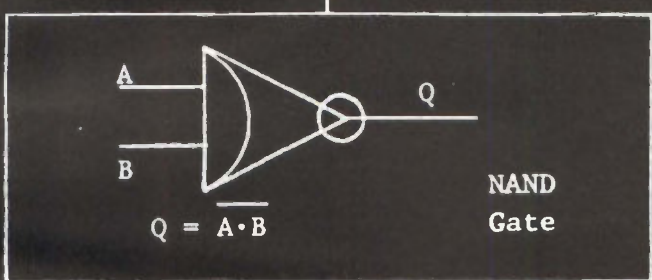
Now you won't have to manipulate equations to make them fit the restrictions of NAND or NOR gates. With Natural Logic the hardware fits the equations without unnecessary inversions.

So you won't need nearly as many circuits to build your logic system. Your system will cost you a lot less. It will be faster and more reliable. It will be easier to mechanize. And it will take up less room.

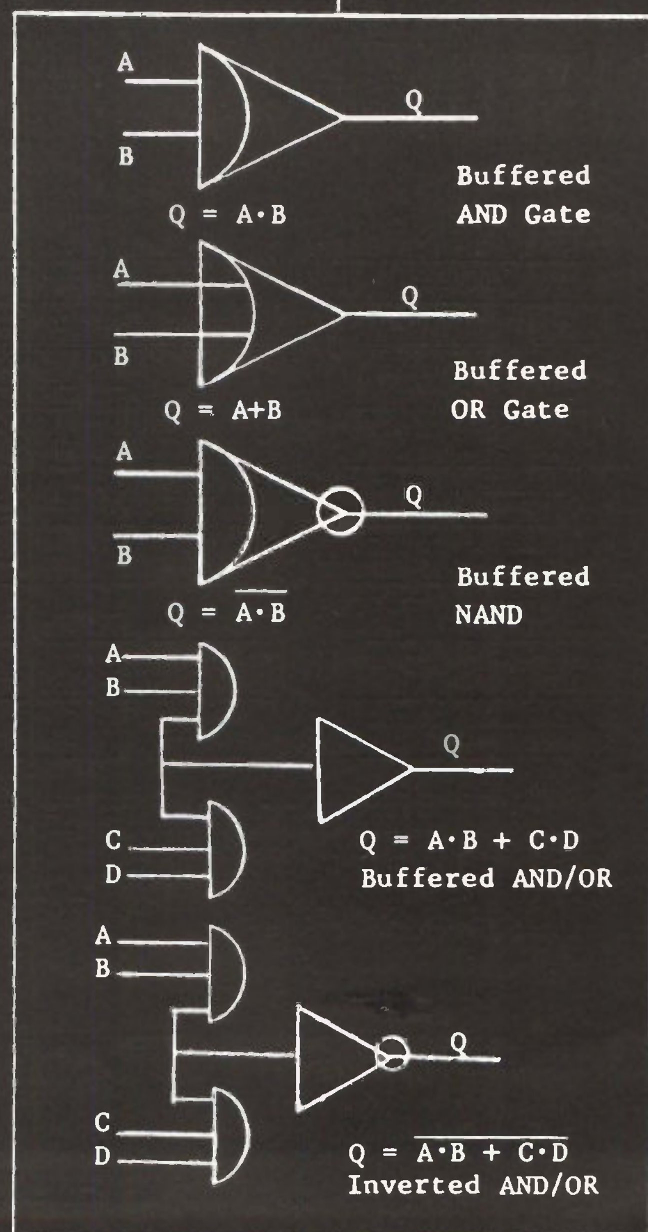
Naturally.

Scientific Data Systems
1649 Seventeenth Street, Santa Monica, California
Offices in principal cities throughout the world

With NAND logic you are stuck with only this, no matter what the equations call for.



With T-Series NATURAL logic you have all these to choose from at a lower price per circuit.



Philbrick Operational Amplifiers for comparison shoppers

Compare their prices†

Philbrick			Prices of Comparable Models				
Feature	Model	Price	A	B	C	D	E
Parametric	SP2AU	$138.	$195.	—	—	—	—
FET	PP25AU	$ 79.	$ 85.	$ 95.	$75.	$85.	$95.
High performance, high impedance	PP35AU	$ 54.	$ 35.	$ 65.	$85.	$42.	—
High performance, ultra-high speed	PP45AU	$ 89.	—	$125.	—	$90.	—
General purpose	PP55AU	$ 15.	$ 19.	—	$18.	$17.	$19.
General purpose, high speed	PP55AHU	$ 19.	$ 58.	$ 95.	$31.	$35.	—
General purpose, high performance	PP85AU	$ 25.	$ 26.	$ 35.	$29.	$24.	$46.

These Philbrick Operational Amplifiers, which meet more than 70% of all requirements, are available in quantity for immediate delivery. Conservatively-rated, they never fail to deliver the promised performance and reliability. Compare Operational Amplifiers and we know you'll concur . . . Philbrick is usually the lowest priced, always the best value.

†U.S. unit prices from published literature—9/66

For more information, demonstration units, or engineering assistance, call your nearest Philbrick engineering representative or Philbrick Researches, Inc.,22 N Allied Drive, Route 128, Dedham, Massachusetts 02026. Phone (617) 329-1600.

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due to CTS automated production techniques and the industry's biggest output.

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1-3/64" dia.
3 watts @85°C

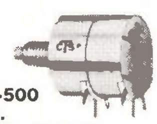
Series 500
3/4" dia.
1-1/2 watts @85°C

Series 600
1/2" dia.
3/4 watt @85°C

Consider these CTS Cermet Pot characteristics:

1. 20 Ω to 5 megohms resistance range.
2. Greater power/size ratio. (See captions.)
3. The environmental stability & higher wattage rating of wirewound.
4. The wide resistance range & infinite resolution of carbon.
5. Extremely high temperature capabilities.
6. Stability under extreme humidity.
7. No catastrophic failures.
8. Low noise. Long life.
9. Exceed MIL-R-23285 (Navy) metal film; far exceed MIL-R-94B.

Series 550
3/4" dia.
2 watts @70°C



Series 2-500
3/4 " dia.
1-1/2 watts @85°C
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Series 385
11/32" dia.
1/8 watt @125°C
For P.C. applications

Series 600PC
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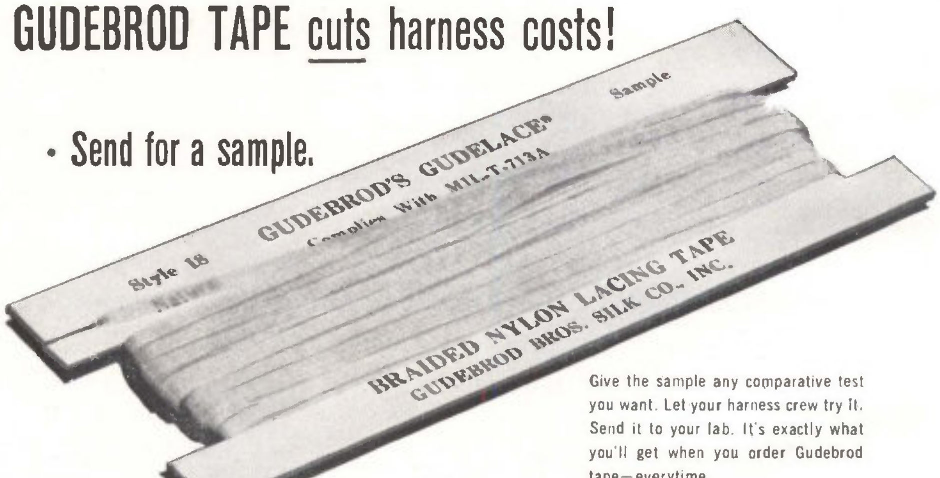
MIL-T-713 calls for 22% to 32% wax coating on LACING TAPE.

• But what really is the right amount for trouble-free, tight-knot lacing?

• GUDEBROD KNOWS. They make yard after yard after yard exactly right!

• GUDEBROD TAPE cuts harness costs!

• Send for a sample.



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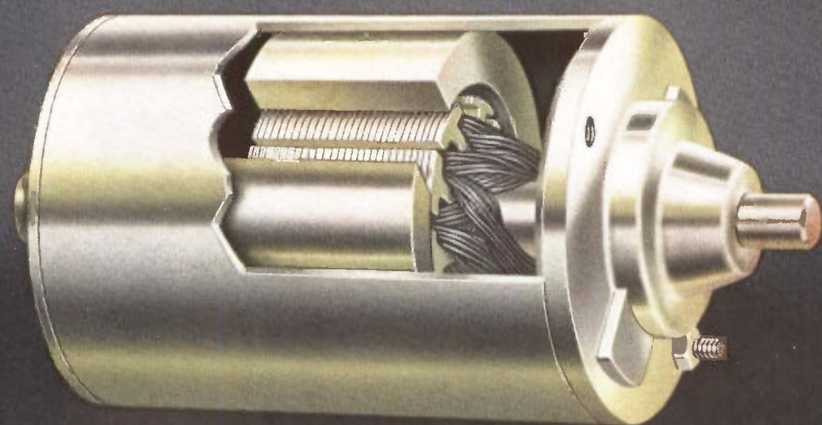
Circle 179 on reader service card→

American Bosch

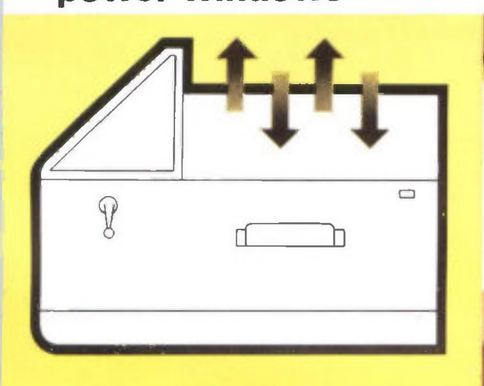
uses Allen-Bradley Oriented Ceramic Permanent Magnets...

because of their uniformity in staying within specifications, and delivery schedules—though tight—are kept!

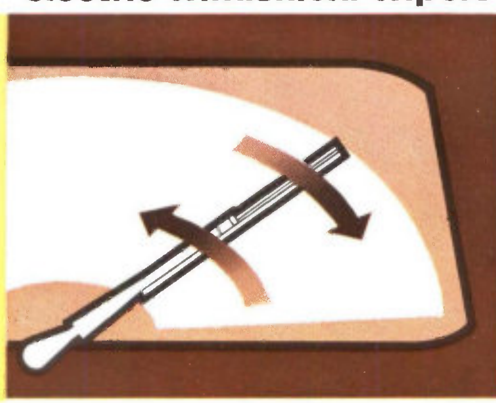


American Bosch permanent magnet motors are used for...

power windows



electric windshield wipers

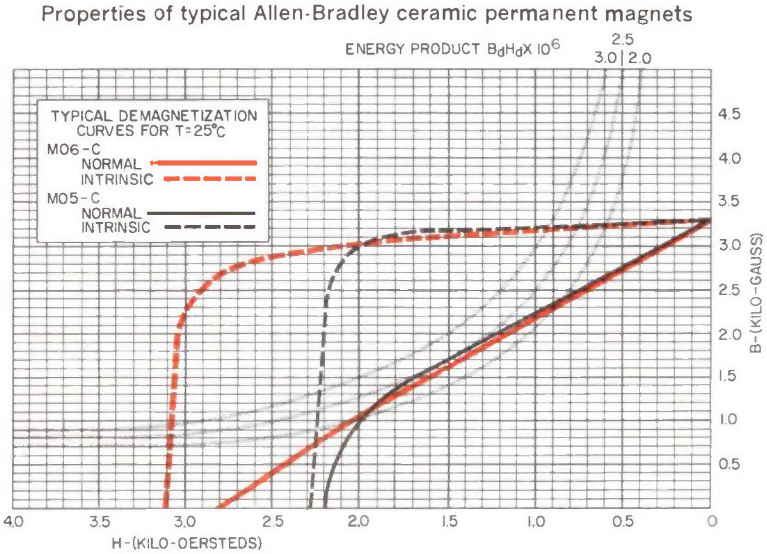


power seats

■ Allen-Bradley's quality control procedures assure the continuously uniform properties—both electrical and physical—that are essential to profitable large volume motor production. The most modern manufacturing facilities in the hands of technically experienced craftsmen produce the highest quality, radially oriented ceramic permanent magnet segments that are presently available.

Allen-Bradley ceramic permanent magnets can be furnished for a wide range of motor sizes—from ¾" diameter up to a 10 hp motor rating. They are available in a variety of types—having different properties—to satisfy your specific requirements. A-B application engineers will be happy to consult with you in developing your dc motors for maximum motor performance. Allen-Bradley Co., 1316 S. Second St., Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Ave., N.Y., N.Y., U.S.A. 10017.

Properties of typical Allen-Bradley ceramic permanent magnets



ALLEN-BRADLEY

QUALITY MOTOR CONTROL

QUALITY ELECTRONIC COMPONENTS

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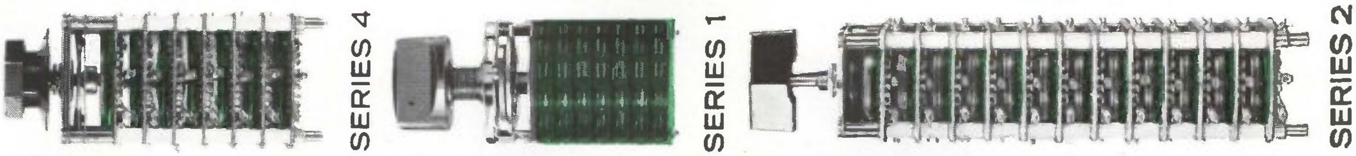
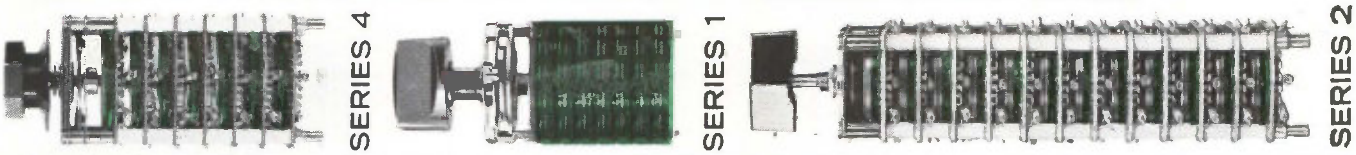


FOR TRULY OUTSTANDING DRY CIRCUIT SWITCHING . . . TRY THESE:



FOR EASIER ROTARY SWITCH SPECIFICATION . . . TRY THESE:

FOR FASTER ROTARY SWITCH DELIVERY . . . TRY THESE:

IF YOU DO, you'll find that Shallcross Series **1**, **2** and **4** precision rotary switch lines offer:

LOWER TOTAL COST — INITIAL COSTS ARE NORMALLY LOWER (often 25 percent or more) than those for rotary switch counterparts claiming comparable quality. INSTALLATION COSTS ARE REDUCED by easily wired flared terminals (identified for location) and rugged construction features that virtually eliminate switch damage during harnessing. MAINTENANCE AND REPLACEMENT COSTS ARE REDUCED to the vanishing point by: (1) 50 in/lb stop strength ratings, (2) multiple contact wipers (for reliable circuit "making"), (3) positive action long life detents, (4) dust protection for internal switch parts, and (5) material-design combinations that reduce voltage breakdown and insulation resistance failures. Add these cost "savers" to lower specification costs (below), and you'll see why Shallcross has the most economical top quality rotary switch line in the industry — as a matter of fact, an investigation will prove that Shallcross switches are often less in total cost than the lowest priced "clip types."

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The best values in quality rotary switching wear this brand—try them.

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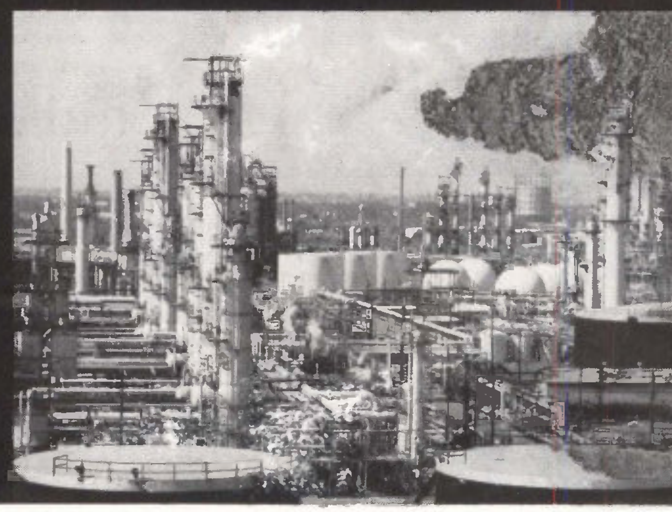
←Circle 180 on reader service card

"How can we scan temperatures at a rate of 10 points/second?"



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Proven EMC temperature scanner systems are now available for countless applications in a variety of industries.

Monitoring temperatures at a rate of up to 10 points a second from 0°C to 500°C with a demonstrated accuracy of 0.1% of full scale, these systems have already saved thousands of man-hours for users in the chemical industry.

These modularly-constructed systems are simple to install, operate and maintain. Pushbutton controls provide monitoring ease and flexibility. Modular units are interchangeable.

The highly reliable systems are constructed from modules with proven reliability of 4.5 million hours MTBF. This gives the typical system an MTBF in excess of 8,000 hours.

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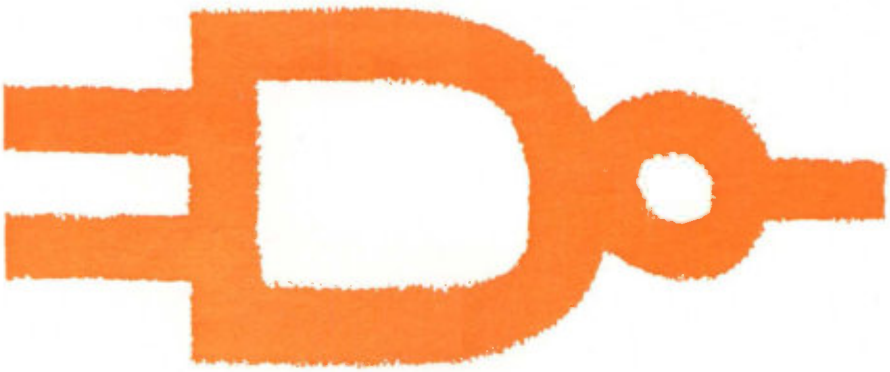
Philco talked to 409 engineers before designing these two 930 DTL circuits.

Dual RS Flip Flop



Transfer Gate Function

Two of the problems most of these engineers mentioned were: a large package unit count; and an excessive amount of external wiring on breadboards. That's why we designed these two circuits. They give you flexibility in design, 930 compatability, and added utility to the entire 930 series.

DUAL RS FLIP FLOP: Two 3-input NAND gates. A basic memory operation with a double set and reset capability—all in one package.

TRANSFER GATE: Has four 2-input NAND gates and one inverter. It will transfer logic functions—even octal—with ease. And you won't have to use an additional package unit for phase change. This has an inverter built right in.

Philco has a complete line of 930 DTL integrated circuits—packaged in flat pack, dual inline, ceramic flat pack, and TO-5 cans. Military and limited temperature range. We would be happy to talk with you about any of these, which include: Dual 4-input Gate, JK or RS Binary, Dual Buffer, Dual 4-input Expander, Dual Power Gate, Clocked Flip Flop, Quad Gate, Binary, Hex Gate, and a one-shot Multivibrator. Available now.

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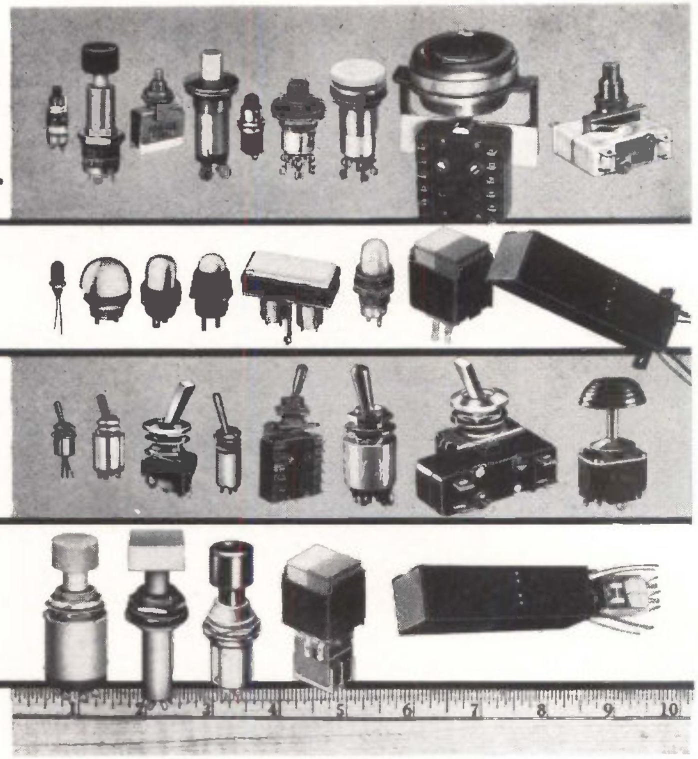
Is this your design department?



Bill can't find a small enough pushbutton.

Ed wants an extra-tiny indicator light.

Joe's checking four sources for a toggle.

George wants a snap-in switchlite.

You fellows ought to know Control Switch!

Rip out the bingo card in this book now and tick off numbers for any or all of the Control Switch catalogs listed below.

If you get all seven catalogs, you'll have the most complete file you can get from any single source!

Control Switch makes more types of switches and switchlites than anybody. So our catalogs offer the best chance of finding what you want . . . first try!

In addition, some manufacturers don't make any of the switches and lights we make. So these catalogs save chasing all over for switches.

Finally, Control Switch makes quality switches. For applications like data processing equipment, space age projects, and instrumentation systems. So our catalogs save horsing around with switches that can't deliver. *Send that bingo card now!*

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#504 Toggle Switch Catalog 180
#505 Indicator Light Catalog 120
#506 Hermetically-Sealed Switch Catalog 130
#507 Switchlite Bulletins 54, 55, 63
#508 Switchlite Catalog 220
#509 Pushbutton Switch Catalog 190
#510 RFI-Shielded Component Bulletin 62

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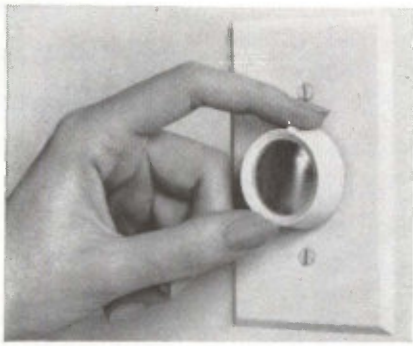
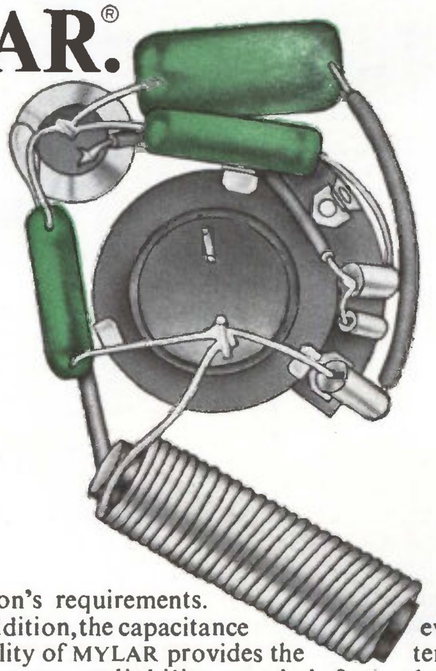


Lutron needed: the best combination of small size, reliability and low cost in capacitors for solid state dimmers.

So Lutron chose: capacitors of MYLAR®



"Only capacitors of MYLAR* give us the size and reliability we must have, and at low cost," says Joseph M. Licata, Chief Engineer. Lutron Electronics Co., Inc.

Lutron's broad line of dimmers is miniaturized to fit single gang boxes for quick, easy installation. Because MYLAR has extremely high dielectric strength in thin gauges, capacitors made from this polyester film can be manufactured small enough to meet Lutron's requirements.

In addition, the capacitance stability of MYLAR provides the long-term reliability needed for trouble-free brightness control of all types of incandescent and fluorescent lighting.

Voltage requirements for Lutron's dimmers are 200 to 600 volts, and in many instances these units operate around the clock. Lutron's own tests and experience indicate capacitors of MYLAR perform well in these conditions, even under extremes of humidity and temperature. Lutron has also found that in many cases, capacitors of MYLAR cost less than paper.

If capacitor size, reliability and price are important to you, check into MYLAR by writing: Du Pont Co., Room 4671A, Wilmington, Delaware 19898. (In Canada write: Du Pont of Canada, Ltd., P.O. Box 660, Montreal, Quebec.)

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Reliability in IF and RF coils!

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Shielded styles with powdered iron cup core and cap provide outstanding protection against feed back caused oscillations and pickup from random noise. Unitized metallic housings insulate against external electrostatic and electromagnetic fields.

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Standardize on CAMBION . . . 21,541 guaranteed electronic components

WE KNOW STORAGE TUBES...AND A LOT MORE

Hughes has made as many direct view storage tubes as all other manufacturers put together. They are in use all over the world in scan converter processing equipment; seismographic survey; medical diagnostic displays; educational and security systems; airborne, marine and ground-based fire control; weather and terrain avoidance radar; air traffic control; sonar; etc.

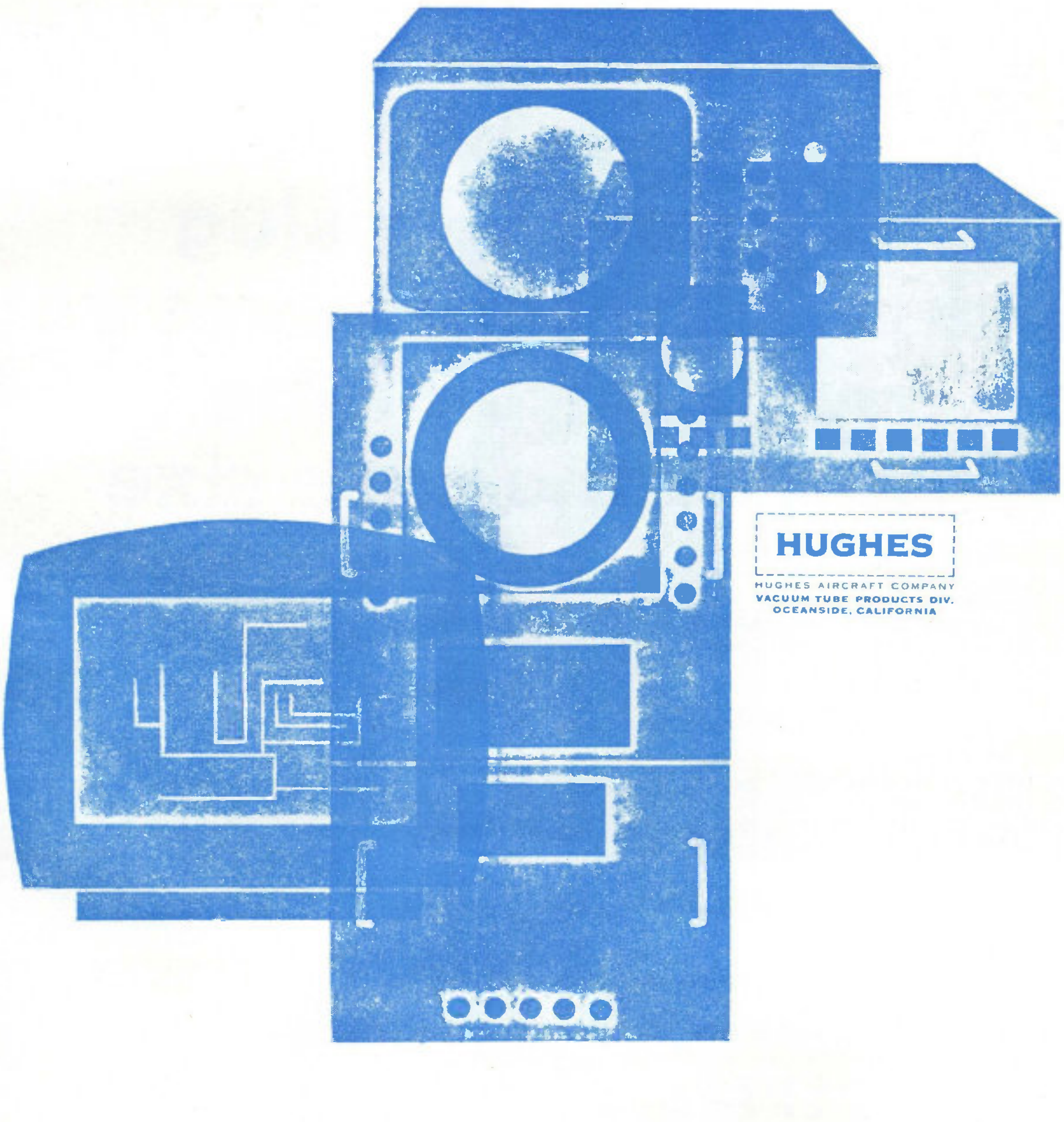
And, one by one, Hughes customers have come to the conclusion that those who know most about tubes and their applications are also the most likely candidates to handle entire special displays. As a result, Hughes has a wealth of experience in the creation of highly specialized storage tube displays, scan converter and motion detection equipments.

Hughes is able to provide for your every commercial display requirement, from tubes alone to complete display indicators. Depend on Hughes experience... in both design and manufacture.

For further information, call or write Hughes Aircraft Company, Vacuum Tube Products Division, 2020 Oceanside Blvd., Oceanside, California 92054. Phone: (714) 722-2101. TWX: 910-322-1380.

EAST: 1284 No. Broad Street, Hillside, New Jersey 07205. Phone: (201) 289-7770. TWX: 710-741-4737.

INTERNATIONAL: Hughes International, Centinela & Teale Streets, Culver City, California 90230. Phone: (213) 391-0711. Telex number: 067-222.



HUGHES

HUGHES AIRCRAFT COMPANY
VACUUM TUBE PRODUCTS DIV.
OCEANSIDE, CALIFORNIA

Circle 187 on reader service card

ELECTRONIC INNOVATIONS IN ACTION

small

smaller

smallest

G.E.'s new wet slug tantalum capacitor gives you the performance of the CL64 in only ½ the case size

Get the highest volt-microfarad product per unit weight and volume of any capacitor you can buy with General Electric's new 69F900 wet slug tantalum capacitor. How? General Electric reduced the case size of the military type (CL64) wet slugs by ½ (it's even smaller when compared to solids). Electrical characteristics and performance remain essentially the same. G.E.'s new 69F900 answers the need for a commerical wet slug capacitor with the high volumetric efficiency demanded by modern high density applications.

G.E.'s new addition to its complete line of tantalum wet slug capacitors has excellent high capacitance retention at low temperatures and can be stored to —65°C. Its wide operating range is —55°C to +85°C. And it meets the parameters of larger military wet slugs: vibration to 2000 Hz, 15g acceleration!

RATING	CASE SIZE	VOLUME
50V, 50μf		
solid (CS12)	.341 x .750	100%
wet slug (CL64)	.281 x .681	58%
69F900	.145 x .600	15%
15V, 80μf		
solid (CS12)	.341 x .750	100%
wet slug (CL64)	.281 x .681	58%
69F900	.145 x .600	15%
6V, 180μf		
solid (CS12)	.279 x .650	100%
wet slug (CL64)	.281 x .641	100%
69F900	.145 x .600	25%

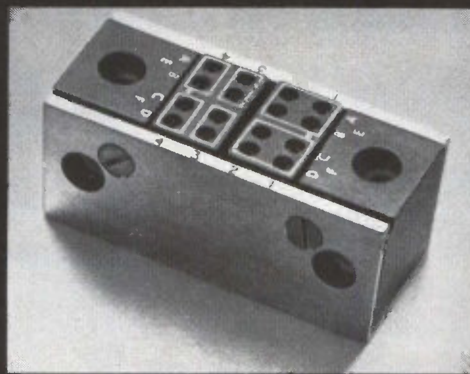
The new sub-miniature 69F900 capacitor is fully insulated and has a low, stable leakage current. Voltage ratings are available from 6–60 volts; capacitance ranges from 3.3–450 microfarads.

Choose from a complete line of G-E wet slug tantalum capacitors to fill your slim, trim circuit needs. Write for GEA-8369 for details about the 69F900 and the other capacitors in General Electric's complete wet slug tantalum line, or ask your G-E sales engineer. **Capacitor Department, Irmo, South Carolina.**

ELECTRONIC COMPONENTS DIVISION

GENERAL ELECTRIC

430-28



Introducing the heat resistant, cold resistant, dust resistant, rust resistant, water resistant, re-order resistant termination device.

It's the Deutsch rear-release, environmental Terminal Junction.

Friends call it TJ for short.

With the TJ, old-fashioned terminal strips are replaced by lightweight, low-cost, high density modules that can take far tougher environments than other terminating devices.

You can use the TJ over and over again, like building blocks. (You take care of the configurations, the TJ takes care of the rest. Think of the savings.)

Details? Call Arco, the distributor who's also a manufacturer.

As a distributor, we're ready to ship you all the Deutsch TJ's you need as fast as you need them. One piece or a thousand.

And as a manufacturer, we have all the engineering staff it takes to help you on application problems.

So call us. Ask for TJ. You'll find it irresistible.

Arco Electronics
A Division of Loral Corporation
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Dallas, Texas/Pasadena, California/
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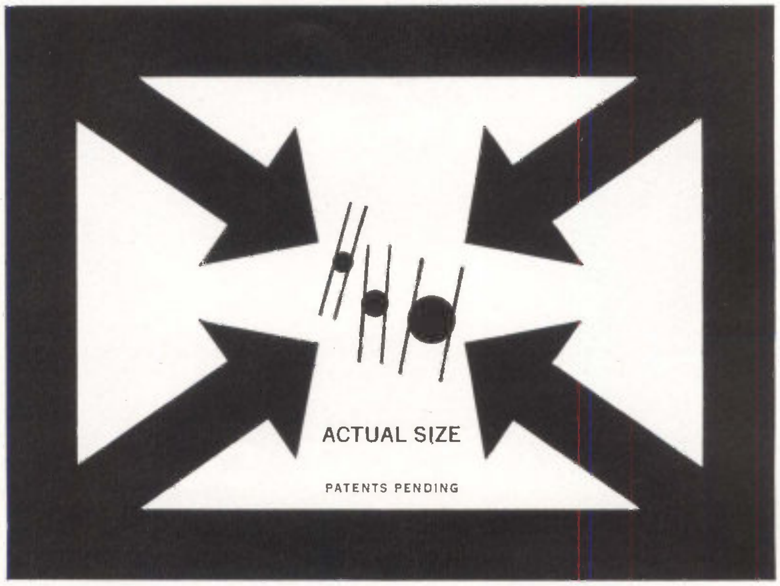
DIVIDED WE STAND

Circle 189 on reader service card

EXTERNAL PACKAGING OF COILS NOW OBSOLETE WITH DELEVAN'S NEW:



MICRO i®

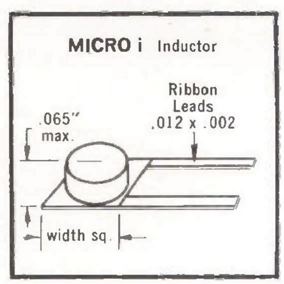
Micro i Inductors are physically compatible with integrated and hybrid circuit packaging. Because of their small size they can be included in miniaturized packages along with other components such as transistors and capacitors eliminating the need for placing the inductor external to the miniaturized package.

These inductors are magnetically shielded to prevent interaction with other components in a small package and have current carrying capabilities which are compatible with normal transistorized circuits. The units are epoxy encapsulated for environmental protection and use powdered iron core materials only.

Excellent inductance stability is provided under the following variable operating conditions:

1. 0 to 100% rated current (AC or DC)
2. Temperature range of −55° to +125°C.

Preferred values as noted in the chart below are available immediately from stock.



ACTUAL SIZE

MICRO i	SIZE	L RANGE	L(uh)	Q	SRF(mc)	DCR(Ω)	DC(ma)
	.065 Height x .100 Square	.1 uh to 10.0 uh	1.0 ±20%	40	125	1.0	266
			4.7 ±20%	40	100	1.8	190
			10 ±20%	40	40	3.8	133
	.065 Height x .150 Square	12 uh to 100 uh	12 ±10%	50	38	4.0	100
			47 ±10%	50	19	8.0	85
			100 ±10%	50	10	15.0	55
	.065 Height x .250 Square	120 uh to 1000 uh	120 ±10%	50	7.5	8.0	40
			470 ±10%	45	3.5	20.0	38
			1000 ±10%	45	3.0	40.0	34

L and Q Values at Standard Q Meter Test Frequencies.

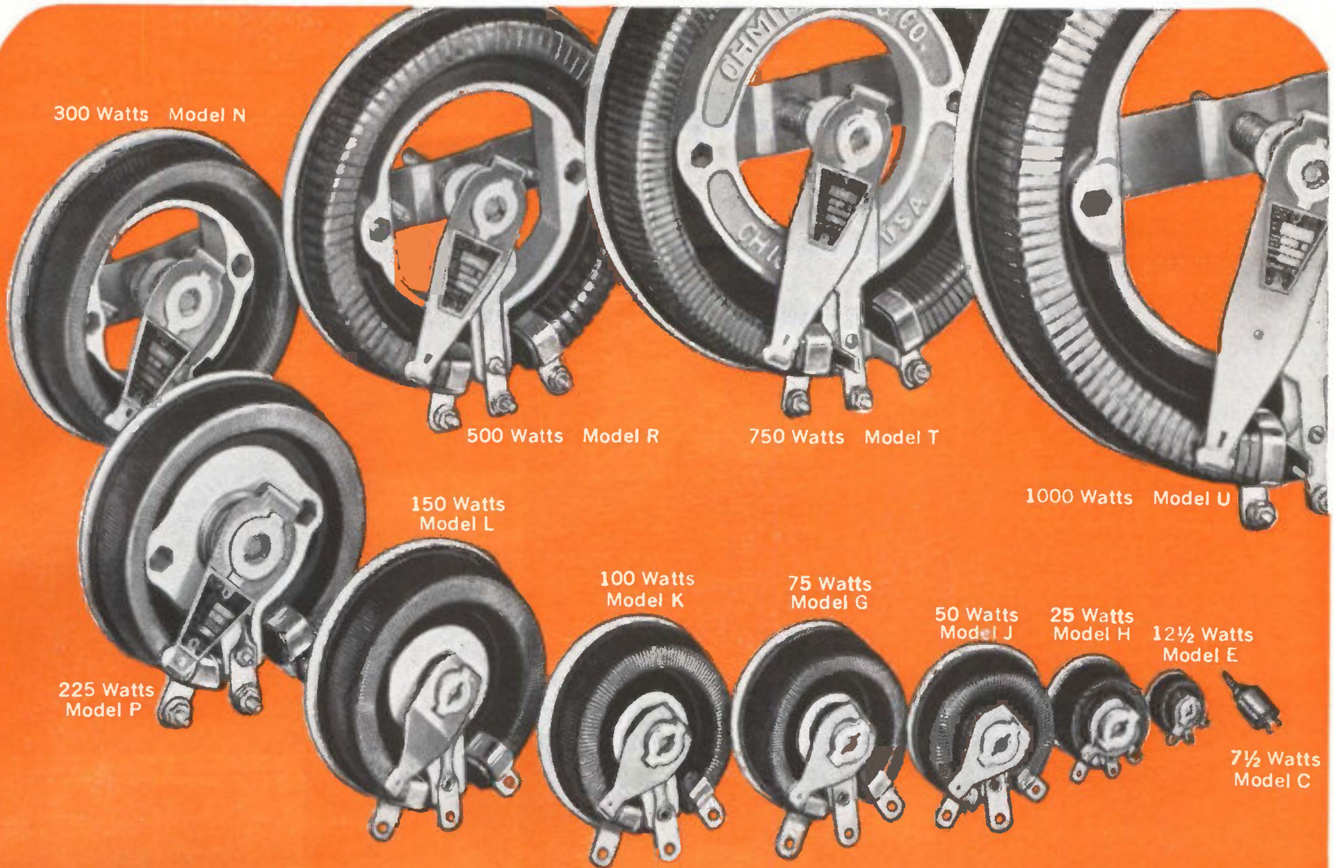
MICRO i DIVISION

Delevan Electronics Corporation / Division

AMERICAN PRECISION INDUSTRIES INC.

270 QUAKER RD. / EAST AURORA, N. Y. / 14052

TELEPHONE 716/652-3600 TELEX 091-293



if it's a rheostat, you can get it from Ohmite

Need a miniature 7½-watt rheostat? Or something at the other extreme, say, 1000 watts? Ohmite makes all 12 basic sizes. With these as a starting point, you can branch out into literally hundreds of electrical, mechanical, and motor-driven variations . . . too many to even begin listing here.

Ohmite is the *only* rheostat supplier who can fill 100% of your requirements (plus many you probably will never run into).

As Near As Your Distributor—There are thousands of stock Ohmite rheostats in distributors' inventories from coast to coast backed up by the world's largest factory stock. So if you need standard rheostats in a hurry, you'll find Ohmite units are the easiest and quickest to lay your hands on . . . no matter where you are located . . . no matter what size you need.

Motor-Driven Rheostats: Technically, these are classified as specials. But Ohmite makes so many of them that some models are practically standard.

"Way Out" Specials? No matter how unusual your requirement, contact the factory. For over 30 years, Ohmite has been solving tough rheostat problems. Maybe yours is even among them.

Write for Big New Catalog 200.

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MANUFACTURING COMPANY
3610 Howard Street, Skokie, Illinois 60076
Phone (312) ORchard 5-2600

RHEOSTATS • POWER RESISTORS • PRECISION RESISTORS • VARIABLE TRANSFORMERS • TANTALUM CAPACITORS • TAP SWITCHES • RELAYS • R.F. CHOKES • SEMICONDUCTOR DIODES

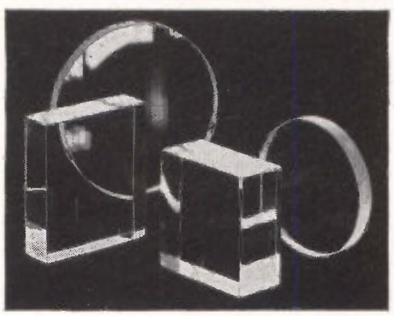
Discovering Q L G

QUARTZ — LUCALOX® — GLASS

QUARTZ, LUCALOX® AND ELECTRONIC GLASS... HARD AT WORK HELPING THE ELECTRONIC INDUSTRY MEET THE UNCOMMON CHALLENGE.

Fused Quartz of highest purity is produced by General Electric with the most complete technical resources available today. You'll find G-E fused quartz used in crystal pulling . . . zone refining . . . semiconductor diffusion . . . research labware. Many new and varied applications are continuously being developed.

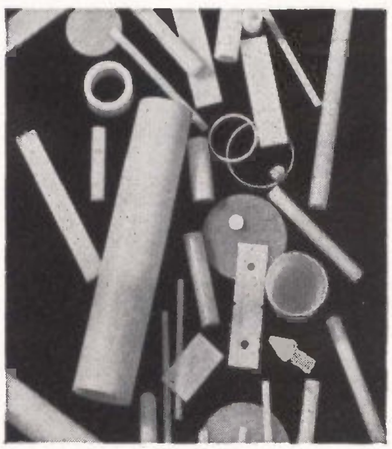
(CIRCLE 489 READERS SERVICE CARD)



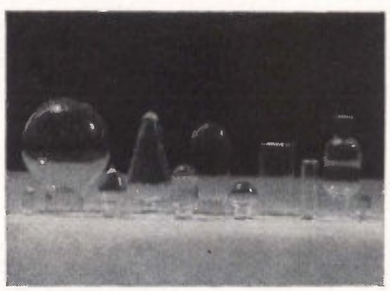
G-E Type 151 Fused Silica, for critical optical applications, is a schlieren grade material offering the highest ultraviolet transmission. Type 151 is ideal for use in laser optics . . . absorption cells . . . spectophotometer optical elements . . . schlieren photography. Now used in many innovative and exciting applications, Type 151 is the newest and highest quality optical material within General Electric's numerous grades.

(CIRCLE 490 READERS SERVICE CARD)

Lucalox®, a highly versatile polycrystalline alumina ceramic, has an extensive number of applications in the chemical, electronic, microwave and high temperature fields. Easily fabricated to complex specifications, Lucalox applications include use as insulators . . . guides . . . microwave windows . . . bearings . . . gyros. Lucalox has high dielectric strength, purity, plus transmission capabilities of up to 90% of total light in the visible spectrum. Standard tubing, rod, plates and discs are available from stock.



(CIRCLE 491 READERS SERVICE CARD)



Electronic Glass from General Electric is available in a wide variety of shapes. Applications for the electronic and associated industries include TV repair necks

. . . electronic tubing . . . miniature bulb blanks . . . subminiature radio tube blanks . . . receiving tube blanks . . . beads and brazing pellets . . . electronic tube flares . . . pressed ware . . . re-draw tubing. General Electric research and technical representatives are always ready to work with customers on specific applications. And at General Electric we welcome new challenges.

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WORLDWIDE SERVICE. For sales and application assistance, contact your nearest regional office: EASTERN, 133 Boyd St., Newark, N. J.: 201 824-5200 • NEW ENGLAND, 50 Industrial Place, Newton Upper Falls, Mass.: 617 332-6200 • WESTERN, 2747 South Malt Ave., Los Angeles, Calif.: 213 723-2541 • MIDWESTERN, Euclid Ave. & Campbell Rd., Willoughby, Ohio: 216 266-4001 • CANADA, Canadian General Electric Co., 165 Dufferin St., Toronto, Ontario: 537-4481 • INTERNATIONAL, International General Electric Co., Export Div., 159 Madison Ave., N. Y., N. Y.: 212 PL-1-1311.

Write for illustrated technical literature

LAMP GLASS DEPARTMENT

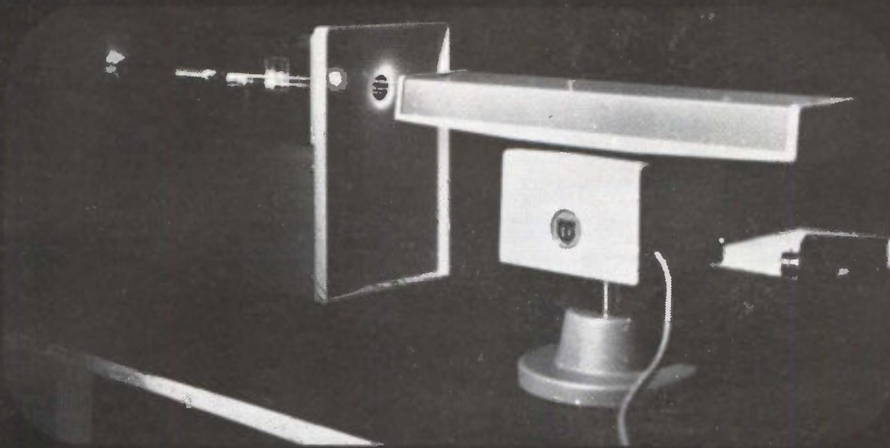
GENERAL ELECTRIC

24400 Highland Road • Cleveland, Ohio 44121

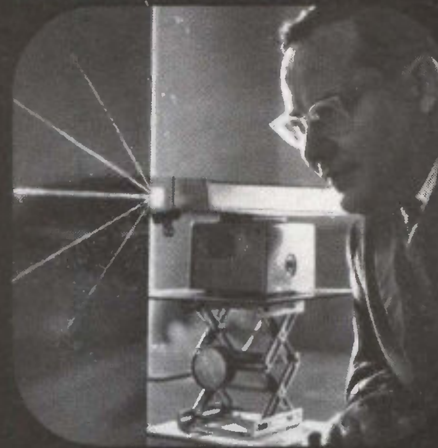
MANUFACTURERS OF LUCALOX® CERAMIC—ELECTRONIC GLASSWARE—FUSED QUARTZ PRODUCTS—JET-TEMP® AND JET-B.O.P. THERMOCOUPLES.

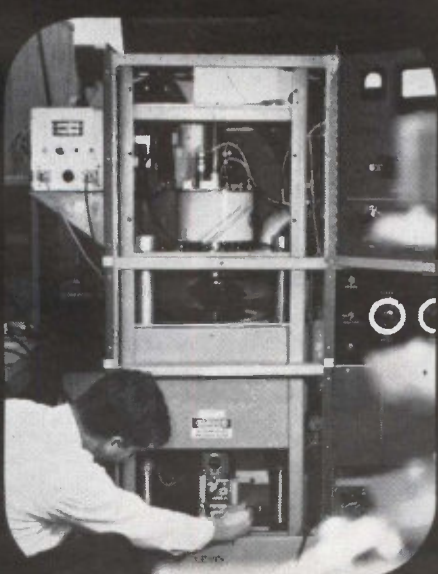
Circle 193 on reader service card→

Optical Alignment at OTI

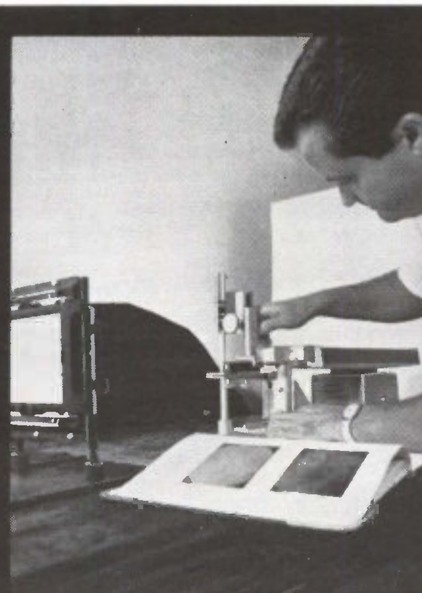


Classroom Demonstration at Stanford





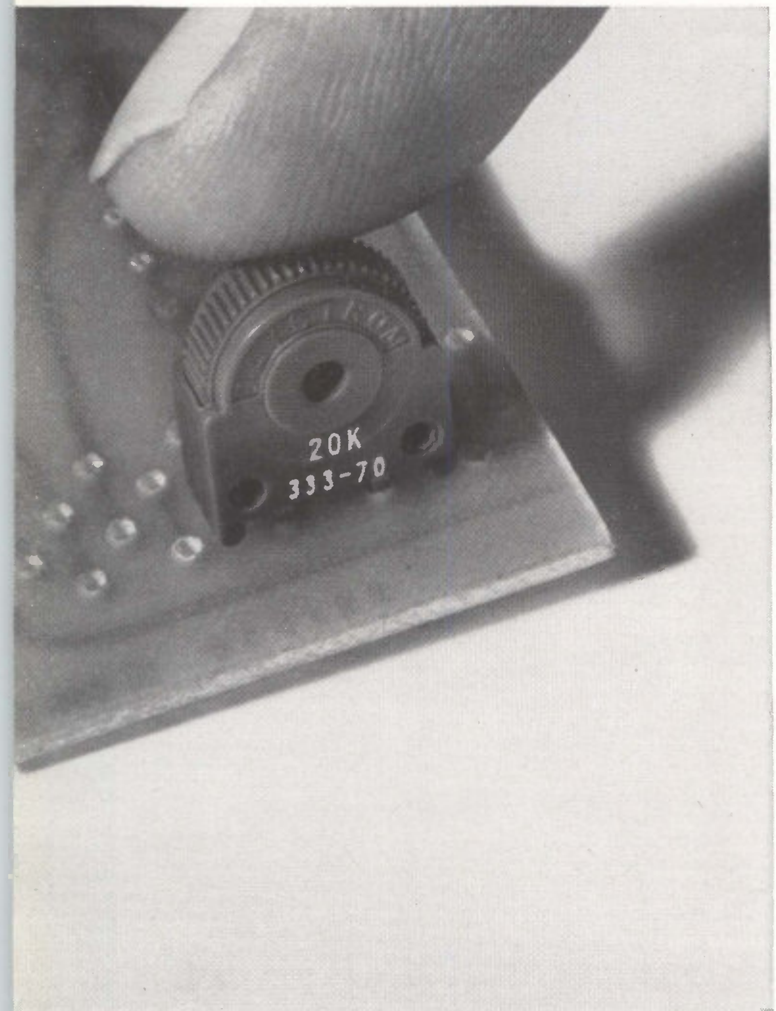
OEM Application at Beckman-Spinco

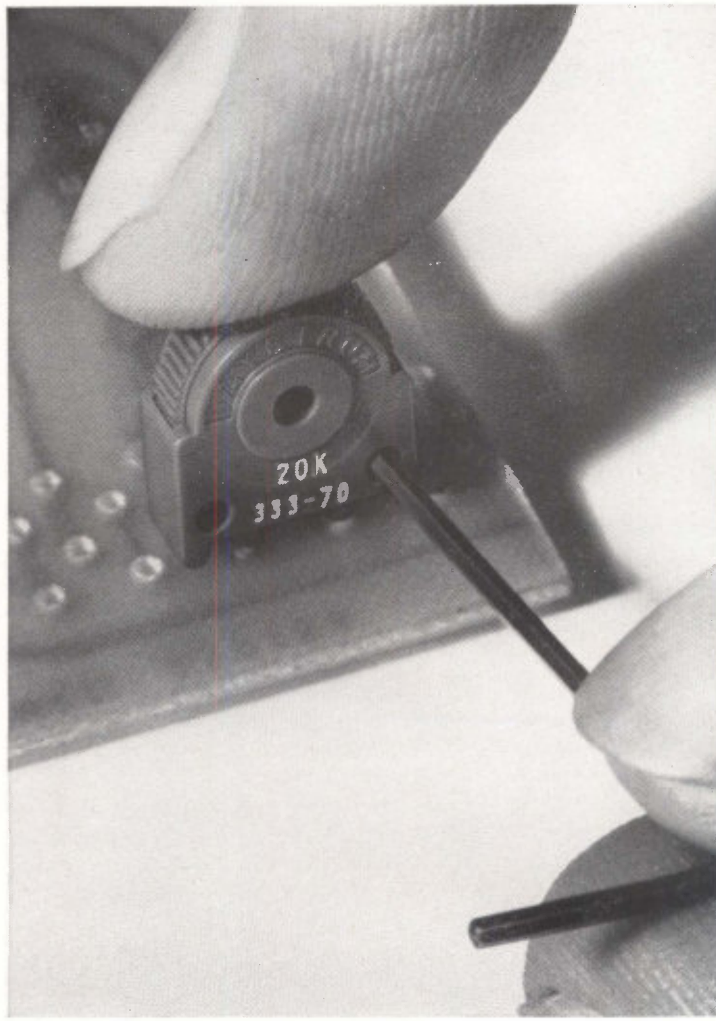


Basic Research at Friden

Mechanical Alignment at Granger Assoc.

It's a bargain, no matter how you trim it





with the flick of a finger... or the turn of a key.

You can trim the Daystrom Model 333 pot with your thumb on the convenient knurled knob. Or, use a hex-key on the Allenhead vernier for finer (4:1) settings.

But dual adjust is just one of the design features that make this low-cost commercial trimmer a bargain. Others are Weston's exclusive wire-in-the-groove construction which locks linearity in and contact noise out—even under shock and vibration ... a slip clutch stop that protects the wiper at the end of rotation ... Suregard™ terminations for long-life reliability.

You'll recognize these features as the same used in Weston's rugged MIL-type Squaretrim® pots.

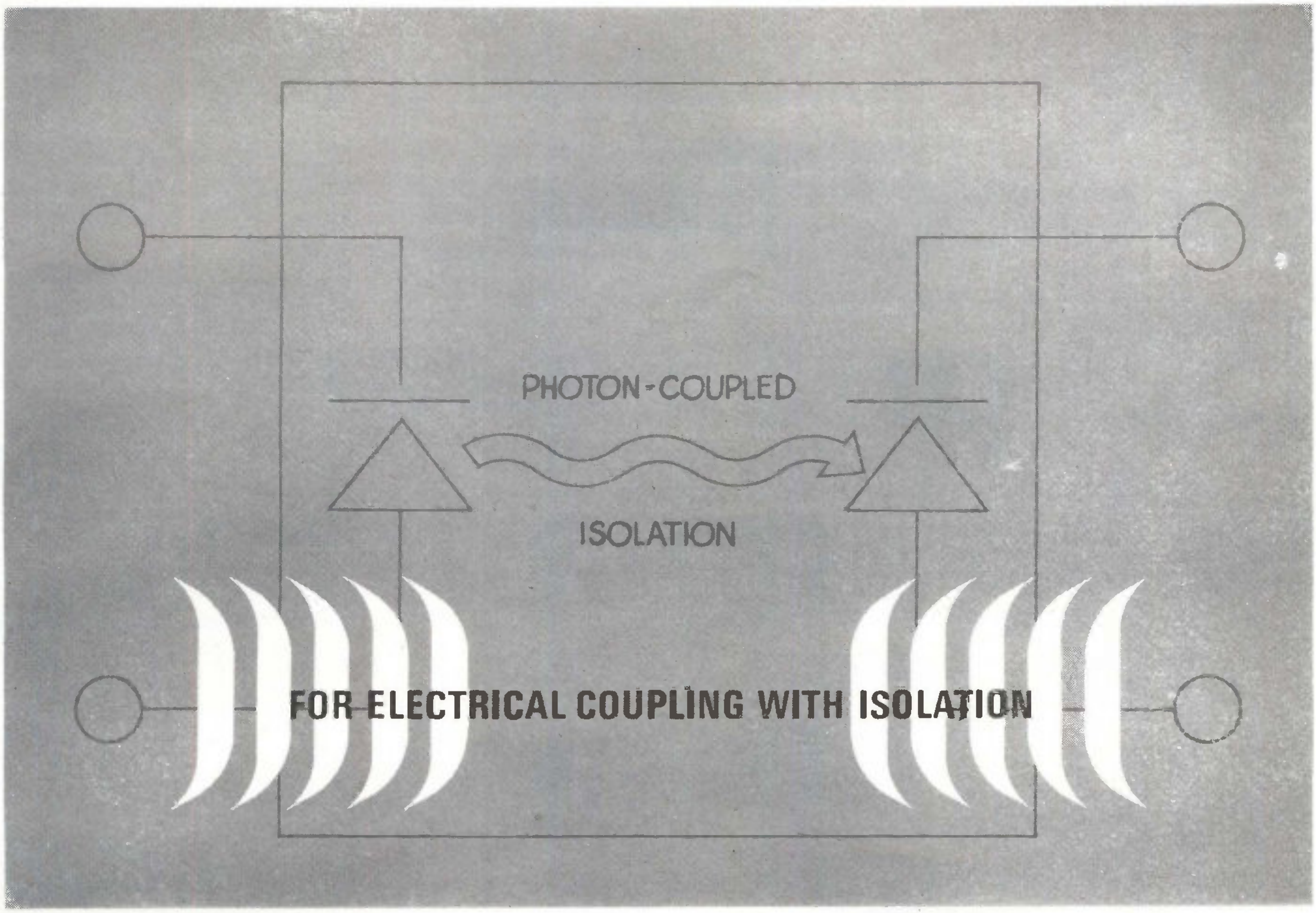
In addition, compact 333 series pots take up less than 1/10 square inch on your PC boards. They're designed for edge mounting, with provision for dip soldering, so they're ideal for automated production techniques. And they'll handle 0.25 watt comfortably—in still air.

The price is a trim $1.25 in lots of 500. Standard values range from 50Ω to 50K. For complete details or evaluation samples, contact your Weston distributor or call:

Weston Instruments, Inc., Weston-Archbald Division
Archbald, Pennsylvania 18403. Phone 717-876-1500

WESTON® *prime source for precision... since 1888*

Circle 194 on reader service card



specify photon-coupled isolators by HPA

Efficient transfer of electrical energy—with maximum isolation between circuits—is possible now with HP Associates' 4310 Photon-Coupled Isolator, newest in the line of HPA optoelectronic devices.

Packaged on a single TO-18 header, the 4310 consists of a low-leakage silicon PIN photodiode, closely coupled to a high-efficiency gallium arsenide infrared light source.

Offering high current transfer efficiency, the 4-terminal device provides electrical decoupling between input and output, dc to MHz.

Other new devices available from HP Associates include GaAs light sources and low-leakage detectors.

Contact your Hewlett-Packard field engineer for complete specifications and application information, or write HP Associates, 620 Page Mill Road, Palo Alto, Calif. 94304, Tel. (415) 321-8510.

Typical specifications HPA 4310 Miniature Photon-Coupled Isolator

		Condition
Current transfer efficiency	0.002	GaAs $I_F = 50$ mA PIN $V_R = -25$ V
Capacitive coupling between input and output diodes	2 pf	f=1 MHz
Resistive coupling between input and output	10^{11} ohms	
Output diode saturation current	10 nA max	$V_R = -20$ V T=25°C
Maximum ratings (output diode): Peak inverse voltage Steady reverse voltage Power dissipation	 200 V 50 V 125 mW	 T=25°C
Maximum rating (input/output): Working voltage	 200 V	
Prices: 1-9 10-99	$55.00 $46.75	

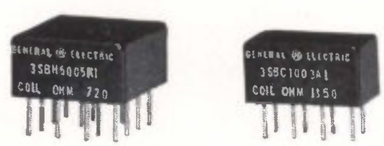
Data subject to change without notice. Prices f.o.b. factory.

HEWLETT PACKARD hp HP ASSOCIATES

1023R

Circle 195 on reader service card

We expect these 150-grid relays to be copied



4-pole 2-pole

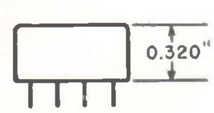
And by 1967 they'll be a standard of the industry

Right now, these General Electric 2- and 4-pole relays are years ahead of the field. Their low, low profile—just 0.32 inch high—lets you stack more circuit boards in the same space.

They're not just cut-down versions, either. These 150-grid relays can perform right up with microminiature relays four times their size.

For example, closing force is about the same to provide snap-action, positive contact mating. In addition, General Electric 150-grid relays meet or exceed environmental and mechanical specs of much larger microminiature relays.

And compared to relays of comparable size, G-E 150-grid space relays have three times the magnetic force and over twice the contact force of their nearest competitor. What's more, they're the only relays in this size range that are all welded to eliminate flux contamination.



ACTUAL SIZE

Your G-E Electronic Components Sales Engineer can tell you more about 150-grid space relays and help with your individual applications. Contact him. Or write for bulletin GEA-8042B, Section 792-38, General Electric Co., Schenectady, N. Y. 12305.

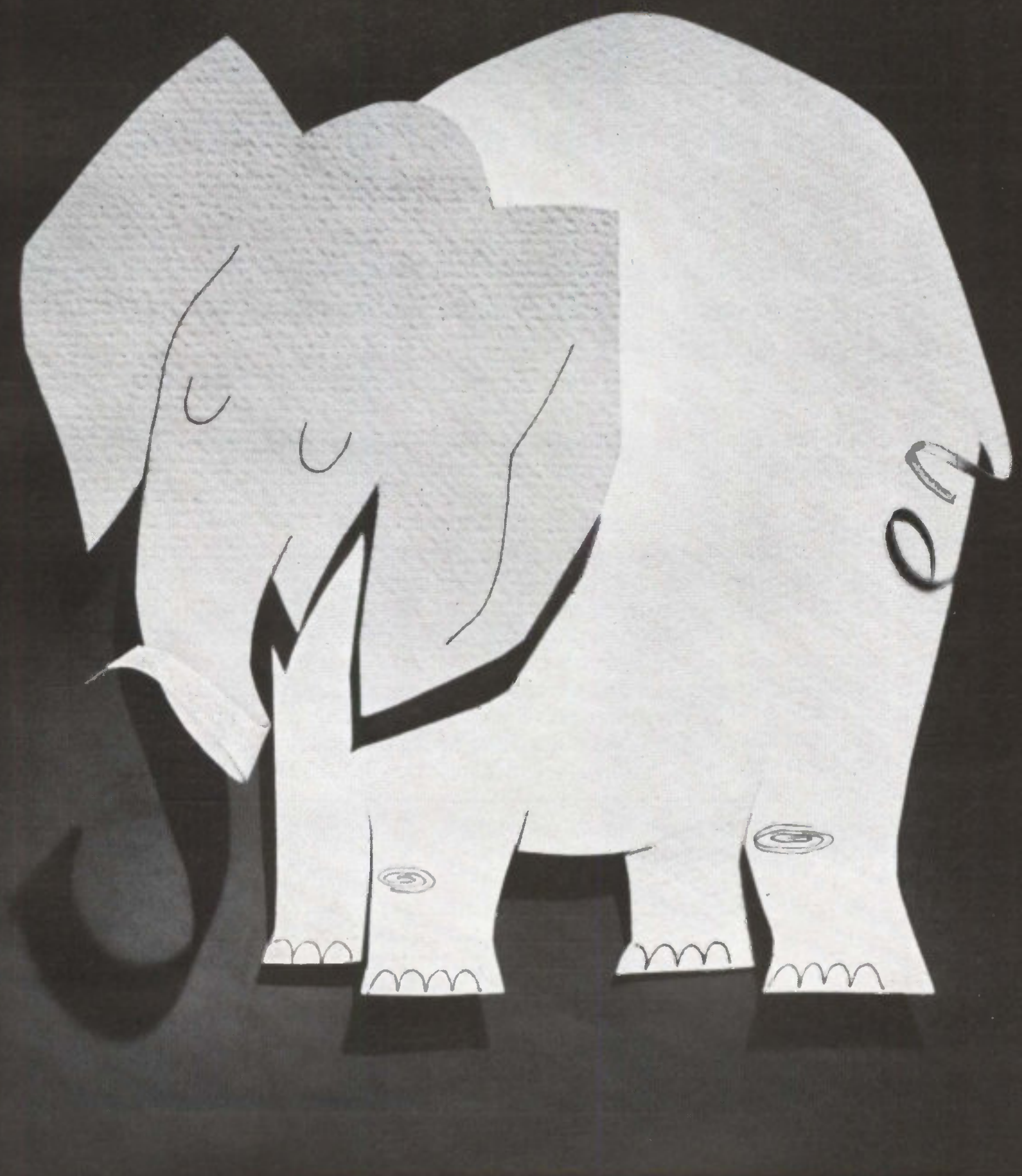
Specialty Control Department, Waynesboro, Va.

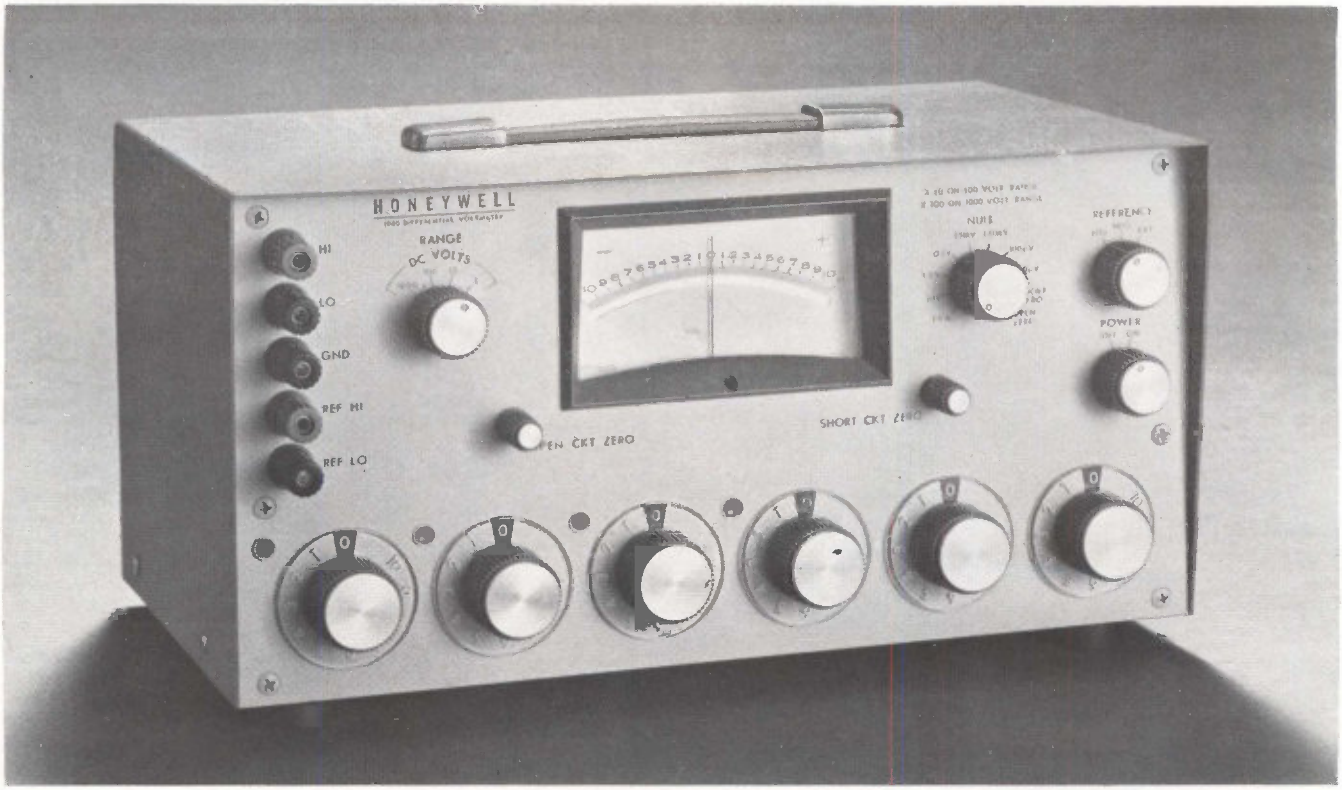
GENERAL ELECTRIC

Memory core testers bought more on price than performance are a lot like white elephants. Nice to look at, maybe. But darn expensive to have around. They have a nasty habit of letting bad cores slip by every now and then. And one bad core on the loose in a plane or stack spells high cost trouble. This kind of hit and miss testing never happens with CTC systems. They deliver driving pulses with unmatched precision and controllability; detect and measure core response with the kind of accuracy that weeds out even the borderline baddies. □White elephants are the big reason you can't afford cheap core testers. You never really stop paying for them. With CTC memory core test systems you pay just once. And in the long run that's peanuts.

COMPUTER TEST CORPORATION
Cherry Hill, New Jersey

a white elephant is just a trunkful of bad cores





Honeywell's new 5 in 1 Instrumentation Package:

own this Model 1000 Differential Voltmeter, and you also own a Differential Ratiometer, a Decade Voltage Divider, a Precision Voltage Reference Source, and an Electronic Null Detector!

Here's the most versatile single instrument any lab can own – five essential measuring functions combined in one neat, fully portable package! Let's look at the new Honeywell Model 1000, function by function.

As a **Precision Differential Voltmeter,** the Model 1000 provides ±0.0025% accurate measurements to your DC signals. And you get 7 digit resolution from 6 decades with 10% overrange (also eliminates time consuming dial manipulation). Potentiometric input impedance to 11V provides errorless measurements to standard cells or high source impedance signals. Polarity is reversible from the front panel.

As a **Differential Ratiometer,** the 1000 gives you precise DC ratio measurements with ±0.001% accuracy. External reference signal level may range up to ±100 VDC. All Voltmeter mode convenience features are applicable when the 1000 is used as a Ratiometer.

As a **Decade Voltage Divider,** the 1000's precision, 6 decade Kelvin-Varley divider network gives accurate voltage level divisions to ±0.001%. AC power not required in this mode.

As a **Precision Voltage Reference Source,** calibrated voltage levels of 6 digit resolution are provided at the 1000's rear panel. Output levels are selected by front panel dials. Levels vary from 0 to 11 VDC, and may be used for calibration of potentiometric instrumentation. Accuracy: ±0.0025%.

As an **Electronic Null Detector,** the 1000 offers high sensitivity for use with balance type instrumentation or other circuitry. Silicon field effect transistors eliminate electro-mechanical choppers and assure drift-free operation. Changes as minute as 10 nanovolts or an input current of 10^{-15} amperes may be detected.

Other features of this versatile instrument include: complete cancellation of common mode, standoff voltages; high superimposed noise rejection; Zener reference supply with 2-3 ppm stability; 4 full-scale ranges of 1, 10, 100, and 1000 VDC; ratio ranges of 1:1, 10:1, and 100:1; recorder outputs on rear panel, and silicon solid-state circuitry throughout. Ask your Honeywell Representative for a demonstration of the Model 1000, or mail coupon for literature.

Honeywell, Test Instruments Div. 9-11A
Denver, Colorado 80217
Please send Model 1000 Literature to:

Name____________________
Company____________________
Address____________________
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LABORATORY STANDARDS

Honeywell

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Multibeam Cassegrain, 94GHz, 10½" dia., 4 overlapping beams and reference beam
Conical Scanning Plano-Convex Lens, 36GHz, 9½" dia.
Azimuth Scanning Reflector-Lens Antenna with Radome, 26 to 40GHz, CSC² θ Pattern. Polarization manually selectable.

Texas Instruments chooses GAF x-ray film to prove there's not the tiniest mistake

To Texas Instruments Incorporated, a prime manufacturer of miniaturized electronic equipment for both industry and government, uses GAF industrial x-ray film to prove zero defects in critical components, assemblies and sub-systems.

Diodes, rectifiers, capacitors, resistors and germanium and silicon transistors, used in everything from hearing aids to missile guidance control systems, are subjected to exhaustive radiographic examination to assure faultless performance and long life.

In the photograph above, Texas Instruments Quality Control Inspector, Mrs. Dorothy Gross, is studying a GAF Industrial 'H-D' radiograph. Industrial 'H-D' is an ultra-fine grain, very high contrast film designed to yield high image definition—even when radiographing minute subjects and very thin materials. Industrial 'H-D' is available in a wide variety of package types and sizes.

Contact your nearest distributor of GAF x-ray products, and he'll introduce you to the GAF X-ray Representative assigned to your area. Or write directly.

gaf **GENERAL ANILINE & FILM CORPORATION**

140 WEST 51 STREET, NEW YORK, NEW YORK 10020

Att: Customer Service Dept. E-1114

Please send me more information on GAF Industrial 'H-D' x-ray film.

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save

Military quality at industrial prices

IRC wirewound rectangular trimmers save space and dollars

IRC's CIRCUITRIM potentiometers offer MIL characteristics at the same price as industrial types. Benefit by upgraded performance and reliability for your industrial needs and impressive savings for your MIL applications.

Both series are designed to perform under environmental requirements of MIL-R-27208. Molded diallyl phthalate cases are rugged, light and practical for use in any military or high grade industrial application. A one-piece, corrosion-resistant shaft and specially designed wiper block system isolate electrical elements and assure "set-and-forget" stability.

The 600 series is designed to MIL-Style RT-11 and is offered with staggered P.C. pins or teflon insulated leads. The 400 series is designed to MIL-Style RT-12 with P.C. pins in-line or teflon insulated leads. It is also available in a thin-line version of RT-11 (Type 400-20) with staggered P.C. pins which offer 30% space savings and complete interchangeability on pre-printed boards.

These low-cost MIL-type units are the result of IRC's years of experience in building high-quality trimmers. Samples available from local sales offices. For prices and data, write: IRC, Inc., 401 N. Broad St., Philadelphia, Pa. 19108.

ONLY IRC OFFERS ALL 4 POPULAR STYLES

Wirewound or infinite resolution elements

CAPSULE SPECIFICATIONS

	TYPE 400	TYPE 600
MIL STYLE	RT-12*	RT-11
POWER	1 W @ 70°C	1 W @ 70°C
TOLERANCE	±5%	±5%
RESISTANCE	10Ω to 50KΩ	10Ω to 50KΩ
TEMPERATURE	—55°C to 150°C	—55°C to 150°C

*Plus thin-line version of RT-11 (Staggered P.C. pins)

IRC®

From .5 to 10,000 *pf*, the CYFM is the second best capacitor you can buy.

pf for *pf*, you can't buy more stability and reliability per dollar than you get in the CORNING® CYFM Capacitor.

You get the kind of stability that only a glass dielectric can hold, that's invariable with time, temperature, and environment.

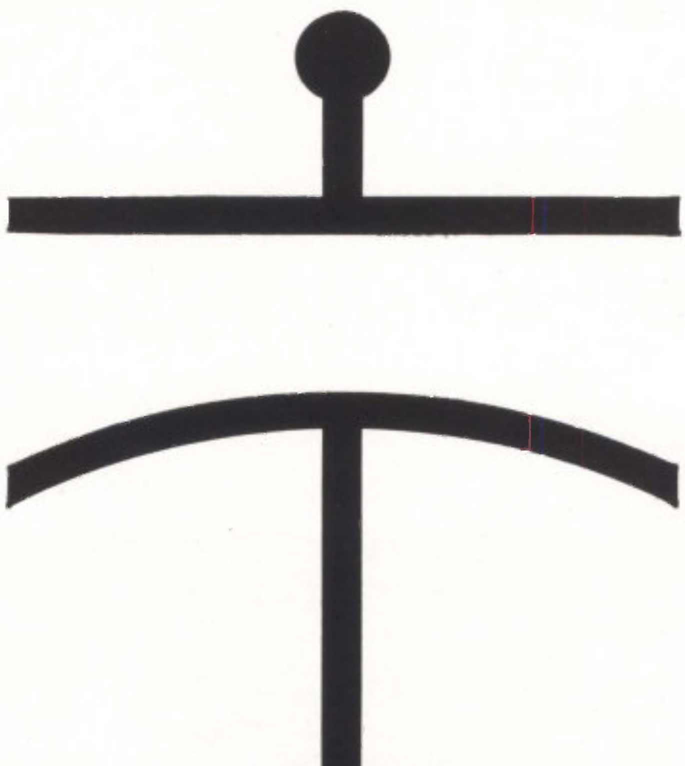
You get reliability that's inherent in the way they're made, which is basically the same process that turns out our ultra-high-reliability CYFR Capacitor.

But you save dollars on the CYFM because we don't put it through all the rigorous CYFR testing.

A CORNING CYFM Capacitor is practically indestructible under severe environmental stresses. We have boiled them in salt water, immersed them in saturated steam, subjected them to 96 hours of salt spray, without a failure or degradation.

After 2000 hours at 125°C with 150% of full rated voltage, capacitance change on a CYFM is less than 0.5%.

Why ever risk an entire system on capacitors that can't give you the assurance of Corning dielectric stability? Get all the economical facts on the CYFM Capacitor in our new CORNING® Glass Capacitor Guide. Send to Corning Glass Works, 3913 Electronics Dr., Raleigh, N.C.



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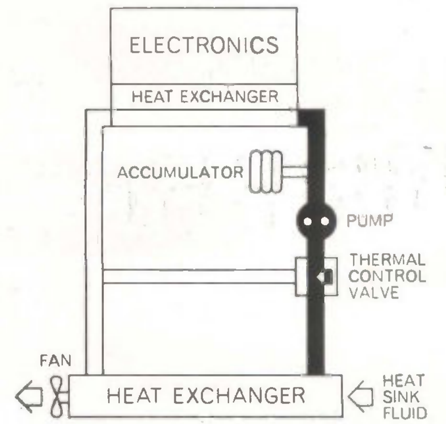

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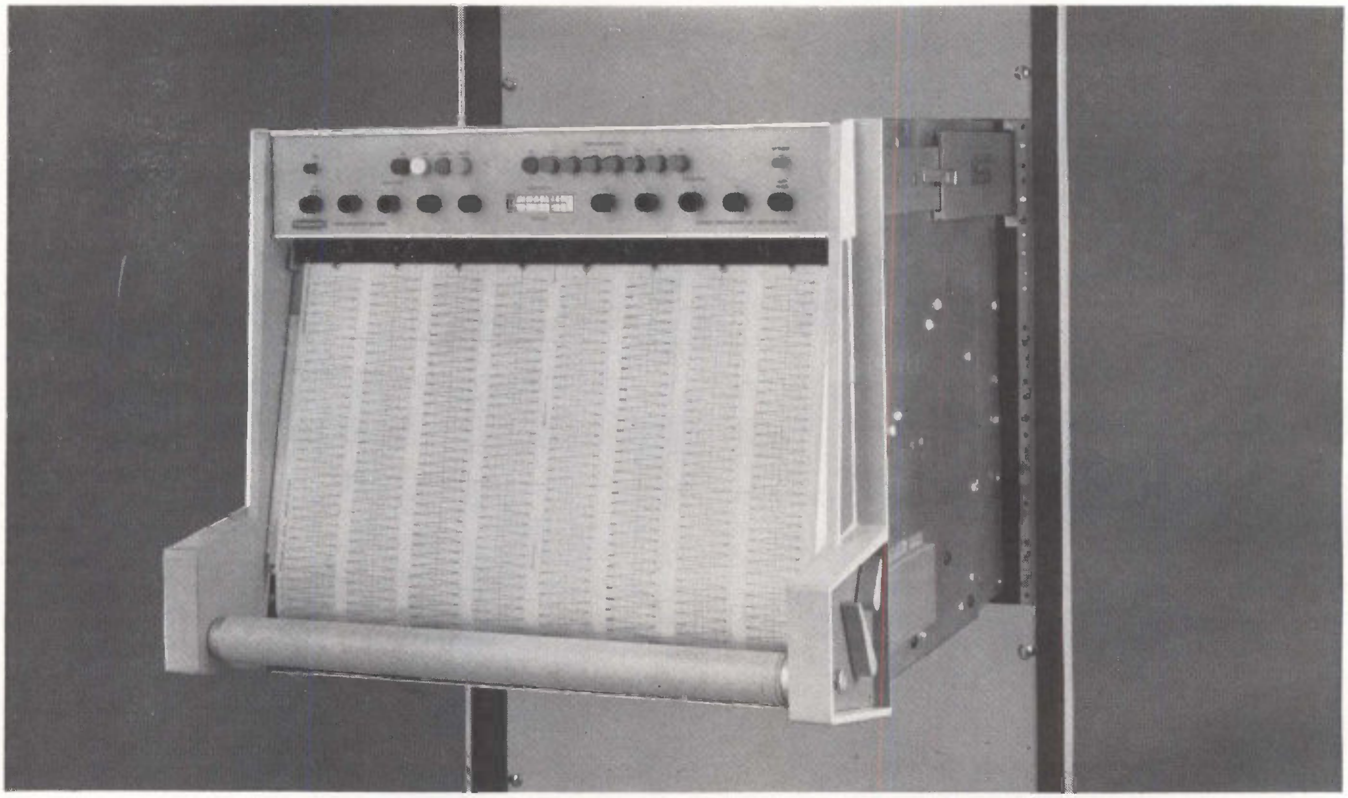

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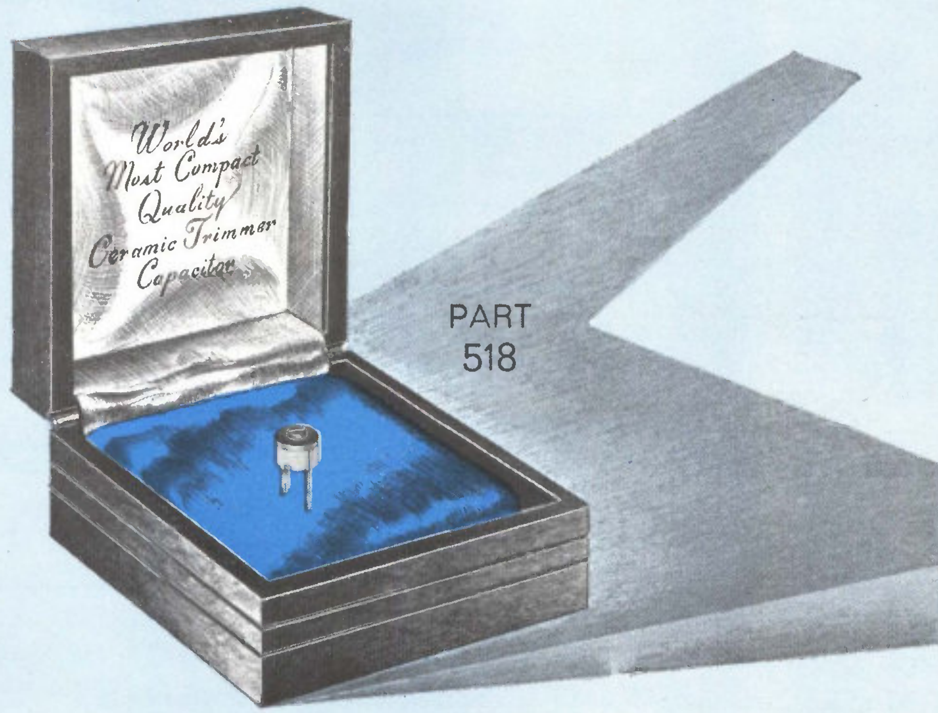

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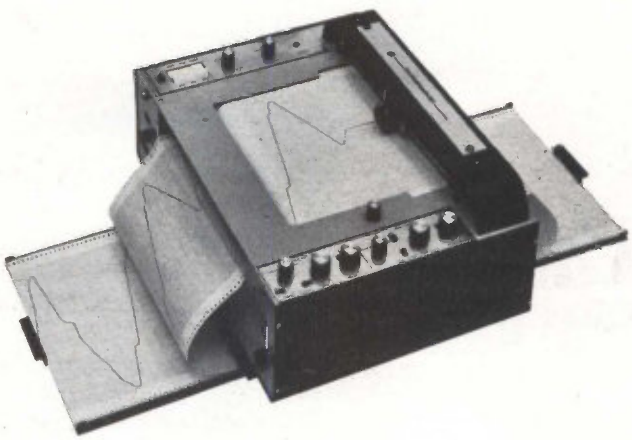

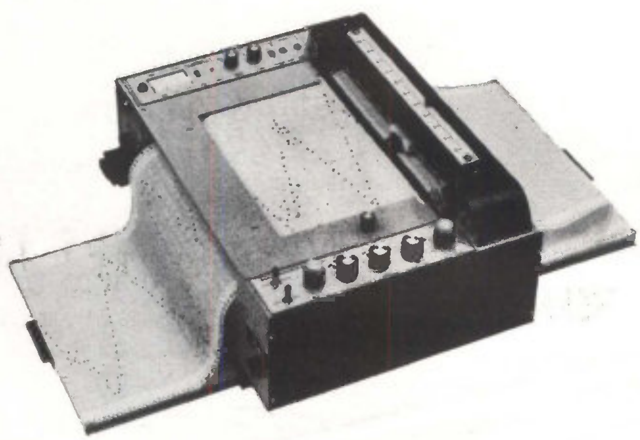

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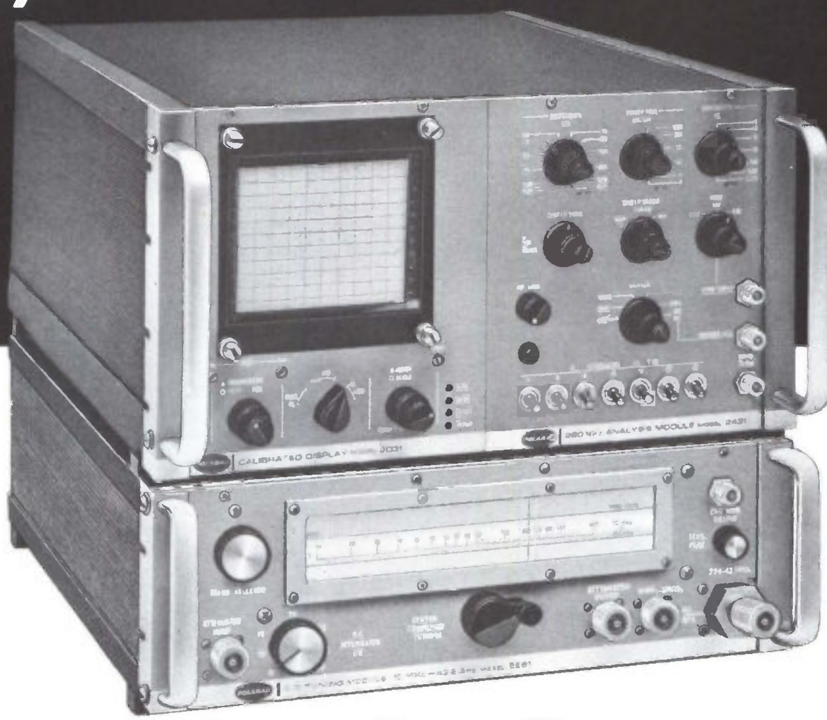

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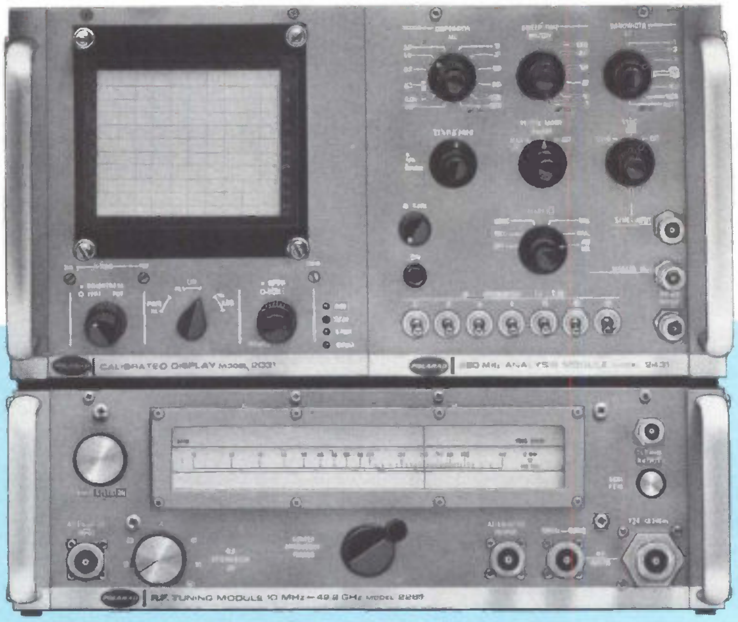

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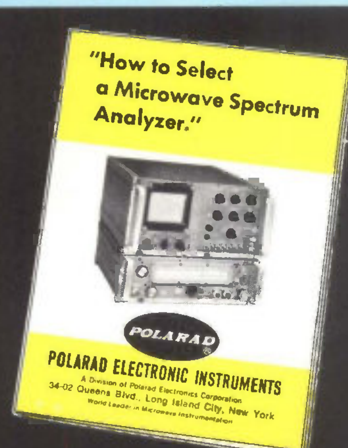

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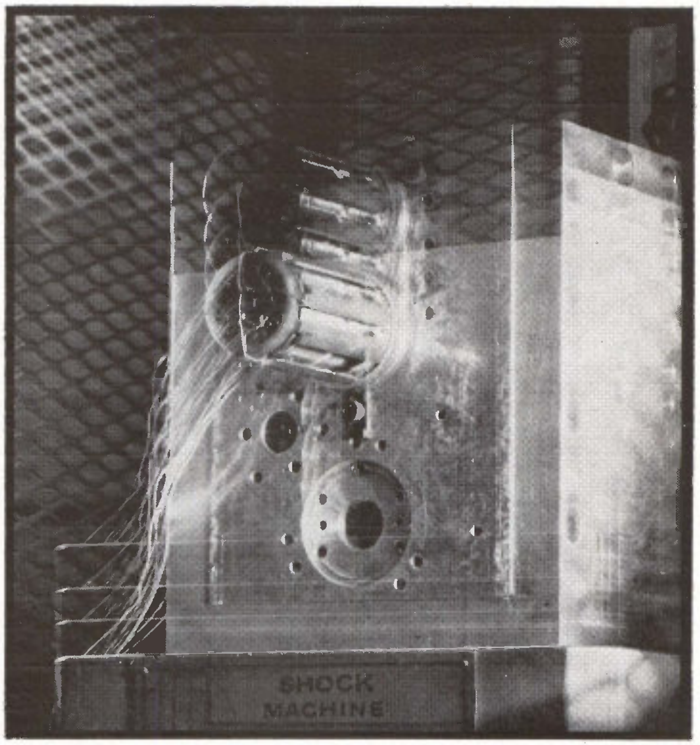

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2N4354	50-500	10mA	60V	100MHz	100ns	400ns	500mA	.42
2N4355	100-400	10mA	60V	100MHz	100ns	400ns	500mA	.55
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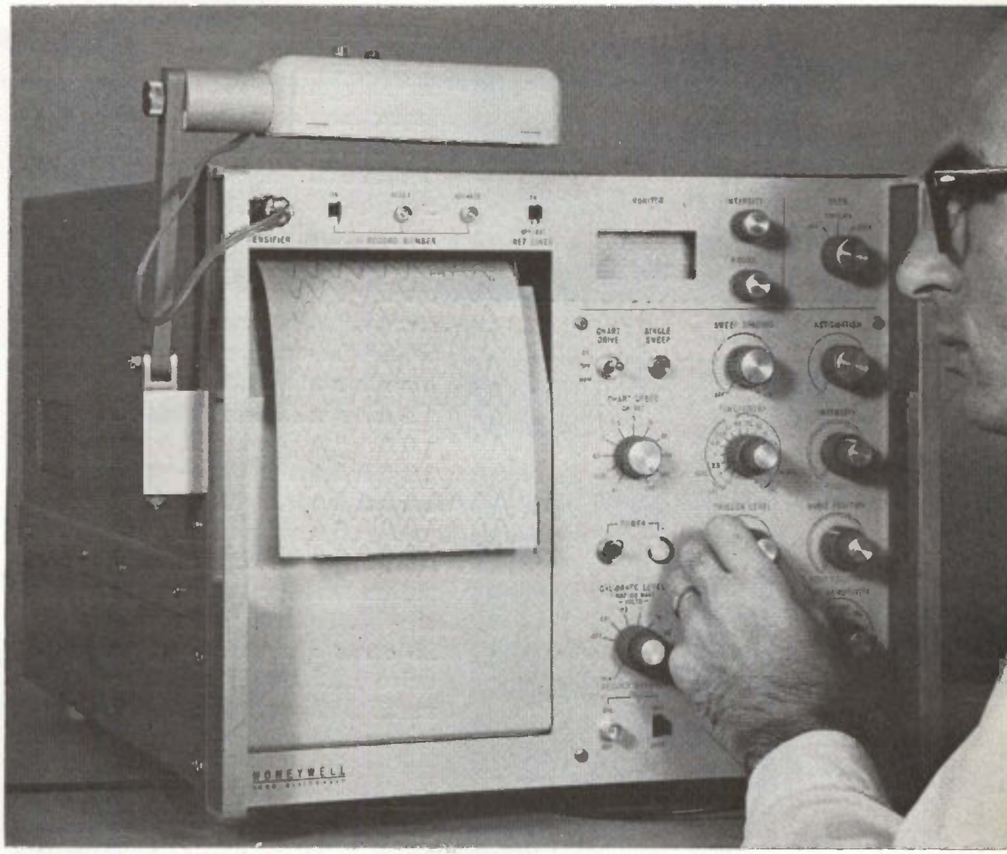
Instrumentation

Oscillograph prints out 1-Mhz signal

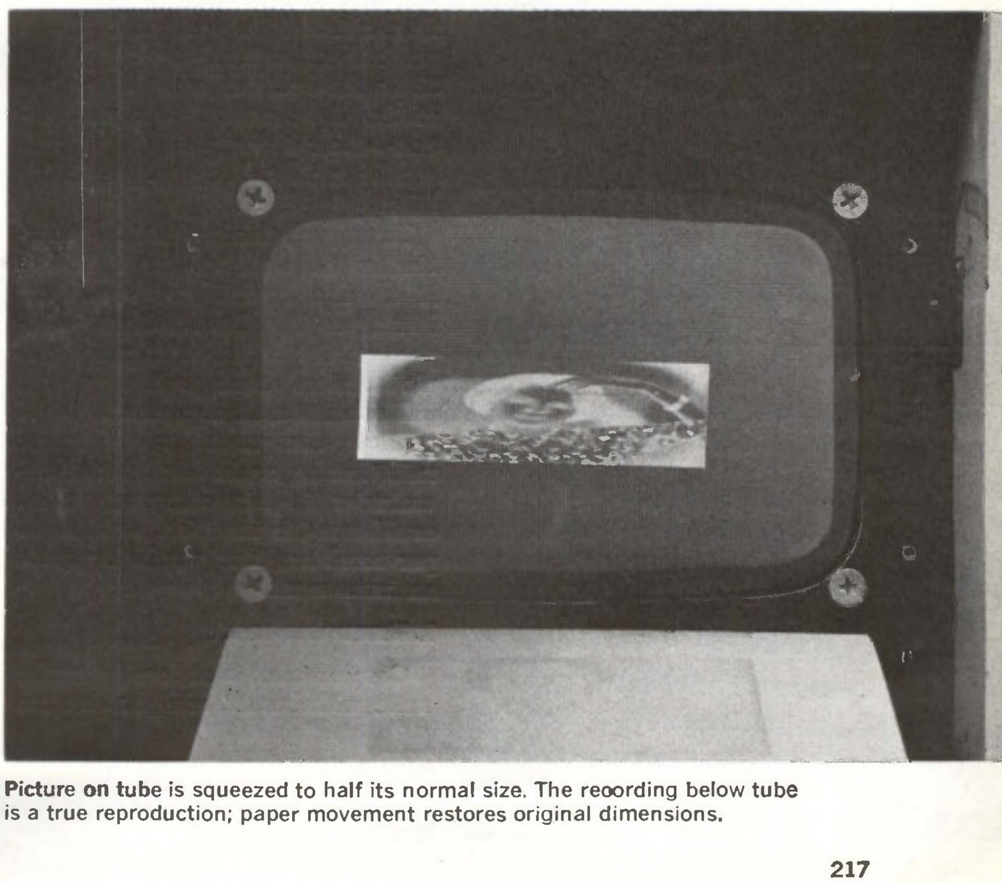
New machine uses electron beam and transverse recording to achieve fantastic speeds

By Walter Barney

San Francisco regional editor



Operator adjusts trigger level. A small monitor oscilloscope enables checking the intensity and focus of the waveform before recording.



Picture on tube is squeezed to half its normal size. The reoording below tube is a true reproduction; paper movement restores original dimensions.

Oscillographs, which produce on a paper chart a direct printed readout of waveforms, have been pretty much limited in frequency response by the speed at which the paper can be moved. At higher frequencies, the tracings tend to jam up and make a big black bar instead of separate lines. A new machine developed at the Denver division of Honeywell, Inc., however, uses a cathode-ray tube's electron beam as the pen, writes across the paper instead of down it, and achieves printout of one million cycles per second—almost a hundred times as fast as the fastest oscillographs now on the market. Even at the 1-megahertz rate, the Honeywell machine writes with peak-to-peak spacing of 0.1 centimeter.

The new oscillograph, the first to make use of transverse recording, is a direct outgrowth of one which Honeywell built two years ago for a Department of Defense customer whose name and need are still secret. Neither machine could have been made without a new kind of crt, whose face is a fiber-optic plate. On a normal tube, light from the phosphorus on the inside of the plate will spread as it passes through the glass, so that by the time it reaches the outside world, the light spot is too fat to write with. The fiber optics keep the spot at its original size.

The numbers associated with the Honeywell machine, designated the Model 1806 Fiber-optic Visicorder, are staggering. Writing across the paper increases the effective chart speed from the nominal 100 inches per second at which the paper travels to over 40,000 inches per second, and the writing speed (the measure of how far the curve would reach if it were pulled into a straight line) from a conventional 50,000 inches per second to more than four million inches per second.

Along with the tremendous frequency response, Honeywell has provided the customer with a number of extras. The 1806 can be used as a superfast x-y plotter, spitting out complicated Lissajous patterns like so many games of tic-tac-toe. To save paper, which costs 20 cents a square foot, the paper drive can be triggered internally by vertical information; transients can be monitored in this way without reviewing miles of normal operation as well. It prints its own reference lines. And most spectacular of all, because the intensity of the electron beam can be modulated like that of any other crt, the 1806 will also pick off individual frames from a television transmission and print them out at the regulation 30 to the second [see photo strip at the left]. Peak Z-axis modulation—the rate at which the beam can be switched on and off—is 3.5 Mhz.

Honeywell thinks that the potentialities of the 1806 are limitless. It has already delivered one to the Pentagon. The Sandia Corp. is reportedly interested in using one to plot a temperature profile across a pulse reactor. A representative of a large component manufacturer said that he could think of 20 laboratories in his company which could use the machine. At $20,000 per machine, that would be quite an investment.

I. Transverse mode

Conventional fast oscillographs write with beams of light that are deflected onto photosensitive paper by tiny galvanometers bearing tinier mirrors. The galvanometers merely move back and forth on one axis, and it is the motion of the paper that provides the time base. At 10 kilohertz, the tracings on paper moving at 200 inches per second—just about the limit for present paper drives—will be jammed together at 50 cycles per inch. At that density, it's pretty hard to analyze a complex waveform. It's even hard to see it.

In the 1806, the paper is pressed against the face of the crt and driven by a silicon controlled rectifier motor at a top speed of 100 inches per second. As the paper emerges from the machine, it passes under an ultraviolet light source that brings out the tracings.

Continuous output. There are other instruments which will record at high frequencies, but none which will provide this direct continuous output. Polaroid high-speed films, for instance, will pick off an instantaneous trace—but the record is not continuous. A high-speed camera will give a continuous record, but the film must be developed. Magnetic tape can record at high frequencies and then be played back at slower speeds, but the process is not direct and the tape recorder itself is not cheap.

The impetus for the development of a machine that would print directly from a cathode-ray tube came from the Pentagon, which gave Honeywell a contract in October of 1962. A little over two years later, the company delivered a prototype of an enormous machine that fits in two 6-foot racks, writes through a 9-inch strip of fiber optics only one-fourth inch wide. The system used commercially available electronics and paper drive; and because the fiber optic strip was so narrow, it could not provide vertical deflection, and the tracings were longitudinal—down the paper. Its response is 10 khz but the system did have Z-axis modulation.

Before the military prototype was even built, Honeywell had begun thinking about commercial applications, and in July, 1964, Don Shafer, a young engineer who had worked on the Pentagon's recorder, was put in charge of the demobilization. It was clear that only transverse recording would permit high-

Tracings of an actual sequence of tv frames illustrate the speed of the fiber-optic oscillograph.

frequency response. Since the oscilloscope itself writes horizontally, there would seem to be no problem: merely make the whole face of the crt of fiber optics, instead of only a thin strip, and follow the bouncing ball. That essentially is what Honeywell did—but it wasn't that easy.

II. Through thick and thin

Normally, a cathode-ray tube is made of a single glass bulb, but if the face is to be made of fiber optics, then face and body must be bonded together. Since fiber optics are weaker than glass, the face plate must be thicker, or the tube will implode when air is pumped out; and bonding a thick plate to a thin tube causes expansion problems.

The 3-by-5 inch plate on the Honeywell machine is a half-inch thick. It contains more than 35 million fibers, each 10 to 15 microns in diameter in hexagonal bundles ⅛ inch across.

Tender care. Honeywell buys its crt's from the Electron Tube division of Sylvania Electric Products, Inc., a subsidiary of the General Telephone & Electronics Corp. Sylvania, in turn, buys the fiber-optic plate from the Mosaic Fabrications Co., of Sturbridge, Mass. It was Mosaic which solved the bonding problem—with tender loving care. Mosaic reportedly brings the tube up to bonding temperature (400°C) at about half a degree a minute and cools it at the same rate. Sylvania follows this same tedious process in the exhaustion and final sealing process. Still, the manufacture is so tricky that Honeywell reports a tube failure rate of from 20% to 30%. Shafer says, though, that he does not regard the failure rate as serious at this stage of development.

Sylvania contributed an improved gun, which provides greater initial spot resolution. The spot diameter on the inside of a typical laboratory oscilloscope is 15 to 30 mils. The Sylvania gun makes spots that are 4 to 7 mils across.

III. Many circuits, small package

Given this essential component, Honeywell designed a completely new oscillograph that is solid state except for the crt itself and some cold-cathode devices in the high-voltage supply and regulator circuits, and which, though more versatile than the huge military system, measures only 14 inches by 16¾ inches by 22¾ inches, and weighs only 120 pounds. The electronics are on 15 printed circuit boards.

To keep the transverse tracings from sloping to the right because of the paper movement, there is a skew correction circuit that tilts the waveform down to the left. Paper speed, sensed by a tachometer, governs the voltage ramp generated by a Miller integrator. Every time a gating pulse from the oscilloscope's sweep generator discharges the capacitor in the integrator, the ramp is summed into the scope's vertical amplifier circuit.

Video signals. If the input is a video signal, rather than a waveform, the paper speed must be compensated for in a different way, since normally it would tend to stretch the picture. Attenuating the vertical deflection squeezes the picture on the crt, by about half, so that the paper movement stretches it into the right dimensions.

The 1806 does not actually pick up every sweep of a video signal, because a tv raster builds its 525-line frame by scanning down 263 lines, then jumping back and filling in the remaining 262. Since the paper has moved past the top of the frame by the time the beam starts filling in the so-called interlace pattern, the 1806 must blank out half the picture.

IV. More to come

The 1806 has achieved printout at the rate of 4 Mhz in the laboratory, and in theory, there is no reason why it could not go even higher, if sweep speed were increased so that discernible peak-to-peak spacings were maintained at the higher frequencies.

Sweep speed in the present machine is 10 microseconds per centimeter, or 120 μsec per sweep across the 5-inch tube. Shafer explains that this speed was originally chosen for a peak response of 100 khz. When Honeywell found that the 1806 would actually respond to 1 Mhz, there was no time to go back and redesign to change sweep speed. In any case, a faster sweep would give rise to totally new problems, since the electron beam would stay on each spot for a much shorter time, and the light intensity would be correspondingly lower.

More sensitive paper might ameliorate that problem. Gene Haugen, product manager, says that the paper manufacturers—principally Kodak, but including Ansco and du Pont—"seem to improve it about twice a year." The easiest answer would be to increase the intensity of the electron beam by increasing the anode-cathode potential—but here again there are problems.

In the present tube, the total acceleration potential is 7,500 volts, the sum of minus 2,500 volts supplied to the cathode and plus 5,000 volts. This low potential was specifically chosen to allow the deflection plates to operate near ground, which is essential for solid state circuitry.

If the potential were increased, the deflection plates would need more and more voltage to swing the beam, and transistors would not be able to handle the job. Moreover, there would be heat dissipation difficulties.

For the present, Honeywell will be satisfied with a 1-Mhz response. It will have the high-frequency field to itself; its chief competitor, the Consolidated Electrodynamics Corp. of Pasadena, Calif., has no plans to make a fiber-optic scope.

No marketing worries. Honeywell does not, however, intend to stand still with the 1806. "I see this as a whole product line," says Haugen. "We plan a multiple channel oscillograph, with as many as six external inputs time-shared by high-speed commutation. We are also thinking of a portable, battery-operated unit, with a smaller scope, that will use more integrated circuits and would cost between $3,000 and $5,000."

From the excitement generated earlier, when Honeywell let it be known that it had a 100-khz oscillograph in development, Haugen is not worried about marketing the new machine. Prospective buyers who came to see 100 khz remained to goggle at 1 Mhz. "People will dream up applications we haven't even thought of," Haugen says cheerfully. The Pentagon is probably busily thinking of some even now.

Thinning the traffic jam

San Jose, Calif., uses a computer system to gather data and formulate strategy for improved vehicular flow

H. L. Mencken saw it coming. The first time he found a "No Parking" sign in front of his Baltimore Sun office, he abandoned his car and never drove again. That was 40 years ago; today America's city streets are clogged with the automobiles of those who did not follow his example. Of all the annoyances of modern city life—smog, noise, overcrowding, and the cover charge—the traffic jam may well be the most exasperating.

Some cities are turning to electronics, in the shape of a digital computer and a variety of sensors, to spread the jam more thinly. San Jose, Calif., has the biggest computerized traffic control system now operating in the United States. For the past two years, San Jose, with a population of about 330,000, and the International Business Machines Corp. have been cooperating on a program in which an IBM 1710 collects data and controls traffic light strategies for 59 intersections along one main artery and in a downtown grid [Electronics, Nov. 29, 1965, p. 30].

IBM contributed the use of the 1710 for the project, but that computer system proved to be too slow to allow San Jose to expand the area under control in the future. The city, which will be on its own when the arrangement with IBM expires at the end of the year, has purchased a much faster 1800, at a cost of $200,000.

Because the system measures traffic flow rather than the progress of individual cars, it cannot make a decision for each car at each light. Eugene E. Mahoney, city traffic engineer in charge of the project, says, however, that total delay for all cars in the area of control has been reduced by 17%.

Although Mahoney has data to show that queues at red lights are now much shorter, he admits that the average San Jose driver may not realize that he is getting through traffic any faster.

"We're nibbling away at seconds, but it adds up to a lot of seconds for a lot of cars," he explains.

I. The approach

IBM's approach ties all elements of the system—lights, controllers, traffic detectors—directly into the central computer. The computer, through a simple local controller, handles each intersection. Therefore, as many as 128 timing patterns can be implemented at each intersection by reaching into a magnetic disk storage drive containing programs, subroutines and complete traffic operating tables required by the system. On a citywide basis an almost unlimited combination of traffic signal timings is available, and the timings can be experimented with simply by changing a program. In addition, certain critical intersections can be controlled by vehicle detectors instead of by computer. If the computer should fail the system reverts to a standard three-dial mode of control.

"IBM is not going into a city with a complete traffic package all tied up in a pink ribbon," points out Oser I. Bermant, program manager for vehicular traffic systems. Rather, the company offers a tool —the combination of the 1800 computer and its programing package. This allows the traffic engineer to deal with the total problem. He can gather information, make decisions on how the information should be used, execute the decisions and then see what effect the control has had on the over-all system.

System in Texas. IBM also has an 1800 computer installed for traffic control in Wichita Falls, Texas. It is also negotiating with a large midwestern city about double the size of San Jose, and two others about the size of San Jose, according to Bermant. Another digital system is being designed for New York City by Sperry Gyroscope Co., a division of the Sperry Rand Corp., which helped to design a system now in use in Toronto.

"Any city of at least 100,000 population will find digital computer-controlled traffic systems competitive with the analog control systems that are available. And digital systems give you so much more flexibility," Bermant asserts.

II. Traffic a go-go

What San Jose has, basically, is an enormous data collection system. A network of 320 induction loop sensors, each with its own curbside amplifier, and 80 pressure pads, collects information. The computer uses this data to make six measurements.

- **Volume.** The number of cars passing over detectors for each approach lane to each signal is noted at five-minute intervals; the computer can be programed to reject measurements that are out of line (more than 2% away from the average).
- **Speed.** This is calculated as a five-minute average on 50 of the detectors—but not always the same 50—using an average vehicle length of 17.1 feet. The speed figure has a high inverse correlation to congestion.
- **Stops.** The computer does not actually count stops, since it has no way of detecting them. Knowing, however, the distance from the loop to the stopline, the average speed, and the condition of the traffic light, it can register as "stopped" any car that has passed the approach loop without enough time to catch the green light. Those which speed up on the yellow signal it considers statistically insignificant. If a queue stretches past

. . . the computer can evaluate traffic daily . . .

the detector loop, of course, the computer cannot count the last cars.

▪ **Demand.** This is the number of vehicles per green-yellow-red cycle which approach a signal in each lane.

▪ **Delay.** This figure, the most important in evaluating the system, is calculated from the number of stops, and is measured in vehicle-seconds.

▪ **Lane occupancy.** Fifty detectors—again not always the same 50—are used to obtain this figure as a five-minute average.

The measurements—some 500,000 a day—are the basis for making changes in the only three variables in a traffic light system: cycle, split, and offset. Cycle is the length of a green-yellow-red sequence, split is the ratio of red time to green time in any given cycle, and offset is the difference in time between green lights at neighboring intersections.

These variables may be manipulated in a number of different patterns. San Jose experimented with six:

▪ A single fixed pattern which does not change at all.

▪ A program of three patterns which are put into effect at fixed times each day.

▪ A program of three patterns which are put into effect according to fluctuations in traffic volume at certain detectors.

▪ A multiple cycle selector system, in which as many as six patterns are available and choice is determined by the volume of flow.

▪ An expansion of the above method, in which any number of patterns derived from previous day's data, may be put into effect either at fixed times or at times determined by traffic volume.

▪ What IBM calls the "microloop" strategy, in which the split may be varied at individual intersections depending on the traffic conditions.

Clearly, each successive strategy has been more complex than the one which preceded it. With the exception of microloop, however, all apply stored programs; microloop takes advantage of spare seconds in arterial traffic to accommodate across traffic, left turns, and pedestrians—the latter are the bane of any traffic control system.

For all its sophistication, however, even microloop can only vary the split by a few seconds.

III. Model solution

Although only six strategies are being employed, each offers a great many tactical variations. Split, for example, can be divided in a number of ways, and differently for selected intersections.

In order to get an idea of how new strategies and tactics will work without actually trying them in traffic, Albert Chang of the research and development laboratory at IBM's San Jose plant, has built a mathematical model of the 59 controlled intersections. Chang uses about four hours a month on an IBM 7094 computer to test new strategies, using data collected by the traffic control system.

Chang believes that the biggest achievement of the computerized traffic system is in the data collection that makes simulation and further study possible. "Everything being done in San Jose now could be performed with conventional equipment," he says, "but we couldn't lay out new designs without the data collected by the computer."

Long way to go. "Sure," says Mahoney, who combines boundless enthusiasm for his system's potentialities with a healthy skepticism for what it can do now, "there are a lot of kinks to be ironed out. We're just getting started. In the beginning, we didn't even know what the detectors were telling us and finding out helped eat up the two years.

"With the computer you can evaluate the traffic system daily. We get data so quickly that an engineer doesn't have time to sit back and say 'What do I do now'? He has an instrument that tells him to get off the dime. Of course, the instrument isn't perfect. Sometimes, in fact, the boys here go nuts because the drivers don't do what the computer thinks they should do. It's all a matter of collecting more data; I am not satisfied yet that we have enough information to show what truly makes changes in traffic performance."

Electronics for grandeur: De Gaulle's foreign policy spurs growth of CSF

Advanced avionics and space hardware are helping President Charles de Gaulle transform his dream of grandeur for France into reality. Much of the electronics is coming from CSF-Compagnie Generale de Telegraphie Sans Fil

By Peter Kilborn

Paris News Bureau

CSF outgrew its old headquarters in downtown Paris and now company is run from sleek new building at Rocquencourt, near Versailles.

Charles de Gaulle's notions of grandeur for France often seem a throwback to 19th century nationalism, but they've kept the country's electronics industry in the forefront of 20th century technology. Perhaps no other company has benefited as much from the French leader's single-mindedness as France's best-known electronics company, CSF-Compagnie Générale de Télégraphie Sans Fil.

To strengthen his say in world affairs, de Gaulle has eschewed the mutual defense of the North Atlantic Treaty Organization—dominated by the United States—and mounted his own nuclear striking force, the "force de frappe." Determined not to let space communications wind up as a monopoly of the U.S. and the Soviet Union, de Gaulle has put France into space. Prompted by prestige, France alone of the major West European countries has picked its own Secam system for color television. And convinced that computers are crucial to industrial independence, de Gaulle has moved to build a durable domestic computer industry.

Pros and cons. All these efforts have brought business to CSF; so much so that the government is far and away CSF's best customer. But what's good for Gaullist grandeur isn't always good for CSF. The company, for example, has seen its military business with the United States dwindle as de Gaulle's foreign policy clashed with American interests. And de Gaulle's desire for a world-class nuclear striking force has opened the doors to some tough competition—U.S. semiconductor manufacturers who set up plants in France to make advanced components.

Aware that too much dependence on government business might be disastrous in the long run, 64-year-old CSF president Maurice Ponte has started to form alliances with other European electronics companies with a view to strengthening CSF's position in consumer and industrial markets.

I. On the bandwagon

Riding the bandwagon fueled by Gaullist ambition, CSF has shown strong growth in recent years. Last year, sales of the parent company and its affiliates totalled $276 million, up in three years from $188 million. Only about 8% of the total came from consumer electronics; thus CSF ranks as France's largest producer of military and industrial electronics equipment. Nonetheless, CSF remains a fairly small company even on a European scale; on a list of the top dozen Western European electronics companies, CSF is near the bottom.

CSF, though, has the stature of an electronics giant in Gaullist France. A pair of CSF transmitters, for example, is transmitting data back from the D-1A satellite launched last February and still being tracked by six CSF-equipped ground stations.

Last month, Defense Minister Pierre Messmer turned up at CSF's new headquarters at Rocquencourt, near Versailles, to hail the production of the 500th "Cyrano" airborne fire control radar. The Cyrano is the kingpin item of avionics equipment in France's Mirage III fighter planes. Other CSF avionics hardware is on Mirage IV strategic bombers, the first-generation delivery vehicle for the force de frappe. When the second-generation missiles go operational in 1969, they'll carry CSF guidance gear.

CSF klystrons power French nuclear research particle accelerators. CSF transmitters and microwave links cover France for the government-owned broadcasting network. CSF owns a third of the Compagnie Française de Télévision, which has the rights to the Secam color-tv system that the de Gaulle government has backed in earnest to bolster French prestige. And CSF has a one-third holding in "Societé S," the company formed at the government's instigation to develop a line of medium computers [Electronics, June 27, p. 197].

Best customer. All in all, direct sales to the government accounted for 42% of CSF's business last year. And Ponte, the company's president, estimates that another 20% to 30% of sales was for CSF-produced components that wound up in hardware ordered by the government. Even the remaining third of sales—mostly industrial equipment and radio and tv receivers—is heavily affected by government policies.

Along with the business it has spawned for CSF in France, de Gaulle's pursuit of independence from the U.S. has made for a good selling climate in Soviet-bloc countries. Russia, of course, has adopted the Secam color-tv system and brought with her into the Secam fold all the countries of Eastern Europe. Russia also will buy CSF know-how to build a color-tube factory that will be turning out between 1 million and 1.5 million tubes annually by 1970.

With the government's help, CSF has sold complete semiconductor factories to Rumania and Bulgaria and a tv-receiver plant to Bulgaria. What's more, a number of East European countries have bought CSF studio equipment and transmitters. And Secam will add to CSF's sales to East Europe. Ponte predicts that sales there of CSF studio equipment and components for receivers may total $20 million by 1970. This is in addition to the company's share of some $10 million in Secam royalties that Compagnie Française de Télévision expects to harvest by 1970.

And de Gaulle's foreign policy hasn't hurt CSF in its traditional major export markets for telecommunications equipment — Africa and Latin America. De Gaulle has a strong aid program for French-speaking African countries and he woos Latin American countries whenever he can.

Mating. Throughout his reign, de Gaulle has waged a campaign to form strong French companies in vital industries through mergers and cooperation agreements. To get companies to join forces he dangles the carrot of government research contracts and hardware buying; when that doesn't work he applies the stick of government pressure.

So far, CSF has had everything to gain by going along with this facet of Gaullism. In 1964, CSF and the Compagnie Générale d'Electricité, another heavyweight in the French electronics industry, signed an agreement that lumped together seven of their subsidiaries specializing in computers, data transmission and automation into a jointly owned company called Compagnie pour l'Informatique et les Techniques Electroniques de Controle (Citec). It was formed, with strong government backing, just after the General Electric Co. swallowed what was then France's only important computer maker, Compagnie des Machines-Bull.

Now de Gaulle's "Plan-Calcul" has whipped the only other firm with significant computer manufacturing potential into Citec. The new member is the Schneider group's Société d'Electronique et d'Automatisme (SAE), which like CSF and CGE owns 30% of the new Société S, so titled until its backers find a suitable name.

Ponte is confident that the new group has the materials and markets to make the operation pay. He cites the success of a Citec subsidiary belonging to CSF—Compagnie Européenne d'Automatisme

Maurice Ponte, president of CSF, says de Gaulle's drive for grandeur helps company grow . . .

. . . Ponte figures government buying accounted for nearly three-fourths of CSF's sales last year . . .

. . . But he says, "French policy, while an important factor in our development, isn't always favorable."

CSF is supplying 28 of these 100-killowatts ultra high-frequency tv transmitter antennas to the state-run French broadcasting network.

Electronique (CAE). Its 1965 sales leaped 180% over 1964 and accounted for 9% of all computers sold in France. All other French computer builders collected only 5% of the market, and the rest went mostly to the International Business Machines Corp. and Bull-GE.

Going along with de Gaulle's policy has resulted in one strange bedfellow for CSF—one of its stiffest competitors for military and industrial business, Compagnie Français Thomson Houston-Hotchkiss Brandt. The two companies will work together in research on integrated circuits. And CSF has joined with a company called Société Industrielle de Liaisons Electriques to develop microelectronic components for export.

II. Backlash

Although the French government is CSF's best customer and a bulwark for the company, the Gaullist scheme of things doesn't always work out to CSF's advantage. "French policy, while an important factor in our development, isn't always favorable," Ponte admits. And says Pierre Braillard, CSF secretary-general, "Let's say the government is a little cumbersome."

A cumbersome diplomatic move, startling when one considers French expertise in the art of diplomacy, helped lose Western Europe for the Secam color-tv system. In an apparent attempt to set up a stampede for the French system, Russia and France announced on the eve of the 1964 International Radio Consultative Committee (CCIR) meeting at Vienna, (where an effort was made to settle on a common color standard for Europe) that they'd teamed up to develop Secam. The heavy-handed attempt turned several wavering countries into supporters of PAL, the West German system that all the major Western European countries—France excepted—have since adopted.

De Gaulle's refusal to let Great Britain enter the Common Market probably hurt CSF's market in England, too, but there's no real way to gauge how much. CSF officials are convinced, though, they'd do better in Britain if she were in the six-nation trading bloc.

U.S. drought. And Ponte says the current friction between U.S. policies and de Gaulle's has been partly responsible for the loss of substantial military business. Until five or six years ago, CSF was picking up about $2 million annually in U.S. Air Force and Navy research contracts. "Those have gone way way down," he says. Radar and high-power tube sales to the U.S. military averaged another $2 million then; that market, too, has nearly dried up.

Some of the retaliation against Gaullist policy has been felt by CSF's two U.S.-based operations, Warnecke Electron Tubes Inc., and the American Radio Co. American Radio is primarily CSF's American sales outlet, but it also makes bright display tubes for airport radar and tv cameras. Bright display and camera production have slipped considerably, but CSF attributes that more to saturated markets than to politics. Warnecke, on the other hand, manufactures equipment developed by CSF under military research contracts and with fewer contracts for CSF, Warnecke's business has dropped.

Whatever these companies' troubles, CSF has no plans to pull out of the U.S. market. Ponte thinks Warnecke might eventually need some sort of overhaul. The Hallicrafters Co. is CSF's partner in Warnecke. "What we really need there," Ponte says, "is a bigger partner," and CSF's technical director, Roger Aubert, has not yet written off the U.S. Department of Defense as a potential customer. CSF still has "a few" important contracts, among them one to develop a special microwave tube for the Air Force.

Hurt at home. De Gaulle's domestic policies sometimes hurt too. Up until last year, CSF had the habit of bringing off sales growth of about 10% yearly. But 1965 brought a slowdown to 7% growth, largely because of the government's rigid price stabilization program. Now that stabilization measures have been eased, Ponte sees another 10% gain in sales for 1966.

However, there's no end in sight to the government's policy of letting U.S. companies set up plants in France if they bring with them advanced technology useful to de Gaulle's military and space programs. Texas Instruments Incorporated, Motorola Inc., Fairchild Camera & Instrument, and Transitron Electronic Corp. all have manufacturing facilities operating in France or about to.

Although this backyard Yankee competition hasn't hurt CSF badly —the company's semiconductor manufacturing subsidiaries are turning out about 13 million transistors and diodes a month and exporting about three-fourths of them —it has kept the output of other French companies well below capacity. Above all, the presence of the U.S. semiconductor giants in France will tend to brake CSF's entry into the integrated circuit business since it will be just another—but perhaps preferred—supplier to the government. So far, CSF's integrated-circuit product line consists solely of transistor-transistor-logic circuits.

III. Beyond de Gaulle

For all the political stability de Gaulle's Fifth Republic has brought to France, there's still plenty of apprehension about what will happen when the General is no longer there to guide the country toward grandeur. Readying for the day when the government might become a less avid buyer of electronics, Ponte has been steering CSF into alliances that will strengthen it in consumer and industrial markets.

With the Common Market wiping out trade barriers in Western Europe and with the domestic market becoming increasingly inadequate to write off the high cost of new-product development, Ponte has started thinking European. CSF's long-term survival, he feels, may even be as part of a "Compagnie Européenne d'Electronique."

"I'm convinced France can't stand alone," he says, "especially with the fantastic rate of techno-

Engineer explains new terminal equipment for microwave data-transmission link.

logical development outside France. We can't do everything. Cooperation with others is vital."

Teamed up. Already Ponte has entered into alliances with two major West German companies. Last month, the CSF computer subsidiary CAE signed an agreement with Telefunken AG to market and service hybrid computers. A month earlier, CSF had picked up a strong partner in the entertainment market when it made a deal with Grundig GmbH. The two companies will work together to develop color-tv receivers—with Grundig's marketing experience complementing CSF's capabilities in IC's.

Although it has tied up with larger companies in its German alliances and some of its joint ventures in France, CSF has managed to obtain equal footing with its partners because of its strength in research. CSF has always been strong in high-power microwave tubes and feels it can keep pace in research with U.S. companies in integrated circuits, the key to everyone's future in electronics. Where CSF runs into trouble is getting promising prototypes into profitable mass production. The domestic market all too often isn't big enough to write off production start-up costs. CSF's alliances point to a solution—expanding the basic market to all Europe.

Education

Learning a trade by computer

Developments in automated teaching promise to provide vocational training by simulating on-the-job conditions

By John Rhea

Electronics Washington Bureau

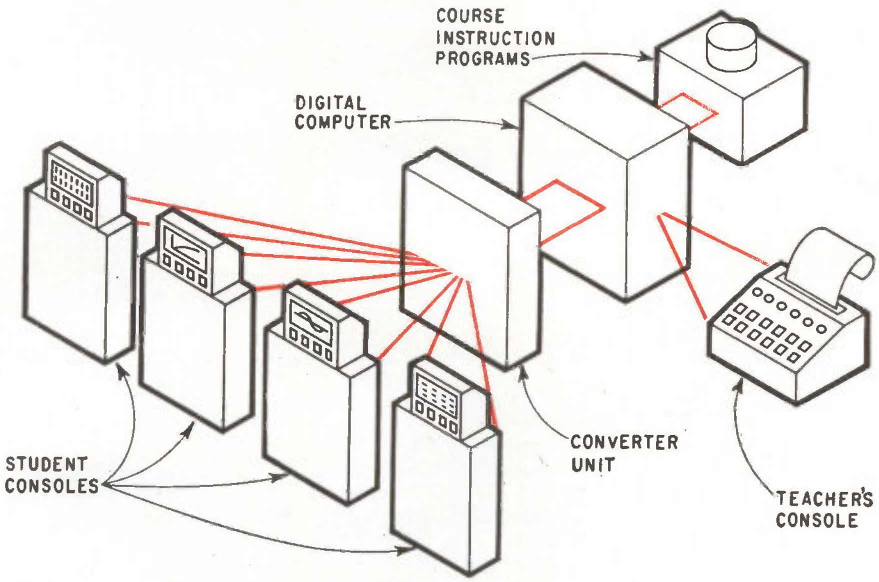
Ever since the military adopted the famous Link trainer to teach pilots to fly in World War 2, the use of simulators to train specialists has steadily increased. Now government, industry and schools are making plans to use the simulation technique on a much broader scale —for vocational education.

Development is under way of computer-aided instruction systems that will simulate on-the-job conditions and give students computer-guided experience with mock-ups of the equipment they actually will be using in their jobs. The computer instructs the student, gives him problems to solve and grades the results. Most important, the computer simulates in real time the actual functions of the equipment the student is learning to operate.

The computer is not an ordinary teaching machine, such as those now used in elementary schools. With present typewriter keyboard systems, students must communicate with the computer in alphanumeric form; in the new system, a computer converts analog data into digital information for processing.

"The mission of laboratory and vocational training facilities is to provide practical experience," says George Hallgren, laboratory director at the International Business Machines Corp.'s Federal Systems division at Gaithersburg, Md. "This practical experience," he adds, "cannot be realized by a mathematical machine that deals only in numbers rather than physical reality. A punched card cannot substitute for a rheostat or a printed page for a tachometer."

Work is already under way in developing the new technique. IBM has developed a prototype system with company funds. The military—which promises to be the biggest single customer for the new method—is spending $4 million a year on research on automated education.



Computer system for vocational education would use student consoles that simulate the actual device the student is learning to operate. His responses, which are in analog form, are converted by the computer for digital processing.

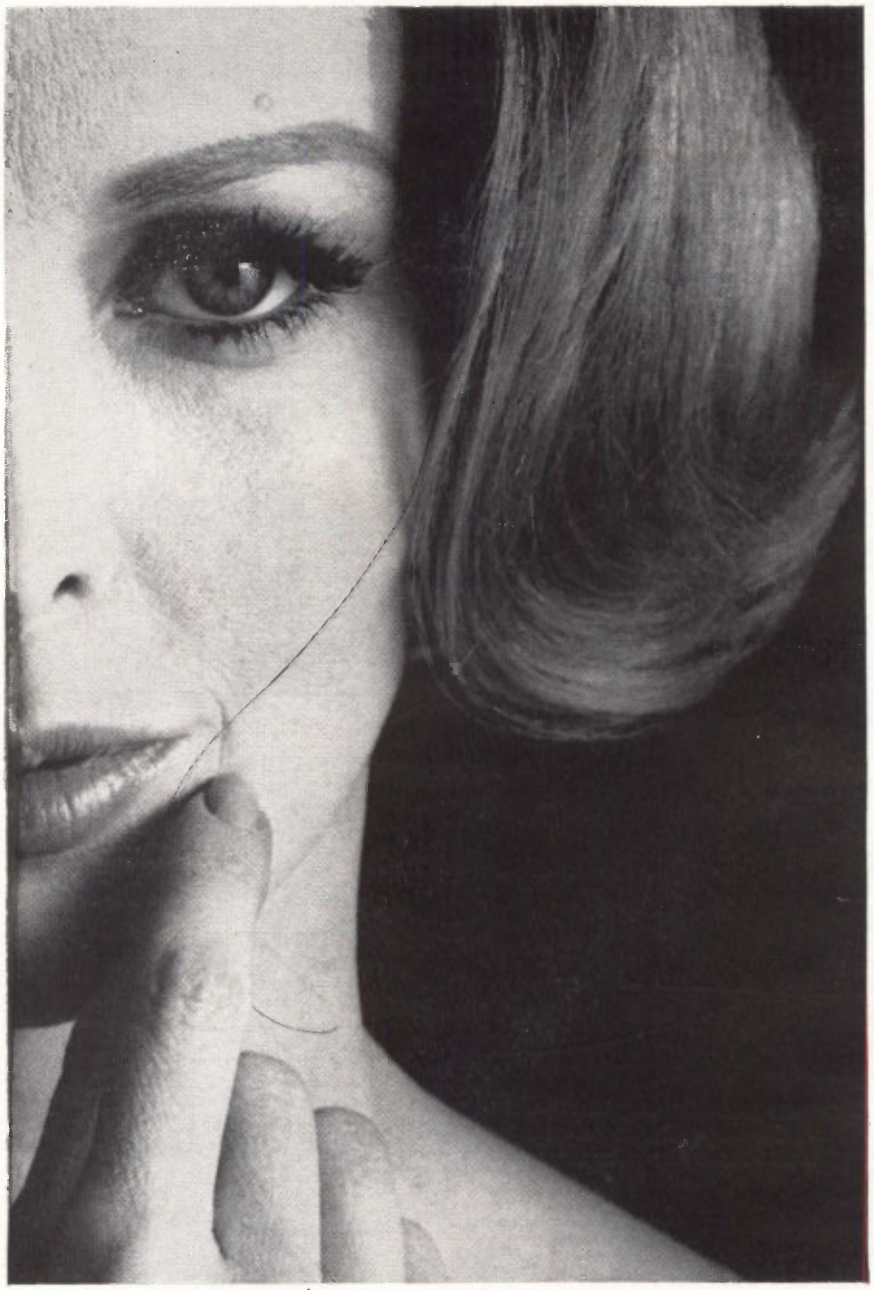
I. Old hat, new feathers

Although the simulation technique is based on military experience in the field, the new programs go several steps further.

Today's compact, high-speed computers automatically record a student's results and permit teachers to analyze individual progress. Computers are available with individual student consoles tailored for each training application. And the list of new innovations is growing to where only economic restraints and the ability to write programs limit the possible uses of computer-aided instruction. Operation of a nuclear reactor, locomotive or oil refinery could all be simulated in real time to give students practical experience, proponents of the technique say.

Market waiting. As is the case with most other technological innovations, the Government is both the spur to research and the biggest customer for finished hardware. Such organizations as the Department of Defense and the Office of Education are working out plans to apply computer-aided instructional systems.

Electronics marketing officials and the educators who will use the equipment are both cagey about making any sales predictions. But the most often heard estimate is that the market will rise from essentially zero at the moment to around $1.5 billion a year by 1972, including both academic and vo-



cational education.

The electronics industry, however, will have to tailor equipment for the education market. Richard Louis Bright, associate commissioner for research at the Office of Education, complains that the industry is trying to sell the schools equipment designed for other purposes. A tape recorder designed for commercial recording is not best for an effective language laboratory, and home television sets are more effective for entertainment than for education, he says. "Most certainly, computers designed for business data processing are not ideally suited for computerized classrooms," says Bright.

Big or small. Bright points out that one of the basic questions yet to be worked out is whether a large central computer hooked to hundreds of terminals via telephone lines is preferable to small computers at the local school level, each with only 30 to 100 consoles. "My guess is that educational institutions will probably go in the direction of large central computers with terminals in many schools," he says. However, he says that if an audio capability is found necessary, small computers will have to be used because audio tapes will have to be stored at each console.

The problem of adapting computer technology to educational needs is more one of redesign than state-of-the-art breakthroughs, according to Bright. The single exception he cites is picture storage and display. With the current technology, adequate speeds are possible only with cathode-ray tube devices. A potentially more economical approach is to digitally code single-frame pictures for readout on demand, something that electronics firms are already researching.

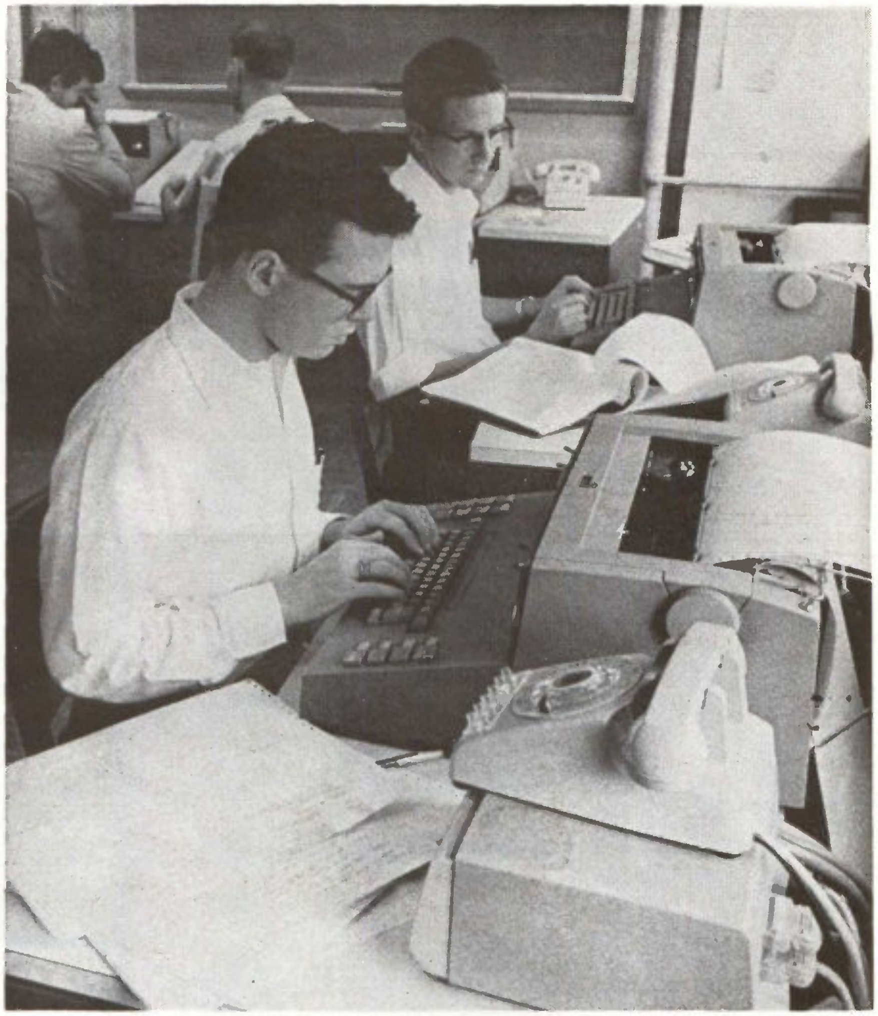
II. IBM stresses software

With an eye to the new market, IBM has built a prototype vocational education system. Hallgren calls the firm's approach "integrated training aid systems" to emphasize that software and peripheral devices, rather than the computer, are the keys to the concept. The console is a mock-up of the equipment the student is learning to operate and is linked to an interface unit, or buffer, that permits analog functions performed by the student to be processed digitally.

The console in the prototype is a custom-built voltmeter like one a student in a basic electronics course would use to measure voltages. Instructions are printed out on an electric typewriter by the computer. If each measurement is made properly, the computer tells the student to go on to the next problem; if the measurement is wrong, it offers hints until the student masters the technique.

Computer ready? The computer for an operational system would "be in the ball park" of an IBM system 360, model 30, or the old standard IBM 1401, according to Hallgren. An instructor's console would be in the loop, but off-line so that he would not be in the process until the student became so bogged down that he could not proceed without help. Having the teacher available reduces programing costs since the computer memory doesn't have to store corrective actions for every possible wrong answer. It also adds a human dimension to an impersonal system.

At the console, the student would be given problems by any suitable output device on the computer. The console could be a simulated control panel for any industrial application—or more novel applications. Hallgren, for instance, keeps in his office a transparent model automobile with color-coded parts that he says could be used in a computerized system to teach automotive mechanics. He also has a small transparent model of the human body that could be used in a system to teach hygiene.



Students at the Massachusetts Institute of Technology use typewriter-like terminals linked by telephone lines to the computer center. With an IBM System/360 time-sharing computer complex, 200 people can use one computer.

III. Computers being drafted

The military, which pioneered automated training methods, is potentially the biggest customer for such equipment although it has not yet installed any major computer-aided instruction systems, vocational or academic. The Defense Department spends $4 billion a year on a wide range of training programs and has an annual "class" of 500,000 recruits. Advanced training costs $2,000 to $12,000 per man. Pilot training, which runs as high as $250,000 for a single jet pilot, totals $1 billion a year for all services.

To cut these staggering costs as well as the time spent in training, the Defense Department spends $4 million a year on research on automated education. All three services are involved: the Army through the Human Resources Research Branch, operated under contract by George Washington University; the Air Force Personnel Research Laboratory, Lackland Air Force Base, Texas; and the Naval Personnel Research Laboratory, San Diego.

Among the test projects initiated are programed instruction courses in basic electronics (but without a computer) at Keesler Air Force Base, Miss., and Lowery Air Force Base, Colo.; a $1-million automated medical training facility being installed at the Brooks Army Medical Center, Texas; and a closed-circuit television system for basic training at Fort Gordon, Ga.

Computer philosophers. Two projects in computer-aided training are under way at the University of Illinois: Plato, an acronym for program logic for automated teaching operations, and Socrates, an acronym for system of organizing content to review and teach educational subjetcs. The work is being directed by the Office of Naval Research and is funded by the Advanced Research Projects Agency. Both techniques link student consoles to a central computer and have been used in teaching some engineering courses.

As results of the projects begin to trickle in, it is becoming obvious that automated methods reduce course time, lower entrance requirements and reduce dropouts, according to Air Force Lt. Col. Ruth Lucas, who coordinates the educational technology programs for the Defense Department. In the electronics course at Lowery Air Force Base, for example, the programed instruction approach

An IBM 1440 computer asked this fifth grade student if the figure on the display was an isosceles triangle. When she replied 'yes', it advanced to a new problem.

cut course time from 420 to 230 hours and permitted entrance requirements to be lowered by 25%.

Fighting times. These benefits are particularly important to the military since electronics technicians go through 45 weeks of training and generally are the top personnel entering the services. Reducing entrance requirements creates a bigger pool of manpower and speeding up the courses gets the men to the battlefield quicker.

The problem now, according to Lucas, is to develop training courses concurrently with new weapons systems so the men will be able to operate them when the weapons reach the field.

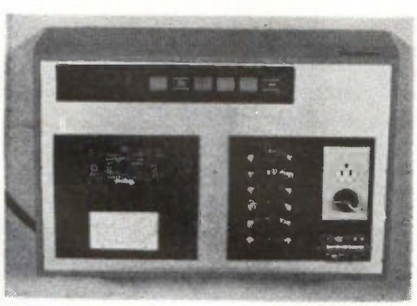
IV. No money, no program

The Office of Education's problems in implementing automated vocational education techniques can be summed up in one word: money. It doesn't have the funds to conduct the major research programs it wants, and the school districts that will be using the vocational education systems can't afford the heavy investments.

The Federal agency is also interested in job retraining and put $4 million into pilot vocational educational projects during the current fiscal year. But the office will not be able to initiate any new projects because of budget cuts just voted by Congress.

Majority unskilled. David Bushnell, director of adult and vocational research in the Education Office's Bureau of Research, says the present programs will be continued at their current rate, but that a bigger effort will soon be necessary. He notes that less than 10% of the nation's school children get any vocational education. Since 19% graduate from college and thus get academic vocational preparation, this leaves 71% of the population that has to pick up skills on the job.

Congressional concern is evidenced by hearings held this summer before the Joint Economic Committee of Congress chaired by Rep. Wright Patman (D., Tex.). The committee, which has pushed the application of automation in other fields, noted in its final report that developments in the storage, processing and communication of information arising from the new technologies are creating a revolution in the nation's system of education. Patman was particularly interested in automated vocational training, which he says, "makes it possible to reduce drastically adult illiteracy and lower earning power caused by inadequate education."



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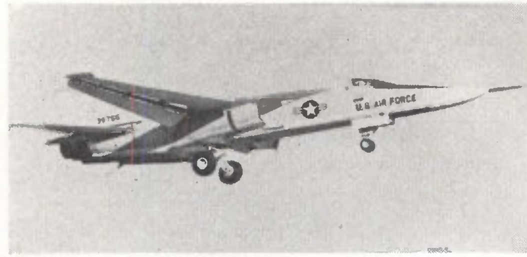
Where the avionics packages will go . . .

Light observation helicopter, above, will use an avionics package called Lohap that Sylvania is building for the Army.



Air Force F-111A will be equipped with the Mark 2 avionics package from the Autonetics division of North American Aviation Corp.

Marine Corp's heavy assault helicopter Sea Stallion, CH-53, above, and the medium helicopter, CH-46 Sea Knight, will use the Navy's IHAS.

Advanced aerial fire support system will use components from several avionics systems. Early models may use the IHAS computer.

Avionics

Feeling the pinch

The trend is still toward integrated avionics systems, but Vietnam costs threaten one program

By William Hickman

Electronics Washington Bureau

The steadily mounting demand for funds for Vietnam is racking up another casualty. This time it's in a concept the Defense Department has been pushing since 1963—integrated avionics.

At present there are five programs under way. One—the integrated light attack avionics system (Ilass)—is threatened with cancellation. According to Department of Defense spokesman Vietnam is putting the squeeze on military projects not contributing directly to the war effort.

Additionally, integrated avionics contractors have another problem. Congress, worried that there might be duplication in the five programs managed by three services, is talking about investigations.

I. No end to trend

However, the trend to put integrated avionics systems in new aircraft continues. Development is going forward on the Mark 2, the Air Force system being built by the Autonetics division of the North American Aviation Corp. for the F-111A, an aircraft the Defense Department intends to use as a fighter-bomber. And the Electronics Systems division of Sylvania Electric Products, Inc., a subsidiary of the General Telephone and Electronics Corp., is building the light observation helicopter avionics package (Lohap) for the Army.

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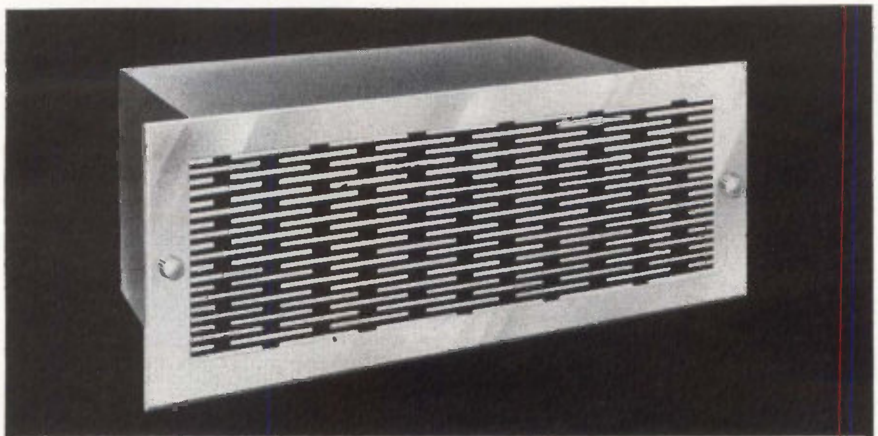
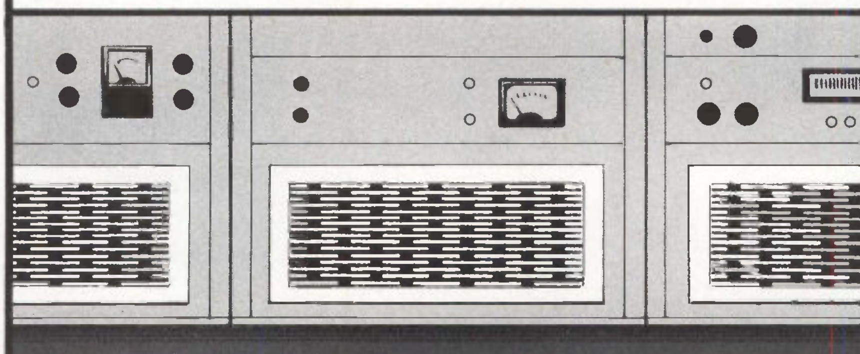




Lohap is a communications complex that will be used in a number of rotary-wing and low-performance, fixed-wing planes.

Prototype testing will begin next month for another program, the Navy's integrated helicopter avionics system (IHAS), but the final avionics package for the advanced aerial fire support system (Aafss) is still up in the air. This package will consist of successful elements from other packages being developed before Aafss. To date, however, no one knows exactly which ones they will be. Lockheed Aircraft Corp. is contractor for the Army program, in charge of both the aircraft and avionics.

Future systems. In addition to the five programs under development, at least three additional integrated systems are on the drawing board:

- A package for the Navy's overweight F-111B. The Navy has not awarded a contract for an avionics system for the F-111B, but it probably will if and when a decision is made to begin production next year. If the Pentagon does order the Navy version of the TFX, the aircraft will carry the Phoenix missile fire control subsystem, coupled with some of the equipment now under development for Ilaas.
- An integrated system is being studied for the improved Mohawk, the next model in Grumman Aircraft Engineering Corp.'s surveillance aircraft series.
- The integrated surveillance and target acquisition system (Istas) is being studied in-house by the Army but has yet to be defined or studied by contractors. Neither the Istas nor the Mohawk system is expected to be funded until expenditures for the Vietnam war are reduced.

An investigation? Congressional groups overseeing the defense budget are all for the concept of integrated avionics, but they don't want duplicated effort. In the summer of 1965 the House Armed Services Committee cut \$3.7 million out of the Navy's budget for Ilaas to encourage the services to unify on integrated avionics development.

The committee expressed "concern about the possible overlap" between Ilaas, IHAS and the Mark 2. It trimmed the budget to "encourage more careful integration" of the three systems to "lower

Money for avionics		
Program	Committed (in millions of dollars)	Estimated total
Ilaas	17.9	100
IHAS	26.7	100
Mark 2	38.9	200

development costs."

The committee is still worried about the possible duplication of effort and its concern may be growing. A spokesman says that the committee plans to look with "great interest" at the services' fiscal 1968 budget requests for integrated avionics projects. He hints a Congressional investigation may be ordered.

II. The three basic systems

The Ilaas program is being developed for the Navy by Sperry Gyroscope Co., a division of the Sperry Rand Corp. The only approved aircraft program that could employ it is the A-7A, and the Navy has indicated it won't be used on that plane, at least the first ones. Two weeks ago, the Navy was ready to announce cancellation of the entire system as far as the A-7A was concerned, but just before the decision was announced, it was determined to examine the system again. If Ilaas does live through the current squeeze, it might emerge with less steam. Navy officials estimate that Ilaas would cost about $230,000 more per unit than existing, less effective, avionics systems.

Sperry's initial contract for Ilaas was $17.9 million. If the system goes into production, the total contract may hit $100 million. Company spokesmen insist that the budget squeeze on military research and development will not slow up the program and they disagree with earlier reports of its possible cancellation [Electronics, Oct. 3, p. 75].

Major Ilaas subcontractors include the Univac division of Sperry which will build the navigation and weapons delivery computer; Autonetics division of North American Aviation Corp., the forward looking radar; LFE Electronics, a division of Laboratory for Electronics, Inc., the data conversion equipment; the AC Electronics division of General Motors Corp., inertial navigation sets; Elliott Automation, Ltd., the heads-up display; and Norden division of United Aircraft Corp., the vertical situation display.

Mark 2. The largest integrated avionics program to date is the Mark 2, which the Air Force is developing for the General Dynamics Corp.'s F-111A supersonic fighter-bomber. Autonetics and its subcontractors will share as much as $200 million in this program [Electronics, July 11, p. 139]. A $38.9-million contract for the development of this system was awarded to Autonetics, and the first units will be delivered in less than three years.

Subcontractors to Autonetics include Texas Instruments Incorporated, for terrain-following radar; Canadian Marconic Co., for the doppler navigator; Norden for displays; the Kearfott Systems division of General Precision Inc., for cockpit weapons control system; ITT Gilfillan, a division of International Telephone and Telegraph Corp., for the horizontal tactical display; Federal Systems division of the International Business Machines Corp., for computers; and Autonetics itself for the inertial platform and attack radar.

IHAS. Moving along on schedule in its second year of development is the Navy's integrated helicopter avionics system (IHAS), which will go on Army, Marine and Navy rotary-wing aircraft.

A major IHAS feature is a computer with a functionally modular design that permits it to perform a variety of tasks, depending on the modules being used. The Navy controls the IHAS development, but the Army, which has an even stronger stake in helicopters, is providing 40% of the money.

The IHAS—and its prime contractor, Teledyne, Inc.—received a minor setback when the Army and Lockheed decided against using all of it in the Aafss, at least in the early models. The avionics configuration for the Aafss is still under study, but the best guess from one Army source is that little more than the IHAS ASN-74(V) computer will be used in the craft. A Navy officer close to the program, however, said he expected the total IHAS package to be used in later models of the Aafss.

The IHAS contract, which was awarded in the spring of 1965, will provide avionics initially for the CH-53A heavy assault helicopter being built by the Sikorsky Aircraft division of United Aircraft Corp., and the CH-46A medium assault helicopter, under construction by the Vertol division of the Boeing Co. Both craft will be used by the Marine Corps.

The Navy and Army both hope to get more users for the IHAS because it would lower the per unit cost by spreading the development cost over more systems and make production cheaper.

Teledyne's development contract for the IHAS is $26.7 million. The ultimate production effort may exceed $100 million in value, but no firm estimates are available.

The Marine helicopters, which will be the first users of the IHAS equipment, will also be equipped with the Lohap system that the government will furnish to Teledyne for integration and installation. Subcontractors to Teledyne for the actual IHAS equipment will include LFE Electronics, for horizontal tactical display; Norden for forward-looking terrain-following radar; TRG, Inc. for the station keeping radar; and Canadian Marconic Co. for the doppler navigator.

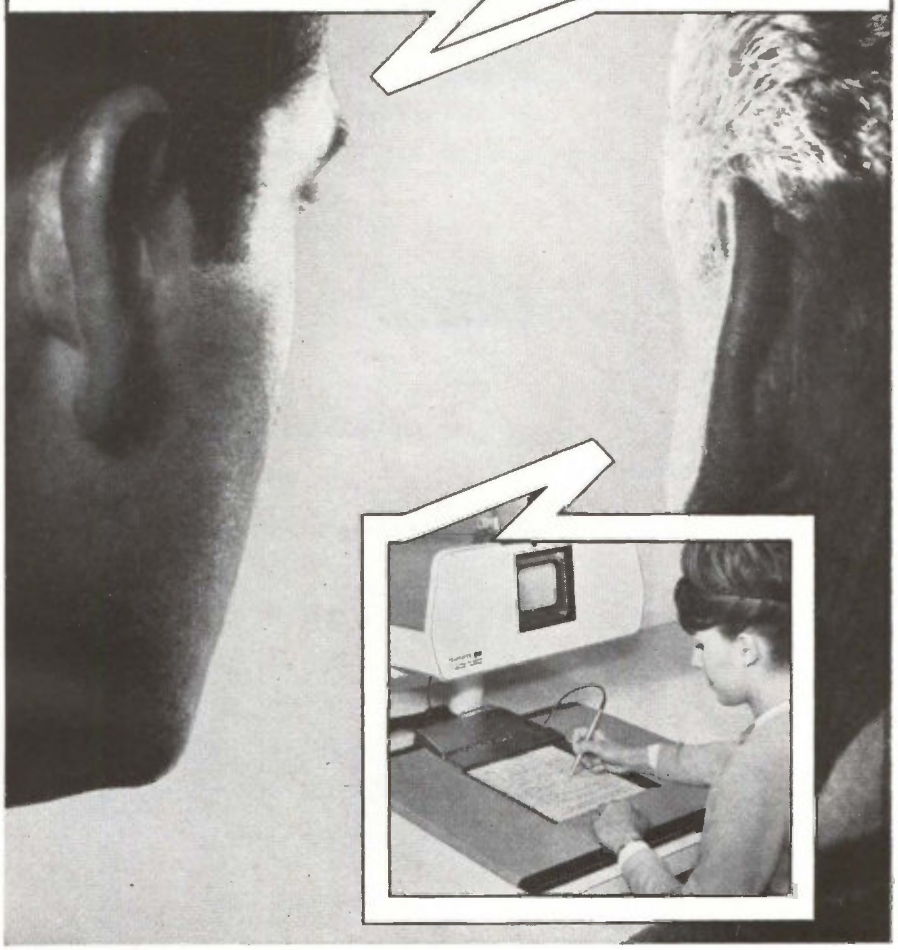
III. A hybrid

For Aafss, a helicopter with wings, Lockheed is combining the central computer from the IHAS, adding the Lohap integrated communications system and installing other subsystems as a part of the total aircraft contract. Lockheed won this contract last spring. The prototype will be tested late next year.

Aafss, which has been having its own cost-justification troubles, is also involved in an interservice struggle—Army versus Air Force. The dispute is over what the Pentagon terms "roles and missions."

In a roles and missions agreement last April, the services decided generally that the Army was to be given the responsibility for owning and operating rotary-wing aircraft and the Air Force for fixed wing planes. The Aafss, which has both rotary wings and fixed wings, then came along and confused the issue. Betting in the Pentagon is on biservice use of the helicopter.

Lohap. Sylvania will begin delivery of the light observation heli-



copter avionics package (Lohap) in late 1968 for installation on Hughes Aircraft Co.'s OV-6A.

Sylvania expects Lohap to bring in up to $60 million in business over the next few years. The present contract calls for 1,825 of the units under a development-initial production award of $16.1 million.

Except for the identification-friend-or-foe unit which will be furnished by the government, Sylvania is building all the major subsystems.

Lohap for airborne relay. The OH-6A, a light observation helicopter, is designed primarily for light tactical transportation use and visual battlefield surveillance. Ordnance delivery systems may be added, but it is unlikely that they will require electronics.

One of the most significant missions of the craft may turn out to be its use as an airborne radio relay station. In addition to three transceivers, which can be installed on the OH-6A, the craft is equipped with a vhf/f-m auxiliary receiver for voice and data reception and a C-6533/ARC communications control unit for switching control. This permits the Lohap system to receive and retransmit voice and data signals, acting as an aerial relay to increase the range of line-of-sight ground equipment.

At least two of the three transceivers in the system will be in each OH-6A. The AN/ARC-114 vhf/fm transceiver and the R-1297/ARC vhf/f-m auxiliary receiver both operate at 30 to 76 megahertz. The AN/ARC-115 vhf/a-m transceiver operates at 116-150 Mhz and the AN/ARC-116 uhf/a-m transceiver is set at 225-400-Mhz.

The mix of transceivers and receivers gives the Lohap system a compatability with all other aircraft, including high performance fighters; with ground troops using units such as the AN/PRC-25-9 or -10; with vehicular sets such as the jeep mounted AN/VRC-25 or -54; and with large transportable units like the AN/TRC-87.

The Lohap, roughly one-third as heavy as the equipment it is replacing, is all solid state and offers complete modularity while being designed for maximum commonality.

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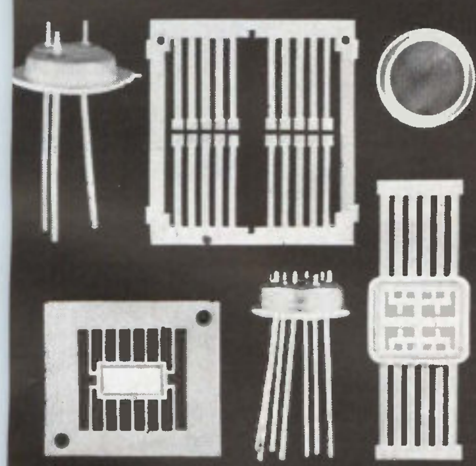

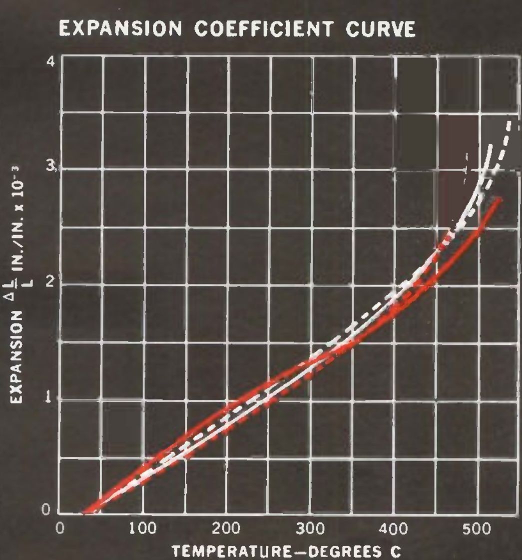

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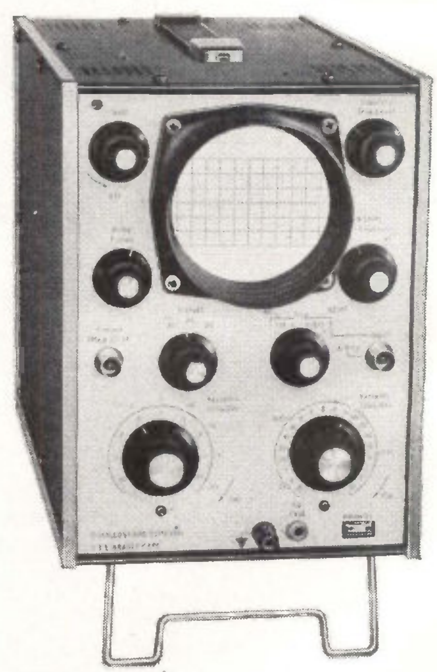

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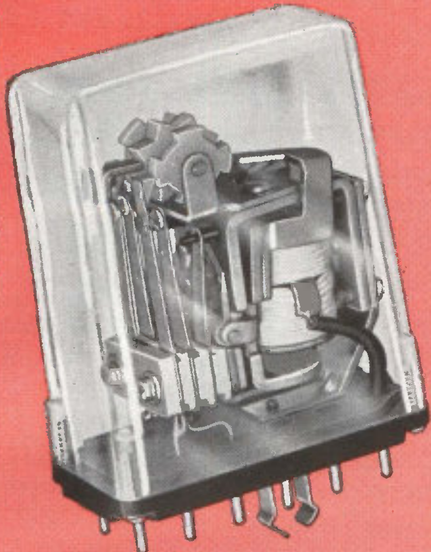

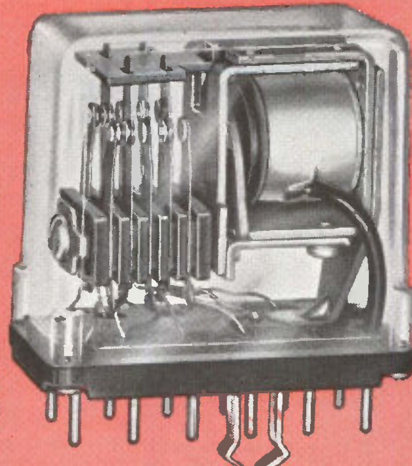

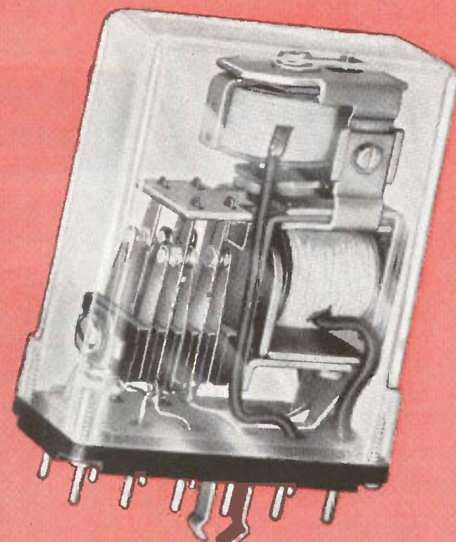

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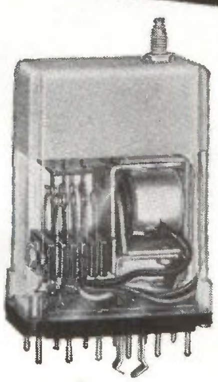

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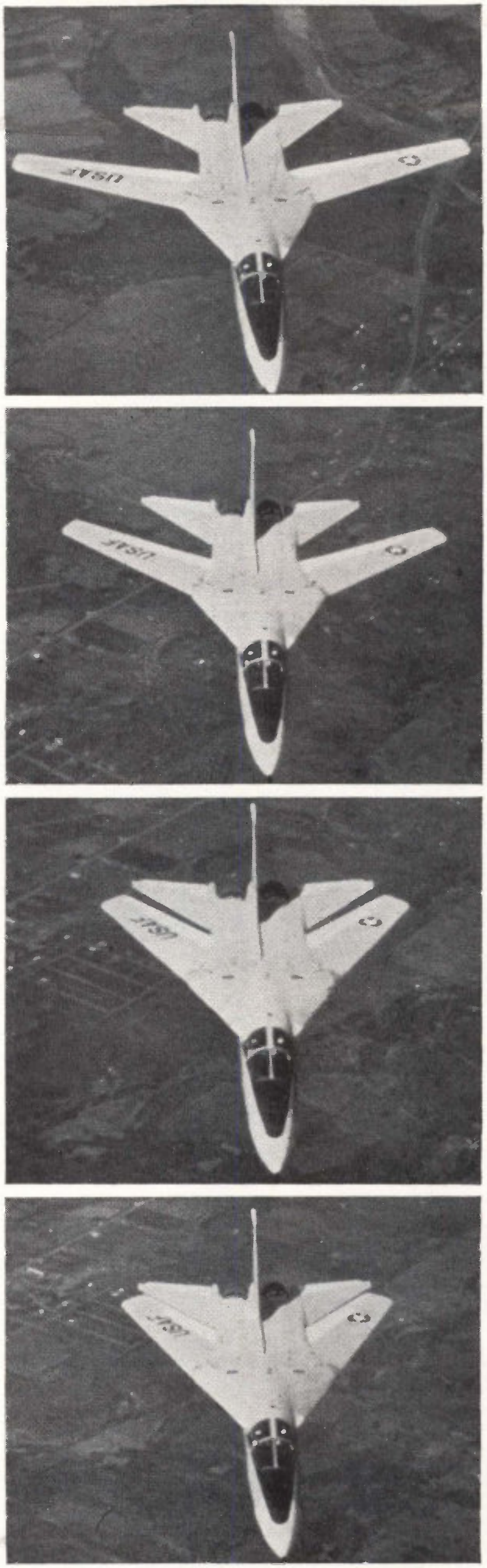

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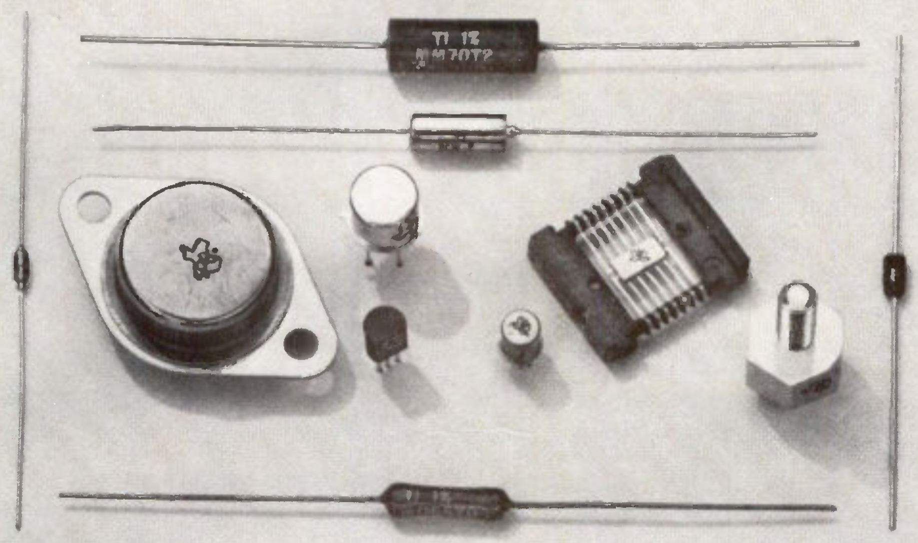

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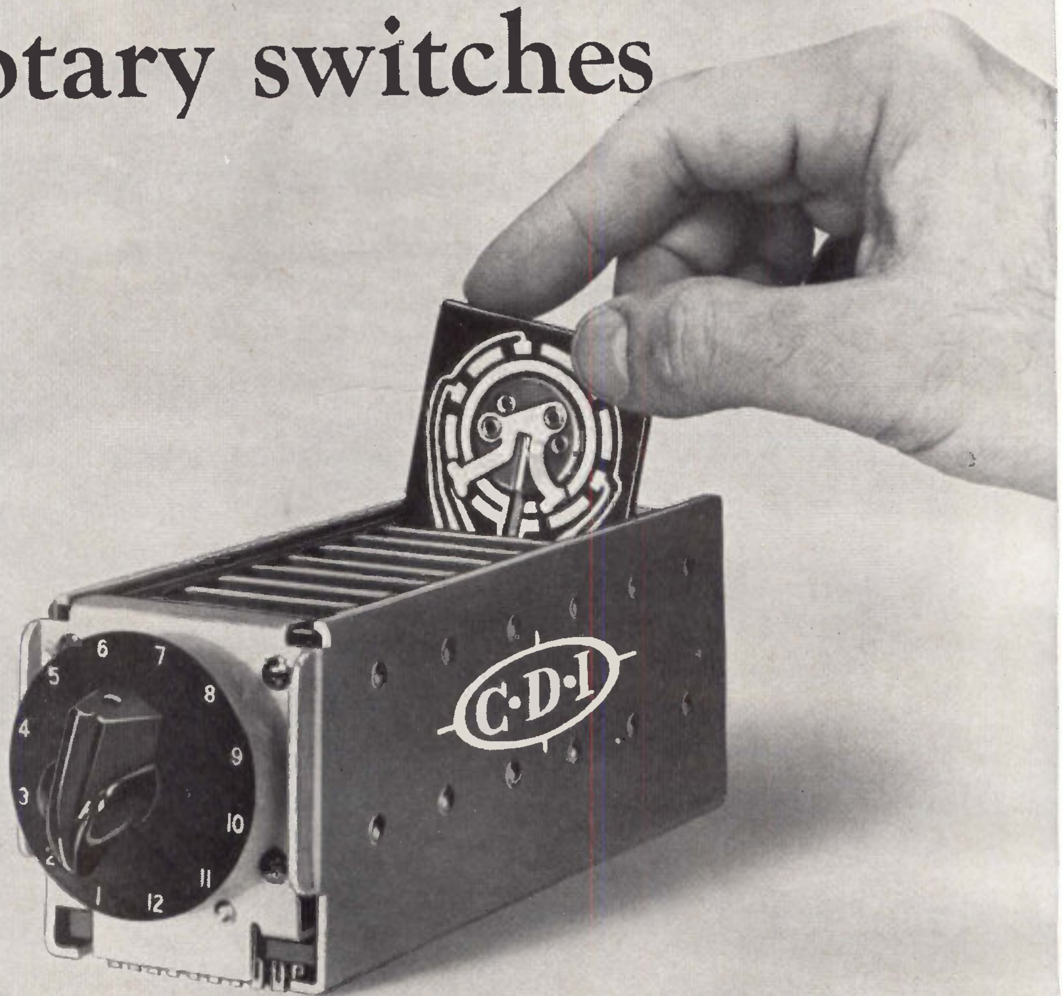

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Northern's Industrial Catalog can locate a source for most any part or assembly. It is a unique find-it-in-a-hurry service of Northern Natural Gas Company that will quickly locate reliable suppliers, sub-contractors and sources for parts, components and sub-assemblies made to your exact specifications. In technical terms, the Northern Plains Industrial Catalog is a computerized compilation of all industrial fabricators in the Northern Plains area—Iowa, Kansas, Minnesota, Nebraska, South Dakota and western Wisconsin. It's the source of information that can tell you where to buy wisely, profitably and quickly. And the service is free. So if you're interested in electronic components, plastics, short run stampings, motors, precision machined parts, instruments, die castings or whatever, fill out the coupon. You'll receive complete information. And if you attach a sketch or specifications of your required components, Northern Natural Gas will send you a specially compiled list of qualified producers.

INDUSTRIAL CATALOG
Area Development Dept. K-2
Northern Natural Gas Co., Omaha, Nebr. 68101

Northern Natural Gas Company

Dear Sirs: Please send Sources of Supply information on: ______________

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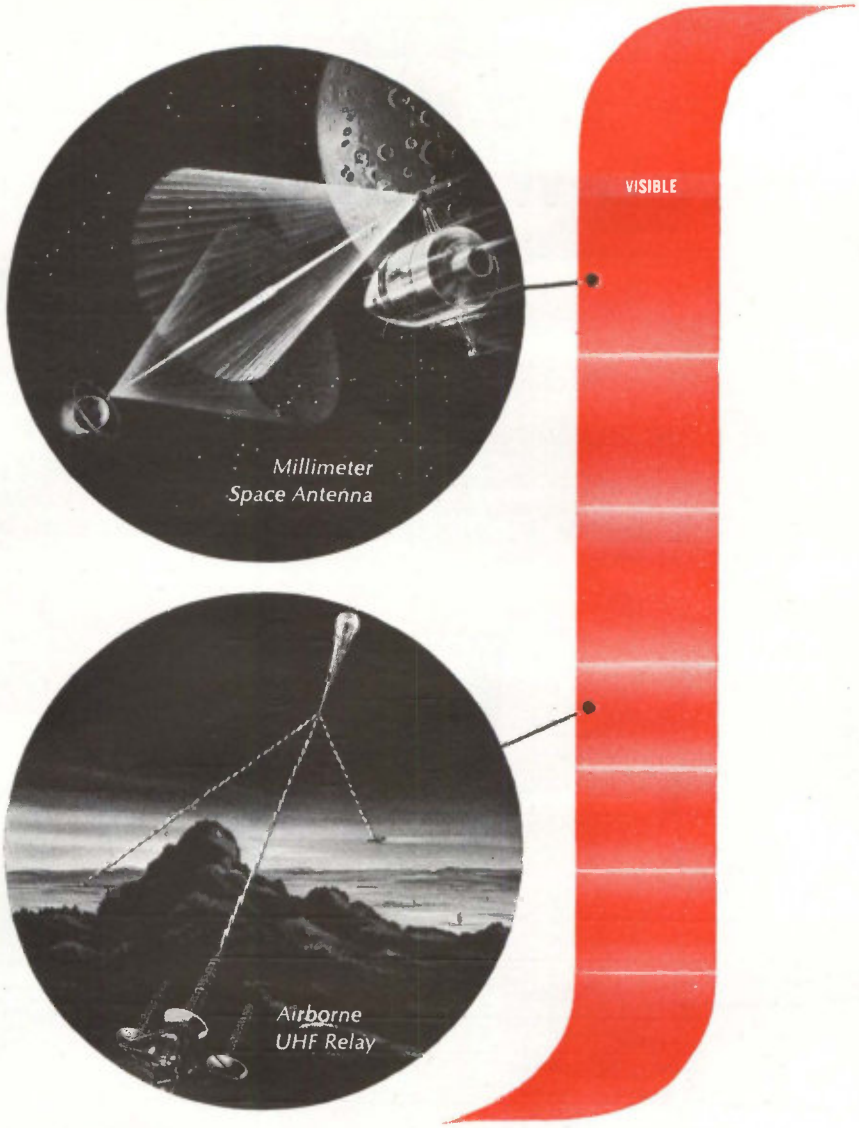

HIGHER AND HIGHER

AIRBORNE UHF RELAYS AND MILLIMETER SPACE ANTENNAS IN THE COMPLETE COMMUNICATIONS SPECTRUM

Recent developments at Sylvania Electronic Systems:

■ Seizing the high ground in tactical UHF radio communications, Sylvania Electronic Systems has demonstrated a UHF relay that is rugged, compact and reliable enough to be borne aloft by a balloon or drone aircraft. With this airborne repeater our Armed Forces can achieve full two-way voice and teletype communications over 500-mile ranges even in the jungles and mountains of Viet Nam.

■ Higher still, orbiting spacecraft must find each other swiftly and communicate enormous amounts of data. Sylvania Electronic Systems has produced a millimeter wave antenna system that will pinpoint another satellite antenna in less than a second. With 10 times the information-handling capacity of conventional lower-frequency systems, millimeter waves meet the needs of space communications.

To meet communications needs from jungle to orbit, Sylvania Electronic Systems is seeking technical and management specialists across the full spectrum of research, development, production and testing. Major centers are in suburban **Boston, Buffalo,** and **San Francisco.** If you are a qualified candidate and would like to receive more specific information on the engineering opportunities, send your resume to: Manager, Professional Staffing, Sylvania Electronic Systems, Division of Sylvania Electric Products Inc., 57 Sylvan Road, Waltham, Mass. 02154.

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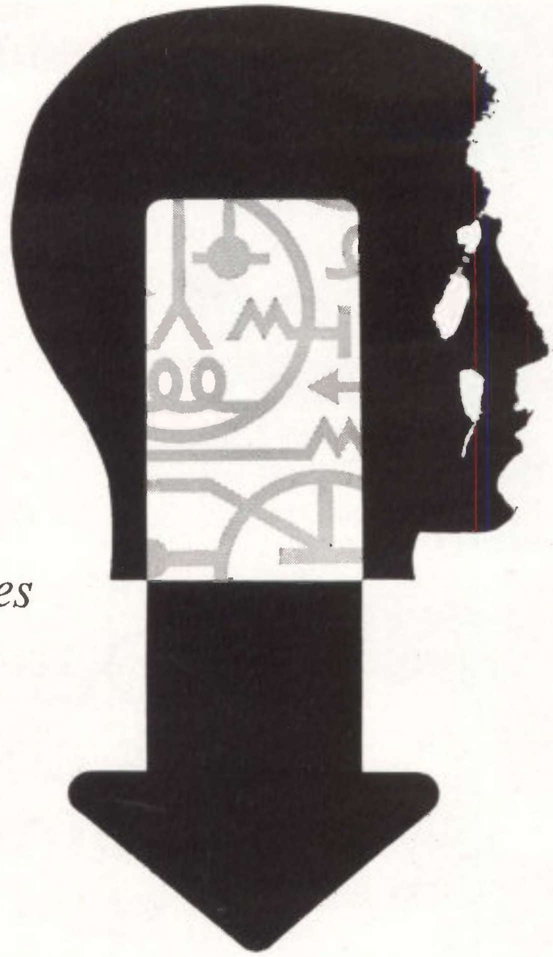
Write: Winchester Electronics, Main St. & Hillside Ave., Oakville, Conn.



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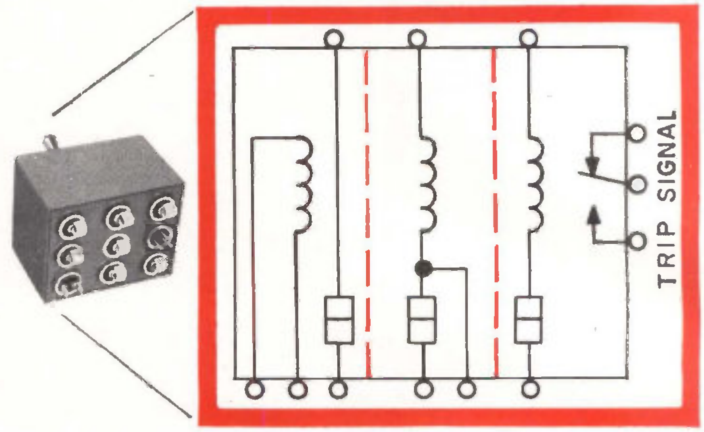
CIRCUIT CONTROL AND PROTECTION BY AIRPAX

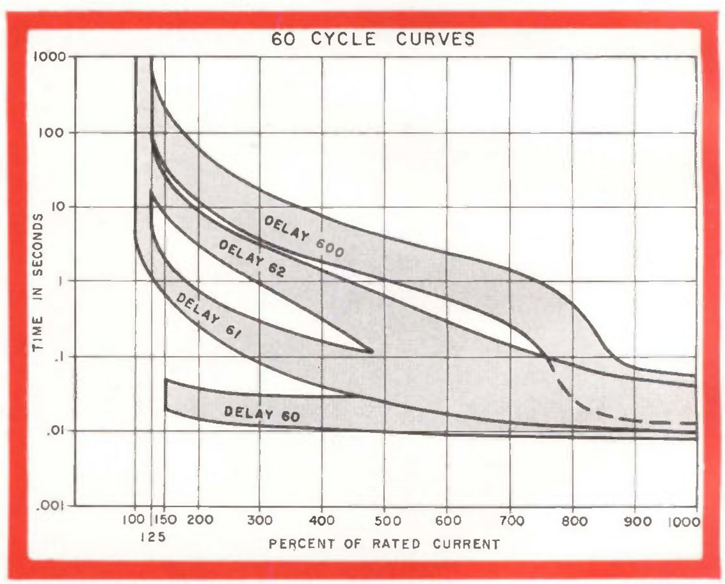
style AP

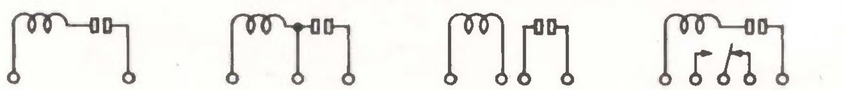
Style AP is all magnetic trip, hermetically sealed, meets MIL-C-39019, available 1, 2 or 3 pole, 10 ma to 20 amperes AC or DC, interrupts 1000 ampere fault at 240 volts AC.



style 50-APL

Style 50-APL is entirely magnetic trip (no heating elements), available 1, 2, 3, 4 and up to 10 poles, 10 ma to 50 amperes AC or DC, will open a 5000 ampere fault at 240 volts AC.





Completely magnetic circuit breakers depend on current only trip. Any coil or combination within listed ranges can be supplied for immediate delivery.

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AIRPAX ELECTRONICS incorporated Cambridge Division, Cambridge, Maryland

Flutter meter replaces six instruments

Device checks on mechanical performance of magnetic tape transports by detecting small variations in tape speeds

As a designer of telemetry systems, Victor A. Ratner often complained about the procedures available for testing wideband tape recorders (1 megahertz and above). He found the test equipment and methods obsolete and criticized the lack of standardization in recorder specifications. As a user he could do little more than complain. But now, as president of the Video Research Corp., Ratner has done something to help end a situation he claims "is impeding the progress of telemetry and its applications" [Electronics, Jan. 25, 1965, p. 90].

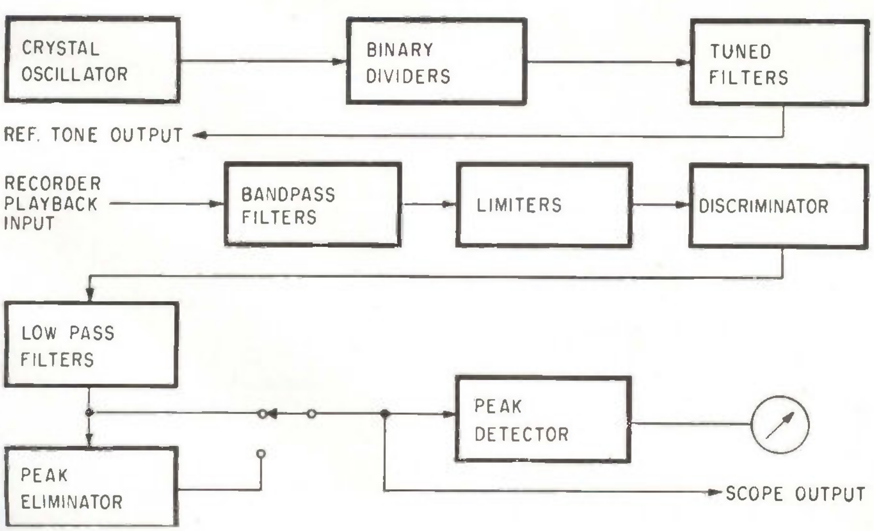
His new company's first commercial product measures tape recorder flutter and replaces the half-dozen separate instruments usually required to make the same measurement. Furthermore, Ratner says, "it is the first flutter meter on the market to operate to the new Inter-Range Instrumentation Group (IRIG) flutter standard 106-66."

Video Research's model VR-3 flutter meter is a self-contained instrument to the point of having its own crystal controlled reference generator. Flutter values as high as 5% can be read directly on the

instrument's dual range peak reading panel meter or observed on an oscilloscope. The instrument can make flutter measurements at all standard tape recorder speeds from 1⅞ to 120 inches per second. A peak eliminator circuit removes output transients caused by tape dropouts and 60 decibels of limiting suppresses amplitude variation effects. The instrument's bandwidth and filter characteristics comply with the recently revised IRIG standard at the seven standard tape speeds.

Accurate measurement of flutter is important. Many consider it the parameter which most comprehensively describes the mechanical performance of a magnetic tape transport. Much effort in the design and manufacture of all types of tape recorders is directed toward minimizing flutter. The flutter specification is often used to compare competing machines and as a precise field check for mechanical wear or improper adjustment. In addition to implementing the new standard techniques, the VR-3 simplifies flutter measurements since it eliminates the need for operator adjustments and calibration. The new instrument also can be battery operated for field use.

The crystal reference generator output is fed to binary dividers where the reference tone frequency is selected. The reference tone frequency varies from 3.13 khz for a speed of 1⅞ inches per second to 100 khz for the 120 ips speed. The tone stability is within 0.01%. The reference is recorded on the tape recorder under test. During playback, flutter, which is directly proportional to short-term speed errors in the tape transport mechanism, shows up as a deviation from the applied reference frequency. A very sensitive discriminator in the instrument detects frequency deviations and an output is provided which can be displayed on an oscilloscope, chart recorder or the panel meter. With a scope, the panel meter eliminates human error from comparative tests by indicating the presence of spikes which often go unnoticed with long sweep periods.



Specifications

Reference frequency	3.13 to 100 khz
Reference output level	1 v peak to peak
Reference output impedance	75 ohms
Recorder playback input level	1 v peak to peak
Recorder playback input impedance	10,000 ohms
Meter ranges	0 to 5% full scale or 0 to 0.5% full scale
Price	$1,750

Video Research Corp., P.O. Box 1428, Rockville, Md. 20850
Circle **350** on reader service card.

Time delay relays offer instant recycle

Time delay relays feature instantaneous return time and accurate recycling periods. This is obtained by utilizing both the heating and cooling time of a thermal element.

The relay has a drop-out time of only 5 msec and may be immediately reoperated with virtually 100% rated time-delay period. Heater resistance appears only during the first third of the timing cycle, while the relay coil is energized for the balance of the delay time.

The units are miniature, voltage and temperature compensated, hermetically sealed and the series MTRH8 conforms to the applicable portions of MIL-R-5757C and MIL-R-19648. The operating delay range is 15 to 300 seconds; voltage range, 24 to 29 v d-c; and vibration, 10 to 2,000 hz at 15 g.
Relay Specialties, 3 Godwin Ave., P.O. Box 223, Fair Lawn, N.J., 07410. **[351]**

Sensing relay responds rapidly

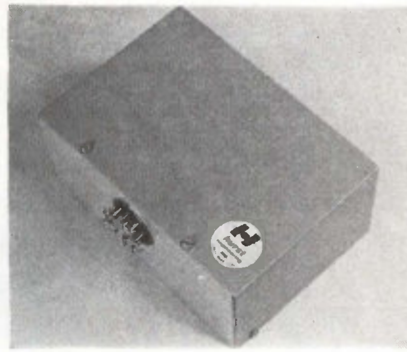
An over-and-under frequency and voltage sensing relay provides rapid response times and protects sensitive electronic equipment from damage by current variations. The compact is particularly suitable for portable power supply systems.

The HFVSR series is available in 60 or 400 hz models. A 20% change out of current specifications will effect relay action in 60 msec on 60 hz operation; 40 msec on 400 hz.

Typical 3-phase sensing provides a frequency drop-out maximum of 57 and 63 hz ±1 on 60 hz; 380 and 420 hz on 400 hz operation. Frequency pull-in maximum is 58 and 62 hz ±1 on 60 hz; 385 and 415 hz on 400 hz operation. Voltage drop-out maximum is 100 and 130 v for both models; voltage pull-in maximum, 105 and 125 v for both models. Sensing can be adjusted to meet specific requirements.

Environmental specifications include an ambient temperature range of −40° to +65° C, 50 g shock for 11 msec and greater than 50,000 cycles of life.

Power requirements are 5 w max-

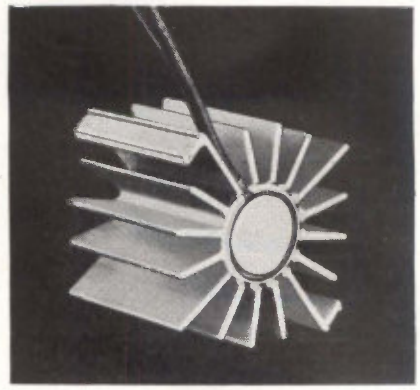


imum; dielectric strength, 1,000 v rms at 60 hz; insulation resistance, 100 megohms minimum. The relay meets requirements of MIL-R-5757.
Hurst Engineering, Inc., 851 18th St., Costa Mesa, Calif., 92627. **[352]**

Resistor design dissipates heat

A wire-wound resistor dissipates heat, reduces temperature coefficient and maintains stable resistance values via the heat-sink principle. The Mighty-Mite design consists of a wire-wound resistor on a ceramic core. This element is solidly embedded in a finned radiator that amplifies more than 10 times the conduction area of the tubular resistor surface to air convection currents. Various lengths of finned radiators are available to comply with space limitations or

New Components



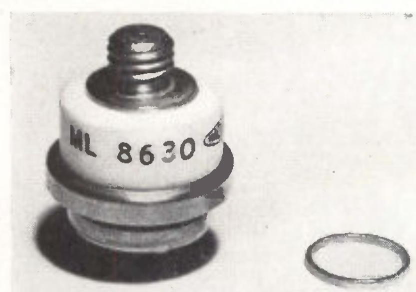
convection cooling requirements of the application. They can also be furnished with forced draft cooling.

The units are intended for high wattage applications such as a dimming or motor control for smooth acceleration of loads or speed regulation.

Mighty-Mite resistors are standardized in design elements to provide a wide range of operating values. The ceramic core is wound with suitable quality wire for the voltage input and circuit resistance value desired.

Thermal Engineering & Design Co., 217 Ash St., Akron, Ohio. [353]

Planar triode enables compact system design



Gold-plating planar triode tubes are helping to reduce size for distance measuring equipment and transponder devices in air traffic control systems. The unit has a thin coating of 24K gold on all exposed metallic surfaces. This permits easy solderizing of connections of the tube to the associated circuit components inside the equipment, thus enabling the design of more compact control units

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- ☐ PA 7600: Extremely high gain bandwidth (9000 MHz).
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for planes and airports.

Inside the 8600 series tube, a microscopically thin gold coating on the 0.0008-in. diameter tungsten wire grid, spaced with more than 150 turns per inch, suppresses electron emission from the grid, which operates at temperatures above 1,500°F without deformation and consequent tube detuning. The gold solution for electroplating the surface and inside grid of the tubes was developed by Engelhard Industries, Inc.

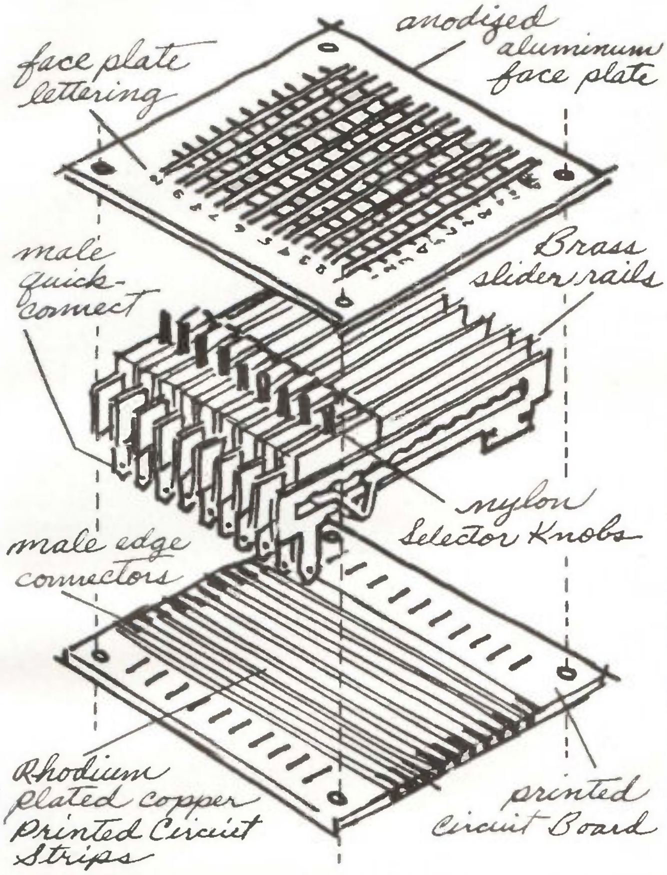
The Machlett Laboratories, Inc., Springdale, Conn., 06879. [354]

Hermetically sealed quartz crystals

A series of Koldweld quartz crystal units for frequency control show extremely low aging rates. Each crystal is hermetically sealed in a pure nickel can with a nickel-plated copper-clad Kovar base. The units are available in volume quantities. The Koldweld process eliminates contaminants from the can's atmosphere, prevents the crystal frequency shift sometimes caused by the heat and flux of solder seals and provides units that are ultra-stable. The container's design meets tentative military specifications for the HC-33/U holder and is supplied either in an evacuated condition or with an atmosphere of dry nitrogen or other inert gas.

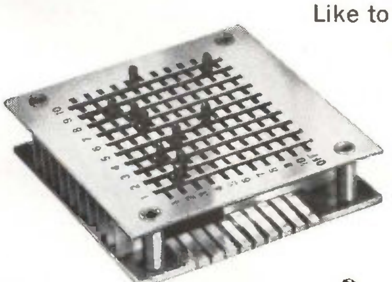
The crystal units meet or exceed the most stringent military specifications. Preliminary studies indicate aging of less than 3×10^{-8}/week

this will explode all your old ideas about programming devices..



NEW CHERRY SELECTOR SWITCH CONNECTS ANY ONE OF 48 INPUT CIRCUITS TO ANY ONE OF 58 OUTPUT CIRCUITS—to program practically *any* device. And it does it *without* costly time-consuming soldering or slow, involved assembly work—and with complete visual clarity.

Like to learn more about this unusual programmer? Write today for full details on the Cherry Selector Switch.



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- Instant switching to any desired number of circuit positions!
- ideal for breadboard setups, laboratory stock, and prototype work—where rapid circuit modification may be desired.

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RCL ELECTRONICS, Inc.

General Sales Office:
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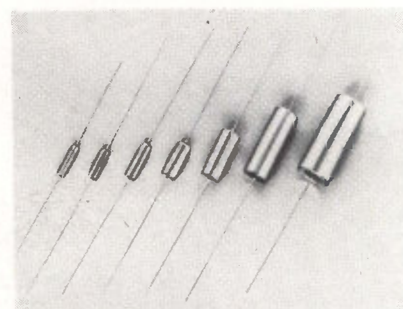
Circle 263 on reader service card

in a 75° C environment after a three-week stabilization period. Frequency ranges available are 1 to 30 Mhz for fundamental types and up to 210 Mhz for overtone types.

Delivery in volume quantities may be obtained four weeks after receipt of order.

Tedford Crystal Laboratories, Inc., 4126 Colerain Ave., Cincinnati, Ohio, 45223. [355]

Miniature capacitors sealed hermetically



A line of miniature, metallized polycarbonate capacitors is available in hermetically sealed glass-to-metal tubular metallic cases. Series 410 capacitors have been designed for applications in sophisticated circuits where extreme miniaturization and stability at high temperatures are necessary.

The capacitors are available in voltage ratings from 100 to 400 v d-c and have a dissipation factor at +25°C of less than 0.3% at 1,000 hz. No voltage derating is required over the entire operating temperature range.

The Gudeman Co., 340 West Huron St., Chicago, Ill., 60610. [356]

Wire-wound trimmer takes less space

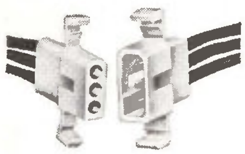
A wire-wound trimmer offers offset printed circuit pins that not only meet the requirements of military style RT-11 but also offer a 30% space saving and are interchangeable with standard RT-11 size units. The trimmer is a thin-

NEW MINIATURE

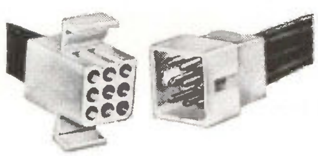
NYLON CONNECTORS

Up to 15 circuit capacity with these low-cost, miniature nylon connectors! Contacts automatically crimped to leads, then securely snap-lock into the housings. Positive polarity prevents misconnections and integral mounting ears provide easy panel installation.

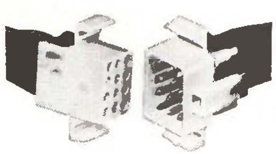
Model 1625-3
Compact three circuit unit for independent circuit isolation.



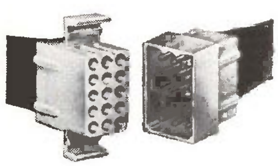
Model 1625-9
Nine circuit connections for fast, multiple circuit wiring.



Model 1625-12
Twelve independent circuits are povided with this unit.



Model 1625-15
Up to 15 separate circuits in this space saving connector.



Write for complete specifications and samples on any of these connectors.

MOLEX® PRODUCTS COMPANY
5241 Katrine Avenue
Downers Grove, Illinois 60515
(312) 969-4550 TWX 910- 695-3533

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Circle 523 on reader service card

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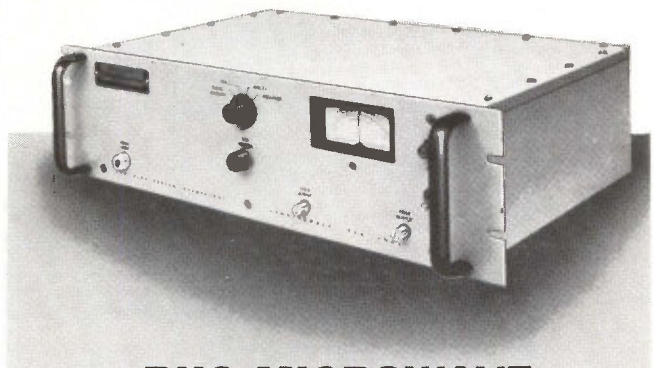

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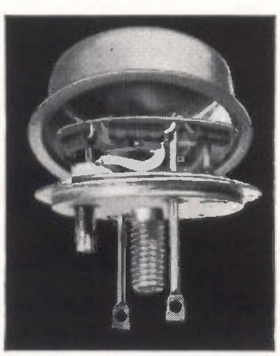
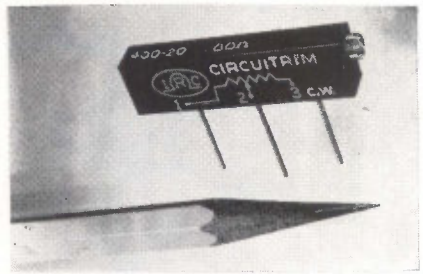


This is the super/reg® synthesized zener diode.

New Components



line version of military style RT-11 and meets requirements of MIL-R-1 27208. The moisture-sealed diallyl phthalate case measures only 0.190 in. wide.

This latest version of the company's wire-wound rectangular trimmer, type 400-20, is available in resistance values from 10 to 50,-000 ohms, ±5% tolerance. They are rated at 1.0 w at 70°C.

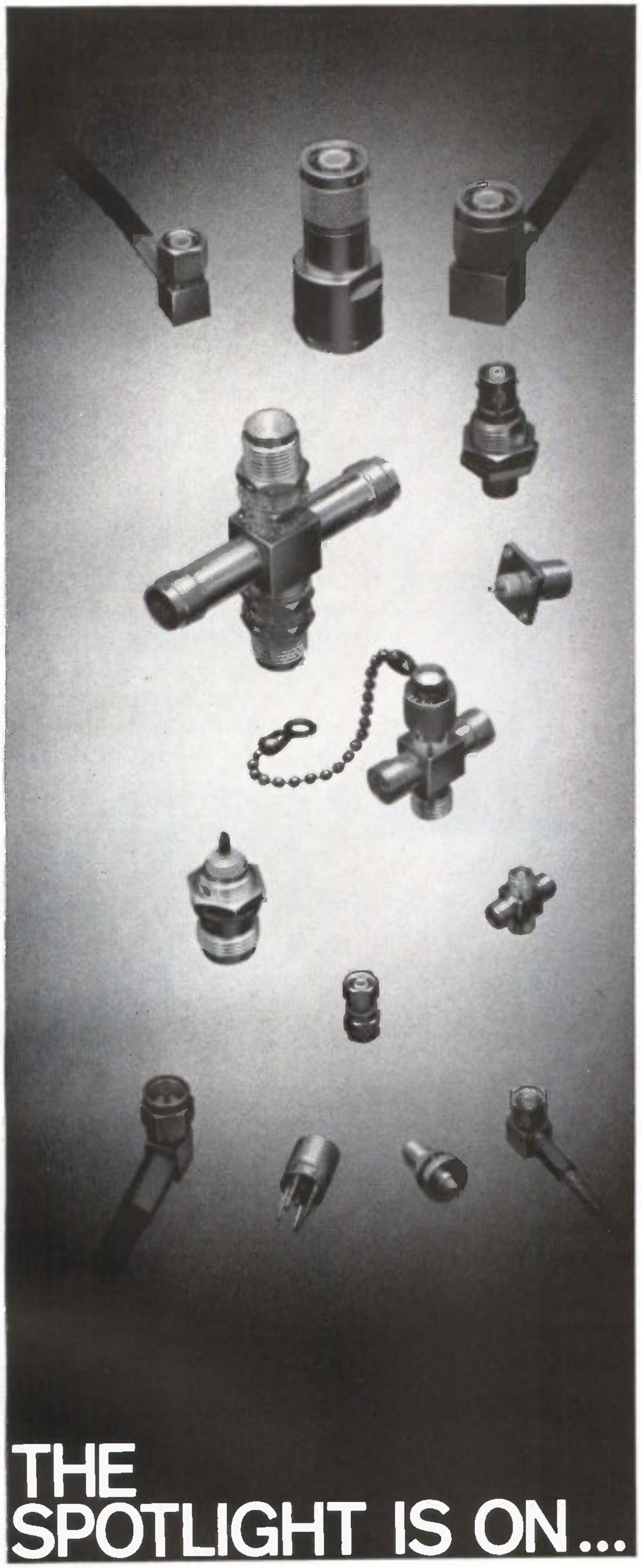
Units require 4 weeks for delivery. Price is $3.56 each in lots of 100.

IRC, Inc., 401 N. Broad St., Philadelphia, Pa., 19108. **[357]**

Tiny adjustment pot is rated 0.2 w at 25°C

The single-turn model 3317, said to be the smallest adjustment potentiometer available, may be obtained in two versions—3317-P for top adjustment and 3317-W for side adjustment.

The unit, in a lightweight all-plastic case, has a resistance range of 20 to 5,000 ohms, a power rating of 0.2 w at 25°C, and an operating temperature range of −55° to +105°C. It measures 3/16 in. x 0.105 in. Other specifications include a resistance tolerance of ±10% standard; vibration, 10 g; shock, 20 g; humidity, MIL-STD-



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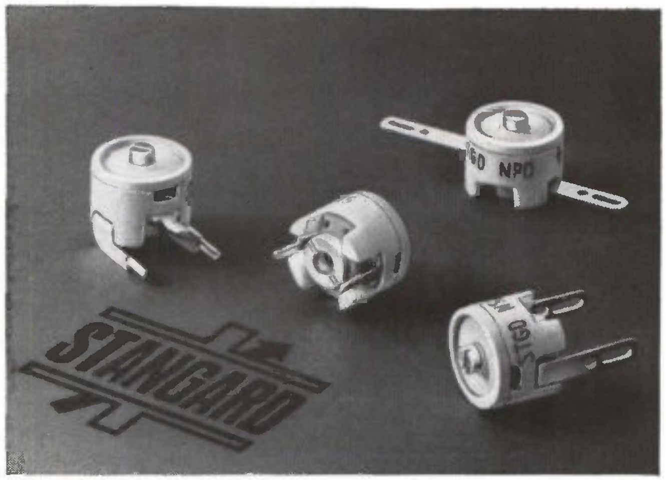
Circle 524 on reader service card

Announcing new low-cost Ceramic Disc Variable Capacitors



Capacitors shown enlarged 50%

JFD Stangard DVC Capacitors

These new Stangard variable ceramic disc capacitors represent an optimum balance of high quality and low cost for commercial and industrial applications.

Eight wide Δ C ranges, each available in 4 versatile mounting configurations, offer high Q and excellent stability in applications such as test equipment, communications equipment, low power transmitters, filters, delay lines, broadcast and television receivers, and other devices requiring adjustable capacitors.

Stangard DVC's offer a unique feature... easy adjustment . . . from either top or bottom. These 3/8" diameter ceramic disc Stangard capacitors meet or exceed the applicable specifications of MIL-C-81.

Write for Bulletin STD-65.

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Circle 267 on reader service card

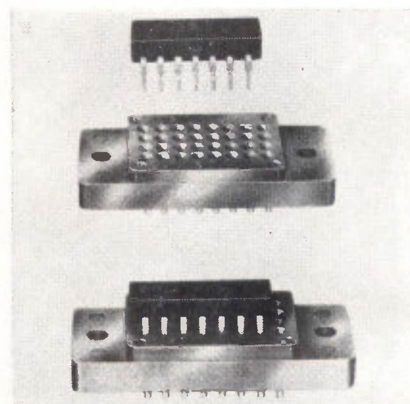
202B, Method 103; weight, approximately 0.08 gram.

Multiple wire welded terminations and flat leads are designed to improve soldering and welding. Stops are provided at each end of travel.

Price is $2.64 each in 100-to 249-piece quantities; delivery, stock to 3 weeks.

Bourns, Inc., Trimpot division, 1200 Columbia Ave., Riverside, Calif., 92507. **[358]**

IC sockets mount in-line packages



All standard in-line circuit packages incorporating 14 to 32 pins can be accommodated by the Cambion series 3792-3799 integrated-circuit sockets. Socket jacks feature cage or flat spring inserts fabricated from beryllium copper and heat treated for long-term electrical contact reliability. Long life is ensured by gold plating on all jack housings and inserts.

Jacks with cage inserts accept pins of 0.020-in. diameter. Jacks with flat ribbon inserts accept all standard flat in-line pins. With either jack style, there is a selection of external configurations. Solder terminal, solder pot, Wire-Wrap or pin/plug terminals may be specified. Nonrotation flats on all jacks ensure uniform positioning in the two-piece molded diallyl socket body. The holder body can be permanently mounted to a circuit board by machine screws and nuts.

The sockets are available from

stock and are priced from $2.60 in quantities of 50 to 99.
Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass., 02138. **[359]**

Image-orthicon tubes for tv broadcasting

The 8673 and 8674 image-orthicon tubes have been designed for high-quality color and black-and-white tv broadcast cameras. The manufacturer reports that both tubes show exceptional stability of sensitivity and resolution capability during extended life and improved electron-optical performance. The tubes have a new high-sensitivity photocathode. The redesigned image section in the tubes reduces distortion and eliminates ghosts, permitting a more closely matched set of three tubes in the color cameras.

The photocathode used in the tubes is a bialkali combination with an efficiency high enough to eliminate the need for an S11 tube in a color trio. Since the bialkali cathode is used in each channel, the transfer characteristics of the three channels may be very closely matched.

The new image section and the new photocathode are combined with a nonstick glass target, field mesh, precision construction, proven electron gun and dynode assembly. Construction of the tubes differs only in the spacing of the mesh from the target. The 8673 has a target-to-mesh capacitance of about 200 pf and so optimizes the signal-to-noise ratio to give quality performance where illumination is sufficient. The 8674 has a target-to-mesh capacitance of about 100 pf and a correspondingly greater sensitivity for use in applications where illumination is limited.

Both tubes are warranted for 1,200 hours.

Mated versions of the 8673 and 8674 image orthicons, for use in color signal transmission have been designated 8673/S and 8674/S.
RCA Electronic Components and Devices, Harrison, N.J. 07029. **[360]**

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Servo components are not all alike, in spite of the fact that international standards dictate identical external appearance. The difference is in the component — reliability and life expectancy — two characteristics which depend solely on quality. The Nifegon trademark symbolizes precision servo components with built-in quality.

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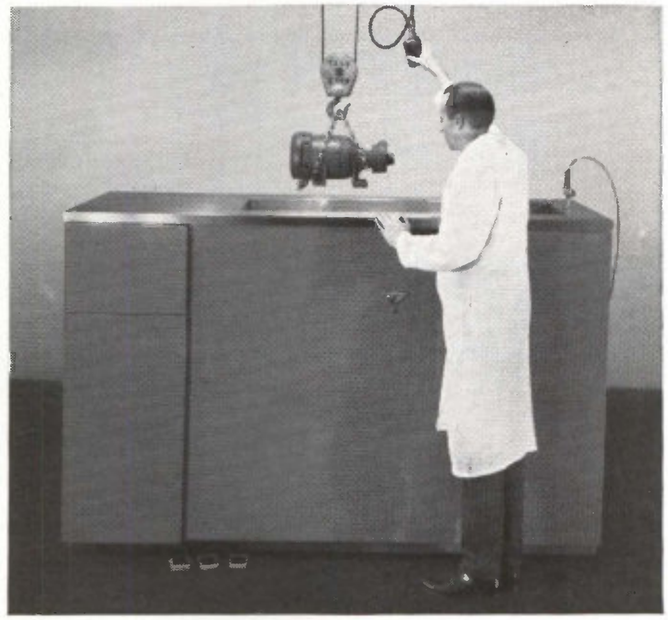
Circle 526 on reader service card

Blackstone's new vapor rinse series for big, bulky assemblies.



[like motors, for instance.]

Now get both ultrasonic scrubbing and vapor rinsing for large, hard-to-clean assemblies with this entirely new Blackstone cleaner.

Available with ultrasonic and vapor rinse tanks in sizes from 12" x 12" x 9" to 24" x 18" x 19", and designed for use with DuPont "Freon"® cleaning solvents, the Large VR features continuous filtration and two control systems. A foot switch controls ultrasonic wash, spray and rinse cycles. The photo-electric control may be used on pre-set ultrasonic cycles for repeated cleaning of like parts.

And consider these other Blackstone features:

- **Rounded-corner 316L Stainless steel tanks**—for easy maintenance and corrosion resistance.
- **Solid-state generator**—providing manual power control from 0 to 100%, a Blackstone exclusive.
- **Automatic timer control**—enabling pre-set wash, spray and rinse sequencing.
- **Vapor tank contamination indicator** (optional)—permits positive control over contamination build-up.
- **Hand-operated spray wand** (optional)—for manual spraying of the cleaned part.

Write and tell us about your cleaning problem. We'll report right back on what a Blackstone VR unit can do for you.

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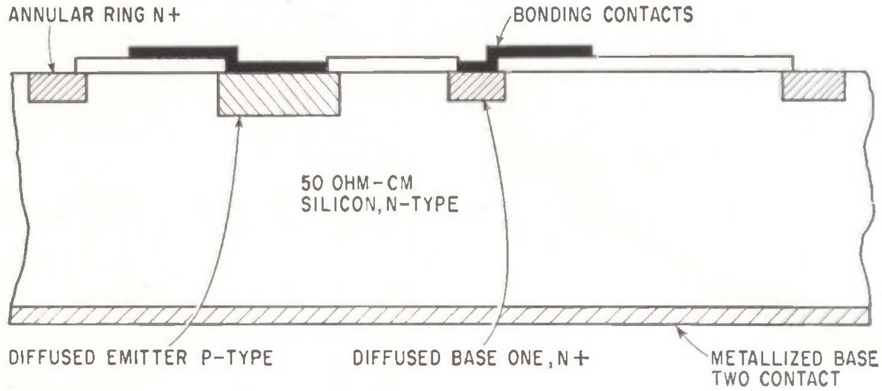
Circle 271 on reader service card

New Semiconductors

Unijunctions with Annular process



Mass production of unijunction transistors with a patented Annular process has begun at the Semiconductor Products division of Motorola, Inc. The company is producing three new types in TO-18 cans and expects to have its first plastic unijunction and an improved version of the current ones in production early next year.

Jack Haenichen, operations manager for thyristors, estimates the market for unijunctions could eventually be in the range of 10 million units annually. "A strong demand developed in the past year, and the capacity was just not there to meet it. We are still catching up —with production of 50,000-plus units a week—but we feel that by the end of the year we will have caught up with the back orders."

The market now is military and industrial, pulse, timing, sensing and thyristor trigger circuits. But Haenichen expects the less expensive plastic units to replace mechanical timers in home appliances and to be used in television oscillator circuits.

In developing a mass-production technique for the Annular process, Haenichen feels the company has made a significant breakthrough. Motorola can produce unijunctions at a lower cost than with the "tedious and costly one-at-a-time process such as the alloy cube structure method."

"We are using a batch-processing technique which allows simultaneous processing of thousands of devices," he explains. "At the same time, we get significant performance improvements. Our devices have peak current as low as 400 nanoamperes and leakage as low as 50 nanoamps."

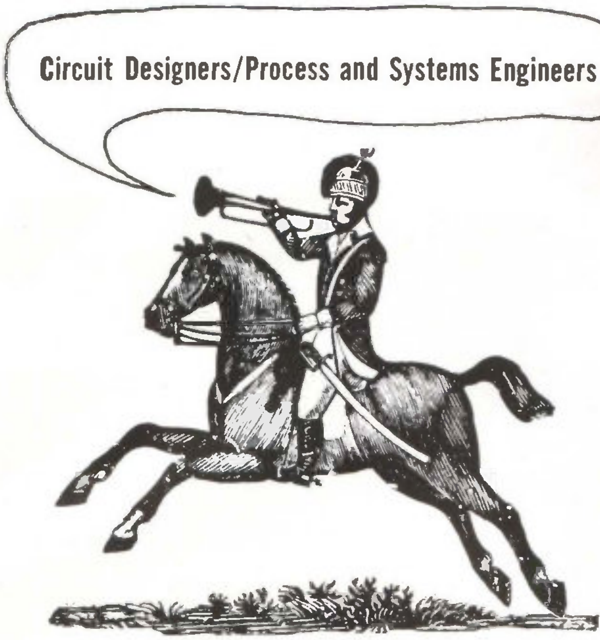
Haenichen says next year's device will better this performance by an order of magnitude. It will work at voltages under 5 volts, so it can operate in battery-powered equipment. The present devices are designed for 10 v or more; at 5 v or less, their characteristics change and they start operating as diodes.

The plastic-packaged device, also due next year, will have characteristics similar to the present types, but will cost only about 50 cents each in large quantities.

In the Annular production process, many devices are formed simultaneously on each wafer of silicon. The silicon's resistivity is 50 ohm-centimeters, about 10 times the usual value. The emitter impurity is diffused through holes etched in the oxide. The wafer is

Specifications

Model number	2N4851	2N4852	2N4853
Peak-point emitter current, max	2.0 μa	2.0 μa	0.4 μa
Emitter reverse current, max	0.10 μa	0.10 μa	0.05 μa
Frequency of oscillation, min	1 Mhz	1 Mhz	1 Mhz
Interbase resistance temperature coefficient	From 0.20%/°C to 0.80%/°C		
Instrinsic standoff ratio, max	0.74	0.85	0.85
Emitter saturation, typical	2.5v	2.5v	2.5v
Valley-point current, min	2.0 ma	4.0 ma	6.0 ma
Modulated interbase current	15 ma	15 ma	15 ma
Base-one peak pulse, min	3v	5 v	6 v
Price	$.80	$.90	$1.50



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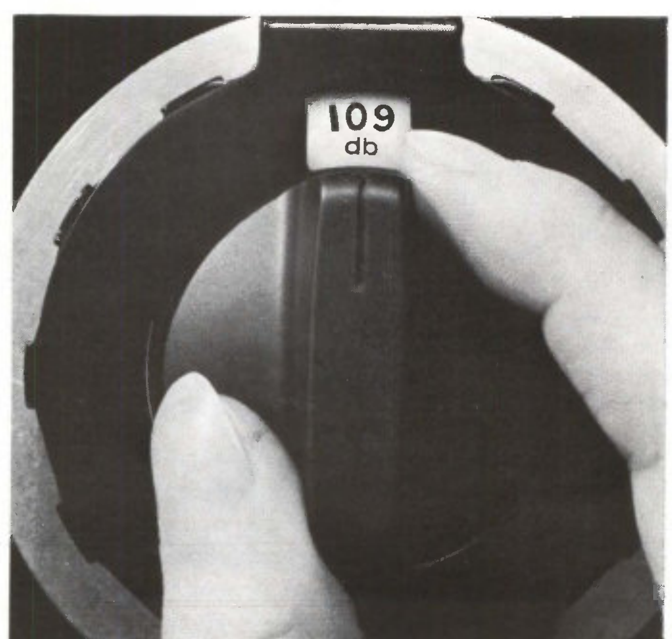
109 dB

is the upper range of a Telonic rotary attenuator that operates over a DC to 1000 MHz frequency spread, is adjustable in 1 dB steps from zero and shows the attenuation **digitally.** Internally, it is constructed with individual pi-pads and precision resistors for optimum accuracy, avoiding tolerance build-up and maintaining a constant, low insertion loss. This unit is the TA-109E. Other rotary models cover 0 to 50 dB in 10 dB steps, 0 to 10 dB in 1 dB steps, 0 to 59 dB in 1 dB steps, 0 to 1 dB in .1 dB steps and 0 to 10.9 in .1 dB steps.

But if you prefer a toggle switch type, there's the TG series in models ranging to 82.5 dB in



oxidized and etched again and the n+ annular ring and base diffusions are made [see diagram]. The wafer is oxidized and etched a third time, to allow evaporation of the aluminum contacts.

Motorola will use the same molding technique for the plastic unijunctions as it now uses for other plastic transistors.

Motorola Semiconductor Products, Inc., Box 955, Phoenix, Ariz. 85001 **[361]**

P-i-n photodiode detects extremely low light

Packaged in a miniature Kovar-ceramic package with a glass lens, the 4205 ultrafast, silicon planar p-i-n photodiode is designed for application in card and tape readers, optical encoders and similar equipment where space is at a premium. This detector also performs as a movement indicator, optical transducer or laser detector. Laser pulses of less than 0.1 nsec can be detected. A gallium-arsenide infrared light source (the 4107) is available in an identical package; the two devices form a convenient and rugged photon-coupled pair.

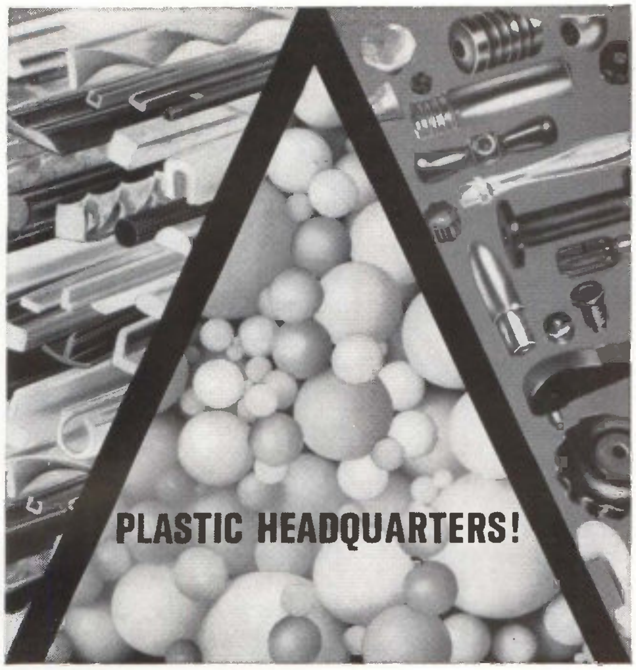
The diode's response time is less than 1 nsec. Frequency response extends from d-c to greater than 1 Ghz. Dark current is less than 150 picoamps, so extremely low light levels can be detected; and the quantum detection response is constant over six decades of light intensity.

These photodiodes are available from stock. Price is $22.50 in quantities of 1 to 9, and $19.15 from 10 to 99.

HP Associates, an affiliate of Hewlett-Packard Co., 620 Page Mill Road, Palo Alto, Calif., 94304 **[362]**

Germanium transistors offer high power gain

A germanium transistor series offers maximum efficiency because of low collector saturation voltage, low input voltage and high current gain. Highest pulse power



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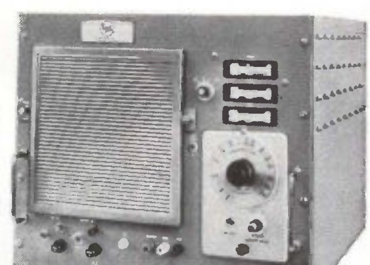

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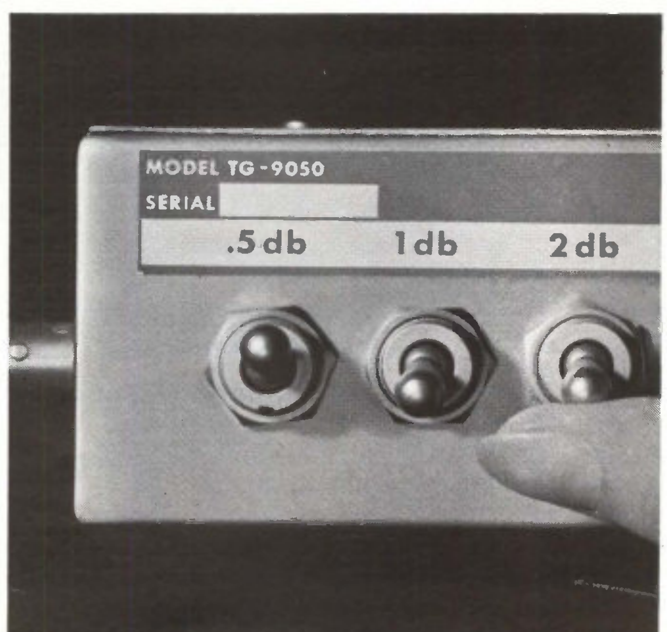
Circle 528 on reader service card

0.5 dB

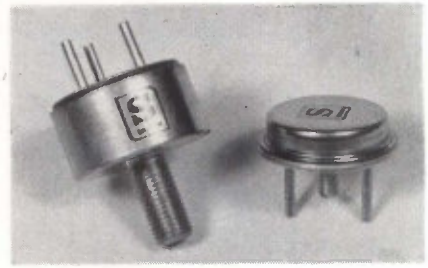
steps, and to 42 and 102 dB in 1 dB steps. To assure long life and precise repeatability these Telonic toggle switch attenuators are heavy-duty type incorporating switch controls with a double knife edge and self-wiping action. Pads are shielded, individually, to prevent leakage, and to permit maximum range. The attenuators operate to 250-300 MHz, and can be furnished in 50 or 75-ohm versions. The unit shown below is a Model TG-9050A with additive steps of .5, 1, 2, 3, 6, 10, 20, 20, and 20 dB.

If you're using these attenuators (or other RF equipment) up to



Circle 275 on reader service card

New Semiconductors



applications result from efficient emitter operation, controlled processing, and improved thermal characteristics.

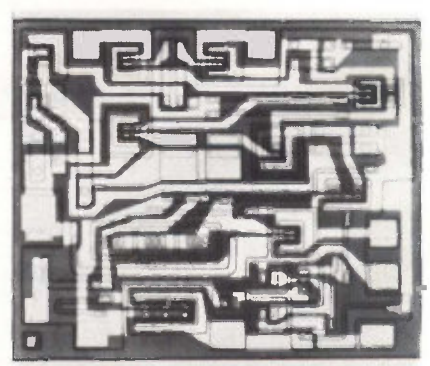
Series SDT1860 and SDT1960 are available in the industry standard TO-36 package as well as a double-ended package that offers a less restrictive hookup of large conductors. As an option, both packages come in flattened or pierced terminals, eliminating an additional terminal connector. A terminal hole size of 0.120 x 0.190 in. can be provided.

Characteristics include a collector-to-emitter saturation voltage of 0.3 v, and a beta of 20 minimum at a full 65 amps of collector current; also, collector-to-emitter voltage readings through 80 v.

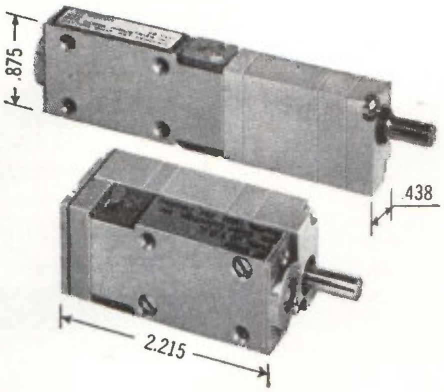
Available from factory the devices are suited for motor speed control, converters and other switching and amplifier applications.

Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. [363]

Sense amplifier with 40-nsec response



Recent improvements in integrated circuit techniques have made possible the MC1540G monolithic



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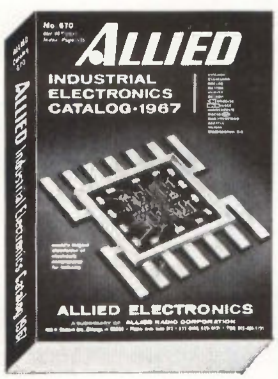

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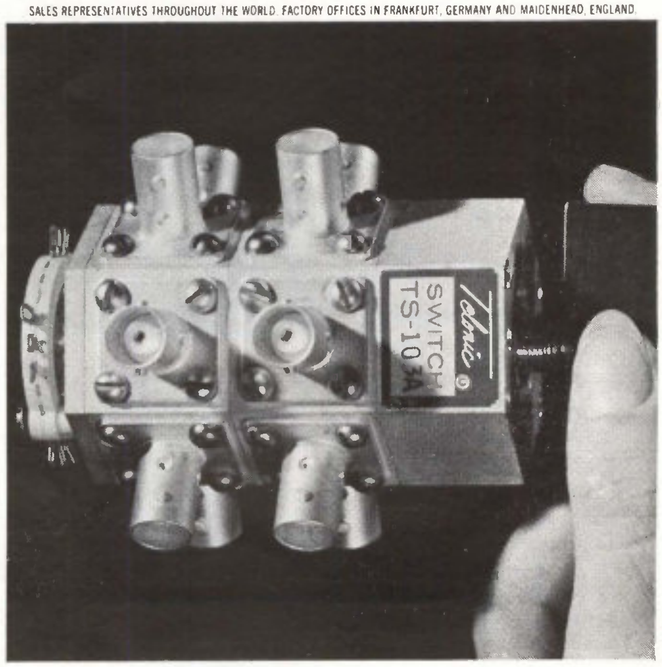


Circle 277 on reader service card

sense amplifier. These improvements allow greater gain stability with large variations in temperature, a narrow uncertainty region over a wide temperature range, a fast response time of 40 nsec plus short recovery times of 50 nsec with a 2-v common mode signal and 80 nsec with a 400-mv differential mode signal.

The MC1540G is designed to detect bipolar differential signals originating from a core memory with cycle times as low as 0.5 μsec, and to translate these signals into saturated logic output signals. It consists of a wideband, two-stage, differential amplifier, a d-c restoration circuit with facilities to externally adjust the input threshold level from 10 to 25 mv without changing the width of the transition region. When pin 6 of the 10-pin TO-5 package is held to -6 v, the nominal threshold is 17 mv.

Also included on the monolithic die is a DTL output gate which makes strobing the sense amplifier possible from any saturated logic family.

Motorola Semiconductor Products Inc., Box 955, Phoenix, Ariz., 85001. **[364]**

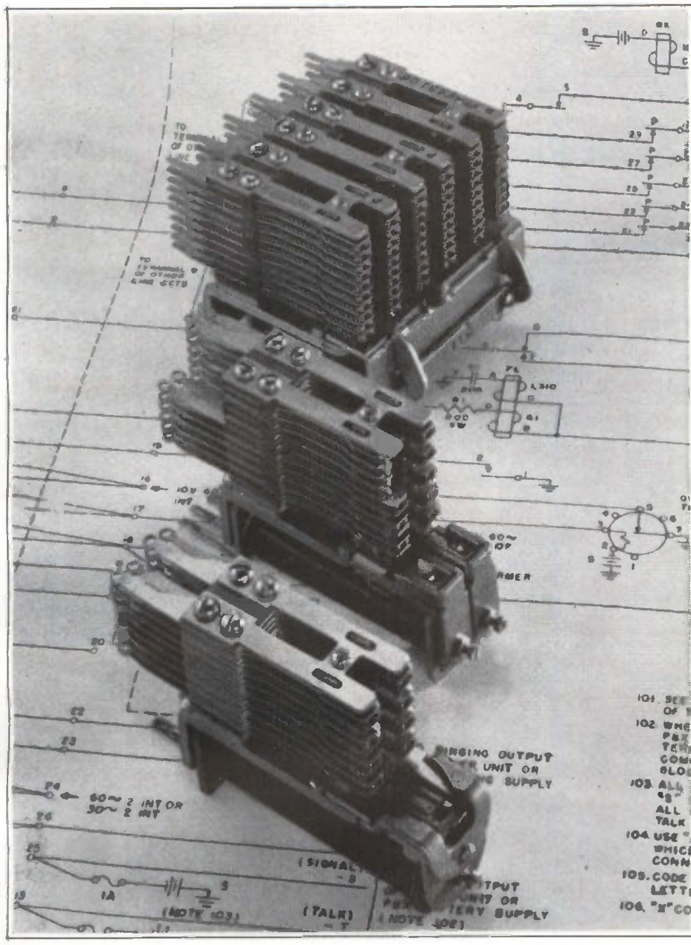
Hermetically sealed thyristor diode

High power and high voltage are features of a new thyristor diode developed by Unitrode. The diode offers firing voltages ranging from 40 to 300 v. Continuous current rating is 1.5 amp and the device will withstand short duration surges as high as 500 amps; 8.3-msec surge rating is 15 amps.

The body size is less than ¼ in. long with a maximum diameter of 0.085 in. These devices all feature the manufacturer's construction that uses two cylindrical metal pins bonded to both faces of a silicon die. The resultant structure is then fused in hard glass which forms a void-free hermetic seal around the junction.

Prices of this UF series vary from $5 to $15, depending on the voltage tolerance and quantity.

Unitrode Corp., 580 Pleasant St., Watertown, Mass. **[365]**



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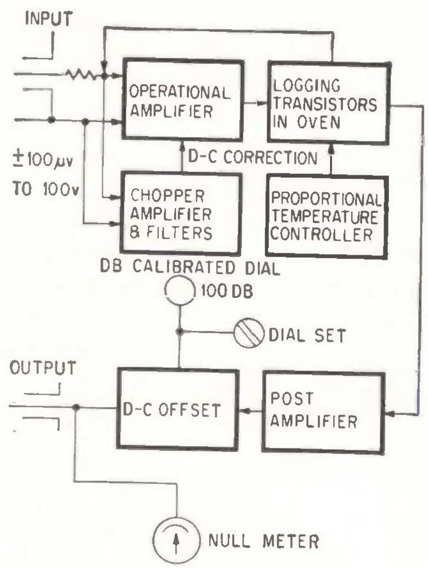
Log converter keeps up with scope



A logarithmic converter that responds fast enough to work with an oscilloscope is now available from Pacific Measurements, Inc. It's the first of its kind to operate with scopes, according to the company. The instrument also operates with digital voltmeters, recorders, high-speed graphic recorders and other common readout devices.

The converter has a wide dynamic range, covering fully just about any phenomenon in a single range without the usual adjustments.

Model 1002 accepts input signals from a low of 100 microvolts to a high of 100 volts. Above 100 millivolts its response time is 2 microseconds; below 100 millivolts, the response time derates—20 µsec at 10 mv, 200 µsec at 1 mv and 2 msec at 100 µv. The dynamic range is 120 decibels (a million-to-one ratio) so a change of 1 db in the input signal results in an output signal change of 50 mv.

Output voltage can be adjusted with a 10-turn potentiometer so that any convenient point can be used as a zero reference level. The potentiometer has a calibrated dial which can be set to a major division when the offset is adjusted, making it easy to add or subtract decibels when reading the output.

An operational amplifier needs high d-c stability and low drift to handle such a wide range of signals. Pacific Measurements provides d-c correction with a chopper amplifier that has an efficient, and silent, photo-chopper at its input.

Drift correction comes from a feedback element—two silicon transistors, one for positive signals, the other for negative signals. For both, the emitter-to-base voltage is proportional to the log of the collector current over a change of eight or nine decades. Since the emitter-to-base potential is also proportional to the absolute temperature of the case, the transistors were placed in an oven. A proportional temperature controller keeps the transistors at a steady temperature.

After leaving the logging transistor, the signal level is only about 3.2 mv per db. A post amplifier strengthens the signal to 50 mv per db, or 1 volt per decade. At this level, the signal can be fed into a readout device without risking serious interference from the power line or other sources. Possible interference from stray signals at the input is prevented by a differential input connection which cancels signals common to the interconnecting cable's center conductor and its shield.

The solid state unit is compact: 5 inches high, 5¼ in. wide and

Specifications

Dynamic range	120 db
Input signal range	100µv to 100 v
Output signal level	0.05 v/db change in output
Response speed	31.6 mv to 100 v, 30 db/µsec derates linearly from 30 db/µsec at 31.6 mv to 3 db/µsec at 100 µv
Input impedance	100,000 ohms ±1%
Output impedance	Under 100 ohms
Accuracy	Better than 0.01 db per db
Signal-to-noise ratio	Better than 10:1, 100 µv to 31.6 mv; better than 50:1, 31.6 mv to 100 v
Drift	Under 10 µv referred to input
Power	50-60 hz, 115-230 v
Price	$660

Technically speaking, men who know meters say nothing in the industry can measure up to the new Auto-Torque. It's built to take it. The first and only band-type meter built by automated machines for reliability never before possible in conventional meters.

More reliable because Auto-Torque meters have half as many parts. No screws. No nuts. No hairsprings. No pivots and jewels. And best of all, no "sticks". The mechanism is self-shielded, too, so it can be mounted on any panel without special calibration. Accuracy is unaffected by external fields.

Another thing. The moving system of the Auto-Torque mechanism is suspended on metal bands under tension. So there's no friction and wear.

What's more, (and this may surprise you) new Auto-Torque meters can actually save you money! Prices to volume buyers are below those for comparable pivot and jewel meters. And there are all kinds of styles to choose from — in fact, the widest selection of band-type meters available today. And they're all a knockout. If you want more information, write to Honeywell Precision Meter Division in Manchester, New Hampshire 03105.

Honeywell
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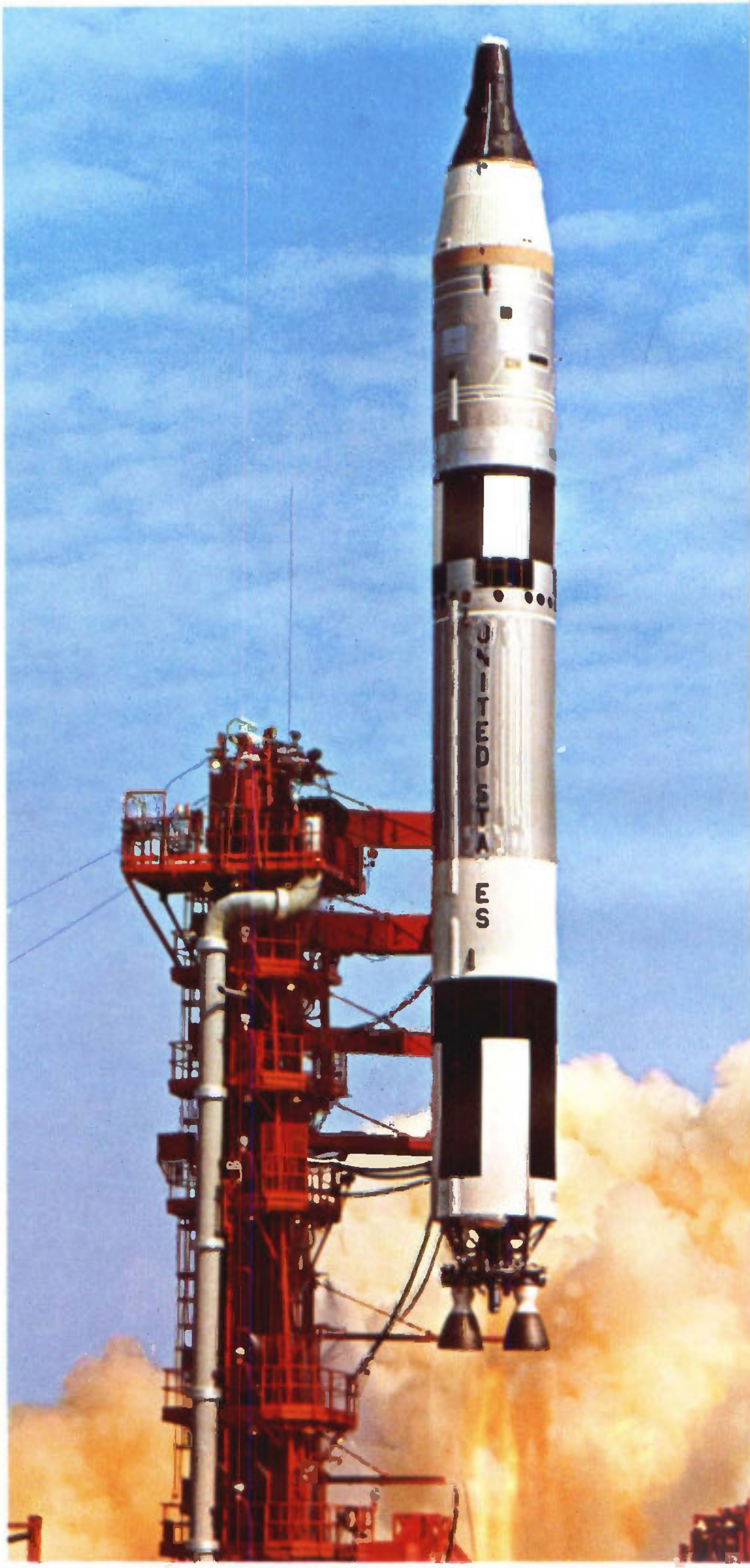

G.E.'s radio guidance system controls altitude, trajectory and velocity at launch. Like Gemini above, it has helped place all manned U.S. spacecraft safely in orbit.

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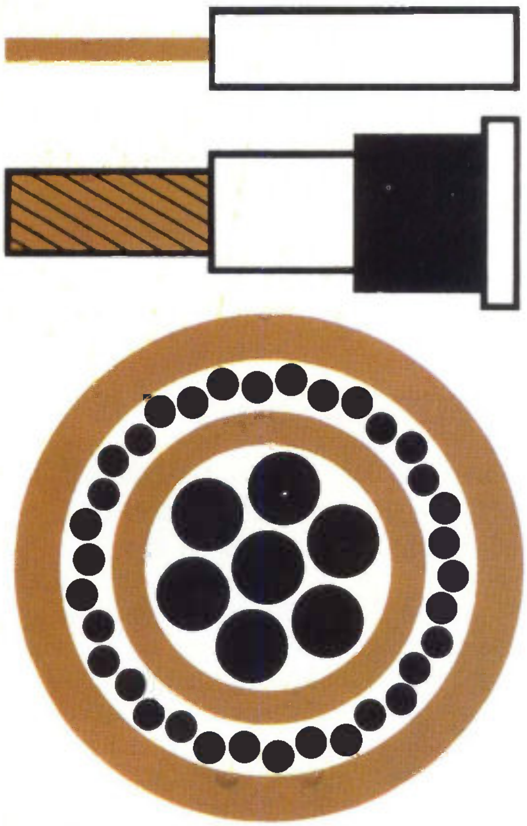

SUPER TEMP WIRE—Specialized high-temperature insulated wire/cable designs . . . from film coated wires, finer than a human hair, to complex multi-conductor and coaxial cables . . . for critical electrical/electronic applications, mark Haveg contributions to wiring projects on Gemini and Apollo man-on-the-moon programs, as well as on the Polaris, Saturn and Titan missile and rocket programs.

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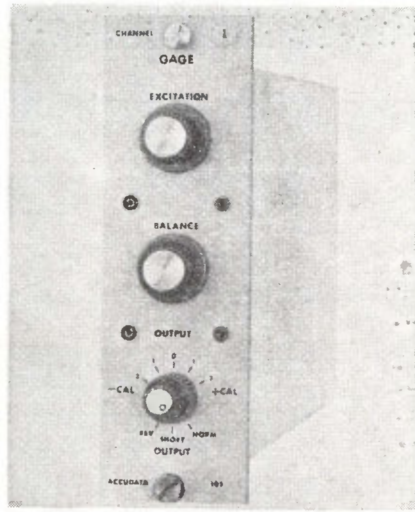
10½ in. deep; it weighs 7 pounds. Dale M. Barger, president of Pacific Measurements, expects the unit to find applications in vibration testing, both general quality control and final testing, nuclear engineering, acoustics, geophysical research, electro-optics, medical electronics and data processing.

Pacific Measurements, Inc., 940 Industrial Ave., Palo Alto, Calif. [371]

Gauge control unit comes in 3 models



A second-generation signal conditioning unit has been designed for control of strain gauge and thermistor-type transducers. The Accudata 105 series is available in three models—the 105-1, 105-2 and 105-3.

Each model offers new control features for balance and calibration, according to the manufacturer, and provides additional operator convenience in the form of new output switching arrangements and front-mounted monitoring jacks.

The basic model, 105-1, controls excitation, balance and sensitivity of both strain gauge and thermistor transducers.

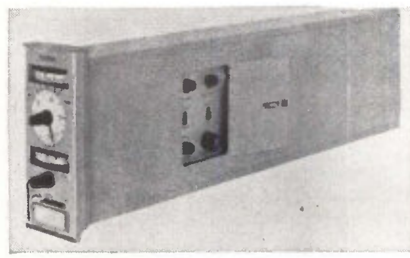
The 105-2, in addition to providing the same functions as the basic unit, contains its own excitation supply. This 12-v model, with its 350-ma output, also may serve as a direct-current source for up to eight 350-ohm gauges.

The 105-3 provides the same functions as the 105-1 and also serves as an individual d-c excitation source with existing or future signal conditioning amplifiers.

Price range of the Accudata 105 series is $105 to $195.

Honeywell Inc., Test Instruments division, 4800 East Dry Creek Road, Denver, Colo., 80217. [372]

Electronic controller offers economy



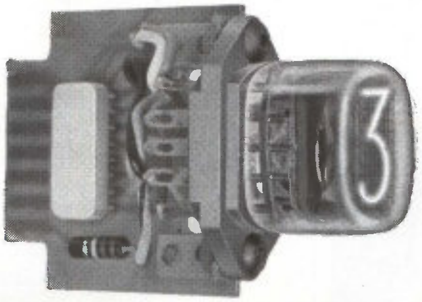
An electronic indicating controller that fills industry's need for a more reliable, economical instrument for process-flow applications is being offered, according to the manufacturer, at a price competitive with pneumatic indicating controllers. Current base price of model 61H is $325 without shelf and accessories.

A built-in force-balance transmiter power supply and a remote-local switch allows the controller to be set electrically by an external device or to be set manually. Components of the proportional-plus-reset controller are on a single, vertically mounted circuit board. All calibration adjustments are potentiometers and there are no selected wire-wound resistors.

Controller operating adjustments include deviation and valve output meters, calibrated set point dial, manual knob and automatic/manual transfer switch.

A four-position automatic/manual transfer switch and a fully transistorized amplification system assure smooth, bumpless transfer of control.

Control mode adjustments, remote/local switch and increase-decrease switch are located on the



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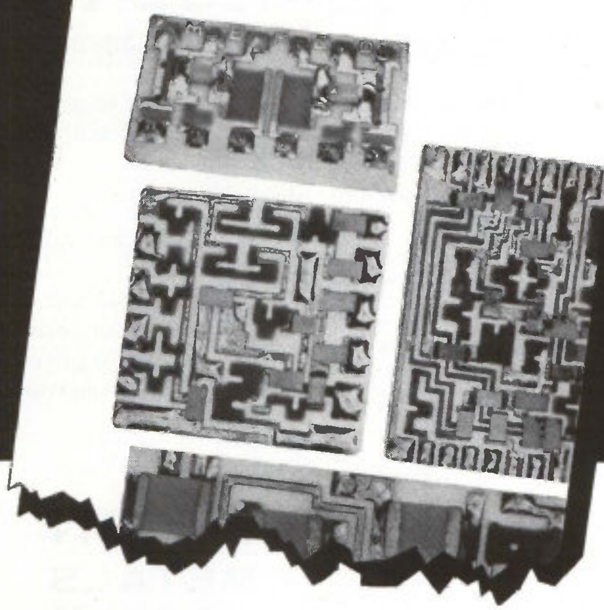

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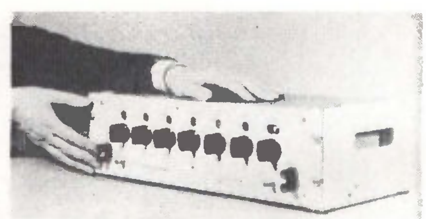
side of the pull-out chassis. A self-storing cord allows the controller to be withdrawn from its panel without interrupting process control.

Optionally available is a new manual memory pointer for the output meter to indicate normal valve position. Also optional are a backlighted nameplate that serves as a visual alarm and a Vu-Line deviation display. When measurement deviates from set point by a predetermined amount, a brilliant red pointer appears from behind a black mask on the deviation meter to warn of an off-normal condition.

The flow controller's 10 to 50 ma d-c input/output signal is compatible with all other controllers, recorders, indicators and auxiliary stations in the electronic Consotrol line. The instrument includes a universal power transformer for operation on nominal 100, 118, 220 and 238 v, ±10%, 50 or 60 hz.

The Foxboro Co., Foxboro, Mass., 02035. **[373]**

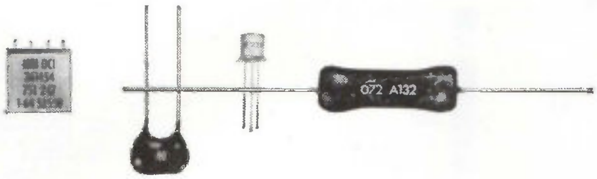
Ratio divider box offers 1 ppm accuracy



Inductive decade ratio divider model RB-504T allows any input-output signal ratio in the range 0 to 1.111110 to be set up with 0.3 part-per-million resolution and 1 ppm accuracy (traceable to NBS), using five front-panel decade switches and a calibrated potentiometer in the sixth decade position. By using a built-in phase reversing transformer, the divider's range is extended to negative ratios, spanning the range −1.111110 to +1.111110 with the same 0.3-ppm resolution and accuracy reduced to 3 ppm.

Frequency range is 50 hz to 3

print electronic components ...efficiently



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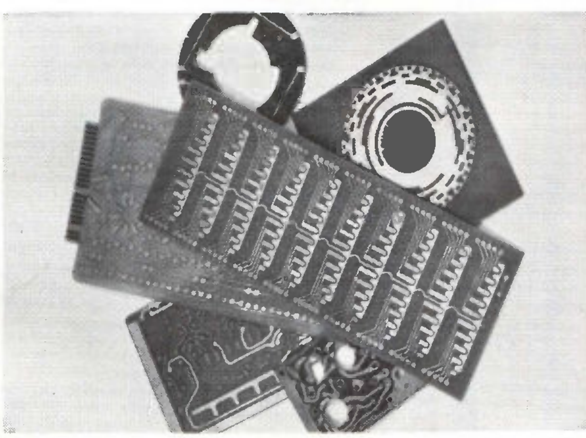
Circle 534 on reader service card

NEW lower-cost, epoxy flame-retardant copper-clad laminate



In response to the demand for a more economical epoxy grade of laminated plastic, Synthane now offers new grade FR-16.

FR-16 is reinforced with a random-oriented glass fiber mat which, because it can be produced on a modified paper machine, costs less than fabric reinforcements used in other flame-retardant grades.

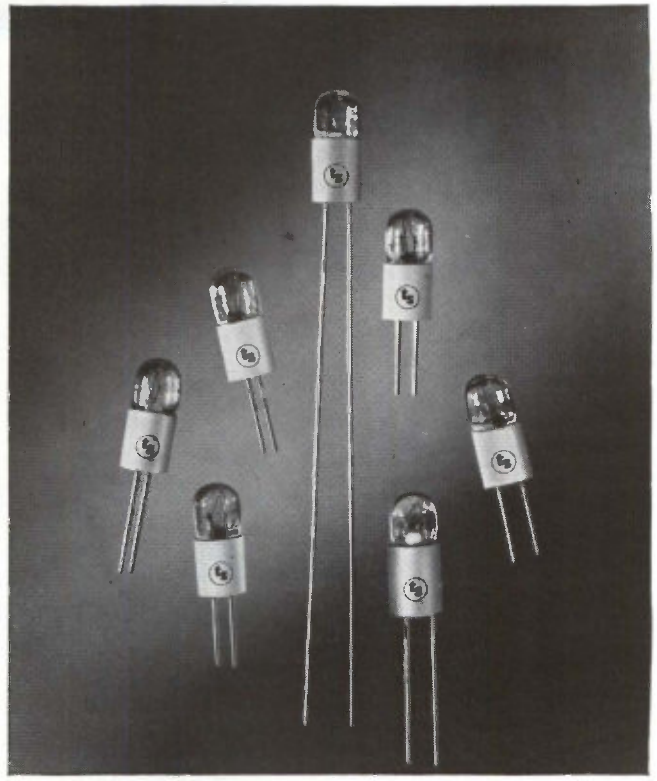
FR-16 is excellent for printed circuits. It is mechanically strong, moisture-resistant, has a low dielectric loss and a high dielectric breakdown. Write Synthane Corporation, 36 River Road, Oaks, Pa. for the FR-16 Engineering Data Bulletin.

Laminated Plastic Sheets, Rods, Tubes and Fabricated Parts

SYNTHANE CORPORATION OAKS, PENNA.

Circle 535 on reader service card

Tu-Pin Molded Base Lamps



A complete light source that requires no mounting socket

Tu-Pin Lamps are standard subminiature bulbs molded into Nylon bases. Bulb and base are an integral unit. The conventional metal base and socket are eliminated.

Fewer parts and connections reduce assembly procedures and contribute to greater product reliability.

Tu-Pin Lamps are ideal for circuit board applications. They can be installed with automated equipment.

All leads are internally sealed against corrosion. Exposed leads can be of non-corrosive material. Molded bases can be color coded for production accuracy.

In addition to Tu-Pin types, Tung-Sol supplies molded base lamps with long leads for computer modules and photocell applications. Complex base configurations can be supplied to specifications. Write for more information.

TUNG-SOL® MOLDED BASE SUBMINIATURE LAMPS
WAGNER ELECTRIC CORPORATION, TUNG-SOL DIVISION
One Summer Avenue, Newark, N. J. 07104

Circle 289 on reader service card

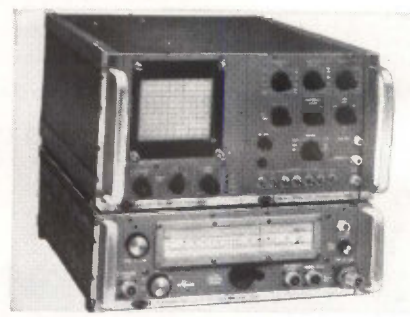
khz, with wider bandwidth operation at reduced accuracy. Maximum applied voltage is 350 v, with input voltage (V) related to operating frequency (F) by $V=0.75F$. Phase shift is less than 1 minute of arc.

Input impedance of the divider without the inverting transformer in circuit is above 200,000 ohms. Impedance is above 10,000 ohms with the transformer in use. Maximum output impedance without the inverting transformer is 8.5 ohms and 10 ohms maximum with the transformer in the circuit.

Price for the complete divider is $890.

North Atlantic Industries, Inc., Terminal Drive, Plainview, N.Y. [374]

Spectrum analyzer uses modular design



Modular design of the model 2882 microwave spectrum analyzer is mechanically and electrically compatible with the other seven modules in the company's spectrum analyzer line and employs the interchangeable display unit in all modular analyzers.

Model 2882 features a frequency range of 10 Mhz to 40 Ghz; high sensitivity on all bands; nine calibrated dispersion ranges from 10 khz to 100 Mhz, plus continuous adjustment, 0 to 100 Mhz; and automatic optimum bandwidth selection for best resolution.

Other features are: four calibrated crystal markers for simplified accurate frequency measurements and stability checks and 60-Mhz predetection output (in addition to normal video output) for time domain analysis. The in-

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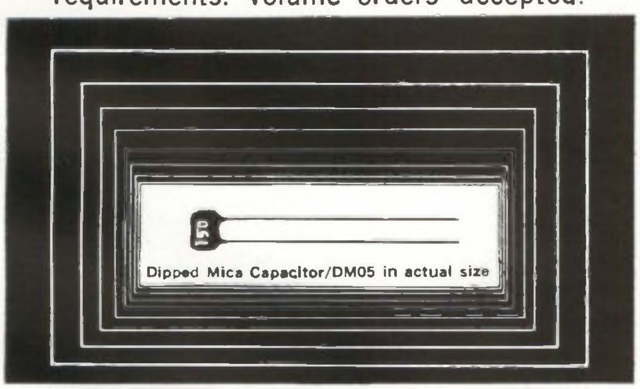

Dipped Mica Capacitor/DM05 in actual size

Types	Max Allowable Capacitance (pf)			Dimension (mm)								
Standard	100 WV	300 WV	500 WV	100 WV			300 WV			500 WV		
				L Max	W Max	T Max	L Max	W Max	T Max	L Max	W Max	T Max
DM05	200	130	–	7.0	5.0	3.5	7.0	5.0	3.5	–	–	–
DM10	440	390	330	8.5	5.5	3.5	8.5	5.5	3.5	8.5	5.5	3.5
DM15(CM05)	2000	1200	510	13.0	11.0	6.5	12.5	10.5	6.0	12.0	10.0	5.5
DM19(CM06)	10000	6800	5100	18.0	15.0	8.5	18.0	15.0	8.0	17.5	15.0	7.5

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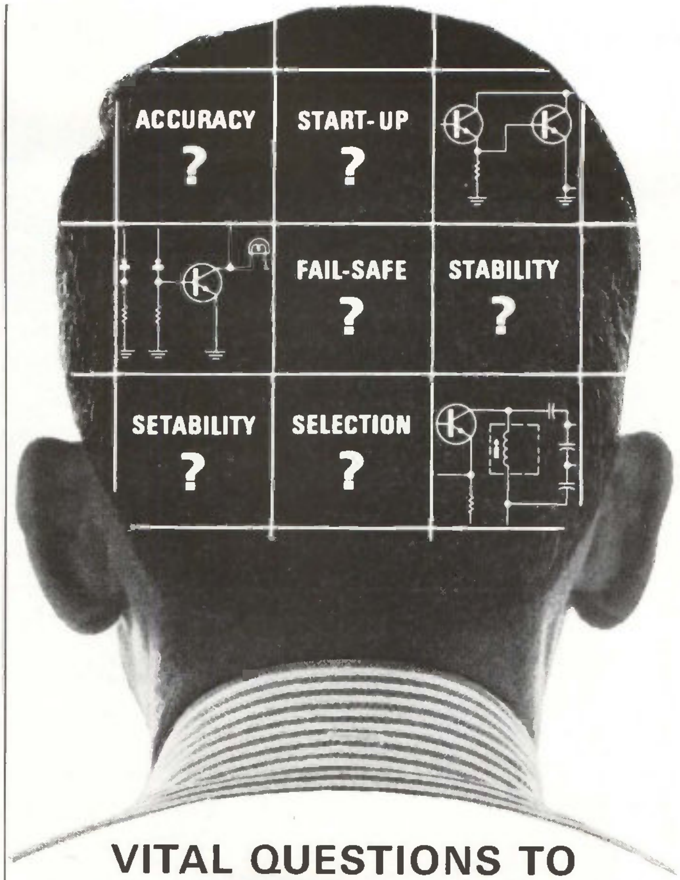

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PRECISION INSTRUMENT PRODUCTS

Circle 291 on reader service card

strument can serve as a synchroscope or receiver and its large rectangular crt (5½ in. x 4½ in.) offers better accuracy and resolution than any other analyzer display on the market, according to the company. It has a calibrated i-f attenuator for precision measurements of 0 to 8 db in 1-db steps.

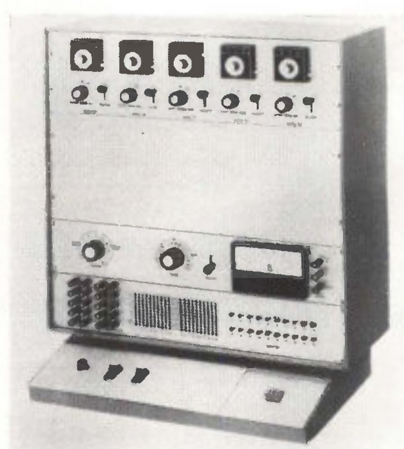
The new design provides choice of log, linear and power displays with automatic corresponding scale and graticule illumination plus continuous broadband sweep, with no gap in coverage.

Applications include analysis of nanosecond r-f and video pulses, determining harmonic and spurious responses in signals, measuring noise spectra and noise-source bandwidth, for rapidly locating leakage signals for rfi, calibrating filters and attenuators and measuring spectral purity of signals over a large dynamic range for countermeasures and jamming.

At its single-unit price of $6,300, the model 2882 is from 15% to 35% lower in price than similar equipment, the company claims. Delivery is 30 days from receipt of order.

Polarad Electronic Instruments, a division of Polarad Electronics Corp., Long Island City, N.Y. [375]

IC tester features modular design



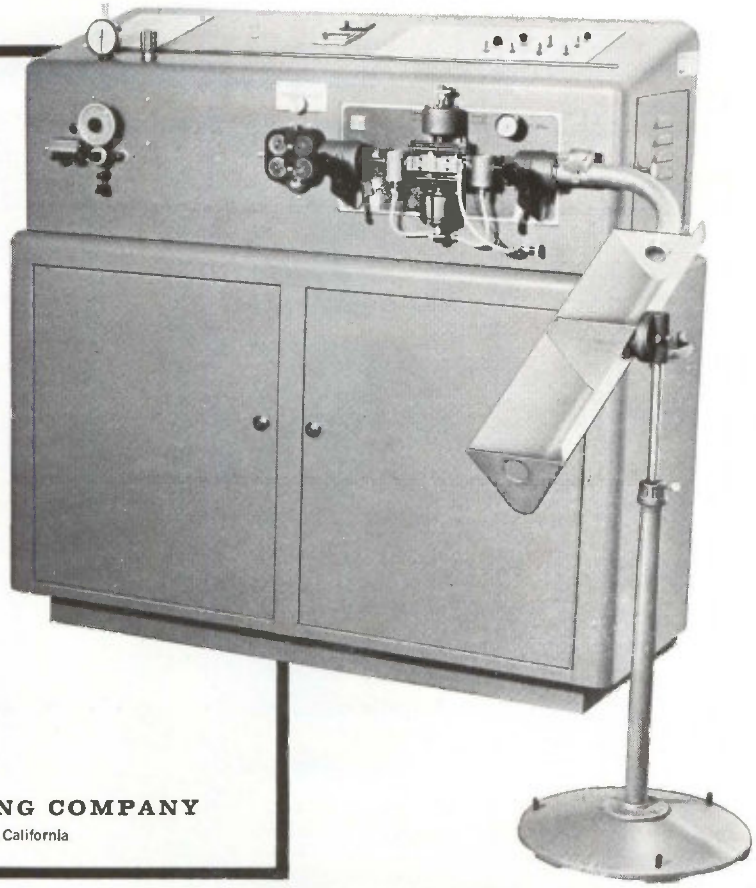
The need for widely varying capabilities in an integrated circuit tester is answered in a modular-design test set, according to the

For solderless wrapped connections, a new automatic wire stripper

The Model 841 Solderless-Wrap Wire Stripper offers high speed preparation of 20-30 AWG solid conductor wire for insertion in a wrapping tool. It cuts wire to lengths of 1″ to 50′ and fully strips 1/8″ to 1 9/16″ from each end without nicking or scraping, whether the insulation be PVC or something as tough as Mil-Ene, Teflon or Kynar. With optional assemblies, you can also use it for shorter stripping of 10-32 AWG stranded wire. Write for information on this and other Eubanks wire strippers.

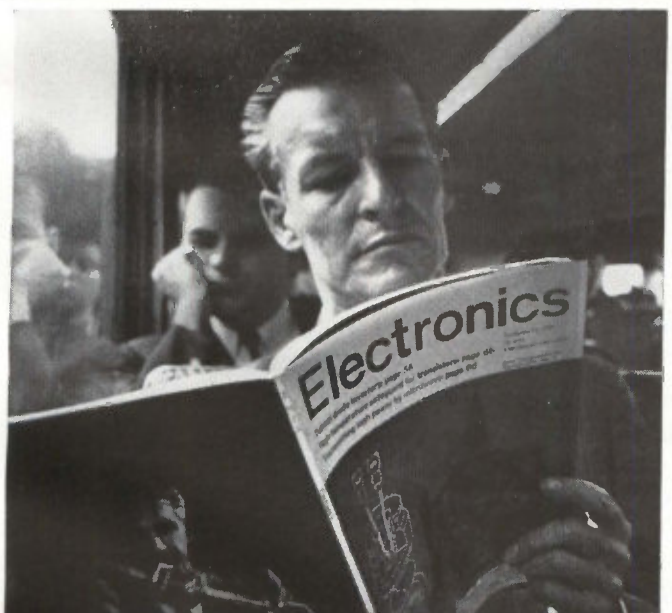
Wire is fully stripped, ready for wrapping tool.

Remaining insulation can be short as ½″.



Eubanks ENGINEERING COMPANY
225 West Duarte Road • Monrovia, California

Circle 538 on reader service card



Great editorial is something he takes to work

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Circle 293 on reader service card

manufacturer. Model 800 IC tester can be ordered with varied combinations of modules and optional features.

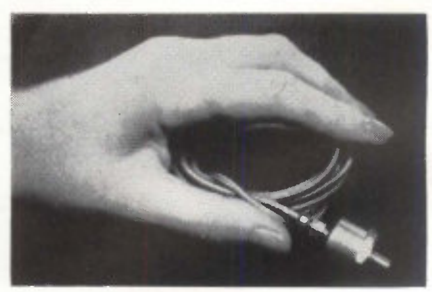
The basic unit is a housing with a base, test socket, and switches, to which can be added in several combinations: a 10x20 or 10x40 crossbar matrix, which allows sequential testing of similar parameters without reprograming; provision for five external inputs or outputs; five analog or digitally-programable power supplies; panel readout meter and ranging switches; connection for an external digital voltmeter or oscilloscope; internal resistance and capacitance loading and a pulse generator.

Model 800 tests all present IC configurations and any foreseeable future developments in the field, according to the manufacturer. Readout is directly from a built-in meter accurate to 1% of full scale. Basic cabinet and modules are standard in size. Solid-state components and integrated circuitry are used throughout.

Price starts at $1,500 for a typical unit; delivery, 60 days.

The Birtcher Corp., Instrument division, 1200 Monterey Pass Road, Monterey Park, Calif., 91754. **[376]**

Accelerometer operates from −300° to +750°F



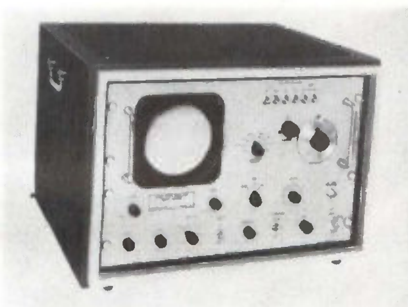
An ultrahigh temperature accelerometer for aircraft and rocket engine testing is well suited to applications requiring exposure to high solar heat fluxes and gamma radiation.

Designated model AQB-4280, the rugged instrument utilizes a sensing element of newly formulated ceramic. The new material allows operation over the extremely broad temperature range of —300° to +750°F. The accelerometer maintains its charge sensitivity within ±10% of its room ambient value (nominally 5.0 picocoulombs/g) over the same temperature range. No external cooling or special installation techniques are needed.

Internally ungrounded, the hermetically sealed instrument has 3% maximum transverse-axis sensitivity and resonant frequency of 30,000 hz minimum.

Weight is 1¼ oz maximum and dimensions are 11/16 in. hexagonal x 0.75 in. high, exclusive of stud and connector.
Gulton Industries, 212 Durham Ave., Metuchen, N.J., 08840. [377]

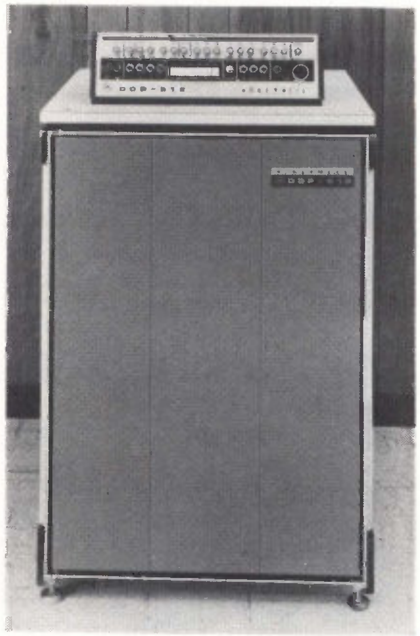
Analyzer functions as bandpass monitor



A spectrum analyzer has been designed for ssb and narrow-band r-f transmitters and exciter waveform envelopes. Model MD500E, with an input center frequency of 500 khz, serves as a bandpass monitor when used with communications receivers for narrow-band, high-resolution analysis of communication channels.

Bandpass amplitude response is ±10%; sweep width is variable from 0 hz to 100 khz calibrated dial, 0 hz to 2 khz calibrated dial (afc); sweep width preset—150 hz, 500 hz, 2 khz and 10 khz; sweep rate—0.1 hz, 1 hz, and 1 hz to 30 hz variable; variable resolution, 10 hz to 2.7 khz; sensitivity—direct, 20 μv full-scale linear conversion and 2 mv full-scale log; amplitude scale—20 db linear, 40 db log; outputs—vertical, horizontal and sync.
Probescope Co., Inc., 211 Robbins Lane, Syosset, L.I., N.Y. [378]

Control computer is small but speedy



A 16-bit computer built with monolithic integrated circuits has entered the market for small, fast control computers. The machine, called the μ-Comp DDP-516, was built by the Computer Control division of Honeywell, Inc. It has a 960-nanosecond memory cycle time. The computer supersedes the company's DDP-116 and the two machines are completely program-compatibile. However, the new computer does 1.4 to 1.7 times as much work and is about $3,000 cheaper. Its basic price is $25,000, including an ASR-33 teletypewriter.

The computer is the first major product introduced by the Honeywell division, formerly the Computer Control Co., since it was acquired last May. The first computer has already been delivered and 90-day delivery is promised for all new orders.

The new machine is designed for real-time, on-line applications in physics research and data acquisition, as well as in railroad and process control.

Memory capacity is 4,096 to 32,768 words. The core memory is the division's ICM-40 integrated circuit memory [Electronics, November 29, 1965, p. 116]. The integrated circuit logic modules are the company's own μ-Pac line. Texas Instruments Incorporated supplied the integrated circuits.

Most operations can be performed in 1.92 microseconds. A single command can address 1,024 memory words. Features include fully parallel organization, indexing, multilevel indirect addressing and a 72-command instruction repertoire with byte manipulation capability. It also has priority interrupt, individually buffered input-output channels and power-failure protection.

Plug-in options include time-sharing, direct memory access when input-output transfer rates of 1 megahertz are needed, a high-speed arithmetic package, memory lockout for program protection, memory parity and a real-time clock.

The computer weighs 250 pounds and fits into a 24-x24-x28-inch cabinet or a 19-inch rack, with the control console a separate and movable unit. Three vertical leaves, which tilt out for easy access, contain the system power supply, the central processor and the memory. Mean time between failures is two years under a normal 40-hour week of operation, or 4,000 hours. The system draws 1 kilowatt of line power.

The standard 250-program package includes a Fortran IV one-pass compiler and a real-time monitor program for time-sharing the computer between real-time and free-time tasks. It has another monitor program for direct memory addressing and a library of sup-

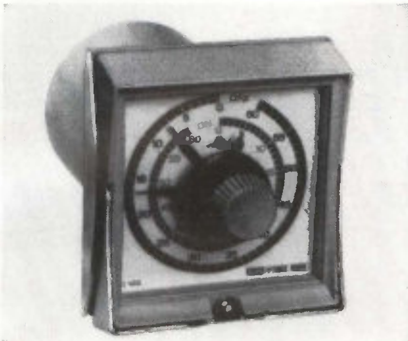
Specifications

Model	μ-Comp DDP-516 computer
Memory cycle time	0.96 μsec
Add or subtract	1.92 μsec
Multiply	5.28 μsec
Divide	10.56 μsec
Single word I/O transfer	1.92 μsec

port programs such as test program updating routines.

Computer Control division, Honeywell, Inc., Old Connecticut Path, Framingham, Mass. 01701. [379]

Repeat cycle timers perform dual function



Plug-in electromechanical timers, designated the HG100 series Flexopulse, repeatedly close and open their single-pole double-throw contacts. They perform tasks formerly requiring two separate timers in a flip-flop arrangement.

As long as the HG100 is energized it oscillates through continuous "off" and "on" periods. Every time the unit's cycle progress pointer passes "0", its two heavy-duty 10-amp contacts transfer. These periods are controlled by setting the color-keyed pointers on the face of the unit. "Off" times are set by the black control knob and pointer on a black scale. "On" times are set by the blue knob and pointer on a blue scale. The HG100's red cycle progress pointer moves between these two settings so its position in its cycle can be readily determined.

An unusually flexible unit, the timer will accept new settings at any time. Should power be cut off, the HG100 holds its position in the cycle and does not reset. When power is restored, the unit begins again at cycle point of power withdrawal.

Other features include a unidirectional motor which eliminates complicated reversing switches and gearing, all susceptible to wear. Reliability is further enhanced by use of a single motor instead of dual units. The HG100's stainless steel directional control mechanism has proven life of over 10 million operations, the company reports.

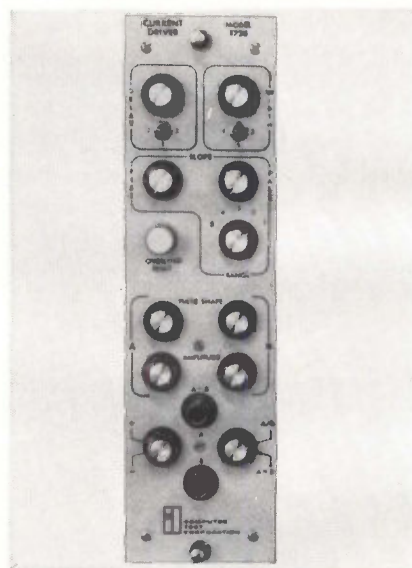
Standard time ranges extend from 30 seconds to 60 hours with a repeat cycle accuracy of ½ of 1% of the dial setting.

The dual-function timers measure 6 in. long x 3 13/16 in. wide x 4½ in. high.

Indicated applications include periodic sampling of processes, conveyor control and signal or warning systems.

E.W. Bliss Co., Eagle Signal division, 736 Federal St., Davenport, Iowa. **[380]**

Current driver delivers dual pulses



Current driver model 1720 has been designed to deliver dual current pulses identical in rise time, fall time, pulse delay and pulse width. In many memory test applications employing coincident current storage techniques, the 1720 can serve effectively as two individual drivers. Output A can drive an X-axis line while output B drives a Y-axis line. Since the current pulse parameters of both outputs are adjusted coincidentally with a single set of controls, the dual output design markedly diminishes test set-up time.

Current amplitudes of the output pulses can be adjusted independent of one another over a continuous range of from 50 milliamperes to 600 ma. The full rated 1-amp output of the driver can be achieved by throwing a front-panel switch which busses the two outputs together internally.

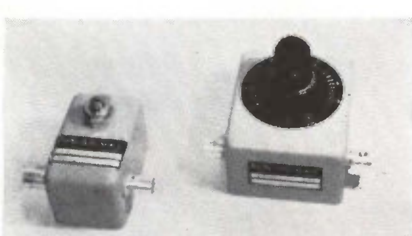
The 1720 is also a true bipolar current driver, developing positive or negative pulses d-c referenced to ground by the simple flick of a front-panel polarity switch. The output voltage rating is 60 volts, positive or negative, and the driver is capable of withstanding a back electromotive force of the same magnitude without damage. The 60 v output, coupled with a low output capacitance of 40 picofarads [worst case], combine to equip the driver with the ability to drive large inductive loads.

The output current pulse has very fast linear rise and fall slopes, extending into the sub-10 nanosecond region. Both rise and fall time can be adjusted independently of one another. Pulse shape is square-cornered, free of any pulse overshoot, ringing or droop. Pulse width is variable from 10 nsec and pulse delay from 0 to 10 microseconds.

The 1720 is both short circuit stable and open circuit stable. Automatic current limiting is provided to a maximum average of 200 ma. When this average current is exceeded, trigger pulses to the driver are automatically disconnected within 5 μsec. Thus, any duty cycle up to approximately 95% can be achieved with the driver.

Computer Test Corp., 3 Computer Drive, Cherry Hill, N.J. [381]

Variable attenuators for low-frequency use



A series of continuously variable attenuators rated at 1 watt in the d-c to 10 Mhz frequency range can also operate above 30 Mhz with only slightly reduced performance characteristics.

The well-matched attenuators have many low-frequency applications, including audio, video and i-f level setting and control both in the laboratory and in the field.

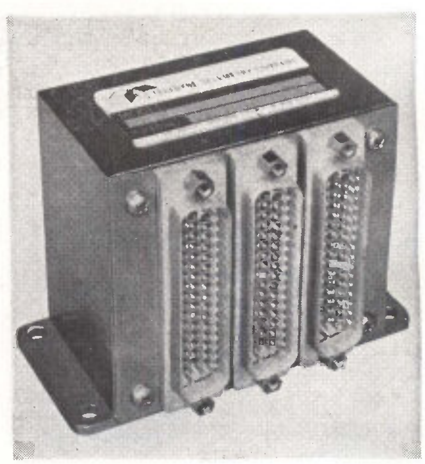
The series consists of two models with identical electrical characteristics. Model AR-1 is uncalibrated and a screwdriver adjusts the attenuation level. Model AR-2 is calibrated with an accuracy of 0.5 db and features a direct reading dial and knob adjustment. Both units have locks.

Specifications include: attenuation range, 0 to 20 db; insertion loss, less than 0.75 db; vswr, typically less than 1.2:1; standard model impedance, 50 ohms; resettability (granularity), 0.1 db; connectors, BNC type; and dimensions (AR-1), 1.44x2.31x1.40 in., (AR-2) 2.67x2.31-x1.38 in.

AR-1 is priced at $60, and AR-2 at $80; delivery is from stock to 30 days.

Merrimac Research and Development, Inc., 41 Fairfield Place, West Caldwell, N.J., 07007 **[382]**

IC pcm systems occupy small space



Using integrated circuits, the 710 pulse code modulation systems require less than one-third the volume of systems with discrete components.

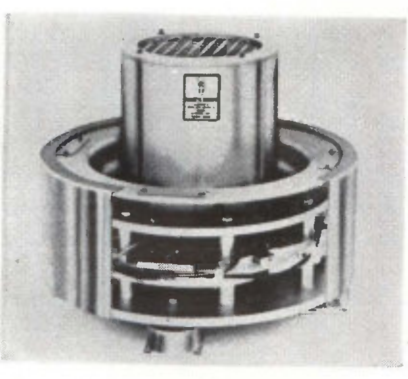
The systems can be programed for any number of high-level, low-level or digital inputs, divisible by eight, up to 256 channels. Input channel mix can be programed for preselected gains from 1 to 1,000 in multiples of eight data inputs.

Sampling rates from 1 to 50,000 words per second are available. Bit rate stability is determined by an internal multivibrator or crystal-controlled clock. Standard channel programing is accomplished sequentially. Random access and sequencing on command are available as options. Standard pcm output is a serial NRZ-C or NRZ-M 10-bit word pulse train.

Other features of type 710 pcm systems include: over-all accuracy up to 0.5%, back currents below 0.1 μa, offset and scatter below 25 μv, field effect transistor analog input gates, differential input impedance greater than 500,000 ohms, high-level input impedance greater than 5 megohms, linearity better than 0.05%, crosstalk less than 0.1%, odd parity bit and word sync bit for each word and two 10-bit frame sync words inserted into the output serial pulse train.

Teledyne Telemetry Co., DynaPlex division, Box 341, Princeton, N.J., 08540. **[383]**

Memory disks provide large capacities



Thirteen models of magnetic memory disks are offered with storage capacities ranging from approximately 100,000 to over 10 million bits. They are available in four series, utilizing 7, 9, 11 and 13-in. diameter disks.

Features include bit packaging densities to 1,000 per inch non-return-to-zero, [600 per inch phase modulation]; a signal-to-noise ratio of 20 db; versatility of operation, with variable motor speeds avail-

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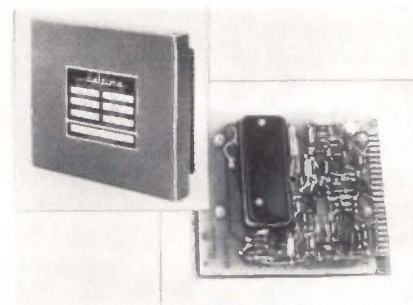
able and record head inductance adjustable to any electronic interface.

Disks range in price [single units] from $3,000 for model 71-64, with total bit capacity of about 600,000, to $13,000 for model 134-512, with bit capacity of 10 million.
General Instrument Corp., Magne-Head division, 13040 South Cerise Ave., Hawthorne, Calif., 90250. **[384]**

Delay module achieves 2,000-μsec range



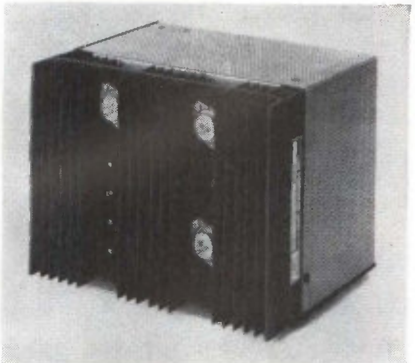
A Deltime delay module offers a 2,000-μsec time delay with 1-Mhz pulse repetition frequency. Model 192A/RZ-1, combines circuitry with a delay line. A digital write-read amplifier for magnetostrictive delay line applications is packaged as a single compact module. The write amplifier drives the delay line; the read amplifier amplifies the delay line output and restores the input pulse waveform. External clocking with a feedback loop results in a recirculating system for digital data storage.

The input logic level of the new module is between —4.6 and —7.8 v; the input pulse width at 50% amplitude is between 0.35 and 0.55 μsec. The delayed output logic level has a range of —6.4 to —7.1 v, with an output current of 0 to 10 ma at —6.6 v. The range of output pulse width at 50% amplitude is 0.45 to 0.50 μsec. These output specifications are quoted for a 25°C ambient temperature.

The unit has a power supply voltage of +12 ±10%, 16 ma maximum; —12 ±10%, 70 ma maximum at 1 khz prf, 120 ma maximum at 1 Mhz prf. Operating

temperature range is 0 to +55°C, although it can be stored at temperatures between −55°C and +80°C.
Sealectro Corp., Mamaroneck, N.Y. 10543. [385]

D-c modular supplies in 11 case sizes



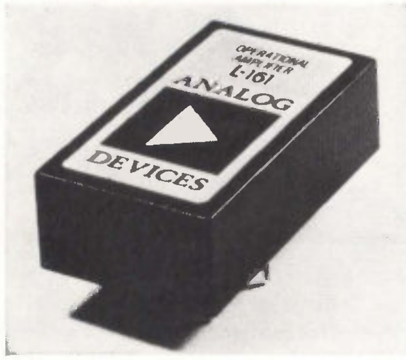
All-silicon, d-c modular power supplies are available with outputs covering the entire range from 0 to 400 v at 0.1 to 20 amperes in 11 different case sizes. All models are available with either 0.5% or 0.01% regulation. Solid state design permits lightweight, compact packaging requiring no forced-air cooling, heat sinking or derating at operating temperatures up to 71°C.

All regulation and control circuits are mounted on a plug-in printed-circuit board. All filter capacitors are computer grade. Automatic overload and short-circuit protection, remote programing and remote sensing are standard features with over-voltage protection available on most models.
ACDC Electronics Inc., 2979 North Ontario St., Burbank, Calif. [386]

Operational amplifier boasts high gain

A d-c differential operational amplifier makes a general-purpose circuit building block for applications requiring high gain combined with wide voltage swing and large output current. Model L-161 has 150,000 d-c gain, ±10 ma output current, and ±20 v (40-v spring) output drive.

Additional features include 1.5-



Mhz gain-bandwidth, 20-khz full-power output, 1.2-v/μsec slewing rate, 20-μv/°C drift, 20-na maximum offset at 25°C, 1.5-na/°C maximum current drift from −25°C to +85°C, 150,000 ohms and 50 megohms differential and common-mode input impedance, 4-μv noise, and ±20-v common-mode rating. (The common-mode rating is claimed to be higher than competitive operational amplifiers designed for ±20-v output.)

Typical uses for the amplifier occur in multiplier and logarithmic circuits, where nonlinear feedback is used. The unit operates from power supplies in the ±23- to ±25-v range and special units can be selected for a particular supply voltage in this range.

The complete amplifier, which is encapsulated into a 1¼-cu-in. p-c mounting module, costs $65.
Analog Devices, 221 Fifth St., Cambridge, Mass. 02142. **[387]**

Power module can take high temperatures

A family of high-temperature converters operates under continuous full-load at 212°F (100°C). The U3D/GB3 series converts 400-hz power to any required output voltage from 5 to 3,650 v d-c at 30 w. Modular parkaging techniques are applied to produce a unit which measures 2¾ in. by 3 in. by 3¼ in. and weighs less than 2.3 lbs.

All silicon semiconductors, tantalum capacitors and MIL- T-27A class T transformers are typical components. True hermetic sealing and full encapsulation enable units to meet the rugged environment of MIL-E-5272C at the higher temperature of 100°C. The modules are designed for the high-temperature environments of aerospace systems.

Short-circuit protection is built in on all GB3 models and special

fail-safe, short-circuit protection is available on U3 models. In addition these converters feature complete isolation of inputs and outputs and an adjustment range of 12% from the nominal output voltage. Design characteristics insure close regulation (0.2%) for line variations of 105 to 125 v a-c. Output ripple is less than 0.2% rms.

Price is $365 each; delivery, 5 to 6 weeks.

Abbott Transistor Laboratories, Inc., 3055 Buckingham Rd., Los Angeles, Calif., 90016. [388]

Noiseless attenuators actuated magnetically

Current variable attenuators utilizing magnetoresistors designated type CVA 3012, are infinite resolution and noiseless attenuators. They can be used for remote volume or gain control circuits as well as electrically isolated signal mixing and

New Subassemblies

remote variation of the gain controlling feedback resistor in operational amplifiers.

The magnetically actuated attenuator is completely encapsulated and is suitable for military and industrial applications.

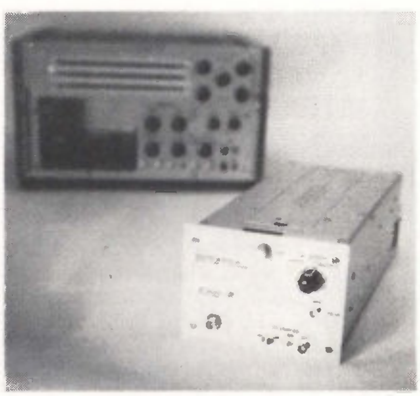
Control current in the range of 0 to 10 ma d-c to 0 to 40 ma d-c, depending on model selected, produces a voltage attenuation change of 6 db. This corresponds to a resistance ratio change of 3 to 1 between two resistors in series. One of these resistances is sensitive to magnetic flux, therefore the resistance changes with current. Nominal resistance of each resistor in the attenuator circuit is 500 ohms.

The CVA3012 attenuator circuit is rated for d-c or a-c voltages to 10 v and will operate over a temperature range of $-55°C$ to $+75°C$. The unit is $1 \times 1\frac{3}{4} \times 2\frac{1}{16}$ in. and weighs 5.3 oz.

Price is \$69.50 in lots of 1 to 9; delivery, 4 weeks.

American Aerospace Controls, Inc., 129 Verdi St., Farmingdale, N.Y. [389]

Oscillator plug-ins are frequency stable



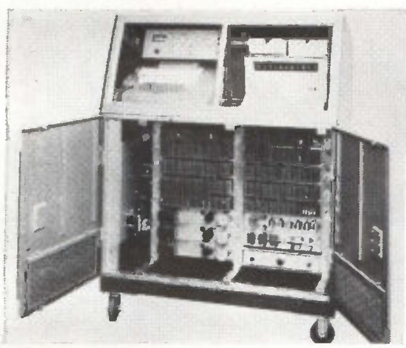
Low-frequency sweep oscillator plug-in units operate from 250 to 500 Mhz and 500 to 1,000 Mhz. Designed for the company's 650 series sweep oscillator, the units extend the range of the instrument from 250 Mhz to 40 Ghz.

The new oscillator plug-in units include magnetically and rfi-shielded, voltage tunable magnetrons. To assure maximum frequency stability, isolation is provided. Oscillator plug-in units may be either externally or internally leveled. The leveling signal is always applied to a p-i-n diode leveler modulator. Output power is characteristically 50 mw, leveled within ± 0.3 db.

Models 651A-S2 and 651A-S3, which are for external leveling, are priced at $1,875. Models 651AK-S2 and 651AK-S3, which include an internal r-f sampler for leveling, are priced at $2,350, Delivery is 30 days.

Alfred Electronics, 3176 Porter Drive, Palo Alto, Calif. [390]

Computing system in a portable cabinet



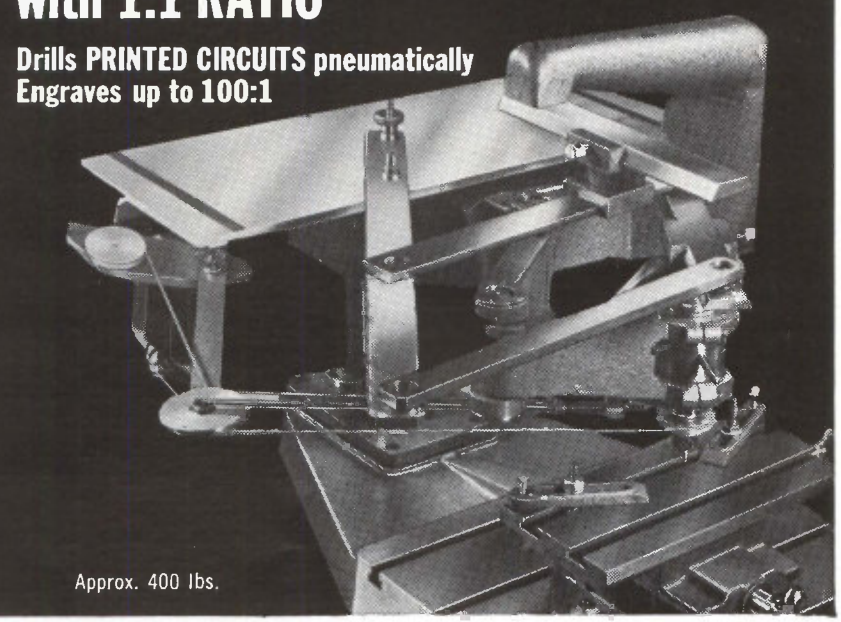
A general-purpose data acquisition and on-line computing system, contained in a single, portable cabinet, can scan and digitize up to 10 analog signals, perform computations on input data and provide output records in typewritten and punched tape form.

Input instructions for model 2315 may be entered through either the computer or the teletypewriter keyboard. Programed instructions are read from dual card readers having a capacity of 160 instructions or from punched tape with an unlimited program capacity. A 3-reel tape handler is built in.

The system includes a total of sixteen 10-digit and ten 4-digit storage registers. It has a built-in self-testing capability.

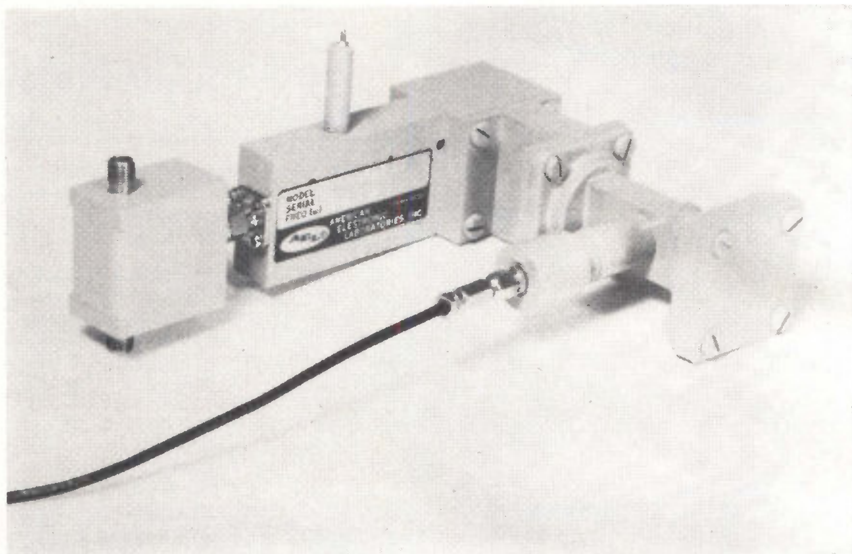
First application for the new system, according to the manufacturer, is monitoring and analyzing a bank of pyrometers in a midwestern steel mill.

Wang Laboratories, Inc., 836 North St., Tewksbury, Mass. [411]



New Microwave

Avalanche diode pumps amplifier



An avalanche diode oscillator is the pump source for a recently developed parametric amplifier for S band. Its manufacturer, the American Electronic Laboratories, Inc., believes that this is the first parametric amplifier to utilize avalanche diodes and will result in reduced costs. AEL builds its own diodes for the amplifier.

The avalanche diode converts d-c directly to the 13.5-gigahertz pump frequency needed to amplify at the S-band telemetry frequencies of 2.2 to 2.3 Ghz. The diode replaces the commonly used varactor multiplier stages or klystron pump sources. Consequently the pump efficiency is higher and the pump unit is smaller. In the new circuit, a varactor diode still serves as the parametric amplifier element, making the unit completely solid state.

As for costs, Jim Kellett, section head of AEL's microwave components laboratory says, "At least at parametric amplifier frequencies through 6 Ghz, we feel that avalanche diode pumps will result in the least expensive parametric system." Kellett indicates that the new amplifier's $4,595 price tag—with power supply—is extremely competitive with klystron-pumped units and is below that of amplifiers

Specifications

Unit	Parametric amplifier
Model	PAR 1612A
Tuneable frequency range	2.2 to 2.3 Ghz
Instantaneous bandwidth	35 Mhz
Maximum noise figure	2.5 db
Nominal gain	17 db
Maximum input at 1 db compression point	—35 dbm
Size	
Parametric amplifier	5⅝x4x1 5/16 in.
Power supply	3¼x3¼x5 in.
Delivery	90-120 days

pumped with varactor multipliers. The approximate cost of the avalanche diode pump alone is $600—about a fifth the cost of a varactor-multiplier pump, he says.

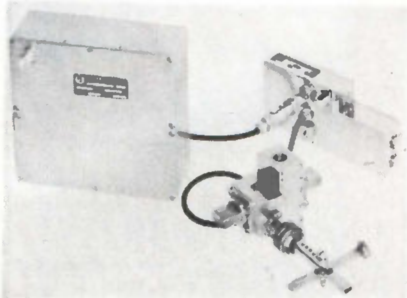
It had been thought that an avalanche diode would be noisy [Electronics, Aug. 8, p. 129], and might degrade the amplifier's low noise performance. AEL discovered, however, that the diode does not degrade the amplifier's noise figure. Tests are under way to evaluate the amplifier's operational life and characteristics under extreme environmental conditions.

The photograph shows a prototype version of the model; the unit for sale includes some slight modifications to reduce size. The commercial model also features a four-port strip-line circulator as the output coupler instead of the prototype's three-port circulator. A 60-

volt, 20-milliampere supply produces both the power for the pump and the bias for the varactor diode.

American Electronics Laboratories, Inc. Richardson Road, Colmar, Pa. [391]

Signal sources offer modular construction



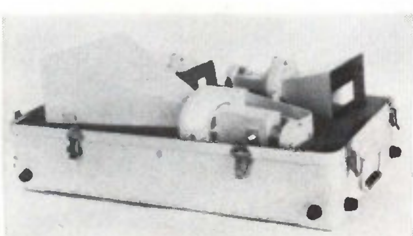
High power and low noise at frequencies up to 0 band (60-90 Ghz) are provided by Bradley solid state, microwave signal sources. Typically, 1 watt is available at X band and 100 mw at Q band (26.5 to 40 Ghz). The output of the O band source in the photograph is 10 mw.

The very low noise makes these sources ideal for doppler radar or other high stability applications. Measured noise is less than 140 db below a watt per hz.

The modular construction is useful in applications where space is at a premium. Also, costs are competitive with klystrons particularly at the higher frequencies.

Edwin Industries Corp., 5858 East Molloy Road, Syracuse, N.Y., 13211 [392]

Horn antennas suppress sidelobes by 25 db



Three horn antennas with compensated apertures have been developed for electrical boresighting airborne antennas. The antennas suppress sidelobes by 25 db in both the E- and H-plane. The horns cover the 2.1 to 12.4 Ghz band in three steps—2.1 to 4, 4 to 7.8, and 7.8 to 12.4 Ghz.

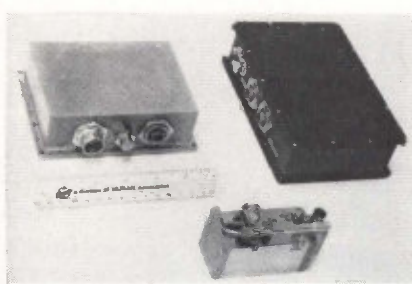
Sidelobe suppression is accomplished by precisely positioning four baffle plates in the pyramidal section of each horn, resulting in binomial aperture distribution in the horn's E-plane. A cosine illumination taper is approximated by coupling the proper amount of energy into each of the horn sectors formed by the baffle plates.

Each horn antenna is bearing-mounted in a precision flange assembly which exactly aligns the electrical and mechanical axis. The bearing surfaces permit horn rotations through a 0 to 90° sector. Further, mechanical limit stops and ball-detent locks, which are precisely located at 0° and 90° points, permit selection of desired E- or H-plane polarization.

Maximum vswr of the antenna is 1.6:1 at the type N female input connector. At the center frequency, the nominal beamwidth is 26° in both planes and the nominal gain is 18 db.

Sperry Microwave Electronics Co., P.O. Box 1828, Clearwater, Fla. **[393]**

Telemetry transmitter rated at 20-w output



A high-power S-band telemetry transmitter is available for use in missile environments. The EM4528 is rated at 20 watts output power, operating at 2.2 to 2.3 Ghz. Frequency stability is ±0.0025%, and is provided through a crystal-referenced automatic-frequency-control servoloop.

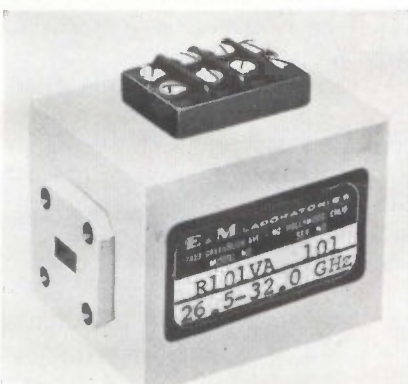
The three-module system includes an exciter, a power amplifier, and a preregulated d-c/d-c converter. All circuits are solid state, except for a rugged planar triode r-f power oscillator. Volume is 110 cu in.; weight, 7.8 lbs.

The EM4528 telemetry transmitter systems will provide high r-f power for any slant range, and will transmit reliably during the stress of missile lift-off. The telemetry system may be field-tuned without special equipment, and is said to be the only one of its kind which has operated successfully during missile launch and flight.

The transmitter system features efficiency of more than 13%, and its high power helps to overcome null and ionization problems which usually occur during down-range transmission. Spurious radiation is avoided because the transmitter generates r-f power directly at the output frequency.

Eimac, division of Varian, 301 Industrial Way, San Carlos, Calif., 94070. **[394]**

Variable attenuators come in 3 models



Ferrite variable attenuators, available in three models, provide complete coverage of the Ka band, 26.5 to 40.0 Ghz.

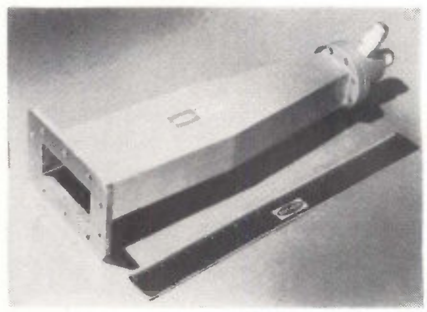
Each model provides continuous, bilateral attenuation to 25 db minimum. Insertion loss is 1.0 db maximum and vswr is 1.3 maximum. Maximum coil current for 25-db minimum attenuation is 100 ma. Model R102VA covers the range from 31.0 to 36.5 Ghz.

These precision units (weighing 3 oz nominal) are suited for applications such as level-set attenuators, servo loop gain controls, on-off switches and amplitude modulators.

Prices may be obtained on request. Delivery is 30 to 45 days after receipt of order.

E&M Laboratories, 7419 Greenbush Ave., North Hollywood, Calif. **[395]**

Waveguide waterload spans 2.7 to 3.8 Ghz



A calorimetric waterload has been developed for high power S-band radars. The G2000T is designed for a variety of applications such as antenna tracking, mobile units, and shipboard and airborne systems. The rugged, compact waveguide waterload measures only 14⅝ in. long and weighs less than 5 lbs.

When used with the proper thermopile and metering, the unit is said to offer an excellent means for reading average power, since its low fluid volume requirement results in unusually fast response in calorimetric measurements.

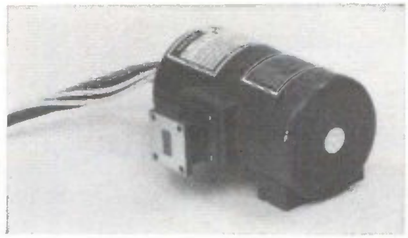
Frequency range for the G2000T is 2.7 to 3.8 Ghz with a 15% bandwidth. Vswr is 1.15 maximum at 80°C. Peak power is 1.5 Mw; average power, 30 kw.

Raytheon Co., Microwave and Power Tube division, Waltham, Mass. **[396]**

Oscillator tube puts out 50 mw

A backward-wave oscillator tube delivers at least 50 mw over a 14-to-17-Ghz tuning range. The magnetically-shielded unit is claimed to be an ideal airborne local oscillator, sweep oscillator, and local oscillator for systems with special packaging requirements. The VA-470N is permanent—magnet-focused.

The compact, convection-cooled



unit is only 3 in. in diameter and 6 in. long, and weighs just 4 lbs. Lighter and smaller models can be supplied for applications requiring less output power and bandwidth.

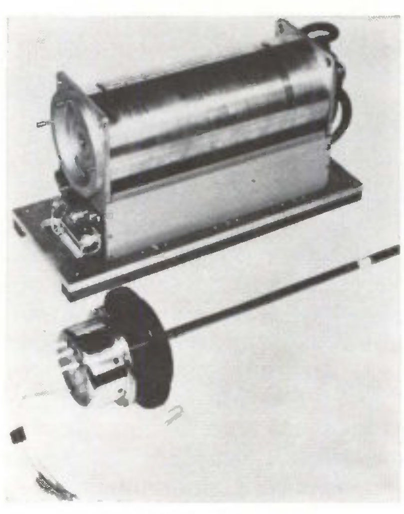
Frequency adjustments are made by varying only the helix voltage. The voltage-versus-frequency curve is exponential and has no discontinuities. A nonintercepting, negative control grid provides means for amplitude modulation without drawing current in the modulation circuit.

Other features include: sturdy metal-ceramic construction, smooth output characteristics, excellent a-m, f-m, and spurious-noise performance, as well as fast sweep-rate capability and outstanding stability, according to the manufacturer.

Small quantity price is under $1,500 each. Delivery takes approximately 60 days.

Varian, Palo Alto Tube division, 611 Hansen Way, Palo Alto, Calif., 94303. [397]

X-band pulsed twt suited for radar



The high power, pulsed traveling-wave amplifier, type TWX16, is suitable for radar applications. It

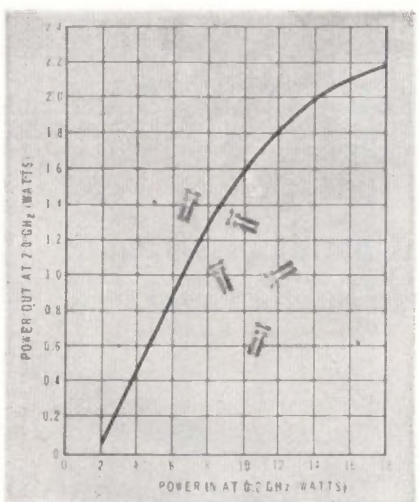
New Microwave

gives over 40 db gain at 5 kw peak output power over a bandwidth of 500 Mhz in the 8 to 9.3 Ghz range. Average power is 30 watts and saturated peak power is 5 to 20 kw. The tube is of metal-ceramic construction with a ring-and-bar slow wave structure that reduces unwanted oscillations. A solenoid mount assembly, type SMX16, focuses the tube and also incorporates the r-f couplings and provides conduction cooling.

The TWX16 operates with the helix maintained at d-c potential to simplify pulse power supply requirements.

The M-O Valve Co. Ltd., a subsidiary of The General Electric Co. Ltd., Brook Green Works, London W.6, England **[398]**

Step recovery diode for telemetry use



Fifteen watts in at 200 Mhz yields 2 watts out at 2 Ghz with the model 0300 step recovery diode. This meets military environmental specifications and one of the unit's important applications is expected to be 2 Ghz telemetry.

The diodes are epitaxial, surface-passivated silicon devices with very abrupt junctions. They are capable of generating high harmonic orders in single stages with good efficiency, the company reports. Maximum power dissipation is 15 w at 50° C case temperature.

The 0300 package features a

threaded base for easy assembly and high power dissipation, and a ground plane flange for positive seating in the holder.

Prices are $55 each in quantities of 1 to 9; $45 each in quantities of 10 to 99. Current delivery estimate is two weeks.

HP Associates, 1501 Page Mill Road, Palo Alto, Calif., 94304. **[399]**

Phase shifter operates in the 805-Mhz range

A varactor-controlled solid state phase shifter has been developed for operation in the 805-Mhz frequency range.

The MA-8352-2L1T features low drive power requirements (typically 0 to 120 v at less than 100 μa), continuously variable phase shift from 0 to 180°, and rapid phase control. Maximum insertion loss is 1.5 db and the vswr is 1.5. The unit can handle power levels up to 100 mw.

The device is employed as an error correction element in a linear accelerator. Other applications include use as a variable phase standard in a microwave impedance bridge, a phase control device in the low level stages of an amplifier chain, and as a modulator for applying audio, video or other data to a microwave carrier.

Availability is 60 to 90 days.

Microwave Associates, Burlington, Mass. **[400]**

Crystal protector features stability

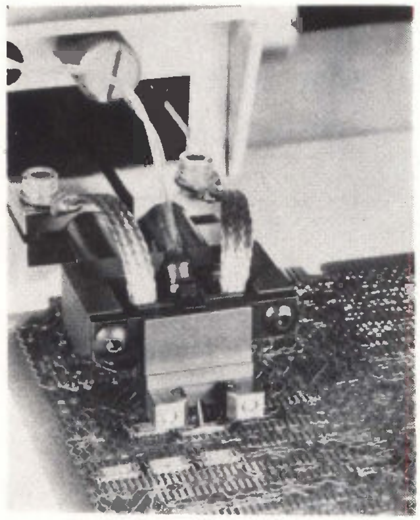
A V-band crystal protector, the BLS-517, is designed for pulsed systems operating between 69.5 and 71.5 Ghz. High-temperature fabrication and processing provide long life and stable operation over a wide temperature range.

General characteristics include a recovery time of 0.5 μsec; insertion loss, 0.8 db; noise figure 0.9 db (including total contribution from insertion loss, ignitor interaction, and ignitor noise); input vswr, 1.3:1; weight, 2 oz; operating temperature, −40° to +85° C; shock, 50 g.

Varian, Bomac division, Salem Road, Beverly, Mass. **[401]**

New Production Equipment

Soldering head joins multilead flatpacks



Model 3007 soldering head allows the attachment of up to seven flatpack leads simultaneously. It features no lead-to-lead voltage gradients, self-alignment, low thermal mass and inertia, and temperature control.

A heated element, specially processed to prevent the application of voltage differentials from lead to lead, reflows the solder on pretinned leads to solder-plated circuit board pads. The patented thermocouple control is employed to sense temperature of the system and terminate the heating rise cycle. The head is spring force limited in the vertical direction and is self-aligning to compensate for boards or fixtures which are not parallel to the surface of the heating element.

Price of the model 3007 seven-lead soldering head is $295.

Development Associates Controls, 123 West Padre St., Santa Barbara, Calif. [402]

Epitaxial system produces films fast

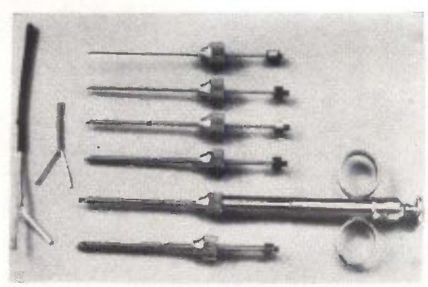
A large epitaxial reactor system, the PMC600, has been developed to meet the requirement for epitaxial slices in the manufacture of microcircuits and discrete component transistors and diodes. The system produces extremely uniform films at the rate of 60 slices per run, says its manufacturer. Until now, according to the manufacturer, the largest systems offered commercially have been under 25 slices per run.

The system is said to produce epitaxial films to specific thickness and resistivity specifications, such as: $\pm 5\%$ film thickness variance within a slice, and $\pm 3\%$ thickness variance slice to slice within the run.

The PMC600 includes a power supply, a 60-slice reactor and a gas control console that can be operated automatically or manually. Price is $41,950 complete; delivery, a maximum of four months.

Pittsburgh Materials & Chemicals Corp., 3400 Old Wm. Penn Highway, Murrysville, Pa., 15668. [403]

Wiring tool separates leads from braiding



The lead ejector is a syringe-like tool that separates the inner lead of a shielded cable from the braiding, making a neatly finished pigtail in one swift operation without breaking wires. No further trimming is needed so the danger from loose wire whiskers getting into electronic equipment is eliminated, the company claims.

Besides aiding in quality control, use of the lead ejector cuts production time and improves the appearance of wiring. It is designed for continuous use and needs little skill to operate. An internal adjustment programs the ejector to produce identical pigtails of any length the user may require.

The tool is supplied with a kit of six interchangeable plungers to fit cable inner lead diameters from 0.039 to 0.140 in. Other sizes of plunger are available to special order.

Price is $36.50; delivery, immediate.

The Bailey Co., 5919 Massachusetts Ave., Washington, D.C., 20016. [404]

Photoresist spinner coats substrates

A four-spindle photoresist spinner, model 1200, has been designed for the uniform coating of semiconductor substrates up to 1½ in. in diameter. It provides independent vacuum switching to allow discriminate use of chucks. Fully controlled solid-state electronic circuitry gives continuously variable 0 to 5,000 or 0 to 15,000-rpm operation with 1- to 99-second time cycling. A front-panel arrest button permits the cycle to be aborted at any time. Dynamic braking imparts instant deceleration. An independent electronic tachometer gives a constant speed check.

A high-quality motor turns the spindles through a power system derived from high-speed grinding-machine-drive principles. The motor is 1/10 h-p, 7,500 rpm, and there are neither clutches nor seals to wear.

Snap-on vacuum chucks run in 3¼-in. diameter resilient polypropylene cups, which retain excess material as well as serving as soft throw-off shields. The cups are easily removed for cleaning and are inexpensive to replace.

Physically, the new spinner is arranged to permit the convenient side-by-side location of as many as three machines for the use of a single operator. The integral design permits easy moving and requires no cutting or drilling. The unit is functionally color harmonized to promote operator-machine compatibility. Controls are grouped for maximum accessibility, convenience, and simplicity to minimize operator error.

Model 1200 spinner is available from stock at a price of $975.

Macronetics, Inc., 220 California Ave., Palo Alto, Calif., 94306 [405]

New Materials

Translucent silicone pours from tube

RTV-118, a clear, precatalyzed liquid silicone rubber is packaged in applicator-type tubes and cartridges as well as bulk containers. The silicone can be used as a potting compound for detailed electrical terminals and apparatus, or as a coating that provides mechanical protection for components. It has a low viscosity (approximately 350 poises at 25°C) in the uncured state.

Following application by brushing, spraying or pouring, RTV-118 cures at room temperature to a flexible, resilient rubber. The curing process starts when the material is exposed to moisture from the air. The material contains no solvent, cures with almost no shrinkage and adheres to most surfaces without the aid of a primer.

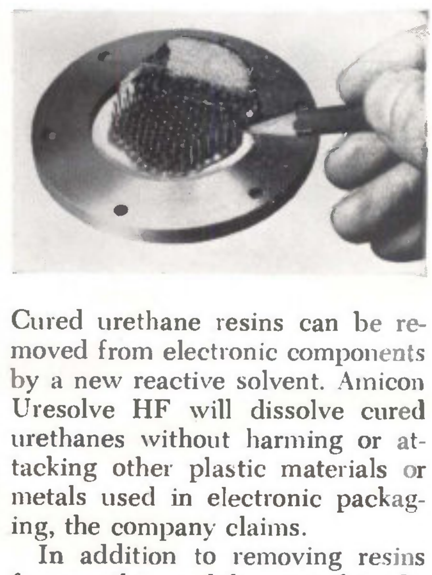
The time required for the material to form a good bond varies with thickness, humidity and temperature. Adhesion continues to improve up to seven days after application. Shear strength on an unprimed surface will be in the range of 80 to 100 psi after 70 hours at 77°F. Priming will improve strength by as much as 50%. The bond strengths obtained with this type of material are claimed to be about 75% to 80% of those achieved with paste-like, one-part RTV silicone sealants.

RTV-118 has a tensile strength of approximately 350 psi after seven-day cure, which is identical to the paste-like, one-part silicone adhesive sealants. It can be employed continuously at temperatures in the −85° to 300°F range but temperatures can be raised to 500°F for short periods. This is similar to the temperature performance of standard silicone adhesive sealants.

Maximum quantity prices are: 3-oz tubes, $1.19 each; 12-oz tubes, $4.60 each; 6-oz polyethylene cartridges, $2.46 each; and 5-gallon pails, $4.90 per lb (45 lbs).

General Electric Co., Waterford, N.Y. **[406]**

Reactive solvent removes urethanes



Cured urethane resins can be removed from electronic components by a new reactive solvent. Amicon Uresolve HF will dissolve cured urethanes without harming or attacking other plastic materials or metals used in electronic packaging, the company claims.

In addition to removing resins from coils, modules, p-c boards, connectors, transformers and controls, Uresolve HF is said to be ideal for reclaiming expensive components and repairing reject assemblies. Other products, the company points out, will either swell or change plastic materials, making reclamation impossible.

Another application relates to packaging. Because of the solvent's slow etching action on DAP and anhydride-cured epoxies, epoxy and other encapsulants adhere better.

Immersing the component in the solvent will completely remove all urethane material. Time depends on the amount of material to be removed. For example, a 1-inch cube of rigid foam will dissolve in one hour or less at room temperature. Printed-circuit board coatings will dissolve in less than an hour. Coatings can be partially removed by brushing or dabbing with a cotton pad, followed by a rinse in water.

Uresolve HF is packaged in containers ranging from 1 quart to 55 gallons. Prices are: 1 quart, $10; 1 gallon, $20; 5 gallons, $15 per gallon and 55 gallon drums, $6.95 per gallon.

Dynaloy, Inc., 408 Adams St., Newark, N.J., 07114. **[407]**

Etch resist-coating for p-c board makers

A nonactivated rosin-base etch resist and protective coating is designed to help manufacture printed-circuit boards faster and more economically.

Called Etchcoat No. 934, the material can be screened onto the raw copper laminate surface in a well-defined pattern and its use eliminates a number of intermediate cleaning and surface protection operations of conventional p-c board manufacture. The Etchcoat was specifically developed to act as an etch resist before etching; after etching it serves as a long-term solderable protective coating which is compatible with all of the company's rosin base fluxes.

Once it's established that the raw copper laminate is solderable, the Etchcoat is screened onto the dry board surface according to a pattern and then cured. A typical curing process would take five minutes at 200°F (93°C). The boards may be etched immediately after curing or can be stored for etching later. Typical etchants—ferric chloride or ammonium persulfate—may be used during etching.

After etching, the boards may be punched and either soldered immediately or stored. Since the Etchcoat also acts as a protective coating, the boards may be stored for long periods without degrading the solderability of the underlying copper surface. The boards may then be taken from storage and soldered (using a rosin base flux) without removing the Etchcoat.

Etchcoat is available in quart, gallon and five-gallon containers.

Alpha Metals, Inc., 56 Water St., Jersey City, N.J., 07304. **[408]**

Circle 319 on reader service card

New Books

Technical writing

Effective Writing for Engineers, Managers, Scientists
Henrietta Tichy
John Wiley & Sons, Inc., 377 pp., $5.95

Henrietta Tichy, an associate professor of English at Hunter College in New York and an authority on technical writing, has produced a guide for those who are tired of formula approaches to better writing and are ready for some serious study.

It is not for the man who wants to settle an occasional argument on grammar. It is, rather, a treatise on organization, emphasis, paragraph development, style, word choice and all the other things that make good writing such hard work. It is a book to be read slowly, earnestly, patiently. The rewards are many: splendid sections on effective organization and fallacies to forget; rich lists of tautologisms and elegant variations, an occasional aphorism ("A little learning can make a very tiring writer"), and some comic relief ("As a suffering reader of many long dissertations, I am often inclined to think that Ph.D. stands for Phony Diction").

Professor Tichy doesn't just solve problems; she annihilates them. To the writer who has trouble beginning a paper she offers "Two Dozen Ways to Begin." If he can begin but is lost for a way to develop his thoughts, she offers analogy, analysis, cause and effect, comparison, definition, details and particulars, examples and illustrations, reiteration and endless variations of these.

"A reader of informational prose," the author says, "is busy and hurried; he wants to grasp as much in as little time as possible." Yet she herself occasionally belabors a point, as in the section on outlining and revising. Sometimes she gives advice that borders on the inane; for instance, the following on instruction manuals: "Words alone may not be enough; illustrations may be necessary." The result is a book that, however excellent, is not for the busy and hurried.

In matters of grammar, Professor Tichy, a very proper writer herself, does her best to sound liberal, at times overdoing it. Her advice on how to avoid the frequent confusion between "disinterested" and "uninterested," for example, is to abandon "disinterested" entirely. Even the permissive Bergen Evans in "A Dictionary of Contemporary American Usage" thinks the distinction worth preserving, and I believe most serious writers would agree.

The author illustrates her points with barrages of quotations, most of which are from technical publications. Except for the repetitions and truisms already noted, she does not talk down to her readers, most of whom will be grateful to be spared a review of fifth-grade syntax. Technically trained readers will also appreciate her logical approaches to paragraph development.

"Effective Writing" may find its chief audience among those who teach writing, both in engineering schools and in industry. This is as it should be, for the author is an old pro at such business. And, through the discipline and pacing of classroom instruction, her excellent material might eventually reach its avowed destination.

Frederick Van Veen
General Radio Co.
West Concord, Mass.

Switching machines

Communication Switching Systems
Murry Rubin and C.E. Haller
Reinhold Publishing Corp., 394 pp., $16.50

The authors have attempted—with considerable success—to cover most of the important factors in the planning and design of communication switching systems. While it is evident their interest is primarily in telegraphy and data switching, they have not neglected voice systems. The text is not confined to switching machines alone, but includes the fundamentals of transmission and traffic. The method of transmitting and the volume to be carried are the most important factors to consider when designing switching equipment.

The treatment is broad, yet usually deep enough to give an appreciation of details. In some cases, however, brevity may leave unanswered questions and force the reader to rely on the references included with each chapter. There is no extensive discussion of design techniques.

Today's communications plant is the result of a long evolutionary process. Recognizing this, the authors devote the first chapter and passages throughout the book to the history of communications systems. This is interesting background and important information in a field where new developments must often be compatible with and dependent upon a vast existing system.

The authors delve into the principles of logic circuits on which the design of a switching machine is based, the principles of the transmission circuits that connect these machines, the patterns of trunking and routing between machines in a network and the nature of the traffic carried by the network. Almost all methods useful in designing combinational and sequential circuits are presented. Unfortunately, as in real life, the choice of which method to use, and when, is left to the reader. Components used for switching, memory and logic operations are described and illustrated with typical circuits. There is sufficient detail to explain how a device functions in a particular system. Chapters on networks and traffic are similarly treated, bringing out the relation to the system as a whole.

After covering fundamentals, the authors launch into the difficult task of describing system synthesis. This reviewer has observed that a vast gap exists between methods for designing small circuits having a few logic elements whose requirements can be precisely stated and the problem of designing a large system whose requirements can be stated only in general terms. The usual way, and the one taken here, is to invent one or more solutions and evaluate them against requirements. The examples are well chosen and illustrate methods now in use.

A final chapter describes a num-

New Books

ber of switching systems that have been built. Time has proved at least one of the systems, the British Post Office's Highgate Wood time-division multiplex, to be of doubtful success. And no mention is made of an important new system, the Bell System's Electronic Switching System Number 1, which has recently gone into production. It is not surprising that this chapter is somewhat out of date since the art is moving so rapidly.

An excellent survey like this covering the principles and techniques underlying large systems for communication switching has long been needed. The technical journals contain many papers dealing with various aspects of this complex subject, but engineers who have not grown up with the art have difficulty placing this information in context with the over-all system. This volume should help them and should be of particular value to those entering this rapidly expanding area.

William Keister
Bell Telephone Laboratories, Inc.
Holmdel, N.J.

Quantum physics for physicists

Advanced Quantum Theory
Paul Roman
Addison-Wesley Publishing Co., Inc.,
735 pp., $17.50

Paul Roman, a professor of physics at Boston University, has brought together many interesting topics in quantum theory, mainly those concerning the application of the theory to nuclear physics. His book will be of interest chiefly to advanced students of nuclear physics. In his effort to cover comprehensively many of the more subtle points of quantum mechanics and quantum theory, the author devotes little space to the basics which would probably be more useful to electronics engineers. The foundations of quantum theory are given, but briefly, and apparently more for the sake of completeness than for informative purposes. Also, practical applications are missing.

All of which cannot be considered a drawback to a book entitled "Advanced Quantum Theory." Roman has done a good job of reviewing and examining various elements of modern advanced quantum theory. He treats each subject clearly and concisely, beginning with first principles, however briefly, and extending to recent results. Unlike some books dealing with recent theories, the notation is consistent throughout.

The book is well written and has a commendable set of problems, together with a number of references and four fine appendixes. Among the recent advances discussed are Richard Feynman's integral equation formulation and the quantum theory of the newly discovered subatomic particles.

Because the text is directed to a specialized audience, engineers not working in nuclear physics should look elsewhere for the answers to their questions about quantum theory.

Albert W. Merrill
University of Southern California
Los Angeles

Recently published

Amplifier Handbook, Richard F. Shea, editor, McGraw-Hill Book Co., 1,495 pp. $37.50

This massive volume may prove to be a classic reference. Twenty-nine authors contributed. The tome is divided into three sections: fundamental network theory, major amplifying devices and amplifier circuits.

Phaselock Techniques, Floyd M. Gardner, John Wiley & Sons, Inc., 182 pp., $8.95

Phaselock problems, from principles through application and testing. Appendixes give mathematical review, design examples, nomenclature and useful formulas. Bibliography is nine pages and references, four and a half.

The Electronic Theory of Heavily Doped Semiconductors, V.L. Bonch-Bruyevich, American Elsevier Publishing Co., 131 pp., $7.50

A review of the quantitative progress made in both the quantum and statistical mechanical aspects of the theory of heavily doped semiconductors by a professor at the Moscow State University. The translation editor, Robert S. Knox, is a physics professor at the University of Rochester.

The Particle Kinetics of Plasmas, I.P. Shkarofsky, T.W. Johnston, M.P. Bachyniski, Addison-Wesley Publishing Co., 518 pp., $17.50

The authors, who work at the RCA Victor Research Labs in Montreal, apply the fundamentals of particle kinetics in gas plasmas to develop basic equations for plasmas under a variety of conditions.

Electron Diffraction and the Nature of Defects in Crystals, Pergamon Press, not paged, $14

Extended abstracts (two and four pages long) of papers presented at a double-barreled conference in Melbourne, Australia, in August, 1965.

Technical Abstracts

Frequency finder

Using frequency synthesizers to evaluate other precision frequency sources

Atherton Noyes Jr.
General Radio Co.
Bolton, Mass.

Unknown frequencies can be measured and displayed instantaneously if a frequency synthesizer is used as a measuring instrument as well as a signal source. The accuracy of the measurement is as good as that of the synthesizer and the frequency measured is limited only by the range of the synthesizer.

Frequencies are generally measured by counting or heterodyning methods. Counting has the disadvantage of giving only the average frequency during the counting interval. It also requires a long interval to resolve the measurement to fractions of a hertz. But it does provide measurement in discrete steps. Heterodyning gives instantaneous measurement, but not discrete steps.

With a frequency synthesizer, discrete frequencies can be measured instantaneously, by finding the zero beat—or direct match—between the unknown frequency and that set on the synthesizer. The synthesizer acts as a frequency standard whose output is equal to the unknown one, or an exact multiple or submultiple of the unknown frequency.

The instant at which a match is found can be determined on an oscilloscope by watching the Lissajous figure. For example, if two stable and supposedly identical frequencies differ by only one millihertz, the discrepancy is apparent in the one-to-one goose egg pattern on the scope. Any phase jitter present will also be apparent. The discrepancy in the frequencies can be determined by adjusting the synthesizer until the Lissajous pattern is a normal one.

The counting technique would require 1,000 seconds to determine that a 1-millihertz discrepancy existed. Any momentary wandering of the unknown frequency during this time would be obscured in the averaging process and could only be detected after many repetitive measurements and statistical analysis of the results.

Suitable frequency synthesizers include those which resolve in steps any desired frequency by means of a repetitive series of circuits. Several available synthesizers of this type have independent controls for setting each digit in the number that defines the output frequency. Most of the available synthesizers also contain a voltage-tunable oscillator that can be continuously adjusted and inserted into the digit train to replace any of the step-adjusted digits.

Since frequency synthesizers are standard laboratory instruments, their use as a measuring device can supplant conventional instruments like error multipliers—used only to compare two frequencies.

Presented at the 21st Annual Instrument Society Conference and Exhibit, New York, Oct. 24-27.

F-m recording

A period modulated carrier technique for data recording

M.A. Maclean
Defense Research Telecommunications Establishment, Ottawa, Ontario

Linearly modulating the period of a carrier overcomes the harmonic generation problem posed by conventional frequency-modulation recorders when the signals recorded have very low frequency components. A harmonic suppression filter isn't needed in the recorder's discriminator and deficiencies in low-frequency response and linearity are bypassed.

The linearly modulated signal provides the discriminator with two independent pieces of timing information—the intervals between peaks of the playback waveform and between zero crossings of the waveform. The duration of each half cycle is a linear function of the amplitude of the signal waveform at the end of a half cycle.

Each reversal of the carrier causes the discriminator to sample a linear voltage ramp. The samples and a peak detector ahead of the demodulator are used to reconstruct the original signal.

Second harmonic output is low because the durations of the carrier half cycles are equal. However, the positive and negative cycles must be symmetrical to prevent noise.

Presented at the Aerospace and Electronics Conference, Washington, Oct. 3-6.

Combining network

40-watt solid state uhf transmitter
R.A. Gardenghi and W.R. Olson
Westinghouse Electric Corp.,
Baltimore, Md.

Although the maximum power output of available ultrahigh-frequency transistors was only five watts, a solid-state transmitter was built that delivers up to 40 watts at 225 to 400 megahertz. The outputs of eight transistors were combined. At lower frequencies, the outputs of up to 60 transistors have been combined.

The basic module in the power stages is a 5-watt amplifier built with a 2N3375 transistor. Gain ranges from 8 decibels at 225 Mhz to nearly 4 db at 400 Mhz. One module forms the first stage, two the predriver stage, four the driver stage and eight the output amplifier. The module outputs are tuned at the outputs of the power combiner networks.

Combining networks are made of transmission-line transformers. N coherent sources are connected to a load, Z_L, through a quarter-wave transmission line whose characteristic impedance equals NZ_L. Isolation between sources is achieved by a star arrangement of resistances equal to Z_L with one point of the star attached to each output. No power is dissipated in the star as long as the sources at each input are coherent.

The 2:1 combiner consists of two quarter-wave transmission lines tied together at one end and having a 100-ohm resistor between the other ends. The 4:1 combiner also follows the basic design. The 8:1 combiner is made from two 4:1 combiners and one 2:1 combiner. Turned around, the combiners function as dividers.

An appropriate sequence of combiners and dividers is used to combine the power from each stage, share it among the amplifiers of the succeeding stage and combine the final outputs. The modulation

Technical Abstracts

signals are applied to the collectors of the drivers and output transistors.

Over-all, the system provides the 53 db of gain needed for a continuous-wave output of 40 watts or 10 watts of carrier output for amplitude modulation. It can also be used as a phase or frequency modulated amplifier.

Presented at the National Electronics Conference Chicago, Oct. 3-5

Tuned antennas

The rectangular cavity slot antenna—theory and design
A.T. Adams,
Syracuse University, Syracuse, N.Y.

Experiments indicate that cavity backed slot antennas can be tuned over a broad band with an applied magnetic field when the antenna is loaded with dielectric, powdered ferrite or solid ferrite.

To build a foundation for his report on the experimental antennas, the author first describes admittance characteristics and calculations, followed by design guides and optimization procedures for operating frequency, bandwidth and efficiency. Experimental data on aperture admittance and operating frequency agreed within a few percent of theoretical data. Efficiency was within 10% of calculations and bandwidth within 20%.

Several different models were made, for operation at frequencies around 300 megahertz. In size and weight, the models were far smaller than air-loaded antennas—as small as 15 cubic inches for an antenna loaded with solid ferrite compared with 2,250 cubic inches for an air-loaded antenna. However, bandwidth and efficiency were also lower. Bandwidth ranged from about one-third to one-sixth that of the large antenna. Efficiency ranged from 30% to 85% compared with 90% for the air-loaded antenna. Directivity was 5 decibels compared with 5.8 db.

The resonant frequency of a ferrite-loaded antenna was raised from 243 Mhz to 320 Mhz, by increasing the applied magnetic field from zero to above one kilogauss.

Presented at the National Electronics Conference, Chicago, Oct. 3-5

New Literature

MOS monolithic subsystems. Philco-Ford Corp., a subsidiary of Ford Motor Co., 2920 San Ysidro Way, Santa Clara, Calif., 95051. A booklet compiled by the company's engineering staff serves as an introduction to the metal oxide silicon monolithic subsystem, a device that offers the same advantages over the conventional double-diffused IC that the transistor originally had over the tube.
Circle **420** on reader service card.

A-c to d-c converter. North Atlantic Industries, Inc., Terminal Drive, Plainview, N.Y., has issued a two-page data sheet on the model PSC-419, a phase-sensitive a-c to d-c converter. **[421]**

Engineering plastics. General Electric Co., Pittsfield, Mass. Brochure CDC-450 lists the mechanical, electrical and thermal properties of Lexan polycarbonate resin, PPO polyphenylene oxide resin, Noryl resin and phenolic molding compounds. **[422]**

Basic reed switch unit. MicroSwitch, a division of Honeywell, Inc., 11 W. Spring St., Freeport, Ill., 61032, has a bulletin on the 1KM series miniature basic dry reed switch unit, that contains two reed switches and a spring-loaded permanent magnet attached to the switch plunger. **[423]**

Microwave swept oscillators. E-H Research Laboratories, Inc., 163 Adeline St., Oakland, Calif., 94607, has issued a six-page color brochure on the model 570 series microwave swept oscillators which cover the 1 to 40-Ghz range. **[424]**

Precision fine wire facilities. Fort Wayne Metals, Inc., 3211 MacArthur Drive, Fort Wayne, Ind., 46809. A four-page brochure, Monograph No. 1, describes the company's facilities to manufacture drawn brazed-strand precision alloy wire. **[425]**

Switches. The Digitran Co., 855 South Arroyo Parkway, Pasadena, Calif., offers a 54-page thumbwheel switch catalog that includes descriptions of all Digiswitch and Miniswitch units with complete technical data on each. **[426]**

R-f terminations. Bird Electronic Corp., 30303 Aurora Road, Cleveland, Ohio 44139. Catalog TLR-5-600-66 lists the company's line of dry and oil-cooled terminations in the power ranges between 5 watts and 600 watts. **[427]**

Transistor parameter measurements. Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif., 94304. Application Note 77-1 describes an important scattering technique for measuring the characteristics of transistors in the 100 to 1,000 Mhz range. **[428]**

Differential amplifier. Computer Test Corp., Cherry Hill, N.J. Engineering bulletin 66-I describes model 2261, a differential sense amplifier with a 50-Mhz upper bandpass. **[429]**

Electronic kits. Heath Co., Benton Harbor, Mich., has available the 108-page 1967 edition of the Heathkit catalog, illustrating over 250 easy-to-build electronic kits. **[430]**

Resistor networks. CTS Research, Inc., 1201 Cumberland Ave., West Lafayette, Ind. Data sheet 3770 gives complete technical details on a line of high-power resistor networks with cermet reliability. **[431]**

IC logic cards. Engineered Electronics Co., 1401 East Chestnut Ave., Santa Ana, Calif., 92702, has published a 20-page technical catalog describing dual in-line integrated-circuit logic cards and related equipment. **[432]**

Backward-wave oscillators. Watkins-Johnson Co., 3333 Hillview Ave., Palo Alto, Calif., 94304. A four-page folder illustrates and describes backward-wave oscillators for military and commercial applications. **[433]**

Germanium transistors. General Instrument Corp., Semiconductor Products Group, 600 W. John St., Hicksville, N.Y., 11802. A comprehensive germanium transistor application guide lists over 130 types manufactured by the company. **[434]**

Power supplies. Electronic Research Associates, Inc., 67 Sand Park Road, Cedar Grove, N.J., 07009. A catalog presents a complete range of power supplies including a-c to d-c, d-c to a-c, a-c to a-c and d-c to d-c models for industry and the military. **[435]**

Decade counter. United Computer Co., 930 W. 23rd St., Unit 8, Tempe, Ariz., 85281, has published a bulletin on the model 1841B decade counter, a compact unit featuring 3-v operation, high reliability integrated circuits, plus 8-line BCD output. **[436]**

Economy semiconductors. Texas Instruments Incorporated, P.O. Box 5012, Dallas, Tex., A 12-page booklet covers product characteristics, application advantages and typical uses of plastic-encapsulated, economy semiconductors for commercial, military and industrial purposes. **[437]**

Millisecond operation recorder. Fischer & Porter Co., 997 Jacksonville Road, Warminster, Pa., 18974. Specification sheet 30A1400 describes the MOR (millisecond operation recorder) that provides an automatic, permanent record of plant operations. **[438]**

Servo analyzer. Canoga Electronics Corp., 8966 Comanche Ave., Chats-

New Literature

worth, Calif., 91311, has issued a two-page data sheet on the model 910A Servodyne, a general purpose servo analyzer. **[439]**

Custom power supplies. Sola Electric division of Sola Basic Industries, 1717 Busse Rd., Elk Grove Village, Ill. Custom-designed power supplies are described in 24-page brochure PS-100. **[440]**

Solid state counters. Anadex Instruments Inc., 7833 Haskell Ave., Van Nuys, Calif., has available a six-page catalog dealing with over 30 standard and special application solid-state counters. **[441]**

Bandpass variable filter. Krohn-Hite Corp., 580 Massachusetts Ave., Cambridge, Mass., 02139. A two-page technical data sheet describes the model 3100 solid-state, bandpass variable filter. **[442]**

D-c to a-c converters. Carter Motor Co., 2762A W. George St., Chicago, Ill., 60618, has released its 1967 catalog, No. 167, covering a line of d-c to a-c converters. **[443]**

Electron tubes. Amperex Electronic Corp., Hicksville, L.I., N.Y., 11802. A condensed catalog, containing descriptions and basic specifications of the company's tube line, serves as a quick reference guide for designers as well as for replacement tube buyers. **[444]**

Resistors. Dale Electronics, Inc., Box 609, Columbus, Neb., 68601, has available a 48-page catalog covering its entire line of standard wire-wound and film resistors. **[445]**

Relays. Adams & Westlake Co., Elkhart, Ind., 46514. Characteristics of an extensive line of mercury-wetted contact relays are discussed in a revised 22-page catalog. **[446]**

Camera channel. The Marconi Co., Ltd., Basildon, Essex, England, offers a brochure that illustrates and describes the V321 vidicon camera channel, which consists basically of a camera and a control unit interconnected by a multi-cored cable. **[447]**

Analog modules. Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz., 85706, offers a catalog describing several broad lines of analog modules including operational amplifiers, function modules, instrumentation amplifiers, power supplies and accessories. **[448]**

Deflection yokes. Syntronic Instruments, Inc., 100 Industrial Road, Addison, Ill. Bulletin 66-6 discusses two new shielded, scan-converter deflection yokes designed for $1\frac{1}{2}$-in. neck diameter scan-converter storage tubes. **[449]**

New Literature

Adjustable stop switches. RCL Electronics, Inc., One Hixon Place, Maplewood, N.J., 07040. A four-page bulletin contains information on a series of ½-in. rotary switches with adjustable stops. [450]

Pressure transducer. Taber Instrument Corp., 107 Goundry St., North Tonawanda, N.Y. Product sheet P-66F7 gives specifications for the F-7, a general purpose pressure transducer. [451]

Tape recorder/reproducer. Leach Corp., 1123 Wilshire Blvd., Los Angeles, Calif., 90017. An eight-page brochure details complete data on a 54-lb portable tape recorder/reproducer that provides instrumentation-quality recording, storage and reproduction of direct, f-m and digital data. [452]

Amplifier and power supply. Massa division, Dynamics Corp. of America, 280 Lincoln St., Hingham, Mass., 02043, has available a data sheet on the model AM-1, a 60-db solid state amplifier and power supply. [453]

IC products. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass., 02138. Two new product folders introduce a comprehensive line of advanced integrated circuit logic assemblies and accessories. [454]

Counter-display instrument. Janus Control Corp., 296 Newton St., Waltham, Mass. Bulletin A076-022 describes the model 650/630, a 5-Mhz, bidirectional digital counter-display instrument. [455]

Pressure transducers. Sparton Corp., P.O. Box 1784, Albuquerque, N.M. Product data sheets 19 and 20 give detailed descriptions and specifications on the types 880 and 890 pressure transducers for use in aerospace and severe environments. [456]

Mixer/modulator. Aertech, 250 Polaris Ave., Mountain View, Calif. A data sheet covers specifications and applications information for model MX500, a vhf mixer/modulator. [457]

Operational amplifiers. Analog Devices, Inc., 221 Fifth St., Cambridge, Mass., offers an application note, which is part 4 of a series entitled "Offset And Drift In Operational Amplifiers." [458]

Power supplies. Elasco Inc., 33 Simmons St., Boston, Mass., 02120. Bulletin 666 describes the 2MS series of dual-source power supplies and the Q series of Microsource power supplies. [459]

Microminature relays. C.P. Clare & Co., 3101 Pratt Blvd., Chicago, Ill., 60645. Type MF (sixth-size) crystal can relays are described in detail in data sheet No. 756. [460]

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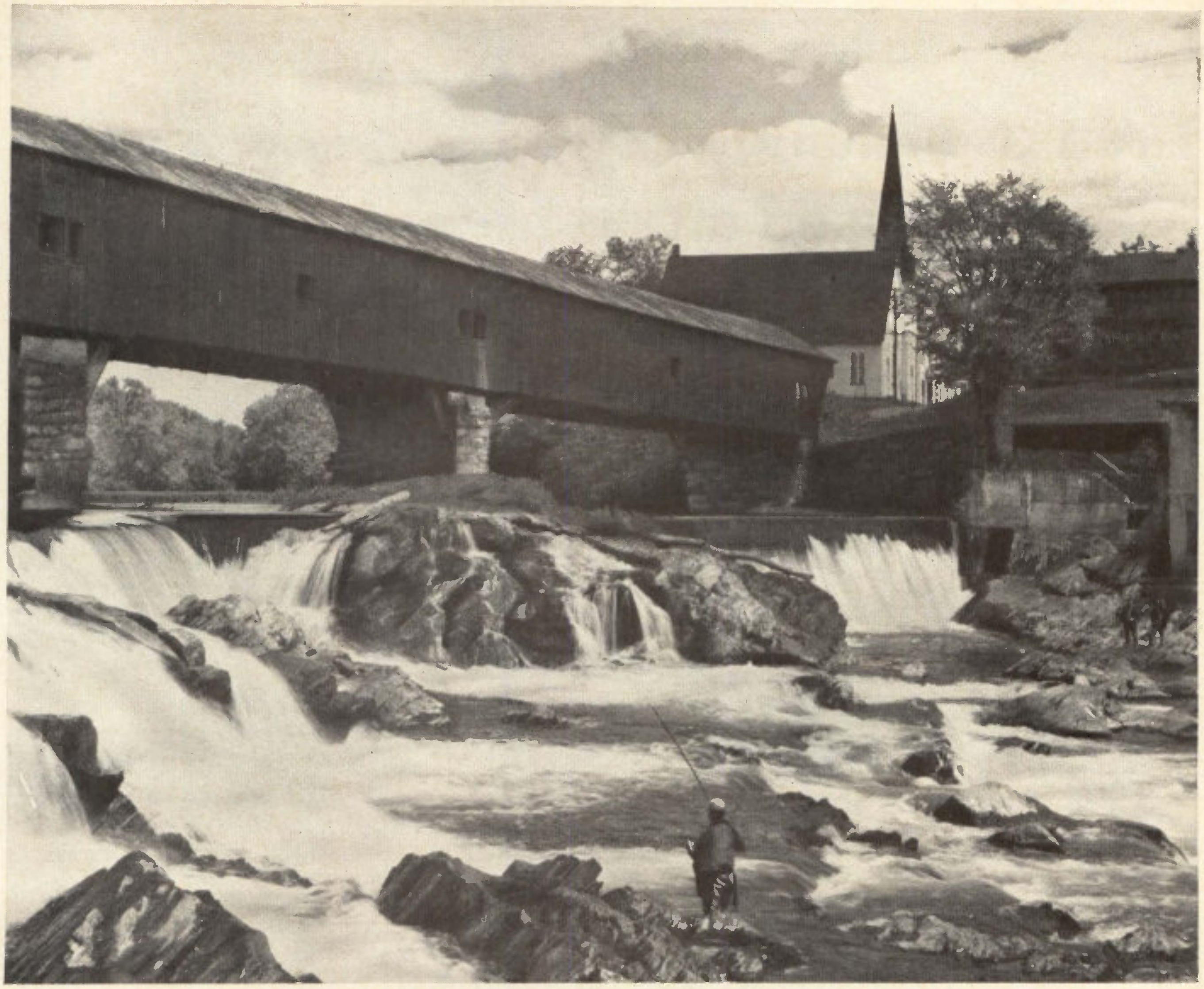

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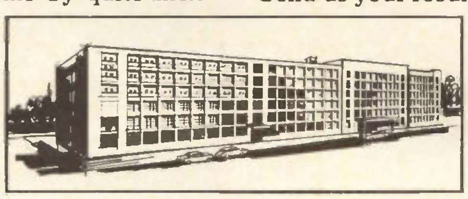

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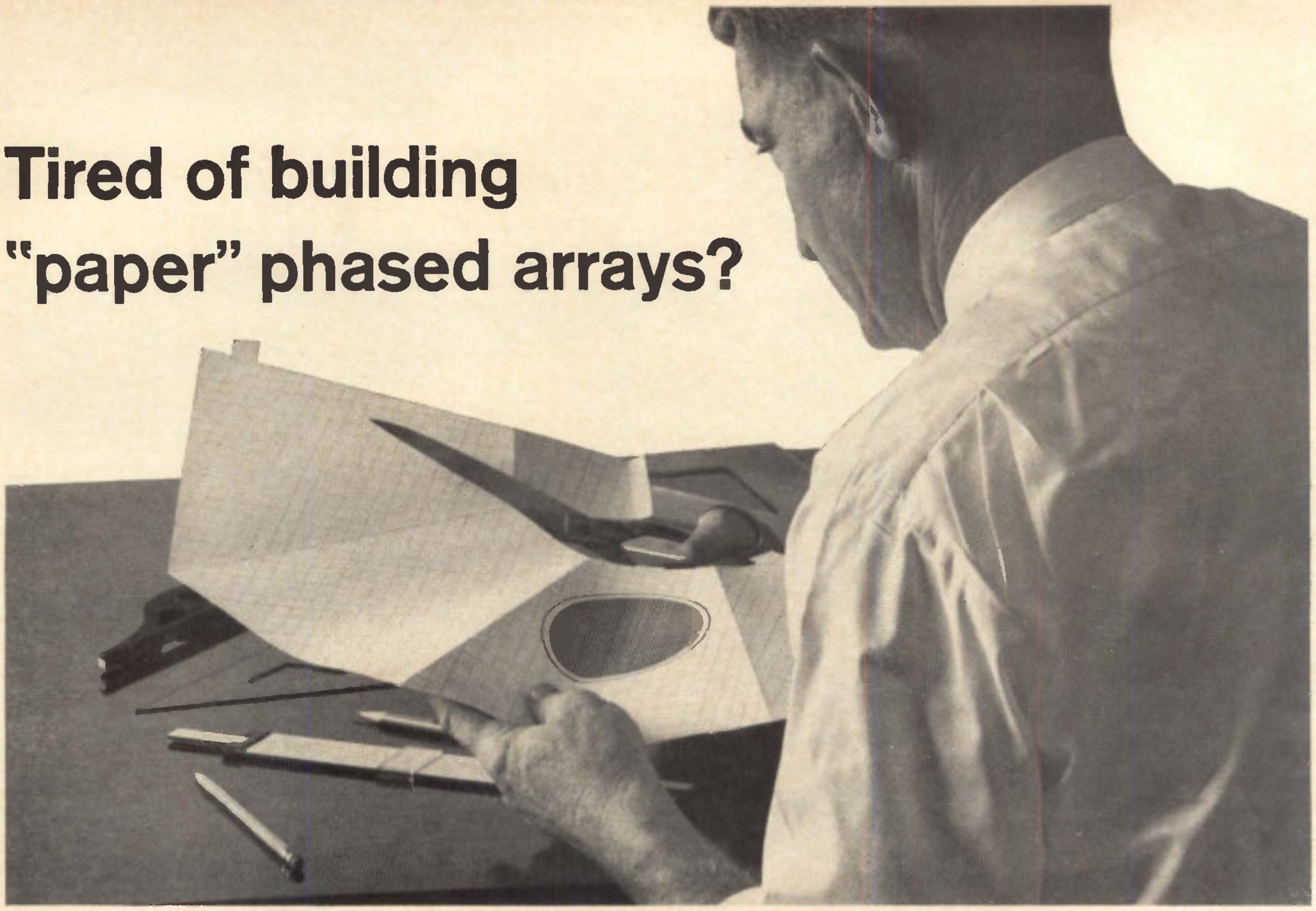

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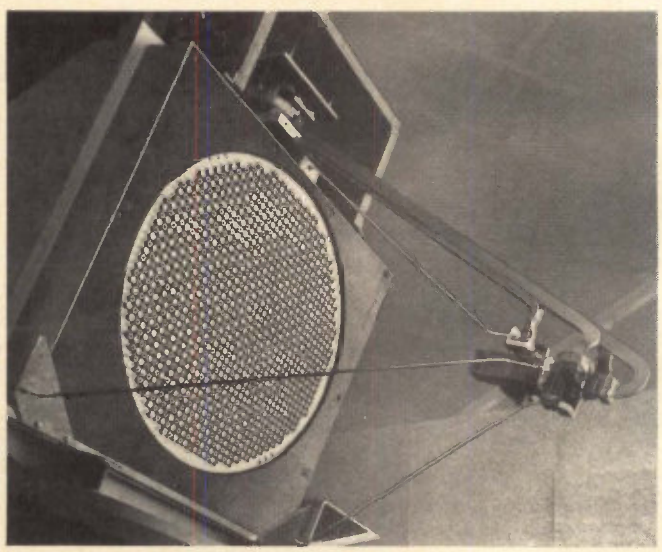

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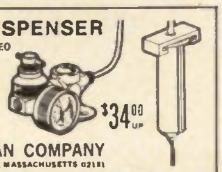

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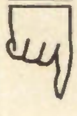

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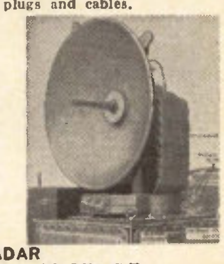

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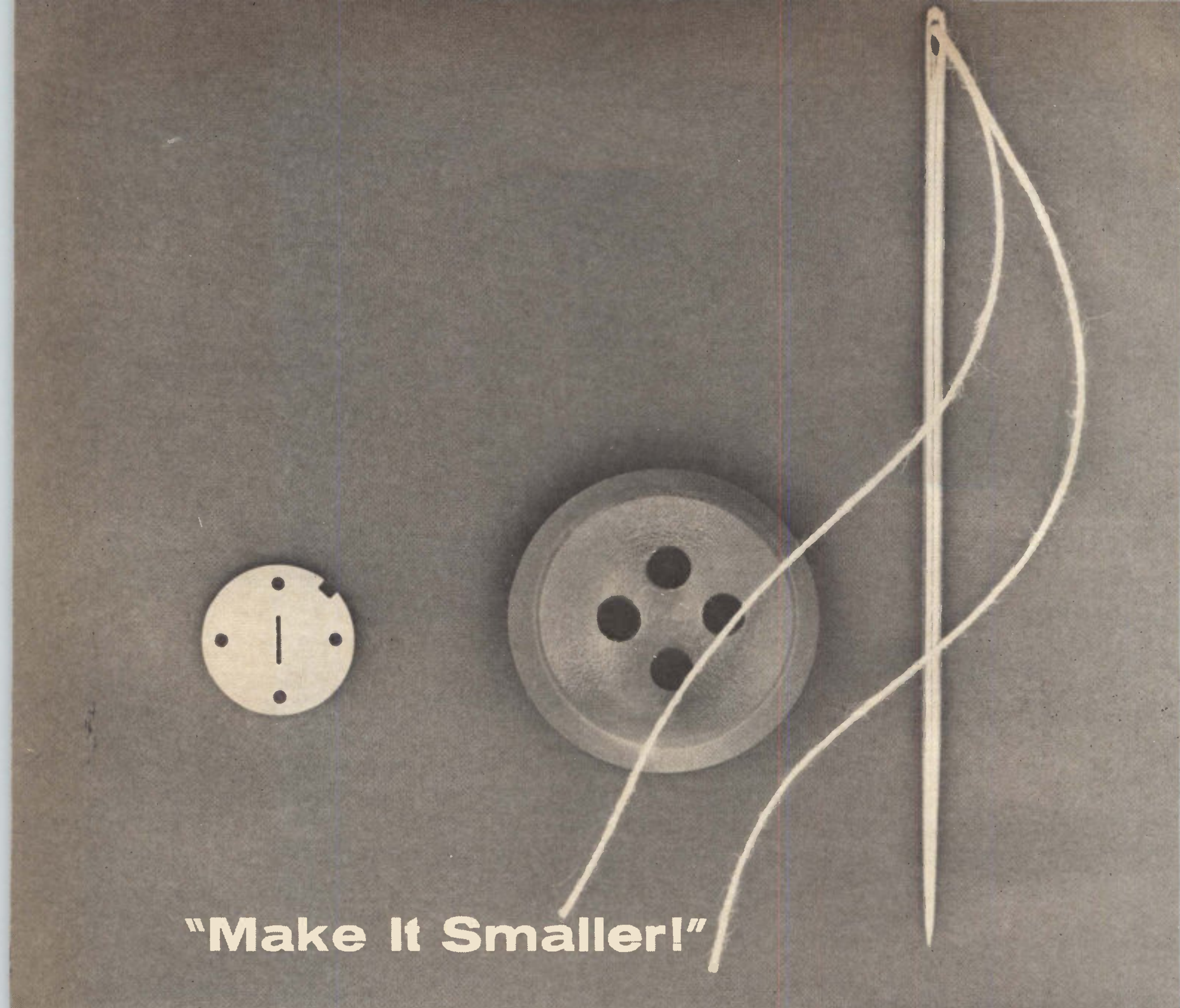

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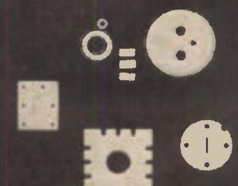
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Newsletter from Abroad

November 14, 1966

IC's a dilemma for some Britons

The Labor government's latest move to foster advanced technology poses a dilemma over integrated circuits for all but the largest companies.

Starting this month, British components makers can shelter behind a tariff barrier of 30%, part of the Laborites' effort to nudge companies into advanced techniques like IC's. But some in the electronics industry think the move could backfire. If too many firms go into IC production, they say, all but a few will become casualties. What's more, American companies like Fairchild Camera & Instrument Corp. and Texas Instruments Incorporated already have reacted to the high tariff. To cope with it, they plan to step up output of their British subsidiaries, promising rough competition for British companies that want to get into IC production.

As a result, prospects are dim for anyone who tries to get into the IC field from scratch. E.M.I. Electronics Ltd., for example, recently joined forces with the Hughes Aircraft Co. to strengthen its IC position. Elliott-Automation Ltd. has a tie with Fairchild. However, Elliott is rushing construction on a $560,000 research facility where it will develop its own IC technology.

Even some large firms like The Plessey Co. are having second thoughts about spending big money to get into IC's when a shakeout looks inevitable. For smaller companies the dilemma is even worse. If they don't switch to IC's soon they may well find themselves with no business by the early 1970's. On the other hand, committing capital now for IC development is difficult. The money market is tight and prospects for a profit are practically nil for the short term.

India reviews television's role

The Indian government plans to take a second look at its policy on the widespread introduction of television. Current plans call for holding off any mass debut until the early 1970's; only five educational tv stations are scheduled to be on the air before then. However, some government planners now think an extensive tv network would be the best way to get information for improving agricultural productivity out to the villages. This puts tv in a new light. As an investment to better the lot of villagers, tv would have high priority. So far, it has been considered a frill.

The review of the government's stance on tv will be part of an effort to implement a recent study that put India's electronics requirements at $3 billion for the 10-year period ending in 1975. To fill them, plant investments totaling $650 million will be needed. Although it is actively wooing foreign companies, the government is sticking to its requirement that companies setting up production plants also do some research and development in India.

Labor promises to buy Australian

Electronics has become a campaign issue in Australia. The opposition Labor Party has picked up the cry of the electronics industry that the government has been passing over home firms and buying defense equipment overseas, mainly in the United States. The industry was especially incensed by recent Australian army acceptance trials of imported tactical radar sets. No domestic supplier was asked to submit designs.

In their bid for victory in the Nov. 26 general election, the Laborites have promised to steer defense orders to Australian companies if their party is returned to power after the ballots are counted.

The campaign pledge comes as the industry is in the midst of a major expansion aimed at cutting imports of military equipment. Manufacturing capacity has been substantially increased in the past few years. Companies like Amalgamated Wireless Ltd., Fairchild Camera & Instrument Corp., Plessey Ltd., EMI Electronics Ltd., Texas Instruments Incorporated and Standard Telephones and Cables Ltd., a subsidiary of the International Telephone and Telegraph Corp., all have spent heavily recently to expand their Australian research and manufacturing facilities.

French maneuver may win Spain for Secam

France now seems to have the upper hand in the jousting to determine which color television system Spain will adopt—PAL or Secam.

After discussions with France's Alain Peyrefitte, Spain's Minister of Industry, Gregorio Lopez Bravo, has agreed to let a team of Secam experts come to Spain next year. The French team will help the state-owned network Television Espanola prepare for color telecasting and then report to the Spanish government, which has the final word on the choice. Secam (for sequential and memory) was developed in France and already has been adopted there and in the Soviet-bloc countries. PAL (for phase-alternation-line) has most of the other European countries in its camp.

The French move surprised backers of PAL and puts them behind in the struggle to win the Iberian market. Both Portugal and Morocco will follow Spain's lead in color tv. [Electronics, Oct. 3, p. 251].

PAL, however, is not yet out of the running. The West German government might well insist on an equal chance for the system, developed by Telefunken AG. West Germany could apply considerable pressure on Spain since the Spanish government is counting heavily on West German backing in its bid for entry into the Common Market.

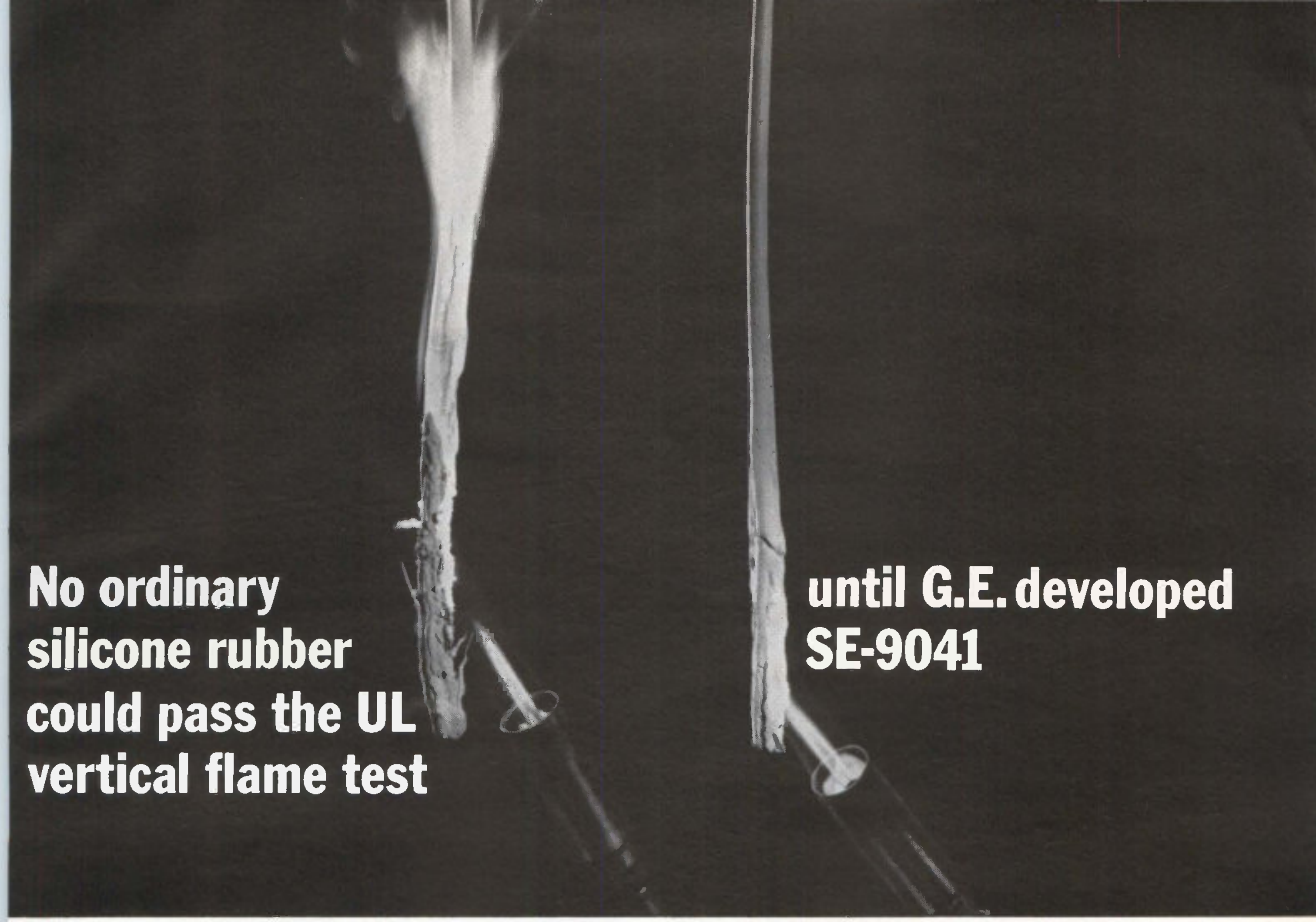
British to try garnet crystals for flat display

A British researcher has come up with a twist that points to still another promising candidate for flat-screen displays to replace bulky cathode-ray tubes. The twist: garnet crystals whose dipoles rotate clockwise or counterclockwise depending on the direction magnetizing current passes through a grid of wires in the display. Rotated clockwise, the dipoles pass light; rotated counterclockwise, they block light. A similar display, but with submicroscopic dipoles dispersed in liquid, has been proposed by Marks Polarized Corp., a U.S. firm [Electronics, July 25, p. 41].

According to A.W. Simpson of the University of Sussex, who invented the device, a 10-inch screen would have 70,000 garnet crystals. Because the crystals are not transparent to visible light, polarized infrared light is beamed on them. The infrared light that passes through the crystals rotated clockwise to form an image is made readable by an infrared converter.

Along with its thinness—the device is about 1-inch thick—the display has the advantage of inherent memory: each crystal remains magnetized in one direction until a current pulse in the opposite direction switches it. As a result, bandwidth needed to change images is only about 500 kilohertz, much lower than a conventional television display.

The British government's National Research Development Corp. sees enough promise in the garnet crystal display to fund feasibility studies on the device. Target date for a prototype is fall 1968.



No ordinary silicone rubber could pass the UL vertical flame test

until G.E. developed SE-9041

Ordinary silicone rubber wire insulation was only half-safe. It met Underwriters' Laboratories requirements when held *horizontally* over a flame, but flunked UL's *vertical* flame test. That's why General Electric developed SE-9041 — the first economical silicone rubber insulation to pass *both* UL flame tests. New SE-9041 meets UL specifications as insulation for any size conductors without flame-retardant exterior braids or saturants.

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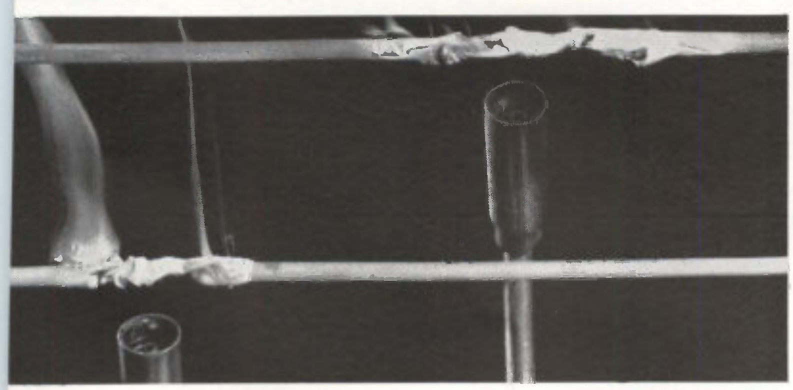
But that's only part of the story. SE-9041 is also superior in dielectric strength. A No. 22 AWG conductor insulated with a 75 mil wall of SE-9041 would have a typical breakdown voltage of 500 volts/mil a-c. About 50% higher than values obtained with previous silicone rubber compounds! We especially formulated this new silicone rubber insulation to hold high-voltage stresses for prolonged periods of time.



For horizontal wiring requirements, any silicone rubber insulation provides superior resistance to flame propagation. It's on the vertical jobs that SE-9041 built a reputation as a firefighter. First among lower-priced silicone insulations to pass the demanding UL vertical flame test.

GENERAL ELECTRIC

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Send me a free sample of SE-9041, plus all the literature you can put your hands on.

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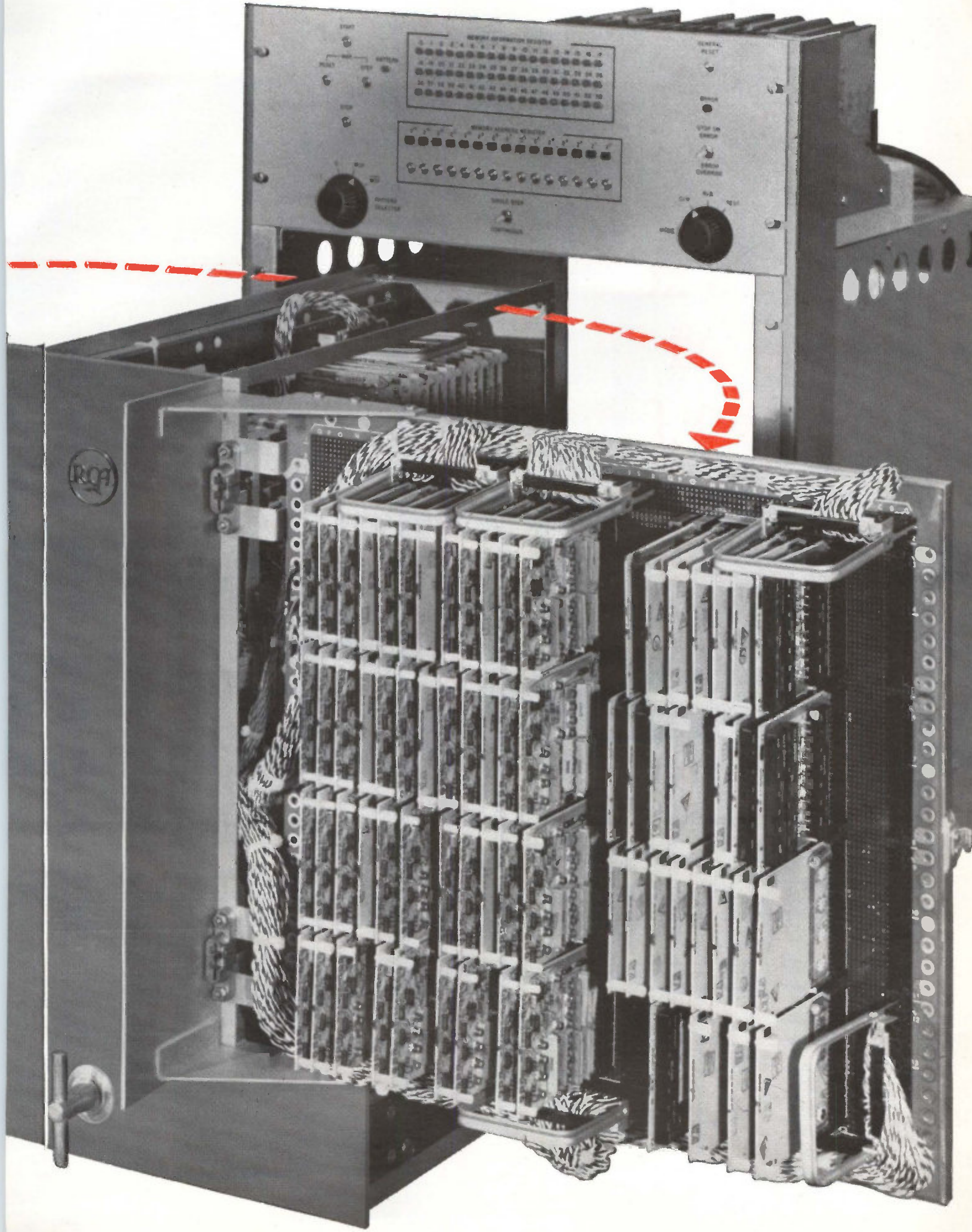
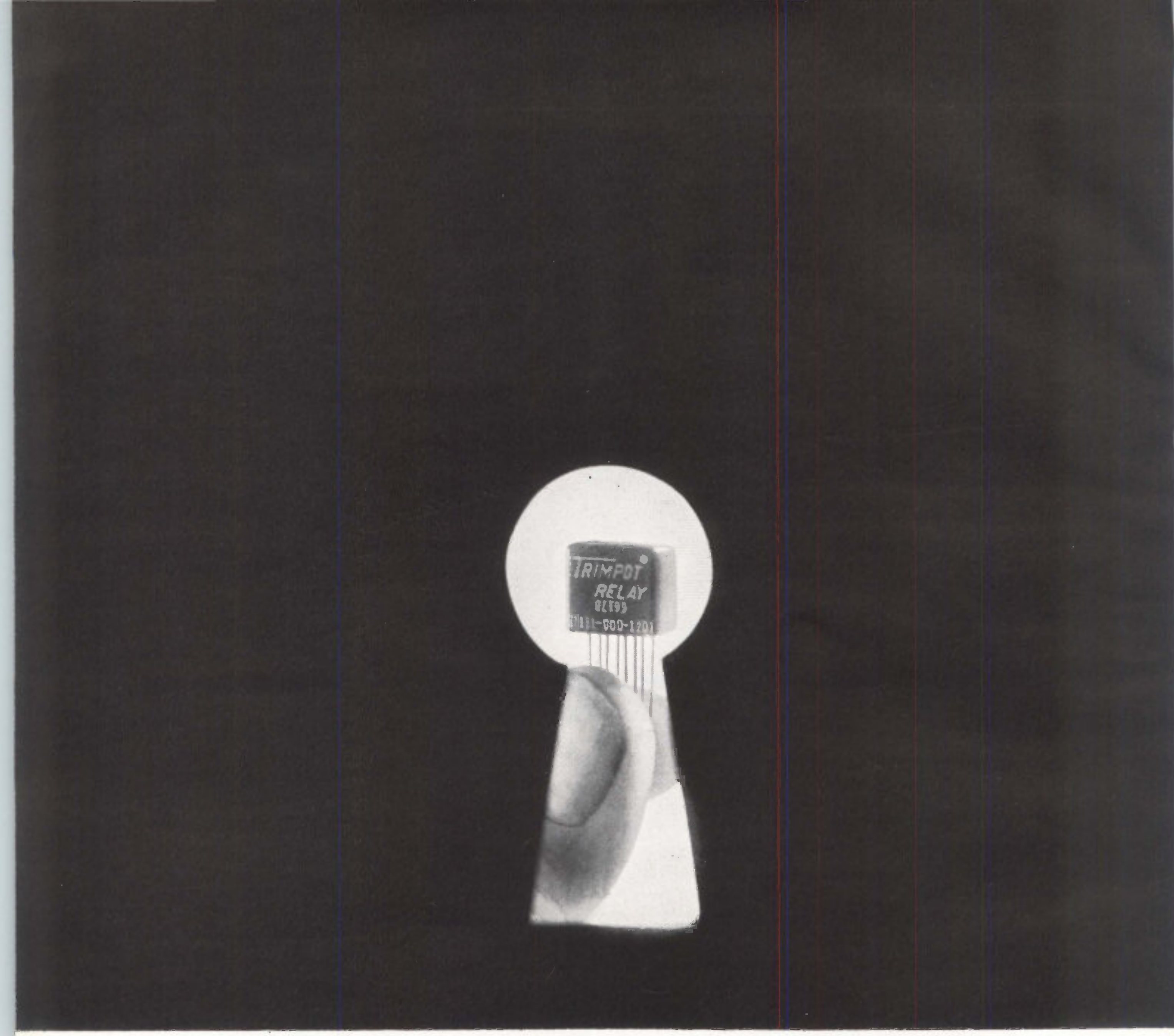
Circle 339 on reader service card





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Designed specifically for industrial use, the Model 3118 clearly reflects Bourns' long experience in military relays. It has the same type motor assembly and structure as the highest quality MIL unit and provides the same 100,000-cycle life. Also, it undergoes the same 5000-operation run-in as well as the rigorous final inspection for coil resistance, dielectric strength, operate and release time, pickup and dropout values, contact resistance and contact bounce. In addition, its damped return spring and balanced armature design assure excellent resistance to shock and vibration.

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Size:	0.26″ x 0.53″ x 0.43″
Pick-up sensitivity:	200 mw, max.
Contacts: DPDT; rating:	1.0 amp resistive at 28 VDC
Operating temp. range:	—55 to +85°C
Shock:	50 G, 11 ms
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Circle 342 on reader service card

November 14, 1966

Electronics Abroad

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Number 23

International

City lights

New York excepted, major cities around the world are faring well with their efforts to unsnarl traffic jams by digital-computer control of stop lights.

Late this month or early next, for example, a Siemens VSR 16,000 computer will take charge of 14 key intersections in Hamburg, first phase of a system that eventually will cover all the major intersections in the city. London traffic authorities haven't run into any snags so far in their scheme to control 68 intersections starting next spring with a Plessey XL digital computer. And the installation of an 80-light experimental system based on a Marconi Myriad computer is proceeding without a hitch in Glasgow.

It's not likely that the troubles New York City is having with its upcoming system, by far the most ambitious yet planned, will scare city fathers elsewhere away from computer traffic control. New York's troubles are with the radar traffic sensors [Electronics, Aug. 22, p. 37]; nearly every one else uses induction loops as sensors. What's more, the systems already operating abroad have performed superbly, so much so that most are being expanded.

Toronto. The first major city to use computer control in a big way was Toronto, which now has a $5 million investment in its system. On its investment, the city has had a substantial return. Its traffic commissioner estimates that trip times have been reduced by as much as 20% and that the number of involuntary stops has been slashed by more than half.

Toronto now has some 500 traffic lights—covering the major arteries—under computer control. Next year, the remaining 250 signals on lightly traveled streets will be tied into the system, which uses a Univac 1107 as its primary computer.

Working with the 1107 is a modified Univac 418 that serves as an on-line input-output buffer for the main computer. With this setup, all automatic control of the lights would be lost should the Univac 1107 go out of operation. Toronto city officials may eliminate that possibility. They are thinking of adding a small magnetic drum memory and two tape units to the Univac 418 so it could carry on alone if the 1107 goes out of operation.

West Berlin. Although they've had nearly 20 months of experience with it, West Berlin city officials still regard their 10-intersection system as experimental. But the results have been good enough for them to plan to add another 27 intersections soon.

A Siemens VSR 16,000 computer (VSR is the acronym for the German words meaning traffic signal computer) rides herd on the present system [Electronics, Sept. 6, 1965, p. 178]. At two intersections, the stop lights are controlled in a pattern that varies with traffic flow. For the other eight intersections, there's a fixed-time program independent of traffic flow.

One of the 10 intersections controlled still retains the original ultrasonic and pressure-tube sensors, but it will be shifted entirely to induction loops as the other nine have been.

A second VSR 16,000 computer will be added to the system when it is expanded to cover 27 more intersections.

Munich. From the original 10 intersections they started out with last February, Munich traffic officials will be up to 160 computer-controlled intersections by the end of this year or early next.

The Munich system uses a British computer, Elliott-Automation Ltd.'s Arch 1000 and selects the flow pattern—from a repertoire of 40 programs—that best matches traffic conditions [Electronics, May 17, 1965, p. 162]. Strategy of the programing is to speed outflow of traffic from congested areas and at the same time hold down inflow. To better do this, a second Elliott

Computer-controlled traffic lights have worked well in European cities where they've been tried. Most cities are expanding their systems.

computer—a 4120—will be added to the system, probably next month. Its primary purpose will be to continuously adapt to existing traffic conditions the preset programs of the Arch 1000.

Munich originally tried radar sensors, but since has shifted to induction loops. Ultrasonic detectors still are used, but only to spot the best locations to install permanent induction loops.

For a report on traffic control in San Jose, Calif., see page 221.

West Germany

State of the market

Even though the major West German companies—as usual—withheld their wares, this year's Electronica components show nonetheless offered a good fix on the 1967 semiconductor market.

At the week-long show in Munich last month, German market experts predicted semiconductor sales would bounce up nearly 12% next year to about $82 million.

As at all component shows recently, integrated circuits were the star attraction at Munich. But IC sales in West Germany are just at their beginnings. A ten-fold increase expected next year will bring IC sales to only $8 million, just about 10% of the total semiconductor market. Although IC's will continue to zoom over the next few years, marketing men generally see plenty of growth ahead for discrete semiconductors.

Plastics on the rise. The discrete component now regarded as most likely to succeed over the short run is the plastic encapsulated transistor [Electronics, July 25, p. 229]. Radios, television sets and phonographs account for about half the semiconductor sales in Germany and it is in entertainment sets especially that plastic transistors are making their inroads.

Prices of plastic transistors have dropped to about 30 cents apiece; they cost $1 a year ago. From a current market share of about 5% in consumer electronics, plastic transistors are expected to climb to 36% next year and on up to 85% by 1968. Additional momentum for plastic transistor sales is expected to come from automotive applications and controls for washing machines and dishwashers.

Niche. Integrated circuit production generally is regarded as the preserve of giant companies, but alert showgoers at Munich spotted an obscure West German company that is making headway in the tough IC market.

The company, Lueberg Technik, has made a niche for itself in custom-made and U.S. military specification thin-film and thick-film circuits. Its production runs range from 1,000 to 10,000 units, volumes the giants generally find unprofitable.

Even when Lueberg runs into competition from a larger company willing to take on limited production, it usually comes in with the low bid. Its prime advantages: low labor costs in the rural district of Lower Bavaria where its plant is located and no license fees to pay. Technologically, Lueberg stands on its own feet except for some production equipment it buys from U.S. companies. And Lueberg often snaps up orders because of its fast delivery times—usually not more than six weeks.

Lueberg's customers are mainly instrument firms in the U.S., West Germany, Belgium and France. Its main products are IC digital input devices, linear amplifiers, buffer stages, digital-to-analog converters and coding disks.

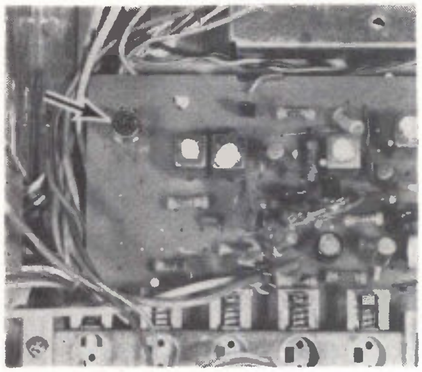
Japan

IC's on the rise

All signs point to a dramatic upsurge next year for sales of Japanese integrated circuits and Hitachi Ltd. doesn't intend to be caught napping.

The company has started to gear up to produce somewhere between 80,000 and 100,000 IC's a month by next fall. To do so, it will spend an additional $4 million for IC production lines; Hitachi already has invested $3 million in development and pilot lines.

At a level of 100,000 circuits a month, Hitachi will still be outdistanced by the Japanese industry's leader, Nippon Electric Co. NEC currently turns out some 60,000 circuits monthly and plans to shoot up to 300,000 by next spring. Hitachi, by contrast, doesn't expect to hit that level until 1968, when it estimates its production will be somewhere between 300,000 and 500,000 circuits monthly. From there, the company plans to climb in 1969 to about 1 million.



Splendid isolation. Hitachi linear IC that replaces 24 discrete components leaves wide open spaces on the printed circuit board of an experimental f-m receiver.

Customers first. At the outset, Hitachi's emphasis will be on metal oxide semiconductor circuits for desk calculators. Present plans call for production of at least 60,000 MOS chips monthly by next fall. For them, Hitachi marketing men see a ready-made market. Japanese desk calculator producers are stepping their output up so fast that shortages of discrete components could develop next year unless there's a switch to IC's. The country's leading desk calculator producer, Hayakawa Electric Co., hopes to have a third-generation model on the market late next year [see following story].

To be sure, Hitachi's early production plans include current mode logic circuits for house use. The circuits will go into Hitachi's 8000 series computers, the version of Radio Corp. of America's Spectra 70 that Hitachi will produce under license. Initially, though, Hitachi will import most of the circuits needed for the 8000 series. Hitachi's marketing strategy, apparently, is to line up a stable of IC customers before it starts to produce heavily for itself.

Sound strategy. Hitachi also has linear IC's on its list. The target is some 10,000 circuits a month by next fall. The initial circuit will be an intermediate-frequency amplifier, limiter, discriminator and first audio stage for television sound channels and frequency-modulation radios. The circuit was pioneered by RCA [Electronics, March 21, p. 137].

Hitachi also plans to develop diode-transistor logic and transistor-transistor logic (TTL). Hitachi has an in-house application for DTL and there may be a whopping domestic market eventually for TTL because it's likely to be the choice of the Nippon Telegraph and Telephone Public Corp. for electronic telephone exchanges.

Desk-bound IC's

Determined to hold its dominant position in the fast-growing Japanese desk calculator field, the Hayakawa Electric Co. intends to market a calculator using integrated circuits sometime during the latter half of 1967.

If Hayakawa holds to its timetable, it will become the first desk-calculator manufacturer in Japan to move up to IC's. But it will trail by almost a year the United States pioneer in the field, the Victor Comptometer Corp. Victor will start delivering its IC calculator to customers next month.

Shopping. Hayakawa recently showed an experimental 12-digit IC calculator, but hasn't built the prototype of a production model. In its experimental calculator, the company used special transistor-transistor-logic circuits that it has developed. They are slower than standard TTL circuits for big computers, but Hayakawa thinks the circuits might be produced for less than computer IC's. Hayakawa currently is shopping around to see what sort of prices semiconductor producers would want to manufacture the special circuits.

However, Hayakawa may still use standard TTL circuits. With the major semiconductor producers getting ready to boost their IC outputs, prices of standard computer circuits might well drop below the level at which Hayakawa's low-cost design could be fabricated. Another possibility is metal oxide semiconductor circuits. Hitachi Ltd. is on the lookout for customers for the MOS units it will have in production next fall [see story above]. Hayakawa's schedule calls for a decision on the IC's by the end of next March, so production can start in the second half of the year.

Savings. In the experimental model, 145 IC packages replace the 350 silicon transistors, 1,100 germanium transistors, 1,200 resistors and 400 capacitors that a comparable 12-digit calculator built of discrete components would require for the logic circuits. The savings in size and power consumption are substantial. Instead of a unit the size of a small overnight bag (9.6 inches high by 15.8 inches wide by 19 inches deep), the experimental IC version is cosmetic-case size (5.4 by 11.8 by 11.7 inches). Its power drain is 15 volt-amperes, compared to 22 va for its discrete counterpart.

The production IC calculator may be even smaller than the experimental unit. A major constraint on the package size is the space needed for the Nixie-like readout tubes and the company has a group at work developing a smaller one. By the time it is ready to start production, Hayakawa expects to have tubes about ½-inch in diameter instead of the ¾-inch tubes it now uses.

Great Britain

Computers on the road

With integrated circuit voltage regulators slated to go into most 1968 models of American cars and more IC automotive applications certain to follow, the auto industry already looks like one of the most promising growth markets for electronics.

An added fillip for the market may be in store from a new British development: a fuel injection system controlled by a small analog computer. To be sure, the prototype version recently introduced by Associated Engineering Ltd. has discrete components. But it points the way to another IC application should a big auto producer adopt the system.

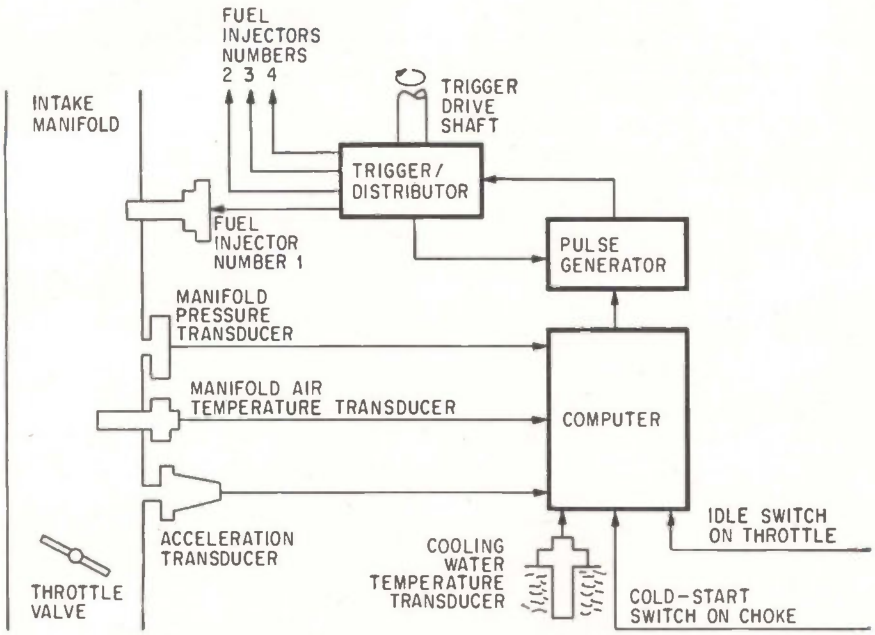
Until it lines up an auto maker, Associated will sell the system as a custom conversion kit at a price upwards of $200. This is more costly than a conventional single-carburetor system but competitive with fancy multiple-carburetor layouts. Associated claims the computer, by keeping the richness of the fuel mixture constantly matched to the engine operating conditions, brings fuel savings of up to 10%.

Clean air. And by whacking down excessive richness the system keeps at a low level unburned hydrocarbons in the exhaust, a chief cause of air pollution by automobiles. Associated also maintains that existing antipollution requirements could be met without afterburners by a combination of computer-controlled fuel injection and combustion chambers designed for low-pollutant emission.

The system controls injection of fuel into each cylinder of an engine by feeding pulses of varying duration to solenoid-operated injectors. The pulse length ranges from 1 millisecond to 10 msec, and the pulse rate is one-half the engine speed since a triggering pulse from a mechanically driven distributor switches the output of the generator onto the injector of the cylinder whose turn it is to fire.

The analog computer develops a pair of output voltage signals that control the duration of the pulses. One prime output to the computer circuit is engine speed, fed in by a discriminator preset to develop a speed signal that matches the volumetric efficiency, or "breathing" capacity, of the engine.

Four sensors. The other computer inputs come from a quartet



Analog computer controls pulse generator so that solenoid-actuated injectors feed an amount of fuel that matches engine conditions.

of transducers. One thermistor monitors the temperature of the engine's cooling-water; this input makes the fuel mixture leaner as the engine warms up. Another thermistor in the intake manifold measures air temperature. This input, along with that of a diaphragm-driven potentiometer that measures absolute pressure, gives an air-density reading for the manifold. A second pressure transducer feeds in a signal when there's a sharp rise in pressure near the butterfly valve in the intake manifold, indicating the driver has pushed the accelerator pedal further down.

In addition to the four transducers for normal running conditions there are two switches that feed in special inputs to the computer. One switch on the choke provides a cold-start signal that increases the richness of the mixture. Another on the accelerator pedal adjusts the mixture for idling.

Zinc by DDC

Direct digital control, fast invading what previously was the exclusive domain of analog systems, added an impressive conquest last month. A system worth nearly $3 million was ordered for a $40 million zinc refining plant now under construction at Avonmouth in western England. The plant is being built for the Imperial Smelting Corp., a subsidiary of Rio Tinto Zinc Corp.

The DDC system will put under computer control a combination sintering and smelting facility with capacity of 90,000 tons a year. The plant will simultaneously extract both zinc and lead from low-grade ores. To control the process, the computer will handle inputs from more than 500 sensors and 800-odd position-sensing switches. In all, there will be over 120 DDC loops. Elliott-Automation Ltd., supplier of the control hardware, believes the Avonmouth plant will have the most elaborate DDC system in existence when it goes on stream in 1968.

Elliott will use for the control system its Arch 2000 computer. Cycle time will be 2 microseconds, even though the memory will be crammed with 16,384 words of process-control information. Much of the program for the computer will have to be written specially for the DDC control, but Elliott expects that standard programs can be used for parts of the operation.

Sort of Siamese. Actually, the Arch 2000 at the outset will serve as a common brain for two separate control systems, one for the smelting plant and the other for the sintering plant. However, after it gains initial operating experience in the plant, Imperial Smelting Corp. plans to expand the computer control to interweave the two systems intimately.

Initially, the computer will take charge of blending ores from various sources and weighing them as they go into the sintering plant, the first step in the process. Sixteen DDC loops will control the weight of ore fed into the oven and another 16 loops will regulate the speed of the conveyor belt passing through it.

In the smelter, actually a short blast furnace, eight loops will control the job of preparing charges of sintered ore and coke for the furnace. Additional computer-controlled operations in the smelter include combustion in the coke preheater, cycling of air into the furnace, distribution of gases within the furnace, alarm scanning and data logging.

More in store. Although the Avonmouth plant will have one of the most sophisticated control systems in the world when it starts up, Ivan E. Lowe, Imperial's chief engineer for instrumentation, already talks about optimizing the entire facility through a more extensive use of the computer in the future.

For one thing, Lowe has in mind a scheme to analyze the slag that comes from the furnace and feed the results back into the system to hold zinc or lead waste in the slag to a minimum. Still another idea is to check the quality of the sintering plant output by X-ray fluorescence and keep the smelting furnace continuously adjusted to match variations in the sinter.

Canada

Red eye in the sky

While Smokey the Bear wages his campaign to convert careless American campers into careful ones, Canadian authorities have turned to electronics to prevent forest fires. During this year's forest-fire season they've used a lightweight, airborne infrared detector to spot smoldering lightning-struck tree stumps, the chief cause of fires in the vast Canadian forests.

The 60-pound system, flown on small forest patrol planes, was developed by Computing Devices of Canada Ltd. Its optical system focuses infrared energy in the 5-micron range onto a thermistor bolometer. The bolometer output is amplified to drive audio and visual alarms in the cockpit. In addition, the infrared pattern is recorded by a camera.

The scanning system searches the terrain 60° on either side of the plane's line of flight. The scan drive is tied into the visual alarm circuitry so that a direction indicator light flashes whenever the system picks up a hot spot. The pilot then can bank around for a closer look.

Temperature differentials as small as 5°C can be spotted by the system. From an altitude of 5,000 feet, for example, the detector can pick up charcoal glowing in a barbecue cooker just two feet square. This gives off about the same heat energy as a smoldering tree stump, which can stay smokeless for days, then burst into flame.

Computer Devices expects its airborne infrared system will find a lot of other non-military uses in addition to forest-fire prevention. With slight modifications, it could

Infrared detector that spots incipient forest fires mounts in small pod on fuselage of patrol plane.

be used to plot thermal gradients in water for fast oceanographic mapping or to locate pollution streams. Other possibilities are spotting icebergs obscured by fog, detecting crevasses in ice fields and mapping thermal gradients on land to locate underlying formations.

Colorful proposal

The order books of Canadian electronics companies will bulge for the next three years if an ambitious Ontario broadcaster has his way.

The broadcaster, 55-year-old Kenneth Soble of Hamilton, wants to set up a $75 million satellite-fed television network that would cover Canada from Newfoundland to the Northwest Territories. Under the scheme, 97 unmanned transmitters linked to 65 ground stations would be broadcasting color-tv programs by 1970.

For all its pie-in-the-sky aspects, Soble's proposal is receiving serious consideration from Canada's Board of Broadcast Governors (BBG), the government body that grants television licenses. For one thing, BBG last spring authorized Soble to undertake a study for the organization of a third Canadian tv network. And Soble has the backing of the Power Corp. of Canada, one of the country's richest companies. Further, the financing proposed offers big pieces of the action to both the government and the public.

Under the proposal, two companies would be formed—National Television Network (NTV) and the Canadian Satellite Corp. (Cansat). Power Corp. would provide the initial working capital, but 70% of NTV's stock would be offered to the government and the public. NTV, in turn, would own 40% of Cansat, with the rest going to the public.

Pair up there. To feed the 65 ground stations, Soble envisions a pair of 950-pound satellites in a stationary orbit 22,400 miles above the equator. A U.S. launch vehicle would put them there. One satellite would be active, the other a spare. Unused channels, six per satellite, would be leased to other broadcasters and communications companies.

The broadcast board will make its determination on Soble's proposal sometime next spring. If the decision is affirmative, RCA Victor Co., an affiliate of the Radio Corp. of America, stands to get the prime contract for the satellites. But with 97 transmitters and 65 ground stations also needed for the network, just about every important electronics producer in the country would get business from NTV.

Sweden

Good turn

Motorists in Sweden will have tc break a long-time habit next fall and Svenska Philips AB hopes to help them do it.

Ever since Swedes first had autos, they've been driving them—as in Britain—on the left hand side of the road. But next September Sweden will swing into line with the rest of the Continent and switch to the right.

Swedish traffic authorities expect that at the outset of the switchover motorists will take particular pains to drive on the right side. But they fear lapses—and collisions as drivers swing by habit to the left side after a turn—when the first blush of attentiveness fades.

All sorts of warning systems, including radio devices and radar units, have been suggested only to be rejected as too costly. But Svenska Philips has come up with a $60 solution, a roadside system that flashes panic lamps whenever a car enters a traffic lane from the wrong direction.

The portable Philips equipment is powered by a 12-volt auto battery and dry cells so it can be set up in a hurry at potentially dangerous intersections. The company, an affiliate of Philips Gloeilampenfabrieken NV of the Netherlands, also expects the system will catch on as a warning signal that police can set up at accidents.

Multivibrators. The system uses

a pair of transistorized multivibrators to sense that a car is passing a checkpoint going the wrong way.

Inputs to these two multivibrators come from rubber-tube pressure switches, the same as used in car-counting equipment, spaced about 10 feet apart. When a car runs over the upstream tube, it switches on a multivibrator with a time constant of 4 seconds. The output of the first multivibrator is applied to the second multivibrator as is the short pulse developed when the car crosses the downstream tube. The second multivibrator—when two inputs are present at the same time—switches on a third multivibrator that flashes the warning lamps for 10 seconds and then resets all the circuits.

With this arrangement, a car running over the rubber tubes in the right direction can't trigger the warning lamps since the first multivibrator isn't turned on when the downstream tube feeds its input to the second multivibrator. The 4-second time constant for the first multivibrator was selected to hold to a minimum false actuation by combinations of cars and trucks following each other in the right direction.

Around the world

Sweden. The Civil Defense Board will reequip itself with 500 fixed and 4,500 mobile very high frequency radio stations over a three-year period ending in 1970. In peacetime, the 320-channel stations are used by police forces, fire brigades and local governments. The 5,000 stations will cost $11 million; suppliers are Svenska Radio AB and Standard Radio and Telefon AB, a subsidiary of the International Telephone and Telegraph Corp.

Italy. The General Instrument Corp. has made its first major move into Europe with the acquisition of Pirelli Applicazoni Elettroniche (PAE), the electronics subsidiary of the Pirelli industrial group. PAE produces a broad line of components, including semiconductors and tantalum capacitors; General Instrument plans a substantial expansion of the product line.

Zambia. Transistor radios and phonographs have started to come off the production line of Supersonic Radio Zambia Ltd., the country's first electronics plant. The plant now employs over 100 people, making it Zambia's largest industrial enterprise except for the copper industry.

Supersonic will export part of its radio output to neighboring African countries. Later it will add television sets and telecommunications equipment to its product line as markets for them develop. The company is a subsidiary of the International Telephone and Telegraph Corp.

Great Britain. Elliott-Automation Ltd. has began a major expansion in Scotland. On the worklist are two new computer plants, one for Elliott's 4100 series and one for its 900 series. In addition, Elliott is rushing construction of a $560,000 research facility for integrated circuits. The company has a long-term IC know-how agreement with Fairchild Camera & Instrument Corp. but wants an independent source of IC technology.

France. Two electronics companies whose mainstay is government business are diversifying into medical electronics.

Intertechnique S.A., whose specialty is nuclear instrumentation, will form a medical division next year. The first product most likely will be a low-beta counter for hospitals.

Electronique Marcel Dassault, the avionics producing subsidiary of airframe manufacturer Générale Aéronautique Marcel Dassault will make its start in medical electronics with electrocardiology instruments.

Japan. Tokyo Shibaura Electric Co. will start selling brushless direct-current motors next year. In the motors, silicon controlled rectifiers replace the conventional mechanical commutator and brushes.

Sweden. Up against a chronic shortage of personnel, Swedish hospitals are expected to spend about $500 million by 1970 for computers and other electronic equipment to automate medical care.

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Frank E. LeBeau [212] 971-6464
Advertising sales manager

Atlanta, Ga. 30309: Michael H. Miller, 1375 Peachtree St., N.E., [404] TR 5-0523

Boston, Mass. 02116: William S. Hodgkinson McGraw-Hill Building, Copley Square, [617] CO 2-1160

Chicago, Ill. 60611: Robert M. Denmead, J. Bradley MacKimm, 645 North Michigan Avenue, [312] MO 4-5800

Cleveland, Ohio 44113: William J. Boyle, 55 Public Square, [216] SU 1-7000

Dallas, Texas 75201: Richard P. Poole, 1800 Republic National Bank Tower, [214] RI 7-9721

Denver, Colo. 80202: Joseph C. Page, David M. Watson, Tower Bldg., 1700 Broadway, [303] 255-5484

Detroit, Michigan 48226: J. Bradley MacKimm, 856 Penobscot Building [313] 962-1793

Houston, Texas 77002: Kenneth George, 2270 Humble Bldg., [713] CA 4-8381

Los Angeles, Calif. 90017: Ian C. Hill, John G. Zisch, 1125 W. 6th St., [213] HU 2-5450

Minneapolis, Minn. 55402: J. Bradley MacKimm, 1104 Northstar Center [612] 332-7425

New York, N. Y. 10036:
Donald R. Furth [212] 971-3615
James R. Pierce [212] 971-3615
George F. Werner [212] 971-3615
500 Fifth Avenue

Philadelphia, Pa. 19103:
Warren H. Gardner, Jeffrey M. Preston, 6 Penn Center Plaza, [215] LO 8-6161

Pittsburgh, Pa. 15222: Warren H. Gardner, 4 Gateway Center, [412] 391-1314

Portland, Ore. 97204: James T. Hauptli, 218 Mohawk Building, 222 S.W. Morrison Street, Phone [503] 223-5118

Rochester, N.Y. 14534: William J. Boyle, nine Greylock Ridge, Pittsford, N.Y., [716] 586-5040

St. Louis, Mo. 63105: Robert M. Denmead The Clayton Tower, 7751 Carondelet Ave. [314] PA 5-7285

San Francisco, Calif. 94111:
James T. Hauptli, 255 California Street, [415] DO 2-4600

London W1: John W. Patten, Edwin S. Murphy Jr., 34 Dover Street, Hyde Park 1451

Milan: 1, via Baracchini Phone: 86-90-617 86-90-656

Frankfurt/Main: Gerd Hinske, Dieter Rothenbach, Elsa-Brandstroem Str. 2 Phone: 72 01 81

Geneva: Michael R. Zeynel, 1, rue du Temple Phone: 31 95 60

Paris VIII: Denis Jacob, Kenneth Davey, 17 Avenue Matignon Phone: 359 6637

Tokyo: Nobuyuki Sato, 1, Kotohiracho Shiba. Minato-Ku [502] 0656

Osaka: Ryosi Kobayashi, 163, Umegee-cho, Kita-ku [362] 8771

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Manager Electronics Buyers' Guide

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Milton Drake [212] 971-3485
Research and circulation manager

Wallis Clarke [212] 971-2187
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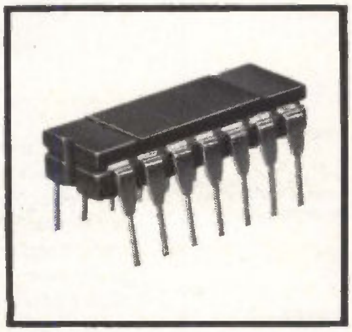
Wallace C. Carmichael [212] 971-3191
Business manager

Stephen R. Weiss [212] 971-2044
Production manager

Thomas M. Egan [212] 971-3140
Production manager Electronics Buyers' Guide

Whose dual in-line 930 DTL?



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OTHERS

Only your purchasing agent knows for sure!

ITT offers all series 930 DTL circuits in a dual in-line package. Circuits manufactured by ITT are identical to and perfectly interchangeable with the other leading brand.

If you're convinced that dual in-line packaging is your answer — if you want the lower component insertion cost, heavier leads and all-ceramic construction that only dual in-line can give you, evaluate ITT.

You can order any series 930 DTL in dual in-line today! Call your ITT distributor or factory representative.

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For critical chopper applications... RCA's new MOS transistor will even work

RCA's new 40460 is an N-channel, depletion type, insulated-full-gate MOS which, because of its symmetry, can be operated "upside down"...works equally well with either positive or negative incoming signals...*does the work of two bipolar transistors.*

RCA's full-gate MOS is especially useful foı chopper applications at extremely low voltage levels... handles input signals from microvolts to volts. It has an inherent offset voltage of zero. This means that the RCA 40460 has none of the tracking problems of matched bipolar devices, caused by temperature changes and extended operation.

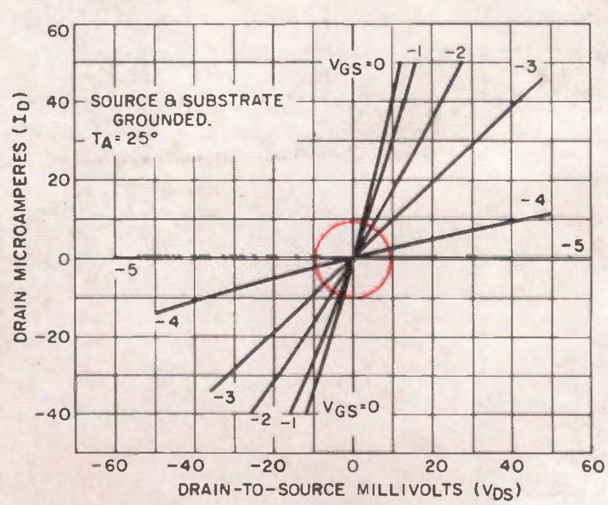
A high "off" resistance of 1000 megohms and a low "on" drain-to-source resistance of only 250 ohms make the RCA 40460 perform like a mechanical chopper, without its drawbacks. And you get all the advantages of solid-state reliability. In addition, long-term stability is assured by a fully metallized gate and a hermetically sealed JEDEC TO-72 4-lead metal case.

TO GET THE MOST FROM YOUR RCA 40460 CHOPPER, use the new RCA 40461 MOS transistor in your chopper amplifier stage, as well as for other critical audio and wideband applications.

Try these devices and see how they improve your chopper design. Check your RCA Field Representative for complete information. For technical bulletins, write RCA Commercial Engineering, Section CN 12-2, Harrison, N. J. 07029.

ALSO AVAILABLE THROUGH YOUR RCA DISTRIBUTOR

RCA's New 40460 MOS Transistor Features ZERO OFFSET VOLTAGE*



*Thermocouple effects and contact potentials may cause erroneous readings

RCA ELECTRONIC COMPONENTS AND DEVICES

The Most Trusted Name in Electronics

Circle 902 on reader service card