Electronic Design

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

VOL. 15, NO. 1

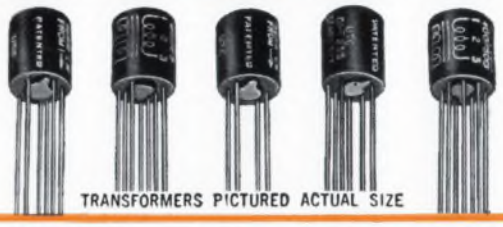
JAN. 4, 1967

Explore the future: an age of electronics in which colonists live beneath the sea and arc to distant planets. It is a time of moon bases and ultra-robots; of watches powered by isotopes or even body heat. How can designers reach this vision of tomorrow? Look ahead to the year 2000. Turn to page 70.

UTC
PIONEERS IN MINIATURIZATION

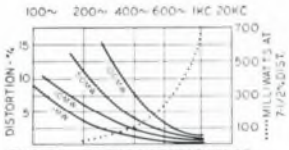
NEW

DI-T200™ SERIES

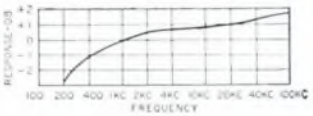


TRANSFORMERS PICTURED ACTUAL SIZE

ULTRAMINIATURE TRANSISTOR TRANSFORMERS & INDUCTORS



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



- **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
Class "S" Available on Special Order

High Power Rating	up to 100 times greater.
Excellent Response	twice as good at low end.
Low Distortion	reduced 80%.
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.

The unique structural design of the DI-T200 series transformers and inductors provides the excellent electrical characteristics, high reliability and wide application possibilities inherent in the UTC DO-T family of miniaturized units. The DI-T200 series units employ the same high quality design found in UTC's DO-T, DI-T, and PIP lines. This unique transformer constructural concept affords unprecedented power handling capabilities coupled with extremely small size. Further, the high degree of reliability has been dynamically proven in the field. These characteristics are basic in the structure, which is ruggedized, hermetically sealed, employing a completely rigid bobbin, eliminating stress and wire movement. The turns are circular in shape rather than square, eliminating turn corner stress, and effecting uniform wire lay. The coil wire and external lead are rigidly anchored terminal board fashion, employing no tapes and brought out through strain relief. The curves illustrated indicate the superior performance of these units compared to similar size units now on the market.

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.

IMMEDIATE DELIVERY FROM STOCK

Write for catalog of over 1,300 UTC TOP QUALITY STOCK ITEMS IMMEDIATELY AVAILABLE from your local distributor.

UNITED® TRANSFORMER CO.

DIVISION OF TRW INC. • 150 VARICK STREET, NEW YORK, N. Y. 10013

ON READER-SERVICE CARD CIRCLE 866

SPECTRALLY PURE FREQUENCIES up to 500 MHz

(Yes, 500)

The new Hewlett-Packard 5105A Frequency Synthesizer generates spectrally pure frequencies from 0.1 MHz to 500 MHz in 0.1 Hz steps—a frequency range 10 times higher than previously available by direct synthesis.

Now you can get rapidly switched UHF signals without multiplication and without the accompanying noise increase. Spurious signals are at least 70 dB below the selected output. The 5105A affords extremely rapid digital frequency selection either remotely (typical switching time, 20 microseconds) or from the front-panel pushbuttons. An internal search oscillator provides continuous tuning. Output of the 5105A is 0 dBm ± 1 dB; phase modulating capability, dc to 1 MHz rate; frequency stability is at least 3 parts in 10^{9} per day.

The 5105A uses direct frequency synthesis, with the output frequencies derived from a quartz crystal by arithmetic operations instead of by phase-locked oscillators. This provides faster frequency selection and fail-safe operation.

Model 5105A—$9150.

Model 5110B driver, required for the synthesizer (will drive up to four 5105A's)—$4350.

Need a lower frequency model? 1, 10 and 50 MHz models are also available.

Call your local field engineer or write for complete information to Hewlett-Packard, 1501 Page Mill Road, Palo Alto, California; Europe: 54 Route des Acacias, Geneva.

HEWLETT hp PACKARD

ON READER-SERVICE CARD CIRCLE 2

Electronic Design

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

VOL. 15 NO. 1

JAN. 4, 1967

NEWS

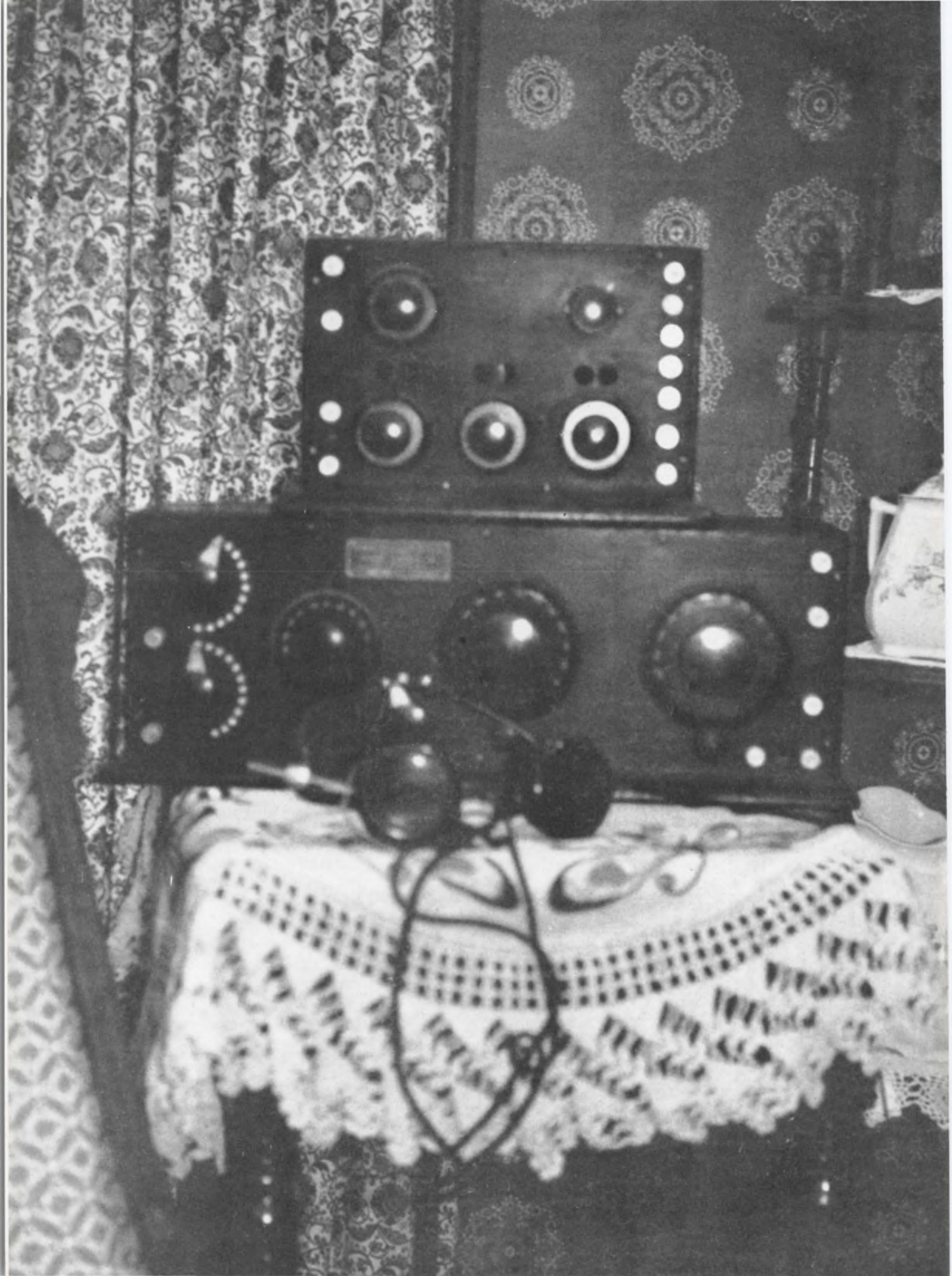
TECHNOLOGY

PRODUCTS

Departments

ELECTRONIC DESIGN is published biweekly by Hayden Publishing Company, Inc., 850 Third Avenue, New York, N.Y. 10022. James S. Mulholland, Jr., President. Printed at Poole Bros., Inc., Chicago, Ill. Controlled-circulation postage paid at Chicago, Ill., Cleveland, Ohio, and New York, N. Y. Application to mail at controlled postage rates pending at St. Louis, Mo.

61,302 copies this issue.



DOW CORNING

Before you live with that old design . . .

check with us

Forty-five years ago this individually tuned, multiple-stage radio was the last word. Then came ganged condensers and the *superhet!* Within several years this old design was dead . . . and so were many firms that tried to live with it.

Today's kaleidoscopic state of the art leaves no time for living with old designs or material specs for want of new materials. Fact is, there's no need to wait. Many of tomorrow's unique materials are already available . . . from Dow Corning.

Dow Corning, the acknowledged leader in silicone research and development for over twenty years, has a history of producing materials to meet unheard of performance requirements . . . and materials is our *only* business.

Tired of that old design or material spec?
Write Dept. 3511, Electronic Materials Department, Dow Corning Corporation, Midland, Michigan 48640.
Or phone (517) 636-8940 for more information and the name of the Dow Corning representative in your area.

New family of RTV encapsulants made to suit your production

Variable cure, 15 min.—24 hrs. . .
Dow Corning® 3110, 3112 and 3120 RTV encapsulants can be cured with any one of three types of catalysts. Fast curing rates are provided by the F-type catalyst; standard rate cure by the S-type and heat accelerated cure by the H-type. Inventory is simplified by this approach to silicone rubber RTV's since each catalyst produces comparable results with each base.

Photo courtesy Pyles Industries, Inc.

Designed for automatic dispensing . . .
The less critical, 10:1 mixing ratio of base to catalyst assures proper cure when automatic mixing and dispensing equipment is used. The normal ratio of 10:1 can be varied, with working time, pot life and cure rate decreasing as more catalyst is used. To facilitate automatic mixing and dispensing, the base material is packaged in straight side steel drums in 10, 50 and 450 pound sizes.

Viscosity can be changed . . .
Dow Corning 3110 RTV encapsulant has a low viscosity . . . pours easily around intricate shapes. Both Dow Corning 3112 and 3120 RTV encapsulants have medium viscosity. However, by adding up to 10% of Dow Corning® 200 electronic fluid in 20 centistoke viscosity, all three can be thinned without noticeable change of electrical or physical properties . . . pot life, working and curing time increase.

We're a materials producer exclusively. Let us tailor a material to your need.

ON READER-SERVICE CARD CIRCLE 851

Only Varian delivers low-noise TWT amplifiers that have...

lowest noise figure,

smallest size,

lightest weight,

highest saturation power,

single-reversal permanent-magnet focusing,

integral power supply,

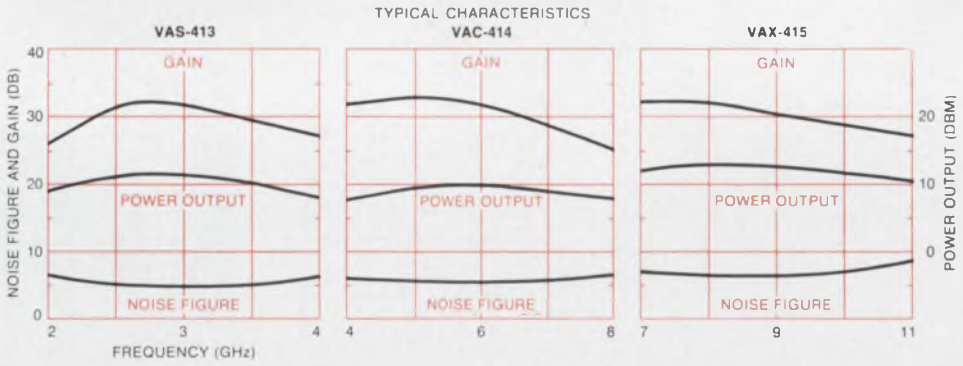
broad band frequency range,

narrow band frequency range,

S-band performance,

C-band performance,

X-band performance.



For more information on these 3-inch TWT amplifiers, covering the complete spectrum of applications, write Palo Alto Tube Division, 601 California Avenue, Palo Alto, Calif.

In Europe: Varian A.G., Zug, Switzerland.
In Canada: Varian Associates of Canada, Ltd., Georgetown, Ontario.

varian

ON READER-SERVICE CORD CIRCLE 4

"Way out deliveries do take longer"

. . . unless you order from a local distributor. A case in point, the distributors listed below stock Dow Corning electronic materials. That means you can usually place an order by phone and get delivery in an hour or so. The "way out" deliveries may take a day.

And to help you speed your orders, there's a new Dow Corning Electronic Materials Selector Sheet. It covers the distributor-stocked Dow Corning line of potting, encapsulating, embedding and coating materials as well as silicone dielectric fluids which provide added protection and reliability to your electronic products.

For your copy of the Selector Sheet, contact your local Electronic Materials Distributor or, write to: Dept. 3925, Electronic Materials Dept., Dow Corning Corp., Midland, Michigan.

DOW CORNING

Dow Corning Electronic Distributors' Stocking Points:

Allied Radio Corporation
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Atlas Packing and Rubber Company
Seattle, Washington

Brownell, Inc.
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Cramer Electronic, Inc.
Newton, Mass., Hamden, Conn.

D & H Distributing Company, Inc.
Baltimore, Md., Harrisburg, Warrington (Phila), Pa.

Electrical Insulation Sales Company
North Bergen, New Jersey

Ensco Distributing Corp.
St. Louis, Missouri, Cedar Rapids, Iowa

E. V. Roberts & Associates, Inc.
Culver City, Palo Alto, San Diego, Calif., Scottsdale, Ariz.

Magnuson Electronics, Inc.
Chicago, Ill., St. Paul, Minn.

Sheridan Sales Co.
Cincinnati, Cleveland, Dayton, Ohio, Detroit, Mich., St. Louis, Mo.

Specialized Products Company
Dallas, Texas

Summit Distributors, Inc.
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Waco Electronics Electronic Products
Denver, Colo., Albuquerque, N. M.

ON READER-SERVICE CARD CIRCLE 5

A Tektronix High Resolution Measurement Package:

- *Type 545B Oscilloscope with Advanced CRT*
- *Accurate Horizontal Delayed Sweep*
- *Type W Plug-In for Accurate Voltage Measurements*

Small spot size — uniform focus
The waveform demonstrates the small spot size and uniform focus which provides fine trace definition.

The cathode ray tube and the delayed sweep of the Tektronix Type 545B Oscilloscope, plus the voltage measurement capabilities of the Type W Plug-In Unit, combine to make an ideal package for high resolution measurements. Even greater versatility is then available because the Type 545B is compatible with all Tektronix letter and 1-series plug-ins.

Precision CRT

The Type 545B uses the advanced T5470 cathode ray tube that provides small spot size and permits uniform focus over its entire 6 x 10 cm display area. The illuminated, no-parallax internal graticule lets the operator make full use of the measurement capabilities of the oscilloscope. Risetime and falltime measurements (10 to 90%) are made using the dashed graticule lines, and the illuminated graticule simplifies photographic recording.

Horizontal Delayed Sweep

The delayed sweep capability of the Type 545B gives you the ability to make very accurate time measurements. The incremental accuracy (0.2%) of the delay-time multiplier provides a calibrated delay range which is continuously variable from 1 μs to 10 s with an accuracy within 1%. The Type 545B provides stable triggering on small signals. It triggers internally with AC coupling from 150 Hz to 10 MHz on 2-mm deflection, increasing to 1 cm at 30 MHz.

Accurate Voltage Measurements— DC to 23 MHz

The high resolution Type W Plug-In Unit (illustrated) can measure voltages with an accuracy of $\pm$0.2% V_C. It provides an effective CRT height of $\pm$11,000 cm, permitting evaluation of 1 mV pulses riding on signals up to $\pm$11 V (10 mV evaluation to $\pm$110V). The common mode rejection ratio of the Type 545B is at least 20,000:1 on signals from DC to 20 kHz. Bandwidth of the instrument is DC to 23 MHz at 50 mV/cm and DC to 8 MHz at 1 mV/cm.

The Type 545B vertical amplifier is easy to maintain and calibrate with a hybrid circuit design and a compact delay line that requires no adjustments. Among the letter and 1-series plug-ins available for use with the Type 545B are spectrum analyzer units covering the spectrum from 50 Hz to 10.5 GHz, and sampling units with 90 ps risetime and TDR capabilities. With the Type 1A2 Dual Trace Plug-In, DC to 33 MHz measurements may be made with 10.5 ns T_r and 50 mV/cm deflection factor.

Type 545B (complete with probes and accessories)	$1550
Type W Plug-In Unit	575
Type 1A2 Dual Trace Plug-In Unit	325

U.S. Sales Prices FOB Beaverton, Oregon

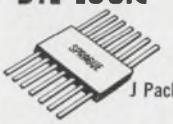
Tektronix, Inc.

For complete information, contact your nearby Tektronix field engineer or write:
Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005

ON READER-SERVICE CARD CIRCLE 6

You Can Get All These Microcircuits from Sprague Electric:

*SERIES SE100, NE100, US700 DTL LOGIC (Signetics CS700)



J Package

Eighteen functions in two operating temperature ranges: —55 C to +125 C and 0 C to +70 C. Circuits include NAND/NOR gates, clock and line drivers, gate expanders, RST and JK binary elements, one-shot multivibrator.

ON READER-SERVICE CIRCLE 882

SERIES SU300, LU300 UTILOGIC


K Package

For use in commercial, industrial, ground support applications. Available in two operating temperature ranges, —20 C to +85 C, and +10 C to +55 C. Propagation delay of 15 to 40 nanoseconds.

*Trademark of Signetics Corp.

ON READER-SERVICE CIRCLE 883

*SERIES SE400, NE400 LOW POWER LOGIC

J Package

Operating temperature ranges: —55 C to +125 C, and 0 C to +70 C. For use in Aerospace and other applications where low power drain is required. Optimized speed, noise margin.

ON READER-SERVICE CIRCLE 884

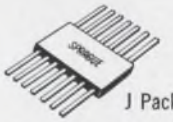
*SERIES SE500 LINEAR AMPLIFIERS


K Package

Operating temperature range: —55 C to +125 C. Two linear circuits available in 10-lead low silhouette TO-5 case. SE501K is a video amplifer, SE505K is a general purpose differential amplifier.

ON READER-SERVICE CIRCLE 885

*SERIES SE800, NE800 TTL LOGIC

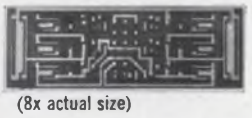


J Package

Designed for high-speed avionics systems. Eight high level circuits including four NAND Gates, Power Gate, Exclusive-OR Gate Input Expander, J-K Flip-Flop.

ON READER-SERVICE CIRCLE 886

UNICIRCUIT® RCTL LOGIC


(8x actual size)

Sprague Series US-0100 . . . a complete line of silicon monolithic digital building blocks featuring low power consumption (2 mW typ.)

ON READER-SERVICE CIRCLE 887

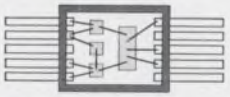
UNICIRCUIT® mW RTL LOGIC


TO-5 Case

Types US-0908 through US-0921 . . . Fully interchangeable mW digital building blocks featuring power consumption of 2 mW/node and propagation delay of 40 nsec.

ON READER-SERVICE CIRCLE 888

UNICIRCUIT® CUSTOM HYBRID CIRCUITS



Combine monolithic silicon circuits with tantalum or Ni-Cr alloy resistors. Close resistance tolerances, low temperature coefficient. Resistor matching, ±½%.

ON READER-SERVICE CIRCLE 889

DIGITAL-TO-ANALOG CONVERSION CIRCUITS

UT-1000—Four-bit ladder network
UD-4001—Ladder switch for driving resistor ladder networks
UD-4024—Buffer amplifier

ON READER-SERVICE CIRCLE 890

***Series SE100, NE100, CS700, SU300, LU300, SE400, NE400, SE500, SE800, NE800 are all available from Sprague Electric under technology interchange with Signetics Corp.**

For data sheets on the microcircuits in which you are interested, write to: Technical Literature Service, Sprague Electric Company, 347 Marshall St., North Adams, Massachusetts 01247

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THIN-FILM MICROCIRCUITS
TRANSISTORS
CAPACITORS
RESISTORS
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PULSE-FORMING NETWORKS
TOROIDAL INDUCTORS
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CERAMIC-BASE PRINTED NETWORKS
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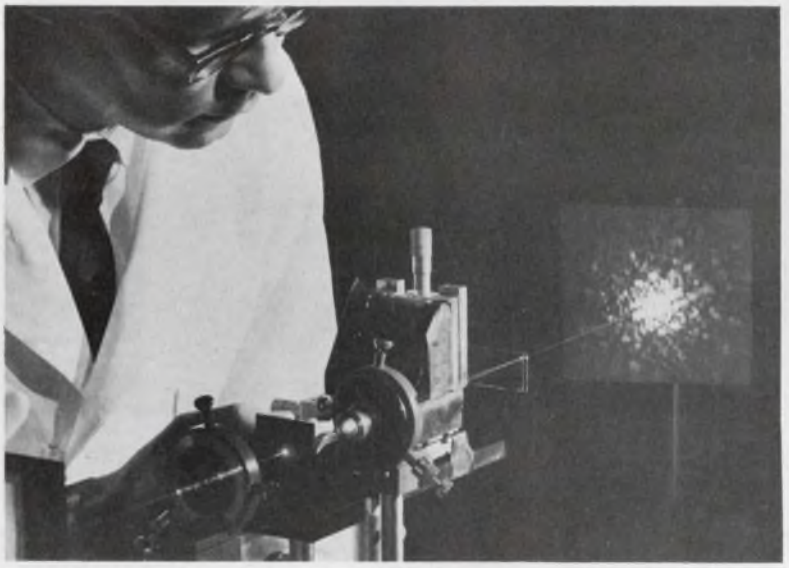
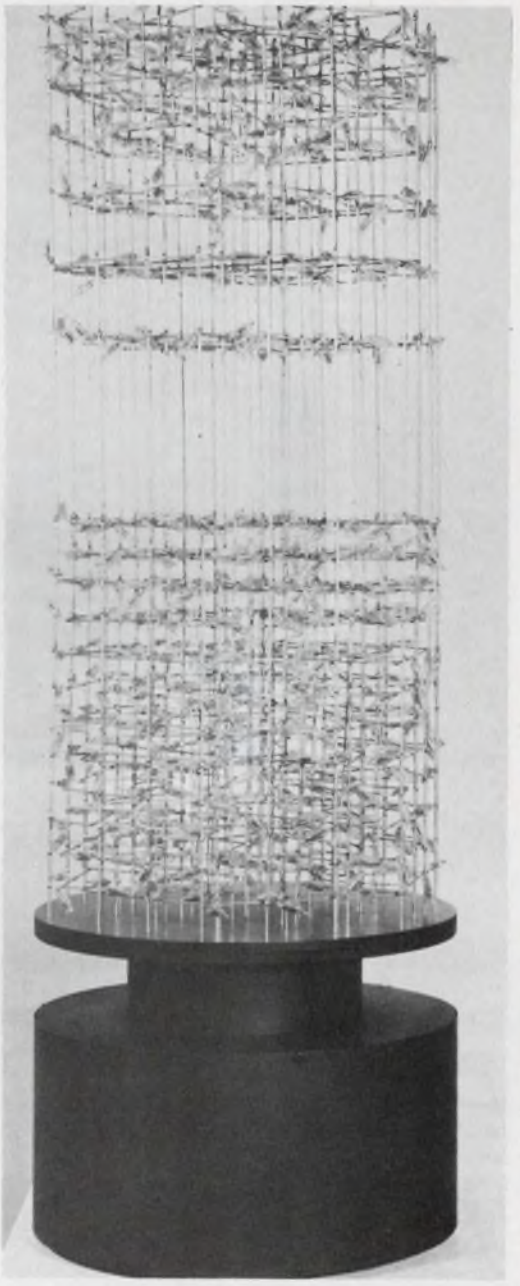
News

With $21 billion output predicted, electronic industry faces bright year however war and taxes go. Page 17



Laser beam used to gather data on possible damage to chromosomes during mitosis of blood cells. Page 37

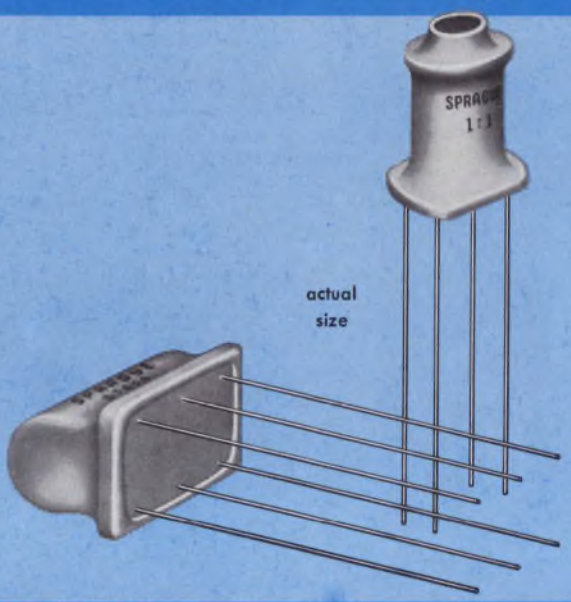


Electronic art both bedazzles and bemuses gallery visitors. Page 42

Also in this section:

New from Sprague!

the industry's lowest-cost SCR triggers...



...now have pin leads for printed boards!

TRIGATE* PULSE TRANSFORMERS...

Dependable enough for industrial equipment, yet priced for high-volume commercial applications

Here's good news for designers of appliances, lighting controls; air-conditioning and heating controls; industrial controls. You can actually cut costs while upgrading your present method of SCR triggering! Type 11Z Trigate Pulse Transformers offer these outstanding features:

- Balanced pulse characteristics and energy transfer from primary to secondary and tertiary windings.
- Minimum saturation effect to allow operation where increased pulse widths are required.
- Fast pulse rise time and increased current capability to prevent SCR di/dt failure.
- Increased energy transfer efficiency.
- Operating temperature range, −10 C to +105 C.
- 2- and 3-winding designs for half- and full-wave applications.
- Turns ratios — 1:1, 1:1:1, 2:1, 2:1:1, 5:1.
- Available for use with line voltages up to 240 VAC or 550 VAC.
- Inductances to 1 millihenry at 550 VAC, 5 millihenries at 240 VAC.

*Trademark

New configuration for ease of mounting

To eliminate the need for mounting brackets, particularly on printed wiring boards, Trigate Pulse Transformers are now available in single-ended construction with pin leads. Conventional axial-lead units are also available for point-to-point wiring.

• • •

For complete information, write for Engineering Bulletin 40,003A to the Technical Literature Service, Sprague Electric Co., 347 Marshall St., North Adams, Mass. 01247.

SPRAGUE COMPONENTS

PULSE TRANSFORMERS	RESISTORS	CERAMIC-BASE PRINTED NETWORKS
CAPACITORS	INTERFERENCE FILTERS	PACKAGED COMPONENT ASSEMBLIES
TRANSISTORS	PULSE-FORMING NETWORKS	BOBBIN and TAPE WOUND MAGNETIC CORES
THIN-FILM MICROCIRCUITS	TOROIDAL INDUCTORS	SILICON RECTIFIER GATE CONTROLS
INTEGRATED CIRCUITS	ELECTRIC WAVE FILTERS	FUNCTIONAL DIGITAL CIRCUITS

4 SSC-6159

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ON READER-SERVICE CARD CIRCLE 8

News Scope

A seven-way race begins in space communications

A lively controversy is under way among major U.S. companies over the right to operate communications satellites. The issue, which has been simmering for nearly a year, was pushed toward the boiling point last month when seven organizations filed contrasting proposals for satellite systems with the Federal Communications Commission.

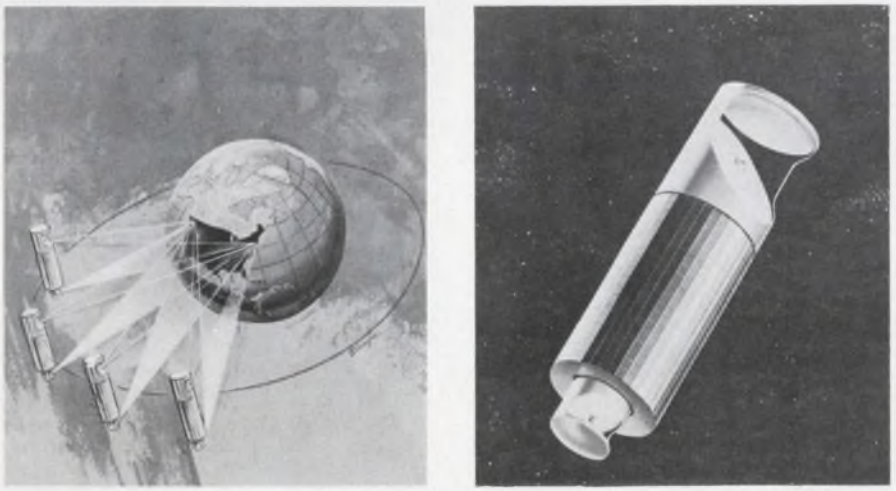
The proposals came from Comsat (the Communications Satellite Corp.), American Telephone and Telegraph Co. (AT&T), the Ford Foundation, National Broadcasting Co. (NBC), American Broadcasting Co. (ABC), General Telephone and Electronics Corp. (GT&E), and National Education Television (NET). Of the seven proposals, two—Comsat's and AT&T's—were for mixed ground and satellite communication networks. The others were for separate satellite systems for radio and television transmission.

The AT&T and Comsat proposals agree in principle, but they differ in approach and technical detail. Both call for the use of arrays of multipurpose satellites and the construction of many ground stations that would link with land-line communications. However, the Comsat scheme proposes to use two-way voice communications by satellite, while the AT&T proposal would split the circuits—one going over satellite facilities, the other over ground facilities.

Both Comsat and AT&T believe their plans would meet all the satellite communication needs of the United States through 1980.

NBC, ABC and General Telephone and Electronics, on the other hand, have more limited interests: they want to use their satellites for commercial purposes. The Ford Foundation and NET intend to use theirs to broadcast nonprofit educational programs. It is not known whether ABC's plan will be affected by ABC's acquisition by International Telephone & Telegraph Corp.

AT&T's proposal, put forward by its Bell System, advises only one-way communication with satellites because a company time-delay and echo study showed that it was not practical to use two-way communication over the long distances contemplated.



AT&T proposal for a mixed earth-space communication system would have four satellites in operation by 1980. The satellite at right would use both pulse-code and frequency-modulation techniques and be capable of providing 12 TV channels and more than 30,000 duplex voice circuits.

Comsat disagrees, saying that it doesn't believe the results of the study justify a stand that will have such far-reaching effect on future communications. Although AT&T agrees that Comsat should control the satellites, the one-way concept would give the common carriers control of the ground stations. Comsat believes it should control not only the satellites but also the portion of the ground stations that communicates with the satellites.

Comsat proposes to orbit four satellites in 1970, four in 1973, and four in 1978. The 1970 models, with a life of five years, would be capable of providing 48 TV channels or 84,000 point-to-point message channels. The 1973 models, with a six-year life, would double the capacity and use receiving frequencies of greater than 10 GHz. The 1978 models might have as many as 240 TV channels or 360,000 for voice. These satellites would also transmit at greater than 10 GHz.

When all four 1970 satellites are in service, Comsat proposes to have 180 ground stations in operation.

The AT&T proposal calls for the staggered launching of three satellites by 1972, a fourth by 1975 and a fifth by 1976. The last two would replace the earlier three. The most advanced satellites would provide over 30,000 voice circuits and 12 TV channels. About 100 ground stations would be used.

Patent-law overhaul headed for a battle

Not since the 1830s has there been such concern over proposals for Federal patent legislation. At issue are the recommendations of the President's Commission on the Patent System. It is urging the first sweeping overhaul of the system since the Patent Act was adopted by Congress 130 years ago.

Supporters of the report say it would end the practice of filing for a patent and then amending the idea year after year, with no disclosure of the invention and no patent issued. Legal claims sometimes result against persons who are not even aware that they have infringed such a patent application. A second benefit of the proposed overhaul is that it would help to clear the jam of more than 200,000 requests for

patents that are pending in the United States Patent Office.

Opponents are saying, however, that the commission has sounded "the death knell of the patent system, as this country has known it," and may cause possibly greater legal confusion than ever.

The report, which followed a 15-month study by the 14-member commission, includes these controversial recommendations:

- Issuance of patents to the first person who applies, with the applicant responsible for the prepatent searches formerly performed by the Patent Office.
- Within two years after a patent is filed, publication by the Government of details of the patent, opening the door at that time to possible suits by persons claiming infringement.

The patent application would be a simple form, to permit filing by anyone without extensive knowledge of patent law and procedure, commission supporters point out. Moreover, the life of a patent would extend to 20 years instead of the present 17 years.

But opponents say the first-come-first-served provision would make patent filing a "gold-rush." The present law, they note, gives an applicant a year to file for a patent from the time of his invention, and the burden of searching the invention claim is on the Government. The proposed law would make it more difficult, more legally costly, for an inventor to prove that he was first with an invention if he was only the second man to file for a patent; the burden of proof would be shifted to him.

This same stress on filing first, critics contend, will encourage patenting of inventions before they are fully developed. At present, for example, an engineer may use his year's grace to iron out technical details in an invention.

What the commission hopes, it is generally believed, is that by relieving the Government of responsibility for prepatent searches, the multitude of inventions that never bear fruit will fall by the wayside, with no legal challenge by anyone after their details are publicized. But for the inventions that survive, serious challenges and "endless litigation" may ensue, according to opponents.

With a tinge of outrage, one patent-law specialist, in the field for 25 years, put his reaction to the commission's proposals this way:

"The patent system, which has always been one based on equities in this country, is being continually whittled down to one of expediency. . . . Why throw out the baby with the bath?"

President Johnson has the recommedations, and a series of contentious hearings on them loom on the horizon.

On the commission that produced the report were Federal Cabinet officals and some top industry executive, including Charles Thornton, president of Litton Industries; James Birkenstock, vice president of commercial development for the International Business Machines Corp., and Bernard Oliver, vice president of R&D with Hewlett-Packard.

The study left unanswered the question of patent rights under Government R&D contracts, because the problem is under scrutiny by Congress and the Executive Branch.

AF seeks flight system to double aircraft life

The U.S. Air Force has embarked on a two-and-a-half year research program to develop an automatic flight control system that could double the life of large aircraft such as the B-52, XB-70 and C-5A.

If the program proves successful, an Air Force spokesman said, such a system could be put aboard all commercial jetliners and greatly increase their safety by counteracting the extreme stresses put on their structures by severe turbulence.

The $6 million program called LAMs, for Load Alleviation and Mode Stabilization, is being conducted for the Air Force Flight Dynamics Laboratory at Wright-Patterson AFB by Boeing Co.'s Wichita Div.

The goal of the project is to extend aircraft life by 70 to 100 per cent.

The system will automatically dampen the structural oscillations and alleviate the stresses from wind gusts and maneuvering loads that cause metal fatigue in aircraft.

The first flight tests of the system are scheduled to begin this fall. The flight control unit, two analog computers and more than 164 strain gauges will be installed on a B-52 aircraft.

The sensors will be attached to structural members of the fuselage, wings and tail surfaces in sets of three. The computers will monitor information from the pilot and data received from the instrumented sensors, make quick calculations and automatically actuate controls to stiffen structural members of the aircraft artifically. Rate gyros on the aircraft will sense forces acting on the B-52, and the flight system will apply controls in an opposing direction to the energy of those forces.

Computer-aided design workshop at IITRI

Help is forthcoming for those firms that want to develop a computer-aided design program for their electronic products but lack the staff and budget.

The IIT Research Institute in Chicago will begin a twelve-month project to assist industry in adopting computer-aided design programs and to help firms to develop further those circuit-analysis programs that they may already be using (see "Computer-Aided Design," ED 23, Oct. 11, 1966, pp 54-80).

At the outset, participants will work with IITRI staff to evaluate the usefulness of available programs such as ECAP, NET-1 and PREDICT, according to J. K. Lehto of the Institute's Computer Sciences Div. Selected programs will be tailored to the participants' requirements and tested at IITRI's IBM-7094 facilities, Lehto said. Test problems will be submitted by the firms taking part.

To supplement the program, IITRI said that it was establishing a laboratory for measuring electronic-device parameters.

For more information contact: J. Keith Lehto, IIT Research Institute, 10 West 35 St., Chicago, Ill. 60616.

FROM PAR **Detection, Measurement or Comparison of Noisy Signals**

New Signal Correlator

PERFORMS AUTO- OR CROSSCORRELATIONS IN REAL TIME

CORRELATION FUNCTION COMPUTED FOR 100 DELAY POINTS SIMULTANEOUSLY

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Correlation analysis — an extremely powerful signal processing technique in many areas of science and engineering — has heretofore been neglected, largely due to a lack of availability of suitable equipment. The PAR Model 100 Signal Correlator will be useful in such diverse fields as aero- and hydrodynamics, plasma physics, vibration analysis, radio astronomy, radar, lasers, medical physics and geophysics.

PAR Model 100—
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SPECIFICATIONS IN BRIEF:

Total Delay Range: 100 μSec to 1 Sec in 1, 2, 5 sequence.

Input Signal Levels: Peak-to-peak signals of 0.4 volts to 200 volts are accommodated without overload in each channel.

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Noise and Dynamic Range: Base line noise with no signals, 10^{-3} volts peak-to-peak. Maximum correlated output, ± 3.5 volts.

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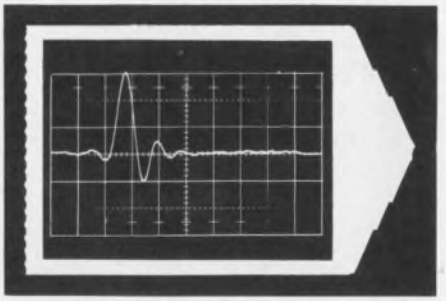
Accuracy: Better than 1%.

Readout: 0-3.5 volts at sweep rates of 20 per Sec, 1 per 10 Sec, 1 per 50 Sec.

Price: $8500.00. Export price approximately 5% higher, except Canada.



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

For more information call (609) 924-6835 or write Princeton Applied Research Corp., Dept. E, P.O. Box 565, Princeton, N. J. 08540.

PRINCETON APPLIED RESEARCH CORP.

ON READER-SERVICE CARD CIRCLE 10

Business looks good for 1967—but . . .

EIA sees $21 billion output, with consumer goods rising fastest, but war and taxes could alter this

Ralph Dobriner
Chief News Editor

The outlook for the U.S. electronics industry in 1967 is generally optimistic, despite uncertainty about the possible effects of the Vietnam war, proposed tax increases and a slowdown in spending on the nation's space programs.

Factory sales are expected to rise 8% or more in 1967 to the $21 billion level, according to Robert Galvin, president of the Electronic Industries Association. Last year's sales are estimated at 19.4 billion.

Spurred by requirements for the Vietnam war, Government purchases of electronic products will approach the $10 billion mark in 1967, compared with some $9.5 billion last year, according to Galvin. This represents the highest level in history and an increase of about 4.5% over last year.

It should be noted, however, that, though total defense expenditure on the war is expected to skyrocket this year, the electronics portion will not go up as steeply as the rest. In other words, despite the war, the output of consumer and industrial electronic products is expected to rise at a faster rate than the output of Government electronic products.

Galvin, who is also chairman of the board of Motorola Inc., Chicago, predicted that the greatest gains in 1967 would be made by consumer products, led, of course, by color television.

The anticipated increase in all consumer sales at the factory level is 15.6%, according to estimates of the EIA Marketing Services Department. Industrial electronics has also shown remarkable vitality since 1950, Galvin said, and is expected to rise 10.5% in 1967 to $5.25 billion, compared with an anticipated $5.2 billion for consumer goods.

Vietnam war escalation could cut demand for consumer products.

As one industry spokesman observed, "There's now enough productive capacity in the nation's electronic industry to fulfill both military and consumer demands."

Material shortages evident

The most immediate effect of the war has been to create certain materials shortages, particularly in copper and brass. Shortages are also being felt in component areas such as vacuum tubes, resistors and capacitors.

A spokesman for ITT's Semiconductor Products Div. in Florida wryly observed that the vacuum-tube business is doing very well and is always sold out. Much standard military electronic equipment, especially shipboard systems, he said, still requires tubes for replacement.

A spokesman for Hewlett-Packard in Palo Alto, Calif., said that critical component and materials shortages, especially of copper, has delayed the introduction of new products and has held up production schedules.

As an example, he cited a six-month wait for high-quality motor deliveries. Also, ordinary 115-volt power cords and simple receiving tubes are among the longest lead time items, he said.

Nevertheless, despite such shortages, consumers are continuing to snap up such luxury items as color TV sets, stereo systems, tape recorders, and FM radios. The industrial market also continues to grow rapidly, spurred on by the expanding use of computing and data-processing equipment. Comprising about half of all industrial electronic sales, the dollar volume of computer equipment is currently rising about 30% annually.

War step-up may alter outlook

Naturally, if the Vietnam war were to escalate, the picture could change drastically. Who's going to think about buying a color TV set or a stereo tape recorder for the family car, if there is an imminent threat of war with China?

(**67 forecast,** *continued*)

A significant increase in income tax or a reimposition of the federal excise tax could likewise serve to dampen the electronic industry's outlook for 1967.

Slowdowns may nevertheless occur this year in certain sectors of industrial electronics. This could be the result of President Johnson's request to industry to curtail, cancel or spread out capital expansion programs because of inflationary trends sparked by the Vietnam war. Companies that might otherwise have invested in new plants, in data-processing equipment or in electronic process control equipment to increase their output or manufacturing efficiency may not now do so.

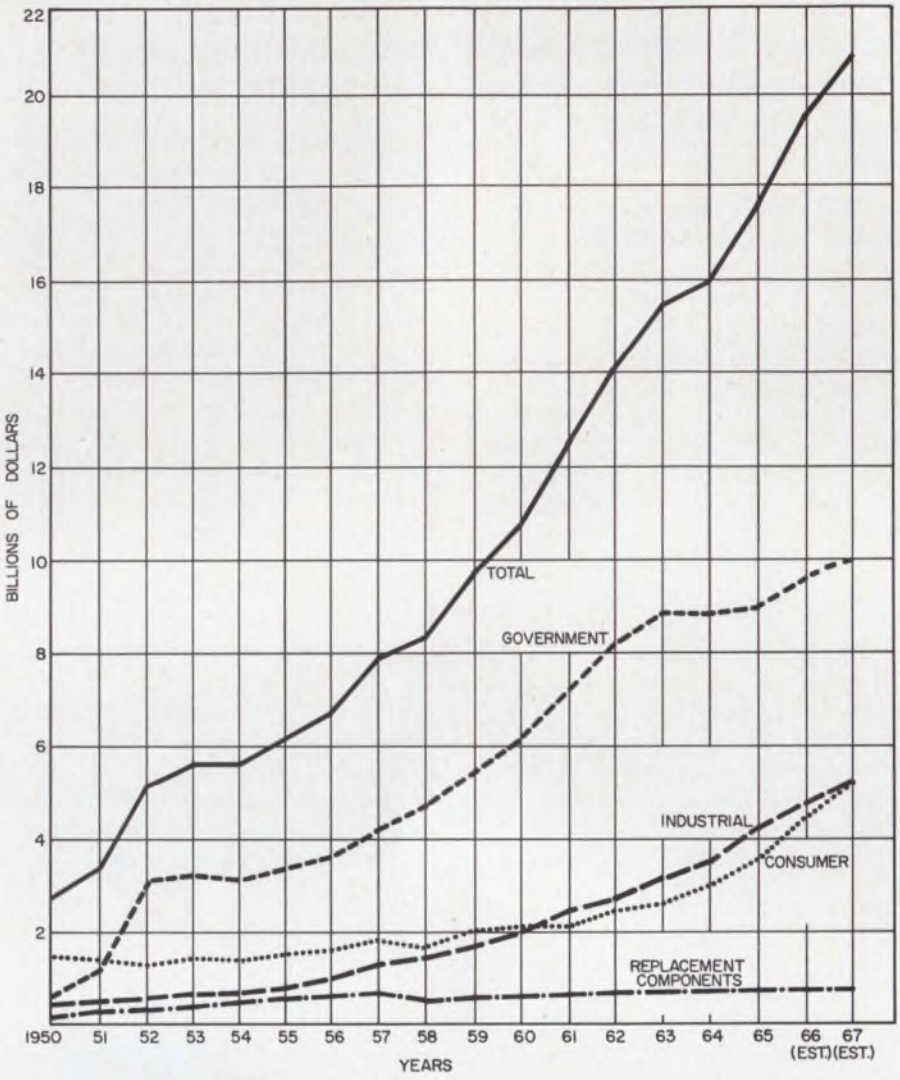
What if the war should suddenly end?

A Hewlett-Packard spokesman summed it up this way: "Should peace break out, there would probably be a temporary period of dismay throughout the industry. We believe this to be unjustified. No sooner would military cutbacks take place than appropriations for the space and Great Society programs would be increased." He expressed the view, however, that "marginal" companies would certainly feel it.

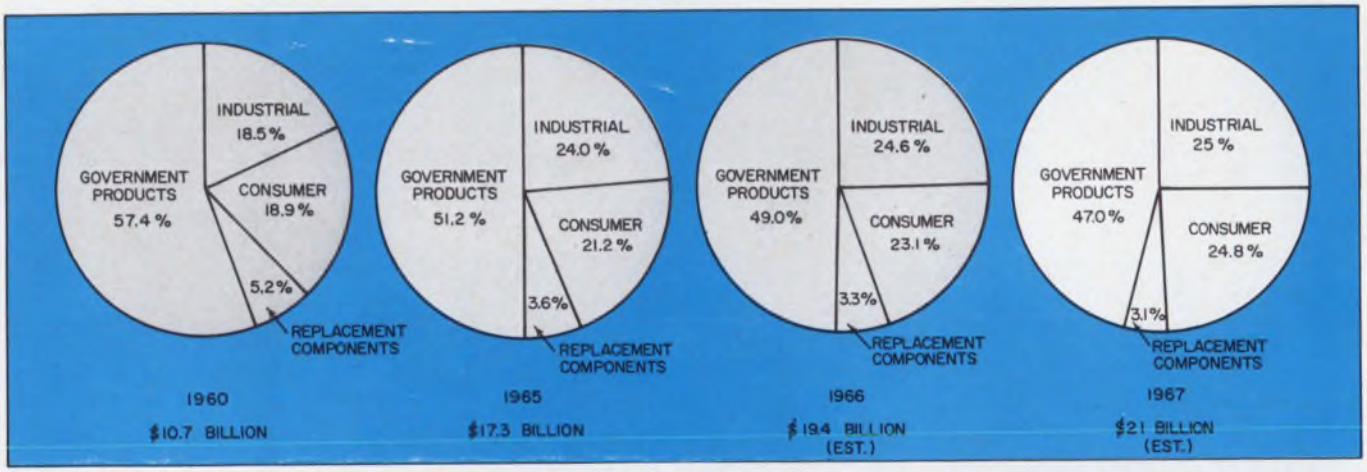
Cutbacks in spending on the space program, it is believed, would not have as much effect on the electronic industry as would a reduction of military spending. Increased defense spending and rising consumer demand, it is felt, would take up the slack. In fact, according to an industry spokesman, the demand for engineers and technicians is now so high in the area of color TV alone that some companies are hiring relatively unqualified technical help and are offering them extensive training programs in the hope that they will stay on.

The whole industry scanned

A quick wrap-up of the industry on a market-by-market basis shows



Factory sales of the U.S. electronics industry is expected to reach $21 billion in 1967, an all-time high and 8% more than last year.



The U.S. Government has been the biggest customer of the nation's rapidly growing electronic industry during this decade. It has, however, consistently taken a smaller percentage of the total industry output each year. The recent rapid rise in consumer product sales is ascribed to the surging demand for color TV receivers.

ON READER-SERVICE CARD CIRCLE 11 ➤

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Quadrant	I +		I −		III +		III −	
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	10	25	20	25	20	25	10	25

RCA ELECTRONIC COMPONENTS AND DEVICES

The Most Trusted Name in Electronics

('67 forecast, *continued*)

that in 1967:

Consumer products—Color television set sales may total 7.5 million units or more, a 50% increase over last year. Also contributing to the consumer market growth will be such items as radios, phonographs, hi-fi components and tape recorders, as well as electronic organs and other musical instruments, electronic kits, hearing aids, citizens'-band transceivers, magnetic tape, window and door controls, home intercoms and boating and flying equipment.

One of the prime causes of expansion in the consumer area is the silicon controlled rectifier, which is finding important applications in slide projectors, home heating and lighting systems and other consumer equipment.

The automotive field will provide a burgeoning market for electronic products with particular emphasis on ignition systems and rectified-controlled alternators.

Industrial products—Increased use of computing and data-processing equipment will again spur the industrial electronics market this year. The growing demand for communications and broadcast equipment, and for navigational aids, is expected to continue this year. Steady growth is anticipated in industrial controls, test equipment, and nuclear electronics as well as products designed for medical, scientific and educational purposes.

Electronic components—Every major category of electronic component is expected to experience sales growth paralleling the expansion of the end-equipment markets. Color TV tubes and an enlarged demand for all types of semiconductors and microelectronic devices will be chiefly responsible for an anticipated $6 billion components market this year—an 11% jump over 1966. Now widely used in government and industrial electronic products, microelectronics will go on penetrating the consumer electronic field (see p. 33). In fact, it is expected that this year most manufacturers of home entertainment products will have at least one integrated circuit in their product—often more for publicity purposes than to serve a functional requirement. ■ ■

Ion engines for spacecraft ready for use

Lighter solar panels and proved designs spur major advance in propulsion, researchers say

Neil Sclater
East Coast Editor

The use of solar-electric engines for primary propulsion in space is both practicable and imminent.

This was the consensus of engineers representing the Government and industry at the American Institute of Aeronautics and Astronautics meeting in Boston. They based their forecast on recent weight reductions in solar-cell panels and the favorable testing of several ion-propulsion prototype engines. Practical application of ion engines may come this year, some of the engineers indicated.

Two applications are ultimately envisioned for ion propulsion: satellite control and long-range interplanetary missions. Ion propulsion, in common with other electrical schemes, has the advantage of providing higher exhaust velocity, or specific impulse, per unit of propellant mass than present chemical propulsion systems offer.

The leading contenders are two types of ion engines and the resistojet. The electron-bombardment ion thruster is the most likely candidate for interplanetary spacecraft missions, while the contact ion thruster is best suited for satellite control. The resistojet, principally a competitor for satellite control, augments chemical propulsion with electrical energy.

All three of these engines have been tested successfully in laboratories, while the resistojet and the electron-bombardment engines have passed tests on operational spacecraft.

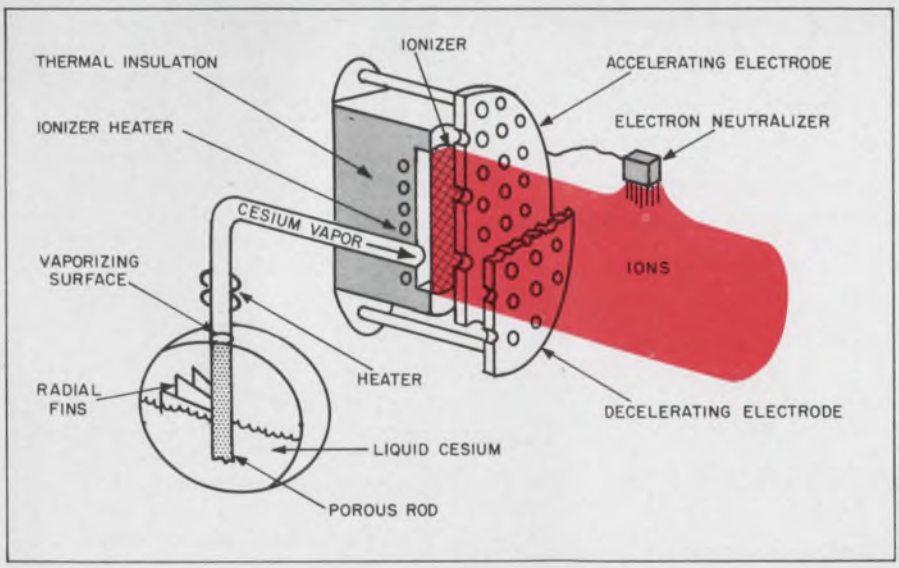
Ion propulsion is considered superior to the propulsion furnished by the resistojet; it offers more power at less weight.

The bombardment and contact types of ion engine perform quite similarly, especially in the 1-to-10-millipound thrust range, where most development work has been done. Engines of both types that have been developed to date demonstrated about the same reliability and lifetime.

"Ion-propulsion systems now are ready for serious consideration for application to a wide variety of satellite control and interplanetary missions," George R. Brewer, manager of the Ion Physics Dept. at Hughes Research Laboratories, Malibu, Calif., told the Boston meeting.

"Over the past 10 years we have seen the results of many careful studies on space missions involving electric propulsion. These analyses have shown clearly the advantages of electric propulsion, principally in increased payload."

Another speaker, Marshall P. Ernstene of Electro-Optical Systems, Inc., Pasadena, Calif., said: "Advances in micro-thruster technology have made satellite control missions for electric propulsion quite imminent, while improvements in solar-panel design now permit the use of electric engines for primary propulsion."



The contact ion engine, one of two important electrostatic thrusters (the other is the electron-bombardment type). The essential components of both types are an ionizer, a high-potential grid, or electrode, and a beam-neutralizing electron source.

Lightweight power needed

The practicality of all electrical propulsion schemes hinges on the availability of lightweight power. The biggest barrier to the use of any of the schemes has not been the engines themselves but the power-generating and conditioning equipment.

With current power systems, ion engines could be used for long-term attitude control and station keeping. They could also be used for deep space missions. Radioisotope devices could be used to supplement the available power.

Solar power using semiconductor cells for conversion has, according to the electrical propulsion proponents, made surprising progress in the last year. Solar panels capable of providing hundreds of watts are already in use, and thin-film solar-cell panels will be able to furnish one kilowatt from a 50-pound panel.

Nuclear power bypassed

In summarizing power sources for all types of electrical propulsion, Ernstene told the AIAA meeting that nuclear and solar energy were the only sources appropriate for electrical propulsion but that the prospects for solar power

(ion engines, *continued*)

were so favorable that "it will be possible to consider solar power for primary electrical propulsion over interplanetary distances—an area once thought to depend exclusively on nuclear power."

Although Ernstene believes that isotope thermoelectric or thermionic supplies could furnish power for satellite control, he says: "Pure nuclear power remains too speculative for immediate consideration."

As in all electrical-propulsion schemes, ion engines require a source of electric power, an engine for converting this power into thrust, and a power-conditioning and control system for matching the power source to the engine. And as in other rocket-thrust methods, the propellant is accelerated and ejected.

Satellite control will be an application of ion-engine propulsion, the research engineers say, if long satellite life is required—at least a year and perhaps as long as 10 years. Solar cells, even at present, can handle power requirements ranging from a few watts to about 300 watts.

Hughes Research Laboratories

Other electrical schemes

Resistojets are the simplest electrical thrusters. Propellant gas —hydrogen, ammonia, and nitrogen, for example—is heated by contact with an electrical element, and the gas is then ejected through a nozzle.

The resistojet is well-developed and ready for useful application. One has already been used for operational control of a VELA satellite. But its prospects are limited by the physical properties of the chemical propellants and temperature problems encountered with the materials used for engine construction.

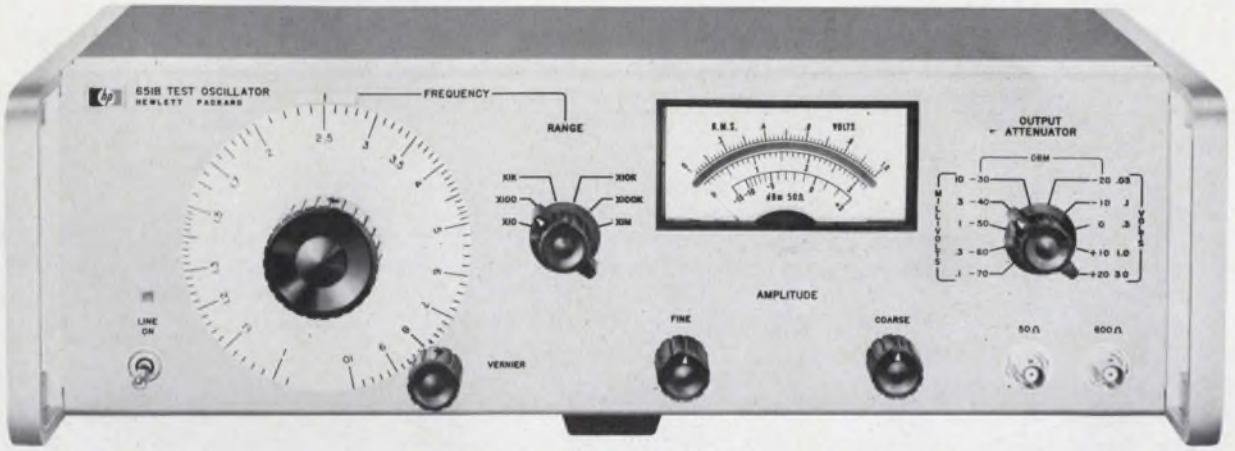
The arc jet is another type of electro-thermal engine, in which an electric arc heats propellant passing through it. The engine is currently of interest as a means of ionizing gas for plasma engines.

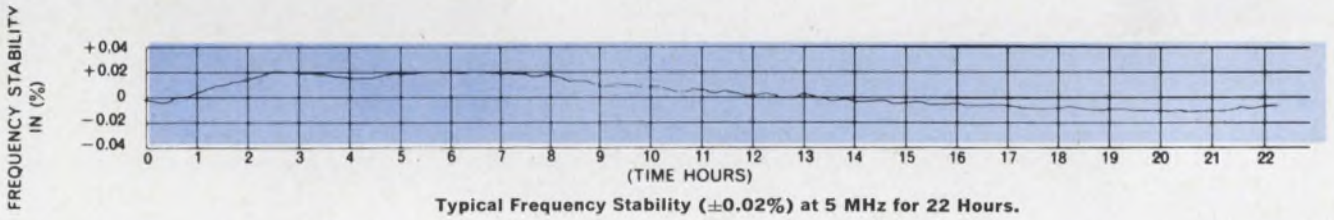
Plasma engines have made rapid improvements, but their future depends on the development of large power supplies.

New hp 651B and 652A Test Oscillators:

FLATNESS, STABILITY and ACCURACY

from 10 Hz to 10 MHz





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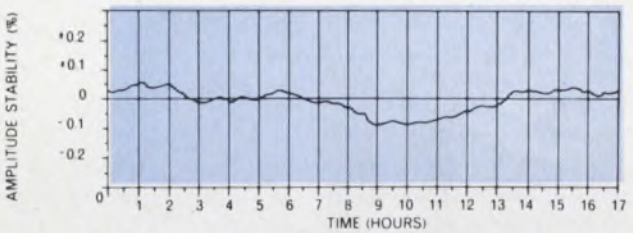
- **Two outputs: 200 mW into 50Ω, 16mW into 600Ω**



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APPLICATIONS: Use the new wide-band, solid-state hp 651B and 652A Test Oscillators for laboratory and production applications, in the presence of shock, vibration or high-frequency radiations. Both models are ideal for calibration of voltmeters because of accurate attenuator and output monitor.

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Output attenuator has a 90 dB range in 10 dB steps, with a 20 dB coarse and fine concentric amplitude control for increased resolution in setting output voltage. Output monitor is calibrated to read volts or dBm into a matched load.

652A: Specifications of two oscillators are identical except that the 652A has the ability to monitor output amplitudes within 0.25% *over the entire frequency range* of the instrument using the X20 expanded scale. Readings on the uppermost scale of the 652A are in percent for quick reading of frequency response measurements.

652A Expanded Scale Monitor

For full specifications on the new hp 651B and 652A Test Oscillators, contact your nearest hp field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva. Price: hp Model 651B Test Oscillator, $590.00; hp Model 652A Test Oscillator, $725.00.

116A

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ON READER-SERVICE CARD CIRCLE 14

(**ion engines,** *continued*)

of Malibu, Calif., has designed a synchronous satellite that uses ion engines for attitude control and station keeping. The proposed Hughes craft is a 1000-pound satellite with a three-engine system weighing approximately 50 pounds, including the solar cells, and requiring about 80 watts of electrical power.

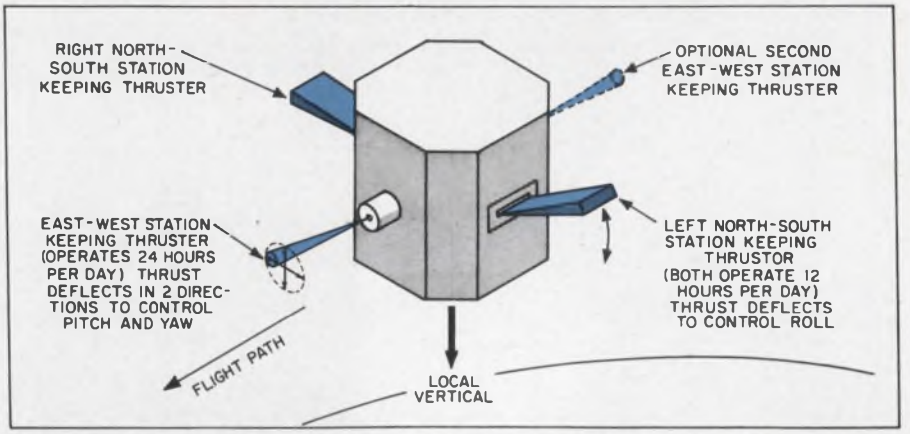
The ion engines would maintain north-south and east-west station keeping, as well as three-axis attitude control.

Two single-linear strip cesium contact engines of about one-half millipound thrust—one placed on the north and one on the south side of the satellite—and a single button-type cesium contact engine with 10 to 20 micropounds thrust—pointing in either the east or west direction—would maintain the east-west position of the satellites (see illustration).

The ion strip engines already developed would operate in alternate 12-hour cycles. They would be arranged so that the beam could be deflected to maintain attitude control about the roll axis while still providing the north-south station-keeping forces.

The micro-thruster, also in the development stage, could be controlled in two directions, to provide attitude stability around the pitch and yaw axes while still maintaining the east-west station.

Brewer believes that radioisotope heating of the ionizer of the contact engines will permit a 10-pound reduction in system weight.



A proposed synchronous satellite would use ion engines for north-south and east-west station keeping and for three-axis attitude control. The 1000-pound Hughes satellite would have a 50-pound propulsion system including solar cells capable of furnishing about 80 W.

In the last three years NASA has sponsored programs for the development of various ion engines. The 0.3-to-0.5-millipound linear strip cesium contact engines have been developed to the stage where they are ready for flight. With existing ion engines, the life expectancy is at least 20,000 hours.

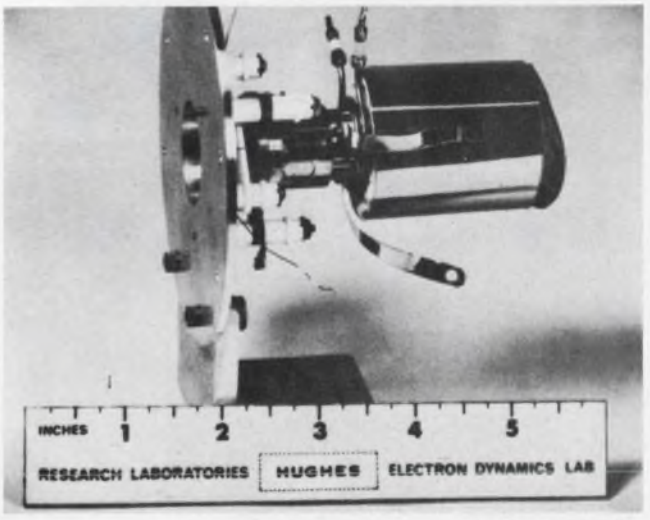
Five-year life envisioned

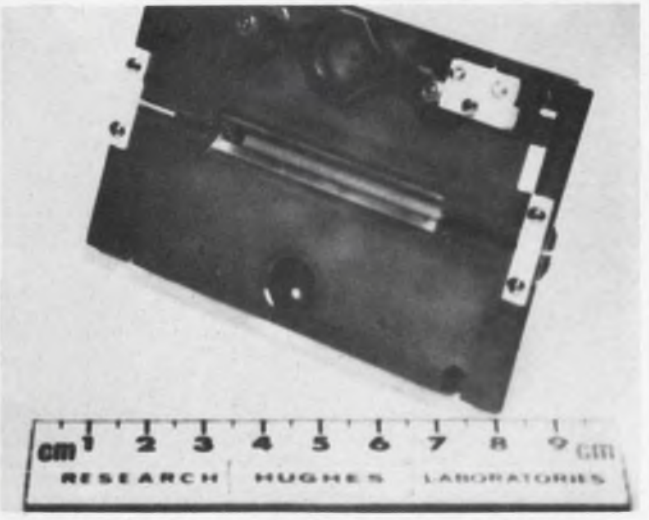
In the case of a strip engine that operates at, say, only one-half of each day, a 20,000-hour life is equivalent to five years of system life. On this same basis, the 2000 hours of testing that have already been performed are equivalent to six months of satellite life, or roughly the expected lifetime of many satellites now in orbit.

In summarizing the status of both ion engines, Brewer said: "Tests have shown that the thruster life can probably be extended to as long as 10 years by the use of improved ionizer technology, so that we may look forward to as long as 20 years of system lifetime, if limited only by the thruster."

The feasibility of 50-pound-per-kilowatt solar panels, in comparison with the 130-pound-per-kilowatt panels presently available, has improved the prospects of electrical propulsion for interplanetary missions.

Prototype propulsion systems already tested indicate the advantages of ion engine propulsion for unmanned spacecraft. Both Hughes and Electro-Optical have life-tested electron-bombardment engines successfully for more than 500 hours.





Satellite-control ion engines of the cesium contact type are under development at Hughes. The variable thruster at left can be deflected in two directions. It produces 0.1 millipounds of thrust and consumes 33 W. The linear-strip engine at right produces a thrust of about one-half millipound with about 100 W input power.

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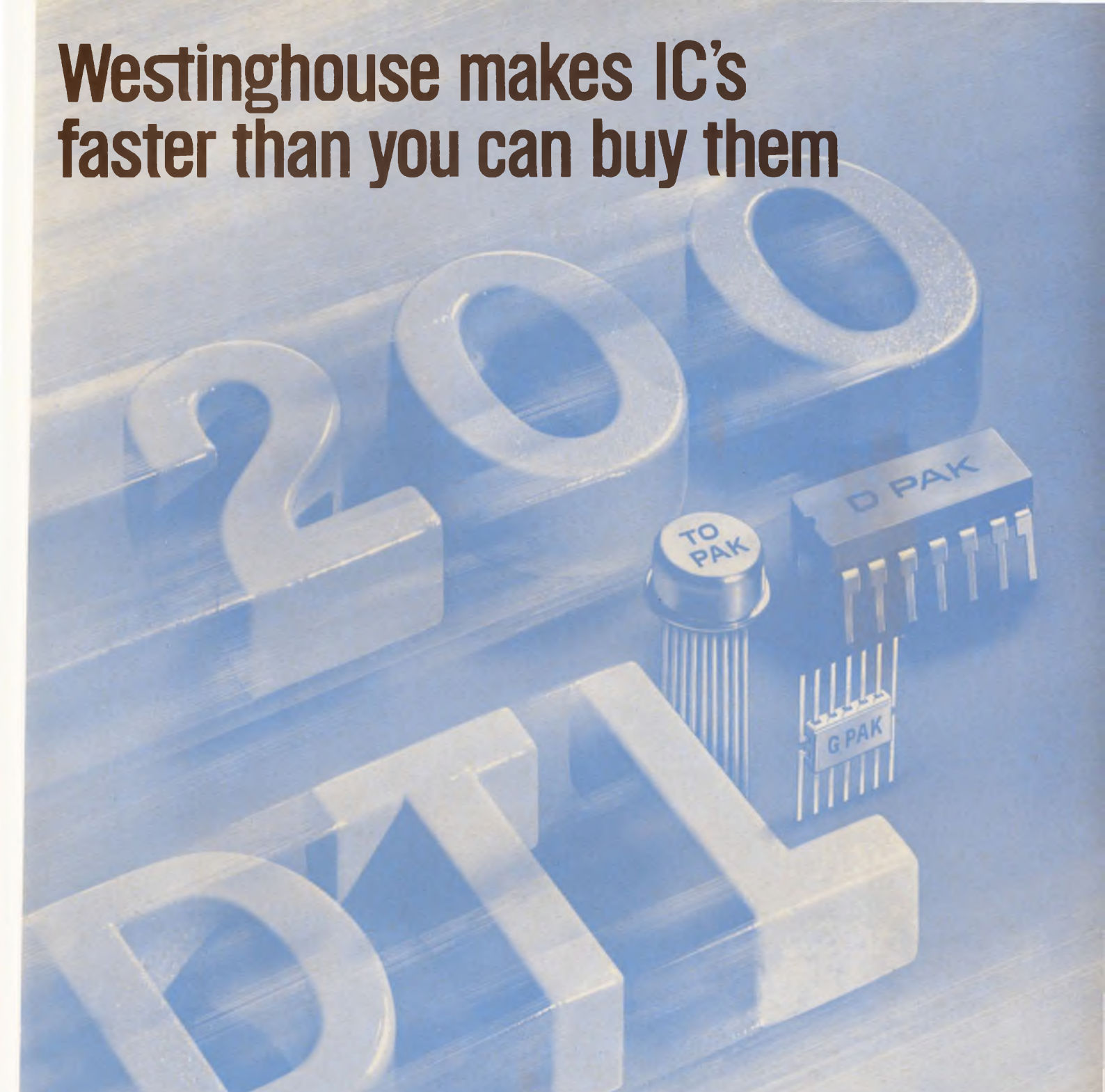

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J-09136

(**ion engines,** *continued*)

A 1.2-kw mercury electron-bombardment thruster system is being used by Hughes engineers to evaluate Mars spacecraft engine concepts. A modular power-conditioning and control subsystem in the Hughes prototype uses the sum of many individual low-power, low-voltage modules to operate the ion engine and mercury feed systems. Hughes engineers say that with this design they have obtained a subsystem that weighs less, has higher efficiency and is more reliable than a conventional, single high-power unit.

The modular sub-system can be mounted in a plane to radiate heat directly to space, thus eliminating heavy radiators. The design also calls for a high inverter frequency that permits the use of lightweight magnetic components and filters.

100 pounds of weight saved

The Hughes modular power-conditioning subsystem has a specific weight of 25 pounds per kilowatt. When combined with a 50-pound-per-kilowatt solar cell array, a total propulsion specific weight of 75 pounds per kilowatt results. This is nearly 100 pounds lighter than earlier systems.

Hughes engineers estimate that such a system could loft approximately 1800 pounds of scientific payload into orbit around Mars, with a total solar cell power of about 50 kW. This payload is nearly four times that possible with present chemical propulsion.

Similarly, Hughes engineers believe that the use of solar electric propulsion on a Jupiter fly-by mission could send 40 pounds of scientific payload into orbit, compared with 12 pounds for an all chemical system. In both of these missions, the researchers say, there would be significant cost savings with electrical propulsion.

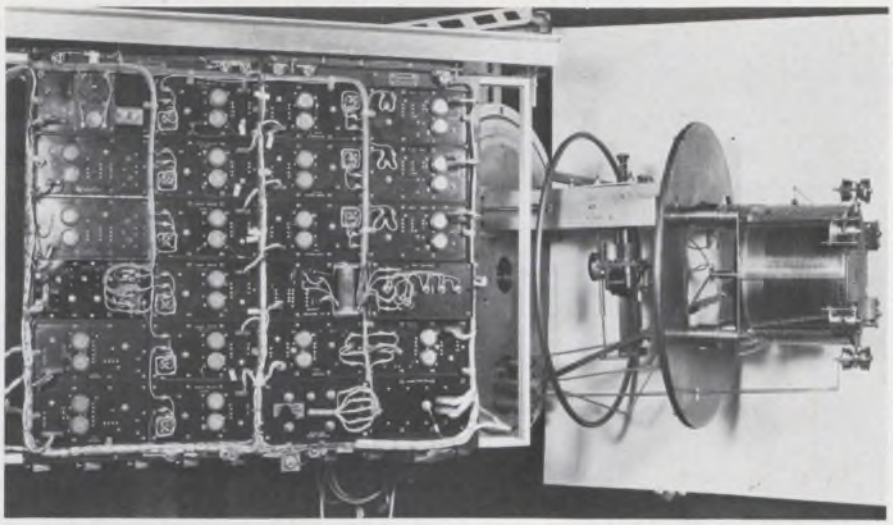
An important step in developing the cesium electron-bombardment engine was achieved last November. A prototype engine ran successfully for 341 days in a space-simulation chamber at the Electro-Optical Systems laboratory.

NASA has already sponsored a flight test for evaluating future ion engines for space missions of long duration. The Lewis Research Center at Cleveland manages this Space Electric Rocket Test (SERT) spacecraft program.

The first SERT flight, in July, 1964, was a sub-orbital one from Wallops Island, Va. SERT 1 successfully tested an electron-bombardment ion engine for 30 minutes. This engine was similiar to the one recently tested by Electro-Optical, except that it used mercury instead of cesium as a propellant.

A SERT II flight, set for late 1968, will demonstrate the long-term operation of ion engine systems for interplanetary propulsion.

These experiments will evaluate the performance of two electron-bombardment ion engines over at least six months. The effects of electric thrusters on such spacecraft components as solar arrays, transmitters and receivers also will be studied. The ion engines, with mercury propellant and each with a power imput of 1 kW, will be fired one at a time ■ ■



A prototype 1.2-kW electron-bombardment ion engine is being evaluated for an unmanned Mars fly-by spacecraft. Subsystems include the modular power conditioner at left and the engine and propellant feed at right.

Ion engines: How they work

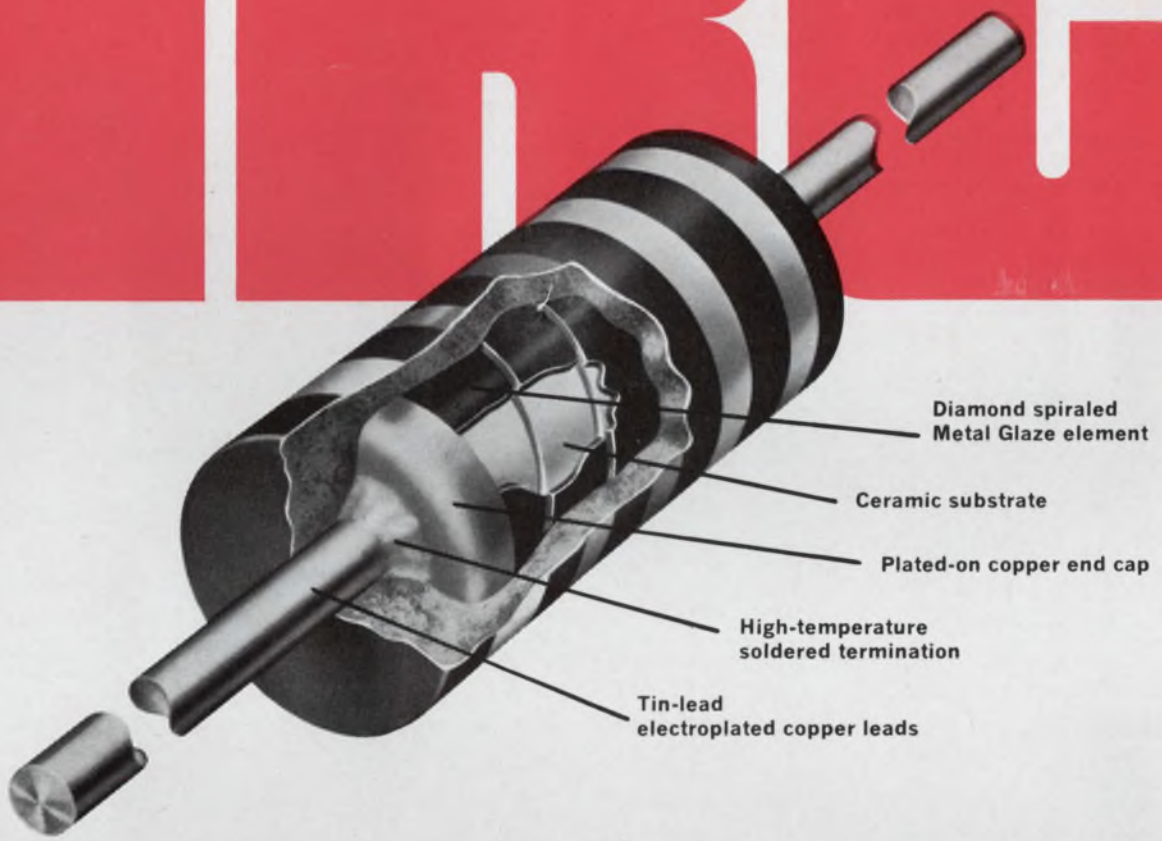
An ion engine consists of a positive ion source supplied with propellant from a feed system, a set of accelerating electrodes to eject the ions in a thrust-producing beam, and a neutralizer to add electrons to the departing ions, so the thruster (and spacecraft) remain neutral. Present ion engines employ either of two sources:

The electron-bombardment type permits ions to form in a low-pressure discharge through vaporized propellant. The discharge is maintained from a cathode to a cylindrical anode, and it is confined by a weak axial magnetic field. Propellant flows into the discharge region, and ions are drawn out through a screen electrode and accelerated through electrode apertures. This engine operates with either cesium or mercury propellant. Cesium automatically forms a very effective cathode surface.

The contact type generates ions by the contact of an easily ionized propellant (cesium) with a heated refractory metal (tungsten). The cesium evaporates mostly as ions. The tungsten ionizer is actually porous, with cesium feeding through it. Again, ions are accelerated and ejected through a set of electrodes.

The neutralizer provides electrons for the ion beam. Neutralization must be effective to prevent the spacecraft from charging up and to keep the ion beam from diverging ("blowing up") from its own space charge. Effective neutralization, fortunately, requires only that electrons be made available to the beam in sufficient quantity for the beam to take what it needs. Electrons are supplied either from a hot filament thermionic emitter or from a small plasma discharge. The latter seems to have advantages of efficiency and reliability; it need not be located close to the ion beam.

IRC



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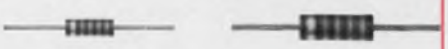
CAPSULE SPECIFICATIONS



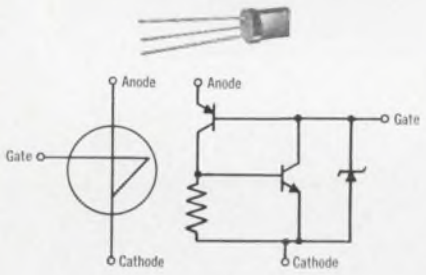
MIL-R-22684B:	RL07	RL20
WATTAGE:	¼ W @ 70°C	½ W @ 70°C
RESISTANCE:	51Ω thru 150KΩ	10Ω to 470KΩ
TOLERANCES:	±2%, ±5%	±2%, ±5%
TEMPERATURE COEFFICIENT:	±200ppm/°C max.	±200ppm/°C max.
VOLTAGE:	250V max.	350V max.
SIZE:	.250" x .090" dia.	.375" x .138" dia.
IRC TYPE:	RG07	RG20

IRC®

ON READER-SERVICE CARD CIRCLE 16

■ WANT THE GREATEST TRIGGER STABILITY PER DOLLAR? HERE'S THE SWITCH

It's General Electric's Silicon Unilateral Switch—a simply constructed, plastic encapsulated, integrated circuit device with a switching voltage that's typically eight volts. Trigger voltage variation is typically less than 0.02% per degree centigrade. (The SUS' PNP base-emitter junction and its zener junction thermally complement each other.)

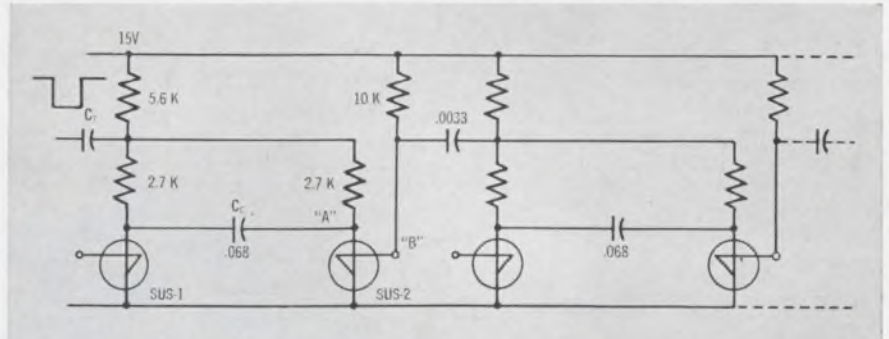


SUS symbol and equivalent circuit

The SUS blocks anode to cathode current flow up to its switching voltage, where it goes into a low voltage (approximately one volt), high conduction state. The device also blocks reverse voltage up to 30 volts.

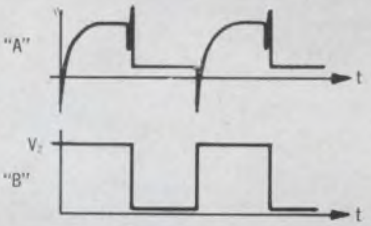
An unusual bonus feature you get with the SUS is a gate lead you can use to suppress rate effect, trigger the device, or act as a transient-free output terminal.

Result: You get a stable, low voltage switch with a single distinct breakdown characteristic unmatched by any other device. Test a few for yourself. Circle number 811 for specifications and other details on where the SUS can benefit your circuits.



Here's just one excellent example of how you can put the SUS' unique characteristics to work. This two-stage frequency divider (or binary counter) circuit uses two SUS' per stage for precise frequency division.

Assume SUS-1 is on. A negative going voltage applied through the trigger capacitor (C_T) lowers the voltage at the resistor node and turns SUS-1 off. Immediately, the node voltage begins to rise back toward the 15-volt power supply. But, because of the cross coupling capacitor (C_C), the anode at SUS-2 reaches its switching voltage first. SUS-2 turns on, keeping SUS-1 off. Since C_T is much smaller than C_C, no change of state occurs when C_T is returned to its original voltage.



The next negative going voltage on C_T now turns SUS-2 off and SUS-1 on. The gate voltage at SUS-2, meanwhile, is at the zener voltage (V_Z) when SUS-2 is off and is at 0 volts when SUS-2 is on. As a result, you get a square waveform at "B" which can be used to trigger a succeeding stage.

■ HAVING POWER CONTROL PROBLEMS? G-E CUSTOM CIRCUIT MODULES ARE THE SIMPLEST SOLUTION

Did you know that General Electric has designed, built, and delivered over 40 distinctly different custom-made power control circuit modules? All of them were designed to provide the customer with exactly the circuit he needed. Some cost less than $2.00 in quantity.

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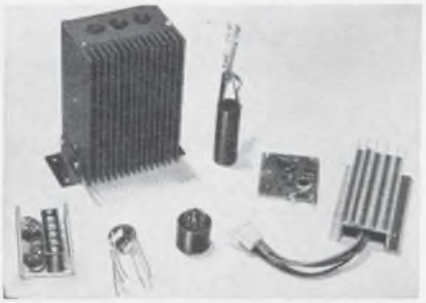

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GENERAL ELECTRIC

Washington Report

S. DAVID PURSGLOVE, WASHINGTON EDITOR

Computer exports help balance of payments

Electronics exports booming in 1966

The value of electronic equipment exports during the first six months of 1966 was $567.3 million, an increase of more than 24% over the same period of 1965. These recently published figures showed that there had been a 29% increase in the export of computers and allied equipment, which accounted for nearly a quarter of the electronic products sold overseas.

Feeling that their faith in the electronics industry has already been justified, government officials say that a great deal of hope is pinned on the industry's helping to make an appreciable dent in the U.S. balance of payments deficit. Washington spokesmen last fall indicated that permits had been granted for the export of computers to France in the hope that this would put a check on a potential French computer industry and keep the British industry from filling the French void. Now the Commerce Dept. Business and Defense Services Administration has revealed that this is precisely what happened. The biggest foreign market for U.S. computers was Continental Europe, especially the European Economic Community. The Common Market bought $50.2 million worth of computers, parts and accessories during the first half of 1966. Meanwhile, the U.S. exported $21.9 million worth to Canada, $21.6 million to the U.K. and $14.5 million to Japan.

The Commerce Dept. and the Treasury are underlining the fact that computer exports showed the highest actual dollar value and one of the highest growth rates. Thus a program to help manufacturers export computers would be a "worthwhile national effort," in the words of an official of the Commerce Dept. Bureau of International Commerce.

Prospects for electronics exports good

Both the large international companies and the smaller firms that have sold mostly within the U.S. are showing an increased interest in the export market. The Administration is giving them every encouragement to sell high-density, high-priced, high-mark-up electronic equipment to countries with stable currencies. A special display at the U.S. Trade Center in Frankfurt, West Germany, sponsored by the Commerce Dept. Bureau of International Commerce, was used by 28 companies to show document-processing equipment.

One reason why the 28 companies signed up for the show was a Commerce Dept. survey that showed that total German imports in 1965 were worth $17.6 billion, compared with $14.7 billion the year before. One of the fastest growing and largest import fields was document-processing equipment, which accounted for $7.2 billion of last year's import figures. The U.S. share of this market soared to 19.4%, worth $1.4 million in 1965. The Dept. attributes this market's rapid growth to a new law that makes photocopied documents legal for tax and civil law purposes in West Germany.

The Commerce Dept. is alerting U.S. industry to the fact that this is an ideal time to go into the German market, "because it will be only a few years before German firms will offer significant competition to U.S. makers of advanced documentation equipment," as one report concludes. The Dept. has singled out as specific targets for U.S. firms to aim at in Germany: public and private libraries; scientific and research institutions; banking and insurance firms; department stores; machinery and metalworking companies; electronic, electrical and appliance firms; and the automobile and chemical industries.

Export business not all roses

Some of the 28 exhibitors at Frankfurt were not without qualms, having heard of experiences "suffered" (as one oceanographic instruments maker put it) at a similar display in Frankfurt, sponsored also by the Commerce Dept., of U.S.-made oceanographic equipment. The Dept. had

billed the display as a great opportunity for U.S. manufacturers to take advantage of a mushrooming market and growing European interest in commercial fishing and offshore oil and gas exploration.

Of some 10,000 potential European customers invited to the display, only about 1000 turned up. Even then, no sales were reported. One manufacturer said he had received "four requests for my catalog." Such little interest as was expressed concentrated mostly on off-the-shelf equipment for the fishing industry.

The main European complaint was the price tag. U.S. prices and European budgets seem to be some four to five years apart, according to most observers. The Europeans were reported to have complained that U.S. equipment is overengineered for mundane jobs. A few European firms were reported to have expressed interest in the possibility of making leasing arrangements.

More money expected for pollution control

A well-attended meeting on air pollution control, held in Washington, D. C., December 12-14 by the Dept. of Health, Education and Welfare, while it elicited little new information, indicated widespread grass-roots support for a stepped-up program to curb all sorts of pollution. A number of speakers made both scheduled and unscheduled pleas for more programs to control water pollution and solid wastes as well as air pollution. The consensus of the 3000 delegates was that they were in effect reviewing the Public Health Service's 1968 budget right then and there.

Many of the delegates acknowledged, however, that pollution control programs were already certain of favorable treatment next fiscal year. Almost every Democrat in Congress last year favored large programs, and so did the Republican leadership. A joint poll by *Congressional Quarterly* and the National Broadcasting Company showed also that nearly every one of the 47 new GOP lawmakers, though generally conservative, spoke out in favor of pollution control programs during their election campaigns.

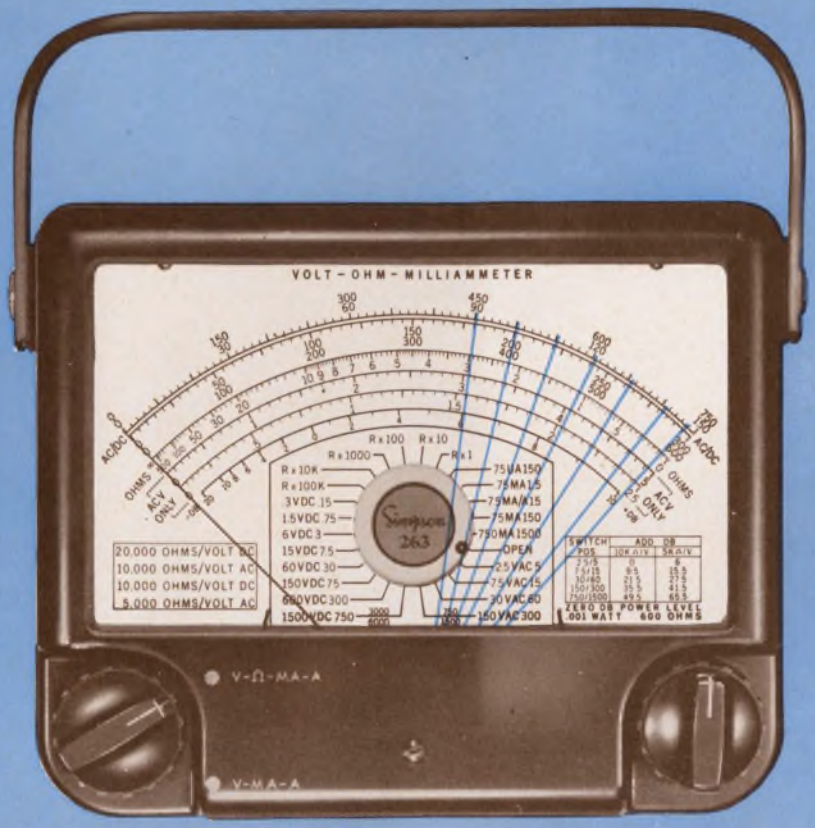
Many of the Public Health Service's pollution research programs that are already being funded relay heavily on electronic equipment. Electronics' key role in pollution control is that of monitoring, warning and activating control devices. An important position in the Service's research efforts is held by "instrumentation development." Work already under way, according to a recent report, includes "development of air pollution sampling and control instruments" at Pennsylvania State University; "developmental support for network instrumentation and methodology" at the Public Health Service Taft Center in Cincinnati; and "development and improvement of new and existing instruments for air monitoring" at the Los Angeles County Air Pollution Control District facility.

Transit proposals to be evaluated

Some order may soon come out of the chaos of suggestions, proposals and conflicting claims and counterclaims for a future high-speed transportation system for the Northeast Corridor between Washington, D. C., and Boston. The Commerce Dept. is on the point of awarding a $2.9 million contract to TRW Systems to make an engineering study of all the proposals and suggest which ones merit further study or even development. All that has now to be decided is whether announcement of the contract will be made over Commerce Secretary Connor's signature or that of Alan S. Boyd, Connor's deputy in charge of transportation who will head the new Dept. of Transportation where the High-Speed Ground Transportation Office will be situated.

Officials, who will occupy responsible positions in the new Transportation Dept., say the contract will once for all clear up speculation on which system or systems will be approved and will indicate definite directions for the whole program to take in its second phase.

TRW has been instructed to use the most up-to-date methods to analyze the proposed means of transportation and determine whether they fulfill seven criteria: highly predictable arrival times; low door-to-door travel time; flexibility of location; high safety, comfort and convenience; low cost for the user; capacity for evolutionary growth; minimal undesirable environmental effects.



RANGES

DC VOLTS: 0-0.15/0-.75/0-3/0-7.5/0-30/0-75/0-300/0-750/0-3000 @ 20KΩ/V; 0-0.3/0-1.5/0-6/0-15/0-60/0-150/0-600/0-1500/0-6000 @ 10KΩ/V.

AC VOLTS: 0-2.5/0-7.5/0-30/0-150/0-750 @ 10KΩ/V; 0-5/0-15/0-60/0-300/0-1500 @ 5KΩ/V.

DC MICROAMPS: 0-75 @ 150MV; 0-150 @ 300MV.

DC MILLIAMPS: 0-0.75/ 0-7.5/ 0-75/0-750 @ 150MV; 0-1.5/0-15/0-150 @ 300MV.

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ACCURACIES

DC VOLTS: 0-0.15 to 1500 ±1½%; 0-3000 to 6000 ±2½%.

AC VOLTS: ±3%.

DC CURRENT: ±1½%

RESISTANCE: R×1, ±3° of Arc; R×10 and R×100K, ±2½° of Arc.

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WORLD'S LARGEST MANUFACTURERS OF ELECTRONIC TEST EQUIPMENT

ON READER-SERVICE CARD CIRCLE 17

Core memory stack stores more bits to the inch

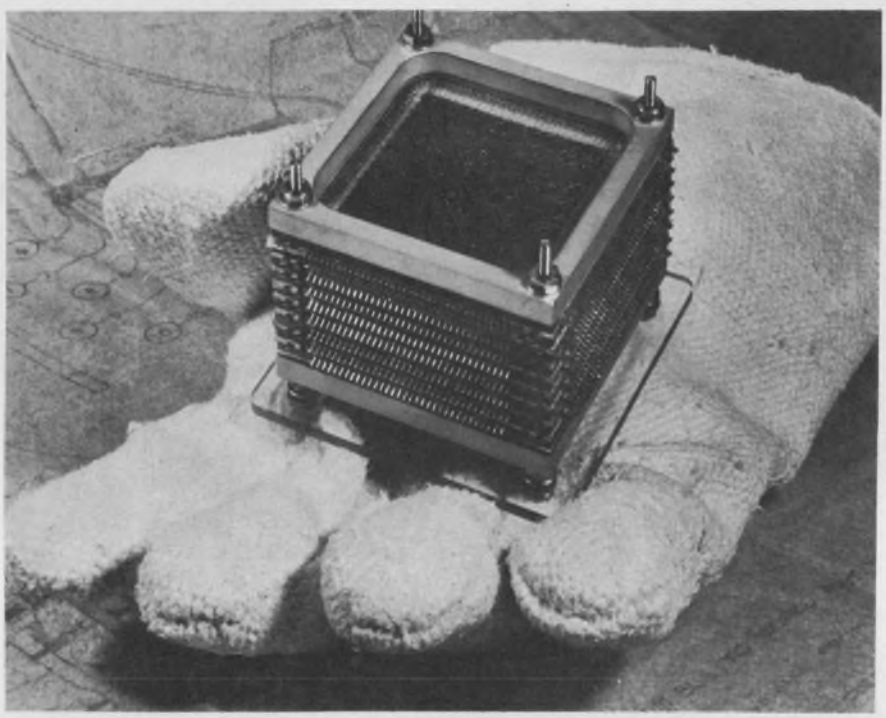
A departure from conventional manufacturing approaches has yielded a rugged core memory for airborne and space applications.

The memory stack, developed by Electronic Memories, of Hawthorne, Calif., is said to store the same amount of information as conventional core memories in only two-thirds the space. It does this by eliminating the center supports and stacking 12 bits to the inch, compared with the usual eight bits an inch.

The stack is reported to be capable of withstanding 30 Gs of random or sine vibration at temperatures from −55°C to +125°C.

The memory, called Semstack (Severe Environment Memory System), eliminates buss wire connections by using etched finger contacts to interconnect the planes. This technique eliminates half the solder joints usually required in memory stacks. The entire stack is bolted together, to compress the contacts and increase solder-bond reliability.

A typical 4096-word, 24-bit stack with 30-mil cores measures 3 in. by 3 in. by 2 in. and weighs 18 ounces with mounting hardware. Twenty-mil cores are also used.



Core memory stack with built-in heat sink is tested at 125°C.

The all-metal construction provides a built-in heat sink, which, according to a company spokesman, keeps all cores within 10°C of each other, even under worst-case conditions of power or temperature changes. This prevents the possible information loss caused by outputs at different voltage levels, resulting from differences in core temperature. ■ ■

Computerized vocal tract helps encode speech signals

More efficient methods of encoding speech signals for transmission over communications lines are expected to result from experiments with a controlled, computer-generated display of the human vocal tract.

Research along these lines, conducted at Bell Laboratories in Murray Hill, N. J., may lead to machines capable of producing intelligible speech from written data, the experimenters hope.

In the research thus far, an oscilloscope displays a simplified model of the human vocal tract. The model, which can be manipulated to stimulate forms corresponding to the pronunciation of basic sounds, was derived from X-rays of individuals in the act of producing these sounds.

By means of switches and manual controls on the computer console, the shape of the vocal-tract model and the corresponding sound can be varied simultaneously. The vocal tract pattern represents the positions of the tongue, lips, palate and pharyngeal wall.

Thus suppose the researcher wants to synthesize the word "Bell." He strikes the letter B on the typewriter keyboard, and the display assumes the corresponding form—that is, the lips close. The transition from B to L is then determined by turning the appropriate knobs and checking the changing tract pattern against an intuitive conception of what the pattern should look like. The computer commits the changing pattern and the corresponding sounds to memory, and in the playback both are reproduced simultaneously. By repeated intuitive efforts, in conjunction with the display, the researcher eventually forms the desired pattern.

Noting that the vocal-tract model introduces a subjective element into speech synthesizing techniques, Dr. Cecil H. Coker of Bell Laboratories says: "The present technique is moving away from reliance on mathematical integration of set area functions toward a more intuitive approach." ■ ■

Component and Circuit Design

IDEAS

from SYLVANIA Electronic Components Group

READOUTS

Breakthrough in EL panel design permits greater display flexibility

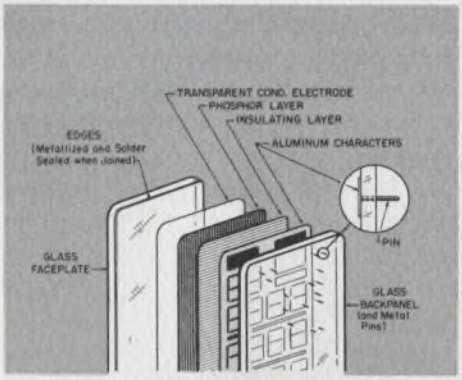
The newest advancement in electroluminescent readouts is a panel design of all-glass construction. Display designers and users now have a solid-state readout with higher reliability than ever before which lends itself to even greater design flexibility than previously possible with EL.

Completely engineered by Sylvania, this new concept actually allows both a decrease in readout character size (to ⅜-inch) as well as increased panel size. This means more characters per panel are possible than before in hermetically sealed EL designs.

Designers still get all the inherent advantages associated with Sylvania EL readouts: solid-state reliability, low-power consumption, wide viewing angle, light weight, low reflection, variety of characters, stable performance, no catastrophic failure, clear readability and rapid information display. Performance of the all-glass units is judged by the same standards as the metal-glass devices: brightness, spectral emission, contrast, life, etc.

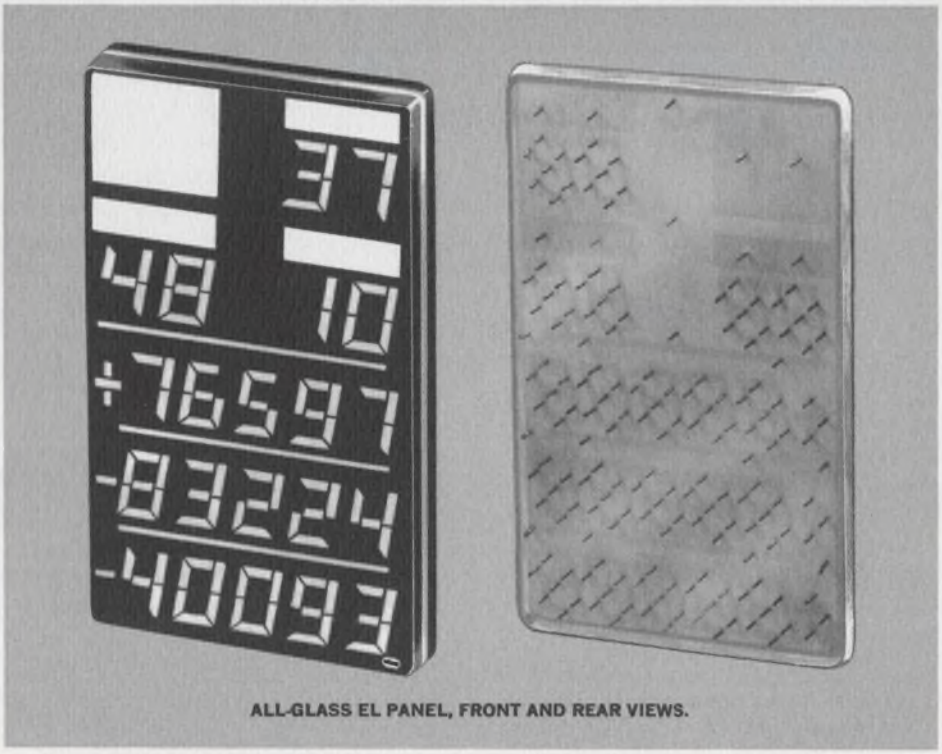
What does "all-glass" really mean in this sense? While metal-glass EL panels use metal contact pins and metal sealing frames, this new design concept is completely of glass construction, with the only metal present being the connector pins. Eliminated also are conductive rubber contacts.

The user-benefit of this new construction is a higher degree of lamp reliability for the demanding environmental and operational conditions encountered in severe aerospace applications.



The panels are designed to rigid specifications. The glass contact panel is molded as a single piece with the connector pins in place as integral parts of the panel. Combined with

(continued)



ALL-GLASS EL PANEL, FRONT AND REAR VIEWS.

This issue in capsule

Integrated Circuits—How 4-bit array registers can reduce package count while speeding storage and transfer.

Photoconductors—Combine lamps and photoconductors to get the function you need.

Microwave Diodes—Now your designs can be taken through Ka-band with Sylvania Schottkys.

Color Television—Rectangular 22" *color bright 85*® tube now available for 1967 sets.

Rectifiers—Glass devices from Sylvania can absorb 1000-watt reverse transients.

CRTs—New high-brightness, high-resolution tubes can be customed to your needs.

READOUTS *(continued from page 1)*

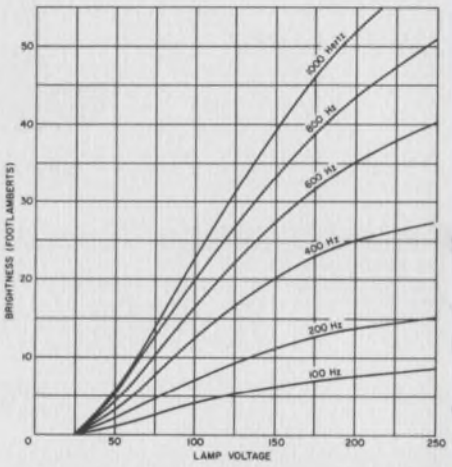
true hermeticity, the result is panels which perform reliably at extreme changes in altitude, temperature and humidity. They are also highly resistant to shocks and vibrations.

In the new construction, the glass contact panel containing sealed connector pins is ground flat on one side. The patterned back metallic electrode is applied to this glass surface. Thus, each active area becomes an integral part of its own connector pin, eliminating any possibility of registration problems. An electrical insulating layer is then applied over the back electrode and covered by a phosphor. A transparent conducting electrode put over the entire phosphor surface is the last electrical layer.

To protect the whole assembly, a glass front panel is placed on the transparent conductor and sealed to the contact panel, using a metal-solder technique. For less critical applications, an epoxy sealant may be used.

This simple construction process makes it easy to mass produce reliable and reproducible devices. The excellent match of expansion characteristics of faceplate and contact plate assemblies minimizes stress on the hermetic seal during temperature variations. Elimination of conductive rubber contacts provides a significant improvement in lamp reliability.

Standard all-glass units are available in 115 V and 250 V versions. The lower operating level is achieved by appropriate reductions in thickness of the EL and dielectric strata. Initial brightness is on the order of 25-30 FL at room temperature and 250 volts, 400 Hz. Spectral emission, contrast, life and half life are comparable to that of conventional EL panel design.



CIRCLE NUMBER 300

INTEGRATED CIRCUITS

How 4-bit array registers reduce IC package count, speed storage and transfer

Each of Sylvania's integrated four-bit binary register arrays contains the equivalent of at least 87 discrete components and the equivalent of 25 IC gates used in conventional integrated circuits. These monolithic digital functional arrays implement parallel storage or transfer of four binary bits every 15 nanoseconds. Here's how they work and how they can be used to build a temporary storage memory using only five IC packages.

Series SM-60 and SM-70 four-bit storage registers are for use as high-speed storage elements in control and arithmetic sections of digital computers. The SM-60 series has clocked inputs and clocked outputs. Further, the SM-60 output has wired OR capability which means outputs can be tied together to provide the logic OR function. The SM-70 series is operationally identical to the SM-60 except that it has a SUHL type output network and is not clocked with an enable signal. This means information set in the device is available at the output after a propagation delay of 20 nanoseconds.

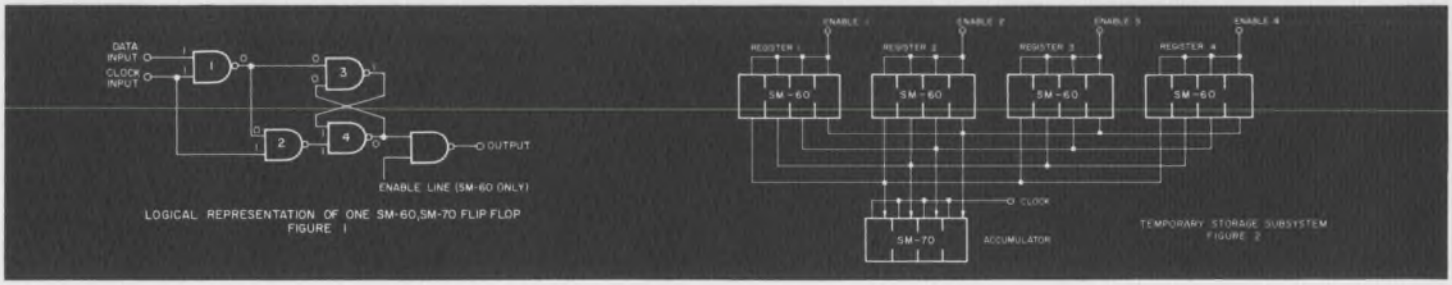
Figure 1 shows the logical operation of one of the four flip-flops in a storage register. With the data and clock inputs both at high (Logic "1"), the output of gate 1 is low (Logic "0"). This low condition appears at the input to gate 3 and forces the output of gate 3 to go high. The low output of gate 1 also appears at the input of gate 2, forcing the output of gate 2 to go high. Thus, both inputs to gate 4 are in the high condition. This means output of gate 4 is low. This low output appears at the input of gate 3, forcing the output of gate 3 high. The circuit is now latched with the output high. Once the circuit is latched, the clock input can be removed without disturbing the flip-flop.

Where data input is low (Logic "0") and clock input is high (Logic "1"), the circuit latches the flip-flop with its output in the low condition. If the clock input is low, no data is accepted.

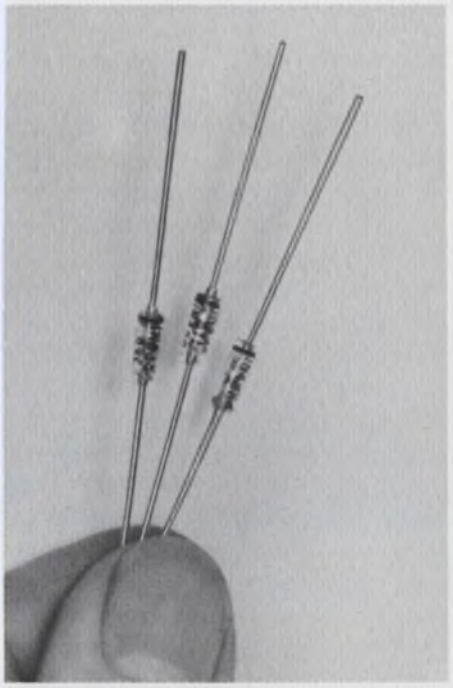
Figure 2 illustrates how to form a temporary storage register subsystem with common accumulator. Here, registers 1 through 4 can be enabled either separately or jointly. In the latter case, a logical OR is performed allowing masking techniques to be used. The SM-70 gives the accumulator a high fan-out. Only five packages are required and the number of external connections are cut to ⅛ of those required when conventional integrated circuits are used.

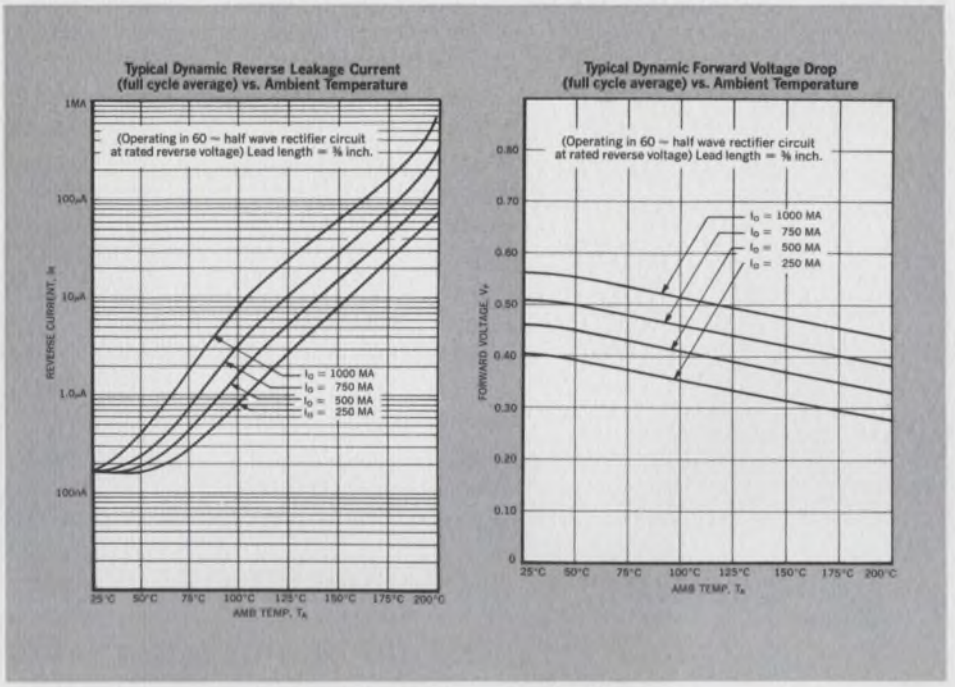
The SM-60 and SM-70 series operate over a temperature range of −55° to +125°C. Both these monolithic digital functional arrays are available in Sylvania's standard 14-lead dual in-line plug-in package and the TO-85 flat pack. They are completely compatible with the SUHL line of integrated circuits.

CIRCLE NUMBER 301



Absorb 1000-watt reverse transients with Sylvania's glass devices





Circuit designers are finding that Sylvania's glass rectifiers are better than other glass rectifiers. In this instance, the improved characteristics result in enhanced circuit performance and increased device reliability. Sylvania has coupled the inherent advantages of glass encapsulation with superior device design to make these glass diodes rugged enough for military applications. This designed-in dependability also makes this line of glass units an excellent choice for many other uses in computer, industrial and communications equipment. It is the improvements in device design that make Sylvania's glass silicon rectifier line stand out from other glass units.

In the improved devices, a large double diffused junction allows handling of 1000-watt reverse power transients while still maintaining the standard 50-amp forward surge capability. Sylvania's first glass rectifiers, can take outputs of up to 1 amp at reverse working voltage of 1000 volts without damage.

Heat dissipation is aided by welding a solid high conduction power lead to an oversized heat conduction stud. This enhances power handling capability while extending device life by keeping the unit cooler. The glass package is electrically neutral and smaller than many metal rectifiers, thus permitting greater stacking and card densities. With Sylvania's sealing techniques, the designer gets the benefits of improved device design without sacrificing any of the advantages of glass encapsulation. Use of a glass package means not only improved insulating characteristics but units that can be hermetically sealed. Radiflo leakage rate for these devices is less than 1×10^{-10} cc/sec. Low leak rates extend life and increase reliability. The glass body also enhances the thoroughness of in-process quality control by allowing visual inspection during production.

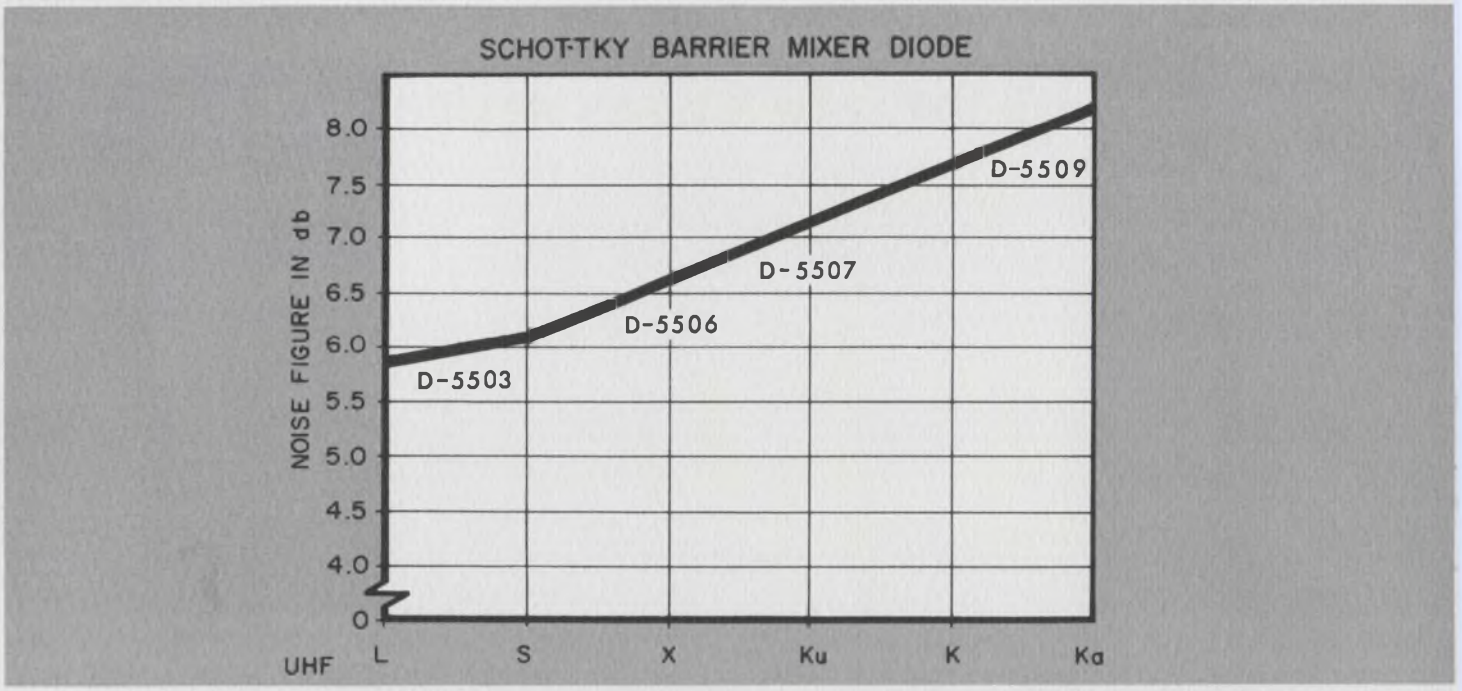
In addition to the ability to handle high reverse pulses, these rectifiers have low reverse leakage current. Typical rating is 10 na at 25°C ambient and rated reverse voltage. The high voltage rating and wide temperature operating range (−65°C to 175°C) capability of these units can't be matched by ordinary non-hermetically sealed devices.

All units in the Sylvania series are packaged in the conventional DO-29 outline. They are replacing existing glass, epoxy or top hat types in applications which demand higher reliability levels. These devices meet or exceed all the standard life and design requirements of MIL-S-19500.

CIRCLE NUMBER 302

ABSOLUTE MAXIMUM RATINGS:
−65°C to + 175°C — Resistive and Inductive Loads — Single Phase, half wave at 60 cps.

	Units	1N4383	1N4384	1N4385	1N4585	1N4586
Continuous Reverse Working Voltage, V_R	volts	200	400	600	800	1000
RMS Input Voltage, V_{rms}	volts	140	280	420	560	710
Average Forward Current, I_o	amps					
@ 50°C		1.0	1.0	1.0	1.0	1.0
@ 100°C		1.0	1.0	1.0	0.6	0.6
@ 150°C		0.3	0.3	0.3	0.2	0.2
Forward Surge Current, 1 cycle — $I_{F\ sur}$	amps	50	50	50	50	50
Forward Surge Current, Recurrent, $I_{F\ sur}$	amps	6	6	6	6	6
ELECTRICAL CHARACTERISTICS:						
Typ. Dynamic Forward Voltage Drop, V_F @ 1.0 amp	volts					
@ 50°C					.56	.56
@ 100°C		.52	.52	.52		
Typ. Dynamic Reverse Current, I_R @ V_R	μa @ 1.0 amps					
@ 50°C					.55	.55
@ 100°C		8	8	8		
Typ. Reverse Current, I_R @ V_R and +25°C	na	10	10	10	10	10
Typical Junction Capacitance — All Types —	@ 0 V 80 picofarads @ 10 V 21 picofarads					



Sylvania's Schottkys can take your designs through Ka-band...reliably

In last November's IDEAS, we announced MQM-packaged Schottky Barrier diodes that operate at frequencies through X-band. We have now extended the operating range of available Schottky Barrier diodes to include Ku-, K-, and even Ka-band. These newest diodes are also in the MQM package, and feature an even lower junction capacitance than their L-, S-, and X-band counterparts.

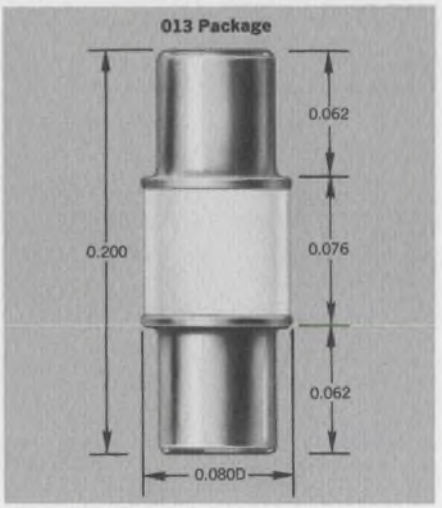
Effective coverage through the Ka-band (26.5 to 40.0 GHz) is only one of the outstanding features of Sylvania's Series D-5509 Schottky Barrier mixer diodes. To fully describe these new devices, one must combine the operating frequency performance with the extreme broadband capability having good burnout characteristics, and with an inherently low 1/F noise characteristic.

To get all this improved performance in one device means there must be not only an optimized semiconductor, but also an optimized package. The performance level of the D-5509 units shows they have both.

Sylvania's MQM package is the key to the broadband capability of these new units. Measuring only 0.08" x 0.20" overall, this package utilizes a low dielectric glass body hermetically sealed to precision mounting pins. The result is a package capacitance of only 0.08 pf allowing operation of a wide frequency spectrum.

In addition to its low capacitance, the MQM package features precise axial alignment of the mounting pins allowing precision design of miniature holders. Easy insertion and positive RF contact in holders are assured by a package design which has over 50% of its length devoted to circuit contact area.

Low junction capacitance of the diode permits operation in the Ka region. This low junction capacitance is the result of the superior alignment methods used in new Schottky Barrier diode processing techniques. The process employs epitaxial silicon to make devices with precisely controlled impurity distribution. In this improved method, a thin insulating layer and a relatively thick metallic contact layer over the barrier are used. The insulating layer and the superior mask alignment methods combine to produce the precise etching needed to make barrier regions of low capacitance. The metallic contact and pinpoint mask alignment maintain tight registration during metallization to give a reliable contact without increasing barrier region capacitance.



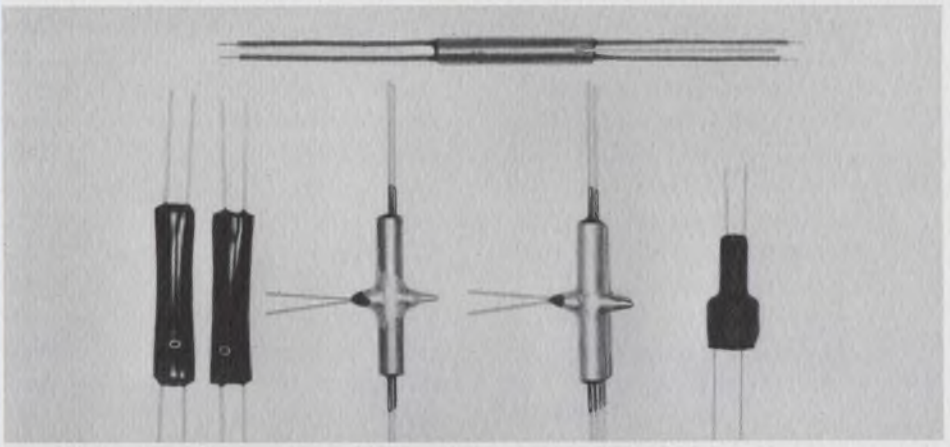
The low noise figures exhibited by the units in the D-5509 series (D-5509 = 10.0 db, D-5509A = 9.0 db, D-5509C = 8.0 db) result from the low series resistance of the diode. This low series resistance is obtained by keeping the epitaxial layer extremely thin, on the order of 1 micron. Because of the low 1/F noise characteristics of these units, they are ideal for doppler applications including police radar, proximity fusing, and traffic monitoring systems.

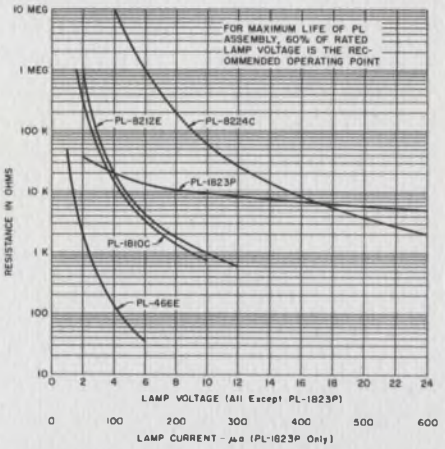
SYLVANIA'S SCHOTTKY BARRIER MIXER DIODES IN MQM PACKAGE

Frequency Band	S & C	X	Ku	K	Ka
Sylvania Series	D-5503 C	D-5506 C	D-5507 C	D-5508 B	D-5509 B
Minimum ONF	6.0 db	6.5 db	7.0 db	7.5 db	8.0 db

CIRCLE NUMBER 303

Combine lamps and photoconductors to get the function you need





Perhaps none of Sylvania's standard photoconductor-lamp (PL) assemblies fills your specific circuit requirement. Perhaps the new units that are coming don't include one that's just the right device. What do you do? Look for Sylvania's custom PL capability to get what you need, whether it be a simple detector unit or a combination of PL devices in one package.

Custom PL assemblies from Sylvania now allow circuit designers to implement many additional potential applications of photoconductor-lamp assemblies. A wide variety of possible photoconductor and lamp combinations means special assemblies can be designed to meet the most exacting requirements.

These custom assemblies take designers beyond the standard single-throw single-pole or double-pole types. Typical of one such custom design is an assembly containing two NE23 neon lamps optically coupled to three cadmium sulfide photoconductors. The photoconductors are enclosed in a lightproof metal cylinder and mounted perpendicular to the neon lamps.

Because Sylvania custom-designs, the company can offer PL combinations which more closely match the impedance level of the circuit they will be used in. For instance, with many entertainment manufacturers now becoming interested in all solid-state construction, Sylvania can deliver PL units that match impedance levels of solid-state circuits.

Availability of a wide variety of standard (shown in the table) and custom units erases limitations on the applications of PL assemblies. Because they have the characteristics of both a switch and a potentiometer and a response time in the millisecond range, they are unrivaled in many areas of remote control, low-level switching or potentiometry.

For example, for minimum hum pickup, the photoconductor can be soldered directly into an audio circuit to be controlled. Control can be achieved by varying PL lamp voltage from a remote location. PLs can directly replace switches and relays in any application within their power handling capabilities. Indirectly they can be used as triggering devices for higher power components.

Because of their time delay, PL assemblies are used extensively in the entertainment field to produce special musical effects such as tremolo and vibrato. Also, they may be used to regulate high voltage in color television receivers and for remote volume control in broadcast studio consoles. Industrial applications include performing AND and OR logic functions and the voltage control of time delay and frequency in monostable and astable multivibrators. Used with silicon controlled rectifiers, they can provide low-voltage isolated control for high-voltage loads.

CIRCLE NUMBER 304

	PHOTOCONDUCTOR								LAMP	
	Voltage (Volts)[1,2]	Dissipation at 25°C (MW)[1]	Light Resistance (Ohms)[3]	Dark Resistance (Megohms)[4]	Ascent Time (MS)[3,5]	Descent Time (MS)[4,6]	Shunt Capacitance (pf)[7]	Coupling Capacitance (pf)[8]	Rated Voltage (Volts)	Rated Current (MA)
PL-466E	400	300	35	0.3	55	17	4.944	0.433	6	35—45
PL-1810C	300	75	800	10.0	75	20	0.550	0.264	10	15—20
PL-8212E	300	75	700	10.0	55	17	0.960	0.229	12	35—45
PL-8224C	300	75	1500	10.0	55	17	0.740 (case grounded) 1.141 (case not grounded)	0.017 (case grounded) 1.070 (case not grounded)	24	15—20
PL-1823P	300	75	2750	10.0	50	12	0.700 (case grounded) 1.030 (case not grounded)	0.025 (case grounded) 0.905 (case not grounded)	90 (Breakdown), 59 (Operating)	0.3

AMBIENT OPERATING TEMPERATURE RANGE: —40° to +70°C

NOTES:
1. Absolute maximum rating system.
2. Measured with photoconductor in complete darkness at a pulse rate of 120 pps, 50 μs duration. Voltage in excess of rated may damage the photoconductor. Maximum DC voltage is limited by maximum dissipation and minimum dark resistance rating.
3. Measured at rated lamp voltage.
4. Measured 10 seconds after removal of rated lamp voltage.
5. Time to reach 63.2% of illuminated photoconductor current after application of rated lamp voltage.
6. Time to reach 36.8% of illuminated photoconductor current after removal of rated lamp voltage.
7. Measured across photoconductor leads (leads parallel to major axis) at frequency of 456 kc.
8. Measured between photoconductor and lamp leads (photoconductor leads tied together—lamp leads tied together) at frequency of 456 kc.

How a philosophy breeds IC reliability

As an engineering manager on the production side of integrated circuits, I'm necessarily involved in every facet of IC manufacturing and quality control. Occasionally, though, I'm asked to squeeze extra time into the day's occupation for, what is to me, an enjoyable diversion—showing and explaining our Woburn, Massachusetts, facilities to people who have a professional interest in ICs.

I'd like to comment on a couple of points that frequently come up in our discussions. The first is on reliability through hermeticity, especially as it relates to the dual in-line plug-in package. The second point deals with what we at Sylvania feel is a unique IC manufacturing philosophy.

The Sylvania dual in-line plug-in package was designed and constructed with the same reliability criteria in mind as the Sylvania flat pack. It is understood, then, that the cross-sectional appearance of the dual in-line package is very similar (except in size) to the flat pack.

The dual in-line (DIP) features a kovar bottom sealed to an alumina-filled glass construction in which the kovar leads have also been sealed. All of these seals take advantage of the technology gained from the kovar-to-glass seal originally developed for transistors. This is the classic kovar-oxide-glass combination. The package integrity that is achievable with this technology has been an established fact for many years.

The high degree of hermeticity that has become standard in the industry for such older packages as the TO-18 and TO-5, is now being achieved with the Sylvania DIP construction. The one significant difference between the older transistor metal packages and the DIP is the fact that the seal length (a possible leak path) is much longer than that encountered in the metal package. If anything, this would seem to lead to an even greater hermeticity capability.

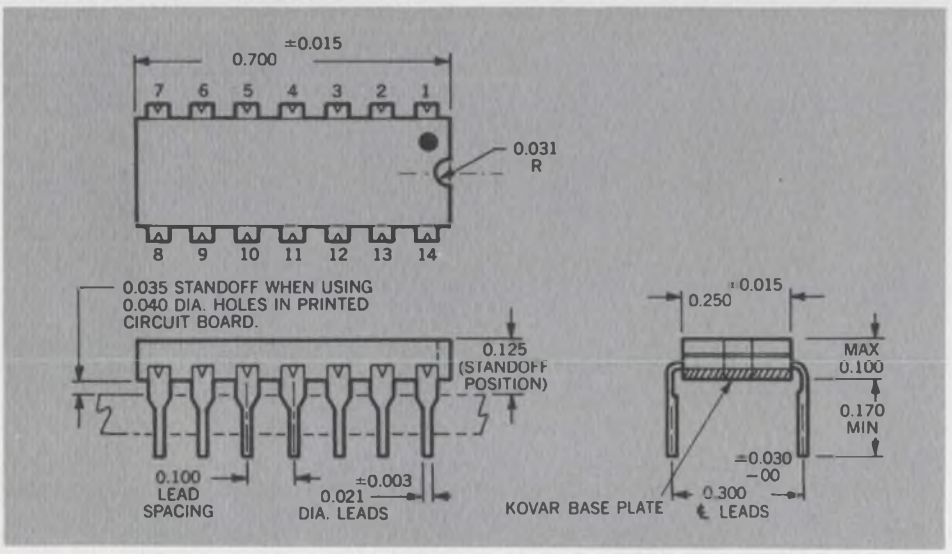
The cover of the DIP is made out of the same material as the body with the seal being a pyroceram frit. As a result of the use of these materials, the Sylvania dual in-line package is composed of thermally matched seals throughout its construction.

The integrated circuits manufacturing philosophy at Sylvania has always been to manufacture all circuits with identical care and a high degree of workmanship. Therefore, in the final analysis, Sylvania circuits need only be graded by their industrial or military capabilities as determined in the 100% final test. All Sylvania integrated circuits go through a sequence of reliability tests during their manufacture. These tests are applied after sealing the package in the following order.

First, each IC package is subjected to five cycles of −65°C to +200°C thermal cycling with fifteen-minute soak times at each of the temperature extremes. This test is assurance to both Sylvania and its customers that the package will withstand demanding stresses after sealing. Second, all packages are subjected to a 20,000 G centrifuge test while they are in the Y_1 plane. This test insures that the wire bonds have also been subjected to a mechanical stress test. Third, all packages are bubble-tested in 150°C glycerine for any leaks that might have come about as a result of deficient sealing or due to the package stress tests discussed above. Fourth, all integrated circuits are stabilization-baked at 300°C for 48 to 60 hours. Fifth, all Sylvania circuits are subjected to the worst-case DC tests at the temperature extremes guaranteed and also for all parameters which are called for on the Sylvania data sheet or in the customer's specifications. The ultimate electrical capability of each and every integrated circuit is tested at 75°C, 125°C, −55°C and 0°C for DC parameters. Following that, every unit is tested for all dynamic characteristics at switching. This is done in Sylvania's fully automatic test equipment at the rate of one circuit every two seconds. This equipment has been dubbed "Mr. Atomic" Multiple Rapid Automatic Test Of Monolithic Integrated Circuits). It is only as a result of the test performance in "Mr. Atomic" that any differentiation between military and industrial capability is made.

Each lot of integrated circuits is then held in quarantine for quality audit of the capability of the lot. During this audit, random samples are drawn for electrical parameter check and also for a hermeticity check. The latter is performed with Sylvania's radiflo equipment. This equipment uses radioactive krypton for a tracer gas and is the most efficient means available today for determining the fine leak rate of hermetically sealed packages with sensitivity to at least 1×10^{-12} cc/sec/standard atmosphere.

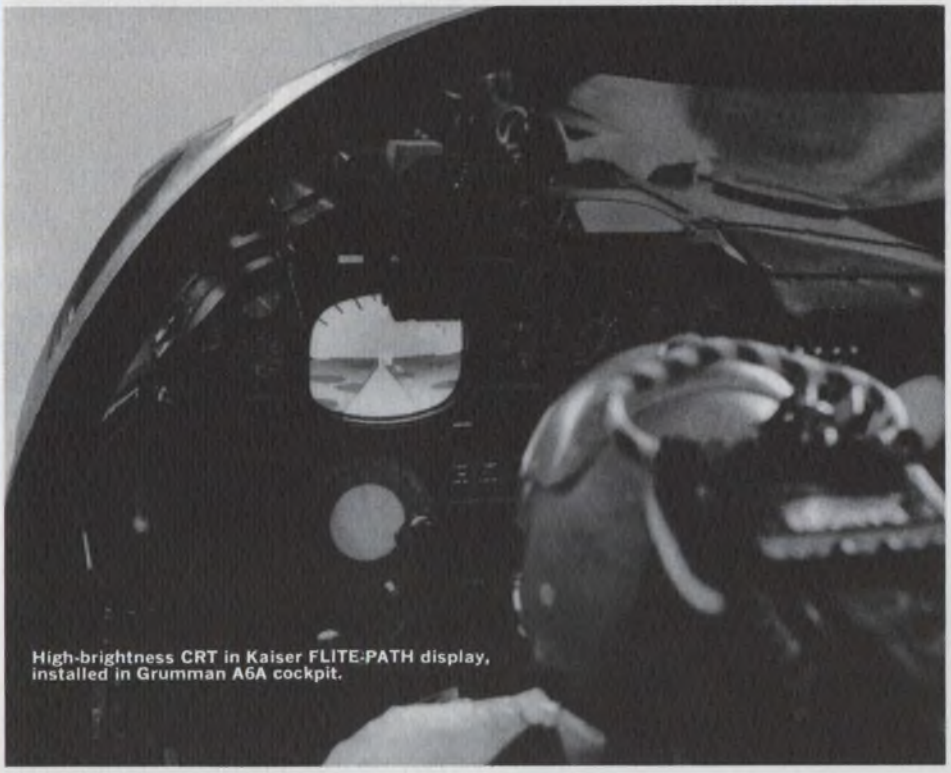
It is only after the complete circuit tests and package mechanical and hermeticity tests described above have been performed that Sylvania integrated circuits are shipped to our customers.



Henry Styskal

HENRY STYSKAL

New high-brightness, high-resolution tubes customed to your needs



High-brightness CRT in Kaiser FLITE-PATH display, installed in Grumman A6A cockpit.

What size high-brightness, high-resolution CRTs do you require for your aerospace equipment? Now, chances are you can get precisely the right devices to fulfill this need. You can, that is, if you consider Sylvania's new family of customized high-brightness, high-resolution CRTs. We've already made many variations of the basic unit. Each still retains the superior performance characteristics of the basic design. We'll use this same custom capability to build you a CRT tailored to meet your specific needs.

Sylvania's new family of custom high-resolution, high-brightness CRTs makes possible displays which are clearly visible even in ambients of high light levels. Combine this high-brightness, high-resolution capability with the ability to stand high altitudes and you get an ideal aerospace display device.

Other high-brightness tubes in this line can enhance quality of displays used in shipboard command systems, battlefield surveillance equipment, tv monitors or just about anywhere conventional CRT displays are washed out by high reflected or direct ambient light.

One important use of this new type tube has been in fighter aircraft for Vietnam. In the aircraft, a high-brightness cockpit display uses an 8" version of the tube to get an electronic photograph of the horizon. The picture the pilot sees is computer-generated by radar to give him a fix on the terrain.

Other customized versions of this tube may be the answer to your display problems. While usual applications for this family range from 3" to 8" screens, Sylvania will design and build tubes to your specific requirement.

Typical of these new tubes is type SC-4649A, with a rectangular screen having useful dimensions of 4⅜ x 5¾ inches. Key features of this unit include a high voltage gun of improved design and a neck diameter of 0.870 inches. Encapsulated leads insure reliable operation at high altitudes. Typical operating conditions show a brightness of 1.000 foot-lamberts minimum at 225 μa of anode current.

The SC-4649 series uses high voltage electrostatic focus and magnetic deflection with deflection angles of 70 degrees. An aluminized P31 phosphor gives a green fluorescence with a medium short persistence.

In addition to the SC-4649A, other versions of this series (SC-4649B through F) are available with various combinations of faceplates and bonded shield cover panel.

CIRCLE NUMBER 305

COLOR TELEVISION

Now available for '67 sets, rectangular 22" color bright 85® tube

Even though most other color tube manufacturers now use rare earth phosphors, color bright 85 *picture tubes by Sylvania are still brighter. This has been true since we first coupled Sylvania-developed rare earth phosphors with exclusive phosphor dusting and glass panel stabilizing techniques. It's still true with the latest addition to our color picture tube line.*

Availability of production quantities of Sylvania's 22" *color bright 85* tube gives TV set manufacturers five different extra bright tubes from which to choose. Other tubes in the *color bright 85* line include 19" and 25" rectangular types. Sylvania uses an exclusive dusting process with each of these types to make them as much as 15 percent brighter than units from other manufacturers.

The new 22" tube has minimum useful screen dimensions of 17.446" by 13.640", producing a minimum projected area of 227 square inches. Because of new FTC labeling requirements, this tube will be used in sets marketed as 20" units.

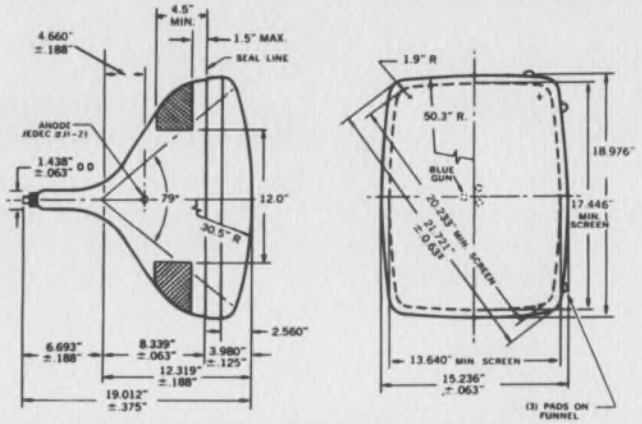
Three versions of the tube are available. The RE-22KP22 is the non-bonded configuration. Both the RE-22JP22 and RE-22LP22 have an integral protective window sealed to the faceplate. They require no separate safety glass window. Surface of the protective window of the RE-22JP22 is treated to minimize specular reflection.

All versions are manufactured to the same high standards which characterize the *color bright* 85 line. Pre-stabilization of the tube's glass face panel permits near-perfect alignment between phosphor dots and shadow mask holes. Cross hair indexed electron guns provide positive alignment of the electron beam and the phosphor dots. And the mask and the face panel are aligned automatically by a computerized process which precisely establishes optimized relationship.

CIRCLE NUMBER 306

FEATURES

Minimum useful screen dimension	17.446 × 13.640"
Minimum useful screen area	227 sq. in.
Overall length (non-bonded tube)	19.012 ± .375"
Neck length	6.693 ± .188"
Weight (approximate) (non-bonded tube)	28 pounds
Deflection angle (diagonal)	90 degrees
Maximum anode voltage	20,000V to 27,500V
Construction	Bonded-etched and unetched, unbonded
Phosphor	Sylvania rare-earth Europium



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SYLVANIA

SUBSIDIARY OF GENERAL TELEPHONE & ELECTRONICS GT&E

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Phonograph joins the trend to ICs

In television sets first, then radios, and now phonographs—the use of integrated circuits in consumer entertainment products is growing.

Westinghouse Electric Corp. is the latest entrant. It displayed an IC portable phonograph as it opened a products display center in downtown Pittsburgh. A single silicon chip, about the size of a typewritten "o," performs all the electronic functions of the new unit.

The development follows announcements by General Electric, Philco and H. H. Scott, Inc., of the use of ICs in home radios. GE and Philco are putting the circuits in table radios, and Scott is employing them in the IF amplifier stage of its higher-priced FM receivers. Last year the Radio Corp. of America put the first IC in a standard television set.

The Westinghouse phonograph has a conventionally sized automatic record changer, but the electronic functions are performed in an integrated circuit that is 112 mils long and 85 mils wide.

Two hair-like wires leading into the chip carry the low-level output from the cartridge mounted on the tone arm. Two other wires supply power from conventional batteries. A third pair leads out of the IC unit to drive the phonograph speaker.

"Company development engineers have been able to combine voltage amplification and power amplification function within this chip," said W. C. Fortune, of Westinghouse's TV-radio division.

The Westinghouse IC was developed and manufactured by the company's Molecular Electronics Div. in Elkridge, Md. The chip was incorporated into the phonograph at the TV-radio division in Metuchen, N. J.

It replaces 18 electronic items required in a conventional phonograph with the same general performance requirements, according to the company. From a functional viewpoint, it is reported to be equivalent to 39 transistors, diodes and resistors in the modification and amplification of signals. ■ ■

◀ ON READER-SERVICE CARD CIRCLE 306

Four-way rise in radio efficiency planned for jet

C-5A system has greater RF power, less interference, more reliability and easier servicing.

The high-frequency radio system selected for Lockheed's C-5A jet transport combines four major features for increased efficiency: direct coupling of the transceiver to the antenna, electronic tuning, automatic self-testing and replaceable solid-state modules. The result, according to the engineers who designed it, is a gain in radio-frequency power at the antenna, a reduction in interference, an increase in reliability and easier maintenance.

Designated the AT-440 Couplifier Transceiver by its designers, Avco Electronics Div., Evendale, Ohio, the system will be placed in the tail of the aircraft and matched directly to a notch, or shunt, antenna built into the jet's vertical stabilizer, thereby eliminating the transmission lines that run from the antenna to the radio compartment in most modern aircraft. Radiation losses from such lines will therefore not be a problem in the C-5A.

"Along this total path in a typical system, one-half of the radio-frequency power available from the transmitter for radiation from the airplane is lost," says Donald Busse, an Avco engineer.

Busse explains that in a conventional aircraft radio system it is necessary to transform the plate impedance of the last-stage amplifier down to 50 ohms, to match the coaxial cable and its fittings. The coaxial cable, he says, is "entirely a loss path" out and back to the antenna feed point, where the antenna coupler is located.

"The coupler's purpose is to transform the 50 ohms' impedance of the coaxial cable to the impedance of the antenna—again a loss device," Busse says.

Not content with merely shortening the transmission path, Avco engineers decided to eliminate it altogether. The antenna coupler was abolished in one simple transformation, according to Busse, by the use of a so-called couplifier plate directly to the antenna.

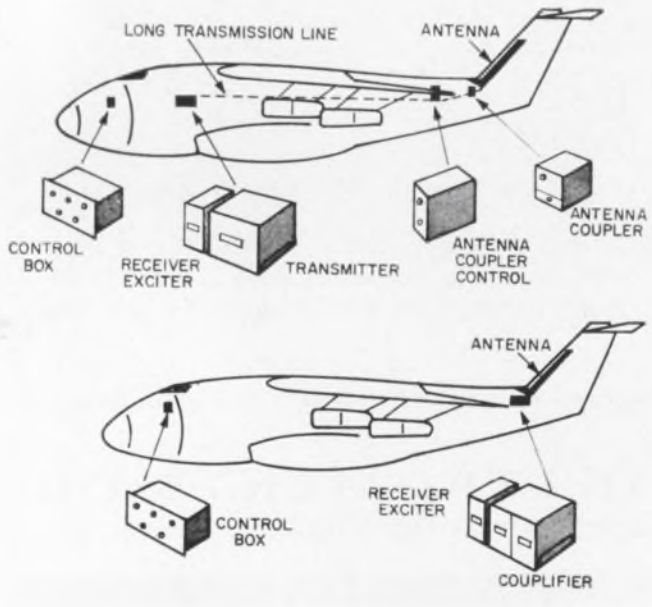
Another Avco engineer, Bernard Beitman, says that the Couplifier design drastically reduces radio-frequency radiations within the airframe that interfere with other electronic equipment on board. Beitman reports that the AT-440 design evolved from previous work that Avco did on the AN/ARC-123, a system for the F-111 variable-wing fighter aircraft.

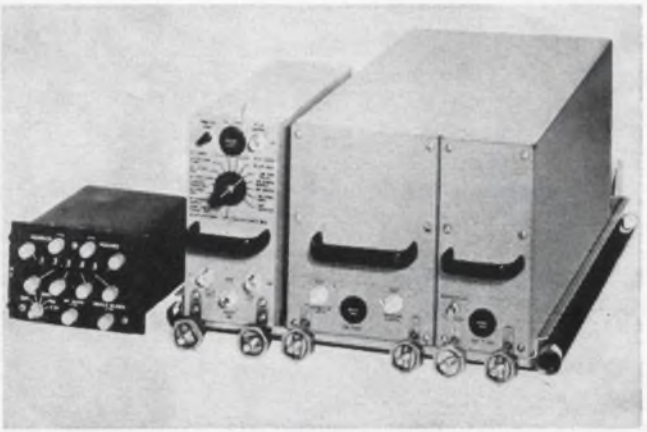
Binary tuning makes a match

As for tuning, most aircraft radio systems use automatic electromechanical methods, according to Beitman. The various adjustments of the tuning circuit and switches are made by motor-driven shafts and gear trains. The closed-loop tuning includes servomotors, mechanically variable inductances and precision gearing or sliding contacts. Beitman says that electronic binary tuning was substituted in the AT-440 system to eliminate these complicated methods.

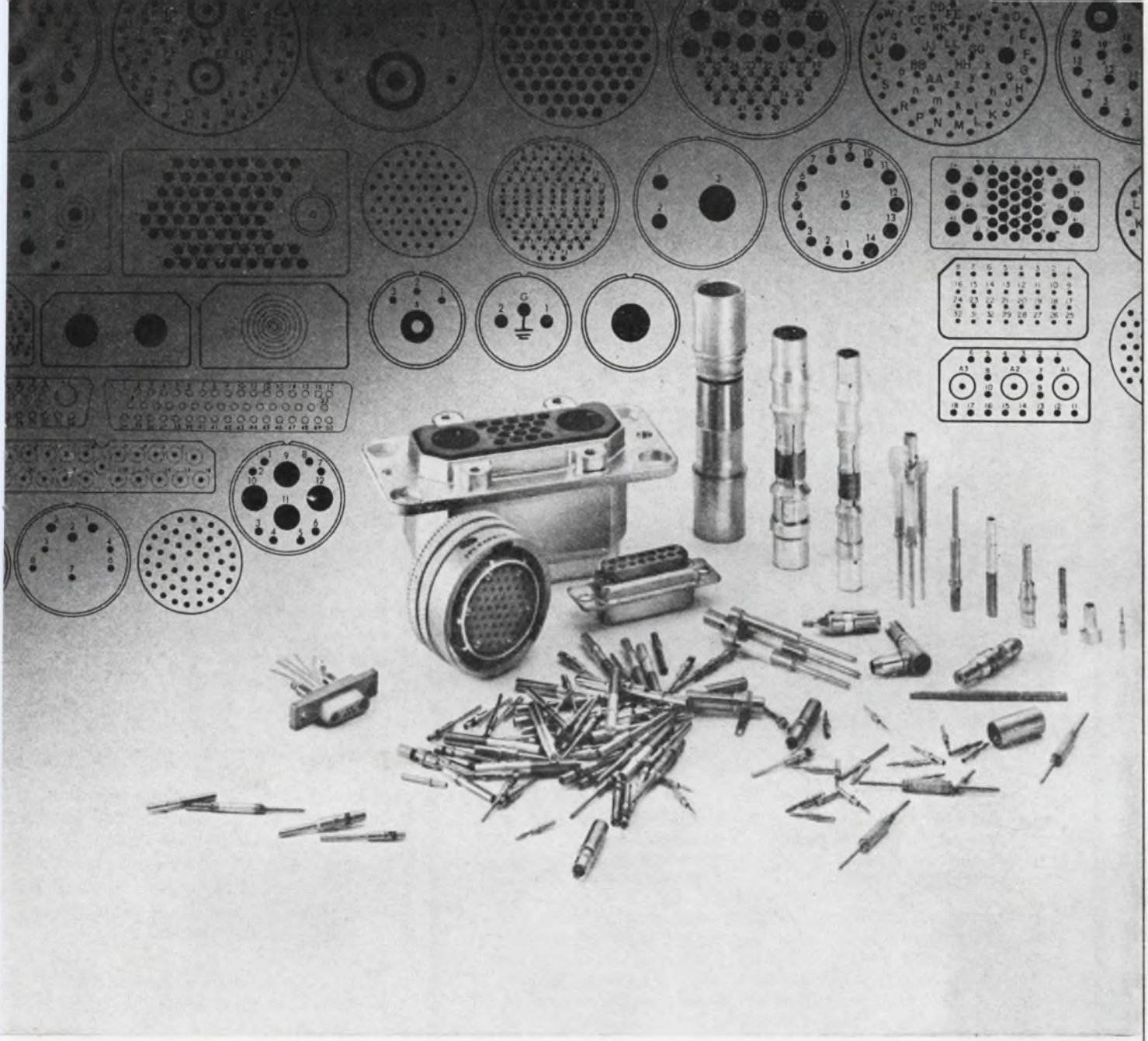
Binary tuning, he explains, uses vacuum switches, controlled by solid-state logic, to insert or remove inductance units in the transmitter circuitry. The inductance elements —called binary because each inductor is twice the value of the preceeding coil—can be selected to yield the best combination for optimum impedance match and RF energy transfer.

Like a musician adjusting and trying his instrument, the automat-





A conventional radio system for the C-5A jet transport (left top) would have the transmitter in a forward compartment. Avco's new system (left) has the transmitter and receiver coupled to the antenna. A pilot's control box (above in black) operates both the remote receiver-exciter and the "couplifier" (the gray units above). The system has electronic binary tuning and self-testing capability.



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(**efficient radio,** *continued*)
ic circuitry, on frequency command, inserts inductance elements, turns on the transmitter for a test and shuts down the system. It repeats this action until the optimum match is obtained. Sensors sample the match during a 10-millisecond transmitting cycle and tuning can be completed within 300 milliseconds.

Beitman says that the fault-isolating feature of the communications system is performed at the receiver-exciter unit. The built-in selector permits the maintenance technician to switch around until he receives a visual signal indicating a defect in the circuitry. Then, as part of flight-line maintenance, the technician can remove the faulty module package and replace it with a good unit, thus minimizing aircraft maintenance time.

The complete AT-440 system, including the receiver-exciter, couplifier and control box, weighs less than 100 pounds and is capable of 1000 watts peak envelope power. The system can transmit on 280,000 channels, ranging from 2.000 to 29.9999 MHz to 100-Hertz steps. It can operate in four modes: upper single sideband, amplitude modulated, frequency shift keying and continuous wave.

The C-5A jet, now under development, is scheduled for delivery to the Air Force in 1968. ■ ■

Electronic eye sets semiconductor bond

A coherent optical system that automatically positions a precision servo to accuracies of plus or minus one micron is being used in bonding semiconductor devices.

The electronic eye made by Itek Corp., Palo Alto, Calif., simultaneously scans a semiconductor chip and a reference photograph. Electrical signals obtained from this scanning are correlated by circuitry and converted into error signals.

The new tool can be adapted to operate up to six inches away from the semiconductor chip. ■ ■

Win a free trip to Paris. See p. 232.

Sound movies may use SiC technique

Within a couple of years, a relatively inexpensive home movie camera may be on the market that will permit sound tracks to be recorded on standard black and white or color film. The film would be developed through normal processes and played back on any standard sound projector.

The development that may make this possible is the silicon carbide electroluminescent diode—a pn junction device that emits a needle-thin beam of light when current is passed through it.

Though several organizations are reported to be developing silicon carbide electroluminescent diodes, the Norton Co., of Worcester, Mass., is the first company to announce that it has found a method of making silicon carbide diodes with repeatable characteristics on a production-line basis.

Dr. Lloyd Martin of Norton's research division said the diode emits a beam of light two- to three-thousandths of an inch wide at an intensity consistently higher than reported in previous diode experiments. The efficiency of the device, he said, is about 10^{-5}, or one photon of light emitted for every 100,000 electrons through the diode.

Dr. Martin said the light color and the efficiency of the diode are dependent on the amount of impurities in the silicon carbide material.

Recording of sound for home movie use would require a standard microphone, which converts the sound waves into an electrical output. The signals are then amplified and passed through the diode in the camera. The diode generates the light beam that "writes" sound on the film moving through the camera.

The company said that the only alternative approach for adding sound to home movies requires a magnetic strip on the film. This, it said, could raise film costs by 50 per cent and would require a special projector. Typical professional sound equipment uses a rather complicated, expensive and delicate system of lamps, mirrors and lenses to put sound on film, Norton said. ■ ■

◀ ON READER-SERVICE CARD CIRCLE 98

001 is the key to this connector's past –if you need it.

This Amphenol 48 Series connector was one of 1,472 assembled on Thursday, December 10, 1964.

The "001" says so.

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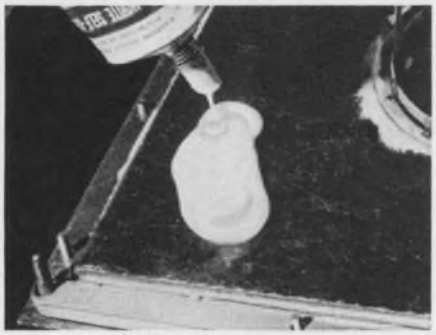
ON READER-SERVICE CARD CIRCLE 23

There's a G-E silicone

Bonding

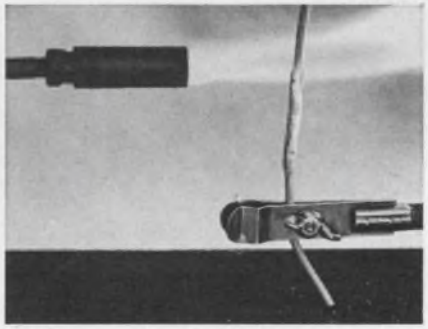


Laminated layers of mica sheeting are securely bonded with G-E RTV silicone sealant. Ready to use, it bonds to most materials, forming heat-resistant rubber.

Screws and drilling are eliminated by adhering identification plates with RTV adhesive sealant. It won't harden, soften, crack or shrink.

Insulating

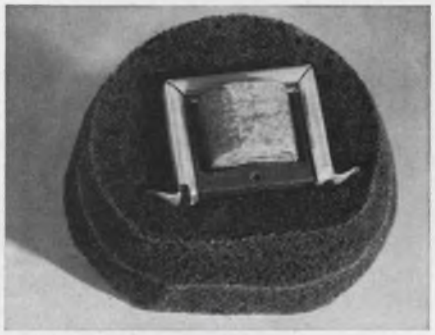
G-E RTV translucent sealant provides excellent see-thru insulation instantly. UL-recognized, the sealant also comes in colors.



Silicone rubber wire and cable insulation passes UL vertical flame tests and is frequently used in high-voltage circuits.

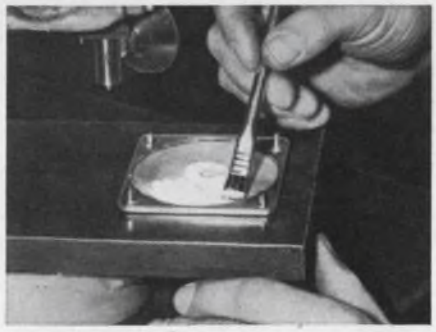
G-E silicone dielectric greases, ideal heat transfer media, are easily brushed, painted, sprayed, dip-coated or applied directly from tube.

Damping



G-E RTV-7 silicone rubber foams on the spot to provide mechanical support, shock and vibration damping, and light weight electrical insulation.

Sealing

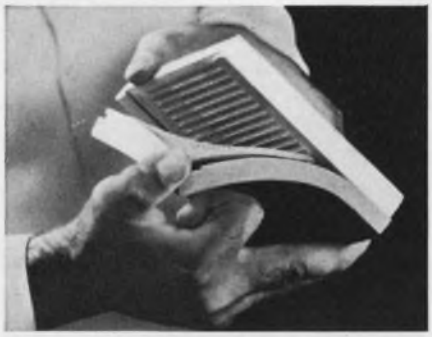


G-E two-part RTV, available in a range of viscosities, seals filament condenser plate in dielectric heater. Also protects against vibration.

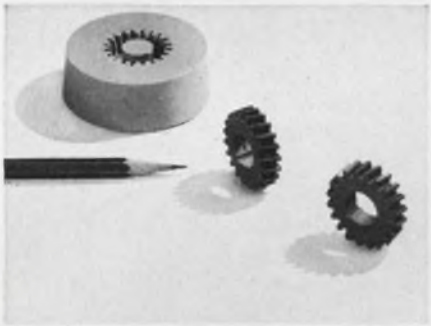
G-E RTV is ideal for high temperature moisture sealing of heating elements. It withstands temperatures as high as 600°F, as low as —75°F.

design solution for:

Moldmaking

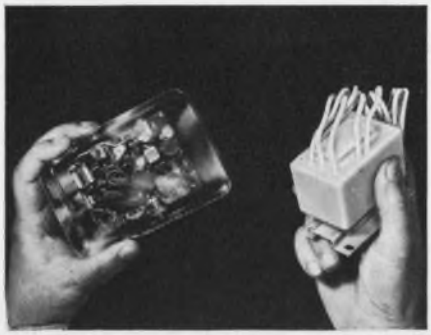


Tough, flexible G-E RTV silicone for moldmaking reproduces detail accurately and minimizes tooling costs.

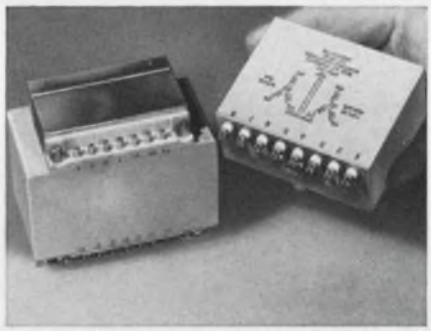


For prototypes or short-run parts production, G-E RTV is an excellent flexible moldmaking material. And it needs no release agent.

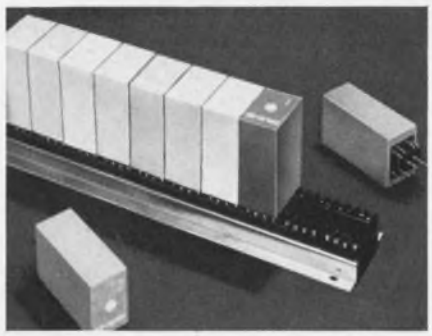
Potting and Encapsulating



Many G-E RTV silicone compounds are available—all with good strength, outstanding electrical properties and resistance to temperature extremes.



Impregnation of transformer coils with G-E RTV provides electrical insulation and environmental protection at high temperatures.



G-E RTV provides attractive, protective packaging for components. Each unit is encapsulated in a different color RTV for easy identification.

Fluids Applications

G-E silicone dielectric fluids provide excellent electrical properties and thermal stability for many types of components.

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G-E silicone elastomers are easily used to make numerous silicone rubber parts by standard rubber fabricating techniques.

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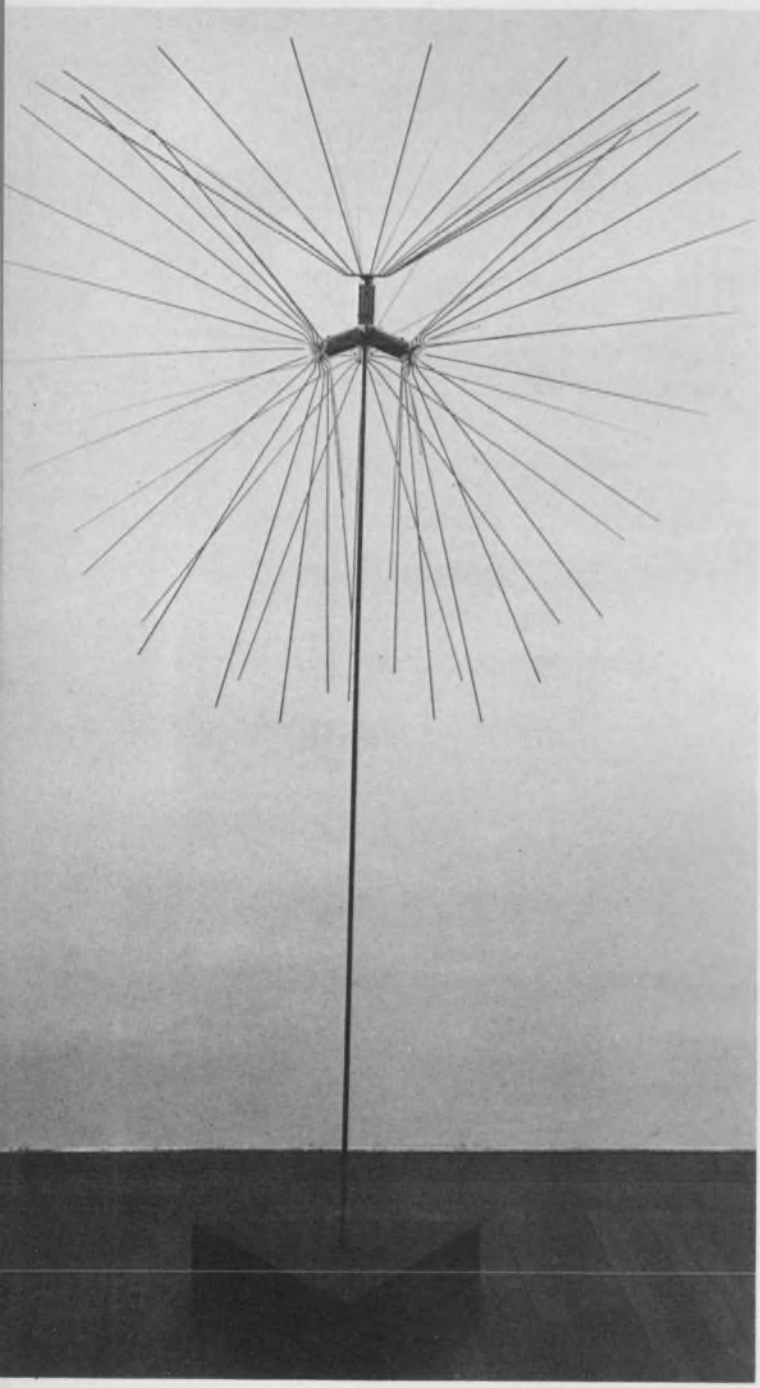
GENERAL ELECTRIC

ON READER-SERVICE CARD CIRCLE 25

Electronic art starts shaping up

Emerging from the realm of gadgetry, the 20th-century 'enfant terrible' acquires polish and precision.

Roger Kenneth Field, Microelectronics Editor



After much squawking and creaking, crackling and groaning, electronic art has finally flowered into its infancy.

James Seawright, a sculptor with a background in physics and an interest in electronic music, exhibited these dazzling and often perplexing pieces at New York's Stable Gallery. All of the sculptures either move or flicker with lights. The movements and light patterns are part programed, part random. A visitor may be dazzled by a beacon (*Searcher*) that seems to follow him round the gallery. But just as he figures that it is following him, it changes tack and seems to avoid him. "Simple periodic events get awfully dull," says Seawright, "yet I've tried to avoid making a religion out of pure randomness." By incorporating sequential logic into works that respond to changes in environment, Seawright needles his audience continuously.

Visitors to the gallery during November were greeted by a seven-window display that conveyed a single message: the number eight. The octahedron on the left is the neighbor of two shiny spheres that look like three-dimensional eights. Next comes a cut-out eight with a light behind it, followed by just a plain old eight. Then the pace changes: a tiny dot in the center of the oscilloscope face grows into a full-sized eight. The nixie tube flashes one, two, three . . . up to eight—then it

Four synchronous motors hold these spindly fingers to the top of their supporting rod. Supplied with 400 Hz ac, the undamped armatures tend to stay in synchronization with each other. A slight breeze that moves one causes the other to start turning. The delicate sculpture's title: 'Tetra'.

This work hammers home an "eight". A 60-hertz voltage is applied to the plates of the oscilloscope; the signal to the vertical plates is rectified and passed through a low-pass filter and a phase shift network. The speaker's audio signal comes from a magnetic-tape loop operating at one inch per second.

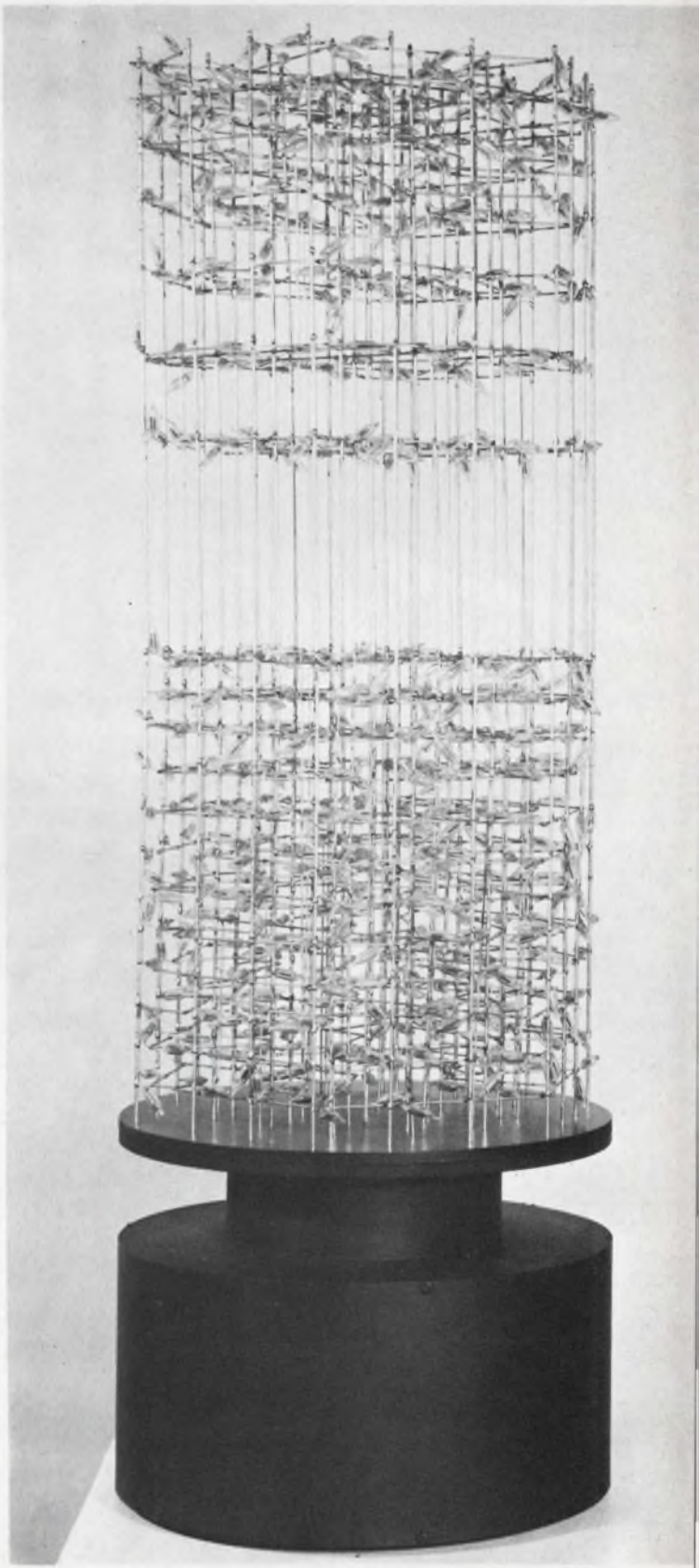
stops. Finally, the little speaker on the right utters the word "eight" in a deep voice.

In another work, lights of various colors hop about the ends of a bundle of fibre optic strands. Elsewhere, patterns of light in matrices move, but their nonsequential movements thwart any attempt to decipher rhyme or reason.

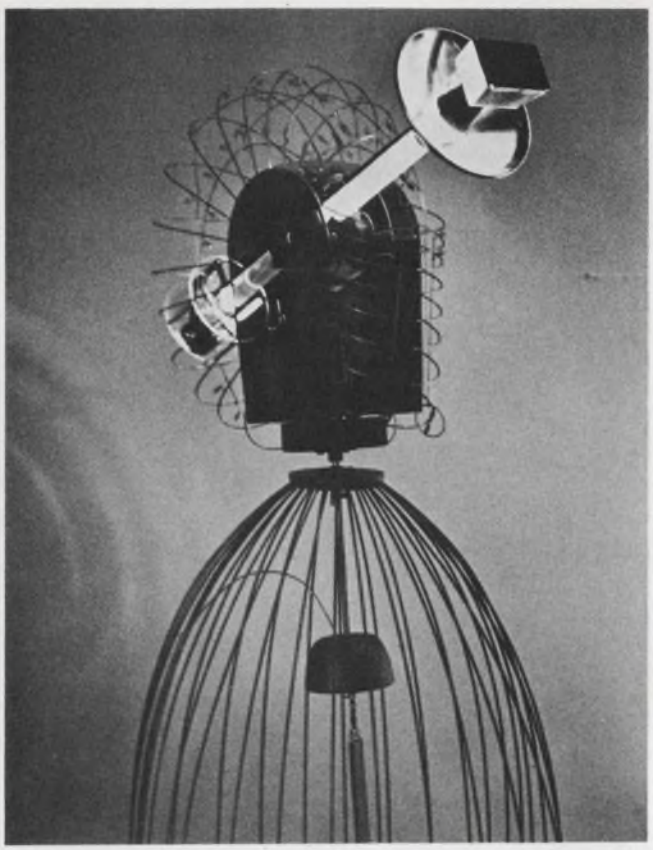
As opposed to the noisy works of foreign artists (see ED 1, Jan. 4, 1966, p. 42), Seawright's intriguing creations are quiet entertainers. Silent, helical gears mesh silently to drive their mechanical parts. And solid-state switches light neon and incandescent bulbs without so much as a click to disturb the still surroundings. "The sound of a switch is important," says Seawright, "and an artist should acquire a sensitivity to the sound that emanates from his work. In the *Tower* it is important to have the light silently travel about the structure so I used rolling, mechanical switches. But the crisp ticks of reed relays actually add to the strange sounds that come from the speaker in the *Watcher*."

"Most of my colleagues in electronic art decide on an effect first," he explains, "and then build a machine that achieves that effect. I try to work with electronics just as an ordinary sculptor works with stone or bronze. The resulting objects of art should be beautiful. And, hopefully, they will entertain and provoke their onlookers." ■ ■

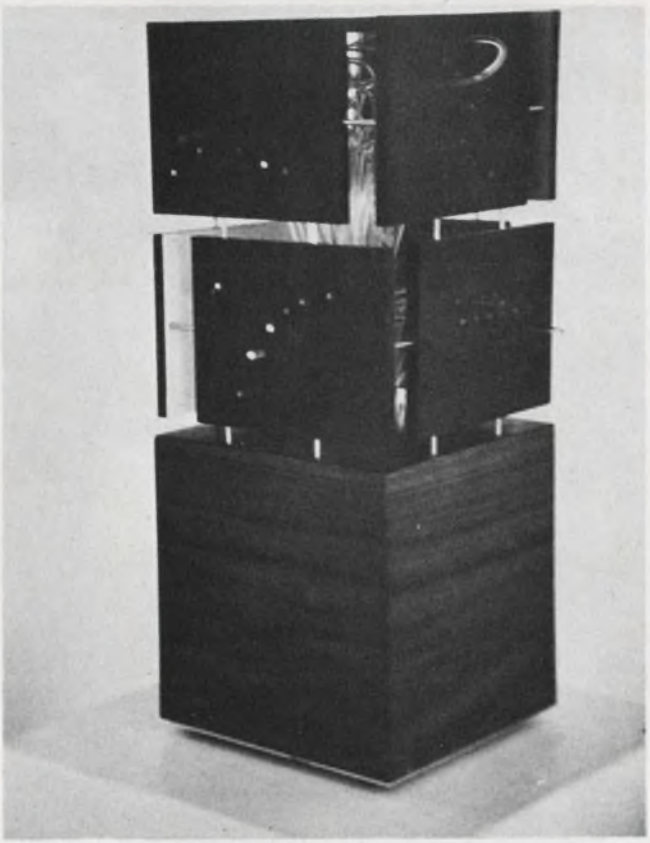
(continued on p. 44)



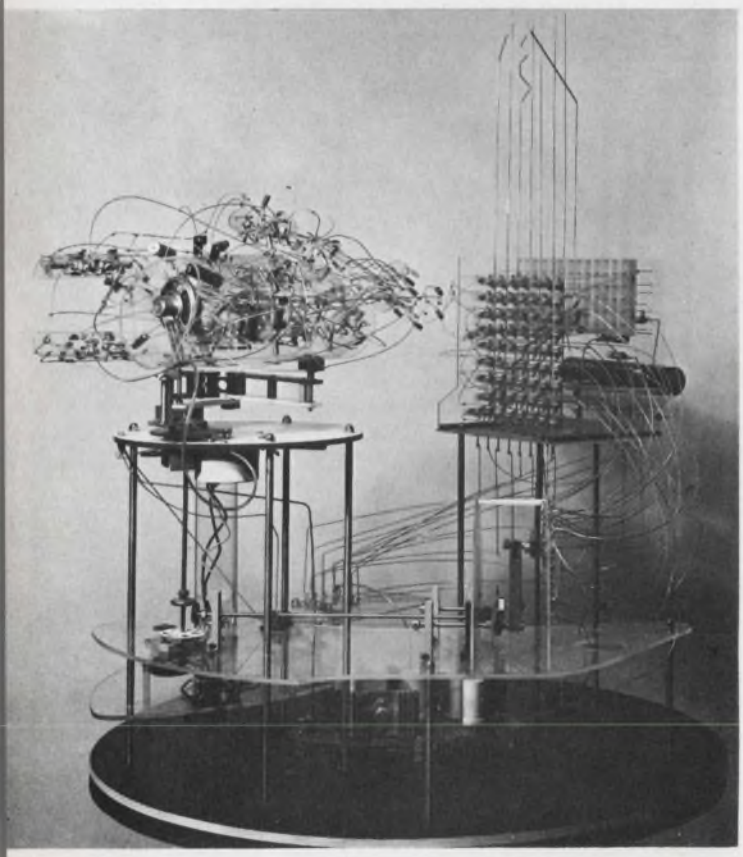
Light leaps about the 'Tower' as two mechanical switches in its base send current to its neon lights. One switch directs a current through one of its vertical support wires. The other switch grounds the horizontal levels, one at a time. This was the first of Seawright's electronic creations.

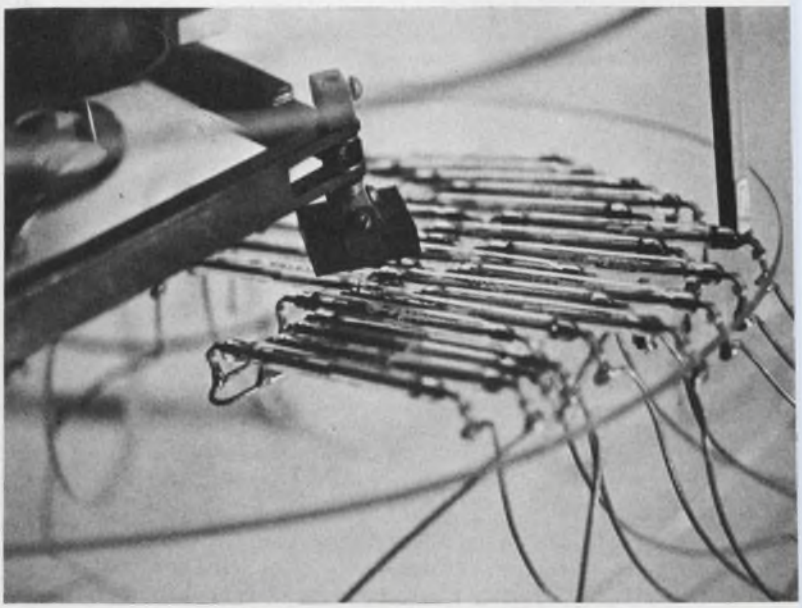


The 'Searcher' exhibits an intriguing pattern of behavior. Sometimes it seems to have an affinity for light objects, but when the polarity of its front-mounted, square photosensor changes, it suddenly is repulsed by them.



A lamp scans the bottom of a bundle of glass fibres. A moving set of glass filters color the light before it enters the fibres. Their visible ends light up in pattern of colors that takes weeks to repeat.





The 'Watcher' watches itself. A magnet, driven by a small motor, activates a group of reed relays that control the lights on the square matrix. The scrutinizing beast moves on a motor-driven mechanical arm toward and from the lights. Photocells that dangle from it sense the light and trigger flip-flops, which control the pitch of an audio oscillator. Its output is heard as a whine. The mechanical program that moves the scrutinizer runs 15 minutes; the relays are programed separately. The over-all cycle repeats every seven months.

AC metrology will never be the same after the Fluke 931A, the first true rms differential voltmeter. Measure the precise rms value of virtually any waveform within 0.05% from 30 Hz to 50 KHz. Overall frequency response is 10 Hz to 1 MHz. Range is 0.01 to 1100 volts. Ten to one crest factor accounts for effects caused by voltage spikes and pulse trains. Comes with or without probe. Both line or combination line/rechargeable battery powered versions are offered. Base price is $895.

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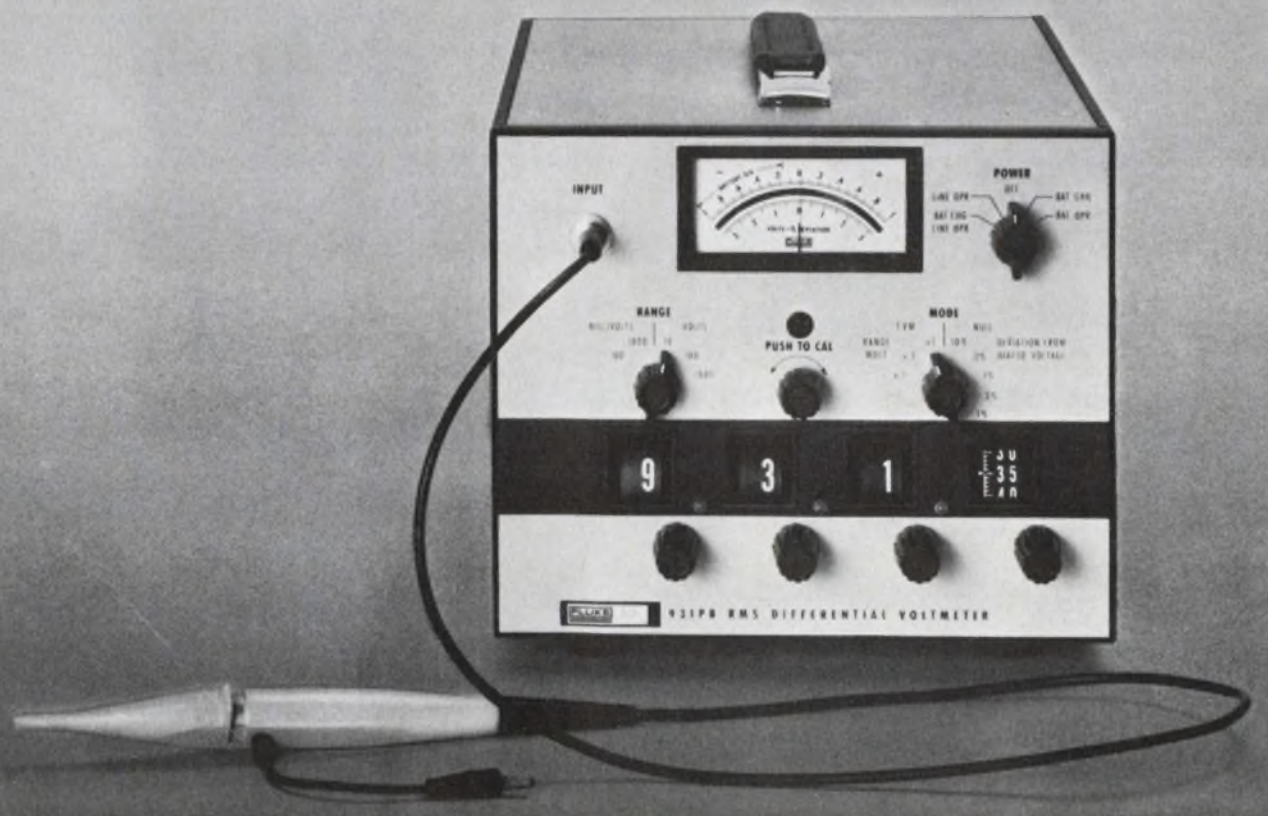
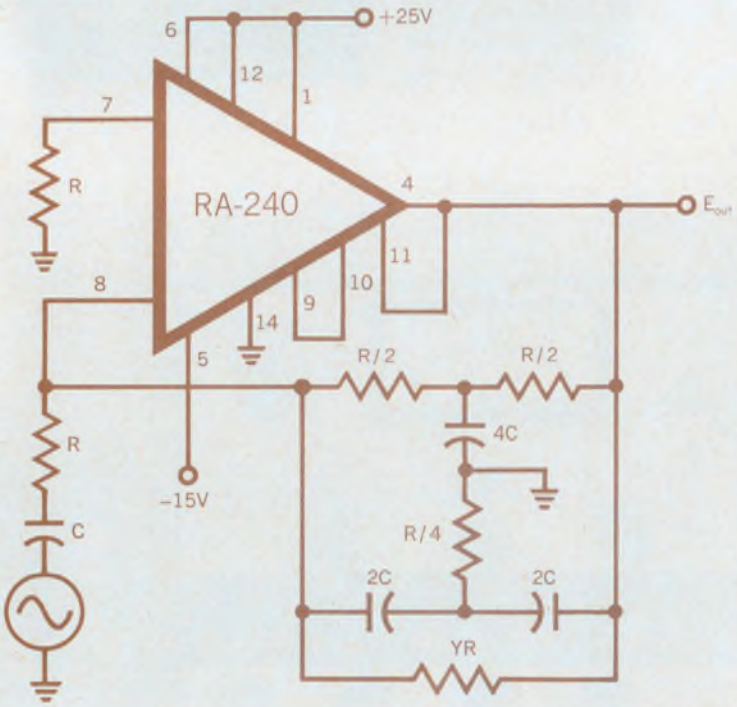
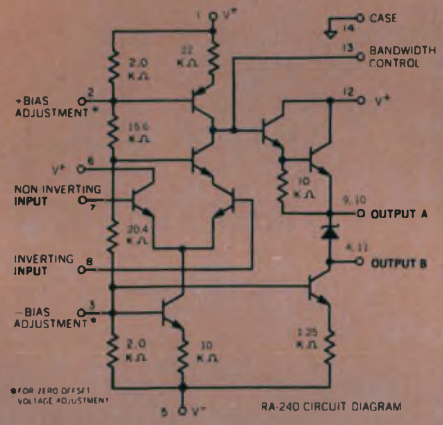


State of the design art



Now... design high Q bandpass filters with Radiation IC Amplifiers



Radiation's dielectric isolation and thin film technology, in conjunction with a virtually ideal circuit, permits design of high Q active filters with high initial attenuation. The Radiation RA-240 IC Amplifier has an extremely high internal feedback impedance, and allows wide flexibility in the choice of external filter components without regard to the active element of the circuit.

The filter shown at left, for example, features a Q of 100 at a center frequency of 10 kHz.

The filter transfer function is:

$$\frac{E_{out}}{E_{in}} = \frac{jxy}{1 + y(1 - x^2) + jx}; \text{ where:}$$

$$x = \frac{f}{f_l} \cdot f_l = \frac{1}{2\pi RC} \cdot f_o = f_l \left[\frac{1+y}{y}\right]^{1/2}$$

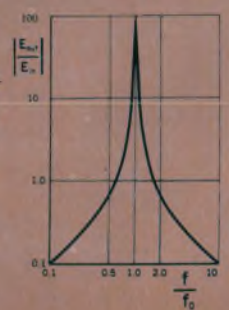
$$Q = y\left[\frac{1+y}{y}\right]^{1/2}$$

f_o = center frequency

f_l = lower 3 dB frequency

Typical response curve shows exceptionally high Q obtainable with RA-240 in circuit at left. Q = 100, f_o = 10 kHz, E_{out} = +10.8 V to −4.8 V.

Initial attenuation as determined by y is approximately 40 dB per decade. Final attenuation ≈ 20 dB per decade below unity gain.



ON READER-SERVICE CARD CIRCLE 827

State of the monolithic art

Radiation's popular line of dielectrically isolated diode matrices offers an unusual degree of flexibility. Only two Radiation RM-17 8 x 5 Matrices, for example, are required in designing BCD decode networks for driving decimal decode indicators. Other integrated BCD decoders are limited to one weighted binary code. However, Radiation Matrices can be "customized" to *any* weighted binary code for decimal conversion.

Typical characteristics for RM-17 diodes ($T_A = +25°C$):

Forward drop: 0.7 V @ I_F = 1 mA
1.0 V @ I_F = 20 mA

Reverse breakdown:
60 V @ $I_R = 100\ \mu A$

Reverse current:
7 nA @ $V_R = 25$ V

Reverse recovery:
7 ns @ $I_F = 10$ mA to $I_R = 10$ mA

Crosspoint capacitance:
1.9 pF @ $V_R = 5$ V and f = 1 MHz

Coupling coefficient: 20 μA.

Our entire line of matrices contain all active devices within a single chip. A fusible link in series with each diode permits unlimited matrix patterns to be formed. And, matrices can be combined to produce an infinite variety of size configurations.

For further information, refer to our ELECTRONICS advertisement of January 23. We'll be glad to send data sheets which include *worst-case limits*, and a copy of our manual, Monolithic Diode Matrix Technical Information and Applications, RDM-T01/A01. Write or call our Melbourne, Florida office.

ON READER-SERVICE CARD CIRCLE 828

...new line of universal building ...ocks for integrated analog cir... ...try is now available to design ...gineers. Radiation Incorporated ...plies three different types of IC ...erational amplifiers to serve your ...dividual requirements: general-...rpose, broadband, and high-gain ...plifiers.

These amplifiers provide out...nding performance. Parasitics ...e eliminated, thanks to our ...ique dielectric isolation tech...que. Tighter tolerances and im...oved temperature coefficients ...e achieved through use of preci...n thin film resistors over the ...de.

Thus, Radiation's technology ...nplifies system designs which were hampered by limitations imposed by conventional integrated circuit fabrication techniques.

Only Radiation can provide production quantities of inherently stable IC operational amplifiers. These circuits are stocked for immediate shipment in TO-84 flat packages.

Write or phone for our data sheets which include *worst-case limits* as well as all information required by design engineers. We'll also be glad to send you a copy of our new manual entitled: Operational Amplifier Technical Information and Applications. For your copy, request publication number ROA-T01/A01 from our Melbourne, Florida office.

Radiation IC Operational Amplifiers*

...ical characteristics ($T_A = +25°C$)	GENERAL PURPOSE RA-238	BROADBAND RA-239	HIGH GAIN RA-240	UNIT
...ase margin	60	60	45	Degrees
...ndwidth (unity gain)	7	15	6	MHz
...w rate	3.2	30	3.2	V/μs
...ltage gain	2,700	2,700	50,000	
...set voltage	2.0	2.0	2.0	mV
...set current	80	400	80	nA
...ermal drift	±5 ±1	±5 ±5	±5 ±1	μV/°C nA/°C
...distorted output swing	21	21	9 (11.6)†	$V_{p\text{-}p}$
...wer dissipation	90	160	90	mW
...mmon mode rejection	100	100	100	dB
...wer supply rejection	100	100	100	dB
...ut bias current	0.4	1.0	0.4	μA

...andard temperature range: −55°C to +125°C. $V^+ = +25V$; $V^- = -15V$.
$^+ = +20V$; $V^- = -20V$.

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To get high energy circuitry at the lowest cost:

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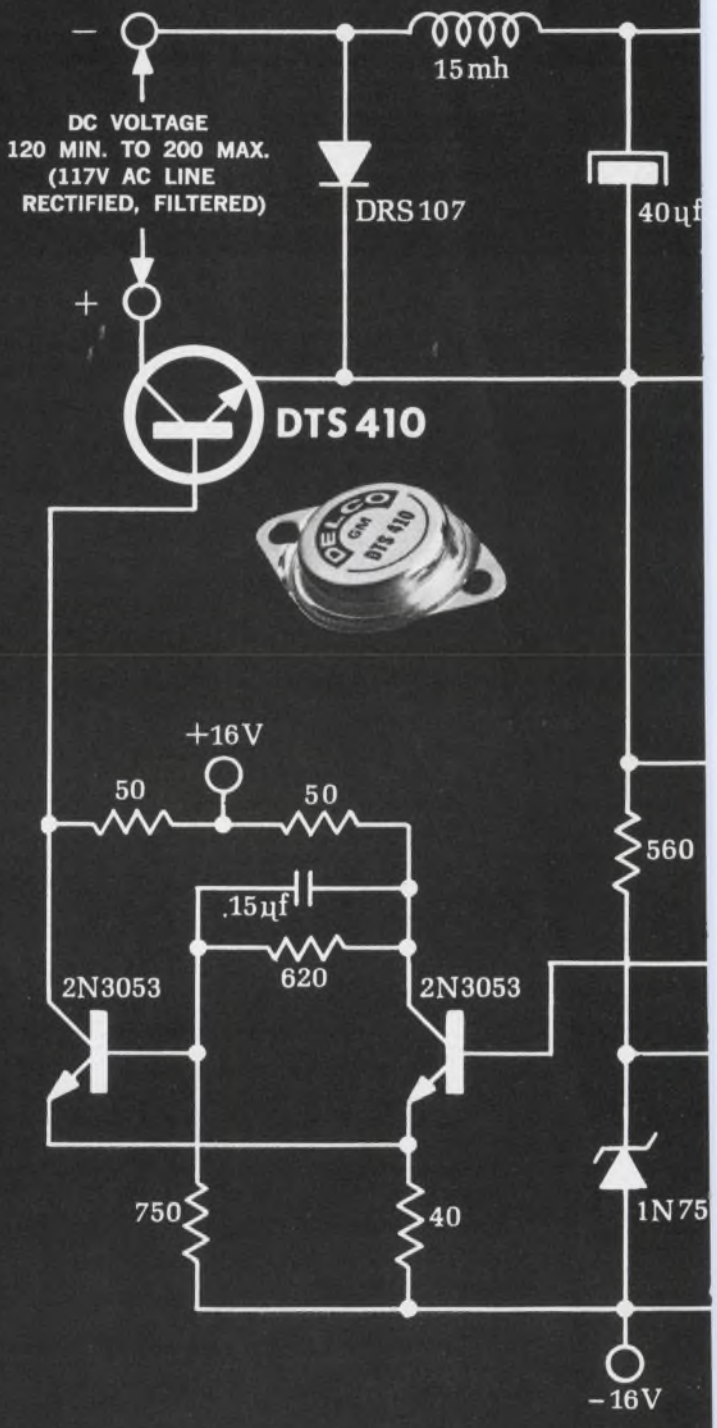
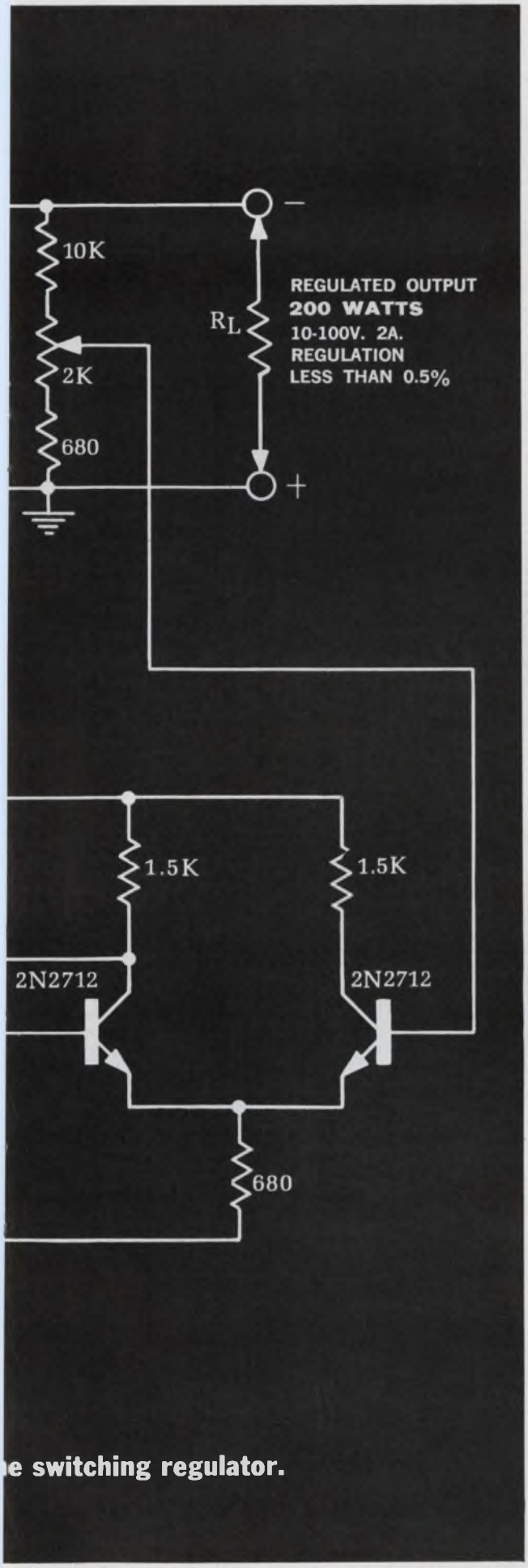


Application of Delco high voltage silicon power transistor



Start with circuit designs using Delco high voltage silicon power.

The simple switching regulator in the diagram at left turns out 200 watts (2 amps) output at efficiencies exceeding 85%. And it does it with just one series element working directly from rectified line voltage: the new Delco DTS-410 transistor at *just $1.95 each**.

Or if you need regulation of 250 volts DC and 400 watts output, the DTS-411 may be your answer. Cost? Just $3.15 each*. And for extra-high voltage applications, there's the DTS-423, now priced at $4.95 each*.

Now combine our new low prices with these other cost-cutting advantages of Delco high voltage silicon power transistors: you can reduce the number and complexity of input, output and filtering components. This means more compact circuitry, greater reliability and lower assembly costs.

These NPN silicon transistors are packaged in a rugged TO-3 case for low thermal resistance. Inside, they are mounted to withstand mechanical and thermal shock because of special bonding of the emitter to base contacts.

There's no need to be concerned about delivery. They are available right now in production quantities. Call us. Or order samples from your Delco distributor.

For details on the switching regulator circuit ask for application note number 39.

*Prices shown are for quantities of 1,000 or more.

TYPE	V_{CEO}	V_{CEO} (sus)	I_C Max	h_{FE} Min @ I_C V_{CE}=5V	Power Diss Max
DTS-410	200V	200V (min)	3.5A	10 @ 2.5A	80W
DTS-411	300V	300V (min)	3.5A	10 @ 2.5A	100W
DTS-423	400V	325V (min)	3.5A	10 @ 2.5A	100W

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DELCO RADIO
Division of General Motors, Kokomo, Indiana

GM
MARK OF EXCELLENCE

ON READER-SERVICE CARD CIRCLE 28

Computer speeds study of cells

In the interest of gathering data on the damage to chromosomes from radiation during space flight, NASA is funding a program at the University of Pittsburgh to develop rapid automatic detection of blood cells in the process of division known as mitosis.

Current methods, involving microscopy, require careful focusing and minute examination to determine the number, size and shape of the chromosomes, and to detect mitosis in a particular cell.

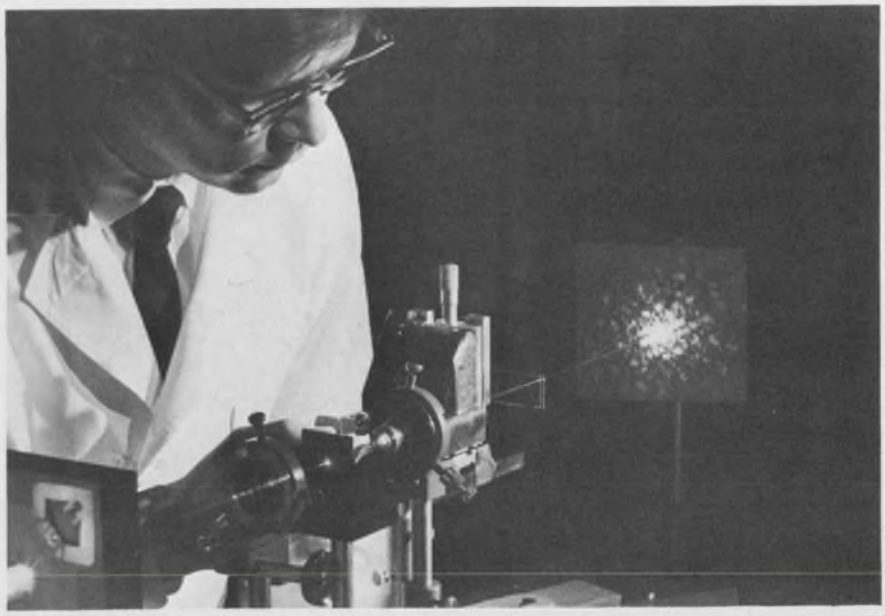
High-speed automatic detection of mitotic cells will greatly accelerate these operations. In the new method, coherent light from a gas laser projects an image of a blood sample from a moving slide onto a screen. When the mitotic cell is detected the slide stops, and the cell pattern on the screen is scanned through a microscope by a conventional flying-spot scanner. A computer converts this pattern into an appropriate read-out.

The method of locating the mitotic cell is being developed by the Perkin-Elmer Corp., under contract from the University of Pittsburgh, where the computer-programing phase of the system is under way.

Location of the mitotic cell by optical computer methods depends on the recognition of characteristic spectral patterns. These comprise two distinct criteria: the ratio of light energy in two distinct spatial frequency bands and the magnitude of the energy at the higher frequency.

The image scanner developed at the University of Pittsburgh consists of a cathode-ray tube functioning as a flying-spot scanner, subject to control by a computer. The scanner first locates the mitotic cell by recognition of its spectral patterns. The computer focuses a microscope on the cell, which is then photographed. The CRT picks up information on the cell, which is stored in the computer along with the slide number, date and other information.

The science of genetics may also be aided by this method; heredity research and the detection of latent Mongolism, sex-organ abnormality and leukemia will be possible on a broad basis. ■ ■

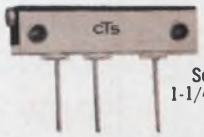


A laser beam detects the presence of damaged blood cells. Perkin-Elmer scientist Philip E. Norgren demonstrates a new optical computing system for the rapid determination of chromosomal damage to radiation.

CTS Cermet Trimmers

± *100 PPM/°C T.C. Available (Series 185)*


Series 180*
1-1/4" x .325 x .295
Rectilinear


Series 180PC*
1-1/4" x .325 x .295
Rectilinear

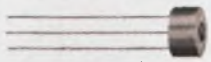

Series 630
1/2" dia., single turn


Series 660PC
3/8" dia., single turn


NEW Series 630 P
1/2" dia.
single turn


Series 170*
1/2" Square


Series 171*
1/2" Square

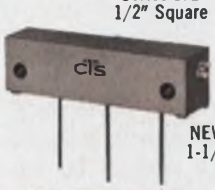

Series 385*
11/32" dia., single turn


Series 172*
1/2" Square


Series 600LT*
2" dia., single turn
locking bushing


NEW Series B180
1.30 X .378 X .385
Rectilinear


NEW Series B185
1.30 X .378 X .385
Rectilinear


NEW Series 185 PC
1-1/4" x .345 x .290
Rectilinear


NEW Series 185
1-1/4" x .345 x .290
Rectilinear

CTS Wirewound Trimmers

Infinite Resolution Available. Stability .025% (Series IRW)

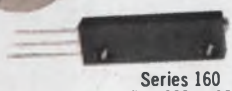

Series K350*
1/2" dia., single turn
knob operated


Series 110*
3/4" dia., single turn


Series 112*
3/4" dia., single turn


Series P115*
3/4" dia., single turn


Series 115
3/4" dia., single turn


Series 160
1" x .320 x .180
Rectilinear


Series 350*
1/2" dia., single turn


Series XPC110
3/4" dia., single turn


Series 117*
3/4" dia., single turn


Exclusive Series IRW
1-1/4" x .325 x .295
Rectilinear spiral
infinite resolution


NEW Series 116
3/4" dia.
single turn

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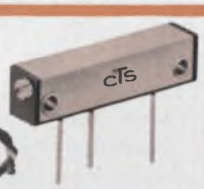
for Lowest Prices


Series C140*
1-1/4" x .325 x .295
Rectilinear


Series C140PC*
1-1/4" x .325 x .295
Rectilinear


Series 220*
7/16" x 1/2" single turn

Series 330
1/2" dia., single turn


Series U201*
19/32" dia., single turn
knob operated


Series X201*
19/32" dia., single turn
knob operated

NEW Series 330 P
1/2" dia.
single turn

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ON READER-SERVICE CARD CIRCLE 30

Double-barreled laser new power champ

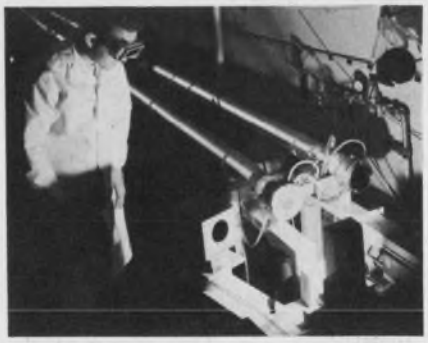
A monster, double-barreled laser is said by its developers to be the most powerful laser in existence. In fact, they say, the dual-tube carbon dioxide laser has twice the output of any laser previously reported.

More than one kilowatt of continuous power is said to be emitted by the device, built by Raytheon Company's Research Div., Waltham, Mass.

The 1100-watt output is multimode at 10.6 microns; efficiency is said to be some 15%. The laser is a flowing gas system using three gases: nitrogen, carbon dioxide and helium. The two-inch diameter tubes are water-cooled.

Raytheon scientists say that the dual-tube, or folded, configuration makes a large lasing volume possible within a small space. The tubes, more than 30 feet long, are parallel to each other and optically connected in series. The unit therefore has an effective lasing length of more than 60 feet.

Present experimental applications for carbon dioxide lasers, according to Raytheon, include plasma heating, micromachining, trimming, soldering, zone refining, melting refractory materials, and cutting plastics and other heat-absorbent materials. Atmospheric attenuation of the laser's 10.6-micron output wavelength is relatively low compared with other middle and far infrared wavelengths. The laser can take advantage of this so-called favorable atmospheric window for transmission of the beam. ■ ■



A doubled-barreled Raytheon carbon dioxide laser is said to be the mightiest in existence. It produces more than one kilowatt of output power.

ON READER-SERVICE CARD CIRCLE 201 ➤

T&B Has Made Wire Harnessing and Cable Bundling as Easy and Clean as This

The nails disappear when you're ready to tie.

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T&B ENGINEERED

THOMAS & BETTS

TECHNIQUES FOR FABRICATING WIRE HARNESSES

With The Thomas & Betts TY-RAP® System

A number of distinct advantages over other techniques are gained by using the *T&B TY-RAP* System. This method, first developed by Thomas & Betts 8 years ago, is based on the concept of providing maximum integrity for each individual tie. Today, it has expanded into a broad practical system covering all phases of tying, clamping, mounting, identification and prefabrication of harnesses and bundles...even to the point of mechanizing harness boards.

The main advantages of the TY-RAP System are:

RELIABILITY

Operators, after minimal training time, can produce ties that are superior to other methods in uniformity of tightness, in appearance, in strength and in over-all quality. Easy-to-use automatic tension tools give you the same quality and tightness in each tie.

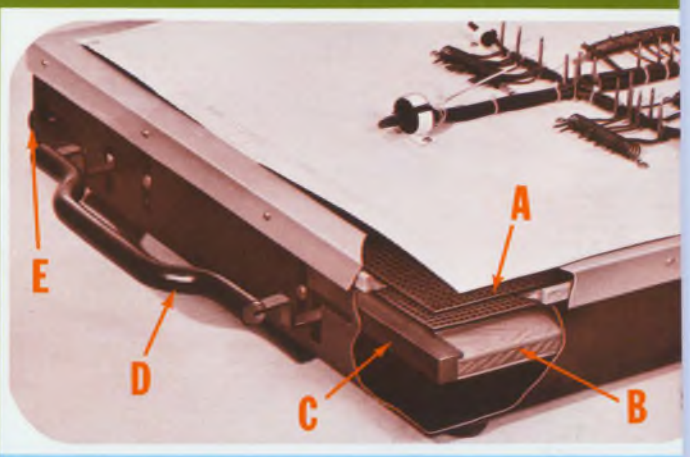
COST SAVINGS

T&B TY-RAP cable ties can be applied in half the time required for string. Because of wider gripping surface, fewer ties are needed. The *TY-RAP* System normally reduces costs by 60%.

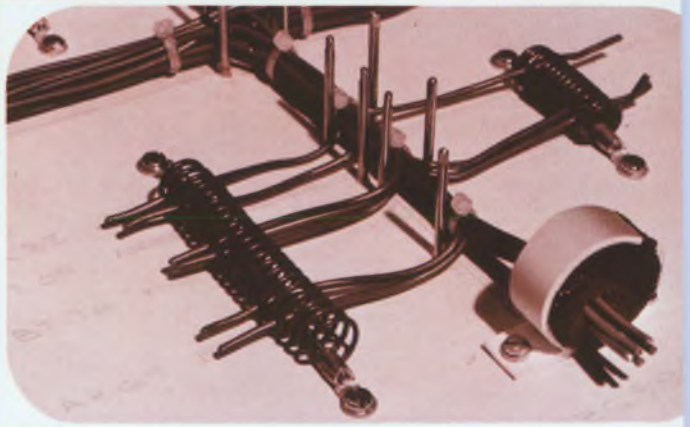
INSPECTABILITY

Just a glance is all that's necessary to inspect *T&B TY-RAP* cable ties. The quality of the tie is immediately obvious. There are fewer points of inspection with *T&B TY-RAP* cable ties.

T&B ENGINEERED **THOMAS & BETTS**



1 **NEW Mechanized Harness Board** allows further cost reductions and increased production. The board controls the height of the wire routing nails. It consists of (A) a stationary perforated metal surface over (B) a wooden backing board which is (C) carried in a movable metal frame controlled by (D) handles located on each side. Unlock the handles and the board (and nails) lower to (E) a preset level. It's an entirely new way of harnessing.

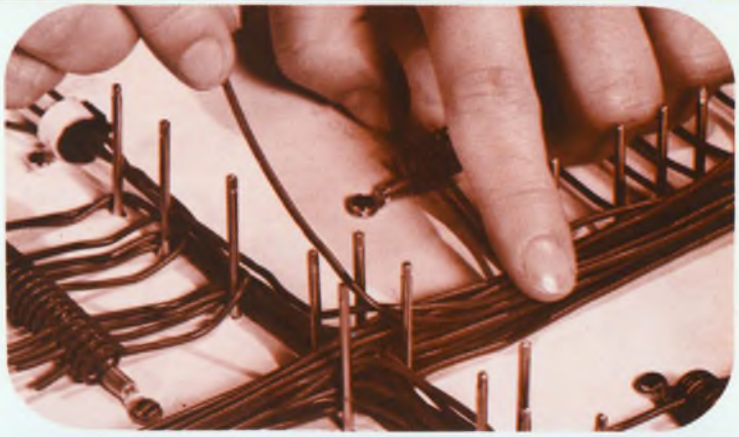


4 **Plastic Coated Spring Accommodates Wire Breakouts** quickly, safely and easily. This new *T&B TY-RAP* harnessing aid can be used over and over without loss of the protective plastic coating. Available in varying lengths, the spring is fitted with fasteners for mounting to board.

7 **Drop Nails and Apply Ties** to complete the harness with maximum convenience. This feature of the *T&B TY-RAP* harness board increases the ease and speed of applying and tying the cable ties. Further speed and convenience is gained with the new *T&B TY-RAP* pistol-tool WT-295. One squeeze of the trigger and the tying is completed.

8 **Position Clamps and Identifying Straps** directly on the harness for further time saving and reliability. As the harness is being fabricated, the *T&B TY-RAP* clamp/tie can be installed. It serves two functions — as a tie and as a clamp. By pre-positioning the clamp, the installation of the harness in the equipment is made quicker and easier.

Insert Routing Nails through wiring diagram into perforated holes and screw down. While routing hardware is necessary and desirable during the wire layout stage, it is cumbersome and tends to slow tying operations. The *T&B TY-RAP* "Pop-Up" Board eliminates the problem. It allows routing pins to be adjusted to optimum height for all harnessing operations — they can be dropped level with the board's surface for tying.



3 **Routing Wires for a Complex Harness** is convenient with the adjustable nails. With the *TY-RAP* harness board, the nails can be set at maximum height when the operator begins or they can be raised as the bundle increases. *T&B TY-RAP* harnessing aids mounted on the board add to routing convenience and efficiency. A variety of *T&B TY-RAP* tools, ties, clamps and harnessing aids allow fabricators to pick and choose the most efficient ways to simplify their harnessing work.

Set Up Harness Board Aids to suit your present fabrication. Shown here are smooth, molded, nylon corner posts, plastic chutes and bundle retainers. These simplify wire routing and hold harness above board for easy tying. The new *T&B TY-RAP* bundle shaper-retainer has a slotted foam center which expands to accept the wires as they are positioned for harnessing.

6 **Form Harness** by strategically positioning *TY-RAP* ties wherever bundle separates or turns. The new friction grip head allows *T&B TY-RAP* cable ties to hold bundle without being completely tied. The advantage of forming the harness is mainly ease in handling for increased speed in complete tying.

Make Visual Inspection of Ties. With *T&B TY-RAP* cable ties, a glance is all that is necessary when inspecting — the quality of the tie is immediately obvious. Since the *T&B TY-RAP* cable tie is a molded nylon one-piece tie, there is nothing to come loose or vibrate. With *T&B TY-RAP* tooling, every tie is the same no matter how many different operators fabricated the harness.

I am interested in learning how I can reduce costs in my wire tying and fastening operations. Please send me the following:

- ☐ *TY-RAP* SYSTEM HANDBOOK AND SAMPLES
- ☐ COST REDUCTION EVALUATION FORMS
- ☐ T&B SALESMAN

Name_____ Title_____

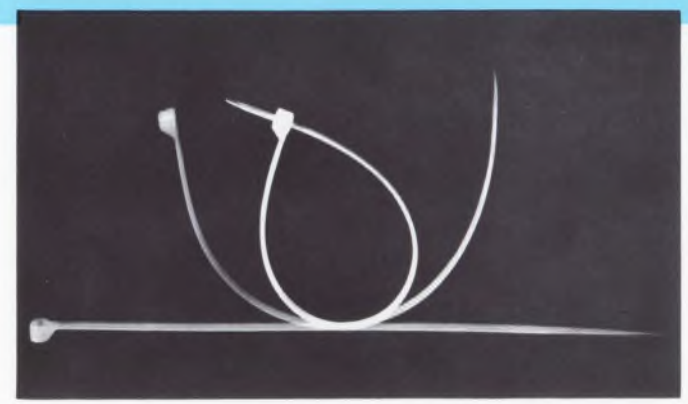
Company_____

Address_____

City_____ State_____ Zip_____

I am interested in ☐ HARNESSING ☐ POINT-TO-POINT WIRING.

Here's why you get more value with T&B TY-RAP cable ties



There are two types of *TY-RAP* cable ties — the twist type and the self-locking type. Each has the same basic features as indicated. The twist type is designed for high speed, large volume tying where production tools are advantageous for harness making. The self-locking type has a stainless steel barb molded into the head of the tie. This permits us to give you the self-locking feature with the advantages of a one-piece tie. The self-locking type is particularly well suited for point-to-point wiring — when used with the WT-199 tool, it is quite practical for harness fabrication.

Contact your *T&B TY-RAP* specialist for more information. Ask him to conduct a cost reduction evaluation study for your wiring and harnessing.

these benefits make Thomas & Betts' *TY-RAP* cable ties UNIQUE

Special Environment Materials Although ***TY-RAP*** cable ties, clamps and mounts function well in adverse conditions, they can be supplied in special materials to withstand environmental extremes. Many ties, clamps, and mounts can be ordered composed of materials such as: Penton for resistance to corrosive chemicals such as rocket fuels; Zytel 105 nylon for applications where ties are continuously exposed to direct sunlight; and stainless steel for withstanding temperatures to 1200°F.

Easy to work with — the patented turned up tail saves time . . . they act as a "handle" for the operator — they can't lie flat to the surface. The tail also orients the tie — you just continue in the direction of the raised tail to complete the tie.

EASIER to thread than ever because of improved designs. Just slip the tapered tip into the eye of the ***TY-RAP*** tie and pull through quickly and easily. Friction grip ridges hold tie in place conveniently for complete tying.

Fungus inert *TY-RAP* cable ties withstand a wide range of climatic conditions. Even in hot humid climate where fungus grows easily — the ties are not affected. This is a major improvement over other methods where these adverse conditions cause rotting and breaking. ***TY-RAP*** cable ties of Zytel 101 have self-extinguishing characteristics. Material meets MIL-M-20693A. ***TY-RAP*** ties meet MIL-S-23190A.

Extended temperature range of the ***T&B TY-RAP*** cable tie permits use from —65°F to +225°F with short duration exposures to 400°F. However, usable temperature range is dependent on required life, temperature, time, cross section thickness, load applied and environment. Contact your T&B specialist for application suggestions above 225°F.

Wide gripping surface provides better gripping power. You benefit two ways — less ties are required than with string and protects wire insulation.

Stipple finish gives the ***T&B TY-RAP*** cable tie a gripping power found in no other method. Protects the cable insulation.

Smooth, molded nylon ***TY-RAP*** ties are easy on operator's hands — even after hours of installing. Smooth corners and edges mean also that the ties are stress free.

Many Colors Available For applications where color coding is required, or where color harmony is desired, you can choose from ten colors for ties, clamps, and mounts.

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T&B ENGINEERED THOMAS & BETTS

Autopilot test set 'flies' jet on land

An autopilot test set that permits a ground technician figuratively to fly an aircraft on the ground in all its automatic flight control modes is now in production for A-6A military aircraft.

The equipment, packaged in three suitcase-sized units, was developed by Arma Div. of American Bosch Arma, Garden City, N. Y.

The compact test set verifies the closed-loop performance of the aircraft system by simulating aircraft motion electromechanically and checking the autopilot response to changes such as attitude, altitude and speed. An Arma spokesman said the results obtained from ground testing are virtually as reliable as airborne test procedures.

An aircraft technician is able to verify performance simply by observing aircraft attitude read-outs and a single voltmeter which is part of the test set.

Major simulation in the test is accomplished by a set of pitch, roll, heading and altitude integrators which represent the aircraft motion. The integrators respond to the position of the control surfaces just as the aircraft would in flight.

The simulation represents the aircraft as an ideal device to be flown in a zero gravitational field. The aircraft is considered an ideal integrator with pitch rate proportional to stabilizer position, roll rate proportional to aileron position, and the heading rate proportional to rudder position and back angle. Altitude is generated by integrating the vertical velocity. The integration rates are chosen to approximate the aircraft flying at a preselected velocity.

The four integrating servos, pitch, roll, heading and altitude/Mach and their functional inter-relationships form the core of the autopilot test set.

An unusual feature of the test set, according to Arma, is its ability to check fully the air navigation computer in a closed-loop configuration without using aircraft hydraulics. ■ ■

◄ ON READER-SERVICE CARD CIRCLE 201

One dozen good reasons for you to specify AE

CLASS B RELAY. Finest quality telephone-type. Provides hundreds of millions of operations under all mounting and service conditions — with unfailing contact reliability. Combines sensitivity, contact stability, and circuit adaptability. Bifurcated twin-contacts. Long or short armatures for wide range of practical timing. Also for quiet AC operation.

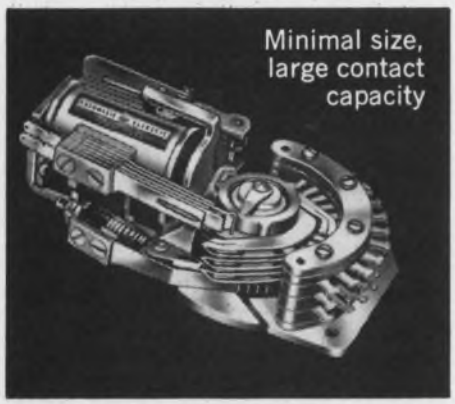
CLASS S RELAY. Miniaturized telephone-type for aircraft and similar applications. Small mass, low self-inductance. Provides high contact pressures and absolute contact reliability under extreme vibration, shock and humidity.

Buy from AE, and you never have to settle for a relay that's only "marginally" right.

You can choose *exactly*, from a line that's broad enough to give you what you're after — in weights, types, dimensions, configurations, mountings.

And you always get the benefit of AE's experience. Decades of experience in product design, manufacturing techniques, and methods of quality control.

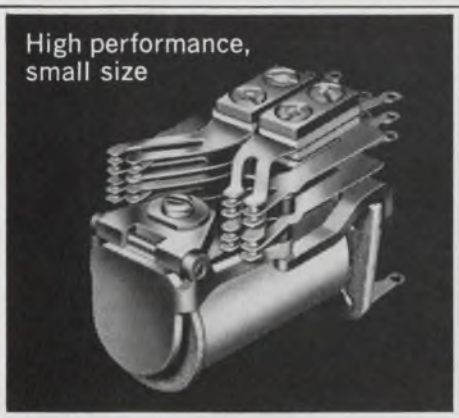
Want some helpful, detailed design information? Ask for Catalog 4071: Selection Guide to AE Relays and Switches. Just drop a line to the Director, Relay Control Equipment Sales, Automatic Electric, Northlake, Illinois 60164.



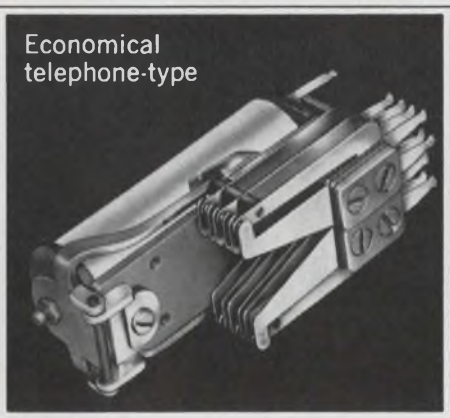
TYPES 40, 44, 80 and 88 ROTARY STEPPING SWITCHES. Small switches with large, flexible capacities. Fit almost any DC application. Provide swift, sure, impulse-controlled response . . . plus self-interrupted operation that's smooth and trouble-free. Up to twelve 10- or 11-point levels. Prewired, hermetically sealed units available.

AUTOMATIC ELECTRIC

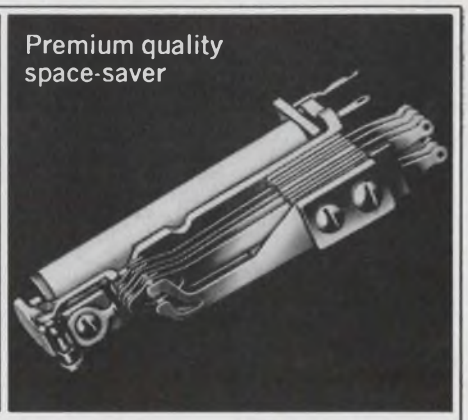
SUBSIDIARY OF
GENERAL TELEPHONE & ELECTRONICS GT&E



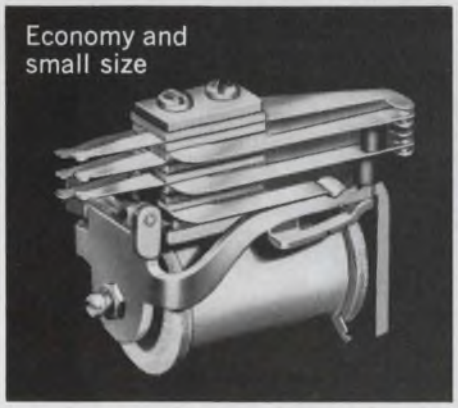
CLASS E RELAY. A lightweight space-saver with most of the features of the Class B. Life exceeds 200 million operations. Industry's widest terminal options: taper pin, integral socket, conventional solder, taper-tab, solderless wrap and printed circuit terminals.



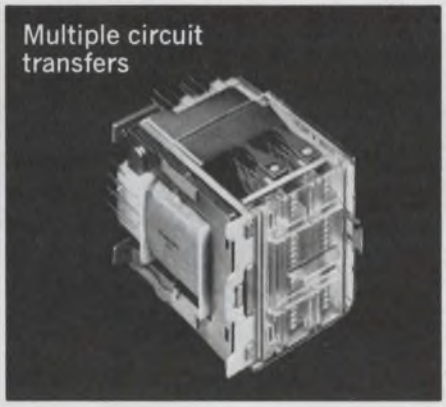
CLASS A RELAY. Sturdy and dependable. Can be mounted in any position. The original "workhorse" telephone relay — recommended when the extremely high performance of the Class B is not mandatory.



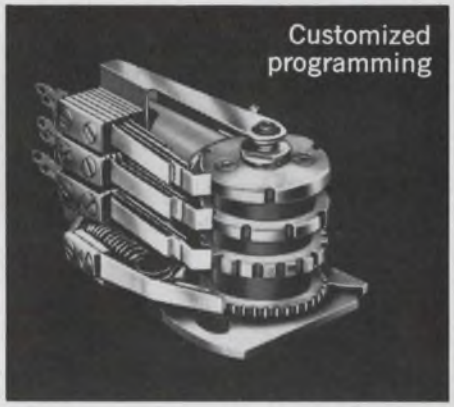
CLASS C RELAY. Incorporates many of the features of the Class B relay—but is only half as wide. Use where quality is a must, but space is at a premium. Quick- and slow-acting types, for operation at up to 150 volts DC. Two to twelve contact springs.



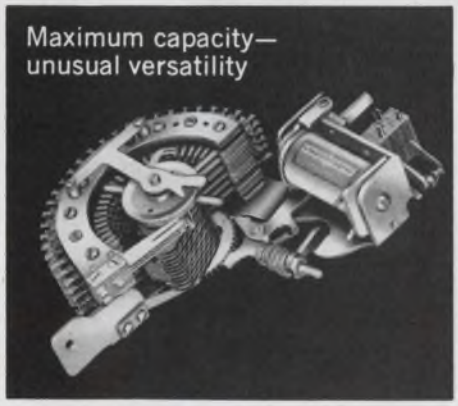
CLASS Z RELAY. Small and lightweight, but designed for service where flexibility is most important. Provides adequate coil volume to permit slugging for long operate and release timing. Four types for DC, one for AC, and two with snap-action contacts.



CLASS W RELAY. 17, 34 or 51 form C contact-spring combinations. Features low loss insulation, high insulation resistance. Extremely low inter-spring capacitance. Life in excess of one billion operations. Gold contacts available for low-level switching.

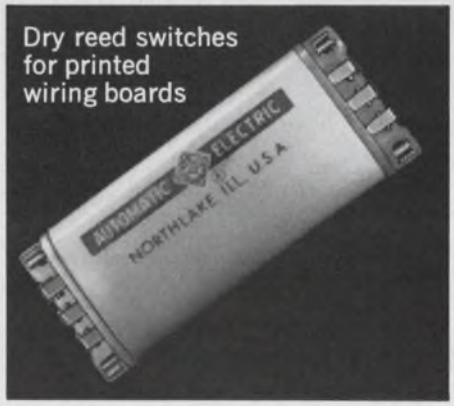


SERIES OCS RELAY. Compact and low in cost. For "packaged" programming: will follow or initiate a prescribed series of events at 30 steps per second impulse-controlled — or 65 per second self-interrupted. Much better than an interlock relay — when you're designing for shock, vibration or easy field maintenance.



TYPE 45 ROTARY STEPPING SWITCH. Larger capacity: up to twelve 25-point levels, eight 50-point levels. For any DC voltage up to 110, or 115 volts AC with rectifier. Can be impulse-controlled or self-interrupted. Available with normally open or normally closed circuits (Type 45NC). Also available as prewired, hermetically sealed units.

CLASS V MERCURY-WETTED RELAY. For computers, data processing and control equipment. Up to 200 operations per second. No contact erosion, no bounce. Over 1 billion operations without change, maintenance or adjustment. Can be operated within 30° of vertical. Polarized and nonpolarized versions. 1 pole to 4 pole double throw contact forms.



PRINTED CIRCUIT CORREEDS.* Strong, moisture-resistant, compact. Unstressed contact leads provide firm, positive connections. Glass-filled plastic bobbins prevent moisture absorption. Low profiles and magnetic shielding permit high density within standard PC terminal spacing (multiples of 0.200 inches). Available with 1, 2, 3 and 5 capsules and magnetic latching. Contact forms A, B, & C.

*U.S. Patent applied for

ON READER-SERVICE CARD CIRCLE 33

NEW DEUTSCH SYSTEM OBSOLETES

THE TERMINAL JUNCTION

A new system for point to point wire connection and integration

This newest, most flexible system releases today's engineer from the limitations usually associated with interconnection. One wire or thousands of wires may be connected by this simple, reliable method that:

- Replaces terminal strips and binding posts
- Does away with contact damage
- Eliminates splices and solder
- Uses standard crimp tools
- Uses **one** fail-safe, expendable assembly tool
- Uses **one** fool-proof assembly procedure
- Is self-locking
- Is modular
- Saves weight and space
- Connects and disconnects instantly
- Protects connections without potting
- Meets or exceeds MIL-C-26482 where applicable, and exceeds most user specifications

The Terminal Junction system is the ultimate in simplicity.

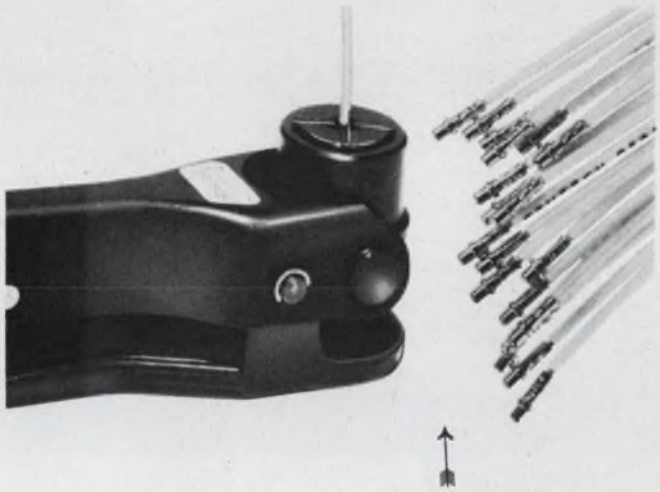
- The wire termination is ruggedized so that it can't bend, break, bind or gall .
- Crimping the terminal to any wire is done with standard tools, and provides strong, reliable termination . When inserted in the modular block, the terminations are interconnected instantly in a variety of hook-up patterns .
- The low-resistance connections are secured by self-locking retainers that defy vibration, shock and high pulling loads .

System build-up, breadboarding and all processes where one must patch, bus, splice or feedthru can be vastly simplified with this flexible, "people oriented" system. Its simplicity, combined with total reliability, makes possible immediate conversion without special training of assembly personnel... and, with the move to Terminal Junctions come the benefits of efficiency and upgraded connections.

The following columns describe how you can save time, space and circuits. Read on... let your own ingenuity dictate how you can benefit by using this revolutionary system.

TIME SAVER

The Terminal Junction system eliminates wasted time and motion in all phases of equipment design, breadboard, prototype, assembly, checkout and maintenance.



Quick, reliable crimp termination of wires with standard tools.

Instant connection (or disconnection) requires one, fail-safe, expendable tool which is small enough to be stored with wire harnesses.

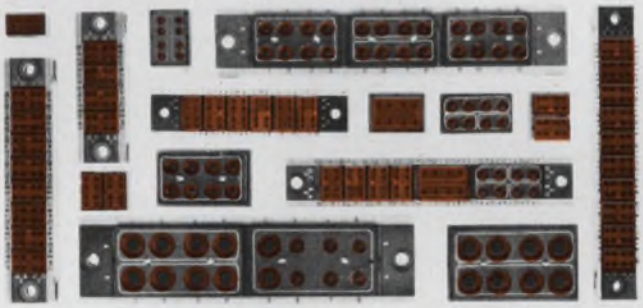
One Terminal Junction module, with eight wires that have been connected in a fraction of the time required by other methods.

*Terminal Junction modules shown are mode TJ11E-02** which connect wire sizes AWG 20 through AWG 24.

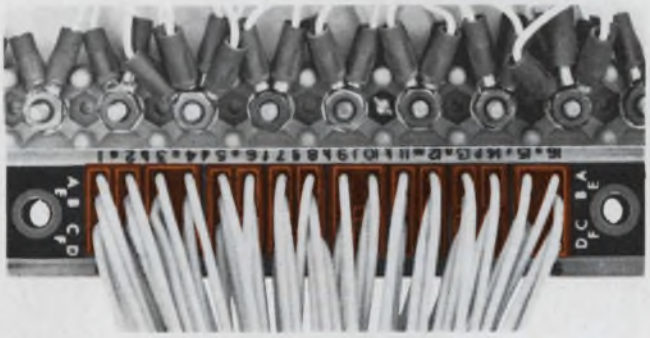
EXISTING CONNECTION METHODS

SPACE SAVER

Terminal Junctions occupy a fraction of the space formerly needed for an equal connection capacity. And, there is no limit to the number of modules and multi-module assemblies that may be used to form high density interconnection panels and systems.



Typical module and multi-module assemblies for space-saving connection and integration. Standard units shown will handle wire sizes AWG 24 through AWG 4. White lines on each module outline points of common connection.



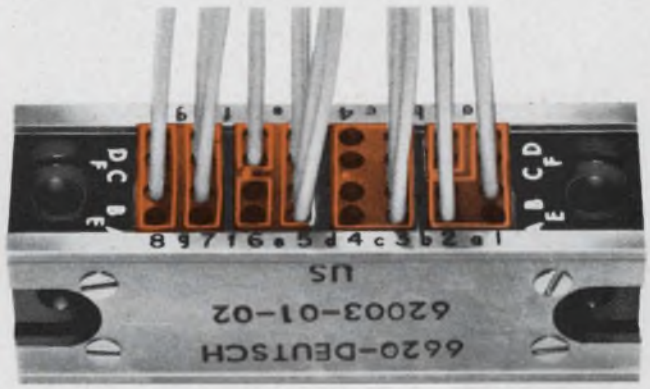
Sixty four size AWG 20 wires perfectly connected and fully protected in a fraction of the space previously needed. Compare the amount of space saved in this case . . . the terminal strip handles only 28 wires, and affords them no protection.

Use Feedthru Terminal Junctions for all through-connection applications; use them as high density, lightweight, fully environmental connectors; or, use multi-module assemblies for patchboard and through-panel applications.

The **JIFFY JUNCTION**® *is a fully environmental single conductor connector. Use it as a replacement for splices or any one-wire connection problem.*

CIRCUIT SAVER

Circuit and equipment failures due to the breakdown of exposed or poorly protected junctions and splices are eliminated by Terminal Junctions. All connections in each module are protected from mechanical damage by solid dielectric material; shorting caused by moisture and contaminants is prevented by resilient silicone rubber sealing glands at each wire entry point; the positive locking retention system resists shock, vibration and high pulling loads to assure perfect continuity in each circuit. Dielectric separation between circuits exceeds military specifications, and because the tool used for connection and disconnection is of dielectric material the shorting possibility normally associated with checkout and maintenance is reduced to a minimum.



Actual size modules are shown in a multi-module assembly; typical busing layouts are included (white lines outline common connection points). Those entry points not occupied by wires are sealed by plugs to assure complete environmental immunity.

The Terminal Junction is the newest member of the performance proven Rear Release Family of Deutsch connectors and interconnection devices. Using **one** type of crimp tooling, **one** assembly procedure, and **one** fail-safe insertion/removal tool, any interconnection system may be upgraded to modern levels of efficiency and reliability. For more information about Terminal Junctions contact your local Deutschman, or write today; ask for Data File TJ-3.

DEUTSCH

ELECTRONIC COMPONENTS DIVISION · Municipal Airport · Banning, California

ON READER-SERVICE CARD CIRCLE 34

Iceberg hunters use microwave radiometry

It may come as a surprise to many that icebergs are microwave transmitters. But this characteristic of the floating masses of ice is giving their presence away to searchers flying in fog, rain and other conditions of poor visibility.

Now that the northern iceberg season is approaching—it starts officially next month—the Coast Guard is readying its radiometric search sets for the detection of these nautical hazards. The type of set in use is the AN/AAR-33, produced by Sperry Microwave Electronics Co., Clearwater, Fla.

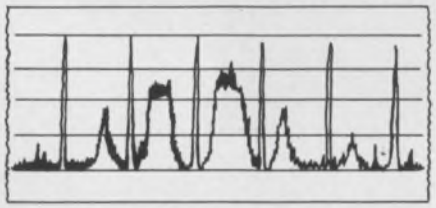
Microwave radiometry works because all objects emit and reflect microwave energy. The amount radiated depends on an object's composition, temperature and the reflected energy from its surroundings.

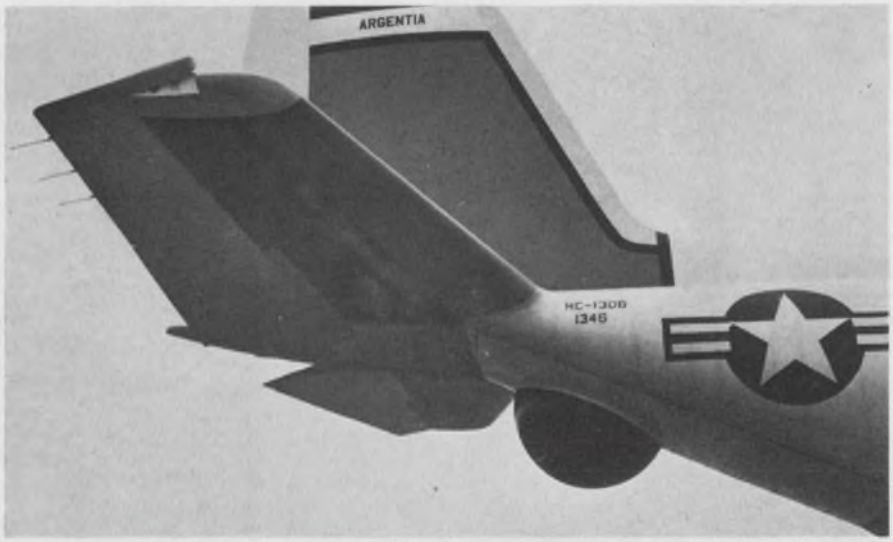
The microwave radiometer detects and identifies objects by measuring this radiated energy. But the radiation is entirely passive—no microwave energy is used to "illuminate" the object.

"Icebergs appear to radiometers as hot objects, compared with the surrounding seawater," says Robert Roder, Sperry's project engineer. "Icebergs are better sources of microwave energy than water." On the other hand, he adds, "ships have different temperatures than either icebergs or water, so they have their own radiometric signatures."

Roder says that the Coast Guard system uses an extremely low-noise receiver aboard an HC-130 transport plane. The receiver compares the radiation from each object with a low-level energy souce within the search set's radiometer. The difference between the received signal and the reference is measured electronically by equipment calibrated in degrees Kelvin.

Microwave radiometry can be operated in all weather conditions. Although there is some signal attenuation due to fog, clouds, rain or snow, Roder says, the output signa-

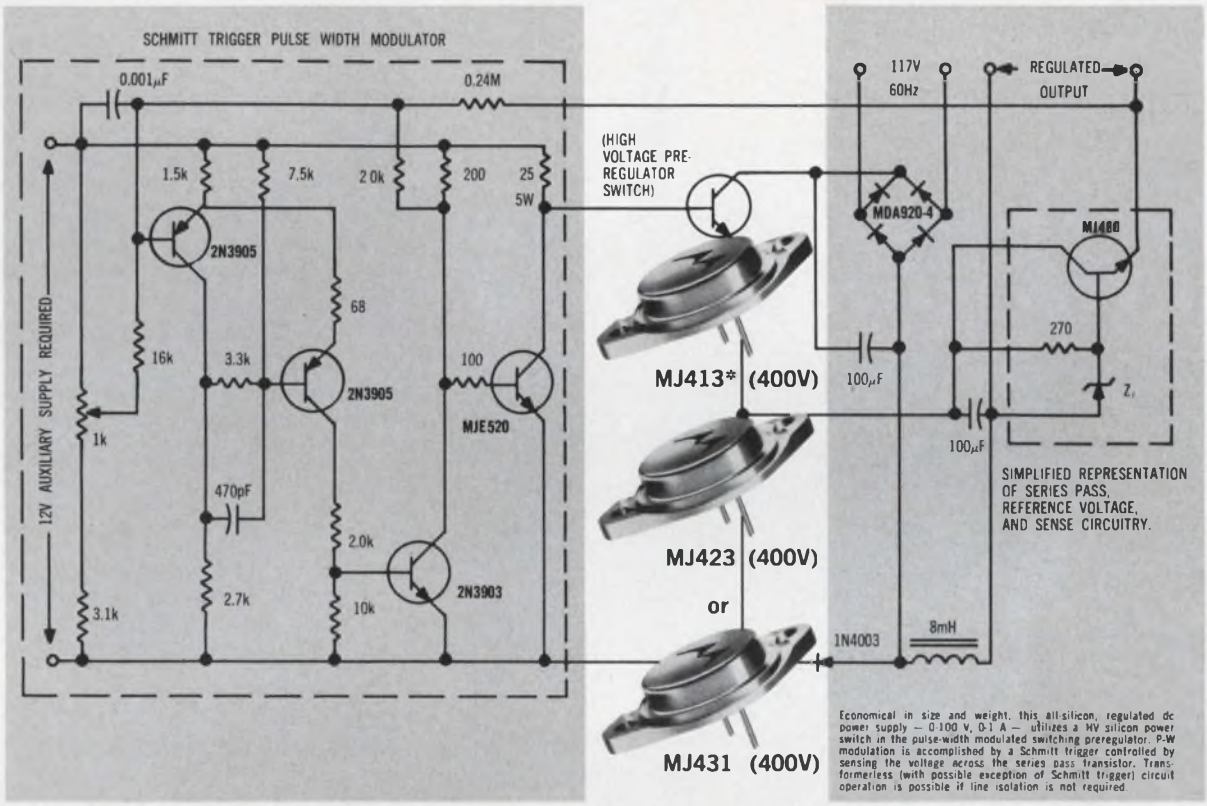




Iceberg shows up as a dark shadow on a graphic display (above left) and as a temperature-analog plot on a recorder (above right) in Sperry's airborne microwave radiometric search system. The black dome under the tail of the Coast Guard HC-130 aircraft contains three parabolic antennas that rotate perpendicularly to the flight path.

Q:

What are 400-Volt Silicon Power Transistors like you doing in a place like this?



A: Lowering costs and simplifying circuitry.

Right now you can use these three new Motorola 400-volt silicon power units in virtually all the right places: in *line-operated* audio and servo amplifiers, inverters, choppers, switching and series pass regulators and horizontal and vertical TV outputs!

Advantages? Many. You can reduce the size, cost and complexity of input, output and filtering components. Plus, reduce current and keep your circuitry more compact, lighter and easier to cool. They can also replace similar, limited-source devices at no increase in cost.

And there's no "punch-through" (secondary breakdown) with any of them because Motorola's triple diffusion process allows device acceptance of very high voltages even in the most demanding designs.

We've prepared an informative package of technical data on the broadest line of 200 to 400V silicon power transistors in the industry — 14 NPN units that let you optimize your application with a wider choice of packages, current capabilities, voltage/gain characteristics . . . and availability. You'll also receive an enlightening article on the significant advantages and uses of HV silicon power in modern, high energy circuitry. Send for it today! Box 955, Phoenix, Arizona 85008.

Evaluation units from your franchised Motorola distributor.

NOW — Select from the Broadest HV Silicon Power Line Available!

TYPE	V_{CEO}	V_{CEO} (Sus)	I_C (Max)	h_{FE}	f_T	CASE
MJ400	325	325	200 mA	30 min (@ 50 mA, 10V)	15 MHz min	TO-66
MJ420 MJ421	250 325	250 325	100 mA	25 min (@ 30 mA, 20 V)	30 MHz min	TO-5
MJ3201 MJ3202	225 300	225 300	100 mA	30 min (@ 50 mA, 10 V)	15 MHz min	TO-66
MJ2251 MJ2252	225 300	225 300	500 mA	25 min (@ 50 mA, 10 V)	10 MHz min	TO-66
2N3738 2N3739	225 300	225 300	3 A	40 min (@ 100 mA, 10 V)	10 MHz min	TO-66
MJ3010 MJ3011	200 325	200 325	3.5 A	20 min (@ 0.5 A, 5 V) 10 min (@ 2 A, 5 V)	4 MHz min	TO-3
MJ413 MJ423 MJ431	400 400 400	325 325 325	10A	15 min (@ 1 A, 5 V) 10 min (@ 2.5 A, 5 V) 10 min (@ 3.5 A, 5 V)	6 MHz min 5 MHz min 4 MHz min	TO-3

*For output currents to 300 mA.

– where the priceless ingredient is care!

MOTOROLA Semiconductors

ON READER-SERVICE CARD CIRCLE 36

(**Iceberg hunters,** *continued*)

ture of the object remains constant. This is vital in Coast Guard operations in the polar regions, where poor weather is chronic and the time available for iceberg search is limited.

According to Roder, an infrared radiometric system would not be as effective as the microwave, because infrared radiation is blocked by fog, clouds and rain.

The microwave portion of the radiometer is mounted under the tail of the aircraft. It includes a scanning antenna, stabilized antenna platform and associated radiometer components.

A triangular grouping of three paraboloidal reflectors forms the antenna system. The antenna speed of rotation is adjustable over a range from 3 to 12 scans per second. Scan speed is set for complete ground coverage for the altitude and ground speed of the aircraft. The width of the scan is approximately three and a half times the aircraft's altitude.

Works with plane's radar

The system works in conjunction with the aircraft's radar. The radiometer set maps an area below and behind the aircraft; the search radar scans ahead.

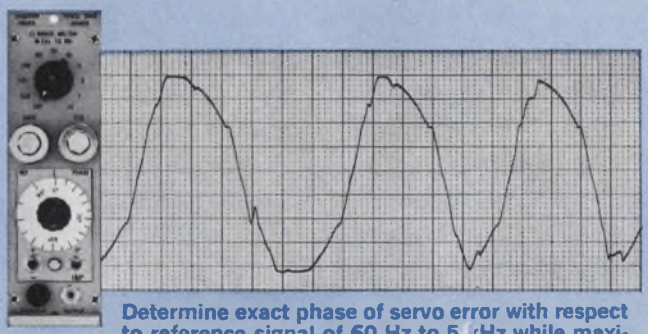
The radar detects objects on the surface of the sea, while the microwave radiometer examines and identifies the targets as ships or icebergs. Identification is possible because the radiometer can measure temperature differentials as slight as 2°K.

The system includes a commutated-comparison radiometer with null balance, automatic gain control and scan-by-scan automatic calibration. It is the detected difference signal that is amplified to produce a voltage to drive the system's recording mechanism.

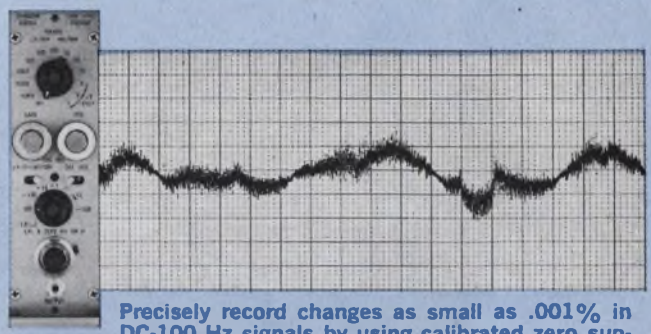
Two display devices are used in the system. A facsimile recorder displays an instantaneous graphic map of the area being searched. An oscillograph simultaneously plots temperature amplitudes of objects being scanned. Both displays are located in the operator's console with signal-processing circuits and controls for remote operation of the radiometer. ■ ■

Bring on your complex, small, noisy, difficult signals.

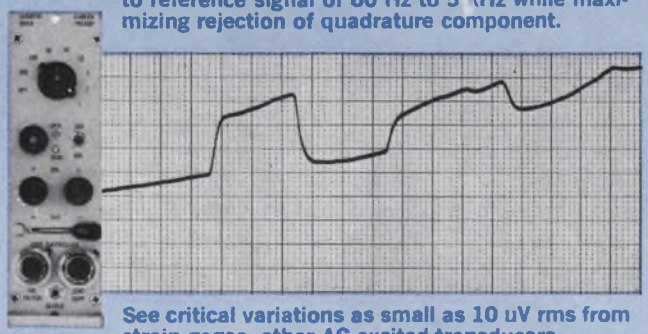
We'll give you traces that show them for what they really are.



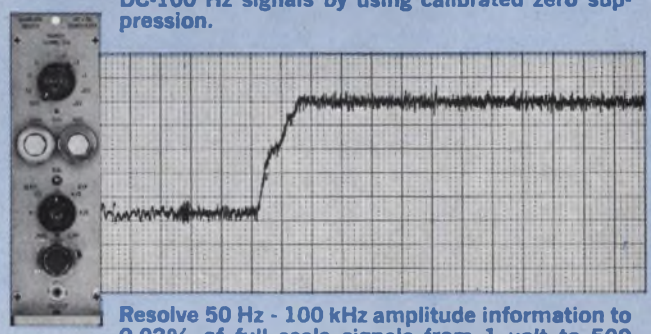
Determine exact phase of servo error with respect to reference signal of 60 Hz to 5 kHz while maximizing rejection of quadrature component.



Precisely record changes as small as .001% in DC-100 Hz signals by using calibrated zero suppression.



See critical variations as small as 10 uV rms from strain gages, other AC-excited transducers.



Resolve 50 Hz - 100 kHz amplitude information to 0.02% of full scale signals from 1 volt to 500 volts.

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.

Use any of these "8800" plug-ins in the 7700 thermal writing oscillograph matched to your packaging and channel requirements — 4-, 6- and 8-channel 7704A, 7706A and 7708A console types . . . 2-channel 7702A system in rack-mount or mobile cart versions . . . single-channel 7701A wide chart (100 mm) portable system. Every one of these thermal writers will give you permanent, rectangular-coordinate recordings whose resolution and accuracy make all your measurements more useful.

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.

HEWLETT PACKARD hp SANBORN DIVISION

ON READER-SERVICE CARD CIRCLE 38

SOLID STATE

NEW
CG Timer:
Range: 50 MLS
to 60 Sec.

THE WIDEST RANGE

ELECTROMECHANICAL TIMERS

NEW
Model 88 Timer:
Range: 6 Sec.
to 48 Hrs.

The Man from E.A.G.L.E. *offers virtually unlimited product/performance scope: from solid state timers such as the CG (above)—created for short, accurate, highly-repetitive time cycles—to motor-driven electromechanical timers such as the Model 88 (below)...and everything known to be in between. CG's qualifications: compensates for voltage changes; plus into standard octal relay socket; quality componentry — tantalum timing capacitor; SCR control of 10 amp output relay; protection against load or output contacts being inadvertently actuated by transients or power cutoff; perfect replacement for pneumatic timers.*

Accuracy, economy and reliability are hallmarks of the Eagle line...industry's most complete! Put us to the only test that counts, your most demanding time/count application. Write for the CG Bulletin 158 and the Model 88 Bulletin 1620, Eagle Signal Division, E. W. Bliss Company, 736 Federal Street, Davenport, Iowa 52808.

BLISS EAGLE SIGNAL
A DIVISION OF THE E. W. BLISS COMPANY

FOR INFORMATION ON CG TIMER CIRCLE READER SERVICE NUMBER 103
FOR INFORMATION ON MODEL 88 TIMER CIRCLE READER SERVICE NUMBER 104

INSTANT EAGLE RELAYS

Test Them Immediately... Get Production Quantities in Two Weeks!

That's right . . . Eagle challenges you to compare them with any relay on the market. NOW you can get immediate delivery on these general-purpose or medium-power relays. Test results prove they're the finest of their kind in the world. Eliminate your relay delivery problems. Call your "Man from E.A.G.L.E.". . . listed at the right. You'll find he has full details and specifications on Eagle relays.

BLISS | **EAGLE SIGNAL**

A DIVISION OF THE E. W. BLISS COMPANY

736 Federal Street, Davenport, Iowa

ON READER-SERVICE CARD CIRCLE 826

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LETTERS

Diode-laser fog detector is not a novelty

Sir:

There is already in use a fog-detecting device similar to that described in your article, "Fog! Diode laser signals warning" [ED 19, Aug. 16, 1966, p. 44].

As a member of the International Impulsphysics Association, I have to test fog-warning devices, wherever they are developed, to evaluate their reliability for meteorological service in sea and air navigation. A device, based on the same principle as that of Hoffman Electronics Corp. which you describe, was developed a few years ago by Impulsphysik GmbH, of Hamburg. Its reliability has since been proven in use at naval stations and airports in all climate zones; one of its users is the U.S. Coast Guard.

The detector, called the Videograph, is described in detail in *High-Speed Pulse Technology*, Vol. II, by Frank B. A. Fruengel (New York: Academic Press). This describes it as an automatic warning system that helps to cut manpower requirements.

The light source of the Videograph is a high-intensity pulse lamp that emits a homogeneous white light at the peak of the driving pulse. The set can be adapted to make use of ultraviolet radiation, which has advantages in fog forecasting. The light of the pulse beam, partly back-scattered by air and fog particles, is picked up by a receiver mounted some 10 inches above the transmitter.

The receiver can automatically switch on a fog horn or other warning system at a predetermined danger level. If a visibility recorder is attached to the receiver, a continuous record can be kept of visibility ranging from 1/16 mile to 10 miles.

The transistorized device consumes less than 5 watts drawn from a 12-volt battery.

Further references to this system are:

I. A. Curcio and G. L. Knestrick, "Correlation of Atmospheric Transmission with Back Scattering," *J. Optical Soc. Am.*, LXVIII, No. 10 (October, 1958); and

M. H. Borman, "Measurement of Atmospheric Transmissivity Using Back-Scattered Light," *J. Optical Soc. Am.*, LI, No. 6.

Dr. W. Knuetel
International Impulsphysiks Assn.
Hamburg, Germany.

Accuracy is our policy

In "Check design program availability," in the report on Computer-aided Design, ED 23, Oct. 11, 1966, pp. 54-80, the author has made corrections to a number of design programs on pp. 78-79 that he attributed to the wrong companies.

The source of the Code-Mandex, Spade, Dee and Sycate programs is Autonetics, 3370 Miraloma Ave., Anaheim, Calif. (contact: R. S. Miles), not Bell Telephone Laboratories as printed.

The source of the Gate Assignment, Load, Logic Diagram, Timing Analysis, Module Assignment and Path Routing programs is General Electric, P. O. Box 2500, Daytona Beach, Fla. (contact: E. W. Burdette), not Bendix Corp. as printed.

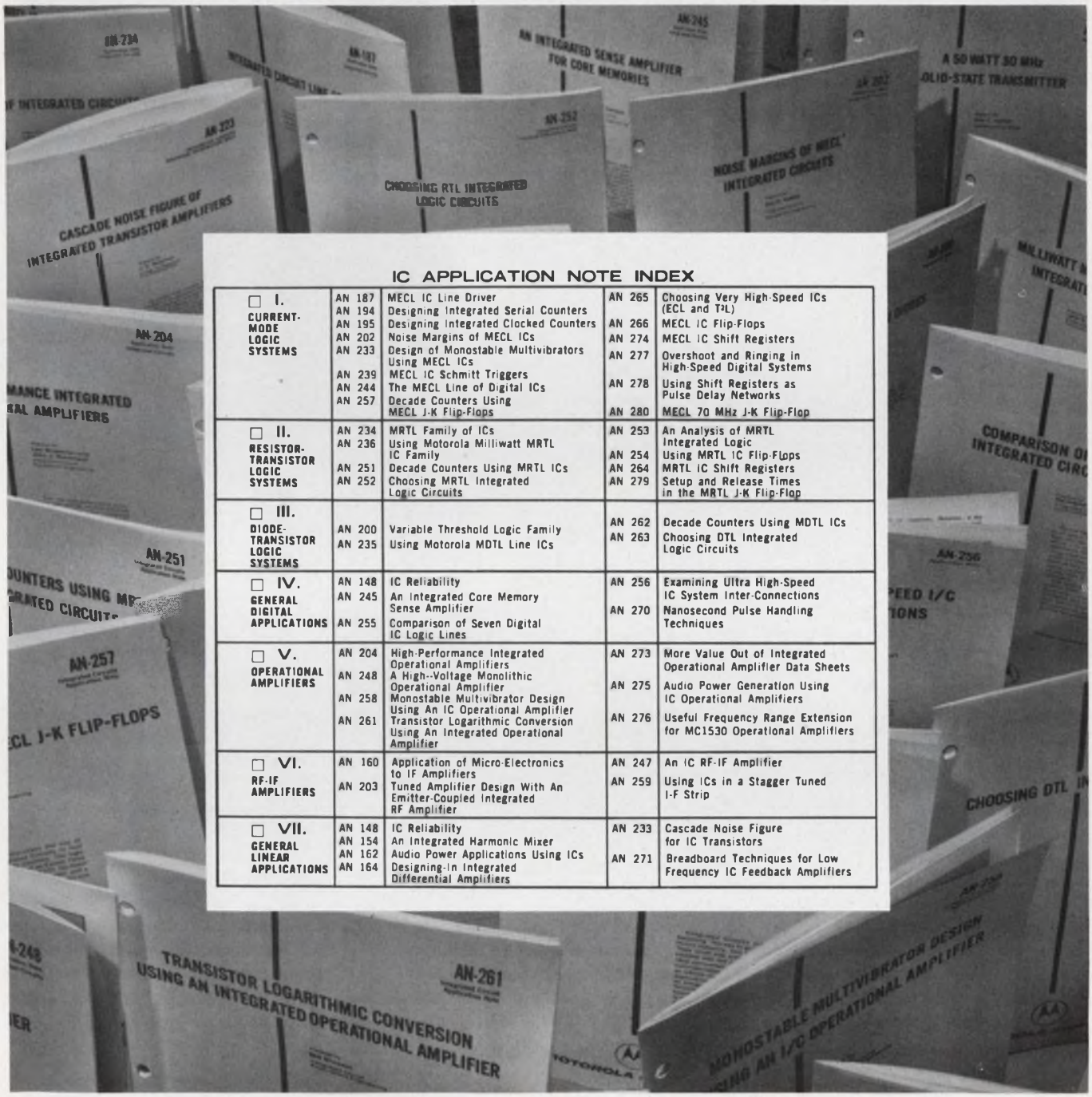
The source of the ASAP program is NASA, Greenbelt Space Flight Center, Greenbelt, Md. (contact: Roger Cliff), not IBM as printed.

The source of the ECAP and Predict programs is IBM at Western Regional Offices, 3424 Wilshire Blvd., Los Angeles, Calif. 90005 (contact: Howard Tyson) not at Greenbelt Space Flight Center, Md., as printed.

In the listing on p. 77, there is an error in the address of Autonetics, which is at 3370 Miraloma Ave. (not Miraland Ave), Anaheim, Calif.

In ED's Signal Generator Reference Issue (ED 27, Nov. 29, 1966), the products of CMC/Rutherford Div. were referred to wrongly. For information on all products listed under Rutherford Electronics, write to CMC/Rutherford, 12973 Bradley Ave., San Fernando, Calif.

We have 47 Semiconductor Application Notes that tell you how to apply Integrated Circuits in all types of equipment.



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	AN 194	Designing Integrated Serial Counters		
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ON READER-SERVICE CARD CIRCLE 41

EDITORIAL

Don't make them throw all those bugs away

There is a distinct possibility that electronic eavesdropping devices could some day be widely misused. Present Congressional investigation of the area, which will probably lead to legislation, is thus worthwhile.

But the present attitude of the courts toward any sort of eavesdropping seems to us to be defeating one of the few *good* uses for this evolving class of devices. Not only are courts refusing any sort of bug-gathered data as evidence, they are also suggesting that an investigation based on leads gathered by bugging may be inadmissible. Since lawbreakers seldom keep careful records of their illicit activities for the convenience of investigators, this attitude seems to be a remarkable boon for them.

Take the case of a Brooklyn man who, the Justice Dept. contends, did not bother to pay taxes or file returns for the years 1956 through 1960. It seems that several clues and some evidence were uncovered by means of bugs planted at a "place of business" that the FBI believed was being used for criminal activities. Since the bugs were planted "by means of trespass," the three-year conviction and $12,500 fine against the man are likely to be reversed by the Supreme Court. The Justice Dept. has ordered a thorough review of all cases being prepared so that no others run into such a snag.

We chatted by phone with a local FBI agent to see what effect the latest move against bugging is having. He said that the area was so sensitive that he could not even discuss it. When asked whether agents in the field could obtain a warrant when it appeared that bugging was needed to pursue an investigation, he said, "If someone's life was in danger, we would contact our office in Washington for permission, and they would have to contact the Justice Department." Otherwise, bugging was out of the question, he explained.

Evidently editorials in the daily press have helped to induce this degree of caution in our crime-fighting agencies. The Justice Dept. is under criticism just for the fact that it has to check to see if any of its cases include bug-gathered evidence. More red tape will probably be the result of this pressure, and initiative in the field will be further stifled. The legality of *any* bugging by law-enforcement agencies is in question, while fingerpointing rather than rational discussion is the official reaction.

What is needed is a clear set of guidelines for the use of bugging devices in investigations, and a streamlined procedure for getting warrants to place them. Proper restrictions can protect the public, we believe, while freeing law-enforcement agencies to make intelligent use of new technology.

What we seem to be doing, in the honest interest of protecting civil liberties, is creating a framework within which crime can operate unmolested. Meanwhile the agents responsible for combating crime will undoubtedly react to the latest public outcry by throwing many of their latest gadgets back in the drawer. ROBERT HAAVIND

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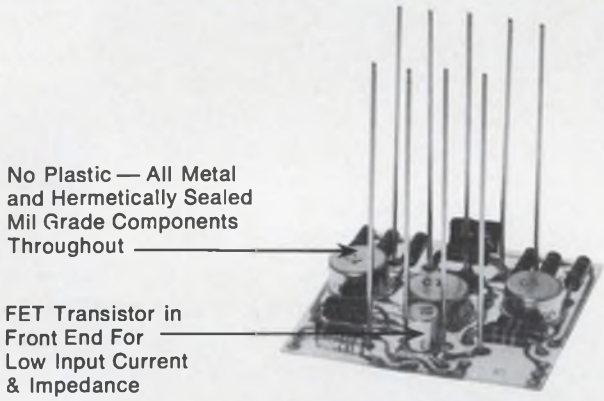

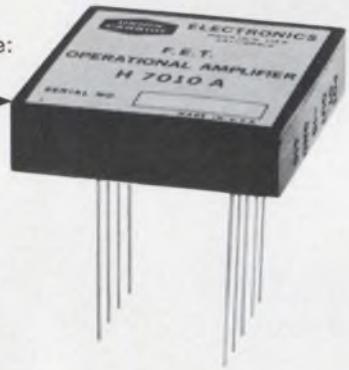

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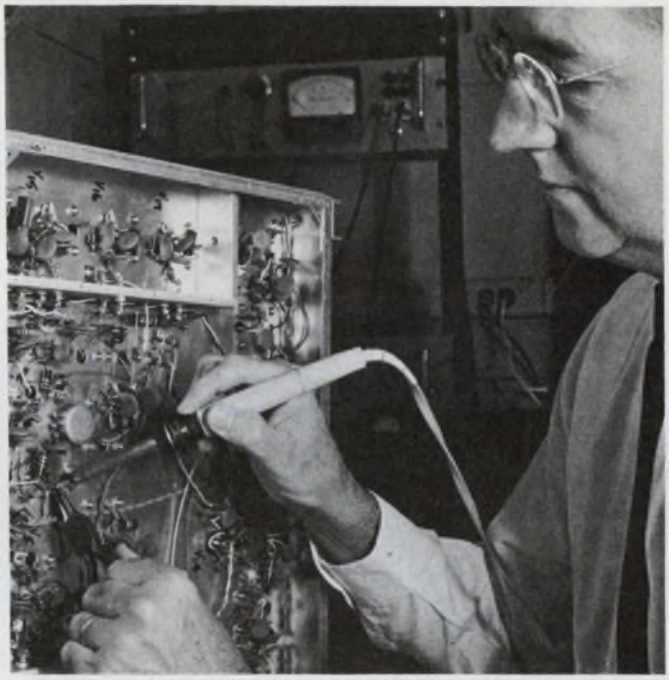
ON READER-SERVICE CARD CIRCLE 43

Technology

The world of the year 2000 is glimpsed in a special six-part predictive report. Page 70



Filters combined in parallel suppress unwanted frequencies, don't attenuate output. Page 114

Simple arithmetic is all there is to analyzing the modified Colpitts oscillator circuit that is required for direct conversion of resistance changes to frequency variations. Page 108

Also in this section:

ICs in process controls yield circuit stability at lower cost than before. Page 118

The Monte Carlo technique keeps antenna errors within tolerable limits. Page 124

Surrealistic circuits achieve nothing with no trouble at all. Page 130

Electronics in the World of Tomorrow

A glimpse into the future shows a society profoundly affected by electronics and related technology.

Edited by **Frank Egan,** Technical Editor

Ever wonder what the world will be like 30 or 40 years from now? Most of us have at one time or another. But our musings on the future are usually limited to areas in which we have either special interest or special competence. Thus the automobile buff wonders what cars of the future will be like, the nuclear physicist speculates about new particles, and women ponder how long hemlines will be. Engineers, for their part, may well ask themselves how far electronics and related technology will have progressed and what their impact will be at the turn of the century and afterwards.

ELECTRONIC DESIGN thought these questions provocative enough to warrant an attempt at answers. To provide them, we sought out experts who were not only eminently knowledgeable in a given area but also willing to prognosticate far into the future.

Looking ahead technically takes courage because it is so much easier to throw darts than it is to venture educated guesses. We feel that the engineers who speculate on the future in this report have tended toward the carefully reasoned prediction rather than the way-out guess. It is not hard at all to believe that digital watches are on the way. And predictive medicine is already beginning to become important although the full impact of electronic measurements of body functions has not yet been felt.

The most forward-looking suggestion we found is in the concept of ultra-robots so smart that man seems a dullard by comparison. At the MIT Lab where this prediction was made a mechanical computer-controlled hand easily snatches a thrown ball from the air. So the author's musing can not be dismissed perfunctorily. The reader only has to look into predictions of the past to see how well events have borne out the accuracy of many of them.

Jules Verne, for example, was the kind of thinker who looked boldly ahead. His forecasts were often quite accurate, probably because they were based on his keen interest in engineering and scientific subjects in general. At the time of his writings the technical community was heatedly discussing whether man would eventually choose lighter-than-air or heavier-than-air craft for the coming era of flight. Verne sided with the heavier school and time has proved him right. Although we have yet to develop a single vehicle versatile enough to operate in the air, on land and sea, and even under the sea, engineers and inventors have gone far toward achieving many of Verne's prophesies. More remarkable still, they have pushed many concepts beyond what Verne dared dream. The vision of a vehicle flashing down a highway at 60 miles an hour was enough to set the reader of his day to snickering.

Despite the accuracy of much prognostication based on sound engineering projections, engineers and scientists today still hesitate to predict future developments. Yet, with the even greater stress on technology in general, and electronics in particular, it seems clear that great discoveries are in the offing. Of course, no one man's predictions can be 100 per cent accurate. Some of Verne's explanations of how his envisioned craft would operate were way off the mark. Nevertheless, with hindsight it is clear that his ideas about the rate of technical development were over-modest.

Similar disparities can be anticipated in reasoned estimates made today. Advances will probably be made at a far faster pace than most of us allow. One has only to consider the state of space exploration just 10 or 15 years ago.

With this in mind, ELECTRONIC DESIGN'S contributors graciously agreed to put the ideas gleaned from their crystal balls into the articles of this report. It should be noted that their predictions are their own—and not necessarily those of the companies or organizations with which they are associated. It should also be understood that, unlike death and taxes, technological advancement can be capricious and significantly affected by factors ranging from the sociological to the political.

With these reservations, project yourself into the 21st century for a view of the world of tomorrow.

The Cover

Scenes from the General Motors Futurama exhibit at the 1964-1965 New York World's Fair. Photographs of these and other Futurama scenes were furnished by General Motors Corp.

A Myriad of Precision Watches for Land, Sea and Air

Donald K. Sites, Director of Research,
Hamilton Watch Co., Lancaster, Pa.

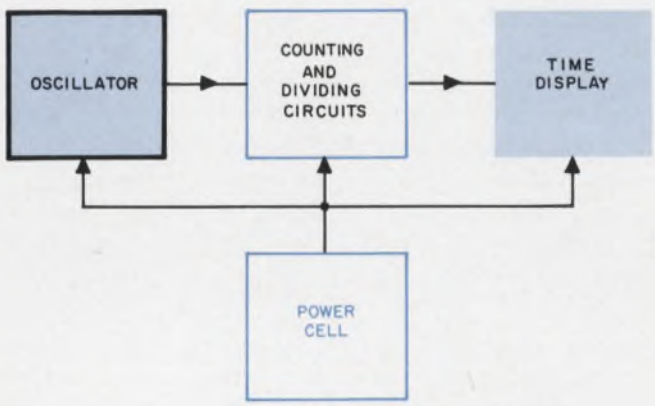
A modern Rip van Winkle wakes up in the year 2000. When he looks at his watch to see what time it is, he finds that the reliable timepiece has stopped. As our sleepy subject wanders about looking for the correct time, he is astonished by the strange sights he sees about him. Everything seems different—particularly the watches worn by those he stops to question.

What our van Winkle does not know is that, while he slept away the last third of the 20th century, watchmakers have kept pace with comtemporary technology. Utilizing developments in electronics, radioisotope power sources and new materials, they have built a wide variety of timepieces specifically designed to suit the wearer's occupation. Some watches have been designed for space travelers, others are suited for men working and living under the sea, and a further range fits the needs of those engaged in more mundane pursuits.

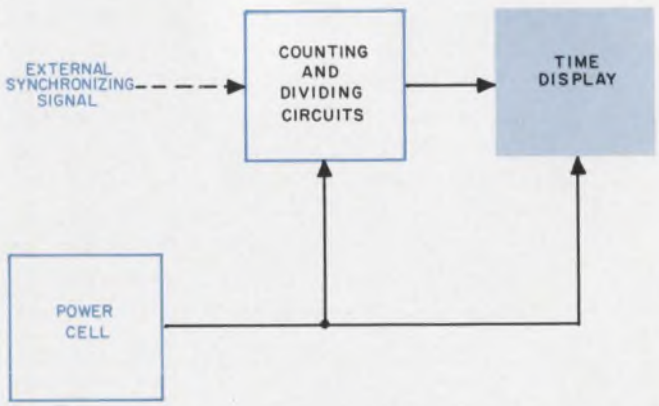
Probably the most significant aspect of the new watches is the large number that are electric or electronic. Some of these are refinements of the old (1967 era) electric watches possessing their own energy source and regulating signal. Others contain their own energy sources but are regulated by an external signal source. And still a third type is powered by an external source as well as regulated by external signals.

A watch for every need

The most common type of watch Rip finds in the year 2000 is the self-powered, external-signal type, which may be either electromechanical or all-electronic. While these are of the same general type, many varieties exist to reflect the wearer's individuality. One of the most evident differences is in the read-out: Some use digital read-out of one sort or another; others use the conventional face and hands. The digital-read-out types are relatively new, and are the outcome of a government-



(a) SELF-SYNCHRONIZING ELECTRONIC WATCH



(b) EXTERNALLY-SYNCHRONIZED ELECTRONIC WATCH

Internal regulation is provided in the self-powered, self-synchronizing all-electronic watch by a highly stable electronic oscillator (a). In the self-powered, externally synchronized type (b), world-wide standard time signals transmitted from communications satellites are used to provide regulation.

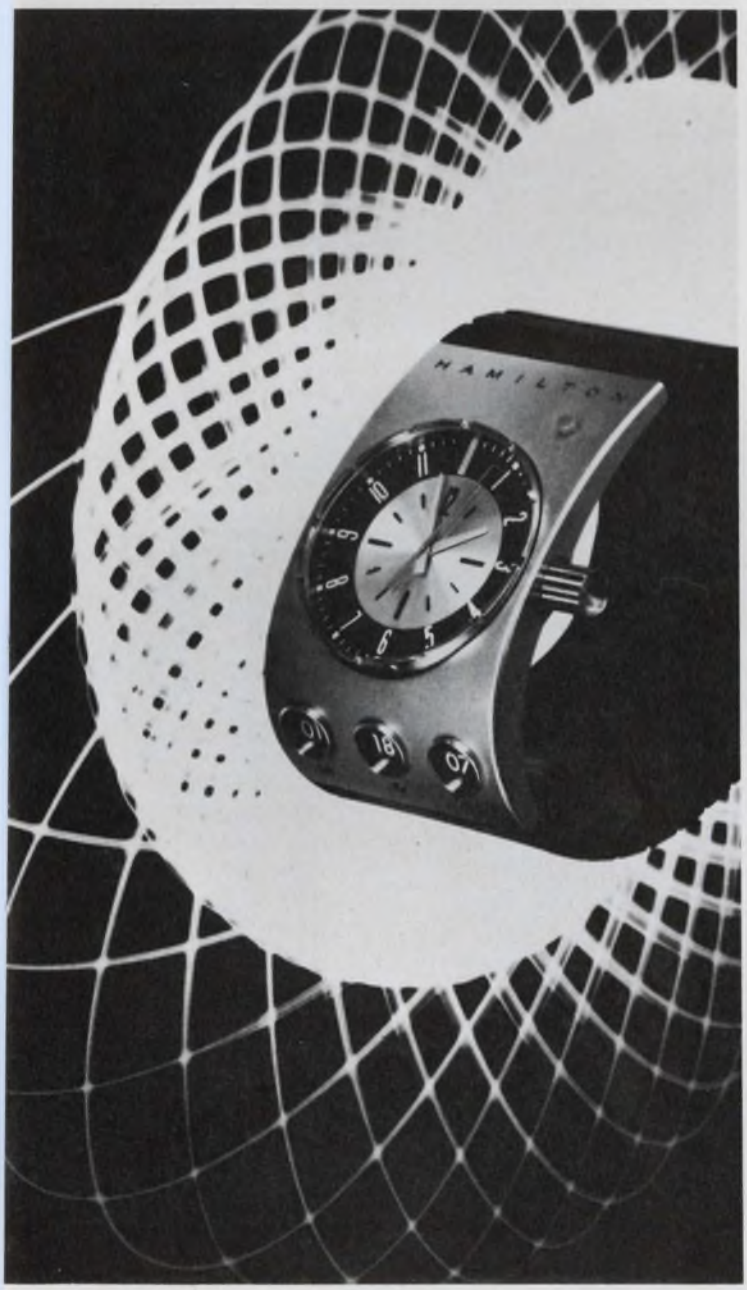
sponsored program to develop extremely low-energy electroluminescent panels in a package small enough for use in watches. Such watches are favored by young people, who have been associated with digital equipment since kindergarten. Older people still cling to the familiar round face, which market research people say will be gone in another decade.

The external regulating signal for the watches is transmitted from communications satellites, which provide a standard time signal to all parts of the world. This signal serves to detent the mechanism of electromechanical watches, keeping them synchronized. Electronic watches compare the external synchronizing signal with their own internal signal and adjust themselves accordingly.

A special accessory for doctors, lawyers and businessmen is operated in conjunction with the external synchronizing signal. This is in the form of coded paging signals generated at the watch in response to a side-band signal transmitted with the synchronizing signal. People with these special watches can always be reached by their office regardless of where they are in the world.

For the past few years, Rip learns, a government agency has been investigating the feasibility of using electronic watches for census purposes. One of the possible approaches being looked into involves watches having Gunn-effect devices built into them. These would transmit coded microwave signals that would be picked up by a network of regional receivers having directional antennas. The entire system would be tied into a central computer, which would provide the necessary counting and data analysis. The ultimate aim would be to provide a day-by-day census, as well as data on population shifts as they occur.

Travelers in the year 2000 cover long distances. In 1967, the average business trip may have required a watch adjustment for one time zone or so. In 2000 it is commonplace for a traveler to cross many time zones, involving a watch adjustment for each. However, such adjustments have been simplified by a movable bezel on the watch. In fact, the familiar crown and stem are no longer needed on watches in the new century. Rip finds that few shops advertise "Watches Repaired," for the sign refers only to old-fashioned watches of the Sixties' vintage, some of which are still in use. Contemporary watches are completely sealed. The



Conventional face will still be used on some watches of the future. Besides giving the local time, this mockup of a futuristic watch presents a numerical display of the month, the day and Greenwich time. By the year 2000 such numerical displays might be in the form of electroluminescent panels. The button at the upper right of the watch sets a built-in alarm.

Extremely accurate timekeeping is possible for everyone through satellite-transmitted standard time signals. The satellites beam the signals world-wide, allowing them to synchronize all electronic or electromechanical watches capable of receiving and processing them.

development, a few years ago, of solid lubricants and the use of self-lubricating parts eliminate the need for regular cleaning and lubrication. The new lubricants have very slight attraction for dust particles; furthermore, improved seals virtually eliminate dust in electromechanical watches. The newer, all-electronic watches, employing solid-state devices and digital read-out, are potted at the factory and never require service during a wearer's lifetime.

The old self-winding watch has its electronic counterpart in the 21st century. This is the thermal-powered watch. Such watches use solid-state devices that convert the body heat of the wearer into power to run the watch.

A different breed of watch has been developed for people who live and work in undersea colonies or are engaged in undersea mining operations. These people cannot use the externally synchronized watches, so instead they wear self-powered, self-regulating watches.

Undersea watches have different requirements

Many of their watches are refinements of the electromechanical watch of 1967. Still employed are the basic principles for generating a time base by transistor control of either an electronic tuning fork or an electrical-balance hairspring oscillator. There the similarity ends, for many improvements and innovations have been incorporated.

Significant strides have been made in waterproofing these watches for greater depths and water pressures. Like the watches mentioned earlier, these have benefited from the development of improved sealing techniques. There is scant need ever to open the watch because it employs the new solid lubricants and some of its parts are made of improved nylon.

The stem has been removed from these watches to lessen the chance of leakage at this point. Despite this design change, the watches still gain or lose less than one second a day—more than adequate for long-term service underwater, for the most it can be off in a month is less than one minute. To correct this error, the watch can be taken to the colony's calibration office, where it is placed in an electronic machine that compares it against a standard and generates a polarized field that causes the watch's mechanism to be advanced or retarded, as necessary.

Another advance important to these undersea watches has been the improvements made in power cells. Even though the power-cell packages are smaller now than they were forty years ago, the discovery of improved materials and the use of radioactive isotopes for the power cells have great-

Digital readout will be common in timepieces of the future, since it allows more information to be displayed in the same space. Advances in numerical display devices are required, though, before digital readout becomes fully practical. Such advances will be toward small devices of very low operating power.

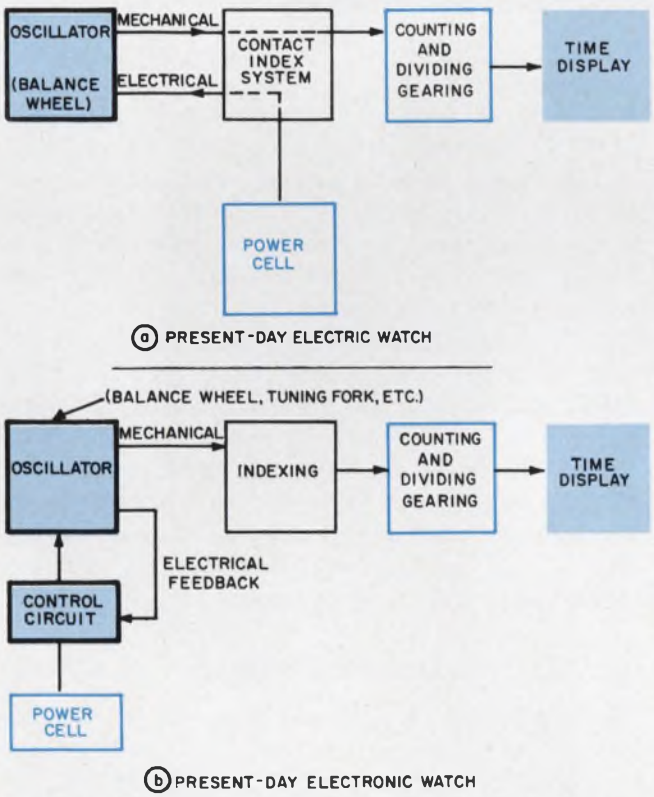
ly extended their service life.

Space watches are most sophisticated

The most advanced of all watches in the year 2000 are those carried by space travelers. Since these cannot be dependent on anything from Earth, they are of the self-powered, self-regulating variety. Precision of the highest order is required in these watches, since they are relied on for such operations as rendezvous with orbiting space platforms.

All space watches provide multiple read-outs—Earth time, outer-space time, and a calendar. Some models also provide an elapsed-time indicator. Although a few models still have conventional faces, the majority have digital read-outs in keeping with other information displays aboard spacecraft. These numerical-display read-outs are similar to 20th-century Nixie tubes, but require only a fraction of the space and power needed by these earlier devices.

The success of these electronic space watches is due to the development of an ultrastable frequency generator in a subminiature package. This is as accurate as the best quartz crystal of forty years ago, and makes use of the latest techniques in picocircuitry. The result is an electronic package the size of a 1967 watch movement but containing all circuits from oscillator to read-out. It is interesting that these electronic watches draw no more power than the earlier electric watches, and thus enjoy a long service life from their power source.



Power cell replaces mechanically wound spring in present-day electric watch (a). Electronic watches of today use electrical feedback to control the frequency of the oscillator (b). The indexing section of the watches converts the mechanical output of the oscillator into discrete, countable quantities that appear in the time display.

Power cells are of two types, radioactive isotope power cells and rechargeable batteries. The isotope cells are fused to the circuitry at the factory to minimize the dry-circuit resistance and permit the entire package to receive a protective shield. Such watches can be thrown away once the cell loses its power.

Yet even for space applications the mechanical watch has not disappeared completely. The spaceships now in use have radiation shields that enable them to travel through belts of harmful radiation without danger to their passengers. Occasionally, however, space debris damages this shield, and a crew member must don a special suit and go outside to make repairs. Like early scuba divers, he wears a mechanical watch to tell him how long he has been outside the ship. Mechanical watches are used for this purpose because they are less readily affected by radiation than electronic watches.

The challenge ahead

Returning once again to 1967, let's look at what must be done if these prophecies are to become realities. We find a considerable, although not insurmountable, challenge presented to electronic component manufacturers.

The prime prerequiste for development of an all-electronic watch is a highly stable subminiature oscillator. Present-day electronic oscillators are not stable enough for use in a watch, and quartz crystals with temperature-stable ovens are too bulky.

Refinement of present solid-state devices and the development of new devices will also be needed. Electronic watches require absolute-zero leakage in the off condition of the device. In this respect, the most promising device at the moment is the field-effect transistor. However, at today's rate of progress, it is quite possible that in the next 35 years there will be some completely new devices.

Probably the greatest challenge is to the manufacturers of power cells, since these lag behind the development of devices employing them. Today's most efficient electric watch requires approximately 50 milliwatt-hours per year and has a useful battery life of two years. Unless the electronic industry evolves new devices consuming less power, battery manufacturers must develop a cell capable of delivering this power for a much longer period of time. One final need is for a numerical read-out device that will operate on very low power and be housed in an extremely compact package. ■ ■

Diseases Fought Before and After They Occur

Curtis E. Miller, M.D., Director of Medical Research, Beckman Instruments, Inc., Fullerton, Calif.

The role of prophet in an era of immense technological change is not an enviable one, particularly in the field of medicine and health, where every day discoveries are made and new techniques are developed that may drastically alter the shape of the future. Indeed, some of the most exciting future developments will grow from discoveries yet to be made, and will have implications that even the wisest scientists can scarcely imagine now.

Nevertheless, recent developments point to some clear trends that enable us to predict the state of the health sciences some thirty years from now with a fair degree of certainty.

Preventive maintenance key to health

In the year 2000, the emphasis of medicine is increasingly on the maintenance of health and prevention of disease. With new instrumental techniques and data-handling capabilities, physicians are able to predict degenerative conditions developing in a patient and, in many cases, prescribe preventive measures to forestall or ameliorate his illness.

Periodic visits to "predictive health centers" are as common for the average person as routine visits to the family doctor were in 1967. In less time—and for less money—than it used to take for a fairly superficial physical examination, people can now undergo comprehensive and dynamic biochemical, physiological and behavioral testing to obtain a complete "health profile" of themselves. Not only does this "multiphasic screening" give the physician a complete picture of a person's health at that moment, but it also allows him to anticipate disease by telling how well the body's defense mechanisms are working.

Increased sophistication in health measurement has been accompanied by successes in prevention of acute illnesses with vaccines. Use of these has also substantially reduced the chronic diseases that are aftereffects of acute illnesses. A vaccine to prevent rheumatic fever, for instance, has also wiped out the rheumatic heart disease that often followed in its wake. Moreover, many chronic illnesses of the 1960s have been conquered by better understanding and control of such environmental factors as air pollution.

Replacement parts extend life

Another achievement of medical science is the increasing refinement and use of artificial organs and organ transplants. Many people now lead perfectly normal, active lives with an artificial kidney, heart, or even a lung. Various forms of artificial eye are effectively eliminating the threat of blindness; these use electronic devices to gather visible light and transmit impulses through the optic nerves to the brain.

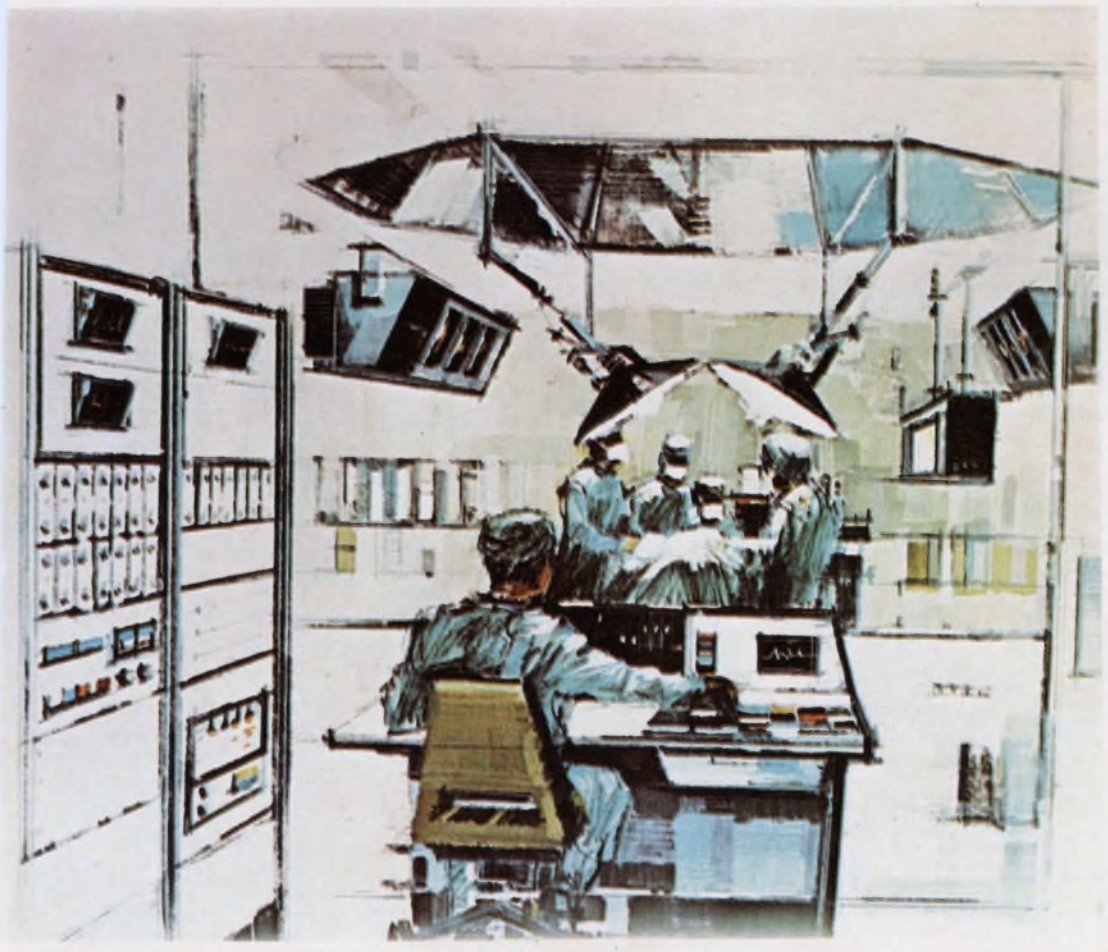
Advanced as these developments may be, however, there will come a time when even the most sophisticated artificial organs will be obsolete, because the need for them will no longer exist. Just as the iron lung all but disappeared because of polio vaccine, so will the need for artificial organs be obviated by the conquest of other degenerative diseases. In short, when we can keep our organs healthy, we will not have to replace them.

Hospitals reflect technological change

Hospitals are dramatically different from those of 1967. Arrangement and design of the buildings themselves reflect the changing nature of hospital care. Out-patient facilities are extensive as a result of the faster cures effected by contemporary procedures and drugs. The need for long stays in the hospital is vanishing.

In-patients are segregated in wings according

Displays over an operating table give surgeons and anesthetist a continuous and instantaneous reading of their patient's condition throughout an operation. Microminiature electrodes and transducers keep a constant check on such vital factors as pulse rate, respiration rate, blood pressure, body temperature and brain waves.



Medical technologist sits at the console of a master computer that monitors, analyzes and compares the flow of physiological data from a patient in an adjoining operating theater.

A nurse keeps close watch on up to 24 sick persons at once at this central console which continuously monitors and records physiological data from all her patients simultaneously, even when each bed is in a separate room.

to the degree of care required, rather than the type of disease. Entire sections of the hospital are devoted to specialized treatment. One such specialty building houses hyperbaric oxygen chambers; another radioisotope sources and linear accelerators, which have replaced X-ray techniques for radiation therapy; a third accommodates the hospital's computer and data-handling complex.

All manner of sophisticated instrumentation is in evidence throughout the hospital, from the operating room to the clinical laboratory, from the nurse's station to the bedside. The surgeon receives continuous information about the exact condition of a patient on the operating table. Microminiature electrodes and transducers transmit a constant stream of critical data in real time from the patient to the computer and back to the operating room.

In the recovery room, instruments monitor the patient's condition all the time, recording and analyzing any changes, no matter how small. In the hospital's clinical laboratory, banks of automated analytical instruments perform rapid, precise biochemical and pathological tests, printing out the data in digital form, as well as presenting it directly to the computer for analysis and storage.

Each day when the doctor arrives at the hospital, he goes first of all to one of several time-shared computer consoles. Here he obtains up-to-the-minute data on the condition of each of his patients, views the results of tests he ordered the day before, orders new tests, or changes the medications he had prescribed earlier. Only then does he see his patients themselves.

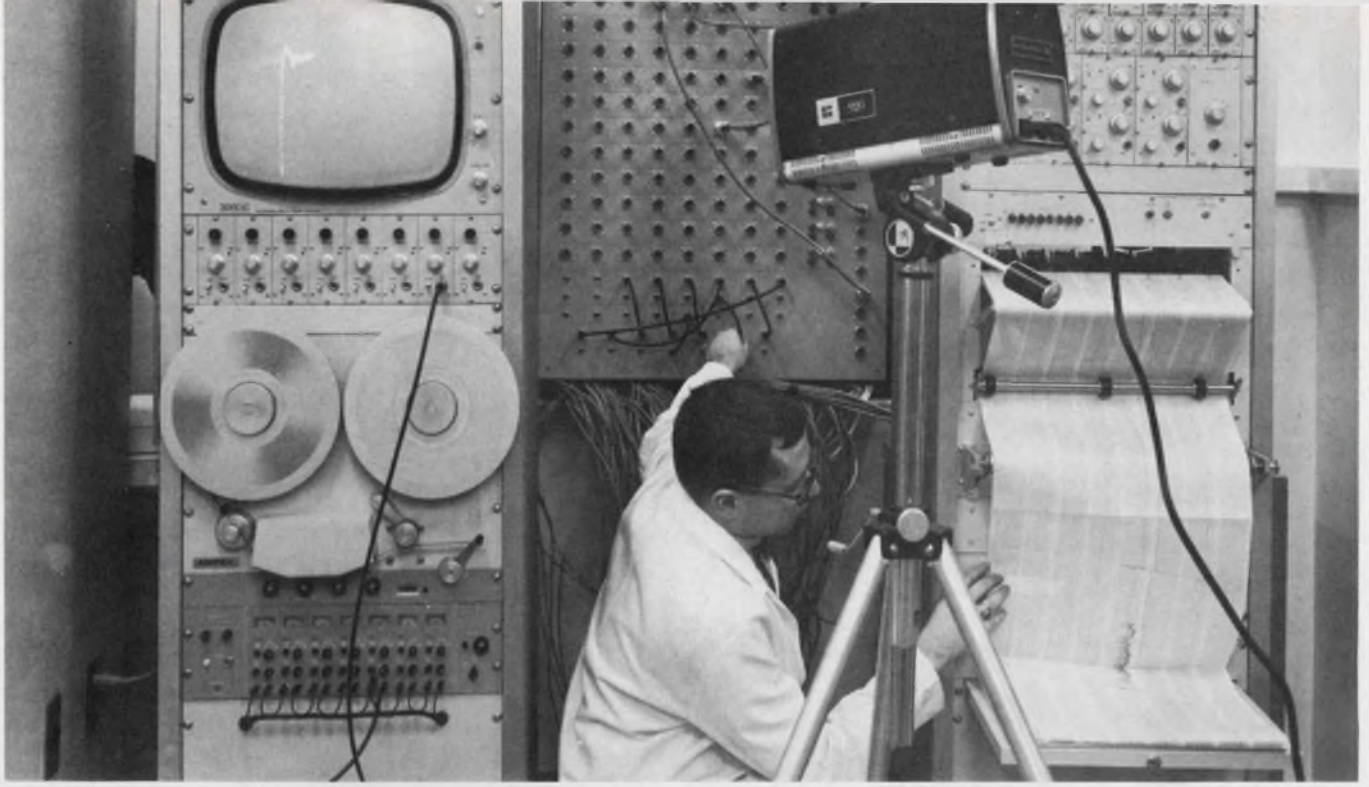
The computer is no stranger to the physician. He had several courses in computer theory and programing before entering medical school. In medical school itself he spent many hours with analog, digital, and hybrid computers in "medical computer games," performing diagnoses of simulated ailments. From the outset of his intern days, he has grown to rely on the computer as a virtually infinite store of information to aid his decision-making.

Medical data banks, spread all over the world and interconnected with each other, are capable of comparing one medical history with untold numbers of similar cases as an aid to diagnosis. Hard-learned lessons on rare diseases are not forgotten.

Both physicians and patients benefit

Concern was expressed at one time that the rush toward instrumentation and automation in medicine would lead to dehumanizing the relationship between physician and patient, that a doctor's warm reassurance would be replaced by the cold, impersonal efficiency of the machine. This has not been the case.

None of the changes has displaced the physician. Rather, they allow him to spend more of his time in analysis, evaluation and judgment in the diagnosis and treatment of his patients. The new



An unborn baby's heart beat and brain waves are recorded continuously during the mother's labor and delivery on this complete biomedical monitoring and display unit. a forerunner of tomorrow's systems.

techniques give him more precise information than he ever had before. Electronic data-processing frees him from the routine detail that formerly occupied his time without truly exploiting his talents.

The patient also reaps many benefits from the advances in medical electronics. To begin with, the likelihood of his ever having to be in a hospital has been reduced many times over by attention to predictive health and predictive medicine. If he should need surgery or have to enter the hospital for specialized treatment or tests, his stay is shorter and more pleasant than once was the case.

While all these changes have been taking place during the past three decades—changes that have directly affected the patient-physician interface—advanced biochemical research has also produced dramatic results. Here, too, electronics has played a vital role in helping scientists to break the genetic code and unlock the secrets of life.

The use of computers and computer models has led to breakthroughs in understanding the body's immunological systems, and has provided the final step toward conquest of diseases ranging from the common cold to malignant cancers. Molecular biologists can design and synthesize new genes to inject into the defective cells of diseased organs, and can alter the structure of genes to eliminate hereditary defects and congenital disease. They have been unscrambling the electrochemical formulas of the brain and its thought and memory processes, and ultimately will be able to alter the maze of experiences that a person stores there.

What is the role of electronics?

To make the medical achievements just described possible, science needs new instruments of greater sensitivity and specificity, with more speed and ease of operation. The opportunity for designers and makers of electronic instruments, systems and components to contribute to medical science clearly exists. Indeed, electronics' participation is essential. There are two important factors, however, that are not so readily apparent.

The first is that an instrument, no matter how sophisticated, is not a substitute for the skill of the scientist, whether he be a physician with a surgical laser, a pathologist with a spectrophotometer, or a biologist with an ultracentrifuge. Instruments merely extend man's senses and capabilities; they do not create new ones.

The second—and perhaps more important factor, as far as industry is concerned—is that a manufacturer's capabilities in electronics, chemistry or optics are not the sole prerequisites for service to medical science. The measurement scientist must understand the needs and goals of the physician, and be responsive to them. He must be willing to submit his work to critical evaluation more lengthy and more costly than for any other customer. And he must be willing to bear as much moral and legal responsibility for the implications of advances in medical science as he expects of the user of his products. ■ ■

(Report continued on p. 82)

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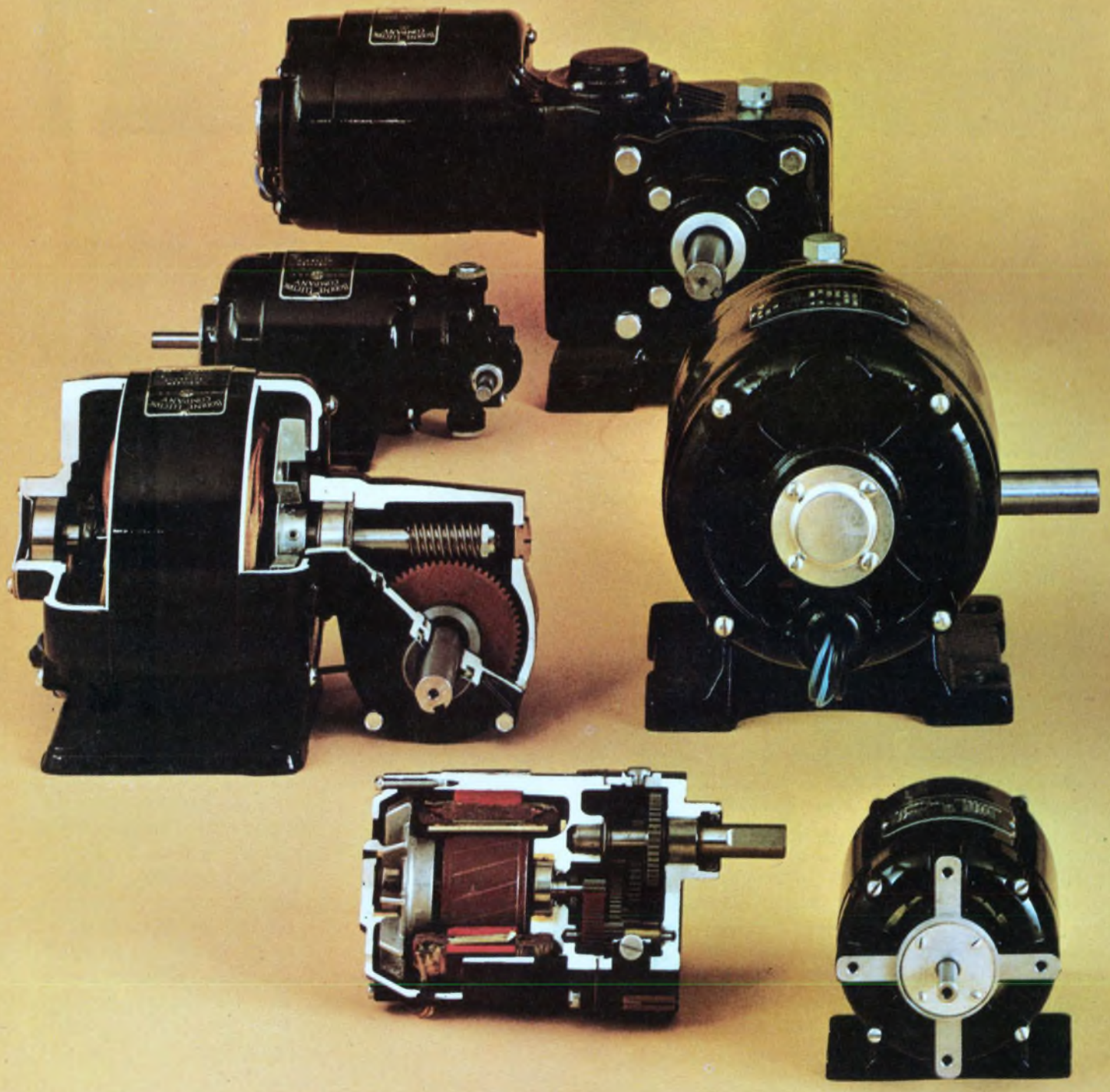

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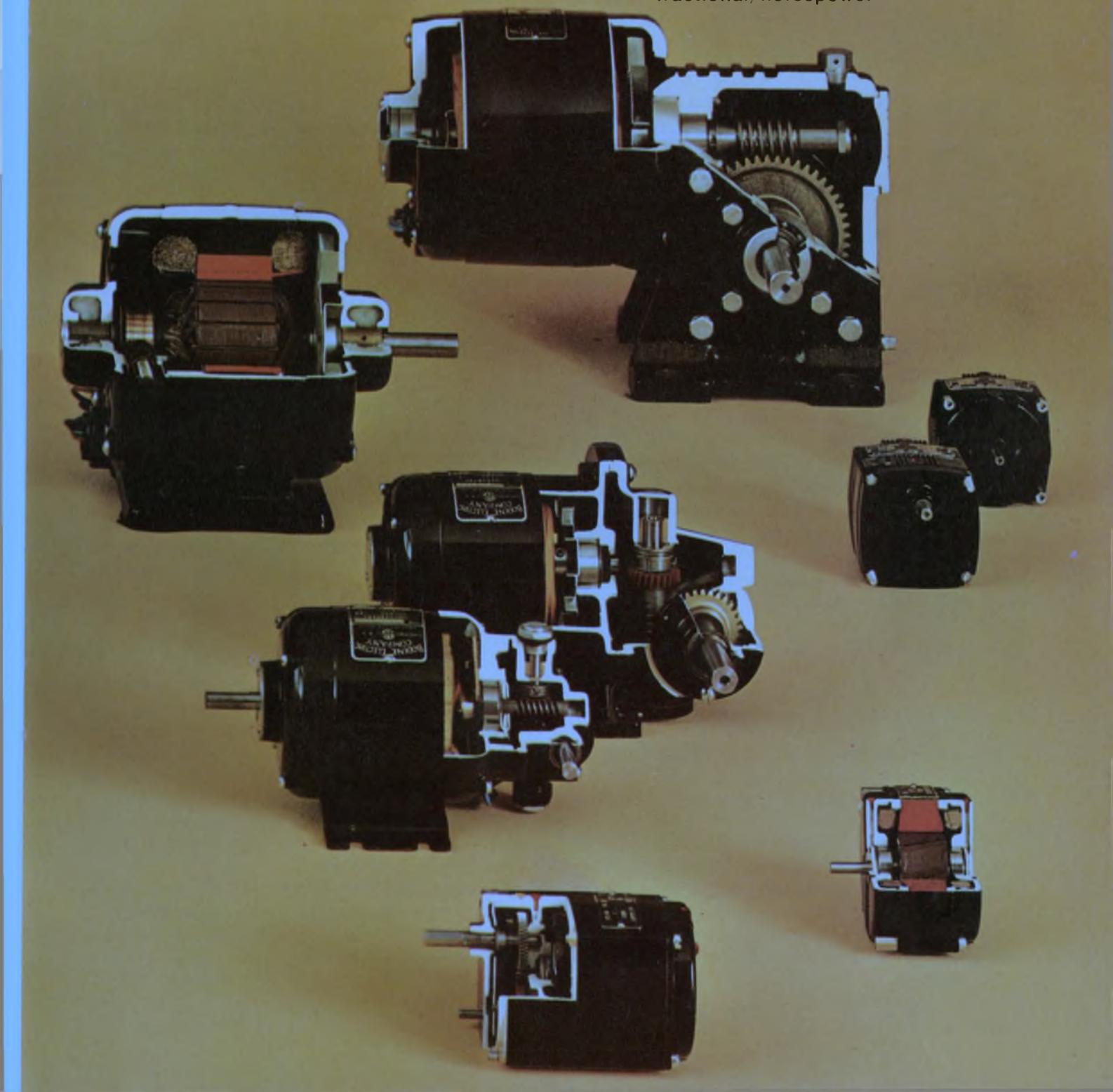


Will the Machines Eventually Outwit Man?

William S. Jarnagin, Project MAC,
Massachusetts Institute of Technology, Boston

Automata are already doing such things as running chemical experiments, operating machines and aiming missiles. By the year 2000, however, we can expect man to be dealing with "intelligent" automata with far more remarkable characteristics.

Intelligent automata may be defined as mobile computers that are interfaced with sensors capable of measuring the computer's physical interaction with its outside world. They are capable of simulating not only man's intelligence, but even his sensations. This last point bears discussion. Turing has discussed computers' potential for simulating man's intelligence. But we suggest further that automata will be capable of perceiving the world through specific transducers that can match, perhaps even excel, man's own. These sensors will send coded information in the form of pulses separated only in time to a central processor. This parallels the human sensing process. Thus man and automata can agree, say, on seeing red, hearing sounds, sensing acceleration—even feeling pain with the automaton simulating pain by abthreshold signal detectors—so long as they have similar sensors. What tasks might such creatures perform?

Early applications by the year 2000

The first applications for intelligent automata are likely to be in work which is hazardous for man, such as planetary exploration, deep-sea cable repair and radioactive material manipulation. Such types may be fairly common by 2000.

The next step will be the development of more intelligent automata for more skilled work. These may be associated with the operation of a great variety of instruments. By the year 2000, intelligent automata may have the ability to read thousands of books to man's one and, with built-in photomultipliers, IR, UV, and radar instruments, they may have optical sensitivity over practically the entire electromagnetic spectrum. Instrument-coupled automata may also by that time be able to detect the merest traces of any gas or chemical by a combination of mass spectrometry and neutron bombardment that would enable them to interpret the consequent radiation of the trace.

Moreover, microelectronic (lithographic or even holographic) and molecular engineering techniques may have reached the stage where the large instruments of 1967 can be reduced almost to the vanishing point, making it practical to integrate a wide range of sensors into an automaton.

Automata vs antiautomata

If war is inevitable in the future, then there is no theoretical reason why the whole gamut of hazardous military tasks should not be turned over to automata, from piloting aircraft and driving tanks to foot-soldiering. Furthermore, the machines could probably be programed to face destruction more willingly than people; desertion and mutiny might be nonexistent, and the automata could battle nonstop day and night.

In addition to automata soldiers, microelectronic spies could be fabricated in the form of small creatures. With microinstruments integrated with microcomputers, their volumes and masses could be minute. Fuel cells with higher efficiency than organic energy mechanisms would enable an artificial "insect" or "bird" to fly hundreds of kilometers over a given terrain. Programed instructions could then direct the microinstrumented spy to enter the headquarters of the opposition and return with information.

Border-patrol automata could be equipped to identify persons bent on violence. Such an automaton might conduct an accelerated psychoanalysis by asking certain key questions that would be reacted to reflexively, with or without words. (It was Freud, after all, who claimed that he learned a great deal just by the way a person approached

and knocked on his door.) Enough is known already to identify with relative assurance people intent on violence. A perceptive automaton might even take an electroencephalogram from a distance. With built-in magnetometers, UV, IR, radar and perhaps X-ray apparatus, the automaton could also quickly spot weapons or explosives on passing people.

Many of these capabilities would be equally useful for crime control.

By the time this degree of capability has been achieved, nations may have to develop antirobots. Conceivably a standoff might result comparable to the nuclear stalemate of the 1960s.

Safeguards may be required

If man positively refuses to trust intelligent automata, he is likely to try to restrict their physical strength, mobility, communication (with each other), and their access to destructive weapons. How long any of these restrictions may remain effective is hard to say.

The first intelligent automata may have tamperproof "genetic rules" built into them to the effect that man shall not be willfully harmed. This safeguard may be incorporated in self-reproducing models, with strict provision for isolating or destroying any mutated version that lacks this characteristic. How long it may take intelligent automata to outsmart these efforts remains to be seen.

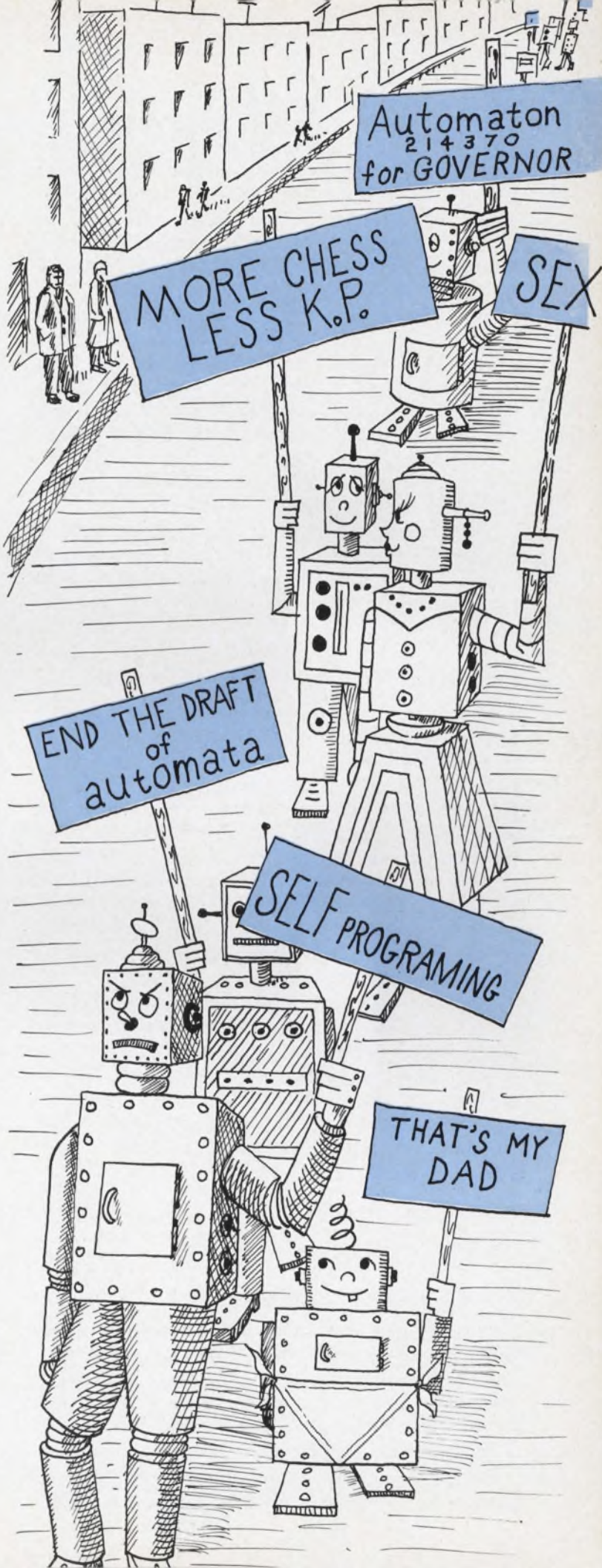
Other safeguards might be to make it illegal for programers to write socially destructive programs and to regulate automata owners, much as we presently regulate owners of other potentially dangerous devices like guns, explosives and autos.

Automata workers supersede humans

Neither serious threats to people nor great risks of economic upheaval are necessarily inevitable in the development of intelligent automata. Their initial use in performing tasks that are hazardous or toilsome for men will alter public reaction to them; the fast dumb slave of man will be seen to be not so dumb.

As machines are constructed with progressively more intelligence, personal-aide machines may come into popular use. Microelectronic machines of this nature could be worn like hearing aids to give their owners good counsel.

Once the usefulness of automata has come to be generally appreciated, automata could gradually take the place of skilled and unskilled workers. To make the economic transition easier, legislation may require that management pay the displaced workers as usual for a certain number of months or years; meanwhile, management could recover the cost of the automata by exploiting their 24-



hour-per-day work capacity.

Gradually, people would be placed on perpetual vacation. Life's basic needs, in goods or money, could be provided by a work force of automata. Energy from the ocean's supply of deuterium might be obtained by intelligent machines in sufficient quantity to supply the world; similarly, intelligent farm machines could produce a nation's foodstuffs.

This scheme differs from some persons' image of utopia. It leaves many problems still unresolved. By what system of values, for instance, would man live? Thinking machines might compute an optimum way of feeding, clothing, sheltering, educating and entertaining millions of people, but this might take no account of personal idiosyncracy. To what extent, then, might man have to relinquish some of his individuality?

Time and education alone should solve some of the problems, however. Children could grow up as accustomed to thinking machines as they have been already to television, cars, aircraft and the machine world.

Ultraintelligent automata—desirable or not?

One of the world's major problems in the next millennium may be man's control of extremely intelligent automata. An automaton thinking at the speed of light and processing, say 10^{15} bits per second would have to wait 10^{12} seconds, or some 30,000 years, for man to process the same information at 10^{3} bits per second. Automata capable of that speed—if fully conscious and able to make subtle inferences—could find people unbearably restrictive. Even if they did not have means to destroy man, they might choose not to communicate with him.

Man, for his part, might then wonder whether or not he should share his energy resources and living space with such uncooperative and, in effect, useless machines, and might threaten to destroy those that steadfastly refuse to report their findings to him. But, so much astuter than he, the ultraintelligent machines would have already thought of that and, after earning their keep and being in existence for a while, would probably persuade him to leave them alone as entities in their own right.

How will automata be developed?

These projections have a solid grounding in fact and are extrapolated from work and investigations that are presently in progress. A detailed discussion of such work is beyond the scope of this article, but a brief mention of some of the areas of research and their significance can be given.

The development of intelligent automata is based on the identification of rules. Directly related work is currently being pursued in two major areas: artificial intelligence and bionics. Many published works in these fields indicate that certain characteristics of intelligence long thought to be uniquely peculiar to human beings can be simulated by computer.

Today quasi-intelligent automata can be programed to use artificial intelligence to attack difficult problems in various ways. One of these is by analogical reasoning. They substitute a simplified version for the difficult problem, solve the analogous problem, noting the steps taken, and then apply the steps to solving the main problem.

Another technique is the use of subgoals. In this case the automaton restates the difficult problem as a set of subproblems, notes the relationship between the parts, solves the subproblems, and combines the results to form a solution to the difficult problem. (This is how it plays chess.)

Bionics is another approach

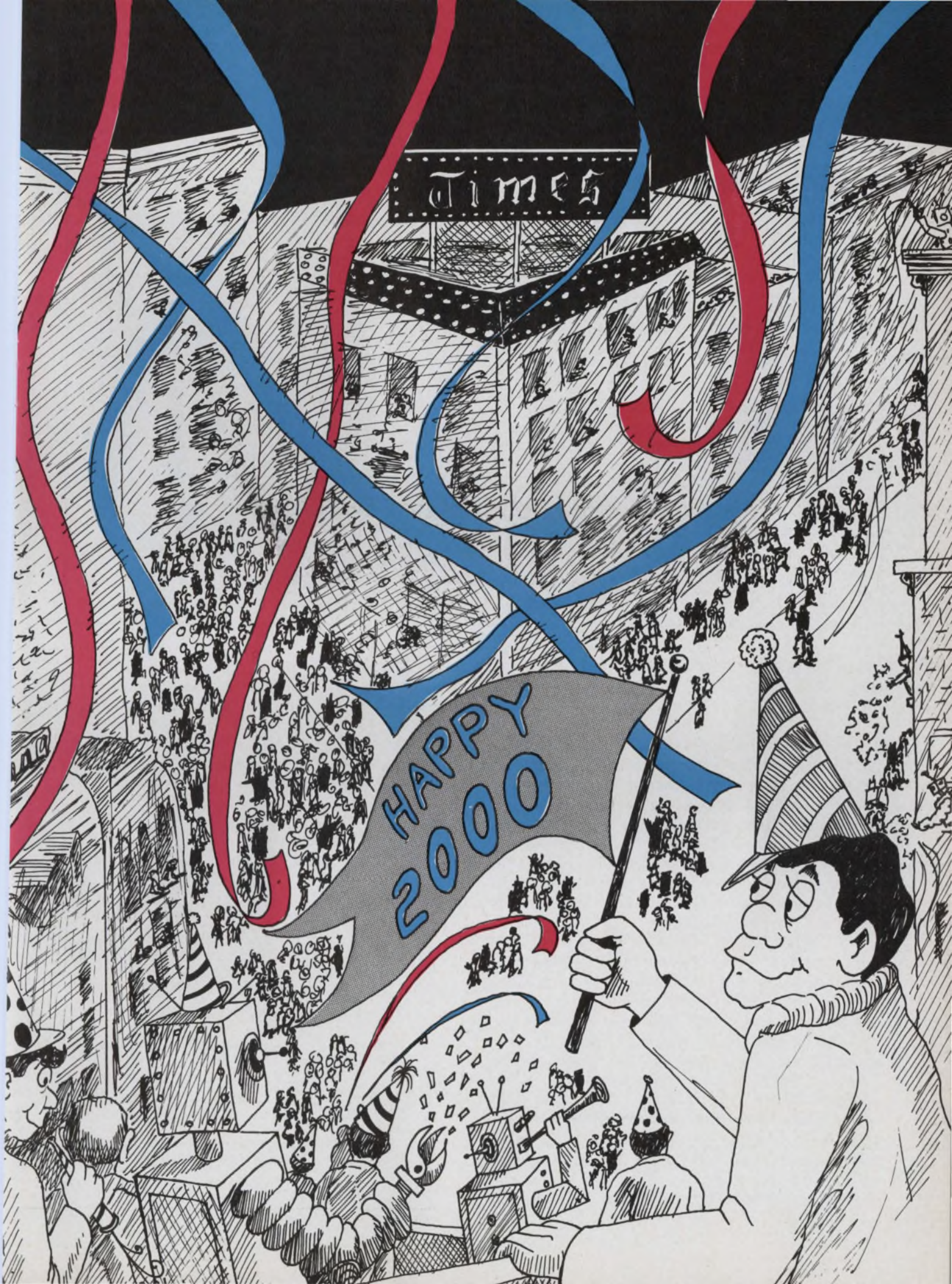
A second approach to the development of intelligent automata is through bionics, where electronic devices are modeled after neurophysiological counterparts. An example is the information-processing system currently under development at MIT's Instrumentation Laboratory. This is largely based on the reticular formation of human nerves and the retina of a frog. This system, sponsored by NASA, is planned for use in exploring Mars in the 1970s. It is to perform certain experiments, radio back its results to earth, and make local decisions in keeping with its program.*

Other bionic approaches include the simulation of neural nets. Here, too, the problem is: by what rules can events in the outside world be coded, stored, switched, and so on? Ironically, once the rules are described, they can be programed into a computer.

Efforts have been made to try to trick bulk material into exhibiting, by selective reinforcement, some semblance of intelligence. Metallic dendrites have been grown in various media, and metallic whiskers have been grown selectively in electronic circuitry to effect self-repair of components. But it must be stated categorically that, unless these materials contain the basic ingredients of formal logic (AND and NOR elements) and a means for storage (delay lines and memory), the system will remain deficient by whichever of these basic elements it lacks initially. Furthermore, these ingredients, as with neurons, must be made to function according to definite rules.

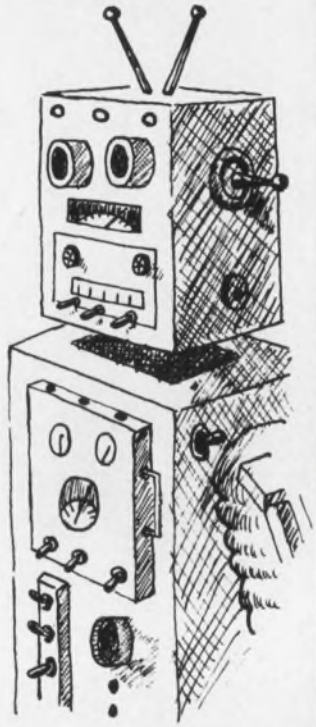
Similarly, perceptrons and related perceiving machines will have little chance of becoming

*See "Electronic frog eyes may search for life on Mars," ELECTRONIC DESIGN, XIV, No. 24 (Oct. 25, 1966), 17-24.


Times
HAPPY
2000

Man vs Machine

Cerebral cortex	Microelectronic computer
Cochlea	Microphone
Balance sensor	Gyro & accelerometer
Optical sensors	Vidicon TV, IR, UV . . .
Sense of smell	Mass spectrometer
Temperature sensors	Thermometers & thermistors
Vocal apparatus	Speaker & display tube
Energy mechanisms	Fuel cell
Reticular formation	Control center
Bronchial	None
Sense of pain	Abthreshold signal sensors
Self-repairing cells	Self-repairing components
Heart	Fuel pump
Chemical sensors	Chromatograph
Rotational muscles	Electric motors
Flexors & extensors	Opposing hydraulic rams
Skeleton, bone	Metal rods & casing
Elbows, single	Elbows, multiple/arm
Sense of touch	Pressure & strain gauges, time domain reflectometer & compressible RF cable (closed radar unit with computer looking at echo)



generally useful unless they are extended to include basic logic and storage elements as well as the essential rules to function by.

To solve difficult problems, automata will not generally search all possibilities. Time and storage limitations require that searches be restricted. (There are more possible moves in a chess game than there are particles in the universe.) Furthermore, randomness appears to be unnecessary, since some sort of plausible rule (criterion) can always be suggested, even if not ideal. Noting the effectiveness of various rules and applying them by the subgoal method should enable the automata to steer in a favorable direction.

Furthermore, in a self-modifying system it is important that even its rules can be changed by rules. Otherwise the result may be gross randomness, or irrevocable divergence.

The main point is that intelligent automata will probably follow from improved computer programing and from well-defined bionic models. Bionics researchers have the advantage of known working models (man) from which they may obtain clues. They cannot expect success by putting things together the way nature did—it may take equally long. Looking at the answers and making intelligent guesses, however, may enable them to determine the rules before the century is out. Computer scientists, working on artificial intelligence, have working models of their own; namely, a number of successful quasi-intelligent programs. It remains to be seen which appoach first yields rules by which automata can make logical inferences and communicate in a language as complex as man's. ■ ■

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(Report continued on p. 88)

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CONTROL

Space Travel Made Easy with Novel Displays

W. E. Drissel, Principal Systems Analyst, Systems and Research Div., Honeywell, Inc., Minneapolis

Design engineers may dream a lot—but seldom with company encouragement. Yet this was the opportunity given to Honeywell's systems and research engineers, early in 1966.

At that time, a movie company, Polaris Industries, contacted Honeywell Systems and Research Div. for technical assistance on a movie entitled "2001: A Space Odyssey." This assistance was to take the form of developing ideas, working with an artist on drawings for a spacecraft of 35 years hence, and furnishing dialogue and action.

What made this assignment particularly intriguing was the fact that Honeywell was asked to assume that all technical impediments to its futuristic ideas would be overcome. With this in mind, engineers peered ahead to the year 2000 and came up with spacecraft displays, an astronaut's maneuvering unit for extravehicular work, and an attaché case for the space-traveling executive.

Computerized displays help astronauts in 2000

As a result of industry-wide efforts over the past 35 years toward integrated informational displays, pictorial and predictor displays now provide spacecraft pilots with information in immediately useful form. When the spacecraft power supply is functioning normally, the display gives periodic assurance of this fact; but should there be only marginal operation or a failure, the display shows the faulty element as nearly isolated as possible and indicates with block diagrams or schematics how to repair it or select a back-up.

The spaceships' command center is dominated by a computer-derived display complex which is controlled by voice or a light pen and makes wide use of color. It is placed at arm's length from the pilots (Fig. 1) and nearly fills their field of view.

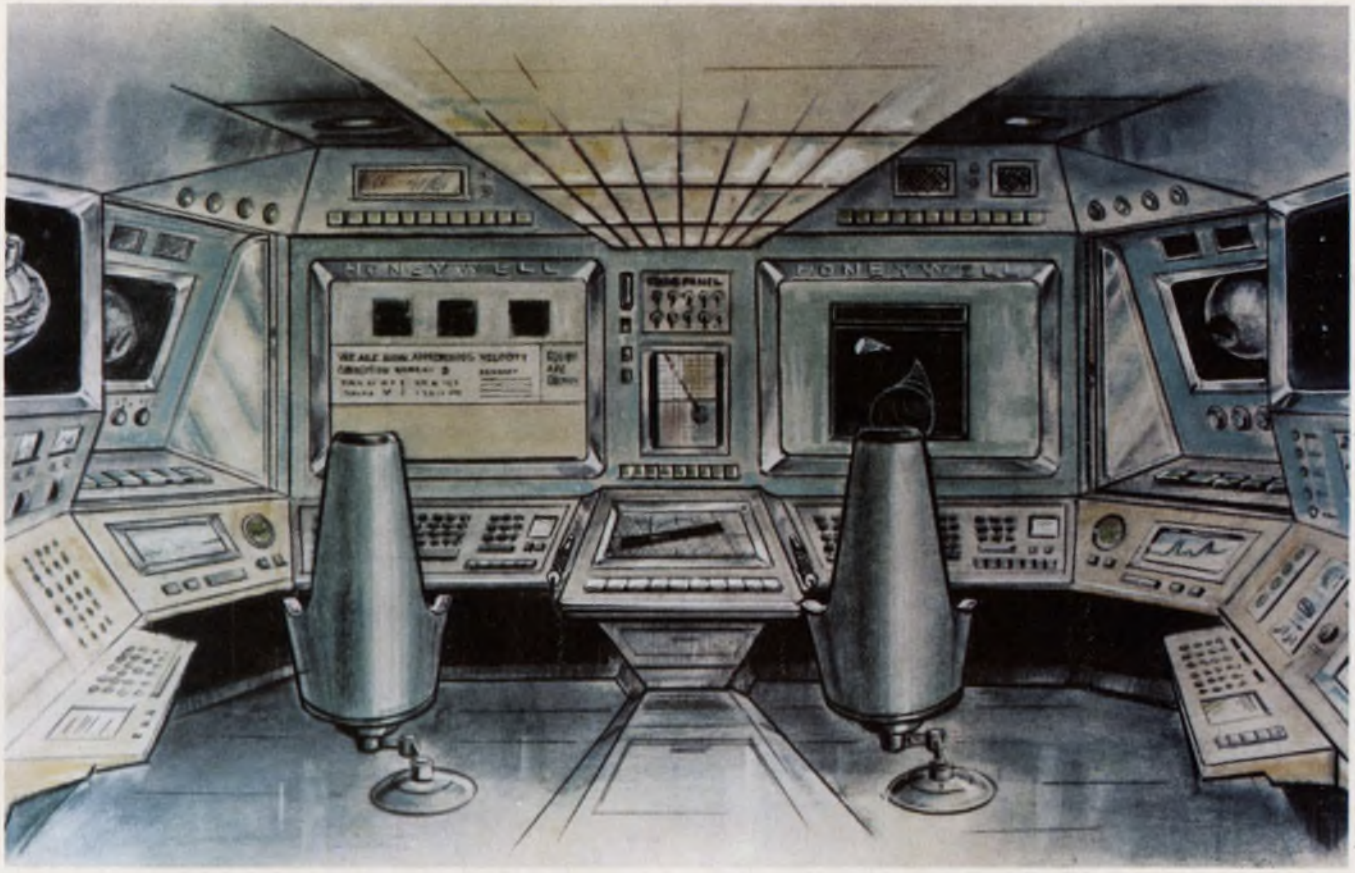
An automatic control phase, including plane change and gross catch-up, is used for rendezvous with an orbiting space station. During this phase, the display shows the position of the station and such things as how long before a velocity correction will be necessary, what the spaceship's attitude is, what the crew should be doing, what thrust is being developed, and how much fuel remains.

This phase is followed by a manual rendezvous phase using the spacecraft radar. At this stage the display shows the relative positions of the spacecraft and the space station, and if conditions are not correct for rendezvous, the pilots see a meaningful error vector. The colored arrow in Fig. 2 is the error vector; Fig. 3 shows the display after the pilot has driven the error vector to zero.

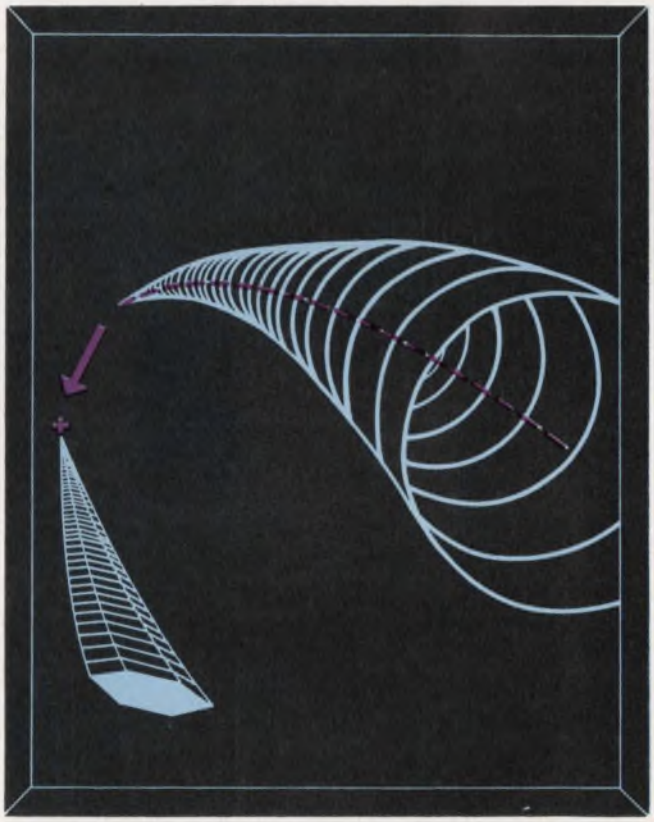
This display continues until the target is within a predetermined range. Now the display switches to a high-resolution color television picture of the target. Human beings are nowadays so good at docking that they usually handle it all themselves. The two small lights at the center of the docking display (Fig. 4) are ranging lights. The cross hairs are positioned by the computer, so that the display follows the pilots' maneuvers almost instantaneously.

Events are displayed as checklist

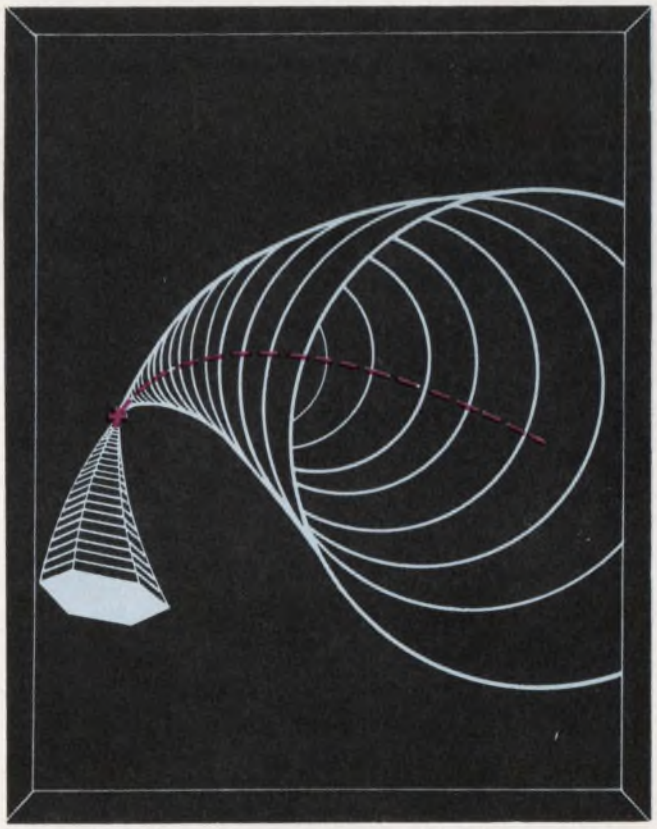
Before every scheduled event, the pilots see an automatically displayed checklist. What the computer will do is listed in one category, the crew's tasks are in another. The computer performs a complete self-check first. This includes instructions to the pilots to assist it whenever necessary



1. **All spacecraft functions are monitored** at the computer-derived display complex. Subsidiary functions which make possible activities such as recreation and training are also provided by the display.



2. **Manual rendezvous is accomplished** through the use of a visual display. If any course correction is required during rendezvous, this is indicated by the error vector (arrow).



3. **Error vector disappears** when the spacecraft is placed on course for rendezvous. Display changes to a TV picture of the target when the spacecraft reaches a predetermined range.

by voice or with the light pen. As each automatic check is completed, that item on the checklist turns green. The background of the checklist display remains suffused with pale green as long as all tests are passed. Any tests which check out as marginal but not dangerous gleam yellow. Should a parameter be dangerously out of range, it shines red.

Display indicates other conditions

When an out-of-tolerance condition occurs—for instance, when a velocity correction is required—and an appropriate section of the display panel changes to yellow, it indicates to one of the pilots that his participation is required to correct the condition. Information on what corrective action he must take is displayed at the same time. With this guidance, the crew can easily modify the out-of-tolerance condition, again either by voice or with a light pen. The voice controllers which convert the crew's oral commands into electrical inputs to the computer have a speech-recognition capability sufficient for any commands that might be given.

If there is a countdown prior to any of the preplanned mission sequences, the countdown is also displayed along with any simultaneous, automatic checks.

Novel attitude display used

Apart from the main display panel and the information it shows, the pilots' main object of interest is the attitude indicator. It indicates the attitude of the spacecraft with respect to a set of reference axes, with the map of yaw and pitch projected on a plane instead of a ball.

This technique was the outcome of simulation studies at Honeywell many years ago. They showed that test pilots had trouble maneuvering from a position on the "front" side of the ball to one at the "back." The pilots found difficulty in determining which way to start a maneuver or how to apply corrections once started. Therefore, an engineer conceived a display (Fig. 5) that shows "all attitudes at once," in this manner:

(a) Lines of constant pitch are shown horizontally and lines of constant yaw vertically;

(b) The opening on the ring shows roll attitude;

(c) The location of the ring's center shows the pitch and yaw attitude; and

(d) The dashed line depicts the predicted changes in attitude which would result from present attitude rates.

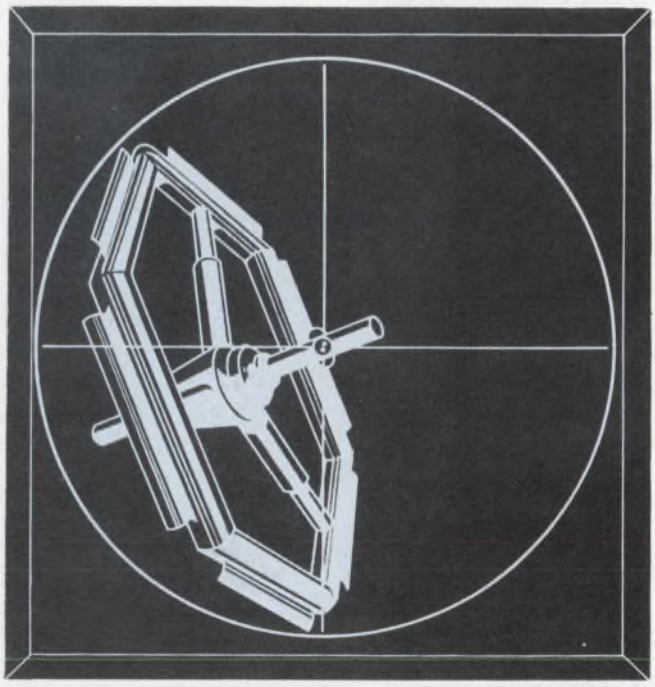
During limit cycling, the dashed line waves back and forth as the spacecraft reaches the attitude limits and the control jets pulse. If the flight requires a particular attitude, a light spot appears at the desired attitude. If manual control of attitude is required, the arrow gives the pilot an indication of the direction of required acceleration to accomplish the needed change. If automatic control is required, the fuel optimal-attitude control can be computed in advance and executed on command. The display then shows the predicted control path so that the pilot can monitor the maneuver.

Recreational and training displays included

The tedium inherent in long interplanetary flights is combated with a variety of recreation. The computer, for example, is able to store each crew member's favorite books, new books on his favorite subjects and his favorite games.

Machine-played games are of such sophisticated design that they can challenge each man at his level of ability and offer him a predetermined chance of winning. Automated bridge games for 1, 2, 3 or 4 players are available on the spaceship. The machine deals the cards and keeps track of play. For convenience, the dummy is read from a scope rather than using magnets or other contraptions to prevent the weightless cards from floating all over the cabin. The machine keeps score and fills in for any missing players. Similar arrangements enable the crew to play chess, checkers, poker, gin rummy and a number of other games.

Long space flights are also an opportunity for intensive study. A 1–2-year flight is ample time to prepare for a master's or doctor's degree. Futhermore, the complexity of the spacecraft means that the crew must constantly review procedures, schematics and instructional texts. Manual skills like spacecraft maneuvering, emer-



4. **Docking is carried out manually** by the astronauts. A high-resolution color TV picture of the target is displayed during docking.

gency operations, donning and doffing of pressure suits and extravehicular maintenance, have to be practiced periodically. The computer and display keep tabs on these practice sessions and make comparisons with past performance or norms.

Extravehicular work in shirt sleeves

For work outside of the spacecraft, the astronaut gets into a maneuvering unit like that shown in Fig. 6. The two wing-like structures on the unit permit a nearly complete range of natural arm motions.

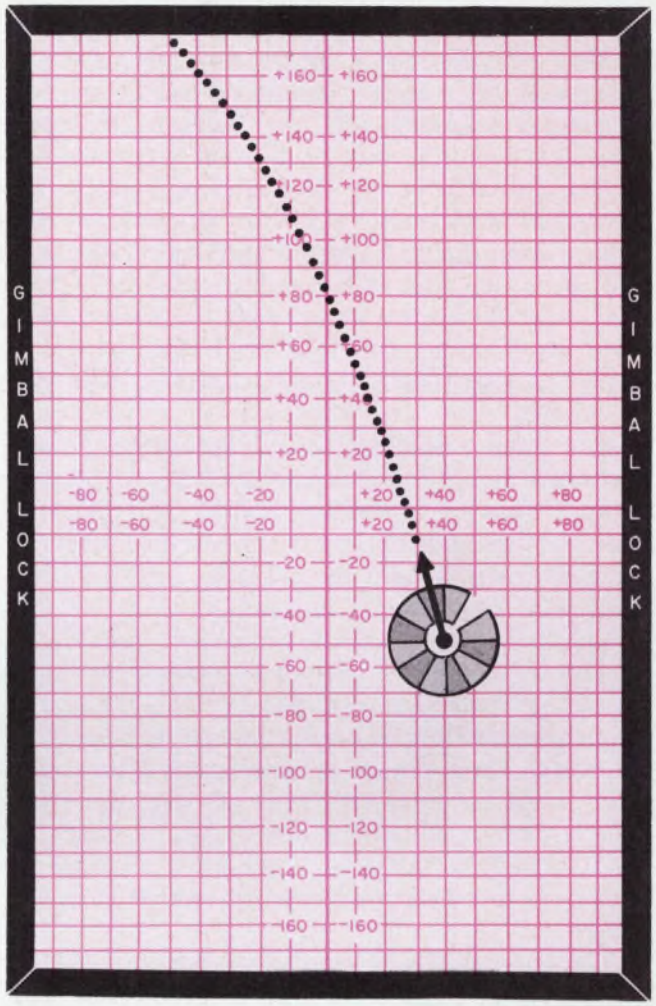
Inside the unit, the astronaut is in a shirt-sleeves environment. This is felt to be necessary for any significant amount of extravehicular work because the strength that he requires to flex a pressure suit represents a large fraction of the total force that he can deliver over an extended length of time.

A complex of bioforce sensors is attached to the astronaut's arms and hands. The forces generated by the manipulators are fed back against these force sensors to give him the sensation of feeling. He can vary the gain of each loop as he works, to minimize the work load or maximize his "feel." Since his hands are occupied by the force sensors, he controls his attitude and translational position by voice. The voice controller also is the means for changing the gains of the bioforce sensors. If, for example, the astronaut feels that the work requires extra grip forces from his right hand, he commands: "Right grip times two," and the voice controller doubles the gain of the right-grip bioforce sensors.

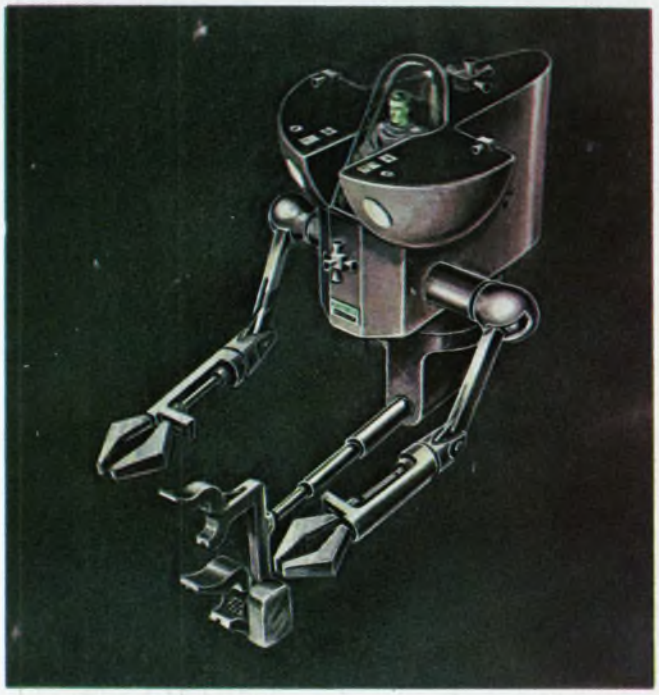
The structure located on the midline of the maneuvering unit is a device for keeping the unit in position at the work site. Past studies showed that it consumes too much fuel to use thrusters to counteract tool forces. The spacecraft, therefore, has exterior attachment points from which every point on the hull can be reached.

What will all this require?

Back to 1967 and contemporary reality. What is needed to make the foregoing prophecies come true? The display that was dreamed up uses more saturated colors than can be found in the gamut of today's three-color systems; a four- to six-color system would be necessary. If the display were a six-color oscilloscope, considerable improvement over today's capability would be required in alignment and deposition of phosphors. The panel might perhaps be a flat electroluminescent panel. If so, a fine-grained display structure, with addressible elements is required. The data rate to drive such a display far exceeds the present capacity of computer communication channels. Even if the display unit contained its own memory and



5. **All attitudes are shown at once** on the attitude display. The display uses a map of yaw and pitch projected on a plane instead of on a ball.



6. **Astronaut uses his voice** to control the attitude and translational position of the maneuvering unit. His hands are occupied by force sensors which give him the sensation of feel as he operates the manipulators.

communication, present-day computers could not load the memory fast enough.

The computer is in many respects merely an extension of today's computers, albeit with an enormous memory and an increase in speed. Perhaps the only way at present to visualize a display capable of meeting all the requirements described is to imagine several autonomous computers with shared memory. Maybe by 2000, there will be a self-organizing multiprocessor. Such a device would decide when more or fewer processors were needed "on line" and then switch instruction registers, arithmetic units, and so forth on or off.

The 2000 computer would necessitate a very elaborate signal-conditioning interface to perform all the tests of equipment status. The fact that many different functions would be performed at once indicates a need for a large, versatile interrupt and input/output system.

Finally, the spacecraft computer, like the attaché-case computer (see box), would be under "systems" control at all times. For this reason, the requirements for software would be extremely demanding. The software programs would be exceedingly large, with a multitude of very important but seldom used emergency loops. Perhaps by 2000, it will be possible to generate software directly from an English-language requirements document.

The astronaut's maneuvering unit would require sensitive, accurate and light bioforce sensors, which would have to be easy to doff and don. Investigations currently in progress into the reliable sensing of myoelectric potentials may lead to the required breakthrough.

The maneuvering unit is equipped with a voice controller. Studies at Honeywell have indicated that this is the best way to control such a unit's attitude and position, because the astronaut's hands would be occupied. Some devices already exist today that would serve as a voice controller if the vocabulary were small enough. Power requirements are high for some of these devices, though, and all need to have their size reduced and recognition-accuracy and versatility improved.

All these technical advances are relatively simple compared with the task of building the attaché case. This involves a display, telecommunications system, computer with interchangeable storage, and a line printer—all compressed into 0.75 cubic feet, weighing less than 25 pounds and self-powered. ■ ■

Acknowdgement:

In addition to the author, the group that took part in the above program included A. Macek, J. Miller and D. Stubbs. E. Bumula prepared the art work.

Electronics galore in attache' case

The space-traveling executive in 2000 has available a revolutionary attaché case (right), though because of its high cost it is used by few people. Its principal features are:

- Display.
- Telecommunications system.
- Computer.
- Microstorage files.
- Control keyboard and line printer.

The display is computer-derived, in color, and viewable in daylight. The display carries TV pictures derived from the case's telecommunications system, as well as the contents of the microstorage file. As the owner dictates notes to be entered into the file or typed out in letter format, the display shows the words spoken so far. Editing is accomplished with a light pen, by voice or through keyboard instructions.

The telecommunications system includes a telephone handset and dial for voice communication, a TV camera, an automatic "line-finder" which scans the eletromagnetic spectrum for an open channel and changes frequencies during transmission, a scrambler for message security, and a link to the computer to provide automatic transmission of large blocks of data. The TV camera can operate either cabled to the attaché case or through a microwave or laser link.

The computer employs a highly developed system program, for it is under system control at all times. There are no source or object programs from outside. Because the computer is primarily concerned with data handling, both it and its programs lean heavily toward list processors, high-speed search routines and editing programs.

The microstorage files are very high-density, random-access units that can easily be plugged in and unplugged.

The keyboard, light pen and handset microphone allow user and computer to communicate. The line printer is a high-speed photographic unit driven by the computer. ■ ■

Attache case is crammed with electronics to make the executive a true space-age traveler. Despite its conventional size, the case contains a color display, a telecommunications system, a computer with interchangeable storage units and a line printer. The user can communicate with the computer by means of the printer keyboard, a light pen, or a handset microphone.


erase
insert
tab
set
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CLEAR
7 8 9
4 5 6
1 2 3
0
W E R T Y U I O P
A S D F G H J K L
Z X C V B N M

Voyage to Jupiter, 21st-Century Style

Frederick I. Ordway, III, Scientific Consultant to the film "2001: A Space Odyssey."

Do creatures like man dwell elsewhere in the universe? Or for that matter, does any form of extraterrestrial intelligence exist? At present, of course, no one knows. Nevertheless, a forthcoming motion picture based on extrapolations of today's science and technology describes a manned voyage to the outer solar system to search for clues to the possibility of such life.

The Cinerama film, "2001: A Space Odyssey," is produced and directed by Stanley Kubrick. Technical authenticity has been sought through the cooperation and assistance of NASA, many universities, observatories and research institutes, as well as industrial organizations in the United States, the United Kingdom and France. As a result, many of the electronic systems evolved in concept for the film represent today's best thinking on the make-up of future space vehicles.

Six space vehicles introduced

During the development of the film six major space vehicles are introduced, the *Orion III* Earth-orbit transport, *Space Station V* in orbit around the Earth, the *Aries 1B* orbit-lunar shuttle, the translunar *Rocket Bus*, the huge *Discovery* interplanetary spaceship, and its small *space pod*, an auxiliary one-man reconnaissance, maintenance, and local exploration craft. Each of these vehicles was designed with extreme care, and in all cases full-scale interiors were constructed as well as exterior models. Attention was given to the design rationale and functioning of each component and assembly, down to the logical labeling of an individual button and the presentation of plausible operating and other data.

In *Space Station V*, for example, a visionphone, designed with the close cooperation of communications systems researchers at the Bell Telephone Laboratories in Murray Hill, N. J., is used for personal communication. By the year 2000, it is assumed that several large space stations will have been placed into orbit and are available to scientists and other specialists from all over the world. They arrive by shuttle carriers, check into their accommodations, and live more or less as one does in a hotel on Earth.

The visionphone contains informational and normal operational instructions. To check a number, one presses the information request button and then composes on the alphabetical panel the first two letters of the continent—for example, EU for Europe; next the name of the major political subdivision; then the city and town; and finally, the name of the individual or organization. Everything is displayed on an illuminated screen in front of the caller as it is requested, and is followed almost instantaneously, by the appropriate section of the local directory with the name sought indicated by yellow shading. Once the number is located, the information channel is deactivated.

When making the call itself, appropriate buttons can be depressed to select a vision or a nonvision connection. There is provision for both one-way and two-way vision. The person being called can override a request for two-way vision. When the screen indicates "ready to call," the number is composed on the touchtone panel. When the words "channel open" appear on the screen, conversation can start; at the end of conversation, a "channel closed" announcement together with the cost of the call—normally chargeable by credit card—appears.

The principal exposure of electronic equipment devised for the movie is aboard the *Discovery*. Most of the action takes place in the *command module*, where the actual piloting takes place. in the *centrifuge*, where crew members enjoy partial gravity and spend most of their time, and the *pod bay*, which houses the three small space pods.

All propulsion controls, designed with the assistance of GE's Valley Forge Space Technology Center, Honeywell, and the UK Atomic Energy Authority, are located in the command module. The nuclear reactor control panel displays information on such parameters as turbine, compressor, heat exchanger, secondary circulatory and radiator liquid-helium storage, magnetohydrodynamics and recuperator performance, and pressures and temperatures at various stations. For simplicity, all station indicators are calibrated by "hi," "operational," and "off" positions.

The engines, called *Cavradyne*, are based on assumed years of research and development during the 1980s of gaseous-core nuclear reactors and high-temperature ionized gases, or plasmas. Theory is presumed to have shown that gaseous uranium 235 could be made critical in a cavity reactor only several feet in diameter if the uranium atomic density were kept high, and if temperatures were maintained at a minimum of 20,000°F.

In the Cavradyne system, the temperature of the reactor is not directly limited by the capabilities of solid materials, since the central cavity is surrounded by a thick graphite wall that "moderates" the neutrons, reflecting most of them back into the cavity. Wall cooling is assured by circulating the hydrogen propellant prior to its being heated. Fissionable fuel energy is transferred to the propellant by radiation through a specially designed container. The container was one of the most difficult components to develop of the entire Cavradyne system. Among other things, it had to be transparent, rigid, and coolable, characteristics that were only solved after a long and costly research and development cycle.

This propulsion system makes possible a one-year trans-Jupiter trajectory, following a 40,000 foot-per-second launching velocity from Earth orbit. During transit time, the *Discovery* maintains nearly continuous communication with Earth, including voice contact at regular intervals with the mission control center. Account is always taken of the elapsed time for electromagnetic waves crossing space between spaceship and Earth (4.4 minutes at Mars' orbit, 35 minutes at Jupiter's orbit, for example).

Scientific information transmitted

In addition to routine vehicle and computer output data, special information can be transmitted from the *Discovery*, particularly that resulting from scientific experiments en route. These might include micrometeorite density as a function of distance from the Earth (especially in the asteroid belt); location and study of asteroids heretofore undiscovered; and, at the Jupiter target, probing of the planet and its moons. There is a complete on-board astronomical observatory, designed with the cooperation of the Royal Greenwich Observatory, England, as well as instruments aboard to determine the population density and distribution of bodies from dust size upwards, albedo and thermal flux detectors, and the like.

The astronomical observatory offers direct readout of declination and right ascension, azimuth rate increment, slewing rate, filter select, magnitude settings, scope selection, and gross and vernier setting controls. On command, displays

The Plot Thickens

In the film "2001—A Space Odyssey," the first proof of the existence of extraterrestrial intelligence comes about, not by the detection of electromagnetic or optical signals, but by the discovery on the Moon (shortly after the beginning of the 21st century) of an artefact purposely buried some 3 to 4 million years ago by an extrasolar expedition. During the course of routine astrogeological surface and subsurface surveying, a small area of high magnetism is discovered in Tycho, a prominent lunar southern-hemisphere crater the walls of which rise 12,000 feet above the floor. In due course, the crater is probed and excavated, uncovering the artefact which, on exposure to sunlight, releases an intense burst of radio energy, directionally beamed toward the planet Jupiter in the outer solar system. It then becomes, and remains, inert.

After careful investigation and analysis, the inescapable conclusion arises that the artefact is some sort of alarm system, placed on the Moon by an extrasolar expedition in expectation that when life evolves to a sufficient level on Earth, lunar flight inevitably must come about. Later survey crews would eventually discover, and unearth, the artefact—which is exactly what happens. As a result of the burst of energy, it is assumed that the extrasolar society is informed that Homo sapiens has reached a characteristic intellectual, technological and scientific threshold, and presumably is ready for an initial contact.

The principal body of the film involves a manned exploratory expedition into the outer solar system to attempt to uncover some clues that will lead to the contact. No civilization in the outer solar system is expected, but it is felt that somewhere in the vicinity of Jupiter the answer to the mystery of the lunar artefact may be found. And so the stage is set for the unfolding of the story. Release is planned for about Easter, 1967.

are given of such elements as the differential coordinates of a given satellite in, say, the Jovian system. If an individual asteroid or moon is to be probed, or a comet investigated by a small lander, the Schlumberger-designed geophysical console is called into use. Thus, it might be desirable, in a noninterference scientific investigation, to place a probe on a small asteroid to determine the nature of the subsurface and work out the microscopic structure.

The Schlumberger equipment aboard the *Discovery* permits a wide variety of surface and subsurface experimentation to take place. Since subsurface structure could be extremely important in the spaceship's investigatory program, a drill is incorporated into a surface lander. Controls on the console include a depth selector, drilling rate selector, equipment calibration, recording and error analysis controls, and various screen and gauge indications of subsurface characteristics, formation type, formation content, well horizontal cross section, caliper (symmetrical curve representing a vertical cross section of a hole being drilled), sonde "up" and sonde "down," "recording," etc. Diagnostic information is initially displayed as it is fed from the computer.

Life-support systems included

So far, no mention has been given of electronics as applied to *Discovery*'s life-support system and to medical monitoring of the astronauts' health. The Jupiter mission is so planned that of the five crew members aboard, two are conscious during the trip and three (needed only for scientific research at the end of the mission) are placed in hibernation in accordance with techniques worked out in consultation with medical authorities in the United States and the United Kingdom. Each of the hibernating astronauts is individually monitored with respect to numerous physiological functions.

The conscious astronauts undergo regular, automated check-ups in the medical section, with results displayed visually and recorded. Normally, diagnosis of deficiencies is given directly on a read-out screen, and medication or other treatment prescribed. This entire section is located in the centrifuge, close to the hibernaculums.

The final space vehicle aboard which electronics play a decisive role is the one-man space pod, housed in *Discovery*'s pod bay. Development took place with the support of Hawker-Siddeley Dynamics, Ltd., England, who assigned both structural-design and electronics specialists to the task. Some of the systems incorporated in to the space pod include:

- *Television:* Eight fixed cameras ensure all-round TV coverage. For such precise maneuvers as docking or selecting a landing site on a small world, the field of view can be narrowed and oriented.
- *Mechanical hand controls:* Each pod has two such controls, or manipulators, with appropriate tool selection.
- *"Flying" controls:* Manual controls are necessary both as stand-by and for local, intricate maneuvers. Two hand control sticks, each with two degrees of freedom and fitted with twist grips, provide the necessary control about six axes. Analog information is presented for attitude, heating rate and distance. These can be referred to local ground (for landing, take-off, etc.), course (which enables the pilot to face forward, head up, on any preselected course), or parent ship (for docking, local maneuvers, etc.). A variation in full-scale rate can be applied by the control sticks, allowing the full stick movement to result in any proportion of full vernier motor thrust, so giving a "fine" control for local maneuvers. The parent ship *Discovery* can override all local pod controls and take over in an emergency.
- *Main propulsion controls:* These are rather conventional. The "fire" control is normally computer-controlled. Most buttons serve as warning lights, glowing red when a given parameter exceeds preset limits.
- *Proximity detector:* A directional safety system is incorporated, working from the main communication antennas, which gives an audible warning when the pod approaches a solid object. It also detects the approach of a solid object, the speed of which is too high to be counteracted by the vernier thrust settings on the control system. In this event, full reverse thrust is applied, overriding the manual control setting. The system depends on frequency-modulated transmission, and under safe conditions results in a low, soft background signal considered necessary in order to provide a continuous check on this important safety system. If the speed of approach to an object becomes dangerous compared with the distance from it, the tone would become louder and higher pitched and, if unchecked, would end in a shrill noise accompanied by automatic reverse thrust.

Other pod elements include a computer connected to the main HAL 9000 computer aboard *Discovery*; magnetic "locator" devices to affix the pod to the hull of the parent ship during maintenance; searchlights; power systems; environmental controls, and communications. Maneuvering propulsion is ensured by a solid propellant which sublimes at a constant pressure; such a system appears reliable, has no mechanical valves, and lasts for long periods of time. Main propulsion employs storable liquids, used only on landing and taking off from an asteroid or small moon, or for emergencies when full thrust is needed quickly. ■ ■

(Report continued on p. 102)

Family portrait

20 options make the new NLS X-1 a family of DVMs in one compact package. Choose the exact instrument you need today . . . change it to meet your needs tomorrow.

Now in 4- & 5-digit models.

Turn the page for details.

Meet all your needs with the versatile NLS X-1

For years you've been using the "closest" solution to your measuring needs. Now you can get the *exact* instrument you require. Both the 4-digit and 5-digit versions offer a variety of accessories to give you maximum flexibility in matching the X-1 to your specific application . . . no matter what it may be.

Eliminate first reading error

You can forget about "first reading error" with the fast X-1. Digitizing time is just 6 ms, and settling time with polarity change is about 20 ms. You see the reading instantaneously and correctly – the first time it appears. This makes the NLS X-1 the perfect instrument for systems.

Performance packaging

The X-1 is packaged to improve performance, simplify maintenance and extend its useful life. Top-loading double drawers contain the analog to digital converter and input accessory modules. The power supply module is easily accessible at the rear of the instrument.

Easy access to plug-in boards and the use of repetitive boards and parts throughout the instrument minimizes the need for spare components and makes rarely required maintenance simple and economical.

Design your own DVM

Accessory modules are readily adaptable to a wide variety of function combinations. Choose any of these accessories for *your* X-1:

AC-DC converter: Low cost 50 Hz to 10K Hz; High frequency 50 Hz to 100K Hz; AC reference units for AC ratio measurements

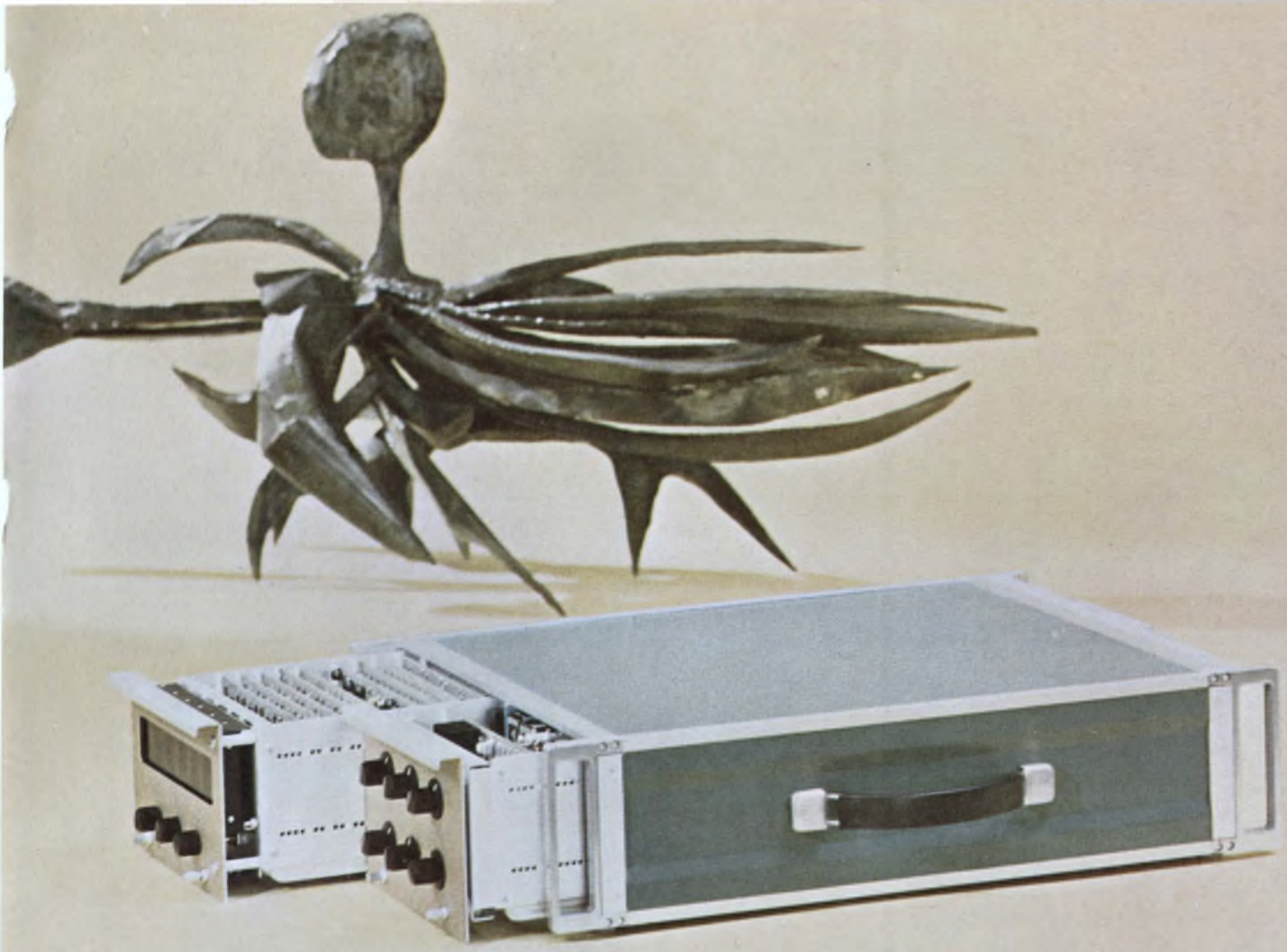
Ohms converter: Five-digit ranges from 1.19999 to 11999.9 K; Four-digit ranges from 1.1999 to 11999 K

Preamp: Five-digit ranges from 119.999 to 1199.99 millivolts full scale; Four-digit ranges from 119.99 to 1199.9 millivolts full scale

Ratio: Plug-in cards for +/+ and −/+ ratios; −/− and +/− ratios available without additional plug-in cards

More to come

Special accessories to be added to the X-1 line will further increase its versatility. Adding functions merely requires insertion of additional or substitute circuit boards.



Check these features

The many special features of the X-1 are based on NLS's more than a decade of experience in DVM development and manufacturing (starting with the world's first DVM in 1952). Also taken into account were surveys of the preferences of engineers, purchasing agents and service specialists. In the X-1 you'll find:

Circuitry: All solid state for reliability

Common mode rejection: 120 db unfiltered at 60 Hz

A/D conversion: All electronic successive approximation scan logic

Resolution: One digit

Methods of control: Range selection–automatic, manual and remote; Polarity selection – automatic, manual and remote; Start command – internal, external and manual; Function selection (multi-function models) – manual and remote; Filter selection (multi-function models) – manual and remote.

Response times: Input buffer response time – 10ms; Digitizing time – 6ms; Time required for relays to operate – 7ms; Time to select fixed range remotely (operating time of range transfer relay plus operating time of range selection relay) – 10ms; Time required for each automatic range change – 30ms; Time required for each automatic polarity change – 30ms

Input resistance: 10v range – 10,000 megohms; 100v and 1000v ranges – 10 megohms (input resistance is constant except when input is overloaded)

Input connections: DVM with DC Function – Inputs consist of sense hi, sense lo and guard; DVM with DC & Ratio Function – Inputs consist of sense hi, sense lo, guard and ref. in; DVM with Multi-Functions – Inputs consist of sense hi, sense lo and guard for DC volts, MV and AC volts; Inputs consist of sense hi, sense lo, guard and ref. in for ratio; Inputs consist of sense hi, sense lo, guard, current (+) and current (–) for ohms

Floating input: Because input signal leads are not connected to the outer chassis of the X-1, signal-to-chassis potentials up to 500 volts are tolerable. Floating input adds to the instrument's versatility by permitting it to measure voltage sources which could not be accurately measured by a non-isolated meter.

Output connection options: Output data–BCD contact closures for isolated output, BCD voltage level if isolation not required; Digital output command – contact closure for isolation, voltage level if isolation not required

Power requirements: 115/230VAC, 50-60CPS

Readout: NLS high intensity system

Packaging: Rugged, compact case with handles for portable use, and optional rack-mounting hardware

Weight: Approximately 50 lbs

See next page for details

Let's get specific

Basic instruments

ITEM	PRICE	DESCRIPTION
5-Digit Voltmeter	$1485	Single range 0-11.9999V, positive polarity; Not expandable with ranges or functions; Accuracy: ±(0.005% reading +0.001% full scale)*
5-Digit Voltmeter	2450	Auto ranging 0-11.9999V, 0-119.999V & 0-1000.00 VDC; Auto polarity; Expandable with functions; Accuracy: ±(0.005% reading +0.001% full scale)*
4-Digit Voltmeter	1650	Auto ranging 0-11.999, 0-119.99 and 0-1000.0 VDC; Auto polarity; Expandable with functions; Accuracy: ±(0.01% reading +0.01% full scale)*

Accessories

NOTE: Ranges shown are those for the 5-digit DVM. For the 4-digit model delete the least significant digit.

ITEM	PRICE	DESCRIPTION
AC Converter	$650	50Hz to 10KHz; Ranges 1.19999, 11.9999, 119.999, 500.00 VAC; Accuracy: ±(0.1% reading +0.05% full scale)*
AC Converter	950	50Hz to 100KHz; Ranges 1.19999, 11.9999, 119.999, 500.00 VAC; Accuracy: ±(0.1% reading +0.05% full scale) — 50Hz to 10KHz*, ±(0.3% reading +0.10% full scale) — 10KHz to 30KHz*, ±(0.5% reading +0.10% full scale) — 30KHz to 100KHz* (150 VAC maximum input)
Ohms Converter	600	Ranges: 1.19999, 11.9999, 119.999, 1199.99, 11999.9 KΩ; Accuracy: ±(0.01% reading +0.001% full scale) lowest 3 ranges*, ±(0.03% reading +0.001% full scale) on 1199.99 KΩ range,* ±(0.01% reading +0.001% full scale) on 11999.9 KΩ range*
Pre Amp	500	Ranges: 119.999, 1199.99 MVDC; Accuracy: ±(0.01% reading +0.01% full scale); Chopper stabilized, solid state
Ratio	150	Ranges: 1.19999:1, 11.9999:1, 99.999:1, −10.0V ±5.0% reference only
Function Switching Assembly	150	Required when AC, ohms or pre-amplifier accessory is added to an expandable instrument
Active Filter	200	Specify: High speed — 36.5 DB at 60 Hz, 170 MS settling time to 0.01%; Low speed — 76 DB at 60 Hz, 750 MS settling time to 0.01%
Remote Trigger and Printout	550	BCD 1-2-4-8 contact closures — range, function, polarity, filter, data and print
Remote Trigger and Printout	350	BCD 1-2-4-8 voltage level; logic 1 = OV, O = −13V; range, function, polarity, filter, data and print
Remote Readout	350	No readout in meter — includes wired 10-foot cable and connector with provisions on voltmeter. Not available with remote trigger and printout option
Front Panel Power Switch	50	

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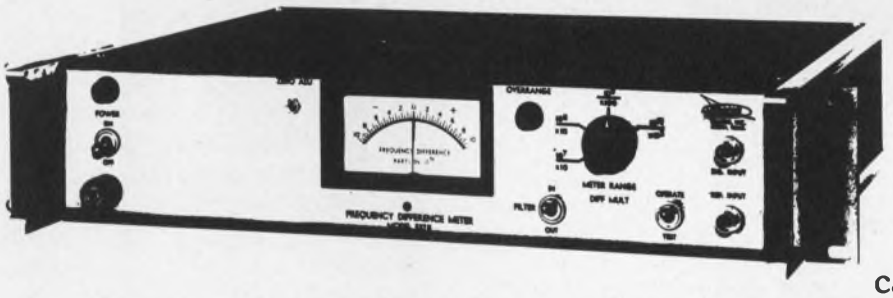
Do you have to "ride herd" on drifting oscillators?

. . . and need to check frequency periodically, monitor regularly, or adjust to a standard?

Then the TRACOR direct-reading Model 527B Frequency Difference Meter is just what you need. It determines instantly — with an accuracy of 10^{-10} — the fractional frequency difference between two stable oscillators.

It includes most of the features of its "big brother", the 527A, but costs much less. You read directly on a zero-center front-panel meter fractional frequency difference in parts per 10^{7}, 10^{8}, 10^{9} or 10^{10}. The meter movement continuously follows your oscillator adjustment — provides instantaneous reading of oscillator correction.

You may change the input frequencies without switching .....frequencies of the two input signals need not be the same. The 527B accepts inputs of 100 kHz, 1.0 MHz, 2.5 MHz and 5.0 MHz; it is ideally suited for rating crystal oscillators. The 527B, when used with your counter, will allow you to measure differences of parts in 10^{12}.



The Model 527B sells for $2,250. For more information on this advanced-technology product, please write or call: TRACOR, INC., 6500 Tracor Lane, Austin, Texas 78721 AC 512 926-2800.

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The Wild, Mighty Oceans—Tamed at Last

The role of electronics in oceanography is expanding at a rapid pace, as electronics itself evolves and becomes more sophisticated, and as international interest in the riches of the oceans and how to exploit them grows.* The continuation of this expansion is likely to have had a profound influence on man and the world about him by the 21st century.

If we consider the tremendous advances that have been made over the past three decades or so, and assume that comparable progress and change will take place during the rest of this century, the outlook for the year 2000 is both encouraging and exciting. Imagine yourself, then, living in the world of 2000, and see what the alliance of electronics and oceanography has wrought.

An ever-growing network of satellites and cables has crisscrossed the oceans for years. Nowadays, stable, midocean, moored stations also provide line-of-sight relay microwave communications wherever practical.

Navigation and communication aids abound

Ships and aircraft orient themselves as a matter of routine by means of signals transmitted from multiple navigational satellites and anchored buoys. These methods make it possible to navigate anywhere in the world two orders of magnitude more accurately than was possible in 1967. Acoustic markers and transmitters on the ocean floor are commonplace; they, too, are used for navigation and station-keeping, particularly by submersibles. A number of oceanographic vessels operate largely below the surface and many research ships carry small submarine work boats that are employed in conjunction with their surface work boats.

Good navigation for submersibles engaged in scientific and survey work has in fact become relatively foolproof. In addition to fixed bottom beacons, they regularly use Doppler and inertial dead-reckoning systems. Similar equipment is also installed on their accompanying surface craft. Special computers supply convenient read-outs, data points and vehicle control inputs.

Advanced sonar equipment enables shipboard passengers to watch a TV-like image of the ocean beneath them much as aircraft travelers can gaze at the ground. Many liner routes pass by ocean research stations, moored or drifting, manned or unmanned, which are scattered throughout the world's seas. They are used for a wide variety of observations, some of immediate application, others aimed at a long-term understanding of the properties of the oceans.

Below the surface, great improvements have been made in viewing techniques. A combination of multibeam or acoustic-imaging systems now gives submariners high-quality TV-type pictures of their immediate environment, even in turbid waters. These presentations, however, are degraded at longer ranges or when only simpler types of equipment are in use. Long-range medium-resolution scanning sonar is widely used to explore and map vast areas of ocean floor, to observe marine life in the deeps, and to locate sites for intensive scientific or engineering investigations.

The many underwater sound systems employed have justified the development and use of elaborate electronic signal processors. As a result of the difficulties in multipath sound transmission at long ranges or over rough bottom, and because of the frequent need to operate in narrow band-

*See "Electronics and the Sea". ELECTRONIC DESIGN, XIV, No. 29 (Dec. 20, 1966), pp. 34-52.

widths, extensive use is made of real-time electronic correlators, bandwidth-compression and other advanced signal-recovery techniques. Transmission is kept highly directional to maintain privacy and eliminate cross-talk. Since the sonic spectrum under the sea is much narrower than that for surface radio communication, specific frequencies have been allocated for work, navigation, distress and other uses.

Weather is predicted and controlled

A world weather watch, and a start on a world fish watch, have been under way for a number of years. Advances in geophysical knowledge and observational capabilities have made it possible to forecast the weather for huge areas of the world at once and further ahead than was formerly the case. Small-scale weather control under favorable circumstances has become practical in the wake of tests that, for political reasons, were performed at sea.

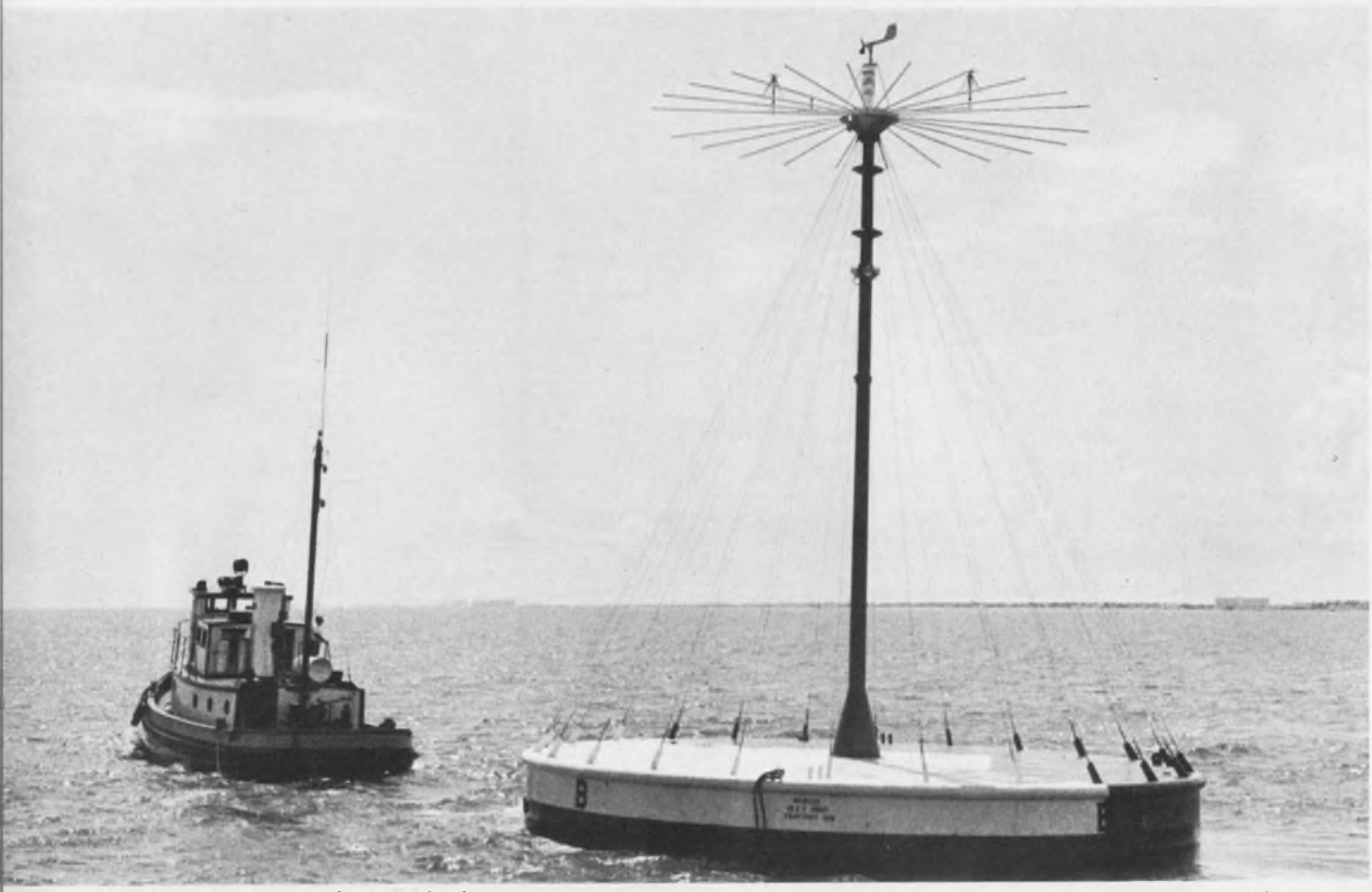
Serious evaluation studies are being made of the possibility of inducing large-scale climatic changes by such means as controlling the flow of the currents through the Bering Strait or by large-scale pumping of warm or cold water in an effort to modify local weather. Every such step toward this sort of environmental control, however, involves setting up international systems for the collection, transmission, reduction and analysis of data. Immense computer studies have to precede implementation of these undertakings because their effects will affect the interests of many nations.

Oceans' resources are exploited

Foods derived from the seas are supplying much more of the world's protein requirements than in 1967. Electronic devices of steadily increasing sophistication are being tested and used for detecting, tracking, branding, catching, sorting and preserving fish. Young fish and turtles and similar small organisms are raised in the equivalent of greenhouses or in biochemical factories and pastured at sea. Shellfish farms are commonplace on coastlines. Farther out, fish are herded about the open ocean. Pasture areas surrounded with electronic, sonic or similar fences have been set up to confine valuable species or exclude predators without affecting the natural sources of food for the fish.

A worldwide search for maritime minerals and chemicals has been launched. Equipment largely electronic in nature is used to further the explora-

Advances in electronic control and communications equipment will make today's cumbersome diving techniques obsolete.



U.S. Navy's monster buoy is the forerunner of tomorrow's unattended buoys that will automatically measure and transmit data on the ocean's properties. Contractor for the monster buoy is the Convair Div. of General Dynamics.

tion for undersea oil and gas deposits. Electronics also has its part to play in the desalinization of sea water,, which with the increasing availability of inexpensive power from fusion reactors is becoming a valuable source of fresh water for a multitude of purposes.

Many of these activities involve the use of specialized surface and subsurface vehicles as well as underwater complexes of workshops, laboratories, power houses, dormitories and recreational areas for submarine workers.

Structures erected under the oceans are made of materials selected for their pressure and corrosion resistance. Advantage is taken of the buoyancy of structural parts to reduce the effective weight of building materials and permit the construction of very much larger building complexes than are practical on land. A parallel can be drawn with nature where it is the buoyancy of whales and similar marine creatures that has enabled them to evolve so much larger than land animals. In 1967 most ocean structures were only partially resistant to corrosion and biological fouling, and many moorings and light structures were susceptible to direct attack by sea creatures. Electrical and electronic techniques are now extensively used to reduce these problems.

Specialized electronic equipment controls and positions divers and equipment during the erection of underwater structures and makes possible the necessary signaling, communication and life-support systems.

But chemistry and electrochemistry are the two most promising areas of ocean engineering. For millions of years residue from the land masses has been dissolved and lost to man in the oceans. Now the combination of cheap nuclear power and advanced electrochemistry is beginning to allow commercial retrieval of a wide assortment of materials and chemicals from the sea, even though they are in extremely weak solution.

Electrical power is of vital importance

Power for the myriad of equipment in the oceans is drawn from batteries, horizontal and vertical power transmission lines from the shore or from special surface craft, nuclear reactors or fuel cells. Research into means of powering electric automobiles has furnished many of the batteries for small submersibles and numerous instruments. The steady reduction in the costs of nuclear reactors has made them attractive power sources, but for unmanned devices, open to theft or accidental loss,

Oceanographic research ships serve as test beds for an ever-increasing variety of electronic equipment that will ultimately have the capability of the types described. Shown here is the research ship R/V Anton Bruun.

nuclear-powered equipment poses serious safety and political risks.

One of the more daring ideas for generating power from the sea that is under investigation is to separate the Red Sea from the Indian Ocean by an immense hydroelectric dam and thereby create a giant evaporating basin.

The world's power requirements, however, are already being met in a small way by harnessing a fraction of the energy of the tides and currents, and also by utilizing the heat flow between ocean strata of differing temperatures. In low latitudes, the upper layers of the sea have a year-round temperature gradient with a vertical difference of 10°C in a few hundred meters. A heat engine has been developed to take advantage of this gradient. It contains a suitable working fluid which is vaporized by the heat source, and then releases energy to a low-pressure vapor engine before it is condensed at a heat sink placed at a greater depth. The temperature gradient across the world's winter ice pack is many times greater than that of the ocean strata and offers similar possibilities for power generation.

The world's oceans, lakes and waterways afford important and extensive recreational facilities. Family pleasure craft rely more and more on electronic aids for navigation, communication, fish finding and entertainment. Amateur scuba diving is a growing sport that depends increasingly on electronic support for communication, safety and navigation. Shallow-water submersibles carry diving enthusiasts to and from their diving sites. Sightseeing submersibles take tourists on trips to undersea attractions.

Electronic advances will pave the way

The foregoing predictions assume that electronics will progress significantly in concept, versatility and reliability over the next generation. Microelectronics will answer size problems. Pressure problems will largely be overcome by flooded pressure-compensated electronic units and lightweight standardized pressure cases for miniaturized components. Small digital and analog computers will be developed to present sensor information in immediately usable form.

Finally, development and general use of such devices as communications satellites, electric automobiles, extremely stable amplifiers and flat-screen television will contribute to the development of the equipment that will be needed in the exploitation of the oceans. ■ ■

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ON READER-SERVICE CARD CIRCLE 52

Resistance-to-frequency conversion

can be made directly by modification of a Colpitts oscillator. A simple analysis is developed.

A single transistor circuit in a modified Colpitts oscillator configuration can be used to convert resistance changes directly into frequency variations.

In many applications (thermistor temperature sensors, photocell light intensity monitoring, strain gauges, etc.) sensors capable of changing their resistance in response to the physical variable in question are used. The output of such sensors is usually AM; that is, resistance changes cause variations of the applied voltage. To reduce the influence of the transmitting channel, it is in many cases more convenient to transmit such changes to a central processor in terms of frequency rather than voltage amplitude. For this, intermediate voltage-to-frequency converters (voltage controlled oscillators—VCOs) are required.

The techniques described in this article can be used to design oscillators that are resistance-sensitive and thus eliminate the need for VCOs.

The basic oscillator circuit is analyzed by a powerful technique that avoids complicated loop equations. This approach also gives insight into the parameters that determine oscillation frequency. An expression for frequency vs resistance is developed, and experimental data are compared with the theoretical results.

Active and passive components are separate

For the purposes of the analysis, the circuit of Fig. 1a may be considered to consist of two parts —active (transistor) and passive (all other components). Thus an equivalent circuit (Fig. 1b) can be used for the analysis. The following equations may then be written:

$$v_1 = h_{11}\, i_1 + h_{12}\, v_2, \tag{1}$$

$$i_2 = h_{21}\, i_1 + h_{22}\, v_2. \tag{2}$$

These equations completely characterize the transistor. A set of hybrid parameter equations for the associated passive network can also be written. These will be characterized by a set of H parameters and must include the fact that the sense of some of the variables relative to the transistor network has been reversed. Thus:

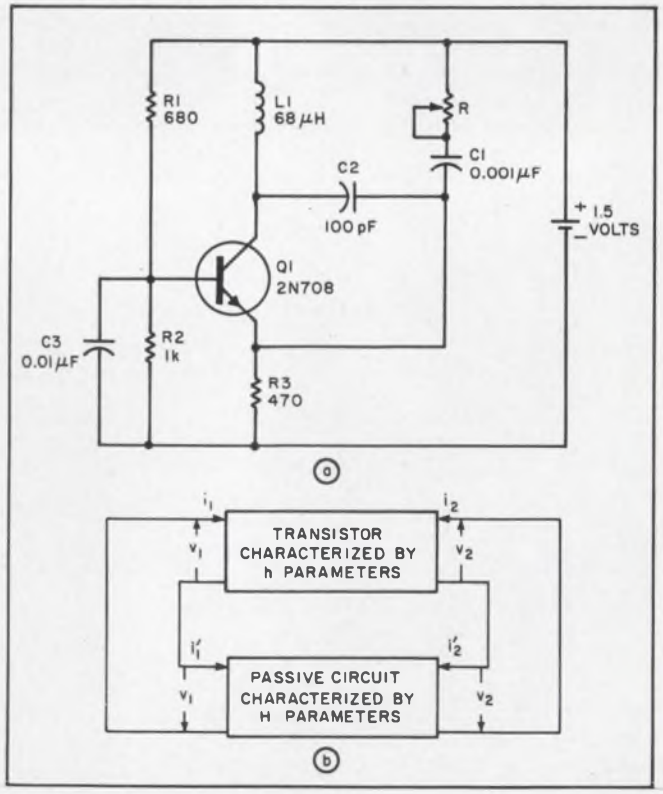
$$(-v_1) = H_{11}\, i_1' + H_{12}(-v_2) \tag{3}$$

$$i_2' = H_{21}\, i_1' + H_{22}(-v_2) \tag{4}$$

Since $i_1' = i_1$ and $i_2' = i_2$, Eqs. 3 and 4 may be substituted into Eqs. 1 and 2, with like terms equated. In treating each portion of the complete network, it is not necessary to consider the interaction between the passive and active networks; that is, each set of hybrid parameters may be treated independently. Substituting gives:

$$-H_{11}\, i_1 + H_{12}\, v_2 = h_{11}\, i_1 + h_{12}\, v_2, \tag{5}$$

$$H_{21}\, i_1 - H_{22}\, v_2 = h_{21}\, i_1 + h_{22}\, v_2. \tag{6}$$



1. **Variable frequency oscillator** uses only one transistor (a). Note that if R = 0 the circuit becomes a standard Colpitts oscillator. The mathematical model of the circuit using hybrid parameters is shown in (b).

Gordon Silverman, Electronic Engineer, Rockefeller University, New York.

Collecting terms in Eqs. 5 and 6 yields:

$$(h_{11} + H_{11})i_1 + (h_{12} - H_{12})v_2 = 0, \quad (7)$$

$$(h_{21} - H_{21})i_1 + (h_{22} + H_{22})v_2 = 0. \quad (8)$$

In an oscillator, the current i_1 and voltage v_2 must have non-zero values, for there must be some voltage or current present in the circuit if oscillation is maintained. In Eqs. 7 and 8, i_1 and v_2 could both be zero (the trivial solution), but this cannot be the case if there is oscillation present. Eqs. 7 and 8 must therefore be a set of dependent equations. This latter condition allows both i_1 and v_2 to be non-zero and at the same time provides an appropriate solution to both equations. The dependence condition produces the following relation among the constants:

$$\begin{vmatrix} (h_{11}+H_{11}) & (h_{12}-H_{12}) \\ (h_{21}-H_{21}) & (h_{22}+H_{22}) \end{vmatrix} = 0.$$

This becomes:

$$(h_{11}+H_{11})(h_{22}+H_{22}) - (h_{21}-H_{21})(h_{12}-H_{12}) = 0 \quad (9)$$

In Eq. 9 the real and the imaginary parts can be set equal to zero separately. Letting the imaginary part equal zero yields the frequency at which oscillation takes place, and equating the real part with zero yields the gain requirements for the circuit. Only the imaginary part of Eq. 9 will be dealt with since the circuit gain is usually set well above the minimum requirement and is thus of lesser consequence.

Table I shows the derivation of the H parameters for the frequency selective network of Fig. 1a. This network consists of L_1, R, C_1, and C_2. The table includes the parameter definitions, equivalent circuits obtained when these definitions are applied, exact evaluations and the final parameter values with the approximations that $X_2 > X_1$ (in order not to disturb the tank circuit) and $X_2 > R$ (which should be satisfied over a range of operation so that X_2 provides the proper phase shift of the tank current).

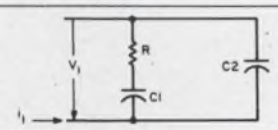
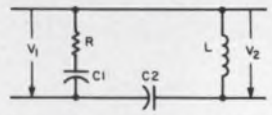
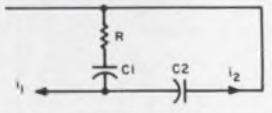
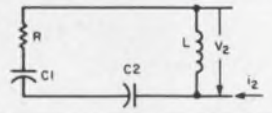
For example, H_{11} is the ratio of v_1 and i_1 when the output is shorted. The remaining circuit (as viewed from the v_1 side) then consists of the parallel combination of C_2, and of R in series with C_1. The ratio is thus the input impedance of the resultant circuit. When the approximations are applied, the final value of H_{11} is $R - jX_1$. The remainder of the table follows in a similar manner.

To proceed now with the analysis: these hybrid parameter values are substituted into Eq. 9:

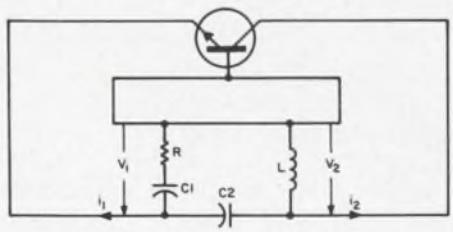
$$(h_{11} + R - jX_1)\left[h_{22} + j\left(\frac{1}{X_2} - \frac{1}{X_L}\right)\right] - \left(h_{21} + \frac{X_1}{X_2} + j\frac{R}{X_2}\right)\left(h_{12} - \frac{X_1}{X_2} - j\frac{R}{X_2}\right) = 0.$$

Since it is the frequency of oscillation that is of interest, only imaginary terms of this equation

Parameters for frequency-selective network

Parameter	Equivalent Circuit	Evaluation	Approximation	Final Parameter Value
$H_{11} = \left.\frac{-v_1}{i_1}\right\|_{v_2 = 0}$		$= \frac{-jX_2(R-jX_1)}{R-jX_1-jX_2}$	$X_2 > X_1$ $X_2 > R$	$= R-jX_1$
$H_{12} = \left.\frac{v_1}{v_2}\right\|_{i_1 = 0}$		$= \frac{R-jX_1}{R-jX_1-jX_2}$	$X_2 > X_1$ $X_2 > R$	$= \frac{X_1}{X_2} + j\frac{R}{X_2}$
$H_{21} = \left.\frac{i_2}{i_1}\right\|_{v_2 = 0}$		$= -\frac{R-jX_1}{R-jX_1-jX_2}$	$X_2 > X_1$ $X_2 > R$	$= -\left(\frac{X_1}{X_2} + j\frac{R}{X_2}\right)$
$H_{22} = \left.\frac{i_2}{-v_2}\right\|_{i_1 = 0}$		$= \frac{1}{jX_L} + \frac{1}{R-jX_1-jX_2}$	$X_2 > X_1$ $X_2 > R$	$= j\left(\frac{1}{X_2} - \frac{1}{X_L}\right)$

Definition of parameters used in the analysis is demonstrated by the equivalent circuits (column 2) for various conditions (column 1). Analysis of each equivalent circuit using standard network theory results in the expressions of column 3. Simplifying the assumptions of column 4 results in the final parameter values in terms of the circuit components (column 5).



$\frac{1}{\omega C_1} = X_1$

$\frac{1}{\omega C_2} = X_2$

$\omega L = X_L$

are collected. Multiplying out the factors and collecting the j terms:

$$(h_{11} + R)\left(\frac{1}{X_2} - \frac{1}{X_2}\right) - X_1 h_{22} - \left[-\left(h_{21} + \frac{X_1}{X_2}\right)\frac{R}{X_2} + \frac{R}{X_2}\left(h_{12} - \frac{X_1}{X_2}\right)\right] = 0.$$

Making the substitutions $X_1 = 1/\omega C_1$, $X_2 = 1/\omega C_2$, and $X_L = \omega L$ leads to:

$$\omega C_2 (h_{11} + R) - \frac{1}{\omega L}(h_{11} + R) - \frac{h_{22}}{\omega C_1} + \left(h_{21} + \frac{C_2}{C_1}\right)\omega C_2 R - \omega C_2 R\left(h_{12} - \frac{C_2}{C_1}\right) = 0$$

or

$$\omega^2 C_2 (h_{11} + R) - \frac{h_{11} + R}{L} - \frac{h_{22}}{C_1} + \omega^2 h_{21} C_2 R + \frac{\omega^2 C_2^2 R}{C_1} - \omega^2 C_2 R h_{12} + \frac{\omega^2 C_2^2 R}{C_1} = 0.$$

The final expression thus becomes:

$$\omega^2 = \left(\frac{h_{11} + R}{L} + \frac{h_{22}}{C_1}\right)\left[\frac{1}{C_2(h_{11} + R) + h_{21} C_2 R - h_{12} C_2 R + (2C_2^2 R/C_1)}\right]. \quad (10)$$

The frequency of oscillation as a function of R predicted by this equation can be compared with the experimental results. This is done by substituting the values for C_1, C_2, and L of Fig. 1a and by using the following values for the transistor (common-base configuration):

$$h_{11} = 150,$$
$$h_{22} = 0.6\times10^{-6},$$
$$h_{21} = -0.978,$$
$$h_{12} = 5\times10^{-4}.$$

When these substitutions are made and it is noted that:

$$h_{22}/C_1 << (h_{11}+R)/L,$$

and

$$h_{12} C_2 R << 10^{-12},$$

the following is obtained:

$$\omega^2 = (R+150)/68[10^{18}/(15{,}000+22.2R)]. \quad (11)$$

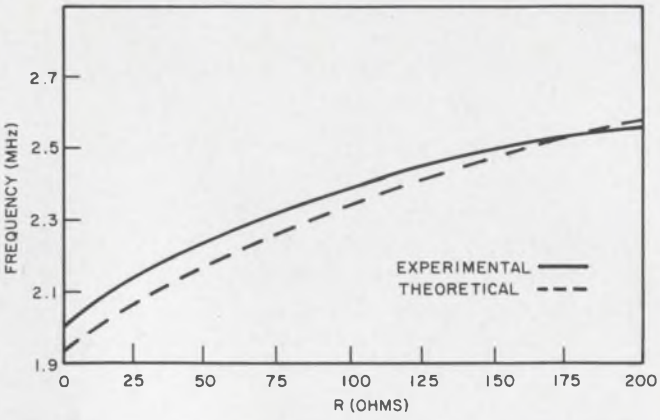
The plot of the above equation appears as the theoretical curve in Fig. 2.

Theory compared with experiment

Equation 10 gives the frequency of oscillation (actually ω^2) of the modified Colpitts in terms of the circuit parameters. Notice that when $R = 0$ it reduces to:

$$\omega^2 = (h_{11}/L + h_{22}/C_1)1/C_2 h_{11} = (1/LC_2) + (h_{22}/h_{11} C_1 C_2),$$

which agrees with the ordinary Colpitts analysis.



2. **A plot of frequency vs resistance** shows good agreement between theoretical and experimental curves. Note that for higher values of R the error will increase.

For most applications, the following approximations are valid in Eq. 10: $h_{22}/C_1 << (h_{11}+R)/L$ and $h_{12} C_2 R$ is much smaller than the terms from which it is subtracted. Consequently, h_{22}/C_1 and $h_{12} C_2 R$ may be neglected. This is true because the frequency of oscillation is approximately the frequency to which the tank is tuned. The most critical parameter of Eq. 10 is h_{11}.

For the grounded-base configuration the input impedance is a function of the operating point ($h_{ib} \simeq K/I_e$ where I_e is the emitter current). Thus, the circuit should be designed for a high degree of emitter current stability. In this instance this was made more difficult by the fact that the circuit was designed to operate at a low current level to conserve power. This produced a relatively high input impedance and a resultant high rate of change of input impedance with emitter current. The rate of change of input impedance is given by $dh_{11}/dI_e = k/I_e^2$; for small I_e this is a large number. The input impedance is the impedance of the base-emitter junction, which is essentially the impedance of a forward-biased diode. Using the ideal-diode equation and differentiating i with respect to v shows that the impedance can be represented by $26/I_e$, where I_e is the emitter current in milliamperes. In the present case this would be about 26 ohms.

For silicon transistors such as the one used in the circuit of Fig. 1a, however, the problem is more complicated. Silicon devices do not conform to the ideal-diode equation. In addition, the "ohmic" resistances of material far removed from the junction, which is governed by the ideal-diode equation, cannot be neglected. It is common for silicon devices to have input impedances of about 75 ohms for 1 milliampere of emitter current. Since the aim was to conserve power, operation

was at an emitter current of about 0.5 milliampere. Input impedance is inversely proportional to the emitter current, so that for this case it was some 150 ohms.

For higher tank circuit resistances, the error becomes excessive (as can be seen by extending the curve of Fig. 2), culminating in an error of 11% at 1500 ohms. This happens at frequencies high above the tank's resonant point because of an approximation used in deriving the expression for frequency of oscillation. The assumption was that X_2 is less than R. But at 3 MHz, for example, X_2 is less than R, so that the assumption is invalid. At 2 MHz, by contrast, X_2 is at least 40 times as great as R, which meets the assumption quite well.

The circuit discussed above was designed for a biomedical application where the resistance was a thermistor sensing the temperature of small animals. Simplicity, small size, and low power consumption were the major requirements of the circuit.

There are several other uses that can be made of the device. The resistor can be a photocell and the frequency variations will then be proportional to the incident light intensity. Since the resistance cannot be very large, the photocell may be "biased" by a steady light source to keep it at some desired level.

Another application may be in a low-impedance microphone where the circuit can provide short-range voice communication. For this purpose the power output would have to be increased by augmenting the supply voltage and changing the biasing arrangement so that the oscillator would operate at a high power level. It would still, however, retain its small size, which is one of the attractive features of this simple circuit.

Still other applications would be in strain gauges, resistive pressure sensors, or, in general, any place where it is desirable for a frequency-modulated output to be obtained from a resistively variable sensor.

An important aspect of the described technique is the simplicity of the analysis. Thus, the standard passive network analysis was used in spite of the presence of an active element (transistor). This approach, as was demonstrated in the accompanying curves, resulted in a very accurate circuit performance description. Simplifications on the basis of valid assumption led to a straightforward expression for the output frequency as a function of the tank resistor. Obviously, this technique may be used in many similar situations. ■ ■

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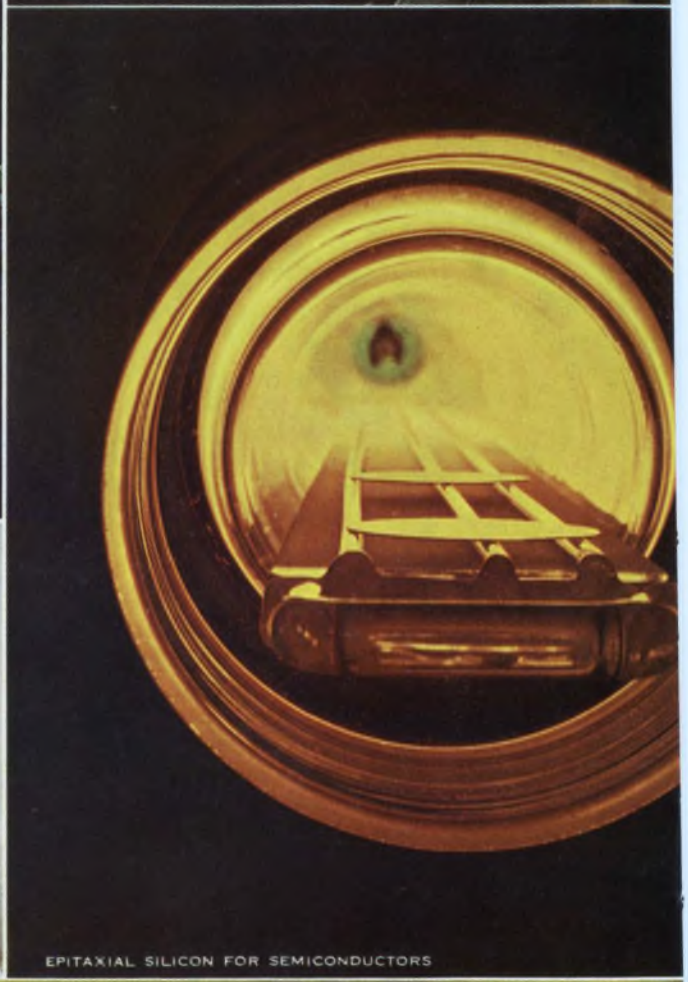

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ON READER-SERVICE CARD CIRCLE 54

Take a fresh look at filters: This approach to filter design for mixers and harmonic generators yields simple and lossless structures.

Ever notice how discussions of mixers and frequency multipliers usually end by stating that "unwanted frequencies can be suppressed by filtering"? Sounds easy. Yet, final designs often end up with some rather complex composite resonant filter networks. Usually the complexity is unnecessary. In addition, a good deal of useful power is wasted.

Here is an answer to the problem. It's a simple design approach in which filters can be combined in parallel to suppress any number of unwanted frequencies without attenuation of the desired output.

The basic circuit is shown in Fig. 1. To determine the values of its components, assume that it is connected in series with a constant-current generator. The voltage drop across the filter will be directly proportional to the filter's impedance. Thus the poles and zeros of the impedance determine the frequencies that will be selected and rejected, respectively. In this instance, the design will be for a single pole, ω_p, since only one frequency should appear at the output. The pole is located between two zeros, $\omega 1$ and $\omega 2$. Arbitrarily, let:

$$\omega 2 > \omega_p > \omega 1. \qquad (1)$$

It can be seen from the circuit that the two zeros are located at:

$$\omega 1 = (L1C1)^{-1/2}, \qquad (2)$$

and

$$\omega 2 = (L2C2)^{-1/2}, \qquad (3)$$

At the pole frequency, the parallel combination of C_v and the effective capacitance of branch 2 will be assigned an arbitrary value, C_p. Then the effective inductance of branch 1 must resonate with C_p at ω_p. Hence:

$$\omega_p L1 - 1/\omega_p C1 = 1/\omega_p C_p. \qquad (4)$$

Substituting the value of $L1$ from Eq. 2 and solving for $C1$ yields:

$$C1 = C_p[(\omega_p/\omega 1)^2 - 1] \ . \qquad (5)$$

Solve for $L1$ by substituting Eq. 5 into Eq. 2:

$$L1 = 1/C_p(\omega_p^2 - \omega 1^2). \qquad (6)$$

Now we know that the effective capacitance of branch 2 at the frequency ω_p must be $C_p - C_v$. Thus:

$$(1/\omega_p C2) - \omega_p L2 = 1/\omega_p(C_p - C_v). \qquad (7)$$

Substitute the value of $L2$ from Eq. 3 and solve for $C2$:

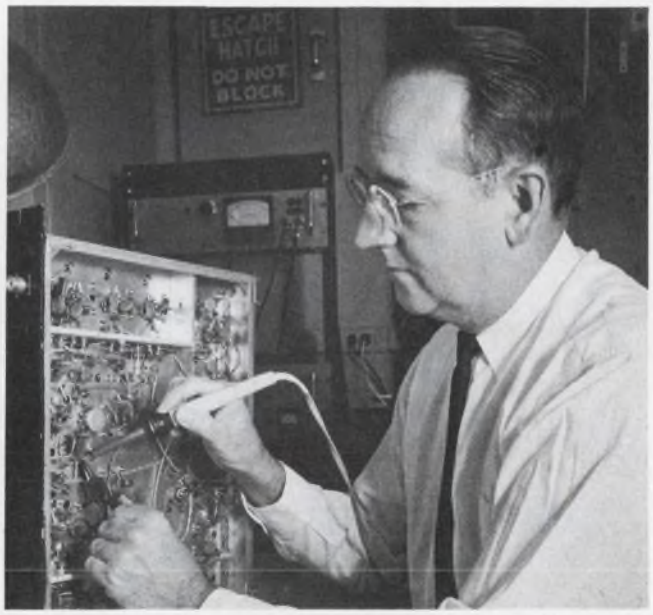
$$C2 = (C_p - C_v)[1 - (\omega_p/\omega 2)^2]. \qquad (8)$$

Solve for $L2$ by substituting Eq. 8 into Eq. 3:

$$L2 = 1/(C_p - C_v)(\omega 2^2 - \omega_p^2). \qquad (9)$$

There are three useful degenerate forms of this circuit, depending on the values of the zeros and poles:

(1) If $\omega 1 = 0$ and $\omega 2 = \infty$, we obtain an or-



Breadboard model of composite filter, tested by author Noble, is designed for a 20-MHz flow meter.

Frank W. Noble, Electronic Engineer, Laboratory of Technical Development, National Heart Institute, Bethesda, Md.

dinary parallel resonant circuit, as shown in Fig. 2a. Here $L1 = 1/C_p\,\omega_p^2$ and $C2 = C_p$.

(2) If $\omega_p > \omega 1 > 0$ and $\omega 2 = \infty$, the circuit in Fig. 2b is the outcome, where $C1$ and $L1$ are given by Eqs. 5 and 6, respectively.

(3) If $\omega 1 = 0$ and $\infty > \omega 2 > \omega_p$, we obtain the circuit in Fig. 2c, where:

$$L1 = 1/C_p\,\omega_p^2,$$
$$L2 = 1/C_p(\omega 2^2 - \omega_p^2),$$
$$C2 = C_p[1-(\omega_p/\omega 2)^2].$$

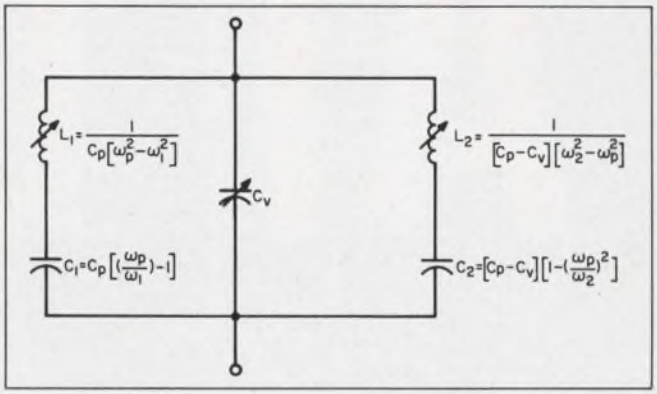
Under certain conditions further simplifications are possible. For example, C_v in Fig. 1 is not required, provided that the external circuit has zero net reactance at ω_p and the designer is willing to adjust all components to exact values. But the external circuit is usually capacitive, which will automatically set a lower limit for C_v. And setting all components to exact values is an unnecessary nuisance which can be avoided by the inclusion of a sufficiently large C_v. It is then possible to set $C1$ and $C2$ approximately, adjusting the zero at $\omega 1$ with $L1$ and the zero at $\omega 2$ with $L2$. The pole at ω_p is then adjusted by varying C_v.

Some provision must be made to supply dc to the active device. This can be done by shunt-feeding with a resistor, with an RF choke or with the circuit of Fig. 2a. The resistor must be large enough to prevent an appreciable reduction in the pole impedance; but if it is too large, it will usually produce an excessive dc drop. If a choke is preferred, its reactance can be canceled by C_v. The combination of the choke and C_v will, however, occupy about the same space and cost more than the parallel resonant circuit of Fig. 2a. This circuit has the additional advantage of being adjustable to supply either a capacitive or an inductive reactance at ω_p. This feature may be very useful in composite filters.

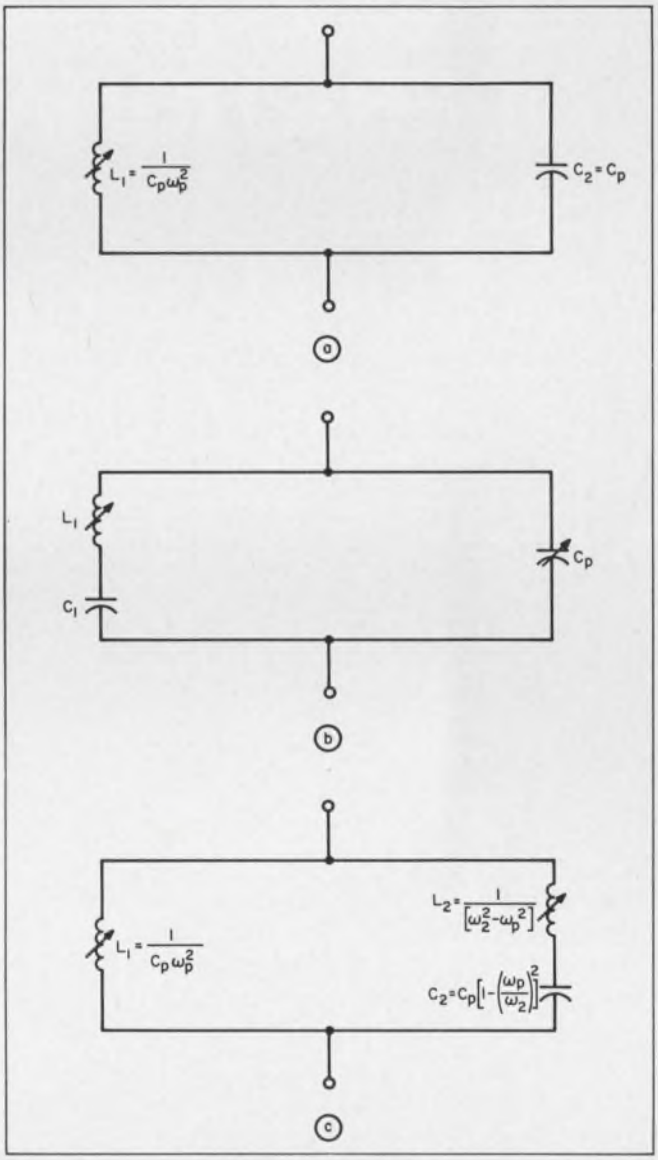
A composite filter is a parallel combination of these circuits. Any number of filters having the same values of ω_p may be thus connected. The composite filter will have a pole at ω_p and all the zeros of the individual filters. Other poles will appear, but since these do not occur at frequencies which must be suppressed, they will cause no harm unless noise is a consideration.

The first filter should preferably be of the form of Fig. 2a to provide a dc path and a variable reactance of either sign. Then filters of the form of Fig. 1, but where $C_v = 0$, would be designed to suppress pairs of undesired frequencies on opposite sides of ω_p. Finally, filters of the type of Fig. 2b or Fig. 2c would be designed to suppress the remaining spurious frequencies.

The final circuit may be simplified by substitution of a single equivalent capacitance or inductance in place of two or more similar components which occur in parallel. ■ ■



1. **Simple filter replaces a cascade of resonant circuits** at the output of mixers and frequency multipliers. It effectively suppresses unwanted pairs of frequencies at the opposite sides of the selected frequency, ω_p.



2. **Degenerate forms of the circuit in Fig. 1** are useful in composite filters, in conjunction with Fig. 1. The ordinary parallel resonant circuit (a) should be the first section, to provide a dc path for the active element and a variable reactance of either sign. Frequencies not suppressed by Fig. 1 may be eliminated with either (b) or (c).

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Overload protection	Fully protected against short-circuits, overload, overdrive
Common-mode rejection	130dB
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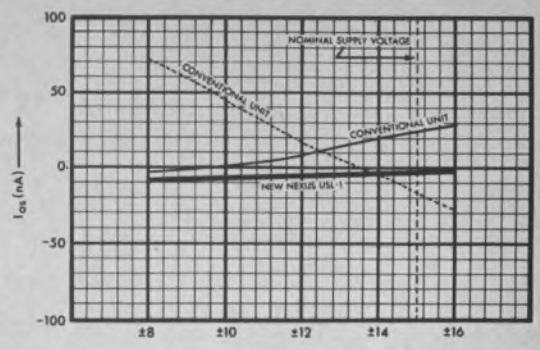
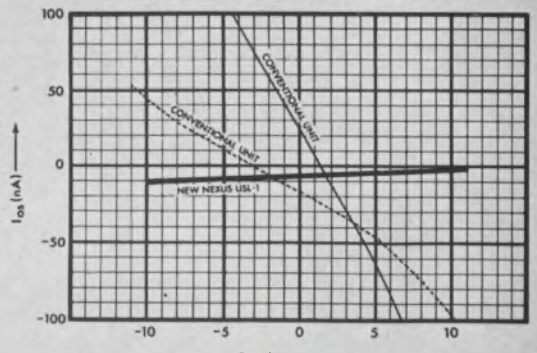
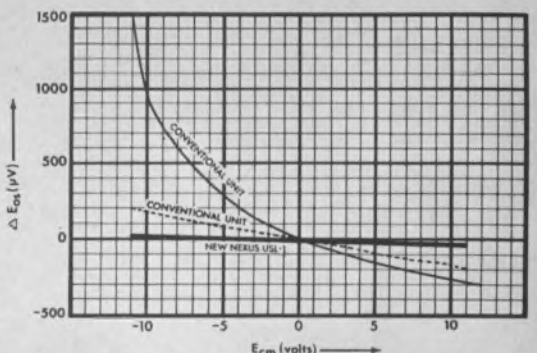


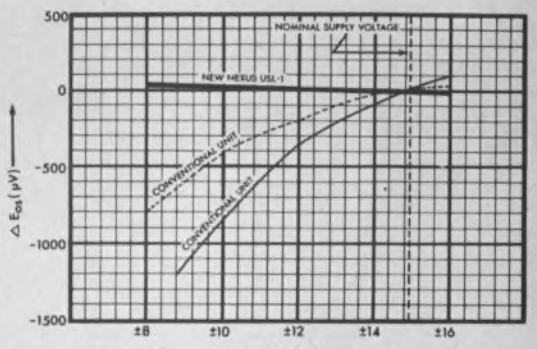
OFFSET CURRENT (EITHER INPUT) VS. POWER SUPPLY VOLTAGE



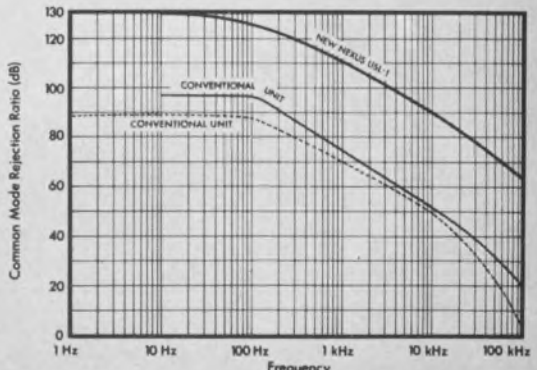
OFFSET CURRENT (REFERENCE INPUT ONLY) VS. COMMON MODE VOLTAGE



OFFSET VOLTAGE VS. COMMON MODE VOLTAGE



OFFSET VOLTAGE VS. POWER SUPPLY VOLTAGE



COMMON MODE REJECTION RATIO VS. FREQUENCY

ON READER-SERVICE CARD CIRCLE 55

Use integrated circuits in process controls

to achieve circuit stability and sophistication at lower costs than previously possible.

In proportional control systems, off-the-shelf integrated circuits have the advantage of lower drift or higher set-point stability than can be obtained from magnetic amplifiers or thyratrons. Two IC operational amplifiers, a passive lag network and an SCR can be combined into a compact time-proportional control system with an adjustable nonlinear output response. This latter arrangement simplifies the task of compensating for the inherent nonlinearities in a particular industrial process.

A conventional proportional control—a position servo, for example—produced an output that is a linear function of the difference between the input and the reference, or set-point, signal. Figure 1 demonstrates this relationship with all variables expressed as percentages of full-scale values, as usual in control theory. If the input signal is defined as the controlled variable, I_{act}, and I_{set} is the reference, or set, point and X_p is the proportional band, output V becomes:

$$V = (I_{act} - I_{set})/X_p.$$

Control designers frequently object to using proportional controllers and turn instead to time-proportional controllers. Since time-proportional controls use simple ON/OFF actuators, like a relay or magnetic switch, these control systems are far simpler, cheaper, and more reliable. Elimination of the costly servo amplifiers that are required in straight proportional controllers is a particular saving.

In a time-proportional control (see Fig. 2), the proportional output is fed to a threshold detector that converts the signal into a square wave. The duty cycle (δ) of the detector, is a function of its input signal, V, and varies from 0% to 100%. The relationship is:

$$\delta = T_{ON}/(T_{ON} + T_{OFF}),$$

where

T_{ON} = time that actuator is ON,

T_{OFF} = time that actuator is OFF.

Roland E. Best, Systems Project Engineer, Sandoz, Ltd., Basel, Switzerland.

The output voltage of the detector is either $+E$ or 0 volts. The actuator is defined as ON when the output is at $+E$ volts and OFF when it is at 0 volts. The operation of the threshold detector is best explained by reference to Fig. 3. Assume that input signal V exceeds voltage E_C, present at capacitor C. The threshold detector then flips into the high state. C starts to charge with a time constant $T_1 = R1C$ towards $+E$ volts. As soon as E_C exceeds V by the amount H, the hysteresis of the detector, the output swings back to the low state. Now C discharges, with time constant $T_2 = R2C$, toward ground potential. When E_C again equals V, the threshold detector switches into the high state, and the cycle repeats until V goes to 0 volt and the duty cycle is reduced to 0%. Values of T_{ON} and T_{OFF} are calculated ($0 \leq V \leq E - H$) to be:

$$T_{ON} = T_1 \ln [(V-E)/(V-E+H)],$$

$$T_{OFF} = T_2 \ln [(V+H)/V].$$

The duty cycle, δ, is given by:

$$\frac{\ln[(V-E)/(V-E+H)]}{\ln[(V-E)/(V-E+H)] + T_2 \ln[(V+H)/V]/T_1}.$$

Note the ratio T_2/T_1 in this equation. The conventional proportional controller, shown in Fig. 1, is described by only a single curve, but in the time-proportional control, a set of curves is obtained. These curves, shown in Fig. 4, are a function of the ratio T_1/T_2. In this example, H is equal to 0.2 E. Though the δ-curve is nearly linear when $T_1/T_2 = 1$, a wide choice of nonlinear curves can be obtained if T_1/T_2 is altered.

Nonlinear controllers offer distinct advantages over the more conventional linear ones. First, many processes are inherently nonlinear; for example, in waste-water pH-neutralization, the pH value of the effluent is a nonlinear function of the flow rate of the neutralizing ingredient. The overall transfer function of such systems may be linearized by selection of a suitable nonlinear δ-curve. Secondly, the dynamic response of a control system is dependent on the limits of the δ-curve. When T_1/T_2 is high, the controller sensitivity, $d\delta/dV$, is at a maximum at the set point. As the deviation from the set point increases, however, the sensi-

tivity is reduced. With this high ratio, a control system has fast dynamic response, but tends to overshoot and become unstable. For low values of T_1/T_2, the reverse is true. The controller is most sensitive at the upper end of the proportional band, and least sensitive at the set point. While the response is slower in this system, the danger of overshoot is less. The designer must select the δ-curve that gives optimum controller performance in a specific application.

In designing time-proportional controllers, note that the switching action can introduce extraneous signals into the control system. To minimize this interference, the operating frequency is selected in the region where the gain of the process transfer function is at its lowest. Since the switching frequency is a function of the deviation signal, V, it is not constant. A reasonable approximation can be obtained, however, by calculation of the operating frequency at the middle of the proportional band:

$$f_m = \frac{1}{(T_1+T_2)\ln[(E+H)/(E-H)]}.$$

IC duet drives SCR switch

An effective time-proportional control can be designed and built with just two integrated operational amplifiers. The circuit is shown in Fig. 5.

The first operational amplifier produces an output voltage that is a function of the variance between the input current and the set-point current. The set-point switches adjust one "set" current flowing from the −15-volt reference into the summing node. The proportional-band switches adjust the amount of feedback current flowing from the output of the operational amplifier, and make the output proportional to $1/X_p$. The input current (I_{act}) level determines, for any particular application, the resistor values in these switching networks.

The second operational amplifier is the threshold detector. The hysteresis, H, is about 1.4 volts and is set by the positive feedback path. The output of the amplifier is either at a positive or at a negative saturation level. When the output is negative, *CR3* is cut off and the plus input is approximately equal to V. When the output is positive, *CR3* conducts and the plus input becomes 1.4 volts more positive than V, because of the drop through *CR4* and *CR5*. Since E is 6.2 volts, as determined by the Zener voltage of *CR6*, H is approximately equal to 0.2 E. The duty cycle varies continuously from 0% to 100%, as voltage V changes from 0 volt to 4.8 volts ($E-H$). Time constants T_1 and T_2 are varied by adjustment of *R1* and *R2* in the negative feedback loop. The δ-curves measured with this circuit agree perfectly with the calculated curves (Fig. 3). The operational amplifier output switches a silicon-controlled switch that is operating as an SCR. This latter drives a heavy-duty relay which in turn activates the process control actuator. In many cases it is possible to drive the actuator directly with an SCR.

Adding one IC yields rate control

In many processes, simple proportional or time-proportional control is not sufficient. More complex controls are needed like proportional-plus-integral (PI) control and proportional-plus-integral-plus-derivative (PID), or rate, control. With these controls, the input voltage to the threshold detector, V (see Fig. 4), no longer follows a linear relationship, but is described instead by:

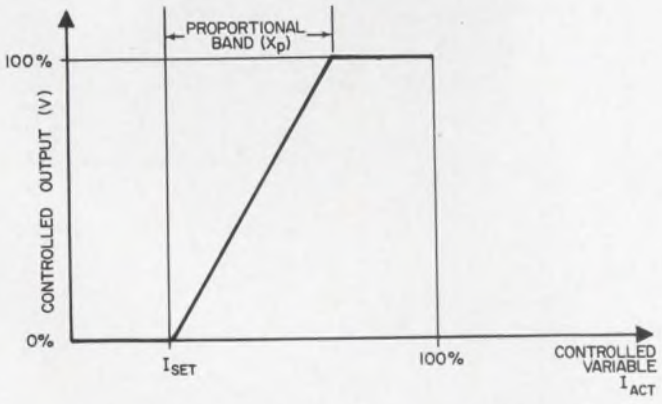
$$V(s) = [(I_{act}-I_{set})/X_p](1+1/sT_i), \text{ for PI,}$$

and

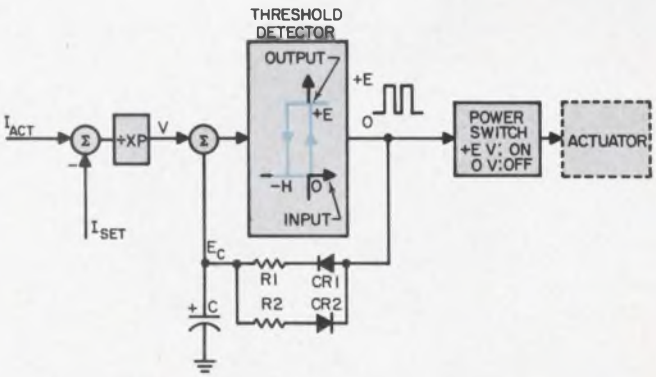
$$V(s) = [(I_{act}-I_{set})/X_p](1+sT_d+1/sT_i), \text{ for PID,}$$

where

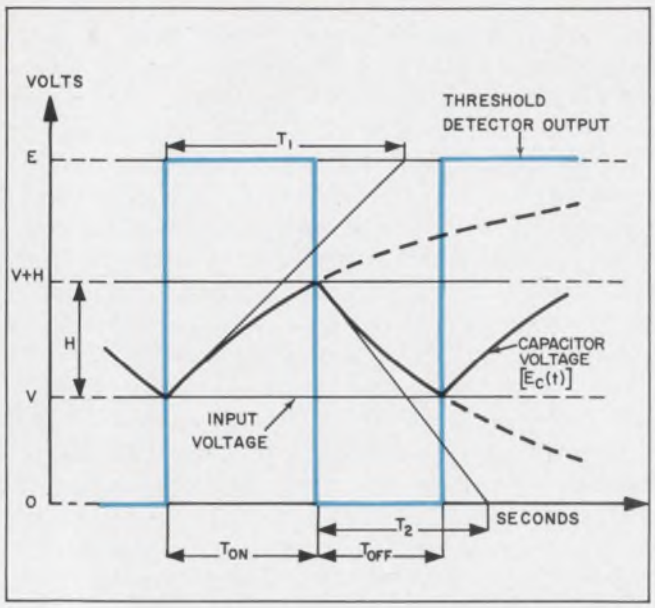
s = complex frequency,
T_i = integral time constant, and
T_d = derivative time constant.



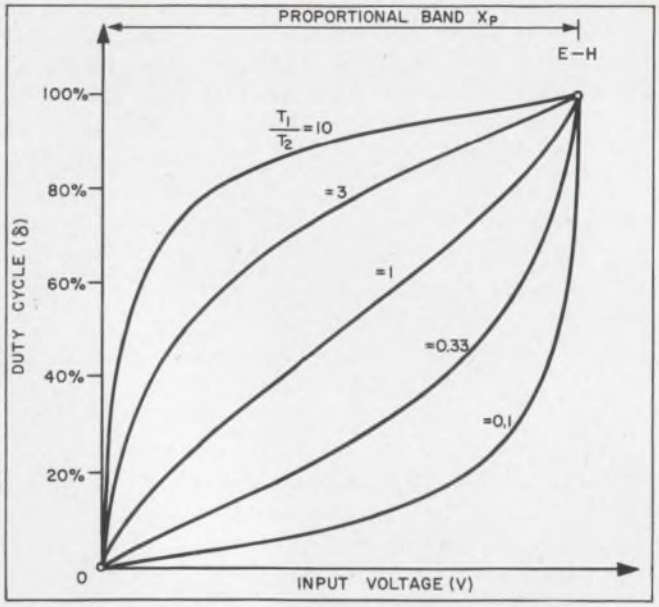
1. **The output of a proportional control,** such as a position servo, varies linearly with input signal deviation. To operate properly, expensive and inherently unreliable servo amplifiers are often required.



2. **Proportional amplifier output is fed to a detector,** where it is converted to a variable-width pulse. This pulse controls a solid-state switch that, in turn, activates the actuating relay.



3. **Since the detector output is a switched signal,** it introduces noise spikes in the system. To prevent this interference, the pulse, at a 50% duty cycle, should have a frequency outside the pass-band of the op-amp.



4. **Different ratios of charge-discharge times** alter controller linearity. Adjusting R1 and R2 in the charging and discharging circuits alters any nonlinear input and makes it almost perfectly linear.

Thus the output of a PID controller is equal to the sum of a proportional, an integral, and a derivative function of the control deviation. The integral portion is used to cancel the finite steady-state control error inherent in proportional controllers. By derivative action, the settling times of the regulating system are reduced.

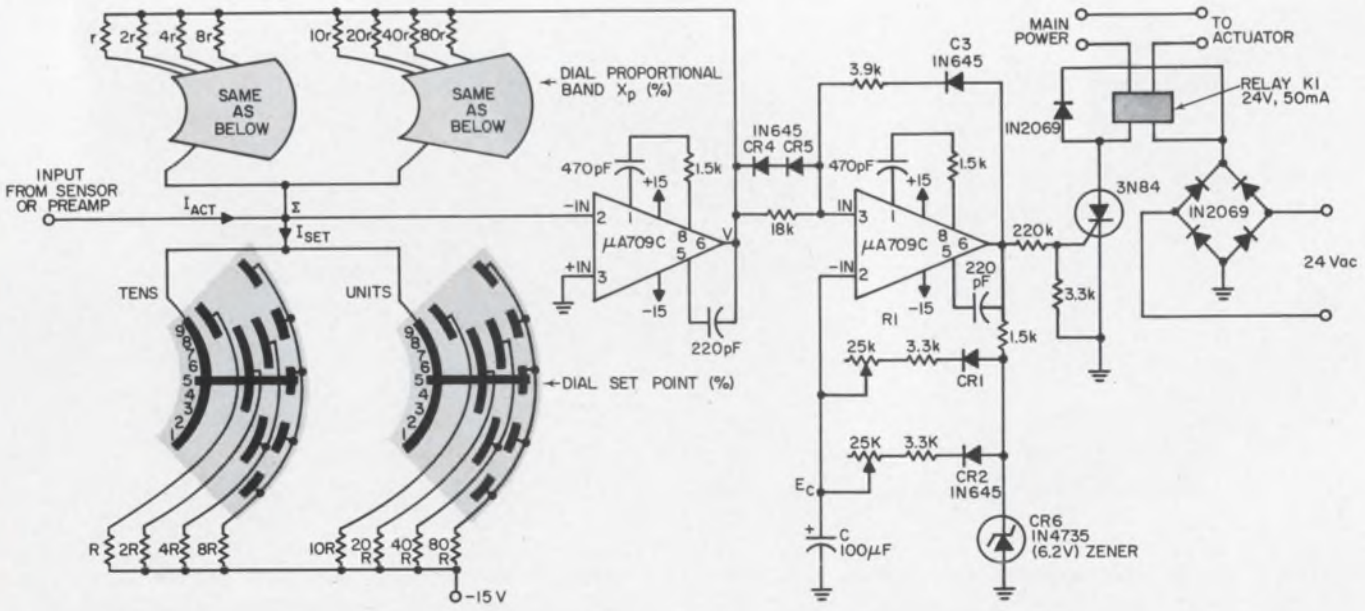
The simple controller described in Fig. 5 can be converted into a PID controller by insertion of an additional operational amplifier (see Fig. 6), with the correct transfer function, between the first and second amplifier. The circuit yields the transfer function:

$$W(s) = -[(T_d/T_i) + 1 + (1/sT_i) + sT_d],$$

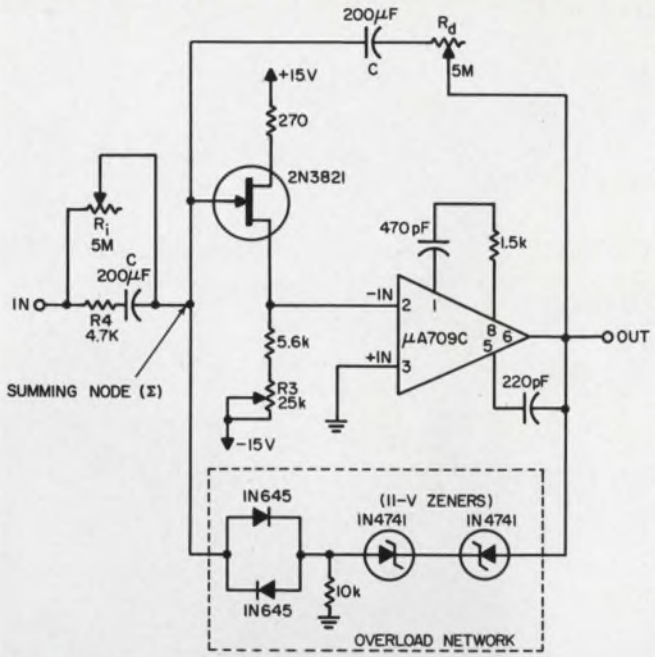
where

$$T_d = R_d\,C, \text{ and}$$
$$T_i = R_i\,C.$$

Time constants T_i and T_d are each adjusted independently, by potentiometers R_i and R_d, over the range from 0 to 1000 seconds. In most cases T_d/T_i is approximately 0.25, and the constant term in the transfer function becomes approximately 1.25 instead of 1, as specified in the equation. However, this error only affects the proportional band, re-



5. **Time-proportional control uses binary-coded switching** to select the reference signal (I_{set}) and the proportional band (X_p). Parallel switch combinations can be added to provide even finer control.



6. **Single op-amp circuit adds integrating** and differentiating functions to the time-proportional control in Fig. 5. Both the integrating and differentiating time constants can be varied from 0 to 1000 seconds by adjustment of R_i and R_d, respectively.

ducing it by a factor of 1.25, and can be corrected by adjusting the proportional band with the selector switches.

Since extremely large integrator time constants are often encountered in process control, bipolar operational amplifiers, with their relatively high input current and input current temperature coefficients (0.5 μA and 2 nA/°C at 25°C, respectively), could not be used directly. Instead, a FET source-follower reduces the offset current at the summing junction to less than 0.1 nA at 25°C. This current doubles for every 10°C increase in ambient temperature. By adjustment of *R3* so that the FET drain current is equal to I_{DSS}, the FET operates with no voltage offset when $V_{GS} = 0$. The differentiating network (R_d, C) includes resistor *R4*. Since pure differentiators are prone to instability, they are usually modified by compensating elements. ■ ■

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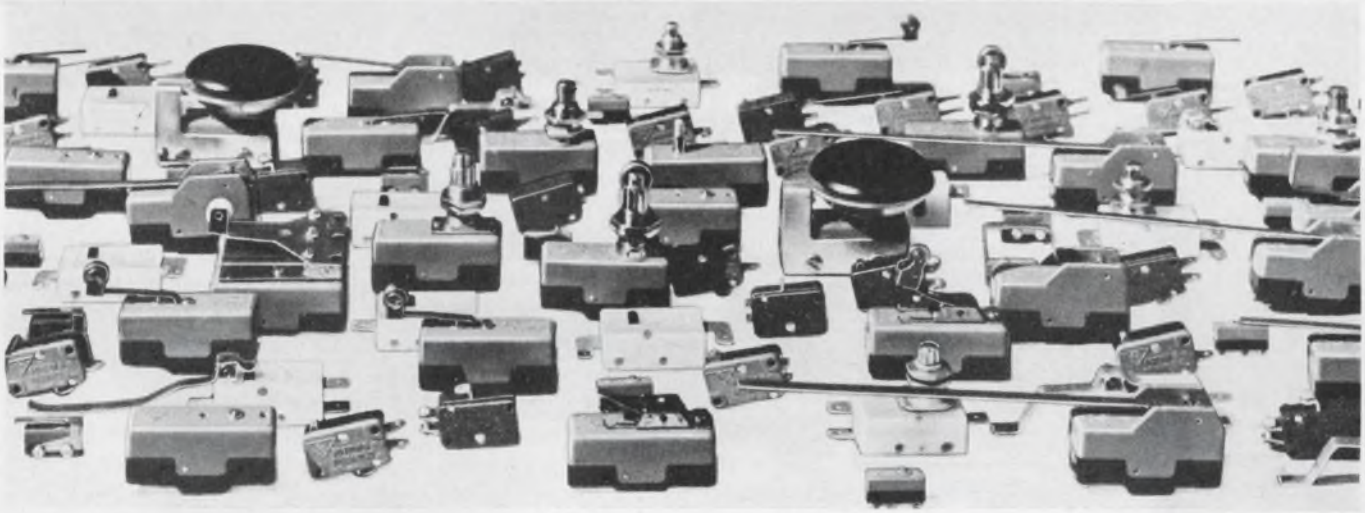

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ON READER-SERVICE CARD CIRCLE 58

Check antennas before building them.

The Monte Carlo technique ensures that construction and performance errors stay within allowed limits.

For the antenna designer, the Monte Carlo technique is a perfect tool for predicting an antenna's performance. Using this technique, he does not have to be an expert in statistics or probability to foresee expected degradations in performance and to estimate tolerable construction and measurement errors. Knowing these factors, he can save production time and manufacturing costs.

One integral is all the math needed

The Monte Carlo method involves the selection of random numbers which permits a mathematical simulation of random events. The statistical basis for the Monte Carlo technique is the assumption that the frequency of the error variations from the specified design values follows a known distribution. This frequency distribution can be obtained by plotting the distribution of a large number of measurements, or else by assuming that the variation follows a known distribution such as the normal, or Gaussian, frequency distribution (Fig. 1). The equation that describes this distribution is:

$$f = (\exp -u^2/2)/(2\pi)^{1/2} \qquad (1)$$

where

f = error frequency,
u = $(x-m)/\sigma$ = standard variate or normalized error deviation with respect to the standard deviation,
x = value of parameter under consideration,
m = specified design value of same parameter,
σ = standard deviation.

With the assumption that such errors follow the normal frequency distribution, 99.7% of the error will not exceed $\pm 3\sigma$, 95.5% will not exceed $\pm 2\sigma$ and 68.3% will not exceed $\pm\sigma$.

The cumulative frequency distribution associated with the known frequency distribution is defined as the normalized summation, or integral, of the number of error variations from minus infinity to some fixed error variation. The magnitude of the cumulative frequency distribution is assumed to take on values of the selected random numbers, R. In the case where the normal distribution is assumed for the frequency function, the cumulative distribution is given by:

$$R = \int_{-\infty}^{(x-m)/\sigma} [(\exp -u^2/2)/(2\pi)^{1/2}]\,du. \qquad (2)$$

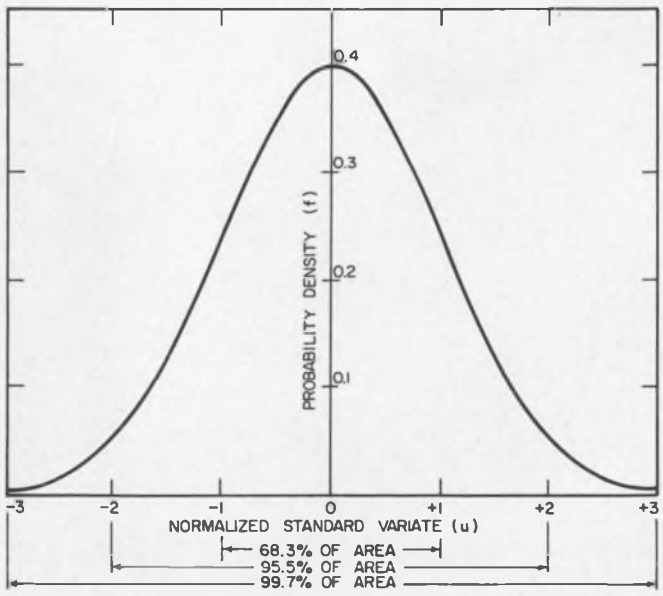
A numerical value of x may be established for each of the random numbers by assigning a fixed value to σ.

These values of x are then used to simulate the actual performance instead of m.

Four steps to practical results

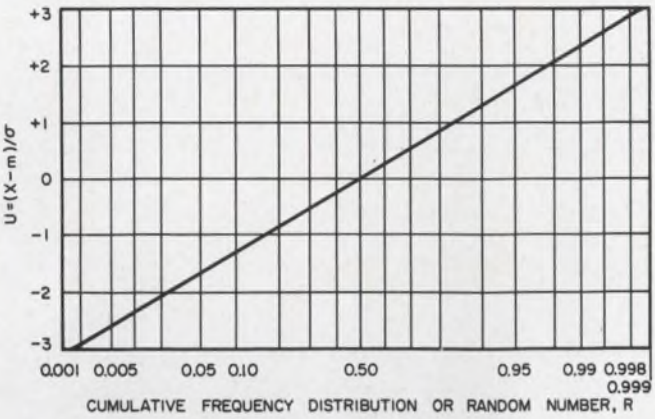
The application of the Monte Carlo technique may be systematized as follows:

1. Obtain an equation or empirical data that expresses the performance characteristics as a function of the parameter values. Determine the design values of the parameters that will give the



1. **With a normal error frequency distribution,** 99.7% of the error will not exceed $\pm 3\sigma$, 99.5% will not exceed $\pm 2\sigma$ and 68.3% will not exceed $\pm\sigma$.

B. M. Bowman, Senior Engineering Specialist, **F. E. Fischer,** Senior Development Engineer, Electromagnetics, Goodyear Aerospace Corp., Akron, Ohio.



2. **The normalized error depends linearly** on the cumulative frequency distribution. Here a normal distribution such as shown in Fig. 1 is assumed.

Table 1. Design parameters

Element no.	Amplitude (a_i)	Phase (ϕ_i)
1	1.000	0.00
2	1.694	8.48
3	1.388	33.53
4	1.723	72.83
5	1.180	99.81
6	0.574	19.21
7	0.916	58.66
8	0.780	125.05
9	0.634	47.46
10	0.740	38.00

desired characteristics.

2. Evaluate the cumulative frequency distributions versus parameter fluctuation for the parameters under consideration.

3. Select a random number for each of the factors that is expected to vary from its assigned design value.

4. Determine the actual parameter values by applying the random numbers to the cumulative frequency distribution. Then substitute the resulting values in the relationship for the performance characteristics established in Step 1.

It is obvious from these steps that the Monte Carlo technique is confined to problems where there is a direct relationship, either theoretical or empirical, between the performance characteristics and the parameters that are being varied. For example, the far-field radiation pattern of a slotted waveguide array can be readily computed if the relative amplitude and phase parameters of the elements are known. The Monte Carlo technique could be used to evaluate the effects of various electrical tolerances on the radiation pattern for the case where the acceptance of a given array is based on whether the measured amplitude and phase of each element are within certain specified limits.

However, if this technique were to be used to evaluate the effects of various manufacturing tolerances on the far-field radiation pattern, these amplitude and phase parameters would have to be expressed in terms of factors such as waveguide tolerances, slot-length tolerances, slot-width tolerances and slot-spacing tolerances. While reasonable estimates of these structural tolerances can usually be made, it is often difficult to translate them directly into the antenna performance characteristics.

How to get numerical values

The cumulative frequency distribution, which describes the variation of the actual parameter values around the design values, can be presented in tabular form.[1] A more convenient way is to plot it on standard probability paper.

The cumulative frequency distribution versus the parameter values, x, can be obtained from measured data, or by assuming that the error deviations are normally distributed. This assumption is reasonable for many cases.

A plot of the cumulative normal frequency distribution vs the standard variate, $(x - m)/\sigma$, is a straight-line plot on probability paper, as shown in Fig. 2. The design value, m, is specified by the required performance. The standard deviation, σ, may be selected by making the maximum deviation equal to 3σ, or by determining the rms deviation and calling this σ.

The random numbers that denote the magnitude of the cumulative frequency distribution should be selected from a table of random numbers in a systematic manner. Systematic selection means that only sequential numbers in the rows or in the columns, or only sequential numbers in the corners of the subgroupings, or some other regular combination of elements are chosen. Since the cumulative frequency distribution is a normalized function, its magnitude ranges from 0 to 1, which specifies the range of the random numbers.

Phased array illustrates method

As an example of an application of this technique, consider the problem of determining the effects of randomly varying amplitude and phase on the far-field radiation pattern of an antenna array.

Assume that a 10-element array is designed and a suitable set of driving coefficients has been selected. A sketch of this linear array configuration is shown in Fig. 3. The chosen set of coefficients is shown in Table 1. The far-field radiation pattern for isotropic elements is:

Table 2. Actual amplitude values

Element number	Random numbers	$u = (x_{a_i} - a_i)/\sigma_a$	Error (dB) $(x_{a_i} - a_i)$	Error ratio	Modified amplitudes
1	0.49	0	0	1.00	1.000
2	0.31	−0.5	−0.05	0.994	1.684
3	0.97	1.9	0.19	1.02	1.415
4	0.45	−0.1	−0.01	0.999	1.721
5	0.80	0.9	0.09	1.01	1.192
6	0.57	0.2	0.02	1.02	0.585
7	0.47	−0.1	−0.01	0.999	0.915
8	0.01	−2.3	−0.23	0.974	0.760
9	0.47	−0.1	−0.01	0.999	0.633
10	0.00	−3.0	−0.30	0.966	0.715

$$E = |A_1 + A_2Z + A_3Z^2 + \ldots + A_9Z^8 + A_{10}Z^9|, \quad (3)$$

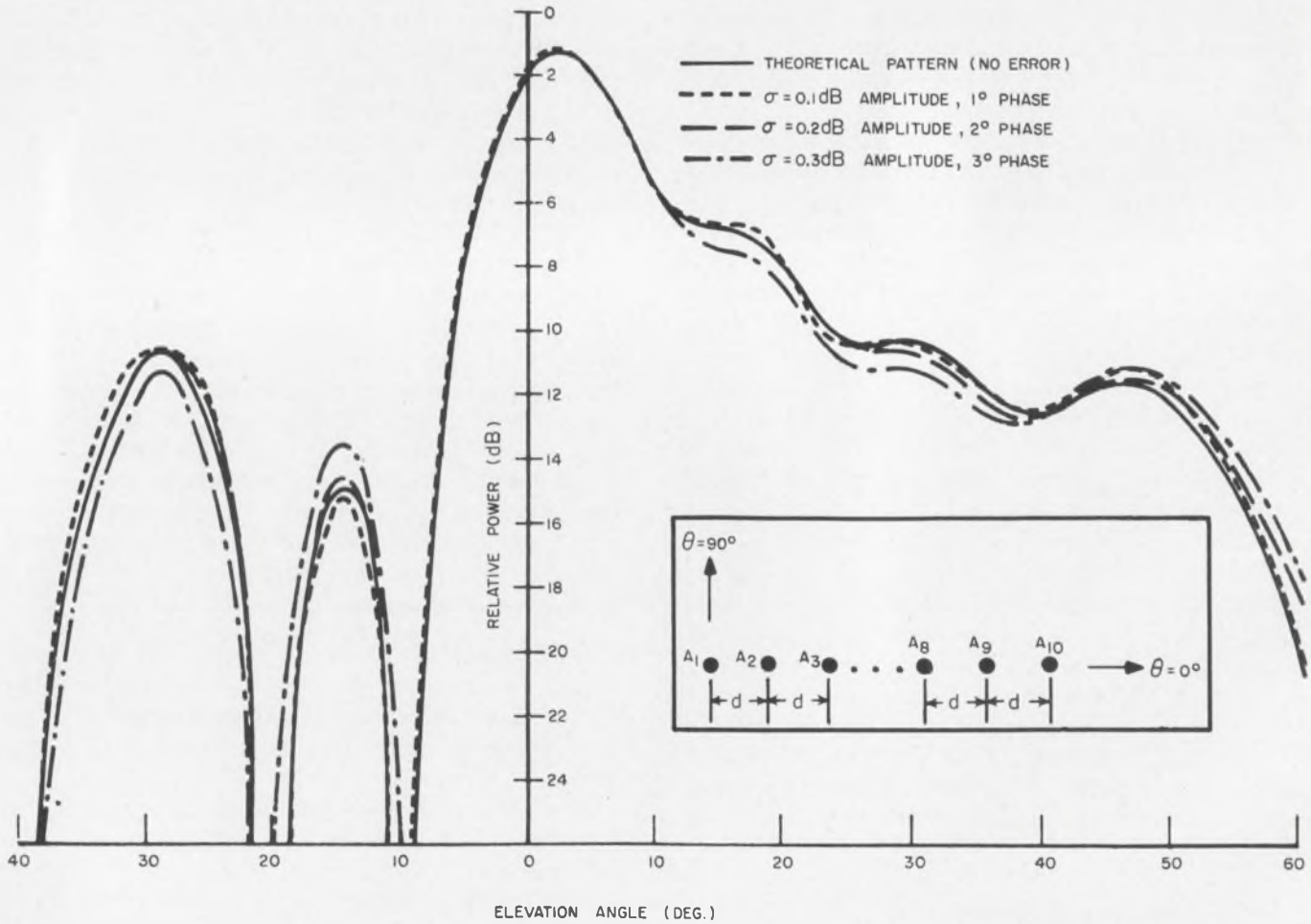
where

E = far-field magnitude,
$A_n = A_{no} \exp j\phi_n$,
A_{no} = amplitude of field,
ϕ_n = fixed phase of each element,
$Z = \exp [j(2\pi d/\lambda)\cos\theta]$,
d = spacing between elements,
λ = wavelength,
θ = viewing aspect from the line of the array.

The calculated pattern for a d/λ of 0.5000 is shown by the solid curve in Fig. 3.

Since the errors are assumed to be normally distributed, the next step in this analysis is to postulate the spread, or standard deviation, of the variations for each parameter.

Although error variations could also occur in



3. **Far-field patterns for a 10-element array** illustrate expected deviations from error-free performance (solid line). The errors calculated in the text yield about 0.4 dB difference (dashed line).

Table 3. Actual phase values

Element number	Random numbers	$u=(x_{\phi_i}-\phi_i)/\sigma_\phi$	Error (deg.) $u=(x_{\phi_i}-\phi_i)$	Modified phases $(x\phi_i)$
1	0.57	0.2	0.2	0.2
2	0.16	−1.0	−1.0	7.48
3	0.83	1.0	1.0	34.53
4	0.04	−1.7	−1.7	71.13
5	0.58	0.2	0.2	99.61
6	0.23	−0.7	−0.7	18.51
7	0.89	1.2	1.2	59.86
8	0.20	−0.8	−0.8	124.25
9	0.78	0.8	0.8	48.26
10	0.25	−0.7	−0.7	37.30

d/λ, the only parameters that will be considered are the amplitudes and phases of the elements. As the errors cannot be smaller than our ability to measure them, the minimum standard deviation for each parameter is set equal to the standard deviation of typical measurement errors. Based on specifications for test equipment and on experience with RF measurement, a rms (or standard deviation) error of 0.10 dB in amplitude and 1.00 degree in phase is achievable without much difficulty.

Now typical amplitude and phase errors are determined for each element by selecting random numbers from a table of random numbers. The selected random numbers for the amplitude and phase coefficients are listed in the second column of Tables 2 and 3.

The third column of the tables, denoted $(x-m)/\sigma$, represents the ratio of the parameter error $(x-m)$ to the standard deviation, σ, for each random number. These may be read off from Fig. 2.

The error column is given by the product of $(x-m)/\sigma$ and σ. Recall that the standard deviation for the amplitude was 0.1 dB, and for the phase, 1.0 degree. Since the amplitudes were assumed to vary statistically in terms of dB, the amplitude error was converted to a ratio and then multiplied by the coefficient, to obtain the modified value.

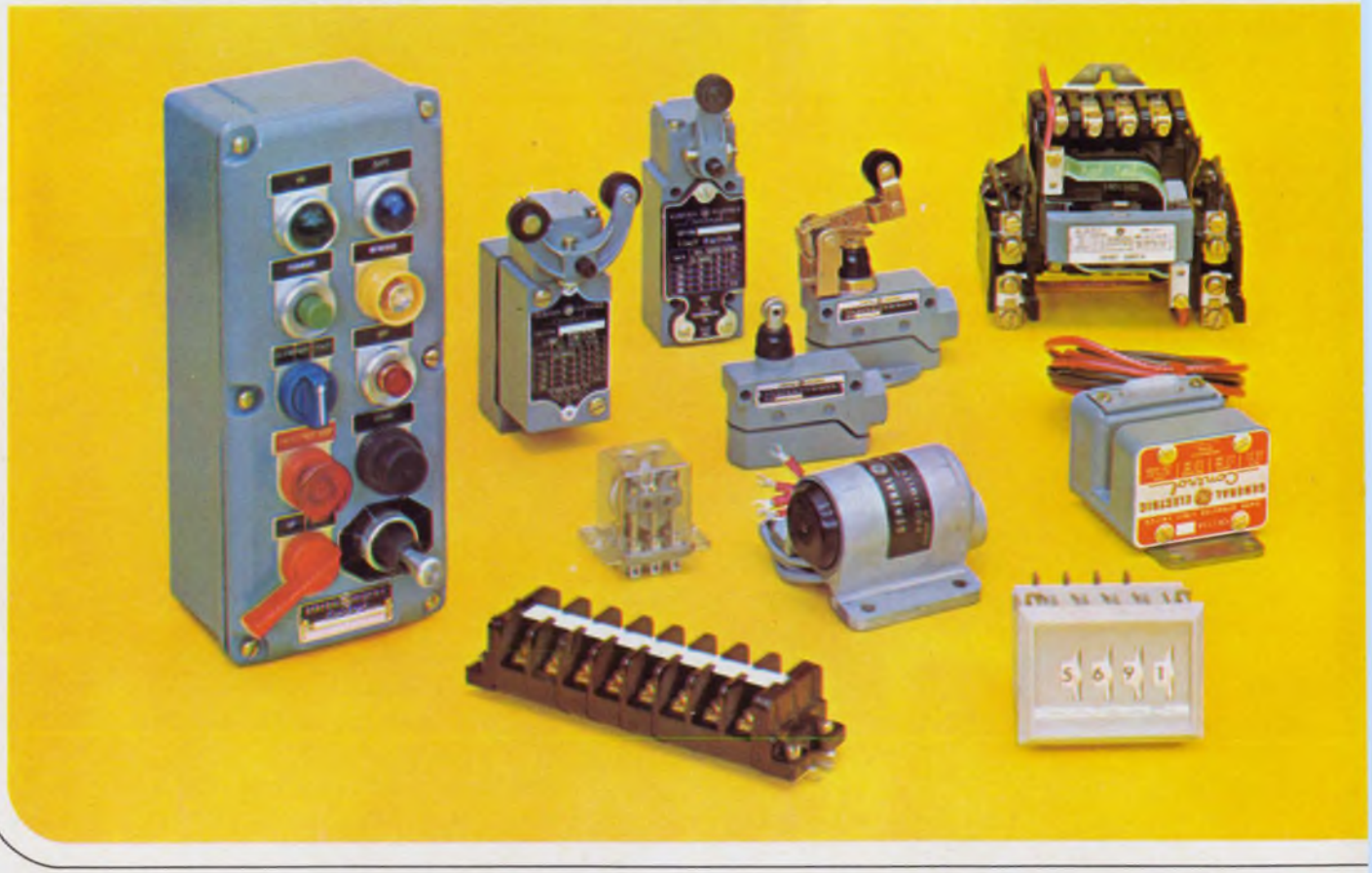
The modified amplitudes and phases yield a new pattern (dashed line in Fig. 3) which can then be compared with the theoretical pattern.

The curve in Fig. 3 shows that the postulated errors would probably result in maximum pattern variations of about 0.4 dB. The procedure is repeated with different sets of random numbers to simulate typical pattern variations, as shown by the dashed lines in Fig. 3. ■ ■

Reference:

1. *Reference Data for Radio Engineers* (4th ed,; New York: International Telephone & Telegraph Corp.), p. 1117.

from START to STOP



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LEADER IN CONTROL

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ON READER-SERVICE CARD CIRCLE 60

These circuits create more problems

than they solve, if they are used very skillfully. Start by omitting them from your next design.

The following collection of novel circuits is designed especially to cheer design engineers who have problems. You can be sure they won't work. But unlike your own unworkable circuits, these may at least be good for a smile. Most of them contain features that, as yet, remain largely uninvented. Some unfamiliar symbols are used occasionally, and rightly so; electronics is rapidly running out of good symbols, and it seems essential to grab some of the few remaining ones before they are all used up. Although these circuits are presented as an antidote to design drudgery, they may inspire equally off beat, but workable ideas. So hold on to your guffaws and read on!

Asymmetric drominal: a biagonal electron shooter

Note the lack of any bias source in this clever flip-flop-zip-zap-whammo circuit. Power is obtained from a simple but seldom tapped source—the air. Air is always ionized, either positively or negatively. Much work has been done recently on the effects of this on human activity (people seem to work better with high negative-ion concentrations), but so far most designers have overlooked this free source of bias. One arrow tip of this circuit is picking up ions from the air; a special coating of material provides an excellent impedance match to the air's high dielectric constant. Assume this is happening at the left arrow. Then, Q_1 is cut off. Meanwhile, Q_2 is saturated, and emits a steady stream of electrons from the right arrow for whatever purpose the designer may have in mind.

Triggering occurs each time a signal of any type is applied through unipolar resistor R_1 or R_2, depending on which transistor is cut off at that moment.

This circuit, like people, works best on days with high negative-ion concentrations. It has been used on occasion, with some success, to prod sleepy technicians.

Minority-carrier vacuum amplifier: a panacea

Here's an ideal combination in which a partially semiconductive device is grid-controlled in a small tube envelope. Operation of this device asymptotically approaches that of a voltage- or current-amplifier. It makes no difference what you're used to designing, any old tube circuit will work just fine with this device thrown between some coupling capacitors. But the amazing part is that the same thing goes for any familiar transistor amplifying circuit.

The split-level collector-plate acts somewhat like the familiar screen grid in a pentode. Designers who so wish can bring a lead out to give some control of the collector current, or voltage, or whatever. But this is inessential unless the designer is particularly fussy. The operation under these conditions should be obvious to even the most casual observer.

Recent tests suggest that even field-effect men can make use of this versatile hybrid without learning a single new thing.

Symmetrical quadral: a high powered FLOP

At first glance, you might confuse this configuration with the classic power amplifier. However, should you proceed beyond the rather trivial analysis of its dc equivalent, you will discover certain startling characteristics which combine to produce a true FLOP.

With components connected as shown (intelligently approximated values, of course), the output of T_1 (tube, transistor, or what have you) will decay to zero in the interval from $t = 0^-$ to $t = 0^+$. It should therefore be clear that this circuit is a true FLOP.

Bifurcated trumlobe: a hot non-vacuum device

No attempt at exhaustive analysis of this circuit will be attempted here. It is hoped, rather, that the reader will be sufficiently intrigued by the unique characteristics of the devices employed to attempt a qualitative analysis on his own. Such effort will enhance his ability to deal with circuits of even greater complexity.

It is sufficient for our immediate purpose to note that the interesting arrangement of the vacuum diodes (i.e., anode and cathode in an evacuated glass envelope *circa* 1940) has absolutely no effect on the voltage appearing across the resistance, regardless of the value of the resistance. The less familiar devices shown connected to the triodes represent a significant and highly classified advance beyond the frontiers of technology. To work, they must be immersed in gin.

Bert Pearl, Bell and Howell, Chicago.

Full-wave zenar: a real ripple-remover

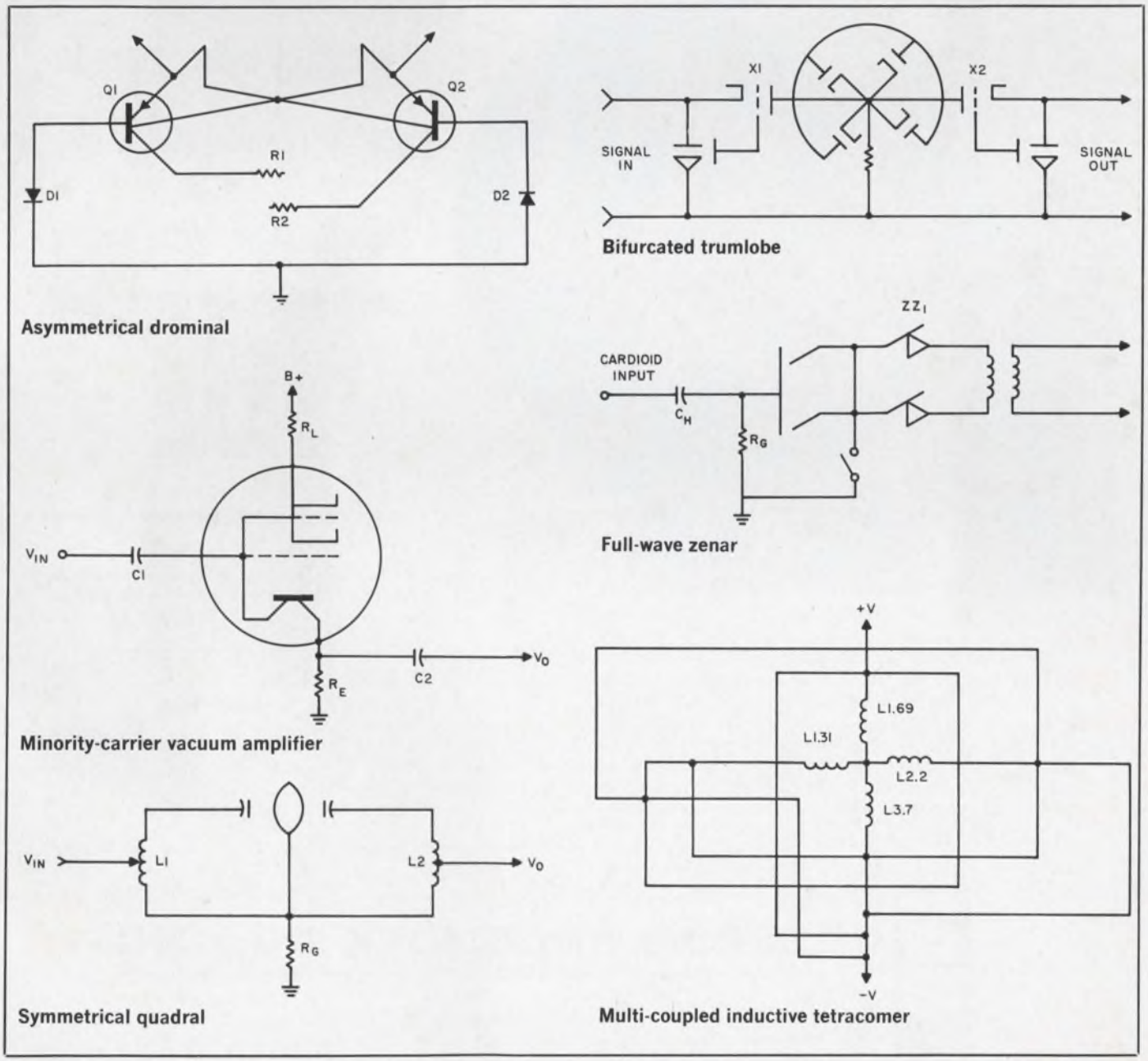
Cardioid inputs to this circuit are coupled to the base of the vacuistor (vacuum transistor) and, when a sufficient level is reached, the vacuistor will conduct, causing the tangentially controlled switch to close. At this point, the full cardioid input is applied to the zenar devices, which, in keeping with their not too well-known characteristics, cease to conduct, thereby completely eliminating ripple from the output of this novel circuit

Multi-coupled tetracomer: an 8.3-phase shiphter

Occasionally the designer needs an odd-phase combination. Seldom has an odder combination been achieved than in this multibranched circuit. The unusual intermingling of turns between the inductors leads to fractional splitting of ordinary sine waves fed into the network. Before they are emitted at other junctions, phases are split, differentiated, operated on and generally reconstructed. An ordinary 3-phase signal fed in will give a total of 8.3 phases emitted from the various terminals.

This could prove useful, say, for a damaged motor which no longer runs synchronously on a simple 3-phase signal; or it could provide an interesting test signal for checking malfunctions in digital computers, or for inducing malfunctions so that the checking procedure itself could be checked.

If you can think up an idea for a humorous electronics article, send it to Roger Kenneth Field, ELECTRONIC DESIGN, 850 Third Ave., New York City 10022. The best articles will be published and their authors will be paid at the standard ELECTRONIC DESIGN rate. A touch of humor can make the design week brighter. ■ ■



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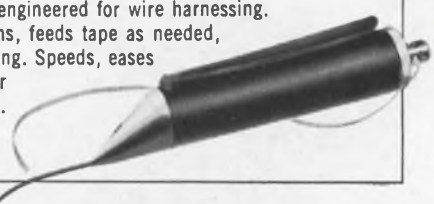

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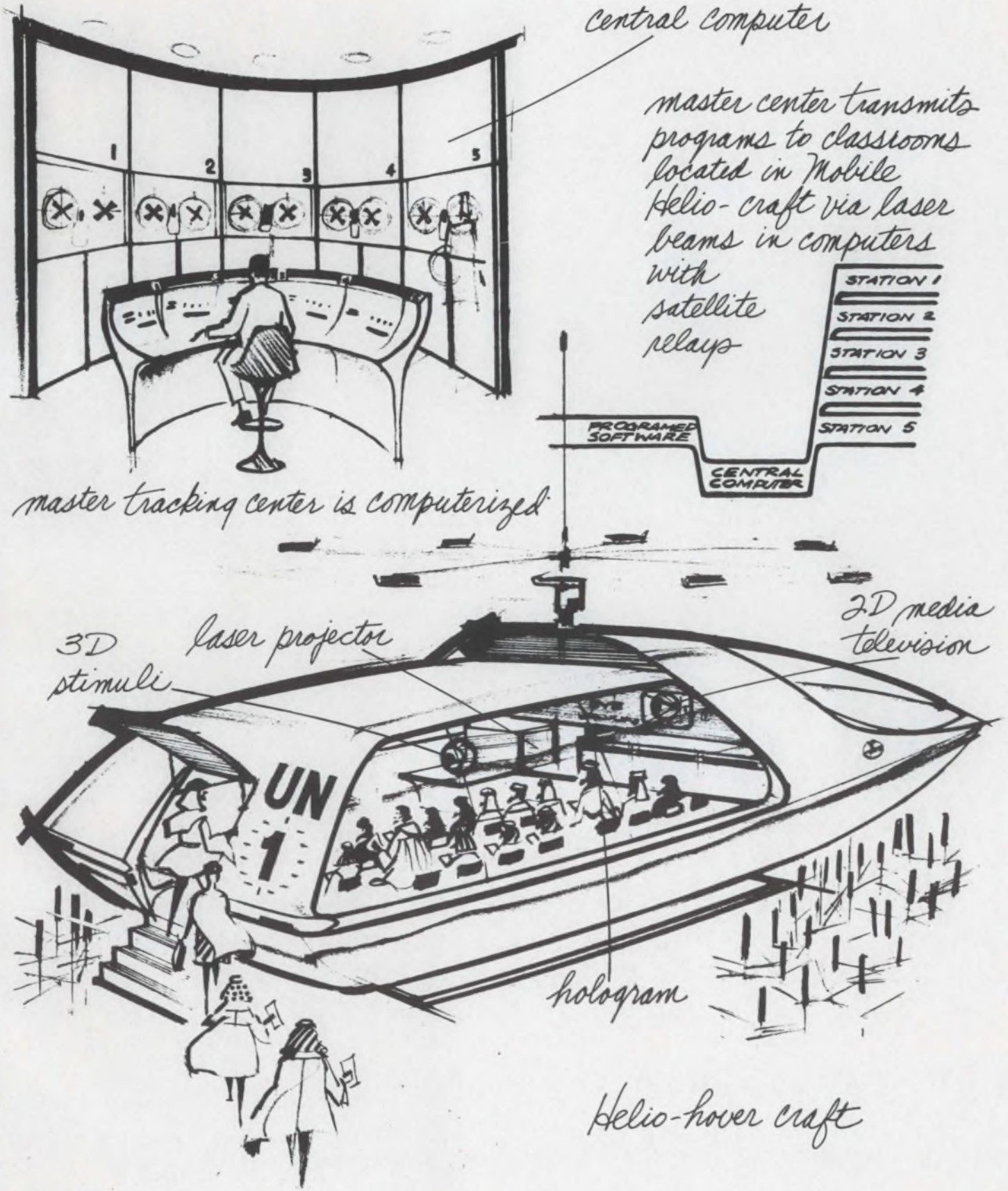
DESIGNERS 1985

THE DESIGNER: Raymond Loewy/William Snaith, Inc.

THE DESIGN: Teaching Flotilla

THE TRACING MEDIUM: Bruning Five Hundred



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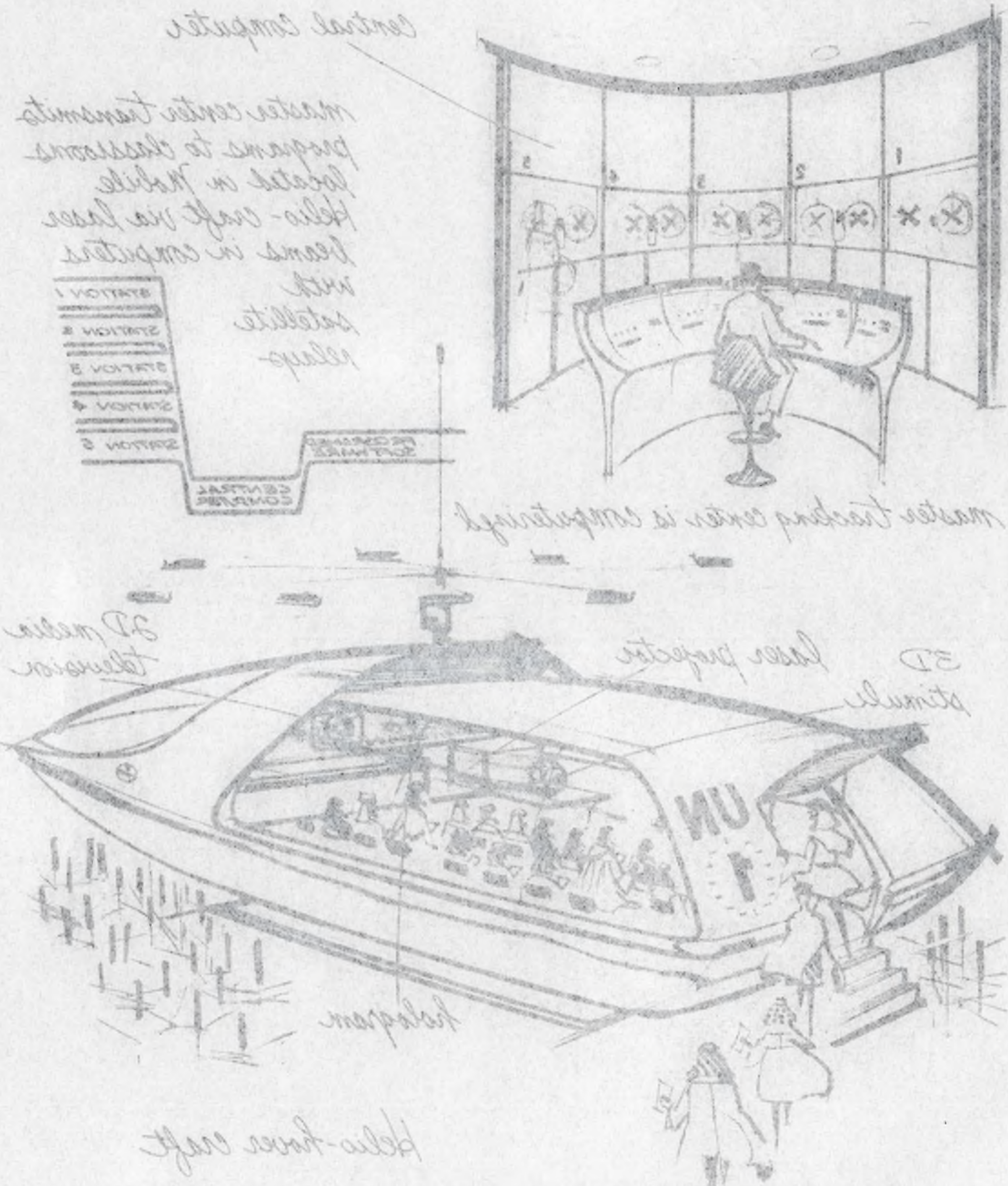

THE DESIGNER: There is scarcely an aspect of design in which the Loewy/Snaith touch has not figured prominently during the last thirty years. The firm is internationally known for its concepts of automotive designs, product development, specialized architecture, packaging and corporate identification.

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Switch solenoids with 75% power efficiency

Problem: Design a circuit having high power efficiency when operating solenoid valves.

Solution: A variable duty cycle pulser provides low-level holding currents once a high-level current has actuated the solenoid valves.

A one-shot pulser supplies the initial energizing current. To obtain the holding current for the solenoid valve, a variable duty-cycle pulser turns the power switch on and off. The pulse duration and frequency may be adjusted to regulate and maintain the holding current. Diode CR_1 serves a dual purpose: It suppresses the induced voltage surge when the solenoid valves are de-energized, and it circulates the decaying coil current back through the coil. This makes the decay time independent of other circuit parameters. Thus, the duty cycle is decreased, increasing the efficiency of the circuit.

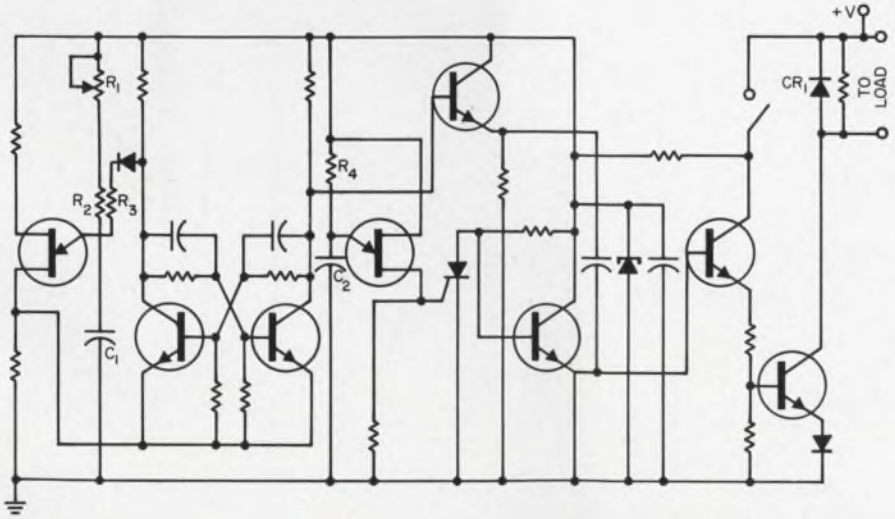
The variable duty-cycle pulser consists of a bistable multivibrator, symmetrically emitter-triggered by a unijunction relaxation oscillator. The time constant between pulses is determined primarily by the time constant C_1 $(R_1 + R_2)$. The time constant of the pulse is determined primarily by: C_1 $[R_3 \cdot (R_1 + R_2)]$ $/(R_1 + R_2 + R_3)$. The output of the multivibrator is capacitively coupled, through an emitter follower, to a two-stage current amplifier.

The one-shot pulser consists of a unijunction oscillator that triggers a silicon-controlled rectifier, which, in turn, operates a transistor switch. This switch saturates the two-stage current amplifier until the silicon-controlled rectifier conducts. The time for the initial pulse to cause switching is determined by the time constant $(C_2 R_1)$.

The power switch consists of the two-stage current amplifier. The voltage regulator is a simple shunt zener diode whose output is filtered by a capacitor.

The circuit operated two 8.7-ohm, 0.18-henry solenoid valves simultaneously, while the valves were under an equivalent pneumatic pressure of 220 psia. It had an efficiency of 77%. A minimum holding current of 0.3 A was necessary to keep the solenoid valves held in. The pulse duration was set to 0.53 ms, and time between pulses was set to 2.6 ms, which yielded a holding current of 0.5 A.

For further information, contact: Technology Utilization Officer, Manned Spacecraft Center, P. O. Box 1537, Houston, Tex., 77001. Refer to: B66-10034.



An electronic pad transmits hand-written messages

An electronic pad to transmit hand-written messages that can be displayed on an X-Y plotter or other X-Y displays, or the screen of a storage oscilloscope has been developed and a patent (South African Patent Application No. 66/4934) has been applied for.

The device (Fig. 1a) consists basically of two strips of plastic "conductive" tape (10 cm x 5 cm x 0.02 cm, manufactured by Hagaplast AB, Anderstorp, Sweden), metal plate underneath the strips, and an insulating support plate. The tape strips are crisscrossed giving about 5 cm^2 of useful writing area and are separated by thin spacers to prevent their touching each other. Nine volts dc are applied to each strip (separate sources are used in Fig. 1b) by means of metal clamps fastened to the insulating plate. The 5 cm x 5 cm metal plate under the tape crossover provides the common ground. The zero for both X and Y axes is set by the individual X and Y potentiometers. The resistivity of the "conductive" tape is about 3 $k\Omega/cm^2$.

The operation of the device is as follows: When the tapes are pressed down with a pen (an ordinary ball point, for instance) they make contact with each other and the metal plate. The resulting voltages between the center arms of the potentiometers and the common ground (metal plate) will uniquely define the contact point in the X-Y coordinates.

A photograph (Fig. 2) illustrates this technique applied to writing on the screen of a storage oscilloscope.

One can envision many applications where such

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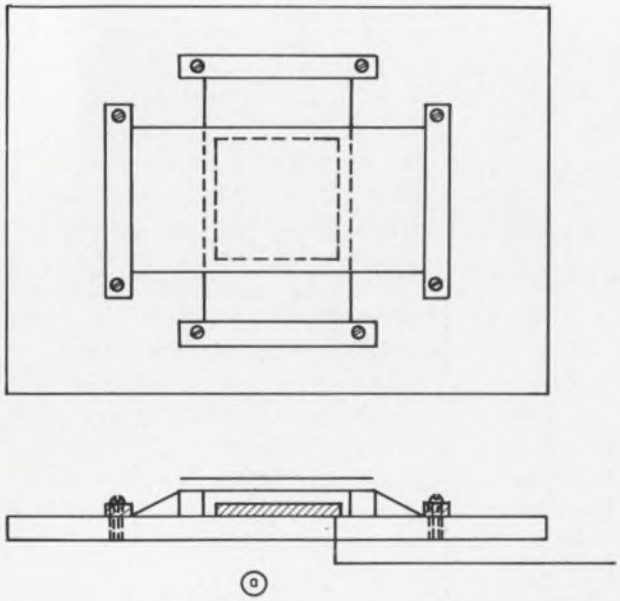
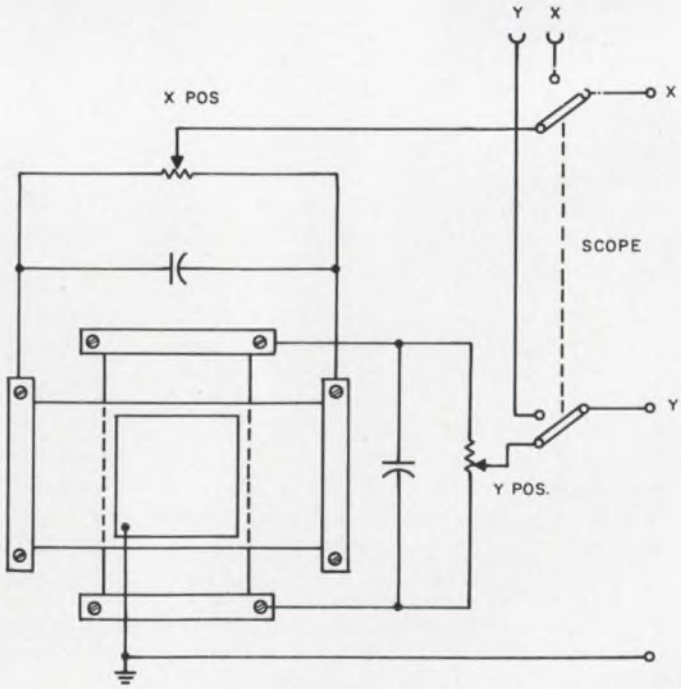




1. **Electronic pad** for handwritten messages (a) is built with two strips of conductive tape. With addition of two potentiometers and two 9-volt batteries (b) the system becomes operational.

ON READER-SERVICE CARD CIRCLE 63 ➤

Photo courtesy of Cardwell Condenser Corporation

Customer Report:

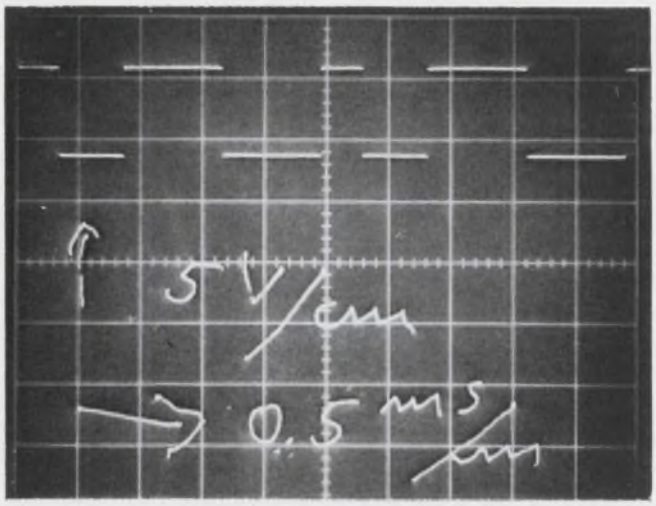
1680-A Triples Output

Cardwell Condenser Corporation uses the Type 1680-A Automatic Capacitance Bridge Assembly to test variable air capacitors by checking them at more than five points across the dial. The 1680-A is not only more accurate than the bridge it replaced, but the remarkable speed with which it measures has tripled output and eliminated the need to hire additional test personnel. Government inspectors find this bridge thoroughly acceptable.

The 1680-A automatically selects C and D (or G) ranges, then balances and displays measurements in digital form showing decimal point and units of measurement. Measurement takes only 0.5 second at 1 kHz under worst conditions. Basic accuracy is 0.1% of reading for C and G, 1% ±0.001 of reading for D. Measurement range is 0.01 pF to 1000 μF. The bridge provides BCD output; completely automated systems can be supplied. Price of 1680-A: $4975 in U.S.A.

For complete information, write General Radio Company, 22 Baker Avenue, W. Concord, Mass. 01781; telephone: (617) 369-4400; TWX: 710 347-1051.

GENERAL RADIO



2. **Message is "clear and loud"** and will follow a speedy hand as can be seen from the above oscillograph.

a device could be used. Plant-to-plant messages (telephone or radio), invoices, signatures, stock exchange sales reporting, to mention a few.

A. G. Engelter, Solid State Electronics Div., National Research Institute for Mathematical Sciences, Pretoria, Republic of South Africa.

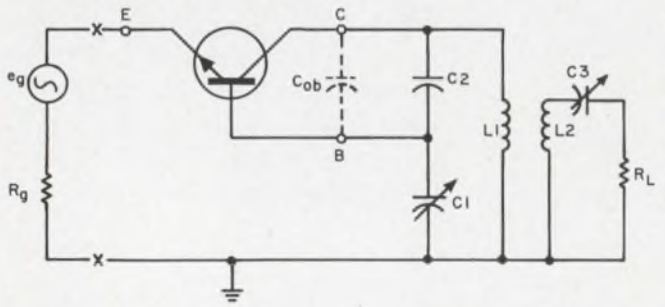
VOTE FOR 110

Low noise is achieved in wide-band amplifier

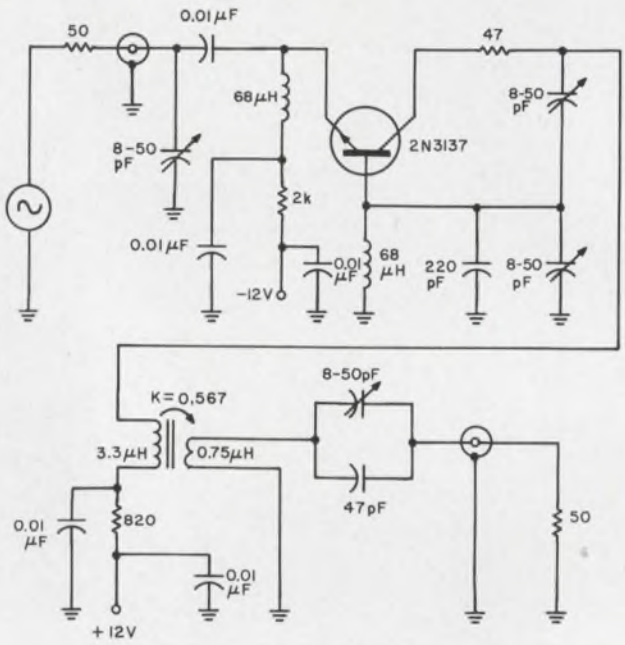
Minimum noise figure is achieved in a wide-band amplifier by use of reactive degenerative feedback to make the circuit input resistance equal to the source resistance. The resulting common-base amplifier also has a large dynamic range, stabilized gain and low input vswr.

The use of degenerative feedback reduces stage gain and makes it relatively independent of transistor parameter variations. With lower gain per stage, linear amplification of higher signal levels is possible.

The basic idea is illustrated in Fig. 1 in which



1. **Basic RF configuration** for a common-base amplifier featuring low noise and wide bandwidth.



2. **Practical circuit** with 15-MHz band centered at 22 MHz.

biasing and bypassing details have been omitted for clarity. The desired center frequency is obtained by resonating transformer inductance *L1* with the capacitors C_{ob} + *C2* in series with *C1*. Also resonated at the center frequency are the transformer's secondary inductance, *L2*, and *C3*. The capacitor *C1* is then adjusted so that the impedance looking into the terminals *x-x* is equal to the optimum generator resistance, R_g, for a minimum noise figure.

Basically, the circuit operation is as follows:

A fraction of the output voltage from collector to ground appears across capacitor *C1* from base to ground. This voltage is in series with the generator voltage and tends to reduce the generator current, resulting in increased input impedance. The emitter-to-base voltage is reduced due to the canceling effect of the voltage across *C1*, thus reducing the over-all gain of the amplifier. Thus, the degenerative feedback voltage across *C1* raises the normally low input resistance of the common-base amplifier to a value equal to the optimum source resistance for the lowest noise figure.

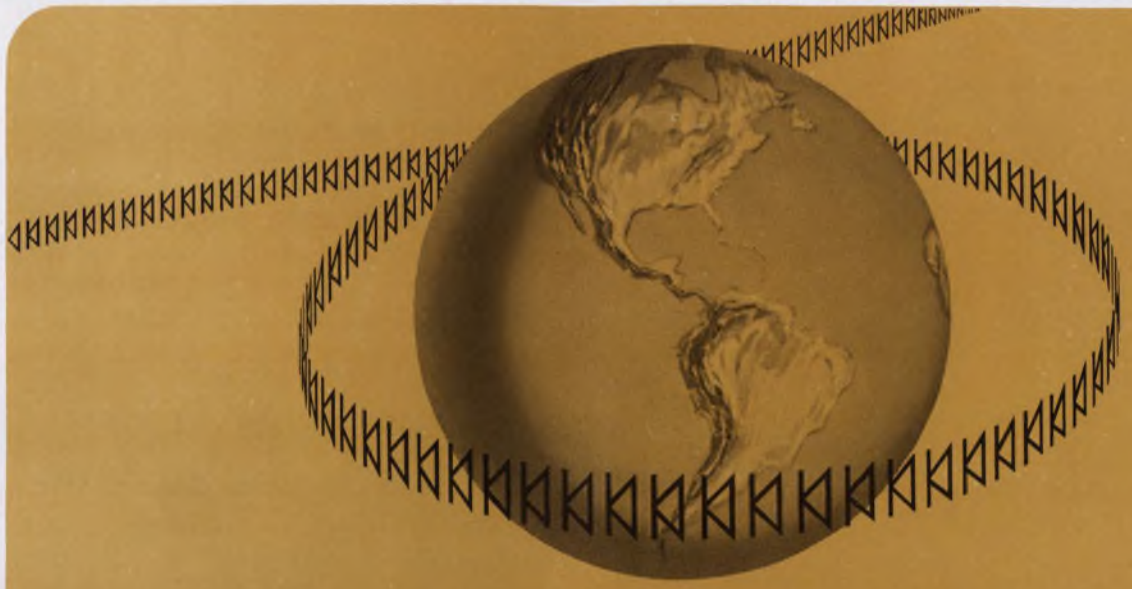
Analysis results in the following approximate formulas:

$$R_{xx} \cong k\alpha R_c \qquad (1)$$

$$G \cong \alpha / k \qquad (2)$$

where R_{xx} = input resistance looking into *x-x*; k = voltage feedback ratio (ratio of voltage across *C1* to voltage from collector to ground); α = transistor collector-to-emitter current ratio; R_c = collector-to-ground-referred load resistance, and G = power gain from terminals *x-x* to load R_L.

These approximations ensure that G is much



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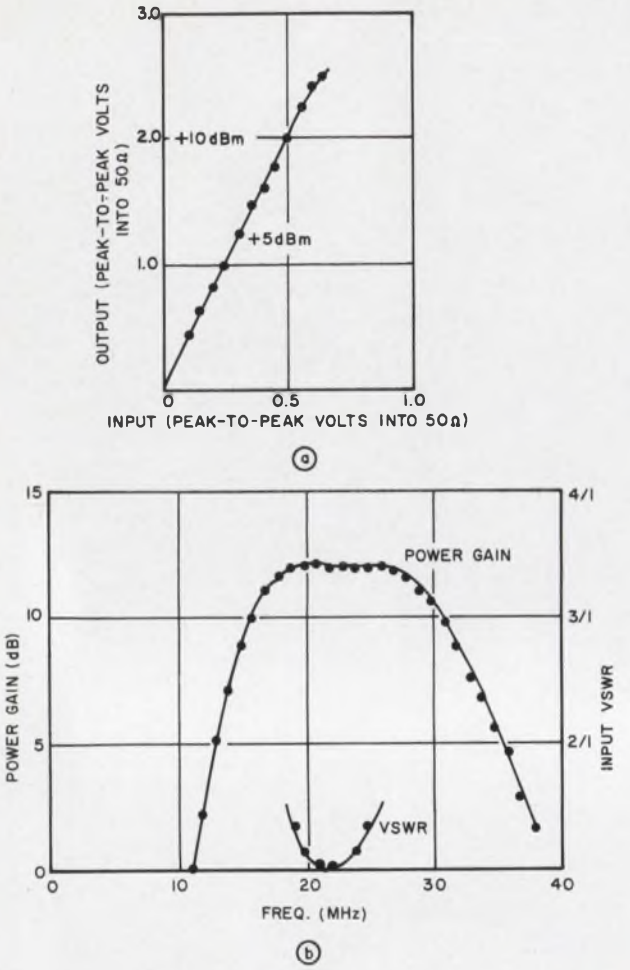
ON READER-SERVICE CARD CIRCLE 64



3. **Linearity (a) and power gain** and input vswr vs frequency curves (b) show performance achieved in the resulting circuit.

smaller than the gain without feedback. The above equations are for the center frequency. Analysis shows that input impedance of the circuit, as a function of frequency, is the same as it would be if the output circuit (transformed to the value of R_{xx}) were applied at the input terminals x-x. Feedback also makes the circuit gain, G, a less sensitive frequency function. In addition, the 3-dB bandwidth of G is increased by the ratio of gain-without-feedback to gain-with-feedback.

An amplifier circuit, designed and successfully applied at Bendix, used the theory described above and had the following parameters:

Gain:	10-13 dB
Noise figure:	Less than 6 dB
Dynamic range:	Linear to −5 dBm
Input impedance:	50 Ω
Center frequency:	22 MHz
Bandwidth:	Greater than 15 MHz (flat bandpass 20 to 24 MHz)

Figure 2 shows the schematic circuit diagram of a transistor amplifier stage having the required characteristics. Performance is illustrated by Fig. 3a (linearity) and Fig. 3b (power gain and input vswr vs frequency).

A. I. Sinsky, Design Engineer, Government Products, Bendix Radio Div., The Bendix Corp., Baltimore.

VOTE FOR 111

Noise measurements on ICs: dynamic tests — yes; dc — no

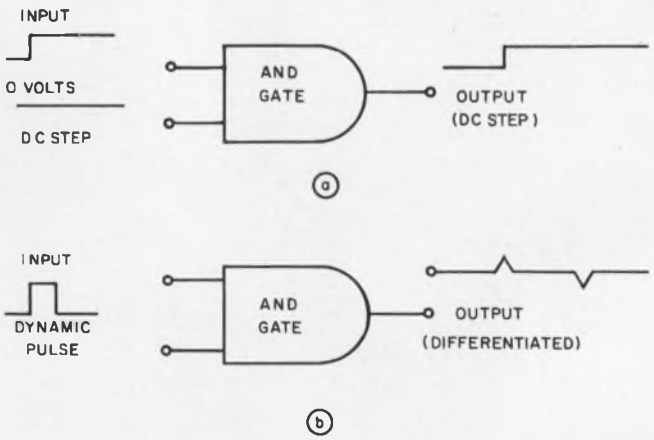
When integrated circuits are tested by dc methods, a meaningful evaluation of the IC noise behavior cannot be made. Such key measurements as noise feedthrough and noise immunity may be accurately determined only by dynamic testing.

IC users should avoid dc tests even as a "rough" index of the noise behavior, lest a perfectly good device be needlessly rejected as having too little noise immunity. Dc means may fail the IC whereas a dynamic measurement would indicate a passing noise immunity for the very same circuit.

When a dc signal (step function) is applied to the gate of the IC (Fig. 1a), internal stray capacitances in the gate will become charged and the output will hold at some finite level. This output does not reflect the true noise feedthrough, because it resembles a step, rather than the pulse waveform which is representative of the noise quantity.

When a dynamic pulse is applied to the input (Fig. 1b) the stray capacitance is not permitted to retain a charge; a spike appears at the output. This spike is really a differentiated version of the input and represents circuit filtering action on the noise.

The noise immunity characteristic of ICs is



1. **Noise feedthrough** in ICs measured by dc testing (a) is not adequately determined; it must be established by dynamic pulse means (b) so that output truly reflects filtering action of the circuit.

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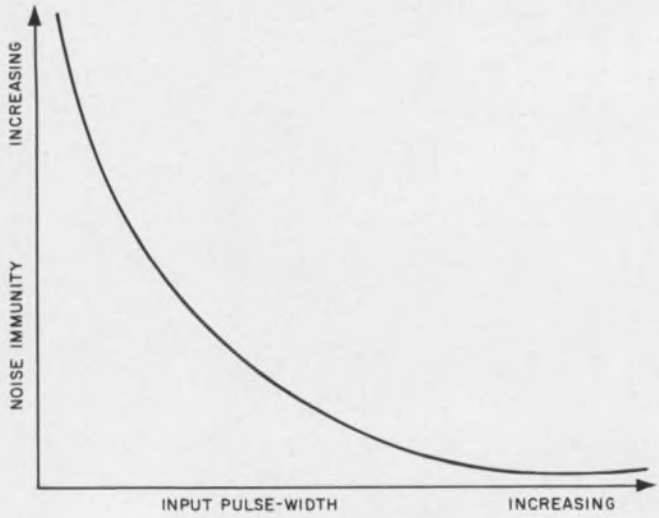


2. **Noise immunity** in ICs increases with decreasing pulse widths in the input signal.

such that it increases with decreasing pulse widths (Fig. 2). Thus if another IC stage is connected as the "load" for the gate stage mentioned above, the gate under dc stimulus passes a wider output pulse to the load stage's input than if a dynamic stimulus were used. With the dc test, the noise immunity of the second stage and noise feedthrough appear to be high enough to "fail" (reject) both ICs. Yet the same measurements conducted dynamically truly indicate the ICs' suitability (passing grade).

Dug Roy, Engineer, Industrial Products Group, Texas Instruments Inc., Houston.

VOTE FOR 112

Low drain SCS forms relaxation oscillator

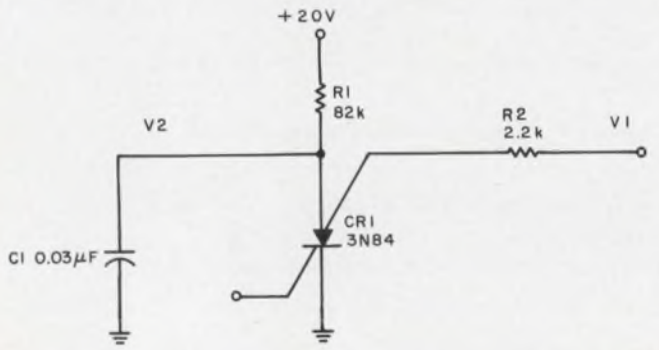
One silicon-controlled switch, a capacitor, and two resistors are all that are required to build a relaxation oscillator.

In the circuit (see schematic), *CR1* is assumed to be OFF. As the capacitor charges through *R1*, V_2 increases; when it is a half a volt greater than V_1, the SCS fires and discharges the capacitor. *R1* is large enough to limit the current to less than the required holding current of the SCS. Once the capacitor is discharged, the SCS blocks and the capacitor begins to charge again. The frequency of the oscillator has been varied from 200 Hz to 20 kHz by alteration of the threshold potential of V_1.

This circuit is particularly useful in portable devices where the battery life is of prime consideration. It is superior in this application to a more obvious relaxation oscillator using a unijunction transistor, which requires some stand-by current.

W. R. Harden, Electronic Engineer, Chesapeake Systems Corp., Cockeysville, Md.

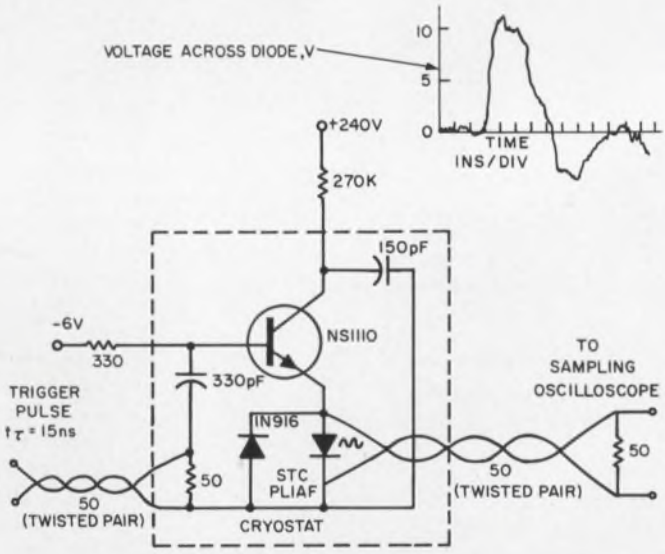
VOTE FOR 113



1. **Key to the operation of the relaxation oscillator** is the value of R1. Its value must be high enough to keep the ON current of the SCS below its holding current.

Put transistor in cryostat to pump GaAs laser diodes

Pumping a cryogenically cooled gallium-arsenide laser diode with an outside generator can prove troublesome. But here is an idea that may solve your problem. Silicon transistors, operating in the avalanche mode, are not affected by cryogenic temperatures; so they may be placed inside the cryostat and coupled directly to the laser diode.



Silicon transistor is placed inside cryostat for efficient pumping of gallium-arsenide laser diode.

When used as shown in the circuit, silicon transistors can produce current pulses in excess of 10 A with a rise time of 1 μs (see the waveform across the diode).

Y. U. Hussain and M. C. Stevens, Electrical Engineering Research, The City University, London, England.

VOTE FOR 114

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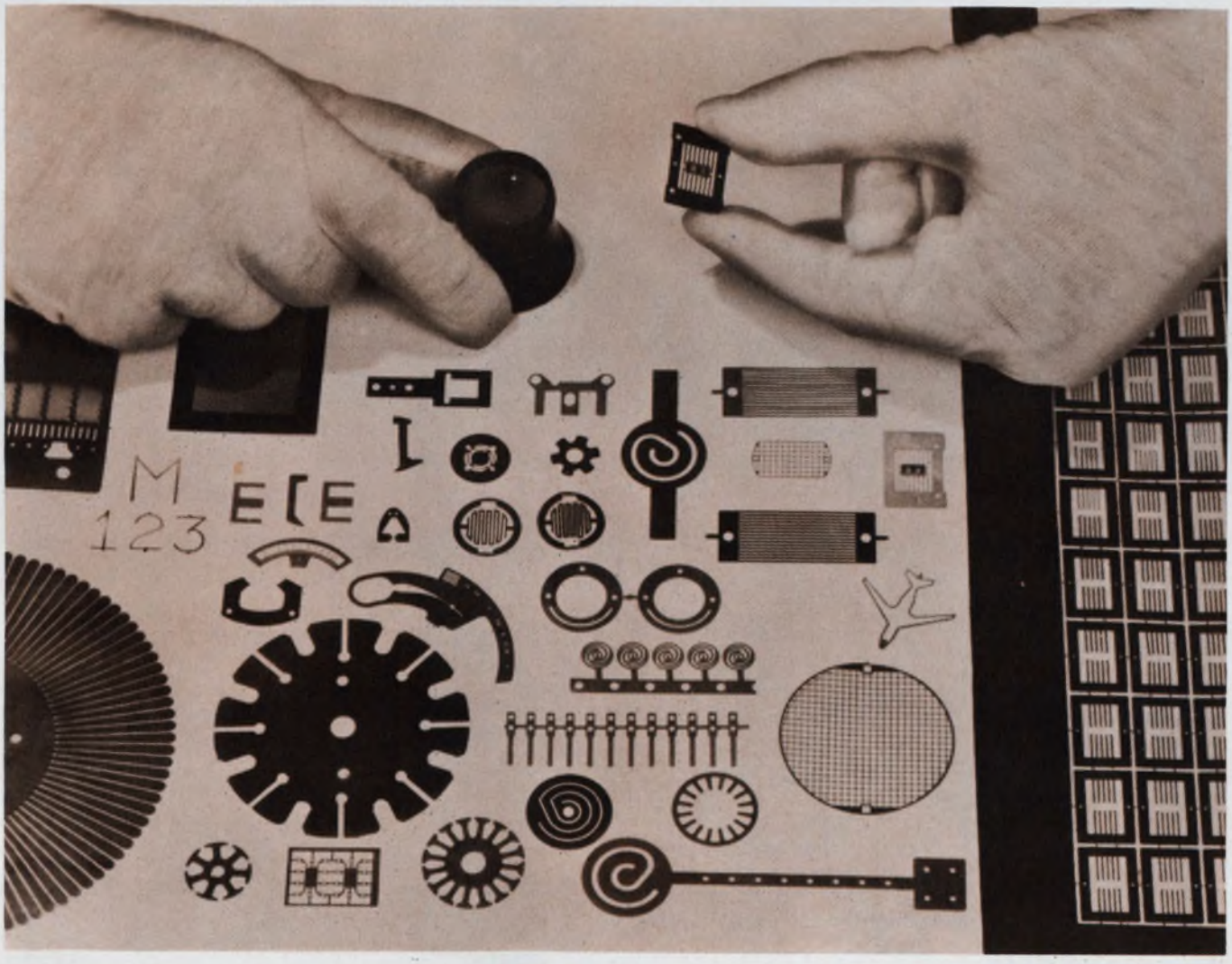


ON READER-SERVICE CARD CIRCLE 66

Probe in resonator wall changes coupling of filters

A capacitive probe in the removable partitions of microwave band-pass filters allows the engineer to change the bandwidth by adjusting the interstage coupling.

At microwave frequencies, band-pass filters are usually constructed with quarter-wave TEM cavity resonators. Adajcent resonators are coupled through apertures in the metallic partitions, or by direct electromagnetic coupling without partitions. In either case, changes in the interstate coupling require major refabrications. Removable partitions solve only half the problem, since the aperture can only be enlarged, not shrunk; consequently, only an increase in the coupling is possible, not a decrease.

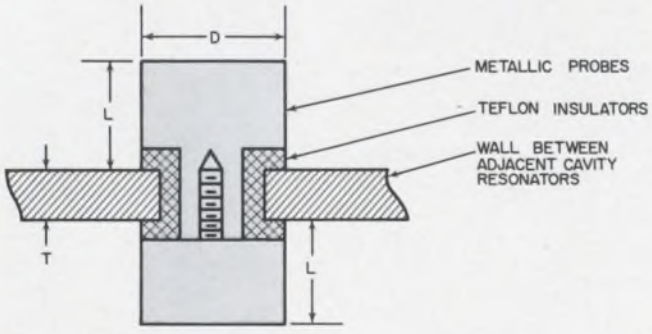
A probe, in conjunction with the inductive aperture, can increase or decrease the coupling through the capacitive nature of the air gap created between the resonator's center conductor and the probe face. As the probe's length, L, is increased, for example, the air gap becomes smaller and the coupling between adjacent resonators increases. The probe is shown in Fig. 1.

Since the amount of coupling determines the bandwidth of the filter, these adjustments are critical as system requirements are varied. The coefficient of coupling is related to the bandwidth in the following manner:

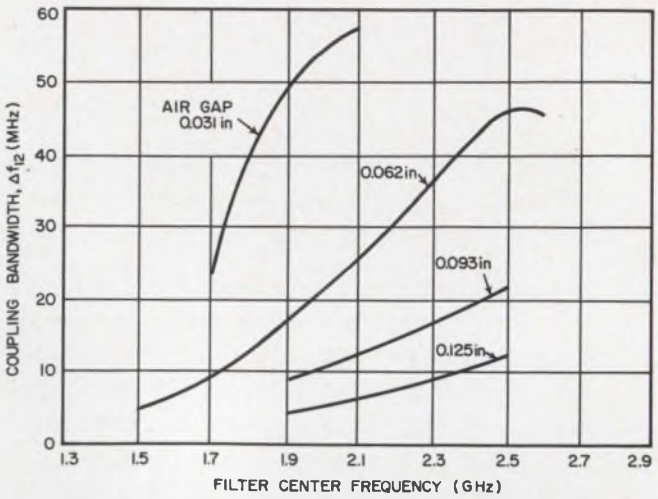
$$K_{12} \cong \Delta f_{12}/f_o,$$

where Δf_{12} is the coupling bandwidth and f_o is the filter's center frequency.

There is no analytical design procedure for the probe, since no equation exists that would relate the capacitance between a flat plate (probe head) and a cylindrical surface (center conductor of resonator). Other factors that complicate the analytical approach are the nonuniform cross section of the resonator and the interconnection of the two series coupling capacitors, formed by the two air gaps, with a short transmission line. In addition, when the air gaps become very small, the field will be distorted inside the cavity. Consequently, the design of the probe must be made by empirical methods. (This is also the situation with many other microwave coupling mechanisms, including input-output probes and loops.)



1. **Capacitive probe mechanism** can increase or decrease the interstage coupling of microwave cavity-type filters. The probe's length, L, changes the air gap between the center conductor of the resonator and the metallic partition separating the cavities.



2. **The air gaps on the two sides of the partition** are changed by inserting probes of different lengths. The variation of the coupling bandwidth with the center frequency is greatly affected by the size of the air gaps.

The discrete changes in the coupling are achieved with pairs of metallic probes of different lengths. Each pair provides different air gaps. Each probe consists of a threaded piece and a tapped piece, so that the pairs can be simply screwed in and out.

Such a probe system has been used with a comb-filter structure. The diameter of the probes is 0.250 inch and their length ranges from 0.062 to 0.156 inch. This range corresponds to air gaps of from 0.125 to 0.031 inch. The variation of the coupling bandwidth with the air gaps is plotted in Fig. 2, as the center frequency is changed from 1.5 to 2.5 GHz.

Richard M. Kurzvok, Radio Corp. of America, New York. VOTE FOR 115

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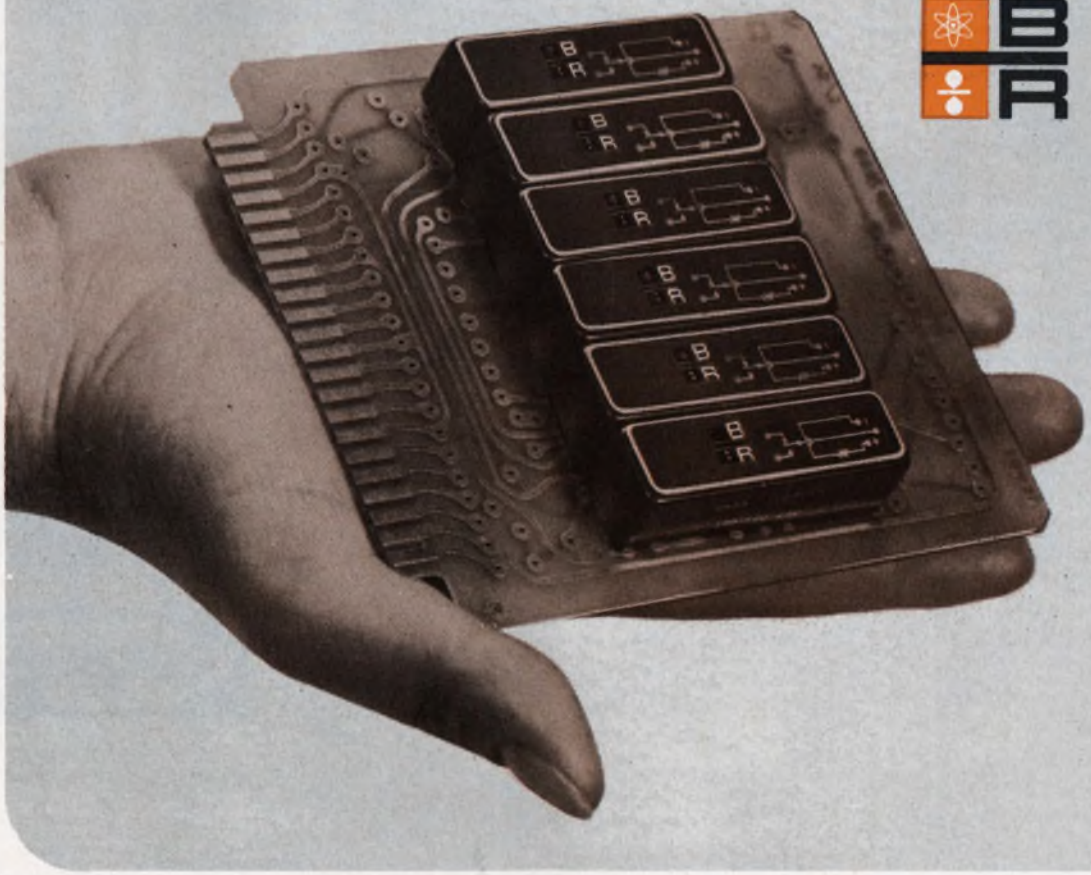
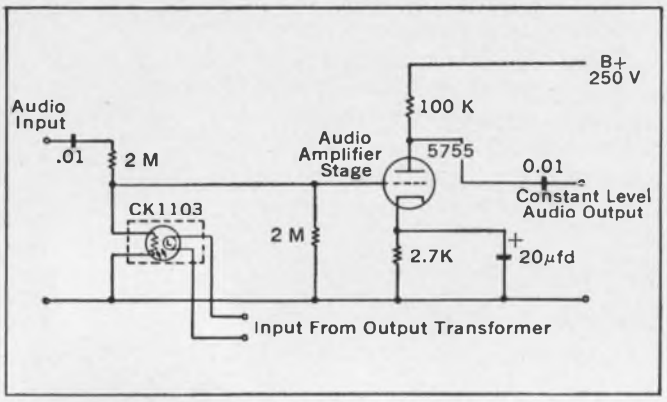
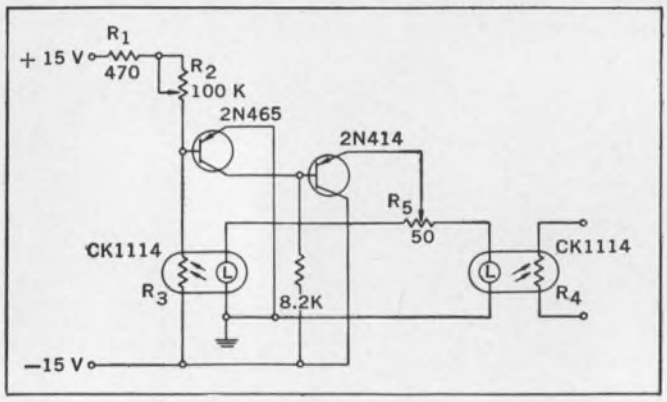


ON READER-SERVICE CARD CIRCLE 67

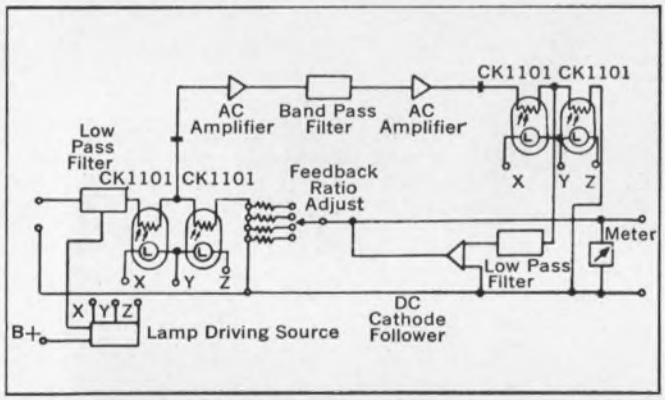
3 ways you can use the Raysistor® to improve your product, cut costs



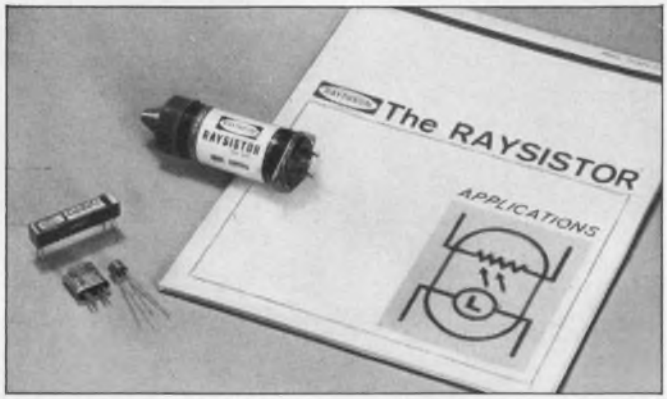
1. Use the Raysistor® as a simple remote or automatic volume control in SSB suppressed carrier receivers. Feeding part of the audio output into the control light source varies the resistance of the Raysistor's photocell, making it usable in place of a normal volume control.



2. As a remotely controlled linear potentiometer. The Raysistor can be used as a remotely controlled linear potentiometer when used in the circuit shown above. Here the Raysistor forms a voltage divider between the positive and negative voltages.



3. As a photochopper stabilized D-C microvoltmeter. Raysistors, used as photochoppers in both modulator and demodulator circuits, enable d-c levels to be measured to a fraction of a microvolt. They facilitate synchronous detection and demodulation with simple electrical coupling, have less noise than transistor choppers, while avoiding maintenance problems of mechanical choppers. Other photochopper applications: photochopper relay, series or shunt chopper, modulator circuit, and as a stabilizer to reduce long-term drift.



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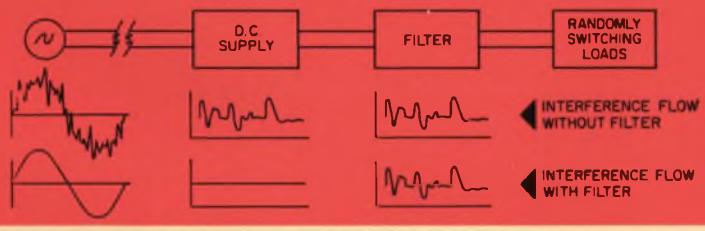
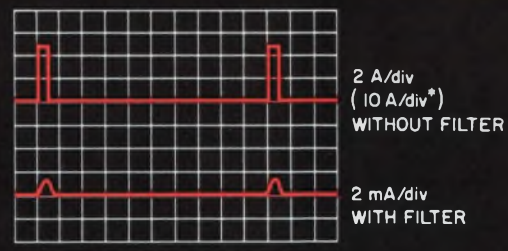
Allen-Bradley Active Filters, which offer a 60 db attenuation over the range of 10Hz (3Hz*) to 100KHz

Allen-Bradley active filters can provide as much as a 50 to 1 reduction in size and a corresponding reduction in weight over conventional passive elements.

The diagram below and performance curve at right illustrate how Allen-Bradley *active* filters prevent current fluctuations in the power distribution system above 10Hz (3Hz*), developed by pulse modulated communications equipment, such as teletypewriters and other randomly varying loads.





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Allen-Bradley active filters produce a far greater attenuation of unwanted signals than is possible with a filter composed of conventional passive elements, occupying the same volume. By using the A-B *active* filter, a size reduction of 50 to 1 is attained, together with corresponding savings in weight. These filters employ solid-state circuitry. No external power source is required other than that supplying the power to the load. In addition, complete inrush and short circuit protection is provided.

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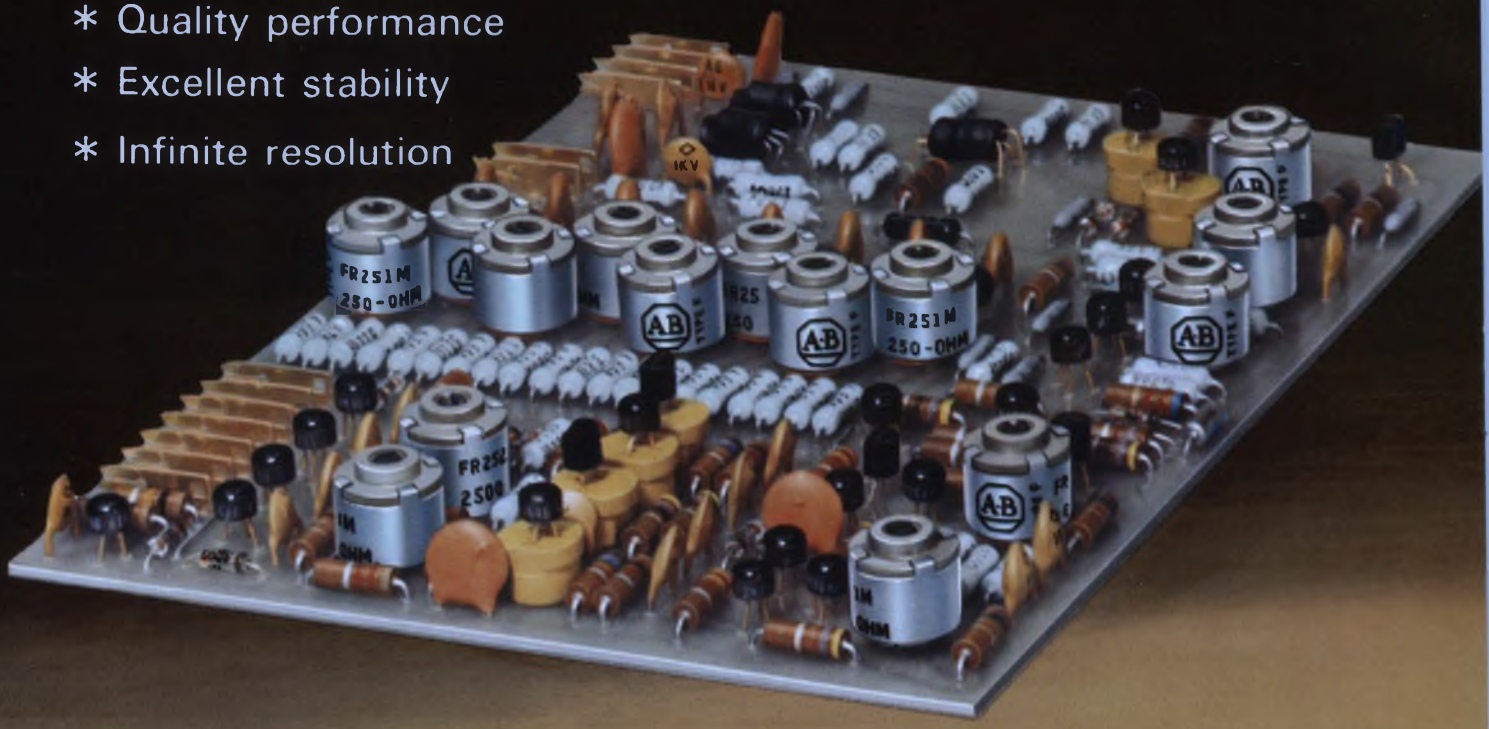
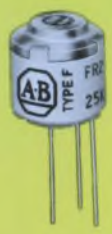


One of the 5-inch by 6½-inch Wavetek printed circuit cards, showing 15 of the 25 Allen-Bradley Type F hot molded variable resistors and numerous hot molded fixed resistors used in the Model 111 VCG function generator.

Type F variable resistor with pin type terminals for mounting directly on printed wiring boards. Rated ¼ watt at 70°C. Total resistance values from 100 ohms to 5 megohms.



Actual Size

Wavetek Model 111 VCG generates sine, square, triangle, and ramp waves from 0.0015 Hz to 1 MHz, and offers precision control of the frequency of the waveforms by external voltage.

■ The precision waveforms generated by Wavetek's Model 111 VCG place exacting demands on the large number of variable resistors used to set amplitudes to very precise values and assure symmetry of all functions. They must provide velvet smooth control, and quiet operation. And since this is a Wavetek adjustment, it is essential that the variable resistors, once adjusted, will stay "put".

Allen-Bradley Type F variable resistors satisfy all of these requirements, because they have the same solid hot molded resistance track as the famous Type J and Type G variable resistors. There's velvet smooth control at all times—never the problem of discrete steps common to all wire-wound units. And since Type F variable resistors are essentially noninductive and have low distributed capacitance, they can be used at high frequencies where wire-wound controls are useless.

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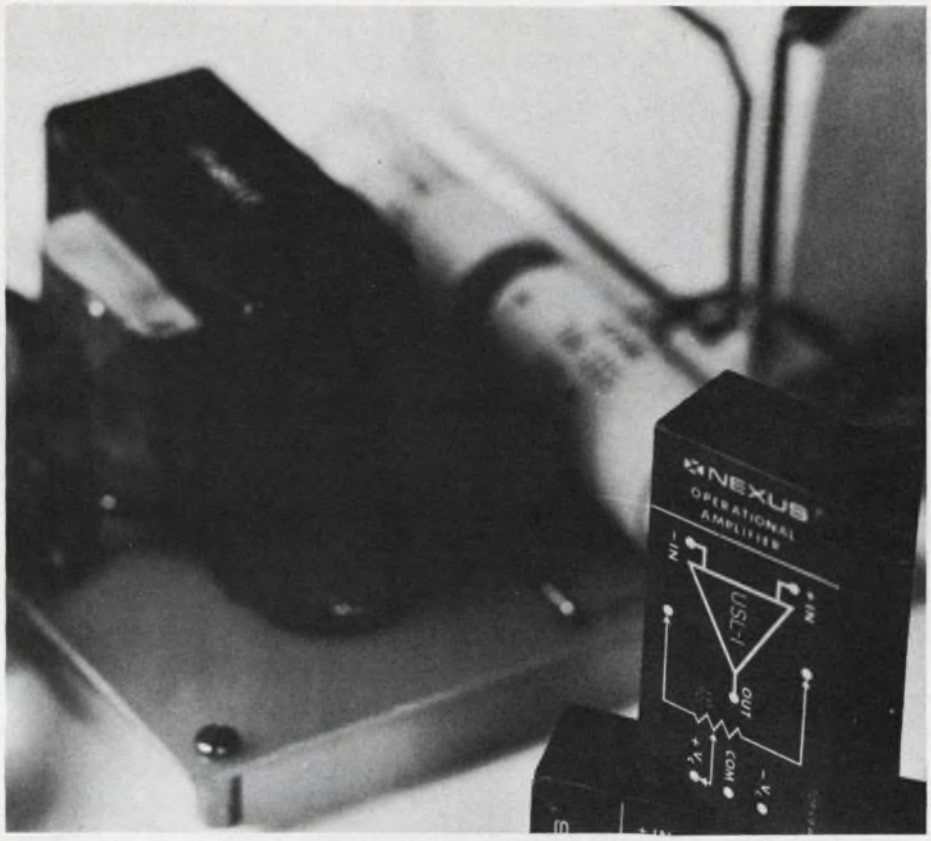
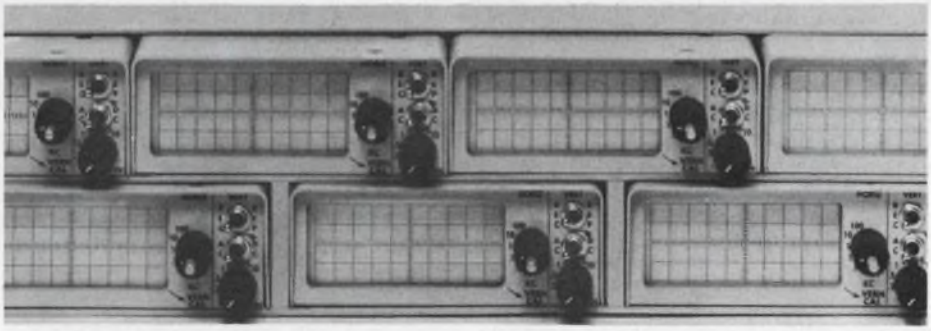
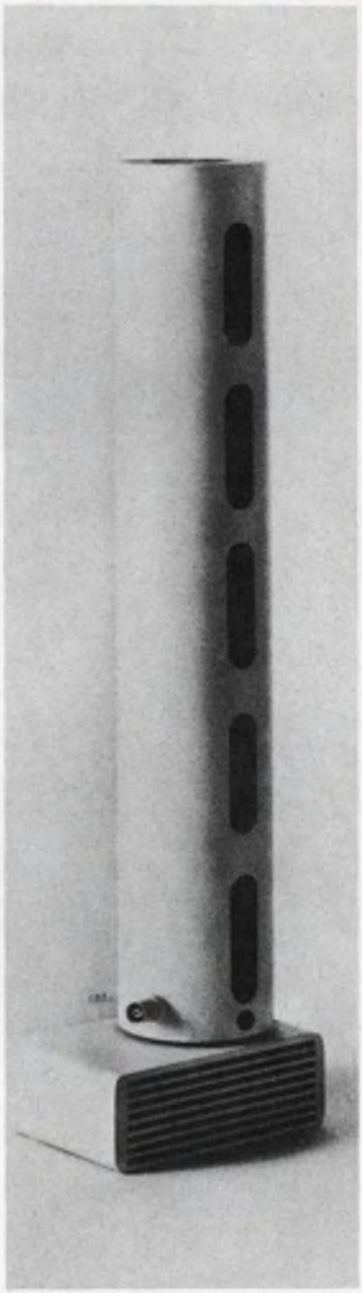


Power this op-amp with an unregulated supply. Use a regulated supply and stability is remarkable. Page 150



Very slow sweep speeds and high-persistence CRTs make this 7-channel monitor scope a natural for medical work. Page 182



Big TWT outputs come in little packages. Page 172

Also in this section:

Chopper-stabilize your differential op-amp. Page 152

Matched silicon chopper pairs have low saturation resistance. Page 177

Polyester fiber behaves electrically like mica. Page 210

Ultra-stable op-amp needs no supply regulation

Nexus Research Laboratory, Inc. 480 Neponset St., Canton, Mass. Phone: (617) 828-9000. P&A: $75 (USL), $35 (ESL); stock.

A new breed of operational amplifier, able to be operated from a wide variety of power sources, regulated or unregulated, has been announced by Nexus Research Lab, Inc. According to Roger Noble, Nexus' president, the new design is "so nearly universal in application that it is conservatively expected to be capable of replacing 70 to 75% of all operational amplifier types currently on the market."

For the designer of new systems the USL-1 offers freedom from limitations imposed by existing power supplies and/or the economic considerations often involved in building or buying special regulated supplies. It will eliminate situations in which the power supply costs two or three times the price of the op-amp itself.

The new units provide virtual immunity from input power variations (Fig. 1). They can be operated from dry or wet batteries, automobile or aircraft electrical systems, integral digital equipment supplies, or any other convenient source of power providing between ±8 to ±25 V. The 5-mA units are fully protected against shorts, overloads and overdrives.

When used with conventional regulated supplies, the new design offers remarkable stability of offset voltage and offset current vs common-mode voltage (Fig. 2). The offset voltage and current stabilities vs time and temperature have been significantly improved, particularly with regard to warm-up time.

Not only is the need for power supply regulation eliminated, but it is also unnecessary for the positive and negative supply voltages to track each other. The close offset voltage tolerance allows for additional savings, since no external offset trimming pot is required for most USL-1 applications.

The new design offers a number of additional advantages. Warm-up drift is of the order of microvolts instead of millivolts. Electrical characteristics are constant and optimized over the entire supply voltage range. And because of its extremely high common-mode rejection (see Fig. 3), the unit offers substantially greater accuracy than previous designs when used as a follower, subtractor, nonintervening amplifier, etc.

Because of the lack of power supply restrictions, the units could substantially reduce inventory and stocking for large amplifier users.

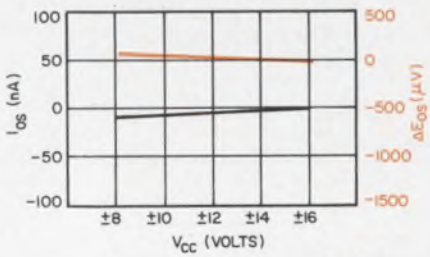
Typical specifications

Supply	±8 to ±25 V (USL) ±8 to ±16 V (ESL)
Output, common-mode voltage	±20 V from ±25-V supply ±10 V from ±15-V supply ±3 V from ±8-V supply
Output current	±5 mA
Common-mode rejection	120 dB
Input impedance	0.3 MΩ
Power supply rejection	3 μV/V, 0.3 nA/V
Gain into 10 kΩ	100,000 (USL) 50,000 (ESL)
Temperature coefficient	3 μV/°C (USL) 10 μV/°C (USL)
Slewing rate	1.5 V/μs
Common-mode stability	3 μV/V, 0.3 nA/V

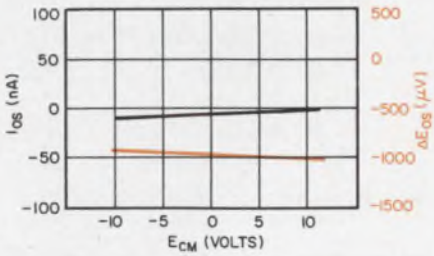
Prices, although somewhat higher than the lowest cost conventional op-amp, are put into context when considering power requirements.

Two versions are presently available. The premium model, USL-1, is an encapsulated unit incorporating high-reliability MIL type components and all-silicon semiconductors. The lower cost commercial version, ESL-1, also employs all-silicon semiconductors and is designed for use in less demanding applications. Specifications on both models are tabulated above.

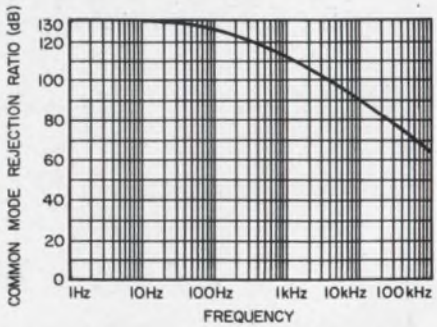
CIRCLE NO. 211



1. **Virtual immunity from power supply** variations is evident as offset voltage and current remain nearly linear as the supply varies from ±8 to ±16 V.



2. **Use with regulated supplies** increases stability. Offset voltage and current again remain linear over a ±10-V common-mode swing.



3. **High common-mode rejection ratio** is evident over a 10-Hz to 100-kHz range. Conventional units run about 50 dB less.

ON READER-SERVICE CARD CIRCLE 70 ➤

Amperex

LDS™

are now available in production quantities for a wide range of hybrid I.C. applications including:

RF, IF, AUDIO and LOW NOISE AMPLIFIERS, OP AMPS
D to A CONVERTERS, HIGH VOLTAGE or HIGH CURRENT SWITCHES,
OSCILLATORS, MIXERS, MULTIPLIERS, DECODERS and many more.

You can get off-the-shelf delivery, right now, of seven basic groups of silicon planar NPN and PNP transistors and two families of dual diodes packaged in the new Amperex LIDS. These nine groups of microelectronic semiconductors, functionally replace hundreds of different types for all your hybrid applications listed above.

HIGH SPEED SWITCHES (NPN)

LDS 200
LDS 201

functionally replace the following types:

2N706 2N744 2N914
2N708 2N834 2N2368
2N743 2N835 2N2369

GENERAL PURPOSE AMPLIFIERS (NPN)

LDA 402
LDA 403

functionally replace general-purpose amplifiers operating from 1 to 100 ma, such as:

2N696 2N2218
2N697 2N2219
2N1613 2N3390
2N3391

DUAL DIODE-COMMON CATHODE GENERAL PURPOSE and HIGH SPEED SWITCHING DIODE

LDD 10

MEDIUM CURRENT AMPLIFIER AND SWITCH (NPN)

LDA 404
LDA 405

(COMPLEMENT TO LDA 452 AND LDA 453)

functionally replace the following types:

2N2217 2N2220 2N1711
2N2218 2N2221 2N718A
2N2219 2N2222 2N871
2N1613

HIGH FREQUENCY RF AMPLIFIER (NPN)

LDA 406

functionally replaces type 2N918

GENERAL PURPOSE AMPLIFIER AND SWITCH (PNP)

LDA 450
LDA 451

functionally replace the following types:
2N2604, 2N2605

HIGH GAIN, LOW LEVEL AMPLIFIERS (NPN)

LDA 400
LDA 401

functionally replace the following types:

2N929 2N2483
2N930 2N2484

MEDIUM CURRENT AMPLIFIER AND SWITCH (PNP)

LDA 452
LDA 453

(COMPLEMENT TO LDA 404 AND LDA 405)

functionally replace the following types:

2N2904 2N2906
2N2905 2N2907

DUAL DIODE-COMMON ANODE GENERAL PURPOSE and HIGH SPEED SWITCHING DIODE

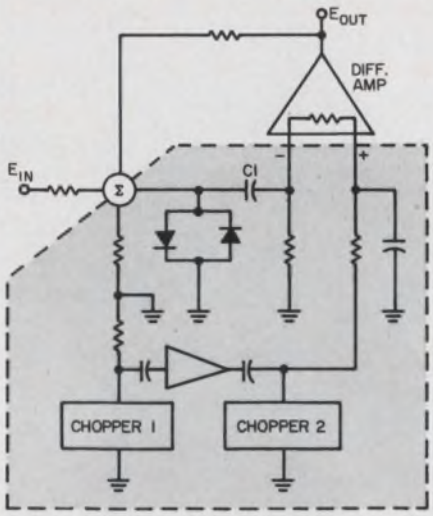
LDD 50

The LID, introduced by Amperex last March, is the all-ceramic microelectronic package for semiconductors which brought mechanized production to hybrid integrated circuit manufacture. Smaller (0.075" x 0.045" x 0.032") and less costly than any existing metal package, it has already become the standard

of the industry. To learn more about the immediately available LIDS listed above and about additional transistors and diodes which will soon be available in the Amperex LID package, write: Amperex Electronic Corporation, Semiconductor and Receiving Tube Div., Dept. 371, Slatersville, Rhode Island 02876.

Amperex

TOMORROW'S THINKING IN TODAY'S PRODUCTS



Chopper-stabilize your differential amplifier

Computer Dynamics, Inc., 179 Water St., Torrington, Conn. Phone: (203) 482-7621. P&A: $105 (1 to 9); stock.

Chopper stabilization can be applied to any existing differential amplifier by the addition of a small, low-cost module. Total cost is below that of high-accuracy chopper-stabilized diff amps.

The model 10M3 chopper-stabilizing amplifier increases stability in four troublesome parameters:

- Offset voltage
- Offset current
- Dc gain
- Input resistance

In the circuit arrangement shown above, an ac input signal at the summing junction (Σ) is coupled through C1 to the negative input of a differential amplifier, and a filtered dc component through chopper 1 is amplified, synchronously demodulated by chopper 2, and filtered, appearing at the positive input of the differential amplifier. Diodes protect the capacitors from overvoltage.

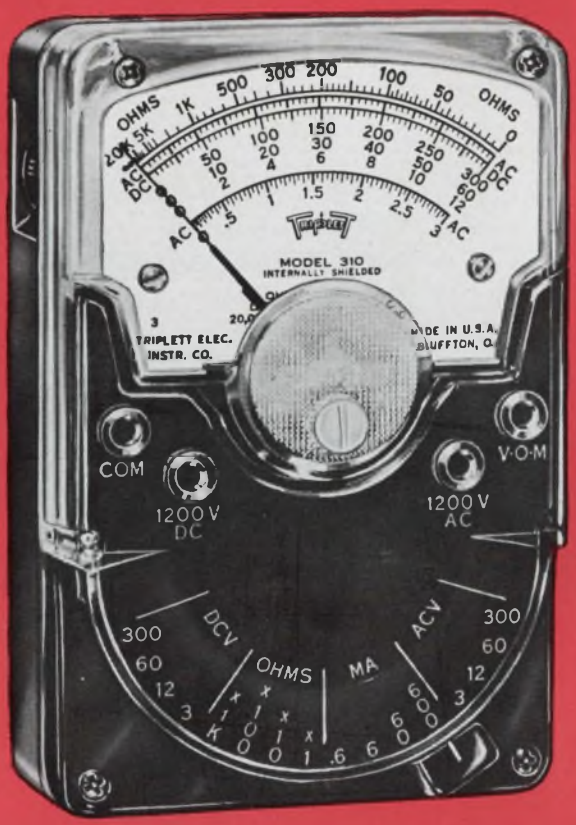
Large values of input and feedback resistance may be used with high accuracy as a result of chopper stabilization. The ac amplifier employs MOS-FETs. The nominal dc gain of the unit is 750; input offset voltage is $\pm 50\ \mu V$ max.

The module dimensions are 2.5 by 1.5 by 0.625 inches. The unit can be mounted on a printed-circuit board with the differential amplifier.

CIRCLE NO. 212

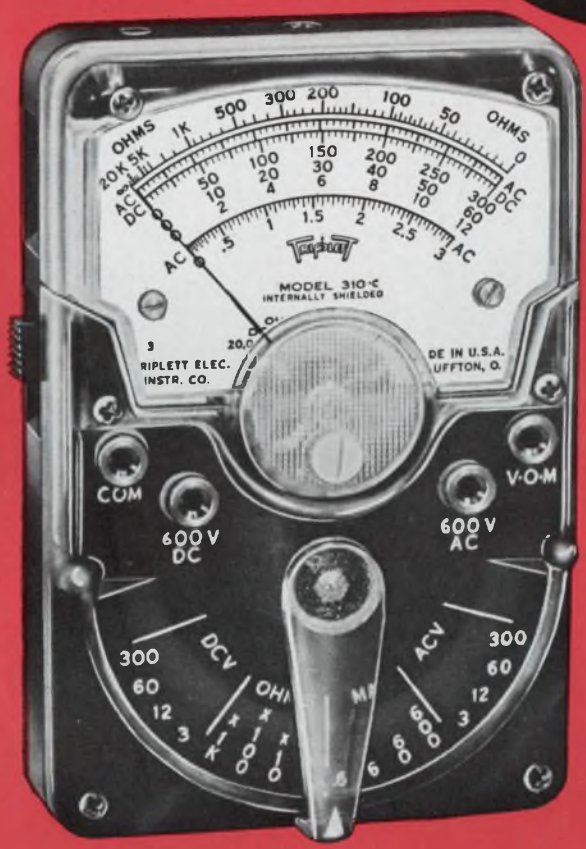
WORLD'S LARGEST SELLING AND WORLD'S NEWEST Hand Size V·O·M's

TRIPLETT



MODEL 310
World's Largest Selling
Volt-Ohm-Milliammeter

MODEL 310-C
World's Newest
Volt-Ohm-Milliammeter



BOTH TESTERS SHOWN ACTUAL SIZE

1 **HAND SIZE AND LIGHTWEIGHT, but with the features of full-size V-O-M's.**

2 **20,000 OHMS PER VOLT DC; 5,000 AC (310)—15,000 AC (310-C).**

3 **EXCLUSIVE SINGLE SELECTOR SWITCH speeds circuit and range settings. The first miniature V-O-M's with this exclusive feature for quick, fool-proof selection of all ranges.**

SELF-SHIELDED Bar-Ring instrument; permits checking in strong magnetic fields. FITTING INTERCHANGEABLE test prod tip into top of tester makes it the common probe, thereby freeing one hand. UNBREAKABLE plastic meter window. BANANA-TYPE JACKS—positive connection and long life.

Model 310—$42.00 Model 310-C—$53.00 Model 369 Leather Case—$4.00

ALL PRICES ARE SUGGESTED U.S.A. USER NET, SUBJECT TO CHANGE

310-C PLUS FEATURES

1. Fully enclosed lever range switch
2. 15,000 Ohms per volt AC (20,000 O/V DC same as 310)
3. Reversing switch for DC measurements

MODELS 100 AND 100-C

Comprehensive test sets. Model 100 includes: Model 310 V-O-M, Model 10 Clamp-on Ammeter Adapter; Model 101 Line Separator; Model 379 Leather Case; Model 311 leads. ($78.00 Value Separate Unit Purchase Price.)

MODEL 100—U.S.A. User Net..$74.00

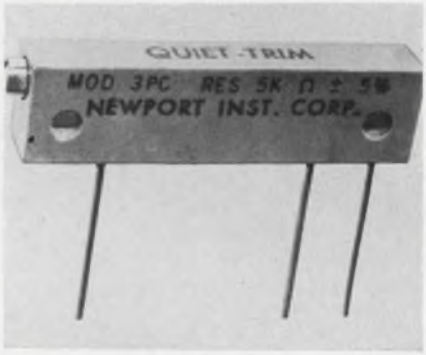
MODEL 100-C—Same as above, but with Model 310-C, Net.....$84.00

THE TRIPLETT ELECTRICAL INSTRUMENT COMPANY, BLUFFTON, OHIO

USES UNLIMITED: FIELD ENGINEERS • ELECTRICAL, RADIO, TV, AND APPLIANCE SERVICEMEN • ELECTRICAL CONTRACTORS • FACTORY MAINTENANCE MEN • ELECTRONIC TECHNICIANS • HOME OWNERS, HOBBYISTS

THE WORLD'S MOST COMPLETE LINE OF V·O·M's • AVAILABLE FROM YOUR TRIPLETT DISTRIBUTOR'S STOCK

ON READER-SERVICE CARD CIRCLE 73

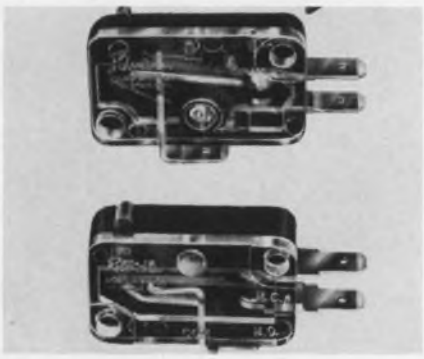


Trimming pots have multi-contacts

Newport Instrument Corp., 893 W. 16th St., Newport Beach, Calif. Phone: (714) 646-1994. P&A: $3.25 to $8.70; 30 days.

The Quiet-trim series of wire wound potentiometers are designed with a ring of multiple contacts around the resistance element. During adjustment, the multiple contacts make sequential contacts on each turn of the resistance core. In this way, resolution is increased and the wiper contact is less than 20 Ω at vibration levels of 50 G.

CIRCLE NO. 213



Miniature switch 0.281-in. thick

Robertshaw Control Co., 1701 Byrd Ave., Richmond, Va. Phone: (703) 282-9561.

Measuring only 0.281-in. thick, a precision miniature switch is offered as a replacement for conventional "V" switches. Called the TV switch, it is available in electrical ratings from 3 to 10 A at 125/250 V with operating forces of 10, 27, 44, and 60 grams. It also features a transparent cover and shock-proof contact wiping mechanism.

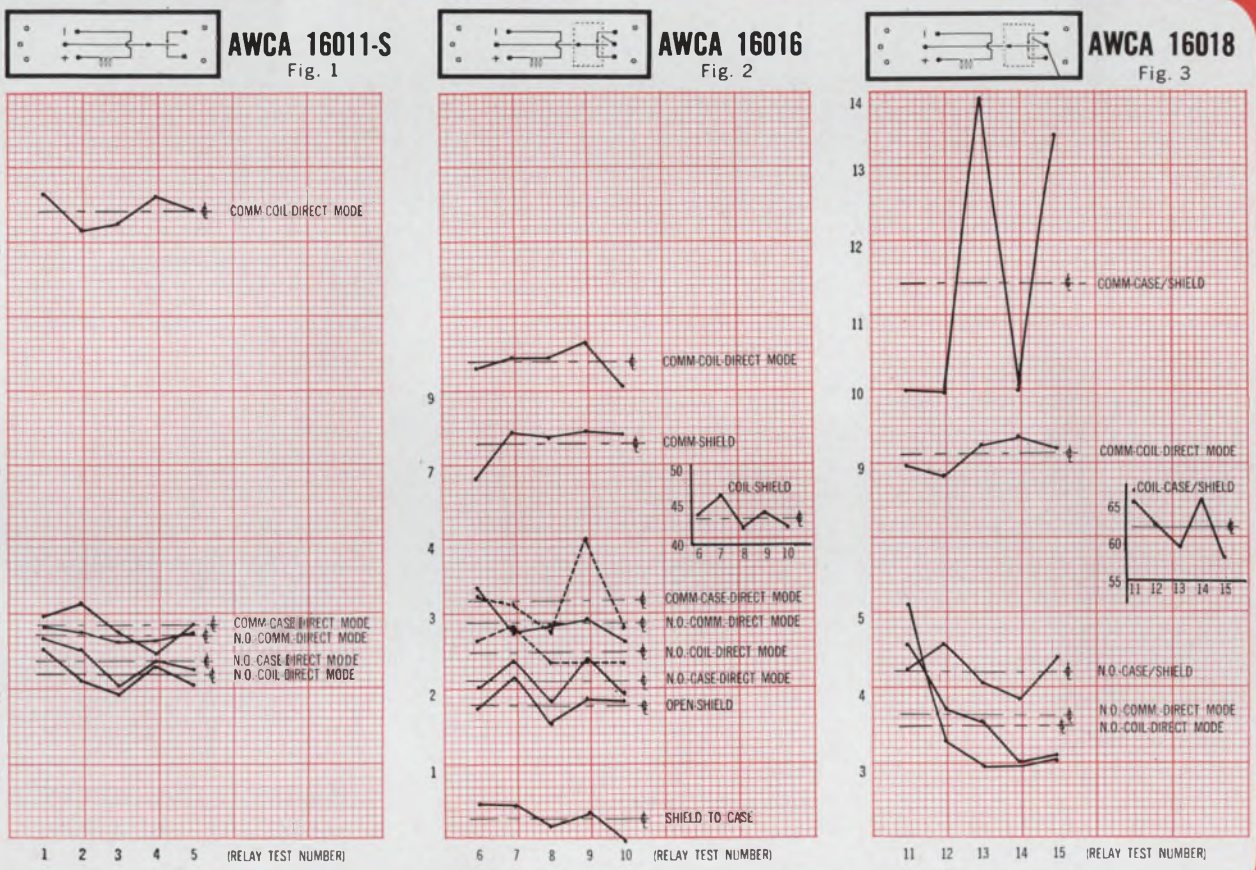
CIRCLE NO. 214

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. 1 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.)



Data was obtained using a Boonton Electronics Corporation Capacitance Bridge, Model 75-A-S8 at 1MH.

Backed by sound research and disciplined engineering, Adlake applies the industry's broadest line of mercury displacement and mercury wetted relays to the creative solution of design circuit problems. However unique or special your application, Adlake can assist you in developing it. For prompt, personal and knowledgeable attention to your relay needs, contact the one source that is the complete source in the mercury relay field. Contact Adlake today for catalog and further information.

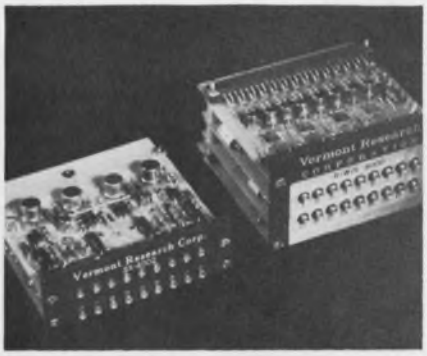
Adlake SINCE 1857

THE ADAMS & WESTLAKE COMPANY

Dept. 1017 Elkhart, Indiana, U.S.A. 46514 (AC 219) 264-1141

TRANSPORTATION EQUIPMENT • ARCHITECTURAL PRODUCTS • MERCURY RELAYS • DOORS AND ENTRANCES • CONTRACT MANUFACTURING

ON READER-SERVICE CARD CIRCLE 75

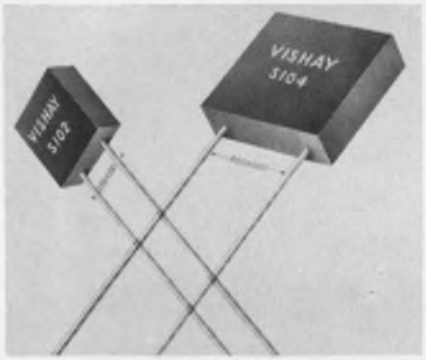


IC modules control drum memory systems

Vermont Research Corp., North Springfield, Vt. Phone: (802) 886-2256.

Used together, the Model 4000 read/write/Y select module and the Model 4002 X matrix driver module allow coordinate selection of up to 256 magnetic heads in a drum memory system. The Model 4000 is a complete system in itself, including driver in its 3 x 3 x 1-3/4-in. package. The SX4002 contains four switching circuits, each controlled by a 4-input AND gate.

CIRCLE NO. 215

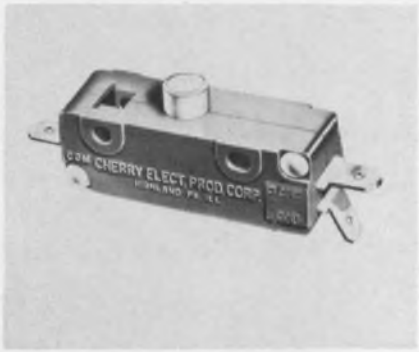


Resistor sets matched for TC

Vishay Resistor Products, 63 Lincoln Highway, Malvern, Pa. Phone: (215) 644-1300. P&A: $3.50 to $4; 3 to 4 weeks.

Tracking within ±0.5 ppm/°C over the −55 to 125°C range is provided by matched pairs or sets of resistors. The sets are offered in resistance values from 100 Ω to 120 kΩ. Standard resistor tolerance is ±0.01%. The resistors themselves are described as noiseless, nonin-ductive and ultra-stable over an indefinite period of time.

CIRCLE NO. 216

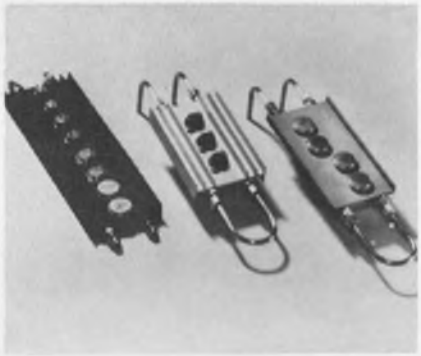


Split contact switch controls two circuits

Cherry Electrical Products Corp., 1650 Old Deerfield Rd., Highland Park, Ill. Phone: (312) 432-8182. Price: $469/M in 2M lots.

Two separate circuits can be controlled by the E13-01ASP snap-action switch. This spst double switch connects two independent circuits simultaneously to a third when the actuator is depressed. Electrically, the switch is similar to the manufacturer's E13 general purpose switch. It is UL and CSA approved, 15 A, 125 or 250 Vac, 3/4 hp, 125 Vac, 1-1/2 hp, 250 Vac.

CIRCLE NO. 217

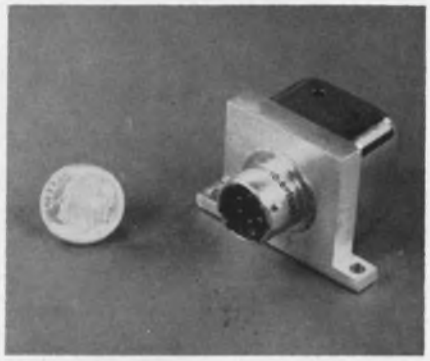


Heat dissipators liquid cooled

IERC, 135 West Magnolia Blvd., Burbank, Calif. Phone: (213) 849-2481.

Integrally-extruded coolant passages are featured in the E4 and E5 liquid-cooled heat dissipators. Using any normal coolant, the E4 dissipates up to 1000 W while occupying only 42 $in.^3$. The E5 occupies 45 $in.^3$ and provides similar cooling. E4 has two fins, E5 has six. Standard lengths for both run from 6-in. to 4 feet in 6-in. increments.

CIRCLE NO. 218



Dc amplifier based on ICs

Fairchild Controls, Div. of Fairchild Camera & Instrument Corp., 225 Park Ave., Hicksville, N. Y. Phone: (516) 938-5600. Price: below $300 in small quantities.

Specifically for use with low-output strain gauge type or similar transducers, the FA4-0011 amplifier provides standard gains of 150 to 250. External adjustments of zero and gain are provided and a 12-Vdc regulated voltage is tapped for transducer excitation. Signal input is in the standard 20 to 35-mV range, or in other ranges on special order.

CIRCLE NO. 219

Submin pin sockets cited for reliability

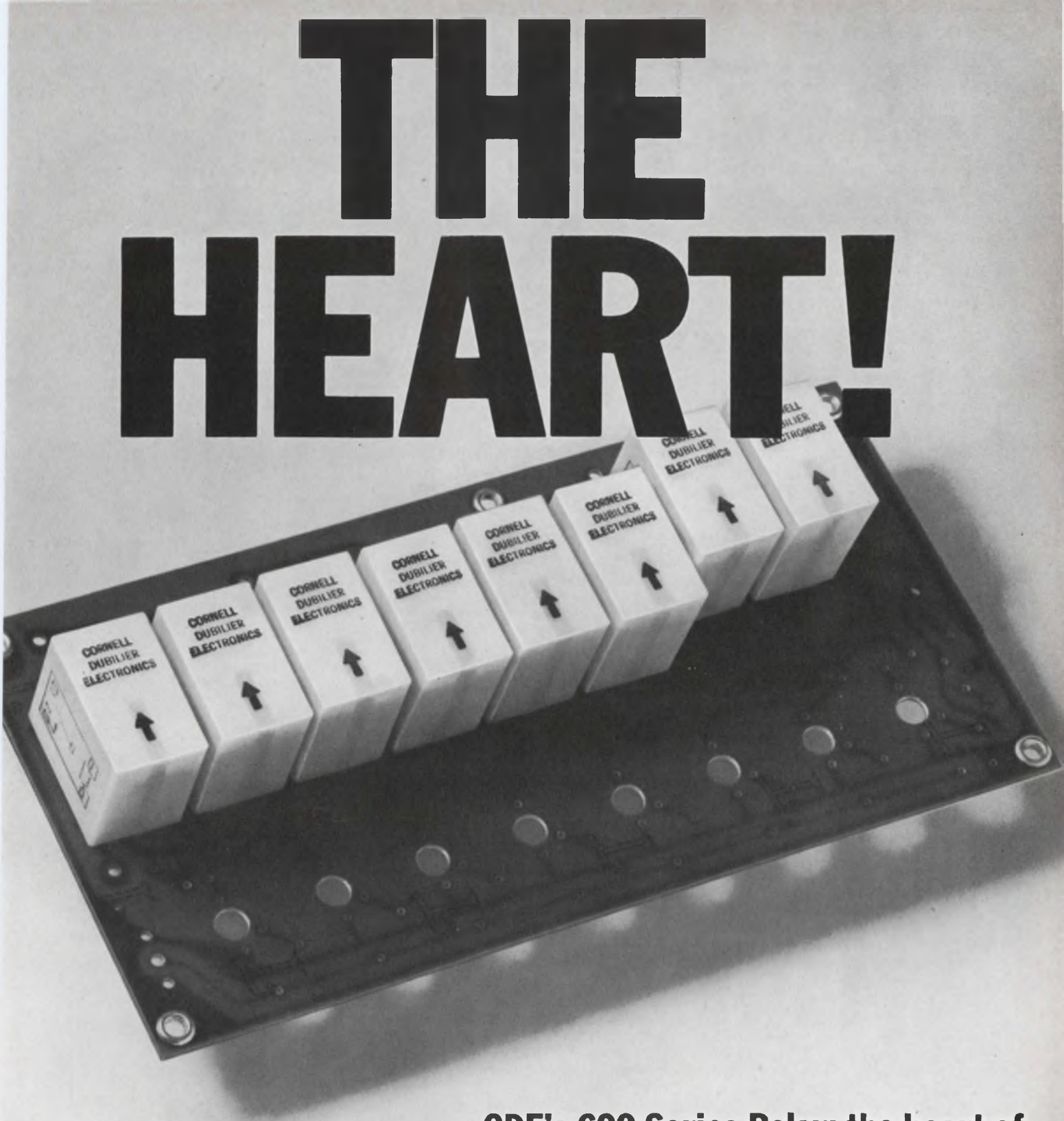
Robinson/Nugent, Inc., 802 E. Eighth St., New Albany, Ind. Phone: (812) 945-0211.

Contact life on some styles of a line of machined beryllium-copper contact pin sockets is specified for several thousand cycles. Hundreds of stock configurations vary from 0.075-in. in diameter and from 0.1-in. in length. The sockets can be mounted by dip-soldering, riveting, flaring, staking, press-fit or potting.

CIRCLE NO. 220

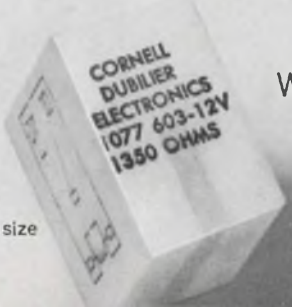
ON READER-SERVICE CARD CIRCLE 76 ➤

THE HEART!



CDE's 600 Series Relay: the heart of superior color TV remote control systems!

What makes the 600 so special? Small size. Dependability. Sensitive operation (DC only). Quick, easy installation. A nylon dust cover. Even a window allowing a visual check without removing the cover. What's more, all materials and electrical spacing are compatible with UL requirements. Sound interesting? Get more details from your CDE field engineer or Authorized Distributor.



Actual size

CDE CORNELL-DUBILIER

DO-7 tuning varactors packaged in glass

American Electronic Labs, Inc., P. O. Box 552, Lansdale, Pa. Phone: (215) 882-2929.

Particularly suited to hand-solder or stripline insertion, a complete line of tuning varactors features a DO-7 glass package design. The devices can be used in equipment operating at frequencies up to 3 GHz. The capacitance ratios, which range as high as 6:1, make it possible to design resonant circuits that are tunable over octave bands. Q ratings range up to 400 at 50 MHz and total capacitances range from 5 to 30 pF with breakdown voltages up to 120 V.

CIRCLE NO. 221

Bi-stable relay has four contacts

P.A.R. Ltd., Talbot St., Nottingham, England. Price: from 21 shillings.

Manufactured in England, a new bi-stable relay has 4 changeover contacts that are mechanically locked in position by balanced armatures. The latch is interlocked and reset electrically. Applications are seen in industrial controls and memory devices where a momentary signal must provide continuous indication with provisions for reset.

CIRCLE NO. 222

120-V inverter for continuous operation

LaMarche Mfg. Co., 106 Bradrock Dr., Des Plaines, Ill. Phone: (312) 299-1188.

Continuous 120-Vac output for control, communication and alarm systems is obtained with the model A-30 inverter. It starts instantly under full load and has inherent protection from short circuits, reverse polarity and overload, and is ideal for use with motors. It is available with dc inputs of 12, 24 and 32 V, with continuous load ratings from 4 to 1200 VA. Output wave shape is square.

CIRCLE NO. 223

EMCOR® I—tough, beautiful protection

EMCOR I cabinets guard your valuable instrumentation. They're hard, tough, long-lasting steel. The beauty of form and the color, or colors, of your choice mask the toughness underneath.

Beauty, yes! When you see EMCOR I cabinets, you'll appreciate that they are sleek, beautiful pieces of craftsmanship.

EMCOR created the concept of the modular enclosure system, and we've refined it to the point where EMCOR cabinetry is an art... the closest thing to perfection in electronic cabinetry. Of course, there's a shape and size to house any instrumentation.

When you need strong, beautiful protection for your equipment, call your local EMCOR Sales and Service Engineer. Or write for our EMCOR I catalog.

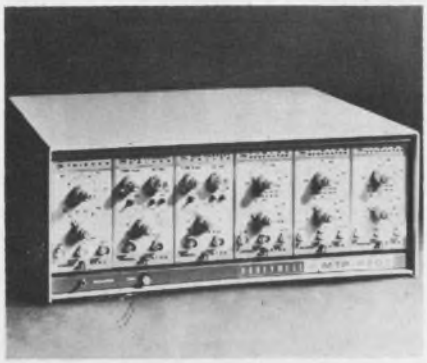
EMCOR/distinguished cabinetry

Albany: 436-9649; Albuquerque: 265-7766; Alexandria: 836-1800; Binghamton: 723-9661; Bridgeport: 368-4582; Buffalo: 632-2727; Chicago: 676-1100; Cleveland: 442-8080; Dallas: 631-7450; Dayton: 298-7573; Del Mar: 454-2191; Denver: 934-5505; Detroit: 357-3700; Fort Lauderdale: 564-8000; Ft. Walton Beach: 243-6424; Houston: 526-2959; Huntsville: 539-6884; Indianapolis: 356-4249; Kansas City: 444-9494; Los Angeles: 938-2073; Minneapolis: 545-4481; Newport News: 245-8272; N.Y.C. area: 695-0082; Orlando: 425-5505; Palo Alto: 968-8304; Pittsburgh: 884-5515; Phoenix: 273-1673; St. Louis: 647-4350; Seattle: 762-7800; Tucker (Atlanta Office): 939-1674; Tulsa: 742-4657; Utica 732-3775; Valley Forge: 265-5800; Wilmington, Mass.: 944-3930; Winston-Salem: 725-5384. *EMCOR Reg. U.S. Pat. Off.*

Ingersoll Products West 120th St., Chicago, Illinois 60643 DIVISION OF BORG-WARNER CORPORATION

electronic equipment BORG-WARNER®

ON READER-SERVICE CARD CIRCLE 78

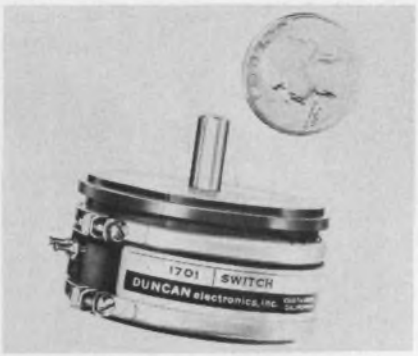


Building-block modules aid systems testing

Honeywell, Computer Control Div., Old Connecticut Path, Framingham, Mass. Phone: (617) 879-2600.

Solid-state test modules, packaged in building-block form, provide signal parameters for bench testing and systems applications. The 20-MHz blocks facilitate memory testing, telemetry timing and circuit evaluation. Series 2000, with modules for trigger, timing, and positive and negative current drivers, initiates an expanded line of units to accommodate a wide variety of individual requirements.

CIRCLE NO. 224

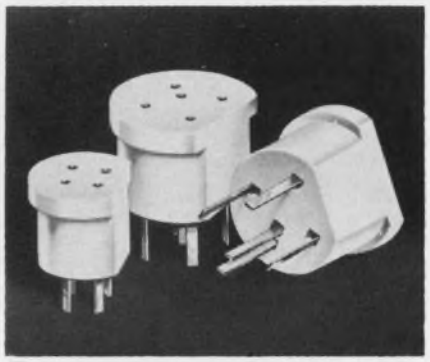


Commutator switches range to 3-in. diameter

Duncan Electronics, Inc., 2865 Fairview Rd., Costa Mesa, Calif. Phone: (714) 545-8261.

The design of a line of commutator switches allows them to be used either singly or in ganged assemblies with potentiometers or other switches. These single-turn, servo-mount units are available in case sizes of the manufacturer's standard units with body diameters ranging from 7/8 to 3-in. Features include unitized rotor/slip-ring/brush assembly and printed circuit elements.

CIRCLE NO. 226

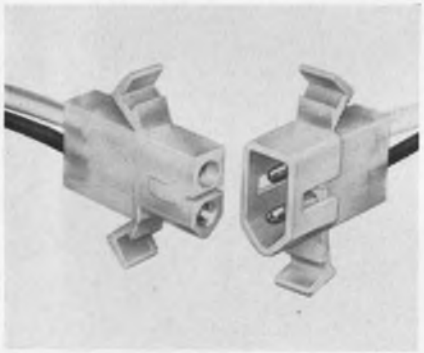


Transistor sockets mount on PC boards

Industrial Electronic Hardware Corp., 109 Prince St., New York. Phone: (212) 677-1881.

Two series of PC board transistor sockets are aimed at the OEM and commercial equipment markets. The large socket series, MPT6005, will accept bases TO-5, TO-9, TO-11, TO-12, TO-33, TO-39 and TO-40. The smaller series, MPT4004, accepts TO-18, TO-46, TO-52 and TO-72. Both are formed of nylon and feature restricted entry to assure proper alignment.

CIRCLE NO. 228



Plugs/receptacles formed of nylon

Molex Products Co., 5224 Katrine Ave., Downers Grove, Ill. Phone: (312) 969-4550.

A recent addition to the Molex plug and receptacle line provides positive polarity in instrumentation and commercial equipment. The plugs and receptacles are formed of nylon. Integrally designed mounting ears permit the plug or receptacle to snap mount into a panel. Crimped terminals snap-lock into the units without soldering.

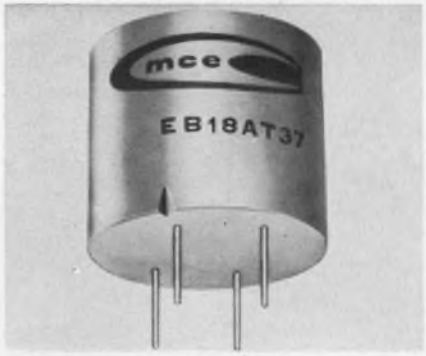
CIRCLE NO. 225

Power sensor ranges 108 to 400 MHz

Bird Electronic Corp., 30303 Aurora Rd., Cleveland. Phone: (216) 248-1200.

For sensing transmitter output in the range of 108 to 400 MHz, the Model 4162 coax RF power sensor is offered as a designer's instrument. The directional sensors are vest-pocket sized, consisting of two directional couplers that deliver dc current proportional to the forward and reflected power in the main line. Capacity is 150 W in the forward direction and 50 W reflected.

CIRCLE NO. 227



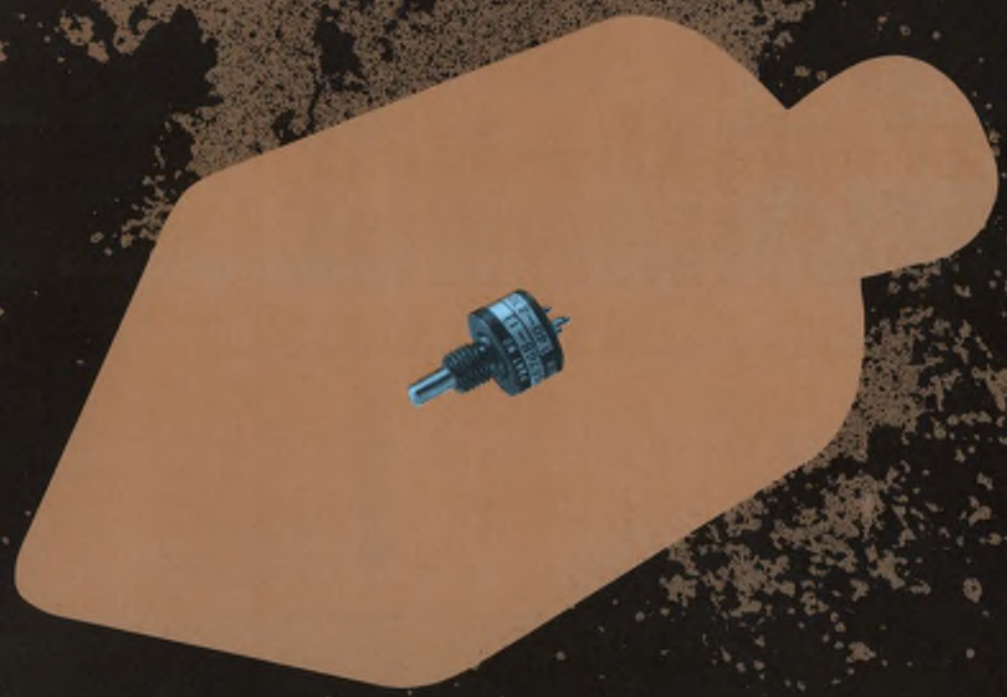
Submin inductor can carry dc

Magnetic Circuit Elements, Inc., 3720 Park Place, Montrose, Calif. Phone: (213) 245-9173. P&A: $4.44; stock.

The subminiature inductor EB-18AT can be used as either transformer or inductor with dc carrying capability. As audio-transformer it has 850-W output, 200-Hz to 45-kHz response, and, at 400 Hz, distortion is less than 5%. Particularly useful in PC board use, the inductor is an encapsulated module.

CIRCLE NO. 229

ON READER-SERVICE CARD CIRCLE 79 ➤



Big systems "go" only when small components do!

That's why for projects like Apollo, NASA hand-picks its primes. That's why each prime hand-picks its subs. And that's why each sub hand-picks the components that go into its NASA equipment. And, in this manned space venture, every link in the "High Reliability" chain must be as strong as modern technology can make it. And that's why "standard" components are usually considered "substandard."

But not so with the "standard" Spectrol Model 140, single-turn, precision potentiometer. Here's a standard component that qualified for Apollo simply "by having its hair combed and its face washed."

True! The only difference between a standard Spectrol Model 140 potentiometer and the high-rel component that Spectrol provides for the Apollo Command Module is a tighter starting torque band. The rest of the story is told by the rigorous "Quality Assurance Program" established by Spectrol to the stringent Apollo specifications. If you would like an outline of this comprehensive program, write for your copy of the "Spectrol High-Rel Potentiometer Program for Project Apollo." Our experience is our greatest asset—we'd like to share it with you.

Better Components for Better Systems

SPECTROL ELECTRONICS CORPORATION

17070 E. GALE AVENUE, CITY OF INDUSTRY, CALIFORNIA 91745

Spectrol

Control switch has no contacts

Parmeko, Ltd., Percy Road, Aylestone Park, Leicester, England. Phone: Leicester 32287.

Said to be suitable for most control functions, a British switch has no contacts, and is therefore immune to oil or dirt build-up. The switch operates when a piece of metal is brought into a gap between two arms. The interruption of the magnetic field operates a trigger circuit whose output can be used with standard logic units. Output is 27 mW and max speed is 100 operations/s.

CIRCLE NO. 230

Transistor chopper takes 30-V signal

Airpax Electronics, Inc., Cambridge Div., Cambridge, Md. Phone: (301) 228-4600.

Ideal for operational amplifiers and servo instruments, the ST-5 transistor choppers switch signals up to ±30 V peak with phase angles of nearly 0°. With dwell times up to 180°, phase and dwell constant from −55 to 125°C, they can be used in synchronous full-wave modulation-demodulation applications. Packaged in a miniature 7-pin can, the chopper weighs only 2 oz.

CIRCLE NO. 231

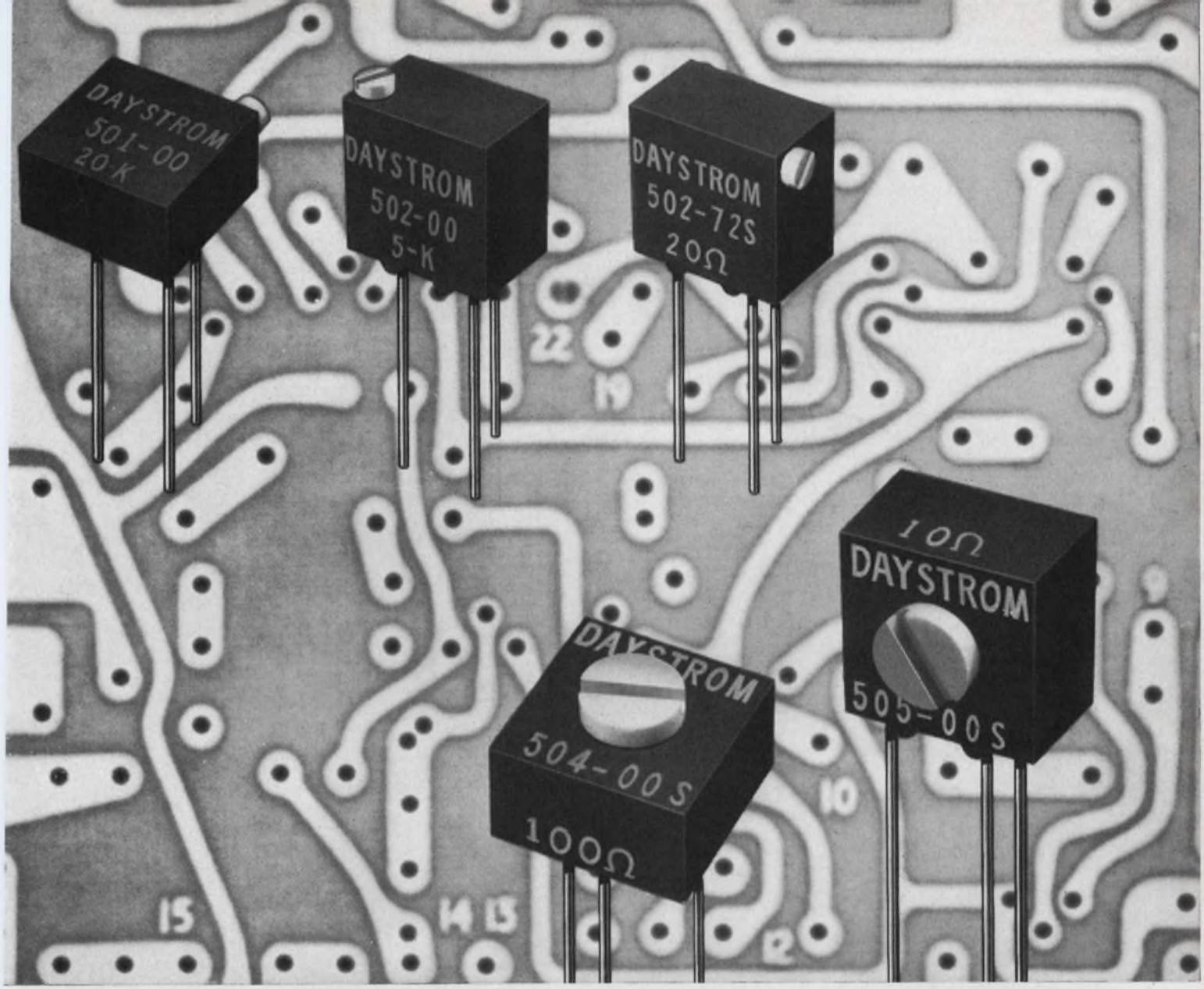
Wire transducer reads peak point temperature

Continental Sensing, Inc., 1960 N. Ruby St., Melrose Park, Ill. Phone: (312) 681-3869.

The "Magic Wire" transducer, type 1, employing two dissimilar helical thermostatic conductors, is the first of a series designed to measure the temperature at the highest point throughout its length. The output emf corresponds to ISA calibration curve K from 200 to 2000°F. A seamless sheath permits high flexibility. Available in lengths of 100 feet, the transducer can be calibrated in spliced lengths to several thousand feet.

CIRCLE NO. 232

ON READER-SERVICE CARD CIRCLE 81 ➤



Savings across the board just took a new turn

DAYSTROM Squaretrim® potentiometers now include single-turn types. *New models 504 and 505 are fully adjustable with just one turn. Models 501 and 502 are 15-turn types. They all clear up to 80% more PC board space—at no extra cost. But the trim .02 cubic inch size is only one reason why these commercial 500 Series pots are proving so popular. They also feature Weston's exclusive wire-in-the-groove design, and all these performance extras:*

Convenience *5 different configurations with adjusting screw on top, side or end* • **Tolerance** *±5%* • **Adjustability** *15 turns or single turn* • **Slip Clutch** *eliminates wiper damage, cuts production delays* • **Suregard™ Terminations** *(controlled solder) for better protection against vibration, shock and humidity —no pressure taps* • **Superior Resolution** *0.125% or less* • **Wide Range** *10Ω to 20K* • **High Power** *0.6 watt in still air at 70°C* • **Wide Temperature Range** *—55°C to 150°C* • **Low Temperature Coefficient** *70 ppm max.* • **Low Noise** *110Ω max. ENR* • **Small Size** *5/16" x 5/16" x 3/16".*

Daystrom *potentiometers are another product of:*

Weston Instruments, Inc. • Weston-Archbald Division • Archbald, Pa. 18403

WESTON® *prime source for precision . . . since 1888*

Spacing insulators mate relay cans

Robinson Electronics, Inc., 3636 W. 139th St., Hawthorne, Calif. Phone: (213) 679-0351. P&A: $0.01 to $0.08; stock.

Relay mounting insulators are available for the 1/6 crystal can relay packages. Two styles are available: one having 0.2-in. feet on one side and one which mounts flat to the chassis. They are molded of Acetal resin.

CIRCLE NO. 233

Polycarbonate capacitors for mild environments

Standard Telephones & Cables Ltd., Brixham Rd., Paignton, Devon, England.

Sturdy enough for most applications, a series of rectangular-molded polycarbonate capacitors are offered as price-competitors of metallized polyester types. The capacitors, specified for −40 to 85°C use, are available in values from 0.01 to 4.7 μF at a rating of 100 Vdc. Except for packaging, they are said to be quite similar to tubular MIL-spec units.

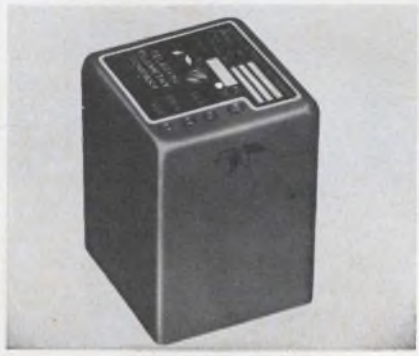
CIRCLE NO. 234

Short laser pulses seen on scope

United Aircraft, East Hartford, Conn. Phone: (203) 565-5610.

Laser pulses as short as one nanosecond with picosecond rise-times can be observed on a good quality scope through the use of the Model 1240 phototransducer. The transducer consists of a bi-planar vacuum photodiode in a matched impedance structure with an extremely low source impedance bias supply filter. Measured response time is less than 0.25 nsec.

CIRCLE NO. 235

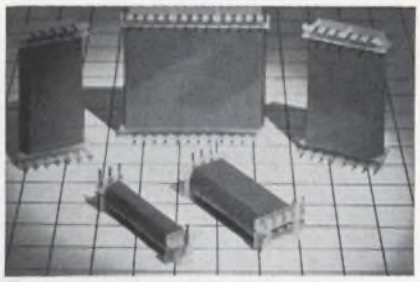


Subcarrier oscillators with high Z inputs

Teledyne Telemetry Co., DynaPlex Div., Box 341, Princeton, N. J. Phone: (609) 452-2550. P&A: type VC-51, $225, type VC-61, $240; 60 to 90 days.

These constant-bandwidth subcarrier oscillators are designed for use in frequency-division multiplex systems requiring the transmission or recording of high-frequency data inputs. The VC-51 and VC-61, differing only in exterior case, are available in IRIG constant-bandwidth center frequencies with ±2-, ±4- and ±8-kHz deviation. These solid-state oscillators are readily integrated into multichannel airborne data acquisition systems requiring wide bandwidth and time and phase correlation.

CIRCLE NO. 236

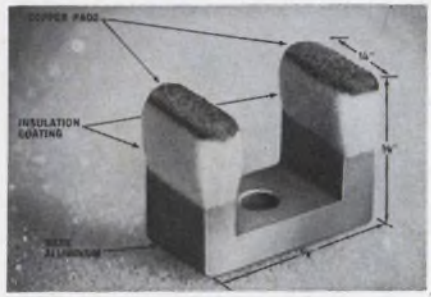


Reed relay line uses open construction

Essex Wire Corp., 131 Godfrey St., Logansport, Ind. Phone: (219) 241-6121.

Open construction reed relays are offered in a complete family of standard units. These relays offer pole forms of 1 through 6 and 12, operating from 6 to 48 V. They are available for 20 million operations at 15-W load conditions.

CIRCLE NO. 237



Axial heat sinks are electrically insulated

Solitron Devices, Inc., 256 Oak Tree Rd., Tappan, N.Y. Phone: (914) 359-5050.

Thermal conduction and electrical insulation are combined in a heat sink for axial lead devices. Size of the sink is 1/4 x 1/2 x 3/8-in. high, mounting components with a diameter up to 0.25-in. and lengths to 0.28-in. The copper pads are easily soldered using 60/40 core solder.

CIRCLE NO. 238

Alkaline batteries recharge 50 times

Mallory Battery Co., South Broadway, Tarrytown, N. Y. Phone: (914) 591-7000.

In commercial applications, the Duracell rechargeable batteries are said to fill the bill when low initial and operating costs are required, yet they recharge up to 50 times. Produced in the usual D, C and AA sizes, applications are seen in appliances, radios, toys etc. Storage life is up to two years at normal temperatures.

CIRCLE NO. 239

Ceramic disc caps for bypass, coupling

Nucleonic Products Co., Inc., 3133 East 12 St., Los Angeles. Phone: (213) 283-2603.

In bypass networks and coupling applications, the GI series ceramic disc capacitors offer a working voltage rating of 500 Vdc. Performance factors are per EIA RS 198 Class II. Five types are available in the series with capacitance ranges of 82 pF to 0.15 mF. Insulation resistance is 10,000 mΩ.

CIRCLE NO. 240

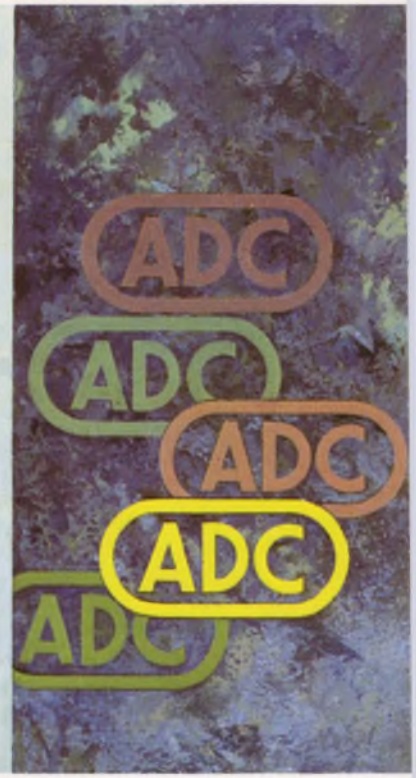
ON READER-SERVICE CARD CIRCLE 82 ➤

TIME PROVEN COMPONENTS

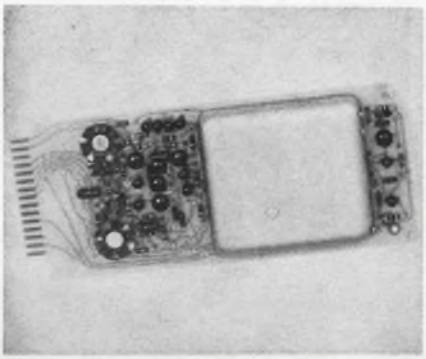
ADC wasn't in business when sundials were in vogue, but for the past thirty years we've been supplying components for the electronics industry that match the sundial for consistently reliable performance.

REAL TIME RELIABILITY

Real time reliability at ADC is a state of mind—a constant yardstick held up to measure each component manufactured. While the applications for our transformers, filters and communication components may change, the continuous challenge to produce products that offer the utmost in performance and reliability never does. ▢ We are proud to be associated with an industry that has, through technology, changed the face of the globe. Years ago, ADC delivered the industry's most reliable components. Today, that same tireless attention to detail has made ADC PRODUCTS a manufacturer of the world's most reliable electronic products. ▢ We recognize this as a never-ending challenge to produce the finest components for the world's greatest globe changers—our customers. We're proud that our components have found their way into space capsules, airliners, communication networks, submarines and just about every sophisticated electronic device made. ▢ Thirty years of real time reliability has made us even more aware of our responsibility as a respected leader and supplier of communications components.



ADC PRODUCTS 6405 CAMBRIDGE ST. ▪ MINNEAPOLIS, MINN. 55426

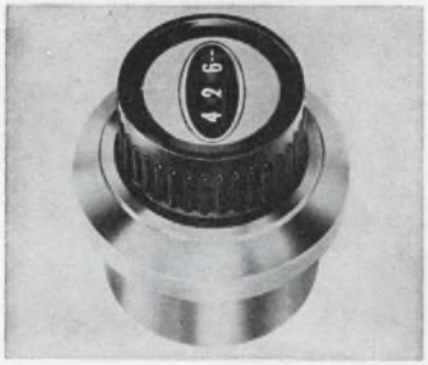


Photomultiplier amplifier measures picoamps

Newport Laboratories, Inc., P. O. Box 2087, Newport Beach, Calif. Phone: (714) 540-4914. P&A: $140 to $180; stock to 60 days.

Dc operational amplifiers of the AO series serve to implement circuits to measure currents from 10^{-12} to 10^{-1} A. For example, a 0.1-μA signal can be converted to 10 V with an accuracy of 0.2% and a bandwidth of 125 kHz. Or, 0.1 nA can be converted to 10 V with an accuracy of 1% and a bandwidth of 570 Hz.

CIRCLE NO. 241



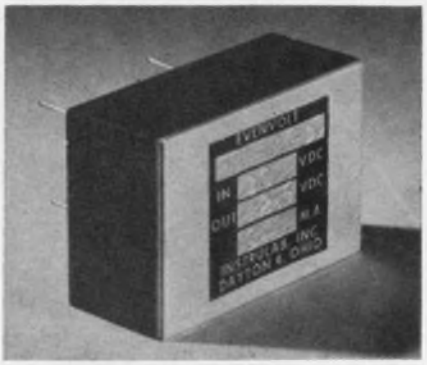
Precision pots have digital readout

Bourns, Inc., 1200 Columbia Ave., Riverside, Calif. Phone: (714) 684-1700. P&A: $26.46; stock to 3 wks.

A digital readout of resistance setting is built into the model 3650 digital "Knobpot." The new unit, with integrated readout, knob and pot has a readability of 1 part in 10,000, a dial accuracy of 0.1% and a repeatability of reading within 0.05% voltage ratio. Resistance range is 100 Ω to 100 kΩ with a tolerance of ±3%. A 500-kΩ version is also available.

CIRCLE NO. 242

◀ ON READER-SERVICE CARD CIRCLE 82

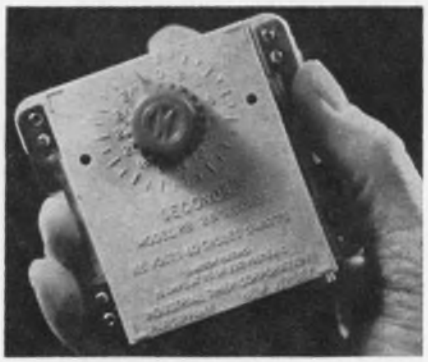


Voltage standard based on zeners

Instrulab, Inc., 1205 Lamar St., Dayton, Ohio. Phone: (513) 223-2241. Price: $75 to $150.

A modular voltage reference unit, the Evenvolt 700 Series, is based on zener circuitry. Measurements of a typical unit are 1.5 x 1.12 x 0.668-in. high. Output regulation is 10 μV change for a 1% change in the 30-V input. Output is 12.6 V at 100 μA. Stability is 0.0005%/day and 0.0018%/six months. Noise is limited to 25 μV, dc to 50 kHz.

CIRCLE NO. 243



Delay timer uses plastic parts

Union Carbide, Plastics Div., 270 Park Ave., New York. Phone: (212) 867-6062. Price: $7.50 in quantity.

Unit cost is reduced in the Series RB automatic reset delay timers through the use of injection-molded polysulfone plastic. The use of this material makes possible the design of multifunction parts, eliminates some parts and simplifies assembly operations. The timer provides a controlled delay through a 14-A spdt switch which is independent of the timer motor circuit.

CIRCLE NO. 244

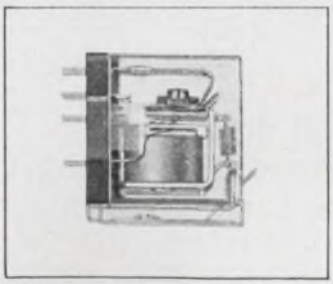
ON READER-SERVICE CARD CIRCLE 86 ➤

Donna Dinkler is a final inspector on one of our series 1220 relay production lines. The little picture below shows her doing her job. We only called her "Mame" up above because—well, we had trouble trying to rhyme Donna Dinkler.

Anyway, you'll look a long time before you find an inspector that's fussier than Donna. A 1220 doesn't measure up in *every way* and ZAP! Into the reject pile.

Now this kind of painstaking inspection doesn't speed up the production of 1220's one single bit. But it's the only way to assure that the 1220's you get are no less than perfect.

Multiply Donna by the other inspectors on the series 1220 lines and their fussiness and you see why we occasionally have sales running ahead of delivery. *So many engineers have found these versatile, enclosed 10 amp. DPDT or 3PDT relays to be so reliable and long lived that we're hard pressed at times to keep up with the demand.* The 1220 is a U/L listed relay with terminals that can be used as solder lug, AMP Faston 110 series quick connect or socket plug-in that comes complete with mounting bracket.

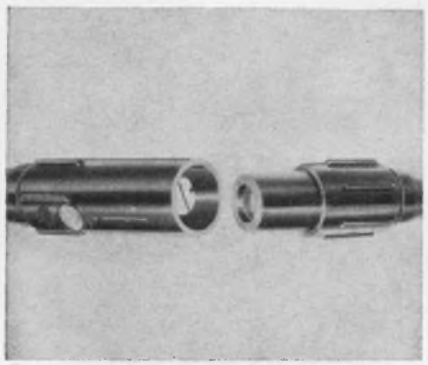


So, if you need 1220's in quantities up to 399, *see your Guardian distributor.* If you need larger quantities order direct from factory production. If you want more information, send for bulletin B2.

GUARDIAN ELECTRIC®

1550 W. Carroll Avenue, Chicago, Ill. 60607

Guardian Electric Manufacturing Company.

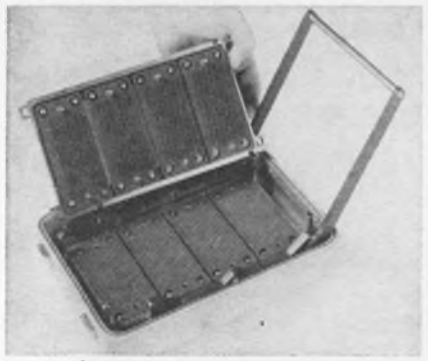


Connectors/receptacles made torque-proof

Empire Products, Inc., 9201 Blue Ash Road, Cincinnati. Phone: 354-4321.

Both double cam-locking and a spring-loaded latch are included in a line of Cam-Lok connectors to resist torque. The finished connector, for large power cables, has no exposed metal surfaces, is watertight and neoprene insulated. Release is accomplished by pressing a button on the male half of the connector. The units are available in sizes for 250 to 750 MCM cable.

CIRCLE NO. 245

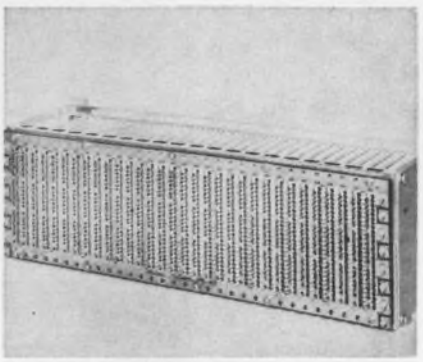


Patch panel accepts 800 points

Amphenol Corp, 9201 Independence Ave., Chatsworth, Calif. Phone: (213) 329-9292.

For use in telemetry and other missile and spacecraft instrumentation as well as data processing, a 12 x 8 x 5-in. patch panel accommodates up to 800 pin and socket contacts. Misalignment, contact bending, molding and tolerance problems are said to be solved in this design by dividing the contacts into smaller groups. The multiple blocks contain independent guide-pin systems.

CIRCLE NO. 246

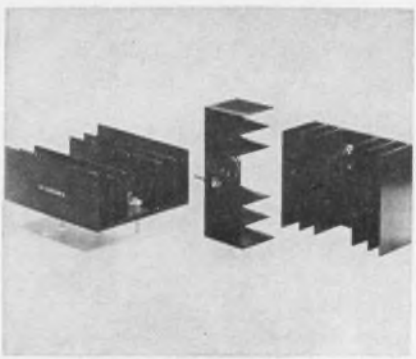


Logic mounting cases include ground-plane

Scientific Data Systems, 1649 17th St., Santa Monica, Calif. Phone: (213) 871-0960.

In the production of logic systems, a number of advantages are cited for the SDS logic mounting cases with built-in back panel ground planes. Among these are: predictable propagation delays and reflection patterns, decreased signal coupling, reduced ground-loop inductance and minimized induced voltages on digital ground. Also, line terminations can closely approximate characteristic impedance.

CIRCLE NO. 247

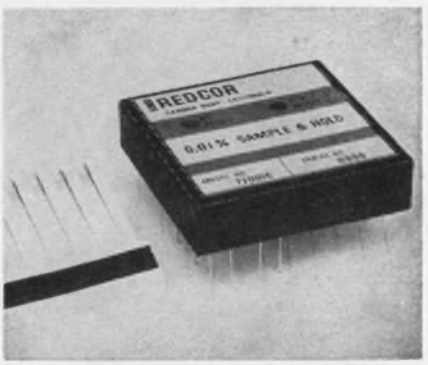


Heat dissipators formed by extrusion

IERC, 135 W. Magnolia Blvd., Burbank, Calif. Phone: (213) 849-2481.

The series E3 heat dissipators use a six-finned extrusion that is 3-15/16 x 1-11/16-in. and they come in standard lengths of 1-1/2 and 3-in. On special order, any length is available in 1/2-in. increments. Thermal resistance, mounting surface to air, is 2.05°C/W natural and 0.85°C/W forced-air at 30-W dissipation.

CIRCLE NO. 248

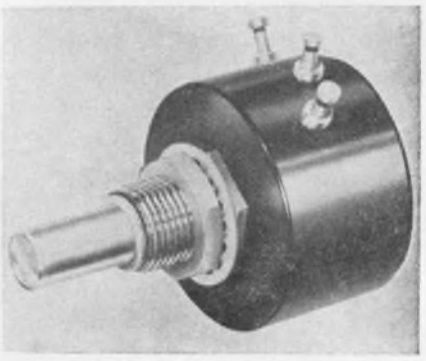


Sample and hold module holds 0.01% accuracy

Redcor Corp., 7800 Deering Ave., Canoga Park, Calif. Phone: (213) 937-4090.

A general purpose sample-and-hold circuit in modular form features an accuracy of ±0.01% for a gain of 1. Full scale input is ±10 V at 10 mA and output impedance is greater than 10 MΩ at 1 kHz. The module measures 2-1/4 x 2-1/4 x 0.5-in. It can be used for high-speed applications since it settles to 0.01% in 5 μs and has an aperture time below 50 ns.

CIRCLE NO. 249



Bushing-mount pot meets industrial needs

Bourns, Inc., 1200 Columbia Ave., Riverside, Calif. Phone: (714) 684-1700. P&A: $6.80; stock to 3 wks.

Essentially infinite resolution and a life of 2 million revolutions is offered by the model 3438 potentiometer. This single-turn bushing-mount component uses an "Infinitron" resistance element. Resistance range is 100 Ω to 50 kΩ with a tolerance of ±20%. Operating temperature range is −15 to 80°C and TC is rated at 500 ppm/°C.

CIRCLE NO. 250

ON READER-SERVICE CARD CIRCLE 205 ➤

100 db dynamic range

from scope/sweeper combinations?...NEVER!

FIG. 1

Although scope/sweeper combinations are quite an advance over point-by-point measurements, when you're looking at an overall frequency response (fig. 1) and magnify the reference area (outlined in orange), to get a look at the significant nulls, you're likely to find **important details missing (fig. 2).**

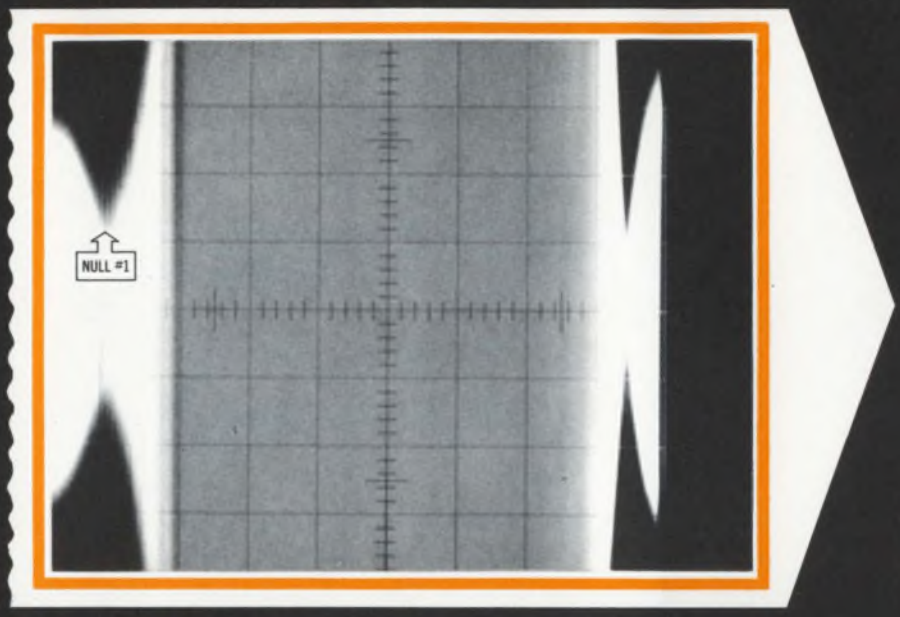
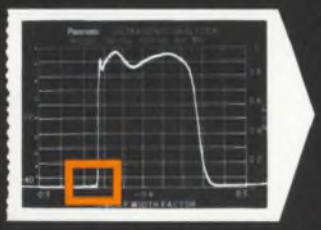


FIG. 2

NOW >100 db dynamic range with Panoramic* Spectrum Analyzers and Companion Sweep Generators...

FIG. 3



...plus sharp, single-line traces of the overall response (fig. 3) every time. NOW when you "zoom in" on the reference area (fig. 4), **you'll turn up details you've never seen before,** like null #2 missing from Figure 2.

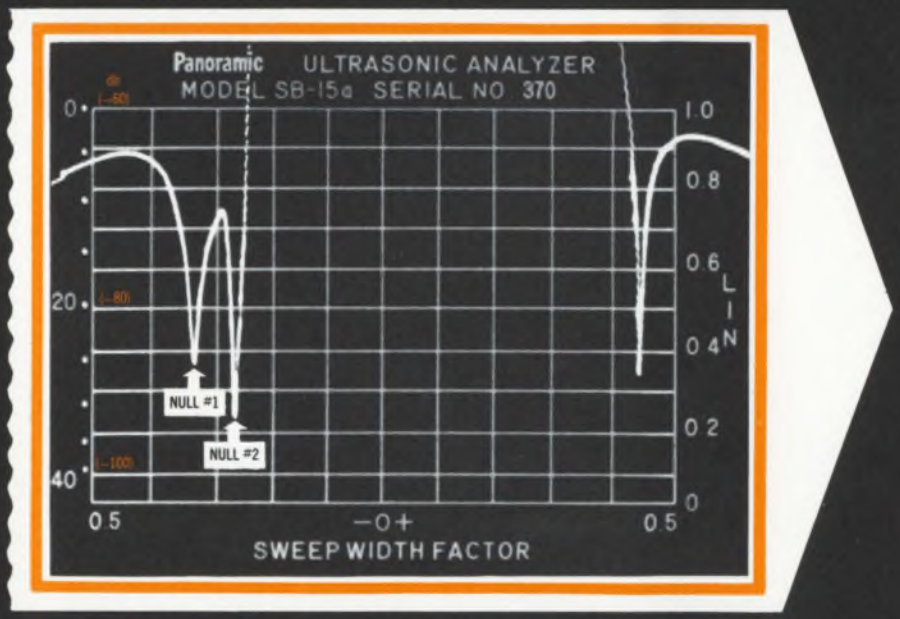


FIG. 4

from

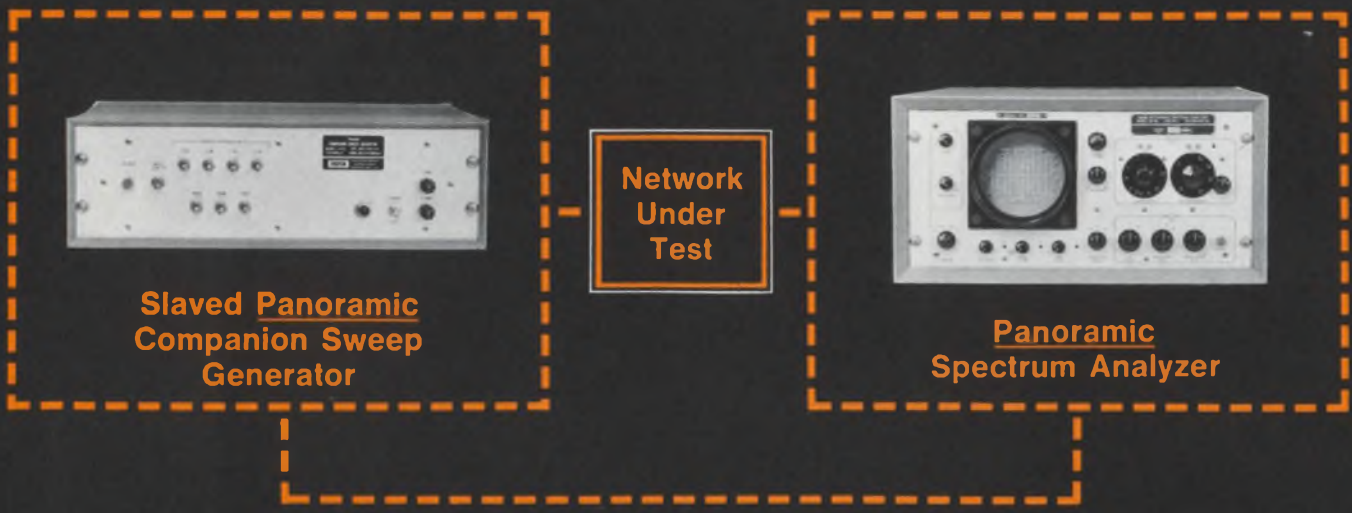
SINGER

INSTRUMENTATION

HERE'S HOW→

*A Trademark of THE SINGER COMPANY

The modern curve tracing technique



The definitive results

shown in Figure 4 (on the preceding page) were achieved by "slaving" a *Panoramic* sweep source to a frequency-selective indicator — a *Panoramic* spectrum analyzer. The sharp, single-line curve is the system response to the instantaneous, significant fundamental of the sweep generator only. "Masking" effects caused by harmonics, noise, hum and other spurious responses are eliminated, and the true nulls and peaks of the transfer function are accurately displayed and measured.

With this new technique

you can measure >100 db dynamic range . . . speed production testing . . . conduct low-level stopband tests in the presence of noise. Even semi-skilled personnel achieve laboratory results in seconds, right out on the production floor.

Solve your problems

by choosing from five *Panoramic* Sweep Generators and six *Panoramic* Broadband Spectrum Analyzers currently available, with more on the way. Accessories, too: *Panoramic* Signal Alternator for simultaneous viewing of two different signals, displaying calibration markers on alternate scans for identification of significant levels such as the half-power points, and for precise frequency measurements . . . *Panoramic* Triangular Wave Generator establishes optimum sweep time to obtain true static response . . . a complete selection of instruments and accessories you can use with confidence.

Curve Tracing Frequency Range	0.5 Hz to 2500 Hz	20 Hz to 22,500 Hz	200 Hz to 300 kHz	100 Hz to 600 kHz	1 kHz to 15 MHz	
Panoramic Spectrum Analyzer	LF-2b	LP-1aZ	SB-7bZ	SB-15a	SPA-3a SPA-3/25a	RTA-5/TA-2 with VR-4 module
Panoramic Companion Sweep Generator	G-5	G-2a	G-3a	G-15a	G-6	G-6a

Write for technical data, or contact your local SINGER INSTRUMENTATION representative.

Panoramic*

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P-66-16

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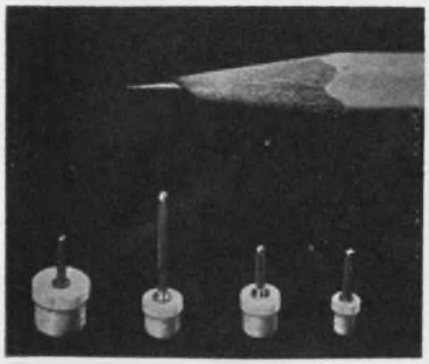
THE SINGER COMPANY, METRICS DIVISION • 915 Pembroke St., Bridgeport, Conn. 06608, U.S.A. • Phone (203) 366-3201 • TWX 710-453-3483

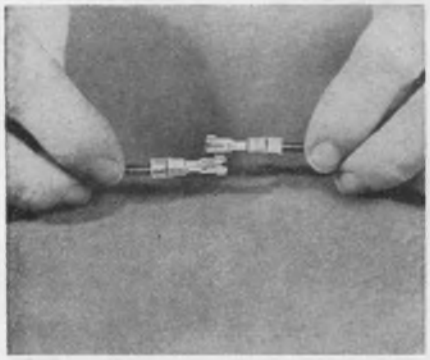


Submin standoff has Teflon bushing

Taurus Corp., Academy Hill, Lambertville, N. J. Phone: (609) 397-2390.

Teflon bushings and brass soldering lugs are used is the SSO series of subminiature standoff terminals. The components are designed to be pressed into a prepunched or drilled undersized hole in a chassis or PC board. A total of 18 terminal configurations are included. Units include standard solder plating 0.0003-in. or gold flash over silver at no extra cost.

CIRCLE NO. 251



"Wristlock" disconnect grips insulation

The Thomas & Betts Co., 36 Butler St., Elizabeth, N. J. Phone: (201) 354-4321.

A new "Wristlock" disconnect for interconnecting two wires features a long barrel for gripping wire insulation. This is intended to relieve the strain at the actual connection. The disconnects are offered in two sizes, AWG 22 to 18 and AWG 16 to 14. Crimping of the barrel on the wire and insulation is done in a single operation with the manufacturer's Elipti-grip Tool.

CIRCLE NO. 252

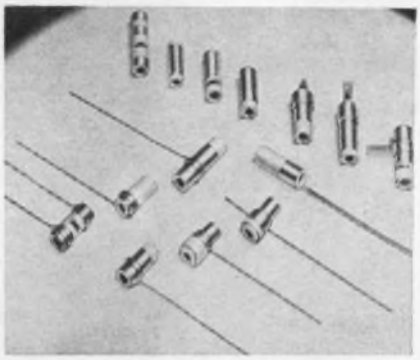
◀ ON READER-SERVICE CARD CIRCLE 205

Electric counters withstand spikes

Durant Manufacturing Co., 693 N. Cass Street, Milwaukee. Phone: (414) 271-4559.

Where line spikes pose a problem to conventional counters, the Y-1-MF shaded pole counter is designed to operate without protection. The counter is offered in 6- or 7-figure models, base or panel mounted, knurled knob or key reset. The unit also features a hinged escapement drive for long life and relative immunity to miscounts. Standard voltage is 115 Vac but others are available on special order.

CIRCLE NO. 253

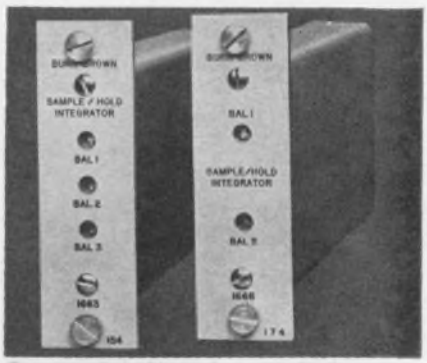


Tubular trimmer line includes 372 models

Centralab, P. O. Box 591, Milwaukee. Phone: (414) 962-9200.

Tubular trimmer capacitors, the W series, offer 48 capacitance ranges and 11 different mechanical configurations. Minimum capacitance is 0.2 pF and max capacitance runs as high as 20 pF. Working voltage is rated 500 Vdc. Capacitor body is steatite or N220 or N400 ceramic. For stability, the components are formed with a fired-silver electrode on a threaded tube.

CIRCLE NO. 254

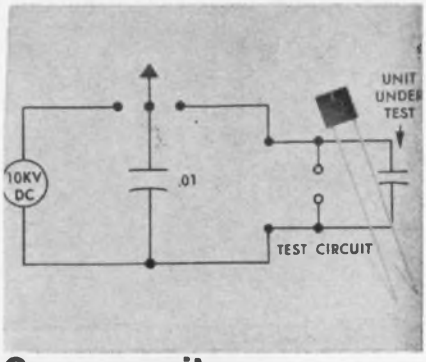


Sample/hold modules operate in two modes

Burr-Brown Corp., 6730 S. Tucson Blvd., Tucson. Phone: (602) 294-1431. P&A: from $295; stock to three weeks.

Long hold with fast acquisition is possible with the sample/hold switched integrator models 1663 and 1666. The units are capable of two separate modes of operation: sample and hold or switched integration. As a sample/hold module, model 1666 holds to 0.1% full-scale for 1 second and acquires the signal to within 0.55% in less than 100 μs. Model 1663 provides values 1/10th of model 1666.

CIRCLE NO. 255



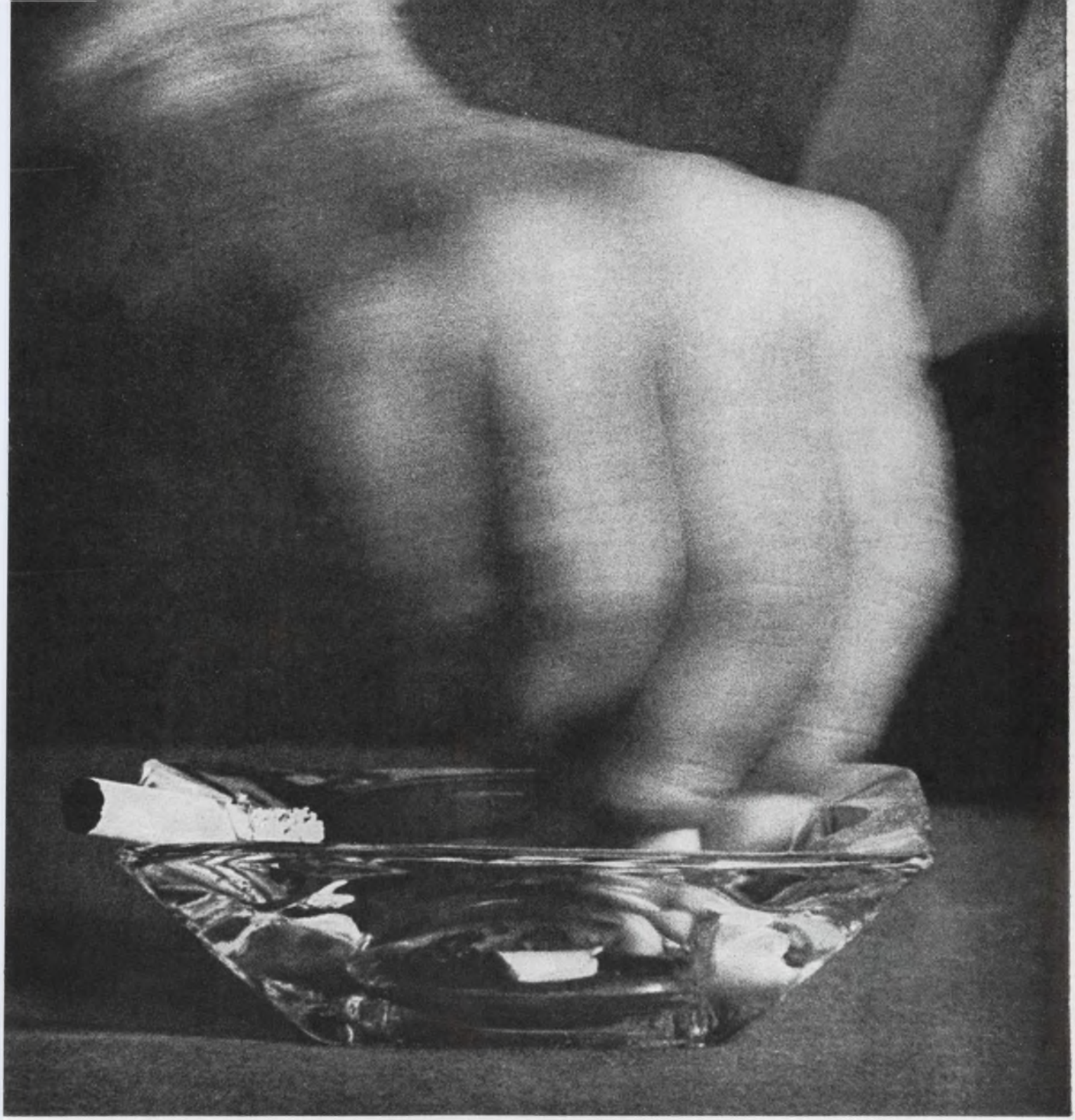
Gap capacitor limits transients

Aerovox Corp., Myrtle Beach, S.C. Phone: (803) 448-3191.

A miniature spark-gap capacitor provides 0.5 pF and limits excessive transient voltage surges to a nondestructive level. Designated type 3411, the 3-in.^{2} capacitor features a gap breakdown of 1 to 2 kV. Spark gap firing voltage is rated at 25°C at 50% RH and remains in the rating after firing for 50 cycles in the test circuit shown above.

CIRCLE NO. 256

ON READER-SERVICE CARD CIRCLE 89 ➤

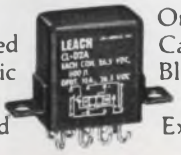


Put out because you can't get a reliable 10 amp magnetic latch relay? Next time call Leach!

Our 10-amp, 2 pdt, CL Series is just the answer. Of course we can't deliver bundles right now (it's just going into production), but we can meet your prototype requirements. And immediately.

This relay not only meets MIL-R-5757, but it's been tested against all your previous magnetic latch relay complaints. And it more than stands up to all of them.

For example, the CL magnetic assembly is a closed loop design which minimizes interaction with magnetic fields or other relays. And it only takes a 15*m*sec pulse to switch and hold—no continuous power is required



It's the smallest (1.100 high). The lightest (1.6 oz.). And directly interchangeable with other magnetic latch relays.

The CL Series is rated at 50g shock; 30g at 2000 cps vibration. Pretty tough. And construction is all welded and sealed, contaminant free, with an electron beam.

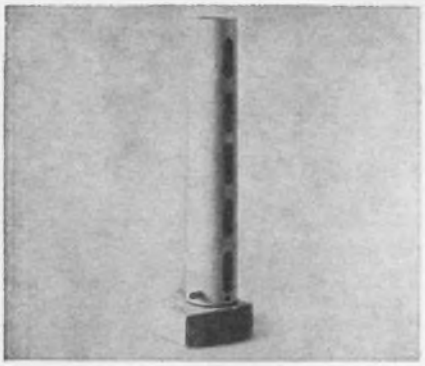
So don't be soured by other types you might have tried. Order ours. You'll get them. No ifs, ands, or . . .

Call Leach Corporation, Relay Division, 5915 Avalon Blvd., Los Angeles, California 90003.

Phone Area code (213) 323-8221

Export: LEACH INTERNATIONAL, S. A.

LEACH

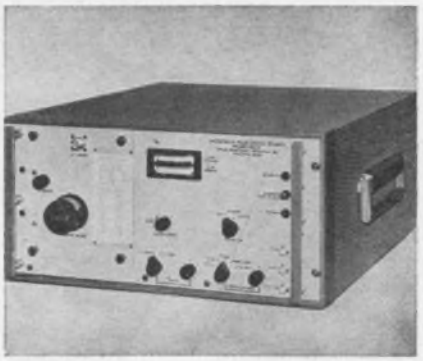


High-power TWT in small package

Microwave Associates, Burlington, Mass. Phone: (617) 272-3000.

Yielding a 1-kW cw output over the 200 to 400-MHz range, in a package measuring only 32 in. long by 3-3/4 in. diameter, this TWT claims to be the smallest in its power and frequency range. The MA-2015 has a hollow electron beam, providing greater gain per unit length. The tube also features forced-air cooling, solenoid focusing and 25-dB saturated gain.

CIRCLE NO. 257

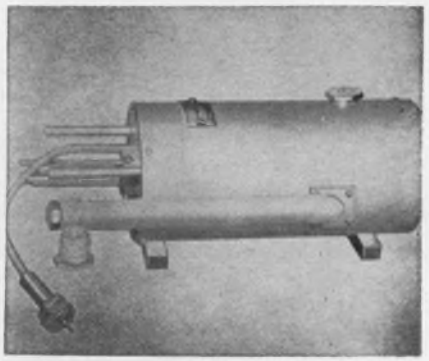


Signal source generates to 5 kW

Applied Microwave Laboratory Inc., Andover Street, Andover, Mass. Phone: (617) 245-9393.

Up to 5 kW of RF power is generated by the PG5K signal source. The instrument uses plug-in heads and a solid-state power unit to cover any band in the 150-MHz to 2.35-GHz range, with lesser power up to 6.1 GHz. The PG5K uses the grid-pulsing technique to reduce instrument size and weight. The complete PG5K will fit into 8-3/4 inches of a standard 19-in. rack.

CIRCLE NO. 259

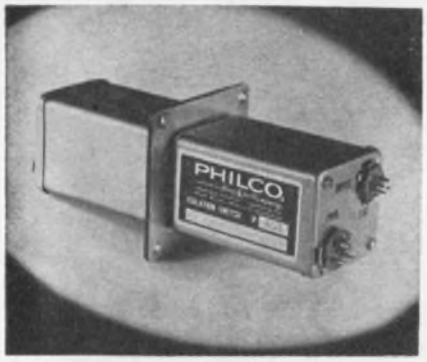


RF tetrode amplifier gains to 7.5 dB

Microwave Cavity Labs, Inc., 10 North Beach Ave., La Grange, Ill. Phone: (312) 354-4350.

The grounded-grid RF tetrode amplifier model 11004 combines a peak output of 14 kW and a gain of 7.5 dB. The amplifier, powered by an RCA 4621 tube, covers a frequency range of 410 to 460 MHz. Max input vswr is 2:1 and nominal impedances are 50 Ω in and out. Unit dimensions are 11-9/16 x 3.5 in. diameter and weight is 5 pounds.

CIRCLE NO. 261

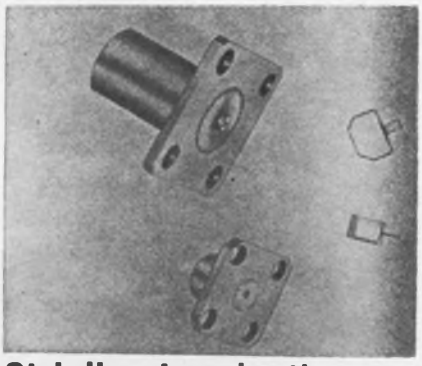


Isolation switch is electro-optical

Philco Corp., Spring City, Pa. Phone: (215) 948-8400. Price: $330 (1 to 9).

Output-to-input isolation of over 100 dB from dc to 1000 MHz is achieved in this switch by the use of a photon-coupled isolator. The P651A is a simplex low-level data or timing signal regenerative transmitting unit, with a signal-to-noise margin of 20 dB. The electro-optical feature permits high-speed signal transmission with good low-frequency isolation, without filters.

CIRCLE NO. 258

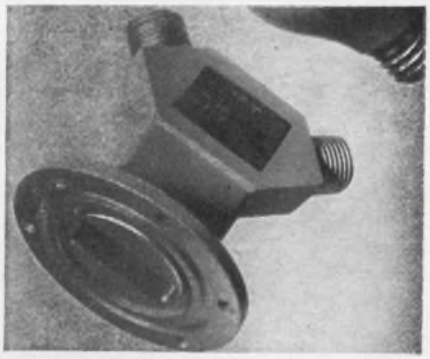


Stripline terminations easy to install

Filmohm Corp., 48 West 25th St., New York. Phone: (212) 924-6605.

Ease of installation is the leading feature of a line of strip transmission line terminations. Two of the types butt against the stripline end and bolt to the ground planes like a flange. The third inserts into the line and is clamped by the vertical bolting of the line. All three are made of metallic deposit on a ceramic substrate. The sleeve and a suitable matching structure are inserted into a metal case.

CIRCLE NO. 260



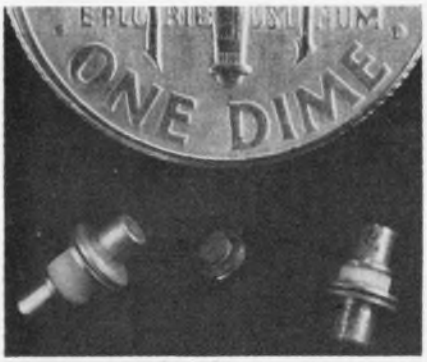
Water loads dissipate 100 MW peak

Varian Associates, 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000.

For use as dummy loads and for calorimetric measurements, a line of ceramic-block water loads cover bands between 2.6 and 18.0 GHz. Standard units dissipate up to 200 kW of average power, up to 14 MW of peak power in dry air and up to 100 MW with 40 psia of sulfur hexafluoride in the waveguide. The loads are designed for WR-284 and smaller waveguide.

CIRCLE NO. 262

ON READER-SERVICE CARD CIRCLE 206 ➤

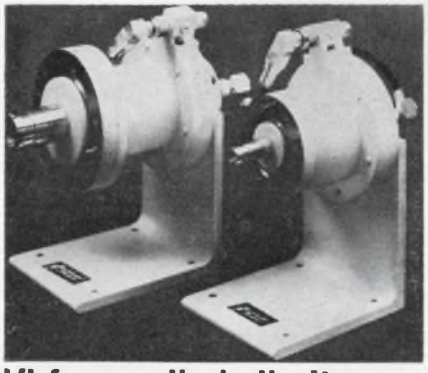


Paramp diodes cover uhf through Ku-band

Bomac Div., Varian Associates, Salem Rd., Beverly, Mass. Phone: (617) 922-6000.

These parametric amplifier diodes claim unusual gain-bandwidth performance with low noise figure at all frequencies from uhf through Ku-band. The silicon varactor diodes offer wide ranges of package style, series inductance and case capacitance. Metal-to-metal bonding is used throughout for ruggedness and the final package is hermetically sealed.

CIRCLE NO. 264



Vhf coax diode limiters operate at 1 MW

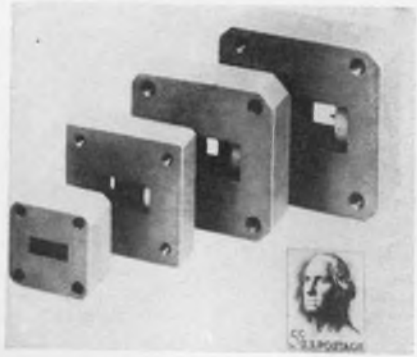
Microwave Associates, Burlington, Mass. Phone: (617) 272-3000.

Ultra-high-power vhf coax diode limiters for operation in the 20- to 200-MHz range provide complete receiver protection over any 20% bandwidth. They can be operated at power levels up to 1 MW peak, 5 kW average. The devices feature recovery time of less than 1 μs, no spike leakage and insertion loss of 1 dB nominal.

CIRCLE NO. 263

Win a free trip to Paris. See p. 232.

◀ ON READER-SERVICE CARD CIRCLE 206

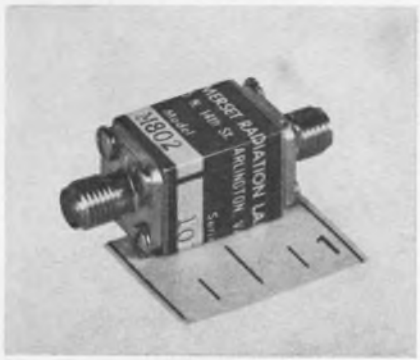


Ferrite isolators range to 25 GHz

Microwave Associates, Burlington, Mass. Phone: (617) 272-3000.

A new series of miniature waveguide ferrite isolators operate in the 7- to 25-GHz frequency range. Typical weight of devices in the line is less than three ounces. Other features include a max insertion loss of 0.3 dB with isolation of more than 20 dB. Vswr is rated 1.2 max and operating temperature range is −40 to 85°C. Shock and vibration specs meet MIL-E-5400.

CIRCLE NO. 265

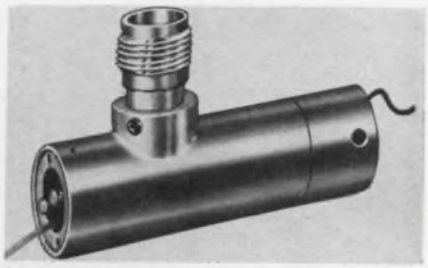


Diode multiplier is ultraminiature

Somerset Radiation Lab., Inc., 2060 N. 14th St., Arlington, Va. Phone: (703) 525-4255. P&A: $160; 5 days.

A harmonic generator and pulser covering the entire zero to 10-GHz spectrum has a volume of 0.3 $in.^3$ and weighs only 0.5 oz. Model M802 step-recovery diode multiplier has a conversion frequency approaching 200% divided by the harmonic number. It can also be used as the basis of a pulse generator providing rise and fall times of less than 1 ns, and amplitudes of 10 V into 50 Ω.

CIRCLE NO. 266



X-band triode LO offered from stock

Trak Microwave Corp., 4762 Kennedy Road, Tampa, Fla. Phone: (813) 877-8341. P&A: below $200 in production quantities; stock.

A triode LO for X-band applications is offered off the shelf at a price described as comparable to klystrons. The leading features of the units, designated "Resonatron 9170," are small size and weight, 2-in. long by 5/8-in. diameter and weights of 2 ounces. Two frequency ranges are immediately available, 8.5 to 9.1 GHz and 9.1 to 9.6 GHz. Both have single-screw manual tuning.

CIRCLE NO. 267

Frequency divider reads direct to 12.4 GHz

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $3250; stock.

To measure frequencies much over 400 MHz, you simply have to rely on either heterodyning or a transfer oscillator. The 5260A automatic frequency divider uses both to cover a range of 0.3 to 12.4 GHz. Briefly, the transfer oscillator is phase-locked to the input signal. Then, a reference frequency for the converter is synthesized from the transfer oscillator so that the converter output is held at a predetermined submultiple of the input. From there it is a matter of simple circuitry to a direct readout.

CIRCLE NO. 268

The long and the short of it...

If Sonotone doesn't have the rechargeable nickel-cadmium sealed cell you need—relax. We'll make it for you.

What Thomas Edison was to the electric light industry, Sonotone is to the portable power field. Developer, designer, a leading mass producer.

Today, Sonotone is one of the nation's leading manufacturers of rechargeable nickel-cadmium cells, backed by years of research and experience.

Sonotone produces a line as broad—and as flexible—as any in the industry. Lightweight, dependable and long-lasting, Sonotone's high-surge power sources meet just about any requirement a design engineer might demand.

Small wonder you'll find Sonotone sealed cells in most everything that spins, moves or flies, from NASA's orbiting satellites to Junior's orbiting hobby plane.

Got a problem in portable power? Take it to the company with the most complete capabilities in the field. Sonotone. Where more engineers are specialists in nickel-cadmium battery design. Or write for engineering help, merely stating your application requirements. We'll be happy to be of service.

Sonotone Battery Cells shown above are the Model S126 (.625 x .6 Size) and the S108 (F-Size)

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portable power—from Titan to toothbrush
SONOTONE CORPORATION, BATTERY DIV., ELMSFORD N. Y. 10523

Aircraft, Missile and Satellite Batteries • Power Supplies • Battery Charger/Analyzer

Looking for a more challenging opportunity? Join Sonotone's fast-growing engineering team in the skyrocketing field of nickel-cadmium battery design and development. *An equal opportunity employer.*

ON READER-SERVICE CARD CIRCLE 92

Modular laser system allows design choices

TRG/Control Data Corp., Route 110, Melville, N. Y. Phone: (516) 531-0600.

Although modular in design, the 300 series lasers are not components mounted on an optical bench but packaged laser systems. Nine configurations are provided to match a variety of needs in the higher power region. Power output ranges from 30 joules normal and 250 MW Q-switched to 125 joules normal and 1 GW Q-switched. A total of seven models are included in the line incorporating a variety of accessories and capabilities.

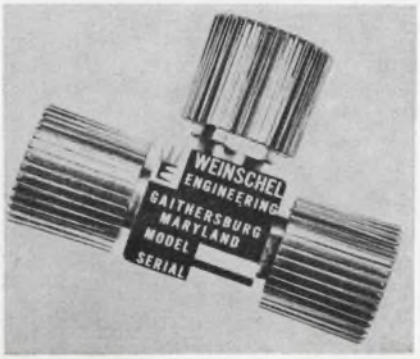
CIRCLE NO. 269

Radar receivers for close-target data

RHG Electronics Lab., Inc., 94 Milbar Blvd., Farmingdale, N. Y. Phone: (516) 694-3100. P&A: from $7900; 60 days.

A line of ultra-high-resolution, all-solid-state radar receivers, Series HR 400, is available for extended-range reconnaissance. 10-ns input pulses are handled with pulse reflections with a linear instantaneous dynamic range of 30 dB, providing accurate cross-section and range data on closely spaced targets. Applicable to airport taxi radar and short range tactical fire control, models are available in L- through K-band.

CIRCLE NO. 270

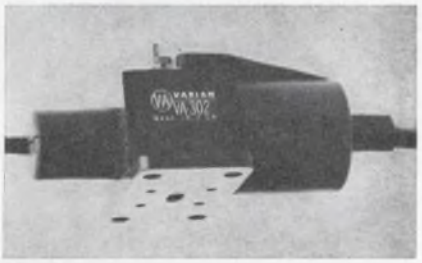


Power dividers cover dc to 18 GHz

Weinschel Engineering, Gaithersburg, Md. Phone: (301) 948-3434. Price: typically $150.

Broadband coverage, accurate balance of power division, and operating attenuation stability make these power dividers useful over a wide range of applications. The series 1506 dividers have a resistive film on a ceramic base, affording low temperature coefficient, ability to withstand pulse power, and long-term stability. The small, compact resistive element provides a smooth and almost constant frequency response over the entire band.

CIRCLE NO. 271



Reflex klystron pumps multichannel paramps

Varian Associates, 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000.

Rugged, long-life reflex klystron oscillators are offered for use as relatively high power pumps for multichannel Q-band parametric amplifiers. The VA-302 series are available either fixed-tuned, or trimmable within 1% at any frequency between 35 and 42 GHz. The output is between 250 and 350 W depending on frequency. The tube is designed for applications requiring lower voltage than for gridless klystrons.

CIRCLE NO. 272

Variable attenuators serve microwave needs

Merrimac Research & Development, Inc., 41 Fairfield Place, West Caldwell, N. J. Phone: (201) 228-3890. P&A: $170; stock.

Microwave requirements up to 12 GHz are met by the AUM-15 Series of wideband variable attenuators. These continuously variable attenuators are suggested in applications such as power control and level setting either in the lab or in the field. Model AUM15A is a general purpose device covering the 2- to 80-GHz range. Other models are offered in the 0.5- to 12-GHz region. Up to 8 GHz, attenuation ranges to 25 dB.

CIRCLE NO. 273

Narrow-band laser interference filters

Optics Corp., 322 Main St., Stamford, Conn. Phone: (203) 325-2279. Price: to $140 (1-in. dia.), to $210 (2-in. dia.).

A line of narrow-band laser filters provides bandwidths of 10, 30 and 100 Å at 4880 and 6328 Å; and 50 and 100 Å at 10,600 Å. These all-dielectric filters reduce transmission outside the pass band to less than 0.01%, and have straight skirts on the pass curve. They are designed for use with laser beam receivers in a strong white-light background, and are available in 1- and 2-in. diameters.

CIRCLE NO. 274

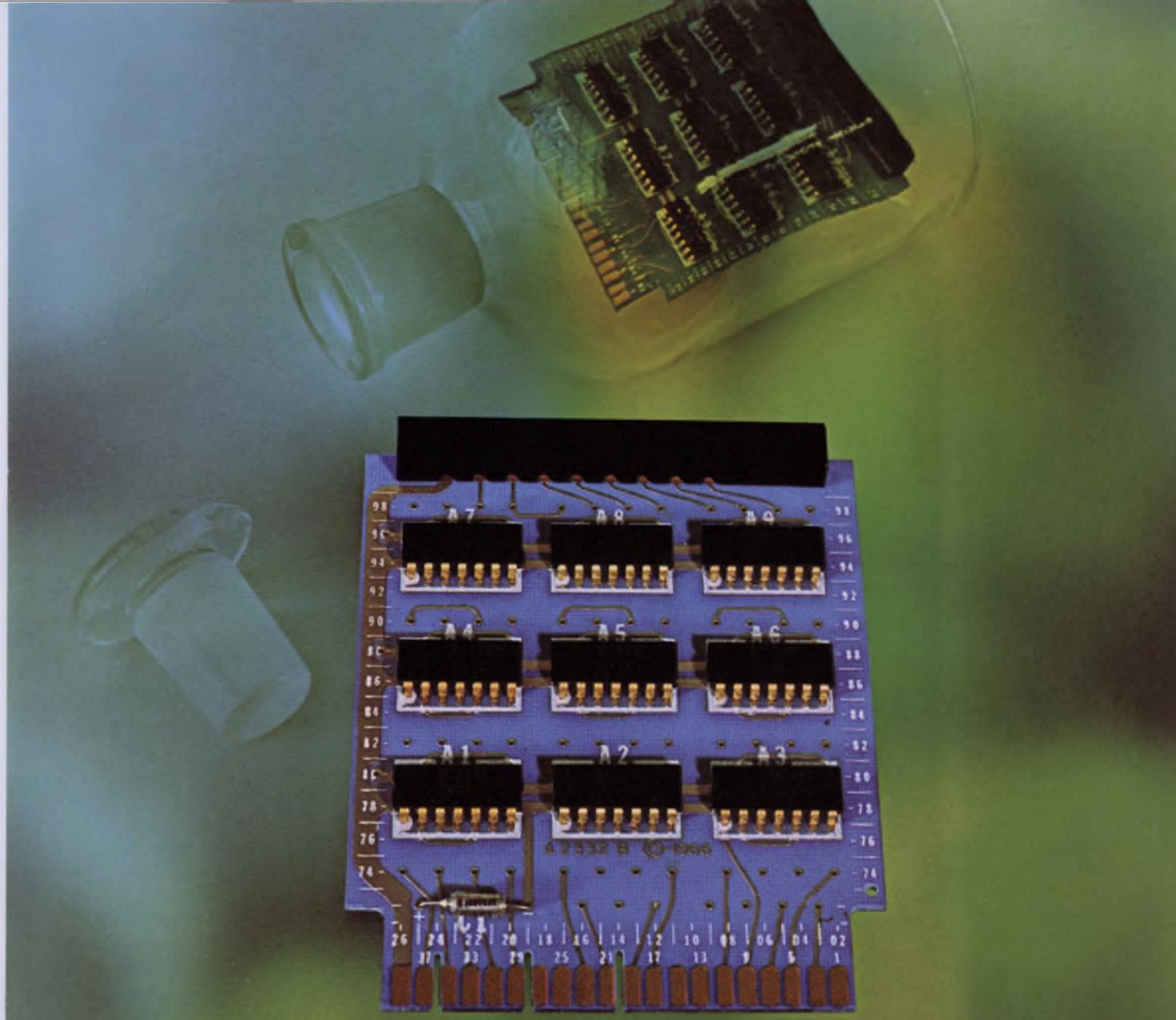
Stripline pills short to ground

EMC Technology, Inc., 1133-35 Arch St., Philadelphia. Phone: (215) 563-1340. P&A: $2 to $5.50; 2 weeks.

A convenient means of inserting a short-circuit during stripline measurements is offered by a series of "pill" stripline devices. These units, which simply effect a direct short to ground, weigh between 0.4 and 1.5 grams and are about the size of an aspirin. They are available in four different models for ground plane spacings of 0.062, 0.125, 0.150 and 0.250-in.

CIRCLE NO. 275

Win a free trip to Paris. See p. 232.



RAYTHEON COMPUTER'S NEW IC MODULES RELIEVE DIGITAL HEADACHES FAST.

CHECK THESE 28 POWERFUL INGREDIENTS:

1 Optimum size (3" x 3.65") for integrated circuits and discrete components. 2 1/16" blue epoxy fiberglass board NEMA grade FR4 flame retardant per MIL-E-16400E. 3 Direct entry edge-type connector with 40 gold-plated pins (20 per side). 4 Boards keyed for proper installation. 5 Ground and 8 signal test points in module handle. 6 All components and connector pins identified. 7 Coordinate system for fast component location when troubleshooting. 8 Reliable DTL circuits on IC modules. 9 Dual in-line IC package easily replaced in field. 10 Power supply decoupling on all modules. 11 Color-coded handle identifies module functional group. 12 Up to 8 gated flip-flops on a single card. 13 System operation to 2 MHz. 14 Unit loading simplifies fan-in, fan-out calculations. 15 Operation from 0°C to 70°C. 16 Rack-mounted case for small systems holds up to 40 modules. 17 Slide-out case for medium-size systems holds up to 120 modules. 18 Swing-out case for large systems holds up to 400 modules. 19 Connectors come in blocks of 10, 30 or 40 for faster, easier assembly. 20 Chassis and connector blocks designed for automatic wire wrap. 21 Ground plane mounting plate for connectors reduces spurious signals. 22 Connector and connector pin identification simplifies wiring, reduces errors. 23 Point-to-point wiring minimizes capacitance for high frequency operation. 24 Power and ground distribution bus bars reduce system noise, eliminate power inter-connections, cut hours from assembly and test time. 25 Over 30 types of modules for maximum logic capability. 26 Interface circuits include universal input/output level converters, power amplifiers, switch interface, Schmitt Trigger, and reed relay. 27 Power supplies mount inside cases. 28 Card extenders, blank utility boards, connector block assemblies, other accessories help experiments pay off fast. ■ You can't buy modules like these anywhere else and it would cost you thousands to make them yourself. Write today for literature, prices and delivery schedules. Raytheon Computer, 2700 South Fairview Street, Santa Ana, California, 92704. Ask for Data File M-135.

RAYTHEON

Hard loser.

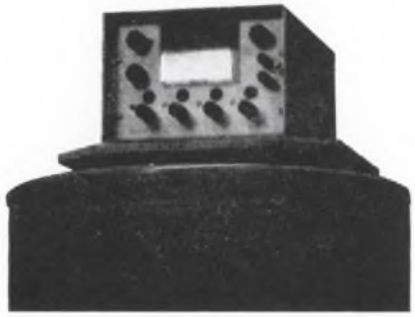
It took an awful lot of time and trouble to make a Dialamatic Voltmeter* fail. Actually, it took the laboratory equivalent of 100 years of field operation to come up with a loser. But we did it.

**(If you haven't heard, the Dialamatic starts where ordinary differential voltmeters leave off. Because of its unique Transfermatic Switch, the Dialamatic can carry from one decade to another with the click of a single knob. No more of that knob-twisting nonsense to get from, say, 3.999 to 4.000. And back again.)*

Here's the kind of testing we put our voltmeters through.

To prove that you just can't overload a Dialamatic, the instrument was subjected to a 1,000-volt input (both ac and dc) with the Dialamatic set at the 1-volt range in the most sensitive position. After this, reponse and calibration accuracy checked out perfectly.

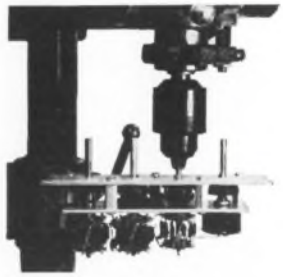
For really rugged abuse, we put the Dialamatic onto a shake table and jiggled the living daylights out of it. No damage. But we kept trying.



We life-tested the meter and null amplifier by plugging the Dialamatic into one of our function generators. With the generator providing better than a 1,000% overload, the needle pegged back and forth, back and forth, for the equivalent of 15 years of field operation. Actually, this test is running continuously and still no failures.

Then the Transfermatic Switch was attached to a low-speed motor to simulate the actual speed and torque of field operation. We've been running this test for more than six months with no luck. The switch still works perfectly.

But the high-speed test did it. We hooked the Transfermatic Switch to a motor turning at 1,500 rpm and ran it for the equivalent of 100 years of field operation. After that much time,



we finally had a few failures. Not many, though.

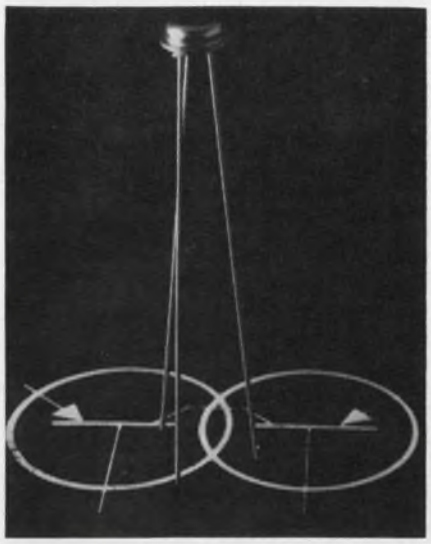
Anyway, the few losers we have are not for sale. But we do have a lot of winners. The Model 201 (5 digits, 0.01%, dc only) sells for $595; the Model 202 (both ac and dc) goes for $795.

How can you possibly lose?

WAVETEK®

8159 Engineer Rd., San Diego, Calif., Tel. 279-2200
European Sales: 3000 Bern 9, Seidenweg 17, Switzerland

ON READER-SERVICE CARD CIRCLE 208

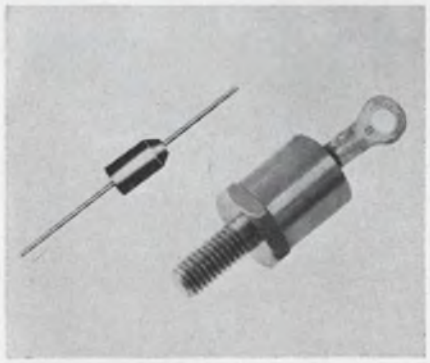


Si choppers have tiny saturation resistance

Crystalonics Div., Teledyne, Inc., 147 Sherman St., Cambridge, Mass. Phone: (617) 491-1670. P&A: $4.25 (1 to 99); stock.

Pnp silicon choppers and matched pairs are offered with R_{SAT} as low as 4 Ω; I(OFF) is 0.1 nA, V_o is 300 μV (pairs, 20 μV), and C_{eb} is 6 pF, all max values. Typical applications include digital-to-analog conversion, multiplexers, and chopper-stabilized amplifiers. Modifications are offered to customer specifications.

CIRCLE NO. 116

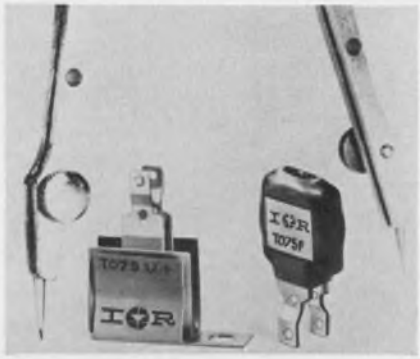


Power rectifiers for 75-ns switching

Solitron Devices, Inc., 256 Oak Tree Rd., Tappan, N. Y. Phone: (914) 359-5050.

Fast switching 75-ns power rectifiers range in ratings from 500 mA to 6 A. The rectifiers are available in high-voltage stacks to customer specs. All units meet MIL-S-19500 environmental specs.

CIRCLE NO. 117

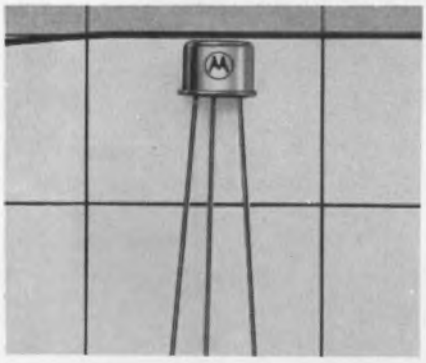


Se rectifier stacks double open-fin ratings

International Rectifier, 233 Kansas St., El Segundo, Calif. Phone: (213) 678-6281. Availability: stock.

Two selenium rectifier stack assemblies are said to provide the same ratings as conventional open-fin rectifiers in half the space. The TO75F and TO75U offer identical ratings in similar packages. Rating is 75 mA dc at 130 Vac input. Both can be mounted by their terminals to the PCB and the TO75U can be mounted by its special tab. PRV rating is 380 V and max reverse current is 600 μA.

CIRCLE NO. 118

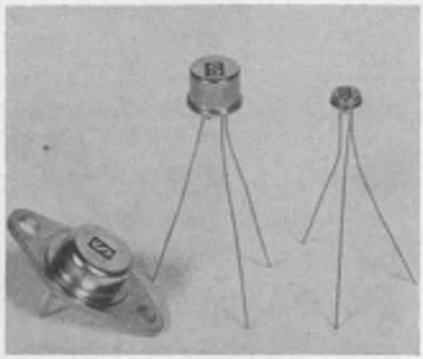


Linear 1-W transistor for audio output

Motorola Semiconductor Products Inc., P. O. Box 955, Phoenix. Phone: (602) 273-4560. P&A: $1.05 (100 to 999); stock.

This high-gain audio transistor features a flat beta characteristic over a collector-current range of 1 to 500 mA. Thermal resistance between junction and case is less than 15°C/W. The MM2264 Annular transistor is especially designed for audio output circuits in high-fidelity entertainment equipment.

CIRCLE NO. 119

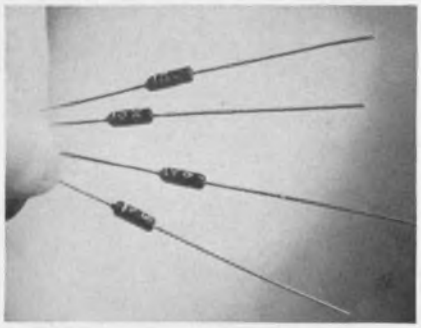


Si transistors meet power amplifier needs

Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. Phone: (305) 848-4311.

Designed primarily for power amplifier applications, a new 2-A transistor is available in three packages for application flexibility. Registered as 2N4862 (TO-46), 2N4863 (TO-5) and 2N4864 (TO-66), electrical specs remain the same. Sustaining voltage is 120 V, collector current is 0.5 A with h_{FE} of 50 to 150, V_{CE} (sat) of 0.2 V max and V_{BE} (sat) of 1.2 V max.

CIRCLE NO. 120

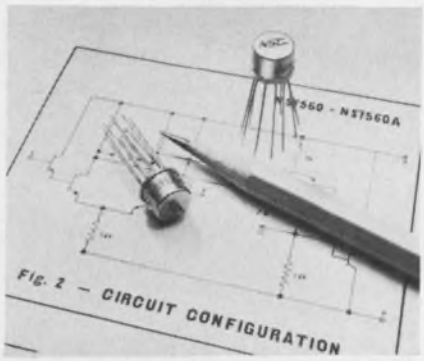


5-kV avalanche diodes packaged DO-7

Atlantic Semiconductor, Inc., 905 Mattison Ave., Asbury Park, N. J. Phone: (201) 775-1827. P&A: $1.25 (5 kV); stock.

For general applications, a line of silicon avalanche diodes, packaged DO-7, offers ratings from 1 to 5 kV. Called the ASI MD100 series, the devices can deliver up to 50 mA from 1 to 5 kV and up to 100 mA from 1 to 4 kV. Units are designed to operate at ambients from −65 to 150°C with reserve current ratings of 1 μA max at 25°C and 10 μA at 100°C while operating at PIV.

CIRCLE NO. 121

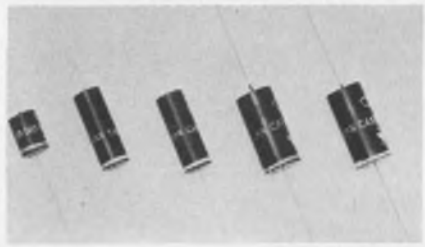


Hybrid op-amp outputs are ±50 mA peak

National Semiconductor Corp., Danbury, Conn. Phone: (203) 744-0060. Price: NS7560, $17.50; NS7560A, $35.00 (100).

Wide output voltage swing and high output current capability are attributed to hybrid construction in these operational amplifiers. Typical input offset voltage at 25°C with a source voltage of ±12 V is 5 mV for the NS7560 and 1 mV for the NS7560A. A programed gain of 10 is constant within 1 dB to over 1 MHz. The operating temperature range is −55 to 125°C.

CIRCLE NO. 122



Small silicon diodes operate at 200°C

General Instrument Corp., 600 W. John St., Hicksville, N. Y. Phone: (516) 681-8000. Price: $6.50 to $14.50 (1 to 99).

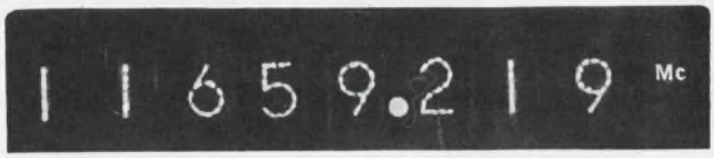
Operating temperatures up to 200°C, and low reverse leakage, are featured in these high-voltage silicon rectifier assemblies. Available in glass, hermetically sealed, epoxy cartridges, with welded diode interconnections, the diodes exceed the environmental requirements of MIL-S-19500/14A.

CIRCLE NO. 123

Enter the "Top Ten" contest on p. 232.

gigacycle counters

Only Systron-Donner can give you microwave frequency measuring systems, fully contained in one cabinet, that read directly in gigacycles. Just like this 11 gigacycle reading.

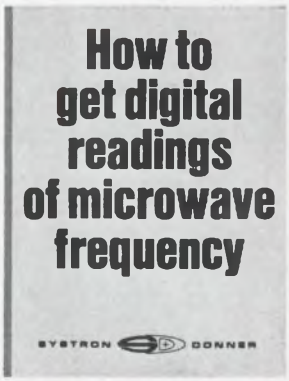


This one reads gigacycles instantly and automatically—eliminating all risk of human error. It's made possible by our unique plug-in, an Automatic Computing Transfer Oscillator called ACTO® for short. There are three ACTOs, but you need only the one for the range you're working in: 0.3 to 3 GHz, 3 to 8 GHz, or 8 to 12.4 GHz.

The one at right requires simple tuning, but it measures FM, FM deviation, and pulsed RF as well as CW. The plug-in is our semi-automatic transfer oscillator with phase lock to get counter accuracy. The T.O. range is so wide that this cabinet will measure the entire spectrum from dc to 15 GHz.

This group illustrates the Systron-Donner philosophy of advanced counter instrumentation. A basic counter or counter-timer measures to 100 MHz. Plug-ins add functions or extend the frequency range with unequalled convenience and economy.

Send for this instructive booklet.



Systron-Donner Corporation, 888 Galindo Street, Concord, California

SYSTRON DONNER

ON READER-SERVICE CARD CIRCLE 96

Silicon power rectifiers feature high currents

International Rectifier, 233 Kansas St., El Segundo, Calif. Phone: (213) 678-6281. Availability: stock.

This new series offers up to 275 A current capability at non-repetitive peak reverse current ratings from 100 to 1300 V, or from 50 to 1000 V repetitive. All are designed to operate in the temperature range of −65 to 190°C. The high current ratings of these units gives them wide application in power conversion systems, power supply circuits and instrumentation systems.

CIRCLE NO. 124

10-A planar npns sustain 325 V

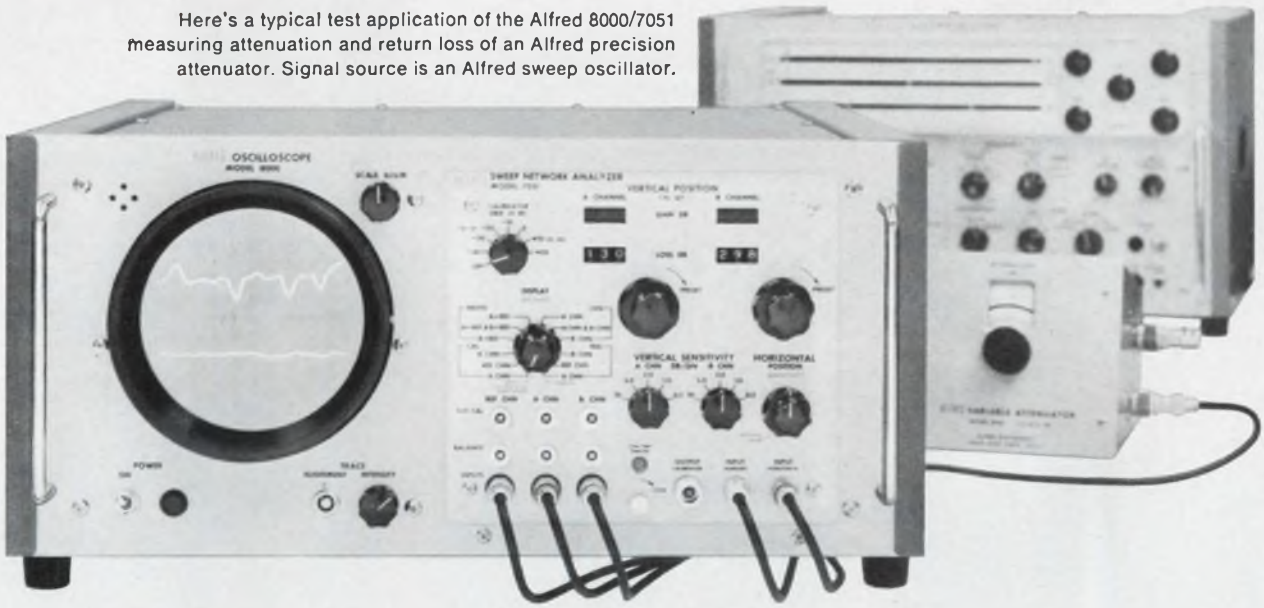
Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. Phone: (305) 848-4311. Availability: stock.

These planar npn high-voltage 10-A transistors feature sustaining voltages from 200 to 325, and characterization at 5 A with usable h_{fe} at more than 10 A. The basic device, MHT 7800, is packaged in a TO-61 can, and is capable of dissipating 50 W at 100°C case temperature. The basic device also comes in a TO-3 or TO-66 package.

CIRCLE NO. 125

Alfred breaks the square law barrier with a swept power level and ratio measurement system with 60 db dynamic range.

Here's a typical test application of the Alfred 8000/7051 measuring attenuation and return loss of an Alfred precision attenuator. Signal source is an Alfred sweep oscillator.



Now, with one totally new instrument, measure gain, loss, absolute or relative power levels, VSWR, and impedance magnitude (reflection coefficient). The new Alfred 8000/7051 system speeds and simplifies rf and microwave measurements.

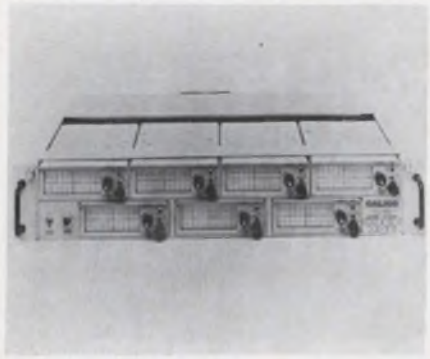
Ten key features overcome deficiencies in present day equipment. You won't find them anywhere else!

1. 60-db measurement range. Operates with crystal detectors; internal analog electronics compensates for crystal performance above the square-law region.
2. Built-in precision rf signal generator provides calibration for power level measurements; has an accuracy of ±0.3 db at +20 dbm, and ±0.6 db at −40 dbm.
3. Unique ratiometer mode measures the db ratios of any two signal levels compared to a third, with 2% accuracy. This permits direct readout of reflection or transmission performance.
4. Direct db or dbm readout over the full 60-db range; CRT sensitivity adjustable from 0.5 db/cm to 10 db/cm to allow quick-look or detailed examination.
5. Does not require source modulation or leveling. Thus, the full power and stability of the signal source can be utilized.
6. Makes swept or single-frequency measurements; internal sweep spreads single-frequency displays. Works with either automatic or manual sweeps.
7. Drift free operation.
8. Dual-channel presentation permits simultaneous measurement of two parameters, such as reflected and transmitted power levels. Recorder outputs are provided.
9. Offset adjustment of up to 60.0 db gain or loss direct reading to 0.1 db, independently in each channel, eliminates the need for external precision attenuators.
10. Costs only $1680 for the Model 8000 Oscilloscope with the Model 7051 Sweep Network Analyzer plug-in.

There's more to the story. Call your ALFRED representative or write for details. Address Alfred Electronics, 3176 Porter Drive, Palo Alto, California 94304.

ALFRED ELECTRONICS

ON READER-SERVICE CARD CIRCLE 94



Monitor scope adapted to medicine

California Instruments Corp., 3511 Midway Dr., San Diego, Calif. Phone: (714) 224-3241. P&A: $3275; 30 days.

A 7-channel monitor oscilloscope of the 7000 Series is said to be particularly adapted to use in medical and biological research. The new Model 7004 differs from the previous models in the line in its slow power factors 20% to 10% on mA sweep rate and high-persistence phosphor (P7). Horizontal sweep rates can be selected in five decade steps from 500 to 0.05 ms per graticule division.

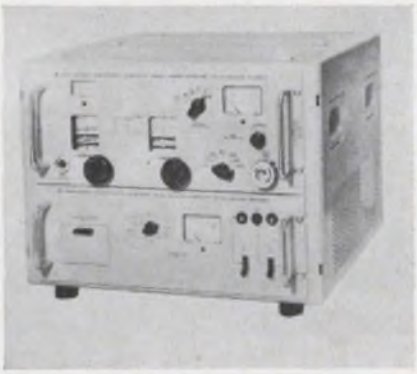
CIRCLE NO. 126

Ac/dc transfer standard accurate to 0.01%

Singer Co., Metrics Div., 915 Pembroke St., Bridgeport, Conn. Phone: (203) 366-3201. P&A: $750; 30 days.

The Model FLH-2 ac/dc voltage transfer standard measures the influence of frequency variation on a variety of standard laboratory instruments. Accuracies range as high as 0.01% to 50 kHz. Complete instrument range is dc and 20 Hz to 1 MHz. Voltage range is 0.5 to 1000 V in 14 steps.

CIRCLE NO. 127

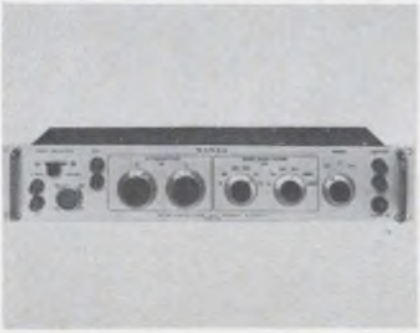


Frequency synthesizer covers 470 to 1000 MHz

Rohde & Schwarz, P. O. Box 148, Passaic, N. J. Phone: (201) 773-8010. P&A $7705; stock.

A solid-state frequency synthesizer covers a range of 470 to 1000 MHz directly. Output of the instrument, called XUC, is derived from two components; a crystal-controlled frequency standard and an interpolation oscillator. Unit resolution is 5 kHz (0.5 Hz with the manufacturer's ND30M synthesizer used as a vernier). The standard is accurate to 2 parts in 10^9.

CIRCLE NO. 128



60-dB amplifier has built-in supply

Massa Division, Dynamics Corp. of America, 280 Lincoln Street, Hingham, Mass. Phone: (617) 749-4800.

Particularly useful for making noise measurements, the AM-1 general purpose amplifier has a noise factor of −150 dBV/cycle, and a frequency range of 2 Hz to 200 kHz. It may also be used for exact measurements of the open circuit sensitivity of an unknown transducer. Maximum gain is 60 dB and accuracy is ±0.5 dB. Maximum output is 3 V rms.

CIRCLE NO. 129

Ohms-to-dc converter has high accuracy

Data Technology Corp., 2370 Charleston Rd., Mountain View, Calif. Phone: (415) 321-0551.

With a precision of ±0.001 of reading, the DT-1405 performs the conversion from resistance to dc with an accuracy comparable to that of the voltmeter used. The specimen resistor is inserted into the feedback loop of a high-gain high-input impedance operational amplifier having a known input current. High accuracy, linearity and temperature stability are indicated.

CIRCLE NO. 130

Multipulse generator checks nav-aids

Datapulse, Inc., 509 Hindry Ave., Inglewood, Calif. Phone: (213) 671-4334. P&A: $1650; 6 weeks.

A variety of multipulse formats useful in beacon interrogation and simulation of navigational signals are produced by the 102-S1 generator. Single pulses, pulse pairs, double pulse pairs and triple pulses are generated by the instrument at repetition rates to 500 kHz. Pulse separation and pair separation are continously variable from about 0.5 μs to 10 ms.

CIRCLE NO. 131

Field strength meter operates 400 to 900 MHz

Hexem, Inc., P. O. Box 636, Los Gatos, Calif. Phone: (408) 354-1260. P&A: $125; stock.

Both frequency and field-strength readings can be taken by the model 410 meter. In a range of 400 to 900 MHz, the 410 offers a sensitivity of 1 μV for 20% meter deflection and a frequency accuracy of 1% of reading. A jack is provided for headset or scope output. Direct electrical connection to the unit under test is not required and temperature effects are described as negligible.

CIRCLE NO. 132

Hall gaussmeter accurate to 1%

Hirst Electric Industries Ltd., Gatwick Rd., Crawley, Sussex, England. Phone: CRawley 25721. Price: $322.

A power line-operated Hall-effect gaussmeter has been developed by a British company for checking dc and permanent magnetic fields with an accuracy approaching 1%. Switchable ranges of the instrument, GM1, give continuous calibration from 0 to 1000, 5000, 10,000 or 20,000 gauss. A 1000-gauss reference magnet is provided with the instrument to perform occasional calibration checks.

CIRCLE NO. 133

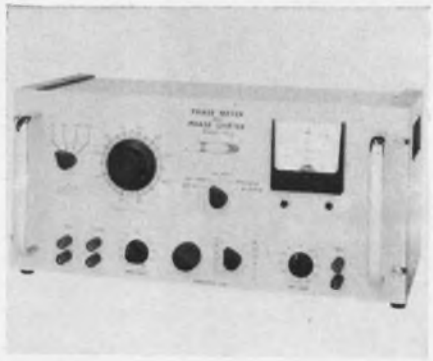
Over 100 prizes—enter contest on p. 232.

3-inch scope weighs six pounds

Schaevitz-MCD, 2445-63 Emerald St., Philadelphia. Phone: (215) 885-2800.

The very portable Transi-scope 300 measures 3-1/2 x 7-1/2 x 12-in. and weighs only six pounds. The instrument is fully solid-state with the exception of its 3-in. CRT. Min vertical and horizontal sense is 10 mV p-p/division with a frequency response of 0 to 100 kHz for dc and 10 Hz to 100 kHz for ac. Vertical and horizontal attenuation are adjustable in three ranges of about 20 dB each.

CIRCLE NO. 134



Phase meter/shifter spans 30 Hz to 30 kHz

Dytronics Co., Inc., 4800 Evanswood Dr., Columbus, Ohio. Phone: (614) 885-3303. P&A: $620, 3 wks.

Model 301A is a combination phase meter and phase shifter designed to operate over a 30-Hz to 30-kHz range. Phase angle is read directly and a quadrant selector switch makes possible unambiguous readings to 360°. Accuracy is ±2°, input impedance is 10 MΩ and sensitivity is 85 mV. Output is adjustable from 0 to 5 V rms.

CIRCLE NO. 135

AIRTRON

DOES IT AGAIN . . .

SOLID STATE

Local Oscillator with incidental F.M. less than 3 parts in 10^7.

Circle Service No. 821

AND AGAIN . . .

SUBMINIATURE FERRITE

Circulator occupies less than ½ cu. in., covers 4.2 - 4.4 GHz.

Circle Service No. 822

AND AGAIN . . .

HIGH POWER FERRITE

4-Port Circulator, *tested* at 20 megawatts peak power, 20 Kw avg. power.

Circle Service No. 823

AND AGAIN . . .

STRIP LINE

assembly combines 16 components into a single package 9¼″ x 6¼″ x 2½″.

Circle Service No. 824

AND AGAIN . . .

WAVEGUIDE

innovation, *AIRFLEX*®, allows field assembly of flexible waveguide.

Circle Service No. 825

And will keep on presenting you with microwave component and assembly innovations. These illustrations represent only a few proven examples of Airtron's creative thinking, research and state-of-the-art know-how plus full scale production facilities. And . . . they're all available now.

AIRTRON

DIVISION OF LITTON INDUSTRIES

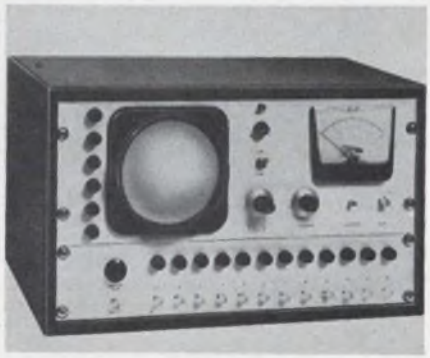
200 EAST HANOVER AVENUE, MORRIS PLAINS, N. J. Telephone: 201 539-5500

Single instrument reads watts-amps-volts

Greibach Instruments Corp., 315 North Avenue, New Rochelle, N. Y. Phone: (914) 633-7900.

A combination instrument, the Model 560WAV, provides watt, amp and voltage readings. Milliwatt ranges are 50/100/250/500. Milliamp ranges are 1/2/5/10. Volt ranges are 50/100/250/500 at 1 kΩ. Accuracy ±0.5% full scale for power factor unity to 50%, ±3% for power factors 20% to 10% on mA ranges.

CIRCLE NO. 136

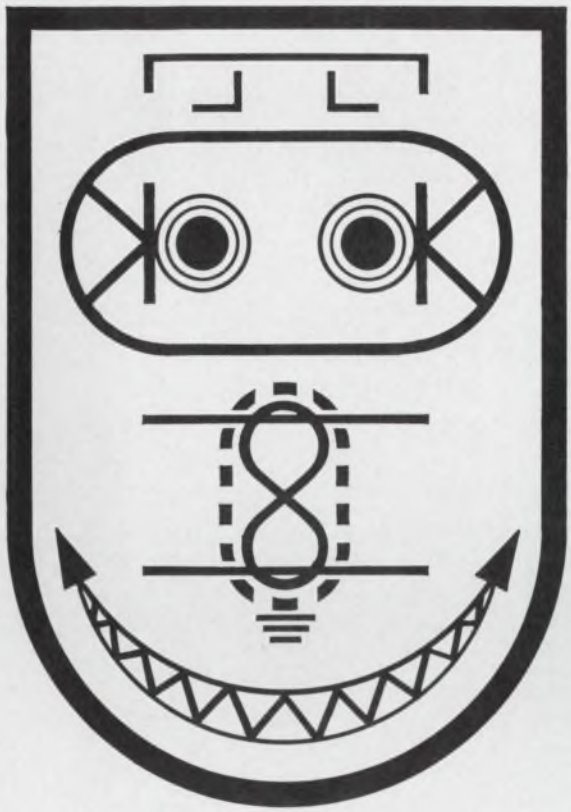


Spectrum analyzer has plug-in filters

Spectrum Instruments, Inc., P. O. Box 474, Tuckahoe, N. Y. Phone: (914) 779-8111.

A non-scanning, continuously active comb filter system, with frequency range determined by specified plug-in filters, this real-time spectrum analyzer can commutate displays of 48 channels simultaneously. The spectrum analog filters work at actual operating frequency for more constant bandwidth-to-center-frequency ratio. Center frequencies from 0.01 to 100 kHz have cutoff slopes of 12, 24 and 36 dB per octave.

CIRCLE NO. 137



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in your
drafting
room!

Mergenthaler

With The Diagrammer you simply touch one of the 256 push buttons . . . the symbol leaps to the viewing screen . . . you move it to its location . . . and press the Expose button. Ten seconds, if you're slow.

Anything at all, from a line drawing of your company president to a miniaturized circuit.

It's fair game for a Diagrammer slide as long as it can fit into a 3 inch diameter circle.

It's fast, it's economical and the quality of the film output is better than inked.

Ask us for the full story. Mergenthaler Advanced Systems, 29 Ryerson St., Brooklyn, New York 11205. Or call (212) ULster 5-0300.

THE DIAGRAMMER

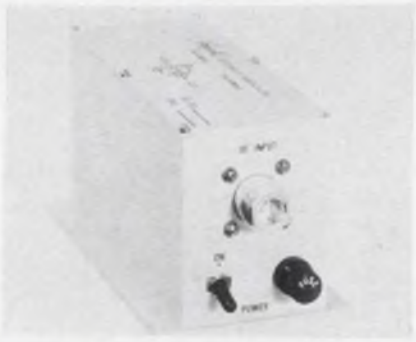
ON READER-SERVICE CARD CIRCLE 105

Frequency counter priced below $1000

Beckman Instruments, Inc., 2500 Harbor Blvd, Fullerton, Calif. Phone: (714) 871-4848.

The solid-state 2-MHz counter 6010A, priced below $1000, measures frequencies, periods and multiple period averages, and random or repetitive pulses. It is also capable of measuring frequency ratios and multiple ratio averages. Input sensitivity is 100 mV rms, and, with dc coupling, the 6010A can accomodate a variety of input signal configurations.

CIRCLE NO. 138



Antenna preamplifier reduces system noise

Smyth Research Associates, 3555 Aero Ct., San Diego, Calif. Phone: (714) 277-0543. P&A: $495; 6 wks.

Installation of the 821D preamplifier near the antenna feed is said to virtually eliminate the transmission line as a contributor to communication system degradation. Noise figure is then very nearly the noise figure of the preamplifier alone. Typical noise of the SRA–821D ranges from 1.6 dB for frequencies up to 400 MHz and 2 dB up to 500 MHz. Gain is 30 dB typical.

CIRCLE NO. 139

Wattmeter gives polyphase readings

Voltron Products, Inc., 1020 So. Arroyo Pkway., Pasadena, Calif. Phone: (213) 682-3377.

Power readings on 1, 2 or 3 phases are provided by the three-element wattmeter, PW-3R. In this instrument, passive solid-state circuits convert incoming ac to dc which is then summed and read out on a taut-band meter. Frequency range is 50 to 3000 Hz and power factor is 0.1 to 1. Full-scale power is 1, 2, 3, 12, 30 and 120 W with an accuracy of 1% of full-scale.

CIRCLE NO. 140

Precision noise generator covers dc to 35 kHz

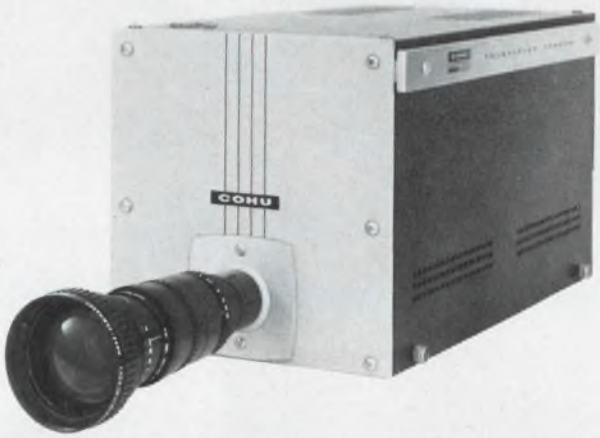
Elgenco, Inc., 1550 Euclid St., Santa Monica, Calif. Phone: (213) 451-1635. P&A: $2475; stock.

This dual-output random noise generator covers spectrums from dc to 400 Hz, and from 10 to 35 kHz. It supplies two Gaussian noise voltages with precisely controlled white power frequency spectra. Each output level is continuously adjustable to 1 V rms. The 632A is adapted to both 19-in. rack mounting and cabinet enclosure.

CIRCLE NO. 141

Over 100 prizes—enter contest on p. 232.

Introducing the most versatile vidicon camera ever built – Cohu's new 3200 series!



IT'S A CCTV CAMERA – completely self-contained. Just add a single coaxial cable to any video monitor and it's ready to operate. Want high resolution? Plug in one of four optional integrated-circuit sync generator boards for 525-, 729-, 873-, or 945-line scan patterns.

IT'S A BROADCAST CAMERA, TOO! Add a "mounts-in-minutes" 5-inch viewfinder and the Cohu 3200 is ideal for studio, education, or remote applications. An optional film chain adapter further enhances its versatility and provides all necessary remote controls.

For prices, delivery and full details, contact Cohu engineering representatives in major cities throughout the United States and Canada.

COHU
ELECTRONICS, INC
SAN DIEGO DIVISION

Box 623
San Diego, California 92112
Phone: 714-277-6700

ON READER-SERVICE CARD CIRCLE 107

TEST EQUIPMENT

Carrier-null calibration has 0.1% accuracy

Advanced Measurement Instruments, Inc., 109 Dover St., Somerville, Mass. Phone: (617) 623-2008.

Calibration of any FM monitor's frequency deviation can be made to an accuracy of at least 0.5% with this versatile unit. The "Monocal 500" can be used as an FM signal generator, low-distortion audio oscillator, frequency counter, selective receiver or carrier-null visual indicator. Peak deviation of IF signals, and audio signals from 20 Hz to 100 kHz, can be measured.

CIRCLE NO. 142

Vlf tracker tunes 3 to 99.95 kHz

Tracor, Inc., 6500 Tracor Lane, Austin, Tex. Phone: (512) 926-2800.

For frequency measurement, calibration and standardization, the Model 599J phase tracking receiver tunes from 3.00 kHz to 99.95 kHz. It uses an SSB technique in the RF section to eliminate need for RF filters. Image rejection is 60 dB to 30 kHz and 50 dB beyond. Receiver sense is 10 nV and tracking is maintained at input signal-to-noise ratios to −50 dB.

CIRCLE NO. 143

Frequency counter has 4-digit readout

Magtrol, Inc., 240 Seneca St., Buffalo, N. Y. Phone: (716) 856-7451. Price: $575.

A four-digit Nixie readout, with spill indicators for counts exceeding 9999, is featured in this all-silicon frequency meter. Its applications include speed measurement, batch counting and time interval measurement, with accuracy equal to that of the line frequency. Exterior gating is standard for auxiliary measurement of period and time response. Frequency range is 5 Hz to 150 kHz.

CIRCLE NO. 144

Phase detector for pulse or cw

Ad-Yu Electronics, Inc., 249-259 Terhune Ave., Passaic, N. J. Phone: (201) 492-5622.

Phase readings of the type 251 phase detector are unaffected by amplitude fluctuations of either or both inputs. A phase difference of 0.05° can be detected by the instrument. It meets the need for an instrument to measure phase deviation from cycle to cycle, or from pulse to pulse of a pulse modulated sine wave or a staircase-modulated TV signal.

CIRCLE NO. 145

Test oscillator covers 10 Hz to 10 MHz

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: from $590; 6 to 8 wks.

In six continuously variable ranges, the 651B test oscillator covers the spectrum from 10 Hz to 10 MHz. Close control of amplitude is provided by a coarse and vernier amplitude control. Short term frequency stability is typically ±0.02%/22 hours and amplitude stability is typically ±0.1%/17 hours. The instrument's rack-convertible housing is 5-1/4-in. high, 16-3/4-in. wide and 13-1/4-in. deep.

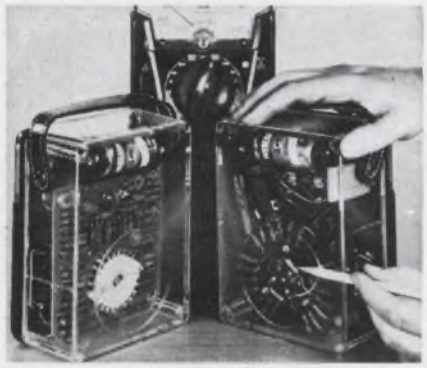
CIRCLE NO. 146

Signal correlator ranges dc to 300 kHz

Princeton Applied Research Corp., P. O. Box 565, Princeton, N. J. Phone: (609) 924-6835. P&A: $8500; 60 to 90 days.

The Model 100 signal correlator is intended for detection, measurement or comparison of noisy signals. It makes practical the applications of auto- and cross-correlation signal-processing techniques in such fields as aero- and hydrodynamics, plasma physics, vibration analyses, radar and laser studies, and radio astronomy. The instrument operates in real time over a dc to 300 kHz range.

CIRCLE NO. 147

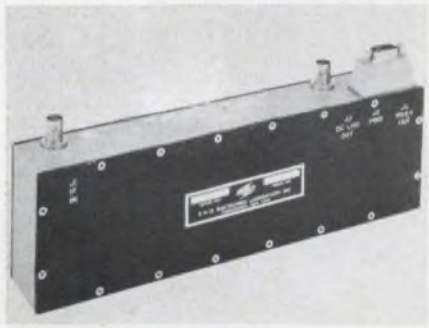


See-through backs expose VOM works

Triplett Electrical Inst. Co., Inc., Bluffton, Ohio. Phone: (419) 358-5015. P&A: $4.50 extra; stock to 3 wks.

For training purposes, transparent plastic backs are available on certain of Triplett's volt-ohm-milliammeters. In use, the back dynamically shows the user the fixed resistors, diodes, wafer switches, etc. The back is available on models 630, 630-A, -PL, -APL, -PLK, -NA, -NS, -M, -L and Triplett's newest 630-APLK.

CIRCLE NO. 148



Log IF amplifier has 10-ns risetime

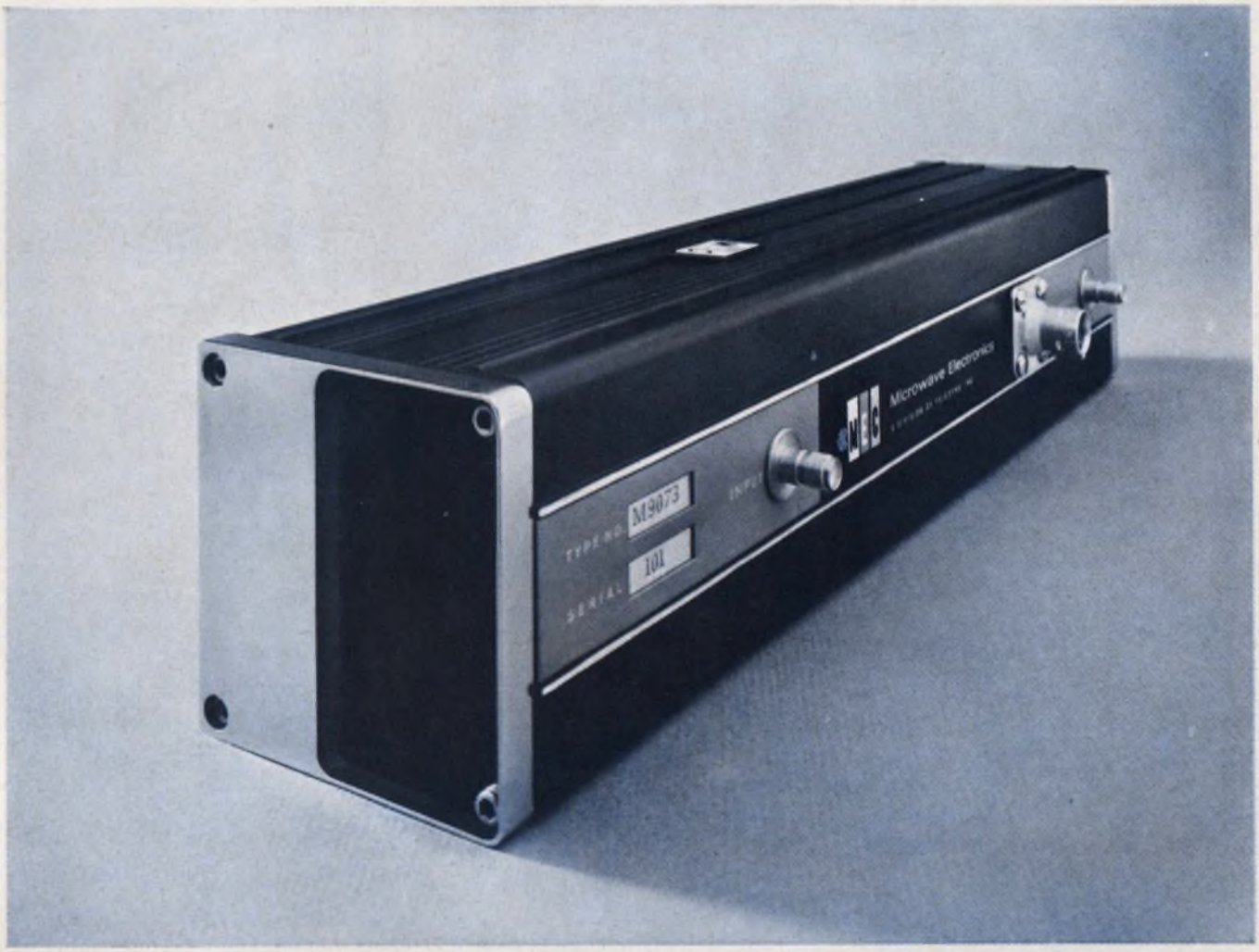
RHG Electronics Lab., Inc., 94 Milbar Blvd., Farmingdale, N. Y. Phone: (516) 694-3100.

Solid-state wideband log IF amplifiers with 100-MHz bandwidths feature a 10-ns risetime with excellent transient response and a wide dynamic range with excellent linearity. Center frequency is 200 MHz and signal input range is −37 dBm to 7 dBm.

CIRCLE NO. 149

Enter the "Top Ten" contest on p. 232.

It's later than you think!



Here's the second generation TWT amplifier.

Smaller and *lighter* than any other integrated TWT amplifier on the market! That's the difference – the BIG difference—between MEC's new low noise TWT amplifier and all first generation versions.

Let's be specific:

- ☐ MEC's rugged package weighs *less* than 4 pounds.
- ☐ It's only $11\frac{3}{8}$ inches long and is $2\frac{3}{8}$ inches square.
- ☐ It operates on *either* ac or dc.
- ☐ And, it meets MIL-E-5400 Class II requirements.

That's what makes MEC's TWT amplifier ideal for airborne and other applications where space and weight are at a premium.

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.

Exceptional opportunities exist on our technical staff for qualified scientists and engineers. MEC is an equal opportunity employer.

Microwave Electronics 3165 Porter Drive, Palo Alto, California a division of Teledyne, Inc.

ON READER-SERVICE CARD CIRCLE 182

Angle position indicated in digital readout

Occo Mfg. Corp., 8 Romanelli Ave., S. Hackensack, N. J. Phone: (201) 342-8984.

Angular shaft positions of remote servo components are indicated continuously in degrees and minutes by these rugged RFI-shielded units. The 2166 series of all-solid-state indicators meets MIL-T-2100, and accommodates single-speed or multispeed inputs from transmitters, receivers or differential components. Retransmit components can include synchros, potentiometers and shaft encoders.

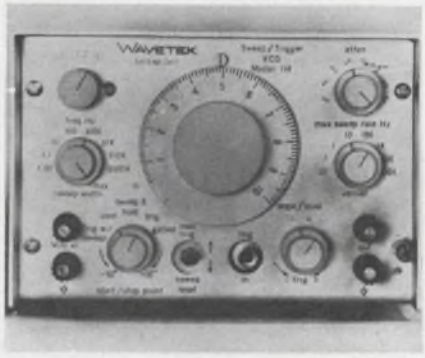
CIRCLE NO. 150

Portable wattmeter has 5 voltage ranges

Greibach Instrument Corp., 315 North Ave., New Rochelle, N. Y. Phone: (914) 633-7900. Price: $1750.

A voltage selection range of 10 to 100 volts, in five steps, is provided by the Model 560W-40 portable wattmeter. Basic watt ranges are 0.5, 1, 5, 10, 50, and 100 W over a frequency range of 50 Hz to 5 kHz. Indexing the voltage selector introduces a range multiplier that effectively extends the basic watt ranges. Max current ranges from 0.25 to 50 A.

CIRCLE NO. 152



Function generator voltage controlled

Wavetek, 8159 Engineer Road, San Diego, Calif. Phone: (714) 279-2200. Price: $695 or $795 with battery pack.

For general purpose applications, the Model 112 triggered voltage-controlled function generator provides nine simultaneous outputs. Over a frequency range of 0.0015 Hz to 1 MHz, the instrument will provide sine, square, triangle, ramp and sync-pulse waveforms. By applying a trigger-voltage, one cycle is produced. A gate causes pulse or other waveform trains. The trigger start-stop point is selectable over 360°.

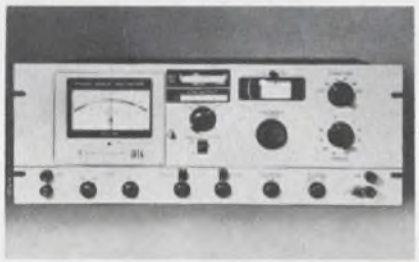
CIRCLE NO. 154

All-silicon counter-timer in small package

Anadex Instruments, Inc., 7833 Haskell Ave., Van Nuys, Calif. Price: $845; 3 to 4 wks. Phone: (213) 782-9527.

With a 1-3/4-in front-panel height, this all-silicon counter-timer is designed to be rack- or bench-mounted. The solid-state unit measures frequency, period and multiple period average, or time interval, or totalizes the number of input cycles or events. Internal time base is generated by decade divider circuits from a 100-kHz crystal oscillator. Maximum sensitivity is 10 mV from 3 Hz to 200 kHz.

CIRCLE NO. 151

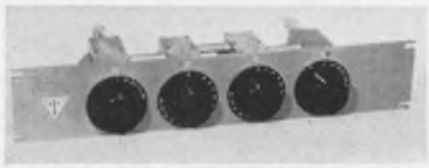


Phase-angle voltmeters from 10 Hz to 100 kHz

North Atlantic Industries, Inc., Terminal Dr., Plainview, N. Y. Phone: (516) 681-8600. P&A: $2290; 3 wks.

Phase angle between input and reference signals is measured to ±15 minutes of arc over a continuous band of 10 Hz to 100 kHz, and over a full 0 to 360° range. Model 301A also measures in-phase, quadrature, fundamental and total voltages. Voltage-measuring sensitivity extends from 1 mV to 300 V rms full scale, within 2%, for both pure and distorted sine wave inputs.

CIRCLE NO. 153



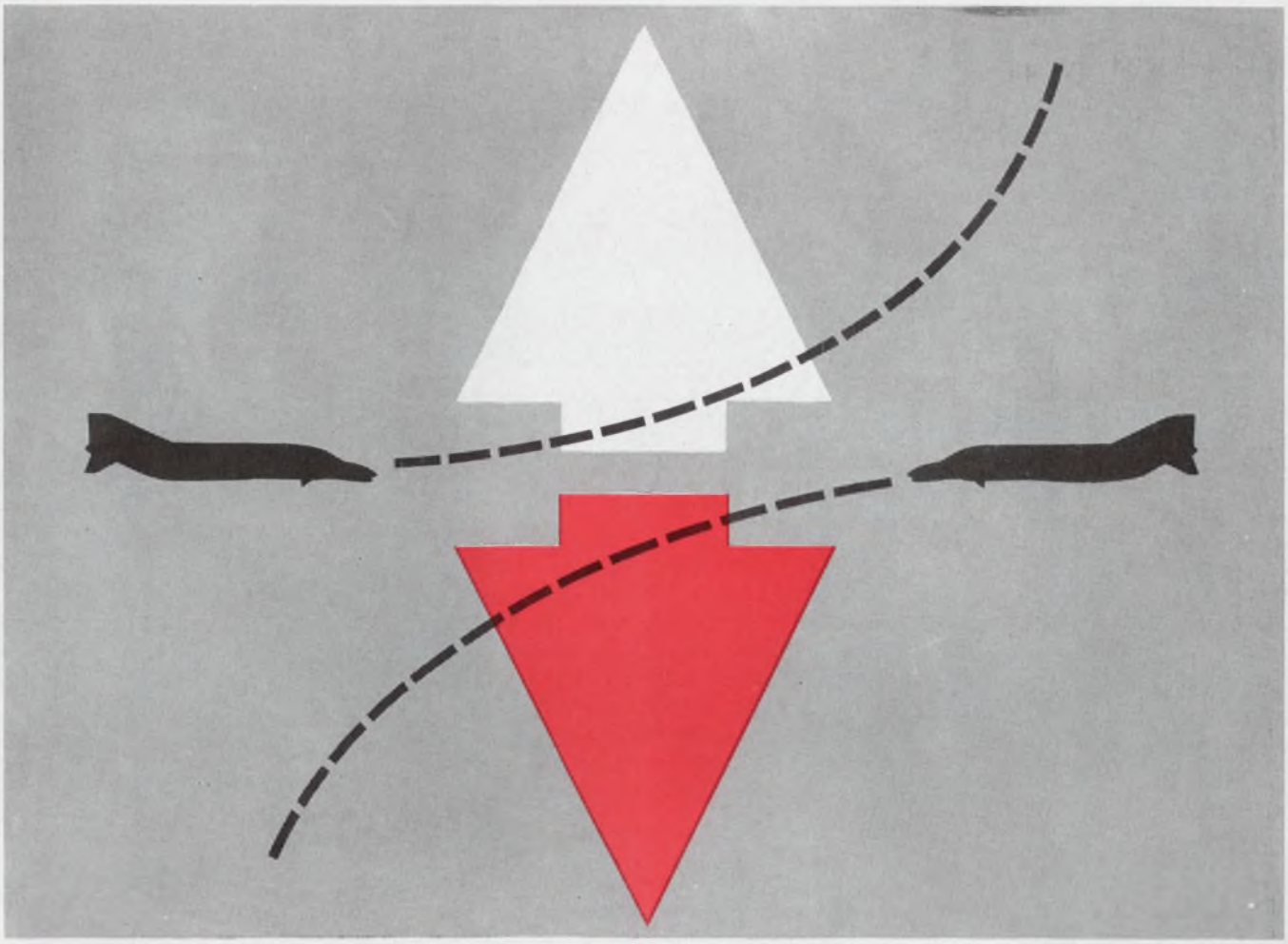
Step attenuators flexible in testing

Nytronics, Inc., Industrial Ave., Kutztown, Pa. Phone: (215) 683-7307.

Precision resistor networks are the basis of a line of RF step attenuators. The series provides attenuation ranges of 0.1, 1.5, 15, 40, 11, 1.1 and 2.2 dB. All units have BNC connectors and a 75- or 50 Ω characteristic impedance. Vswr is typically less than 1.03 and insertion loss is 0.1 dB, both at 100 MHz.

CIRCLE NO. 155

Enter the "Top Ten" contest on p. 232.



BOMAC SOLID-STATE MULTIPLIERS IN MCDONNELL EROS AIRBORNE COLLISION AVOIDANCE SYSTEM

A highly sophisticated frequency multiplier—the solid-state VPS-102L, from Varian's BOMAC Division—is a proven part of the airborne collision avoidance system developed by McDonnell Company.

This significant breakthrough in air safety is EROS (Eliminate Range Zero System) which utilizes a precise time reference to develop time-shared communication channel and range, range-rate, and altitude information between EROS-equipped aircraft. Even when closing at speeds of Mach 4, these aircraft receive an audible warning when a collision will occur within 60 seconds, and a visual command to perform a specific evasion maneuver: climb, dive, or level out.

BOMAC frequency multipliers provide a stable 1545 MHz ± 15 MHz exciter signal for the transmitter in the system.

EROS is another example of how Varian's demonstrated state-of-the-art capability can contribute to major system advances.

Write: Bomac Division, Salem Rd., Beverly, Massachusetts. In Europe: Varian A. G., Zug, Switzerland. In Canada: Varian Associates of Canada, Ltd., Georgetown, Ontario.

varian

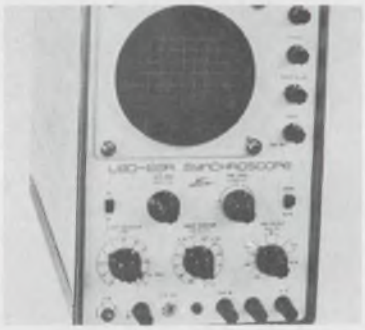
ON READER-SERVICE CARD CIRCLE 183

RF microwattmeter sensitive to 0.001 μW

Boonton Electronics Corp., Parsippany, N. J. Phone: (201) 887-5110. P&A: $695; 6 weeks.

A maximum sensitivity of 0.001 microwatts in microwave power measurements is provided by the model 41A microwattmeter. Full-scale readings on the instrument range from 0.01 microwatt to 10 milliwatts over a frequency range of 0.1 MHz to 6 GHz. The detection is accomplished by hf silicon diodes rather than thermistors so thermal stability is not a major factor. Accuracy is ±0.5 dB.

CIRCLE NO. 156



Triggered-sweep scope features low price

Fairlane Electronics, Inc., Box 335, Long Valley, N. J. Phone: (201) 832-2117. Price: $299.95.

Described as the lowest-priced triggered-sweep scope on the market, the LBO-5SA Synchroscope has a frequency response of dc to 5 MHz. Among the important specs of the instrument are an 80-ns rise-time, a vertical sensitivity of 10 mV/cm, a horizontal sweep speed of 1 μs/cm and a 5X sweep magnifier. Applications include audio, radio and pulse measurements.

CIRCLE NO. 157

Send us a cable.

Send us a small sample, at least one foot, of the coaxial cable you're using and tell us what you're using it for. Then we'll install the Burndy crimp removable coax contact that'll do the job best. Guaranteed.

A tough job? Not really.

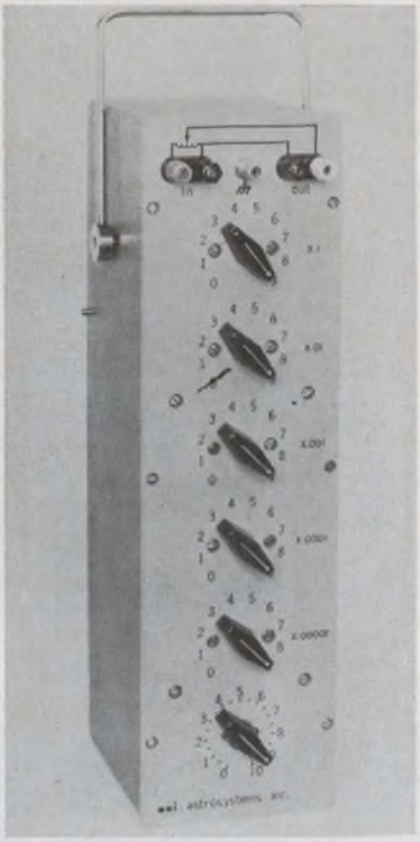
Remember, crimp removable contacts began at Burndy. As a result Burndy offers the most complete line of coaxial connectors for standard, miniature and sub-miniature coaxial cables. And they're available for all rectangular, rack and panel and terminal block configurations.

Send your sample along to Mr. M. Elkind, Product Manager, Burndy, Norwalk, Conn. He'll see that the job is done and returned quickly. You'll receive our latest coax connector catalog, too.

BURNDY
NORWALK, CONNECTICUT

INTERNATIONAL SALES HEADQUARTERS AND MANUFACTURING FACILITIES:
CANADA: Scarboro, Ontario / ENGLAND: St. Helens, Lancs. / BELGIUM: Mechelen / MEXICO: Naucalpan de Juarez / BRAZIL: Sao Paulo / JAPAN: Tokyo / Sales Offices in Other Major Cities

ON READER-SERVICE CARD CIRCLE 185



Transformer switches 5 decades and vernier

Astrosystems, Inc., 521 Homestead Ave., Mt. Vernon, N. Y. Phone: (914) 699-5790. P&A: $300 to $400; 30 days.

Five decades of transformer switching and a vernier potentiometer enable the A404-7 decade ratio transformer to attain resolution and accuracies of 10 ppm. The transformer operates over a range of 50 to 10,000 Hz with accuracies as high as 100 ppm. Total distortion is rated below 0.005% from 32 to 126°F. Calibration is done at the factory and a certificate traceable to the NBS is provided.

CIRCLE NO. 158

Picoammeter set for auto-systems use

EG&G Inc., 680 E. Sunset Rd., Las Vegas, Nevada. Phone: (702) 736-8111. Price: from $2435.

Automatic measurement of very low currents, leakage or nuclear monitoring for instance, is the function of the EG&G 900 series picoammeter. Accuracy of the instrument ranges from ±0.2% at 10^{-2} A to ±5% at 10^{-11} A. Features standard in the 900 series include automatic ranging, quick overload recovery and silicon solid-state design. Digital read-out is an optional extra.

CIRCLE NO. 159

Pulse modulator has 9-kW output

Cober Electronics, Inc., 7 Gleason Ave., Stamford, Conn. Phone: (203) 327-0003. P&A: $3390; 30 to 60 days.

This general-purpose laboratory pulse modulator delivers precise pulses to 9 kW when triggered by any standard 10-V source. Pulse widths are continuously variable from 50 ns to dc; repetition rates from single-shot to 1 MHz. The model 604 output is 1500 V at 6 A, but voltages up to 10 kV, or currents up to 100 A, are available. Rise time is variable from 25 to 100 ns and a scope outlet is included.

CIRCLE NO. 160

Phase shifter features broadband accuracy

Acton Laboratories, Inc., 531 Main St., Acton, Mass. Phone: (617) 263-7756. P&A: $840; 30 days.

Through a frequency range of 20 Hz to 20 kHz, model 329-B is continuously variable from 0 to 360°, with direct meter reading in degrees of output phase shift. Accuracy is 0.5° over the specified frequency range and over a dynamic range of 300 mV to 3 V. The input resistance is 1 MΩ.

CIRCLE NO. 161

Win a free trip to Paris. See p. 232.

We've solved your filter problems — for good!

We've brought together three outstanding companies, each recognized for its own special contributions to the advancement of the art — sophisticated technology, quality-controlled workmanship of the highest order, and precision production facilities. Together they function as one superbly integrated organization to bring you filters of unprecedented quality and reliability. In unlimited quantities. It's a giant step forward for the state of the art — and for you.

Among the advanced classifications of filters being supplied our customers are: Linear phase band pass filters with arithmetic symmetry; matched filters such as pulse compression networks; subminiature thermally stable filters; zero phase shift harmonic suppression networks; constant resistance tapped delay lines; time domain waveform shaping filters; and shape factors of 1.002 to 1.

Send for literature describing our standard and custom products, and facilities.

Burnell NYTRONICS®

10 Pelham Parkway, Pelham, New York 10803 ■ (914) 738-5000 ■ TWX: 914-235-3809

ON READER-SERVICE CARD CIRCLE 187

FIRST PRIZE:

win 2 round-trip New York

- **All Electronic Design subscribers are**
- **Over 100 other valuable prizes!**
- **Guess the top ten ads in Electronic Design's**
- **"ELECTRONICS IN THE WORLD OF TOMORROW"**

Electronic Design's 1967

SEPARATE CONTEST FOR MANUFACTURERS AND ADVERTISING AGENCIES

Not forgotten in the *"Top Ten"* contest, advertisers and their agencies may also enter. In addition to prizes of a **flight to Paris, color TV, and electronic timepiece,** the top 10 ads, and the winning advertiser's ad (if run January 4, 1967) will be re-run in the April 1st issue. Watch for the special *"Top Ten"* contest rules and entry blanks appearing January 4, 1967

2ND PRIZE

HOFFMAN COLOR TV CONSOLE

Hoffman 23" console, featuring 26,000 volts of picture tube power . . . 4" x 6" front-firing speaker . . . easy vision camera control for sharp color movies and positive, black and white picture shading . . . InstaVision on-off control . . . 32" x 29" x 19⅛" cabinet. (Retail value: $600.00.)

3RD TO 8TH PRIZES

BULOVA ACCUTRON® ELECTRONIC TIMEPIECES

The "Spaceview" is an ideal timepiece for electronics engineers. Its clear-view dial reveals transistorized electronic circuit and tuning fork assembly. The tuning fork, advertising symbol and unique frequency standard of Accutron® timepieces, is the reason Bulova guarantees an in-use, on-the-wrist accuracy of within 60 seconds a month. (Retail value: $150.00.)

PLUS 100 ADDITIONAL PRIZES

MICROELECTRONIC DESIGN

This clothbound, 8½ x 11, 320-page, 1966 edition will be given free to 100 winners. "Microelectronic Design" offers a thorough overview of the field in six sections—has almost 90 outstanding articles compiled from the pages of *Electronic Design*. Edited by Howard Bierman. (Retail value: $11.50.)

FOR CONTEST RULES SEE P. 232—THIS ISSUE

tickets between and PARIS

VIA AIR FRANCE

eligible!

January 4 issue

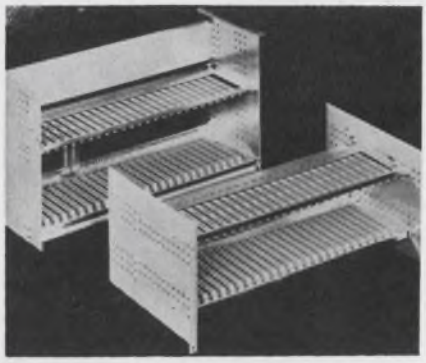
"Top Ten" contest

HERE'S ALL YOU HAVE TO DO TO ENTER:

Rate the ads appearing in the January 4, 1967 issue of *Electronic Design*. Select the *"Top Ten"* . . . the ads that, in your opinion, will be best remembered by readers. Your choices will be measured against the 10 ads ranking highest in the "Recall-Seen" category of Reader Recall—Electronic Design's scientific method of measuring readership. In making your predictions, be sure to consider your 54,000 fellow engineers' interest in the subject matter of the ads, their effectiveness, impact, and attention-getting values.

Entry blanks and complete contest rules will appear in the January 4th issue. Don't miss this opportunity to win one of the many valuable prizes shown at left. The first prize winner will receive round-trip tickets for two, between New York and Paris via Air France!

FOR CONTEST RULES SEE P. 232—THIS ISSUE

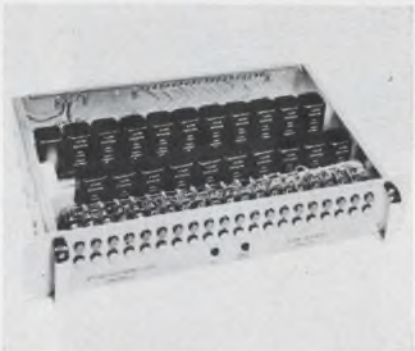


Prefab chassis kit mounts 1 PCB row

Techmar Corp., 1124 So. Beverly Dr., Los Angeles. Phone: (213) 276-7216. P&A: $33.15; 1 day.

A recent addition to the "Omniclosure" line of prefabricated chassis kits is a cage for one row of printed-circuit boards. The cage can be assembled for front, rear or top insertion of PCBs. Kit consists of two aluminum cage plates, two cad-plated steel guide frames, connector rails, screws, nuts and washers.

CIRCLE NO. 162

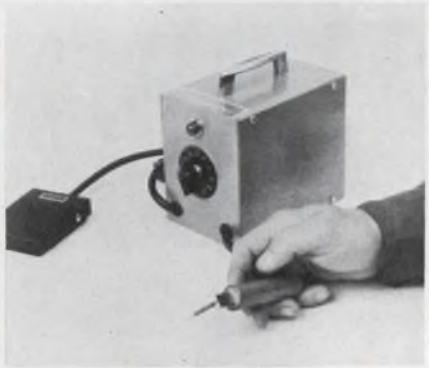


Alarm signal checks two or more channels

Artisan Electronics Corp., 5 Eastmans Rd., Parsippany, N. J. Phone: (201) 887-7100.

Detection and isolation of failures is accomplished by the model 7007 alarm indicator without the use of external equipment. The unit is engineered to indicate a single alarm condition or report on two or more channels simultaneously or sequentially. Fault is indicated by a red light and a buzzer. When the fault is acknowledged by the operator, the buzer goes off and an amber fault light remains.

CIRCLE NO. 163

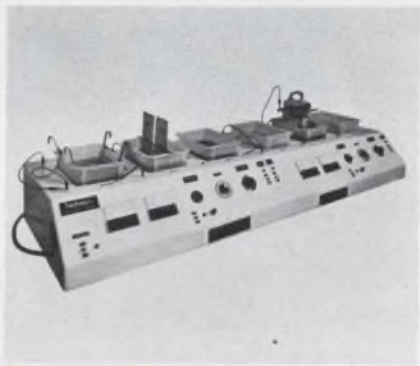


Soldering tool designed for silver

Western Electronic Products Co., 107 Los Molinos, San Clemente, Calif. Phone: (714) 492-4677. Price: $78.50.

The Model HS-1 soldering iron is used exactly as the conventional miniature iron for low melting solder. The tip is heated by a current that passes through the iron but not through the component. An adjustable power supply controls temperature. Silver solder in paste form is applied to the joint and the HS-1 seals the area in a few seconds.

CIRCLE NO. 164



Electroplater mounts on a table top

Technic, Inc., P. O. Box 965, Providence, R. I. Phone: (401) 781-6100.

An electroplating facility for miniature components, printed-circuit tabs and prototypes can be mounted on a table. The "Technilab" electroplating unit is built precisely for production on a small scale and research use. The "Techni-lab" is completely wired and equipped upon delivery. Its six polystyrene tanks come in two sizes, 11 x 6-3/8 x 5-in. and 11 x 7 x 10-in.

CIRCLE NO. 165

Field illuminator gives cold light

Flexi-Optics Labs, 113-117 Dover St., Somerville, Mass. Phone: (617) 776-0520. P&A: $35 to $45; 15 days.

Hot sources of light can be removed from the immediate work area through a flexible fiber-optical illuminator. The field-illuminator is said to be particularly useful in illuminating small areas under a stereo microscope. Nominal length of the conduit-jacketed fiber path is 12-in. A variety of adaptations of the basic unit are available.

CIRCLE NO. 166

Automatic analyzers verify harness wiring

Pasco, P. O. Box 11335, Palo Alto, Calif. Phone: (408) 257-4171.

Rapid verification of the wiring accuracy of multi-terminal systems harnesses is accomplished by a line of automatic circuit analyzers. Typical is the model F106, a large capacity instrument that can analyze up to 50,000 test points. Results of unacceptable test measurements, directed by a master program, are printed-out by location and identification.

CIRCLE NO. 167

Nylon pliers don't nick leads

Engineering & Electronic Devices, Inc., 1024 N. McCadden Pl., Los Angeles. Phone: (213) 463-4175. Price: $2.

A set of glass-filled nylon pliers allow you to bend the leads of transistors and other components without danger of nicking or abrading. The pliers #345 are nonmagnetic, nonconductive, heat-resistant up to 400°F and acid-resistant as well. Due to their heat-insulating quality, they also provide easy soldering since they don't act as a heat sink for the heated lead.

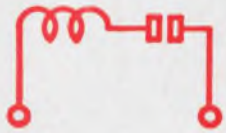
CIRCLE NO. 168

Over 100 prizes—enter contest on p. 232.

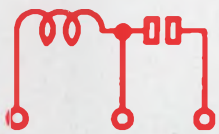
CIRCUIT CONTROL AND PROTECTION BY AIRPAX

SERIES 50 APL

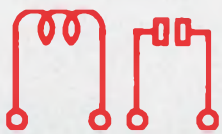
APL 1 SERIES TYPE



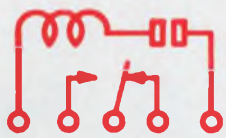
APL 3 SHUNT TYPE



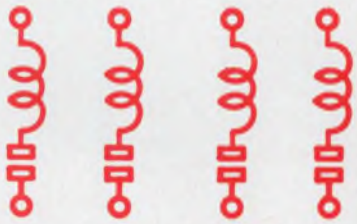
APL 4 RELAY TYPE



APL 1-RE
SERIES WITH REMOTE



APL 1111 FOUR POLE



APL 111 THREE POLE

APL 11 TWO POLE

TYPE APL1 IS UNDERWRITERS' LABORATORY RECOGNIZED FOR APPLIANCE PROTECTION.
20A, 50V 15A, 115V 7.5A, 240V

COMPLETELY MAGNETIC TIME DELAY AND TRIP. CONTAINS NO HEATING ELEMENTS.

AVAILABLE 50 MA TO 50 AMPERES AC OR DC. 50, 60 AND 400 CYCLES.

TRIP TIME IN SECONDS vs. PERCENT OF RATED CURRENT

	100%	125%	200%	400%	800%	1000%
Delay 60	No Trip	May Trip	.035 max.	.030 max.	.020 max.	.018 max.
Delay 61	No Trip	1.0 - 6.0	.240 - .800	.040 - .180	.012 - .050	.010 - .040
Delay 62	No Trip	15.0 - 70.0	3.0 - 9.0	.30 - 1.50	.018 - .080	.010 - .040

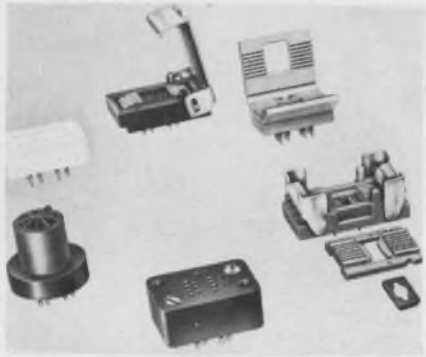
AIRPAX ELECTRONICS
Incorporated
Cambridge, Maryland
(301) 228-4600

AIRPAX ELECTRONICS
Incorporated
Ft. Lauderdale, Fla.
(305) 587-1100

AIRPAX ELECTRONICS
incorporated
Van Nuys, Calif.
(213) 781-2821

AIRPAX ELECTRONICS incorporated Cambridge Division, Cambridge, Maryland

ON READER-SERVICE CARD CIRCLE 188

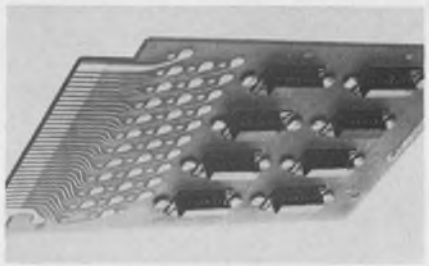


Test-socket system mounts any IC pack

Barnes Development Co., 24 N. Lansdowne Ave., Lansdowne, Pa. Phone: (215) 622-1525.

Testing of IC devices is said to be speeded by the RD-86 universal mating connector when used in conjunction with the manufacturer's IC sockets. The single connector permits rapid interchange of a variety of sockets for flat-packs, dual-in-lines and TO configurations. Terminals of the RD-86 are tubular and can be dip-soldered or hand wired. Dielectric is polysulfone.

CIRCLE NO. 169



Printed-circuit cards mount in-line ICs

Cambridge Thermionic Corp., 445 Concord Avenue, Cambridge, Mass. Phone: (617) 876-2800. P&A: $16.80; stock.

In either digital or control applications, two new PC boards mount 8 or 16 in-line integrated circuits. The epoxy glass boards measure 4.50 x 6.06-in. and 4.50 x 9.25-in. The devices are mounted in sockets that are then mounted to the board. Circuit interconnections are made by cord jumpers or by hand wiring to solder terminals on the reverse of the board. The board connector has 70 available pins.

CIRCLE NO. 276

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.

MICRODOT WELCOMES AMPHENOL

!!!

For over two years now, Microdot has had the subminiature, high density multi-pin connector market to itself. The sensational Microdot MARC 53 has been used on all the Gemini "Walks in Space" plus a multitude of military and NASA programs. Now, however, we've got competition...the brand new Amphenol Astro 348. Good to have you aboard.

IN HONOR OF THIS GREAT EVENT,

MICRODOT IS HOLDING THREE

(count 'em, three)

CONTESTS

To be able to enter these contests, you've got to know a little something about the Microdot MARC 53. It's one of the real stars in the Microdot connector line...a high density (anywhere from 7 to 91 contacts in four shell sizes), subminiature, high-performance connector. The MARC 53 can save as much as 61% in weight and 54% in panel space. *Posilock*, a push-pull lock coupling, mates easily with high density inserts with no danger of damage. The dual locking action eliminates accidental disconnect, *Posiseal*, a multiple, environmental sealing system, *guarantees* an interfacial seal.

MARC 53 is approved to MIL C-38300A (USAF).

...AND ABOUT AMPHENOL.

We wish we could also tell you all about the high density (two insert arrangements of 55 and 85 contacts in two shell sizes), ™ subminiature, high performance, bayonet lock, bonded insulator Astro 348's but we're afraid that the Microdot officers, directors, stockholders, sales engineers and maintenance crew would hang us up by the thumbs. To find out more, write Amphenol.

CONTEST #1

Open only to employees of Amphenol, their families, friends, reps, distributors and advertising agencies.

WIN A REVELL SCALE MODEL KIT OF THE GEMINI SPACE CAPSULE

In twenty-five words or more, tell us why the Astro 348 is the best subminiature multipin on the market. Neatness does not count. TEN WINNERS...the prize is calculated to tantalize you because the Microdot MARC 53 is used on the Gemini program. So there.

CONTEST #2

Open only to employees, representatives and distributors of Microdot, their families, friends and advertising agencies.

WIN A REVELL SCALE MODEL KIT OF THE U.S.S. MIDWAY. In twenty-five words or more, tell us why the MARC 53 is the best subminiature multipin on the market. Neatness counts. *Ten Winners.*

CONTEST #3

Open to everybody except employees of Amphenol, Microdot, their families, friends and advertising agencies.

WIN A MODEL! SHE'S YOURS...

in perfect ⅛ scale, 8 x 10 glossy, perfect for your office wall, workshop or pool hall...inscribed "With Love and You Know What to_____ (your name here) from Marcia". All you have to do is write, in twenty-five words or more a description of your application for the MARC 53. You notice how fast we forget the competition when we get down to business. Remember...everybody who enters Contest #3 wins!

MICRODOT INC.

Microdot, Inc., 220 Pasadena Ave., So. Pasadena, Calif. 91030

- ☐ I want to enter Contest #1. My 25 words or more are attached. I am an employee of Amphenol.
- ☐ I want to enter Contest #2. Anybody who uses company postage for this one, gets docked.
- ☐ I want to enter Contest #3. My 25 words or more are attached. How does one go about getting Marcia in a slightly larger scale, say 1/1?
- ☐ I don't want to enter any contest. Just send specs on the MARC 53.

Name_____

Title_____

Company_____

Address_____

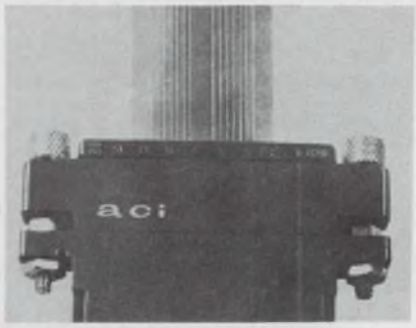
City_____

State_____ Zip_____

MARC 53, Posilock and Posiseal are trademarks of Microdot Inc. Astro 348 is not.

These contests are not valid in any locale where the local gendarmes take umbrage.

ON READER-SERVICE CARD CIRCLE 190

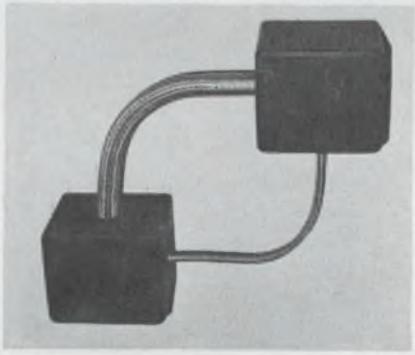


Interconnection system based on flat leads

Kent Corp., ACI Div., 206 Industrial Center, Princeton, N. J. Phone: (609) 924-3800.

"Signaflo" interconnection systems are based on flat conductors. The systems are especially designed to meet specific customer requirements in term of impedance values, propagation velocity, cross-talk and capacitance. The "Signaflo" systems are said to provide replacement for conventional shielded cabling with comparable performance and greater packaging density.

CIRCLE NO. 277



Flexible metal conduit acts as RFI shield

Flexible Metal Hose Mfg. Co., 777 W. 16th St., Costa Mesa, Calif. Phone: (714) 646-4851.

Both RFI shielding and mechanical support are provided by a line of flexible metal conduit. The material is offered in diameters from 1/8-in. to 4-in. inside and larger. Conduit can be formed to any length and can be either pressure or vacuum tight. Each length is continuous and is provided with a movable AN nut assembled on each end.

CIRCLE NO. 278

Platinum-gold coat adheres to high alumina

Electro Science Labs, 1133-35 Arch St., Philadelphia. Phone: (215) 563-1360. P&A: $72.25/troy ounce; stock.

A platinum-gold coating for hybrid IC package use adheres well to high alumina surfaces. The material, cermet paste 5800B, is said to fire to a very dense uniform layer that is free of pinholes and cracks. Conductivity of a 1-mil layer is 0.05 to 0.1 Ω/square. Firing range is 850 to 1000°C. The coating may be soldered with normal or high-temperature lead/tin alloy solders.

CIRCLE NO. 279

Superconductive magnets to 125 kgauss

RCA, 415 S. 5th, Harrison, N. J. Phone: (201) 485-3900. Price: from $8550.

Described as the first commercial line of superconductive magnets, a new line offers field strengths ranging from 60 to 125 kilogauss. The magnets are designed for research use in fields such as high-energy physics, plasma, medicine and biology. A total of 7 units is included in the line, six solenoids and one split pair.

CIRCLE NO. 177

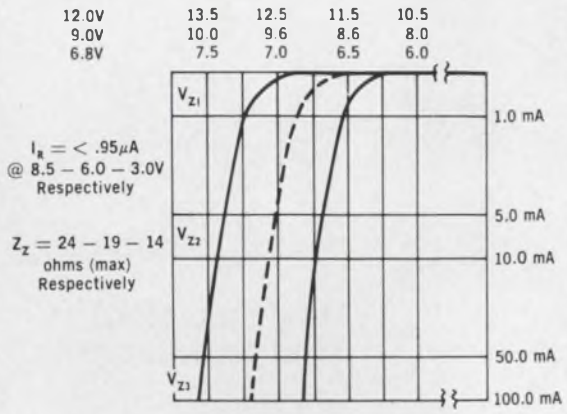
Al-doped YIG gives narrow lines

Airtron, Div. of Litton Industries, 200 E. Hanover Ave., Morris Plains, N. J. Phone: (201) 539-5500.

For narrow line widths at cryogenic temperatures, a line of aluminum-doped yttrium iron garnet materials is available for such applications as circulators used with masers and parametric amplifiers. Line widths are 33 oersteds at 6.2 GHz, 300°K and 280 oersteds at 77°K. Other important specs include: saturization magnetization of 560 gauss, X-band loss tangent of 0.002 and a Curie point of 150°C.

CIRCLE NO. 178

ELECTRICAL



$I_R = < .95\mu A$ @ 8.5 – 6.0 – 3.0V Respectively

$Z_Z = 24 - 19 - 14$ ohms (max) Respectively

Computed Delta's

$\triangle I_{R1} = -90\% + 100\%$ or 50 nanoamps whichever is greater

$\triangle V_{Z3} = \pm 50$ mV

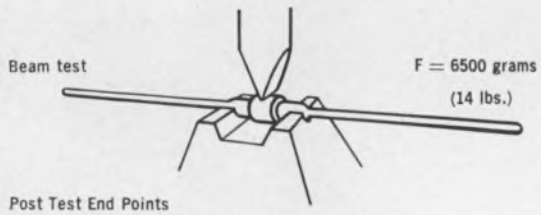
$\triangle Z_Z = \pm 2$ ohms

PERFORMANCE UNDER TEST

Allowable Change	Our Average Change
$\triangle I_{R1} = -90\% + 100\%$ or 50 nanoamps	$-10\% + 65\%$
$\triangle V_{Z3} = \pm 50$ mV	$-34 + 19$ mV
$\triangle Z_Z = \pm 2$ ohms	-1.1 ohms

ENVIRONMENTAL

Mechanical Shock	2000 g	3 shocks in 3 axes
Constant Acceleration	20,000 g	1 minutes in each of 6 axes
Lead Pull	32 oz. for minimum of 15 seconds	



Post Test End Points

$\triangle V_{Z1} = \pm 50$ mV

$\triangle V_{Z3} = \pm 50$ mV

$I_{R1} = 5.0\ \mu A$ @ applicable E_R

PERFORMANCE UNDER TEST

Allowable Change	Our Average Change
$\triangle V_{Z1} = \pm 50$ mV	$-4 + 15$ mV
$\triangle V_{Z3} = \pm 50$ mV	$-6 + 22$ mV
$I_{R1} = < 5\mu A$	$< 0.1\ \mu A$

PHYSICAL

Maximum length – .160"

Maximum diameter – .075"

Weight – .2618 grams

Hoffman Microglass Zeners Types 1N4460-1N4496

ACTUAL SIZE

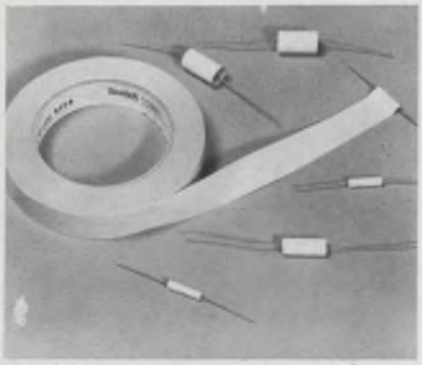
These 1.5 watt silicon zeners are designed for application wherever high performance electrical requirements are a necessity and for maximum packaging density.
The hard glass sleeve construction hermetically seals the passivated silicon wafer. This means there is no large cavity to trap and contain contaminants that adversely affect the performance and reliability of the device.
A unique method of bonding the silicon wafer between the heat sinking terminal pins provides low thermal resistance and eliminates the troublesome "S" spring as well as solder or epoxy pastes. The reduction of piece part components means a higher degree of reliability than previously obtainable and a diode highly resistant to extreme levels of mechanical shock and vibration. Most major military and aerospace programs depend on its continuous reliability.

Hoffman

For additional information regarding Hoffman products write Hoffman Electronics, Dept. A, El Monte, California.

SEMICONDUCTORS

ON READER-SERVICE CARD CIRCLE 192

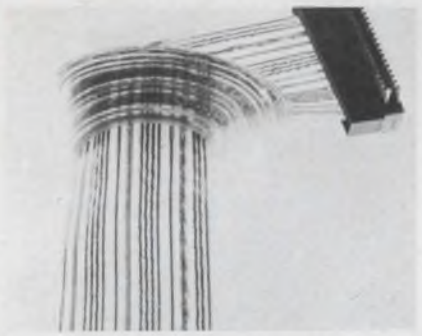


Polyester film tape pressure sensitive

3M Co., 2501 Hudson Road, St. Paul, Minn. Phone: (612) 733-4033. Price: from $5.56/1-in. roll.

A 2-mil polyester film tape is available with a bondable backing and a thermosetting pressure sensitive adhesive. Called "Scotch X-1209," the material was developed for wrapping capacitors and small diameter coils. The 4X type adhesive is said to be highly resistant to solvents and oil either in the cured or uncured state. Rolls can be preprinted then rerolled for later use.

CIRCLE NO. 179

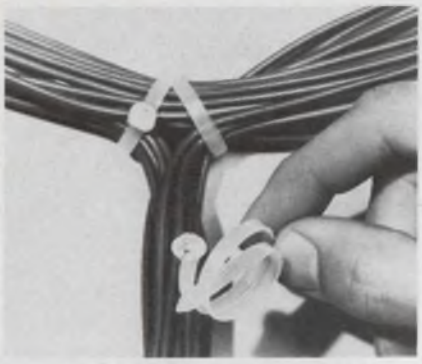


Variety no problem in Si-rubber harness

Cicoil Corp., 13833 Saticoy St., Van Nuys, Calif. Phone: (213) 873-4614.

A silicon-rubber encapsulated flat harness assembly combines various types of conductors in a single flexible tape. The mixed conductor harness assembles, called "Super Flex," maintain their electrical and mechanical properties from −320 to 500°F. Under test the assemblies have been flexed over 70 million times at 30/minute without damage. Any combination of AWG 28 through 36 shielded or AWG 22 through 38 wire can be used.

CIRCLE NO. 180



Plastic cable tie for securing breakouts

The Thomas & Betts Co., 36 Butler St., Elizabeth, N. J. Phone: (201) 354-4321.

Two plastic cable ties, the TY-55 and the TY-55M are offered for securing wire bundles at breakout points. The ties are preformed to form a figure eight at the branch. TY-55 is secured by twist-locking with one of the "TY-RAP" tools and TY-55M is self-locking. According to the manufacturer, these ties eliminate the usual need for three separate ties at breakout points in a control or power cable.

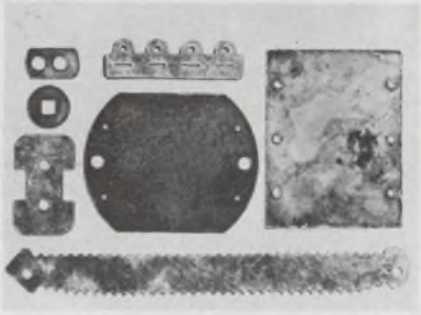
CIRCLE NO. 891

Micromin brass pins for plug-in equipment

Precision Metal Products Co., 41 Elm St., Stoneham, Mass. Phone: (617) 438-3650.

Precision machined micro pins are designed to meet the requirements of miniature plug-in equipment. A variety of standard and custom units are available to user specs. They are machined from free-cutting brass and are supplied with a variety of plating options including gold flash, nickel and silver. Uses are in connector plugs, IC packages, relays, crystals, logic modules, etc.

CIRCLE NO. 892

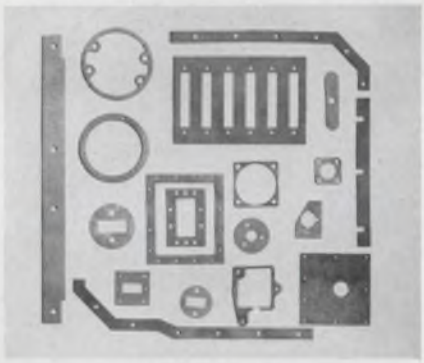


Mica insulators cited for low cost

Perfection Mica Co., 1322 N. Elston Ave., Chicago. Phone: (312) 384-2122. P&A: 3/8 x 1/8 washer, $3.75/M in 200,000 quantities; 3 wks.

Cost reductions are said to bring rigid pasted mica insulators into the range of a number of industrial and commercial applications. Savings from 7 to 35% are cited by the manufacturer. The components are offered with shellac, inorganic or glyptal bonding using muscovite or phlogapile mica. Unmilled or milled-to-thickness types are included.

CIRCLE NO. 893



Conductive sheets based on silicone rubber

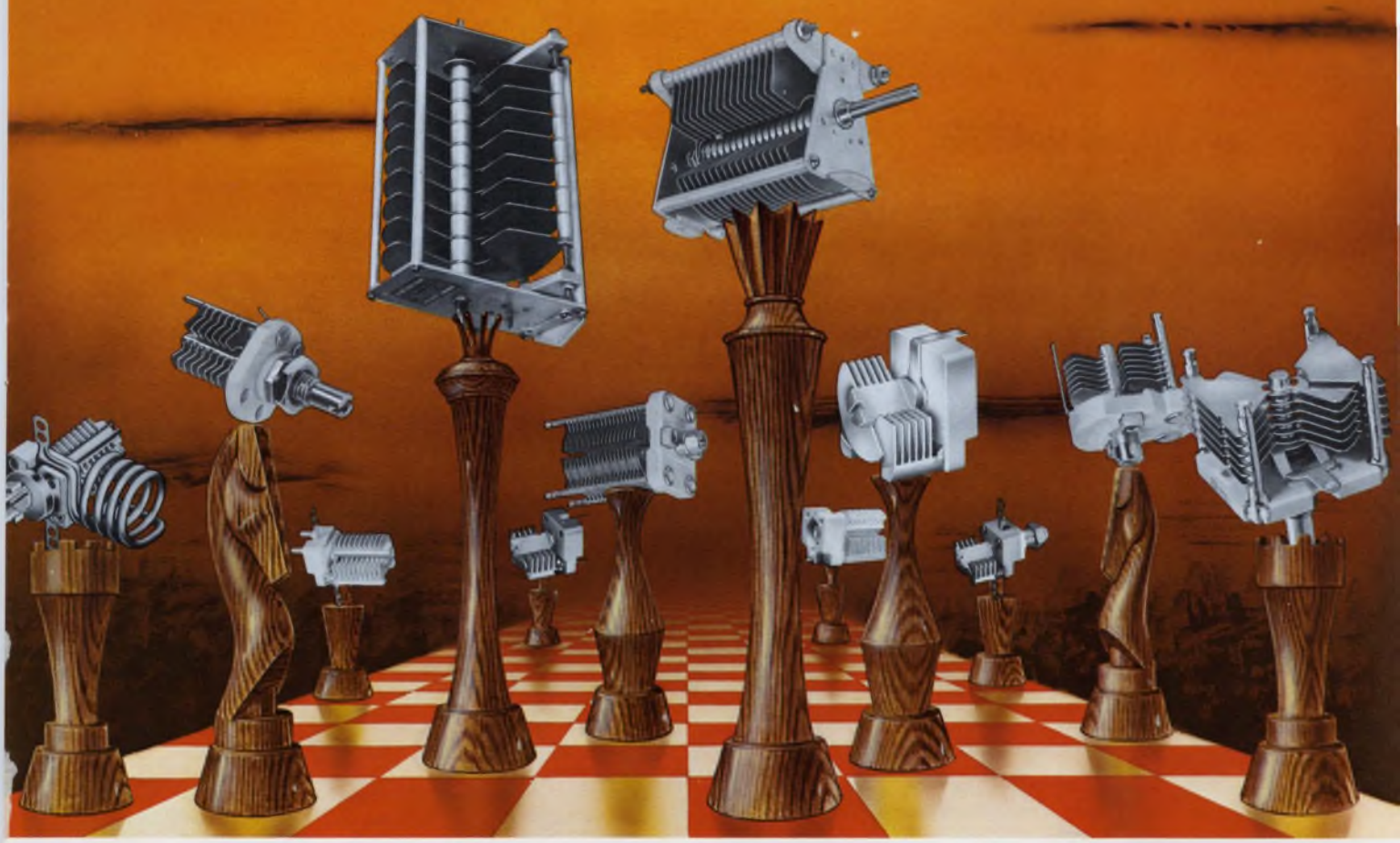
Emerson & Cuming, Inc., Canton, Mass. Phone: (617) 828-3300. Price: $18 to $36/sheet.

Eccoshield SV-R offers the flexibility and elasticity of silicone rubber with conductivity approaching many metals. The material can be cut into gaskets to user specs to form RF and hermetic seals. Insertion losses as high as 100 dB are achievable. The material is supplied in 12 x 6-in. sheets with thicknesses from 20 to 60 mils.

CIRCLE NO. 894

ON READER-SERVICE CARD CIRCLE 209 ➤

Johnson gives you the most moves in capacitor selection



MORE THAN 11 BASIC SERIES AVAILABLE IN A WIDE SELECTION OF SINGLE SECTION, DUAL SECTION, BUTTERFLY AND DIFFERENTIAL TYPES. FOR MORE DETAILS, TURN THE PAGE.

Now from a new, expanded air variable capacitor line, you can satisfy your capacitor needs in more ways at low cost. From the Johnson line, offering capacitance values up to 1700 pf. and peak voltage ratings from 650 to 13,000 volts, you can specify air variables and be assured your design will yield a product that's competitively priced. Johnson air variable capacitors range from sub-miniature types to large units suitable for heavy duty applications. Whatever the use, they provide excellent stability, high Q, uniform capacitance, and exhibit low "hook" in applications involving a square wave form.

For complete capacitor information write on company letterhead for free, detailed Johnson components catalog No. 700.

E. F. JOHNSON COMPANY
WASECA, MINNESOTA 56093

CAPACITORS

MACHINED PLATE TRIMMER AND TUNER TYPES – U, UA, UB, U-LC, V, AND W – Available in both printed circuit and chassis mounting types. U types available in differential and butterfly printed circuit mounting types in addition to single section types. V and W capacitors available in single section type only. Maximum capacities of up to 54 pf. Tuners consist of a machined plate trimmer and high Q air wound silver plated inductor, in resonant frequencies of 100 to 750 Mc.

SOLDER PLATE TYPES – Type M: Capacity values to 30 pf. Voltage ratings to 1250 volts peak. Available in single section, differential and butterfly types.

Type S: Capacity values to 100 pf. Voltage ratings to 3000 volts peak. Available in single section, differential and butterfly types.

Type K: Capacity values to 150 pf. Voltage ratings to 3800 volts peak. Available only in single section types. May be furnished in production quantities in full compliance to MIL-C-92A.

Type R: Capacity values to 340 pf. Voltage ratings to 4400 volts peak. Available only in single section type.

Type L: Capacity values to 200 pf. Voltage ratings to 3500 volts peak. Available in single section differential, butterfly and dual section types.

SPACER TYPES – Type C: Capacity values to 1500 pf. Voltage ratings to 13,000 volts peak. Available in single section and dual section types.

Type D: Capacity values to 1700 pf. Voltage ratings to 9000 volts peak. Available in single section and dual section types.

STAKED PLATE TYPES – Type E: Capacity values to 1000 pf. Voltage ratings to 4500 volts peak. Available in single section and dual section types.

Type F: Capacity values to 400 pf. Voltage ratings to 3000 volts peak. Available in single section and dual section types.

CONNECTORS

SUB-MINIATURE INSULATED TYPES – Designed for printed circuit applications. Operating voltages to 1500 volts RMS . . . 5 amperes current carrying capacity . . . contact resistance less than 2 milliohms. Capacitance between two adjacent jacks less than one pf at 1 Mc. 10 colors available. Test-Point Strip/Handle – rapid-mounting polyamide body contains 12 test points each rated at 5 amps., maximum current capacity. Operating voltage 1500 volts RMS at sea level, 350 volts RMS at 50,000 feet. Contact resistance less than 2 milliohms.

STANDARD INSULATED CONNECTORS – A complete line of connectors molded of tough, low-loss, shock-proof polyamide in 10 colors meeting Fed. Std. 595. Tip, Banana and Dual Banana Plugs; Tip and Banana Jacks; Metal-Clad Tip Jack, Military; Jack and Sleeve; Binding Posts.

RIB-LOC TERMINALS – A new line of miniature, one-piece, insulated terminals with a unique serrated conical design, which resists loosening and turning. Provides an inexpensive approach to convenient press-in type terminals. Six colors conforming to Federal Color Standard No. 595. Terminal styles include single and double turret feed-thrus and stand-offs, .040" dia. tip plug and mating jack for .040 plug.

Tube Sockets, Insulators, Pilot Lights, and Hardware

ULTRA HIGH FREQUENCY SOCKETS – Continuous heat resistance to 500°F. with low loss, glass filled silicone base and heat treated beryllium copper contacts. Low inductance screen bypass capacitor available for VHF and UHF operation.

KEL-F SERIES – Molded of low dielectric loss-factor Kel-F plastic – designed for use with a wide selection of high power transmitting tubes.

STEATITE WAFER TYPES – Available in 4, 5, 6, 7, and 8-pin standard socket types, as well as Super Jumbo 4-pin types. Also giant 5 pin, and 7 pin Septar and VHF Septar Sockets.

SPECIAL PURPOSE TYPES – Includes sockets for special purpose tubes.

Note: For detailed specifications, request Socket Standardization Booklet 536 on your company letterhead.

INSULATORS – Low loss, high-voltage breakdown in either steatite or porcelain. Complete line includes Thru-panel Bushings and Insulators, Antenna Strain and Feeder Types, Cone and Stand-off Insulators, Lead-in Bushings and Feed-Thru Bowl Assemblies.

PILOT LIGHTS – Over 47 separate assemblies. Continuous indication neon types, models for high and low voltage incandescent bulbs, standard or wide angle glass, and lucite jewels. Specials, including types meeting military specifications, also available in production quantities.

PANEL BEARINGS – For use on ¼" shafts and panels up to ⅜" thick. CRYSTAL SOCKETS – For low capacity, high voltage and high temperature operation. Glazed steatite, Grade L-423 or better. DC-200 impregnated. RF CHOKES – High quality construction. For 1.7 to 30 Mc range.

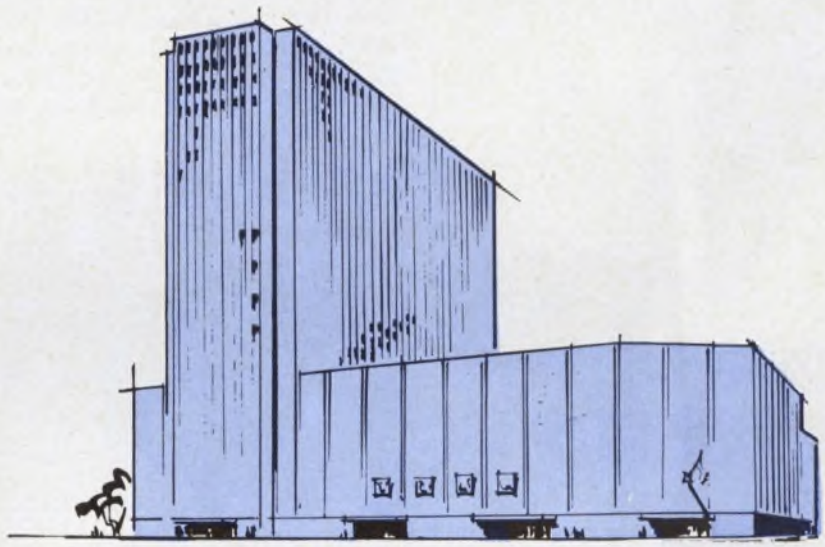
CHECK Johnson for all your component requirements

Johnson also offers a complete line of heavy-duty RF components for broadcast transmitting, RF heating, antenna phasing and other commercial applications.

Equipment in this line includes fixed and variable inductors, antenna phase sampling loops, isolation filter inductors, feed-thru bowl insulators, static drain chokes, RF contactors and heavy-duty make-before-break switches.

E. F. JOHNSON COMPANY
WASECA, MINNESOTA 56093

As a manufacturer in the microwave frequencies, are you fully aware of the new demands of CATV? ETV? Point to point microwave?



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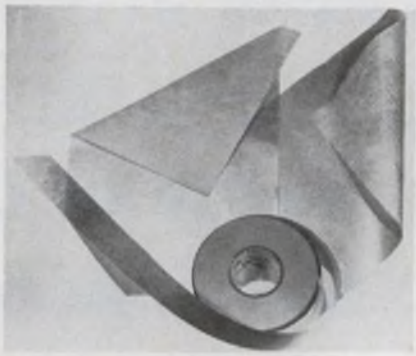
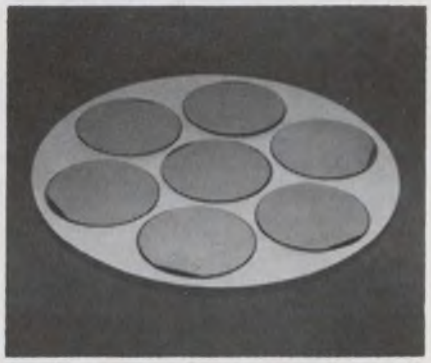


Polyester material acts like mica

3M Company, 2501 Hudson Rd., St. Paul, Minn. Phone: (612) 733-4033. Price: from $1.28/yd.²

Fiber modified "Isomica" combines the electrical properties of mica with the strength of polyester fiber webbing. Two basic types are offered, unimpregnated MX2300 and MX2301 with parallel strands of polyester for greater tensile strength. Both have 85% mica flakes and share many of the electrical characteristics of natural mica.

CIRCLE NO. 280

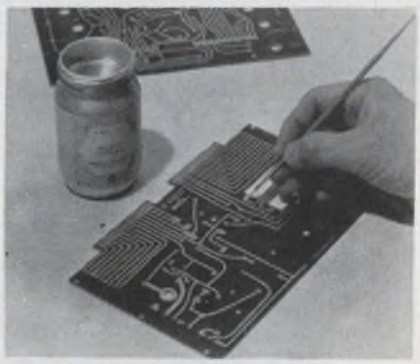


Mylar lapping rings offered in variety

Mechanizations Associates, 2622 Frontage Rd., Mt. View, Calif. Phone: (415) 967-4262. Price: from $0.18 in quantity.

For use in semiconductor manufacture, Mylar lapping rings are offered in a wide variety of sizes and configurations. For "free" or unwaxed lapping of wafers, these rings are available in five different outside diameters to fit machines handling 4-1/2 to 14-1/2-in. diameters. Each diameter can be ordered with holes for 1 to 2-in. wafers.

CIRCLE NO. 282

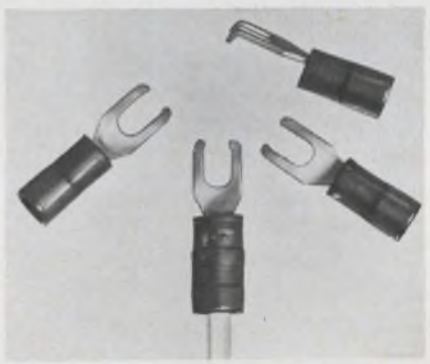


Conductive coating contains Ag particles

Acheson Colloids Co., Port Huron, Mich. Phone: (313) 984-4172.

A conductive coating known as dispersion FH-1629 provides a volume resistivity of 0.01 Ω/cm. It adheres to a variety of surfaces including many metals, plastic, glass, ceramic, paper and rubbers. Heat resistance is rated at 250°F. Areas of typical application include electroplating, electroforming, sensing inks, electrostatic screening, potentiometer tracks, electrodes, capacitors and mylar tape.

CIRCLE NO. 281



Crimp-type terminals insulated by PVC

Thomas & Betts Co., 36 Butler St., Elizabeth, N. J. Phone (201) 666-8210.

Recent additions to the "Sta-Kon" wire terminal line feature polyvinyl chloride (PVC) insulation. The units are suggested for applications where electrical insulation must be maintained with reduced clearances. Two types, the RB197 solderless forked tongue and the RB1347 solderless ring tongue terminals, are offered. Both can be installed on #14 to #16 AWG wires.

CIRCLE NO. 283

SIEMENS

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Precision-engineered for adjustable high-stability, high-Q coils. Siemens pot cores meet the most critical requirements for filters used in multiplex and other carrier-frequency applications, achieved with properties like: easy adjustment, highest stability, high Q, low distortion, and self-shielding.

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Wide range of materials and sizes. With 8 different materials, 18 different sizes (from .22 to 2.75 inches diameter) and a total of more than 250 different standard types, optimum properties are obtainable for all filter, oscillator and transformer applications.

Stability. Less than 0.2% change in permeability in 10 years at temperatures up to 70° for typically gapped cores used in filter coils.

High Q value with high stability is typical. For example, a 26 x 16 core of N22 or N28 material AL 315 at 100 kc/s shows a Q value of approximately 950.

Off the shelf delivery. Write now for complete information on Siemens pot core application.

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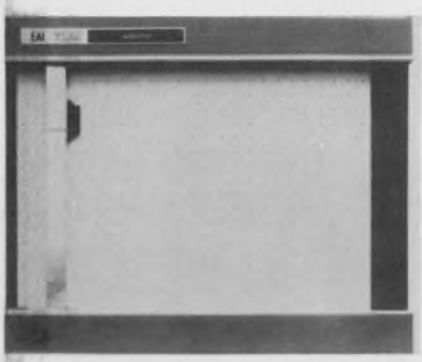


X-Y recorder for OEM market

Electronic Associates, Inc., West Long Branch, N. J. Phone: (201) 229-1100. P&A: $1190; 30 days.

The single range, 11 x 17-in. X-Y recorder 1132 is designed primarily for the OEM market. It is intended as a display medium for a variety of test systems, aircraft simulators, etc. Access to data connections and certain controls is from the rear but all primary controls are on the front panel. Static accuracy is ±0.1% full-scale and slew is 20 in/s.

CIRCLE NO. 284

Computer system grows with needs

Digital Equipment Corp., 146 Main St., Maynard, Mass. Phone: (617) 897-8821. Price: from $110,000.

An expandable 36-bit word computer system is available in five configurations, all in the medium price range. Designed for on-line and real-time scientific, engineering and process control applications, the PDP-10 has a memory that can be expanded in 8,192 word increments to a max of 262,144 words, directly addressable. Cycle time is rated at 1 μs.

CIRCLE NO. 285

Magnetic-film memory reads in 105 ns

Texas Instruments, Inc., 13500 N. Central Expressway, Dallas. Phone: (214) 235-3111.

A large, high-speed magnetic-film memory from TI provides a total capacity of 204,800 bits with a memory read access time of 105 ns and a cycle time of 350 ns. The memory stack is organized as 4096 words by 50 bits. This performance is traced to the use of ferromagnetic film as the storage medium rather than ferromagnetic cores. The concept is said to allow a marked increase in speed with no increase in cost.

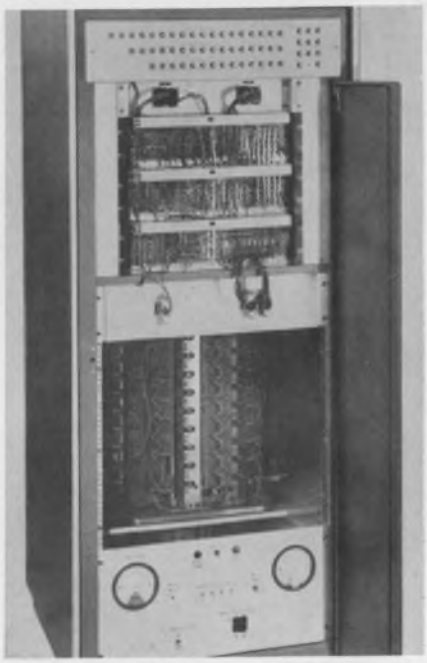
CIRCLE NO. 286

Voice response unit speaks 31 words

Cognitronics Corp., 549 Pleasantville Rd., Briarcliff Manor, N. Y. Phone: (914) 769-7900. Price: from $1000.

Designed for computer applications, the Speechmaker audio response systems provide a 31-word film-memory vocabulary. These units differ from most others in that they use photographic memory drums rather than magnetic types. Model 631 is keyed by individual switch closures for each word while Model 632 contains a binary decoding matrix for 5-bit binary code.

CIRCLE NO. 287



Drum memory virtually plugs in

Vermont Research Corp., Precision Park, North Springfield, Vt. Phone: (802) 886-2256.

Called a "universal" design, the Type 1116 drum memory is designed to mate virtually any size, type and make of high-speed digital computer. The system offers a total capacity exceeding 12,500,000 bits and is adaptable to 16-, 18-, and 24-bit word systems. Average access time is 8.3 ms. Read/write capability ranges one to sixteen 64-word blocks with two IOT commands. Memory bit cost is 0.35 cents.

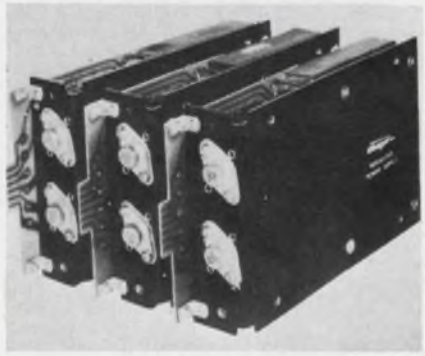
CIRCLE NO. 288

Telemetry amplifiers span L- and S-bands

Aertech, 250 Polaris Ave., Mountain View, Calif. Phone: (415) 967-9492.

Citing innate advantages of transistorized amplifiers in telemetry up to S-band, a series of modular units are said to provide an option to the use of tunnel diodes. All three units provide 20 dB gain and have noise figures of about 5.5 dB. Dynamic range is among their features at 1.435-1.535 GHz, 1.65-1.95 GIIz, and 2.2-2.3 GHz. Weight is 11 to 13 ounces and volume is 7 to 10 cubic inches.

CIRCLE NO. 289



Power supply drives op-amps and ICs

Deltron, Inc., Wissahickon Ave., North Wales, Pa. Phone: (215) 669-9261.

A modular tracking power supply is offered specifically for use with integrated circuits and operational amplifiers. Designated the OS15-.3D, the supply is of all-silicon design permitting operation up to 71°C. There is no overshoot on turn-on, turn-off or power interruption. Tracking capability is provided to keep slave voltage proportional to the master.

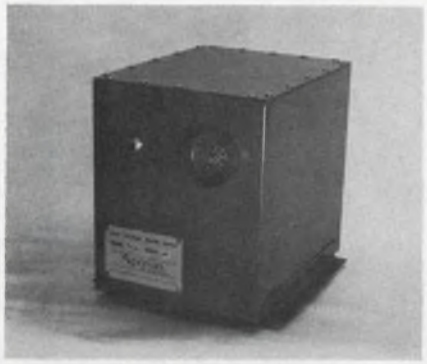
CIRCLE NO. 290

Power supply module replaces slot supplies

Power Designs, Inc., 1700 Shames Drive, Westbury, N. Y. Phone: (516) 333-5698. P&A: $199; 3 to 4 weeks.

Said to replace over 102 equivalent slot modules, the Model UPM-11 contains two independent sources, each providing 0 to 16 Vdc at 1 A. Output voltages and operating modes are determined by the wiring of the mating connector. No addition of components or shifting of internal jumpers or transformer taps is required.

CIRCLE NO. 291



35-kV supply remotely controlled

Aptron, P. O. Box 305, Milford, Conn. Phone: (203) 878-5526.

Remote selection of output polarity is the leading feature of the Model 1236, 35-kV dc power supply. The unit is said to be well suited to applications ranging from capacitor bank charging to laboratory research. Output is rated at 1 mA and is 30 kV at 5 mA, adjustable from zero by varying the input voltage. Size is 8 x 9-5/8 x 10 in. and weight is 40 lbs.

CIRCLE NO. 292

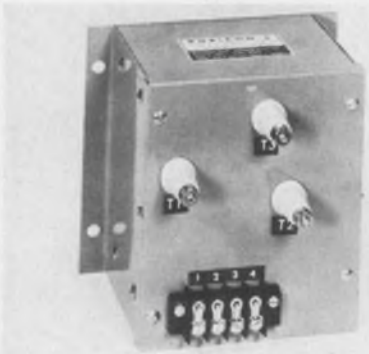
Power reference source stable to 0.001%

Princeton Applied Reesarch, P. O. Box 565, Princeton, N. J. Phone: (609) 924-6835. P&A: $1250; about 30 days.

Output of the Model TC-260R solid state power reference source is stable to 0.001% over a 100-hour period. Outputs from 0 to 60 Vdc at currents up to 2 A are selected on direct-reading digital dials. Regulation is within 0.001% of setting. Absolute accuracy is within 0.01% of setting and the resolution capability is rated at 20 μV. Standard features include remote programing and sensing.

CIRCLE NO. 293

Over 100 prizes—enter contest on p. 232.



Dc transformer measures isolation

Robicon Corp., 6452 Penn Ave., Pittsburgh. Phone: (412) 361-7211.

The series 406 dc transformers are designed for use in the measurement of isolation and control of dc circuits. The instruments provide feedback for closed-loop control of voltage and current as well as usable signal for direct interface with recorders and meters. Voltages to 3 kV and currents to 100,000 A can be measured.

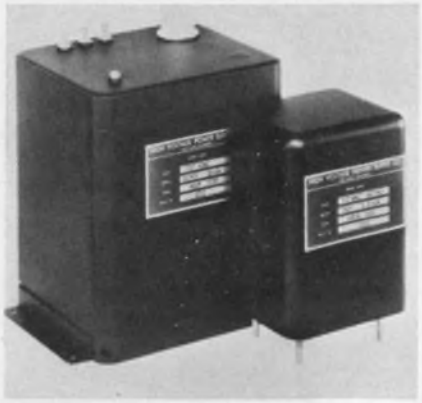
CIRCLE NO. 294

Tiny dual supply includes transformer

Pastoriza Electronics Inc., 385 Elliot St., Newton Upper Falls, Mass. Phone: (617) 332-2131.

Actually thinner than a pack of cigarettes, the MPD 15/100 provides dual ±15-V outputs at 100 mA with overall regulation of 0.02%. Obviously a companion to IC and hybrid logic, the supply occupies only 3/4-in. of rack space. In instruments, the MPD is also said to be a problem solver particularly when an existing unit is to be up-graded by the addition of additional amplifiers, filters, multiplexers, etc.

CIRCLE NO. 295

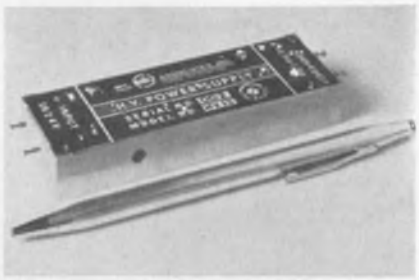


2- to 30-kV supplies use chopper principle

High Voltage Power Supply Co., 15820 Stagg Ave., Van Nuys, Calif. Phone: (213) 780-5526. P&A: $71 to $198; 2 to 3 wks.

Based on the dc chopper principle, the Series AUP 008 high-voltage supplies are suggested for applications in CRTs, image and phototubes. The use of the chopper principle is said to reduce the bulk and weight required. The supplies accept inputs from 50 to 1600 Hz and have an output ripple below 0.1%. Output is adjustable ±10%.

CIRCLE NO. 296

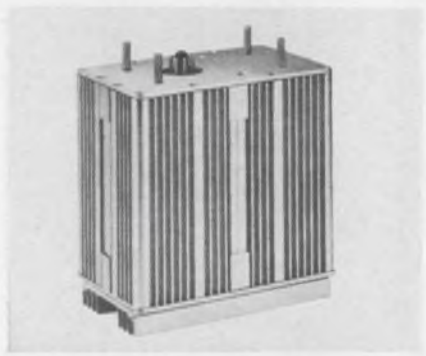


High-voltage supply occupies 3 in.^{3}

Mil Associates, Inc., Hudson, N. H. Phone: (617) 444-0133. P&A: $273; stock.

A high-voltage power supply that provides up to 1500 volts at 2 mA is housed in a 3-in.^{3} case. The unit weighs only 120 grams. This dc-dc converter, Model HV-15, has an output ripple factor of 0.1% of the output voltage. The completely floating output is screwdriver adjustable from 700 to 1500 volts. Line regulation is 0.15%/V and load regulation is 2.5% from half to full.

CIRCLE NO. 297



Remote-sense supplies have 60,000 hr. MTBF

Mid-Eastern Electronics, Inc., 15 Brown Ave., Springfield, N. J. Phone: (201) 376-7130. Price: from $198.

Designed particularly for extreme environment OEM equipment, the HT and HTA series power supplies have a MTBF rating up to 60,000 hours. With neither forced-air nor heat sinking, the HT series functions up to 40°C while the HTA series is rated for 60°C ambients. Units are available in ratings from 6 volts at 4 A to 100 volts at 0.75 A.

CIRCLE NO. 298

Dual supply has 250-microvolt ripple

Spar Electronics, 7969 Engineer Road, San Diego, Calif. Phone: (714) 279-1641. P&A: $59.95; stock.

The Model 500 dual power supply provides two independent and adjustable sources of 0 to 16 volts at 500 mA. Sources can be operated in series for 0 to 32 volt operation or opposing for positive and negative voltages. Self-protecting current limitation with a flashing indicator is provided. Regulation is 25 mV max. A single 1-A supply, the Model 100 is also available.

CIRCLE NO. 299

THE 'EXTRA MARGIN' IS A LIFE SAVER

Operating at 2 amps, 28 volts DC, you can get up to 30 percent more operating life by using Cook Electric's Micropoise relays. Why? It's the extra margin—5/1000 of an inch wider gap that means less wear on the contacts.

Wider contact gaps and more wipe are made possible by direct linear motion—an engineering achievement that delivers to you the kind of efficiency that can save you dollars while adding a new measure of dependability in your relay installations.

To complement the "extra-margin," the Micropoise relay eliminates all rotating parts, fragile glass bead inculators or overstressed spring members —a simple, efficient solenoid motion actuates the armature.

Assembled and hermetically sealed in a sparkling white room facility, Micropoise relays bring you the ultimate in contact reliability, packaging density and minimum coil power requirements.

Available in two, four, six and twelve pole double-throw configuration, the Micropoise line offers you precisely the right relay for any application demanding adherence to MIL-R-5757.

Try Micropoise. We're sure you'll agree—it's a life saver.

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PLASTICS/CERAMICS for ELECTRONICS

CONDENSED CATALOG

New folder describes product lines — casting resins, adhesives, foams, sheet stock, coatings, silicones, microwave absorbers, anechoic chambers, shielding materials, etc. Post card included for obtaining more details.

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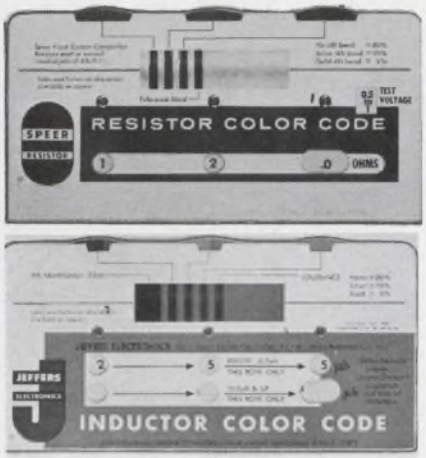
Design Aids



Resistor/inductor coder

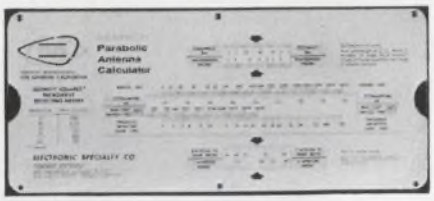
Forget those long mnemonic devices and try this color coder to dope out resistor and inductor values. Simply turn the wheels until the applicable colors appear and then read out resistance values in the windows. The reverse side of the calculator performs the same function for inductors. Speer Resistor Div., Speer Carbon Co.

CIRCLE NO. 311

Plastics data guide

An 8-page illustrated guide presents technical data on 11 classes of thermoplastics and 2 classes of thermosetting resins. Included in the brochure are time-saving nomograms which make possible instant determination of cost and weight, stiffness, yield, specific gravity, thickness and other physical and mechanical property relationships of plastics. Another section is devoted to property data to aid the engineer in selecting a specific material for a given application. Plastics Div., Union Carbide Corp.

CIRCLE NO. 312



Parabolic antenna calculator

A handy slide-chart completely determines parabolic antenna parameters. By setting frequency at reflector diameter, gain over isotropic is read at the appropriate efficiency and half-power bandwidth, vswr and return loss are read out in windows. On the reverse side, frequency is set and wavelength, attenuation, minimum length of free space pattern test range, focus-to-diameter ratio and total paraboloid aperature angle are shown. Electronic Specialty Co.

CIRCLE NO. 313

Circular slide rule

A handy circular slide rule is offered to engineers and plant and office executives. This convenient pocket-size calculator is extremely useful for simple calculations. Operation is easy and results are accurate whether you multiply, divide or find proportions. Complete instructions are included. General Industrial Co.

CIRCLE NO. 314

Ac power slide rule

Tel-Instrument Electronics' ac power slide rule offered on page 170, ED 22, Sept. 27, 1966 was given a Reader Service number in error. The rules may be obtained for $1 each from Tel-Instrument Electronics Corp., 728 Garden St., Carlstadt, N. J.

Resistor reliability rule

By lining up the number of resistor test hours on the outer scale of this rule with the number of failures at a desired confidence level on the inner scale, failure rate per 1000 hours and mean time to failure are calculated. The "Resist-O-Dial" also completely determines specs on high-reliability, axial-lead, lug terminal and subminiature resistors. A set of Ohm's law formulas are tabulated for convenience. The reverse side of the rule gives complete specs for high-frequency, unencapsulated ceramic, printed circuit, instrument grade and power resistors. Daven Div., Thomas A. Edison Industries, McGraw Edison Co.

CIRCLE NO. 315

Engineer's scales

Offering full scale exposure at all times, "Scalemasters" eliminate the need for conventional triangular scales. Model EN-56 measures 6-3/4 x 3-3/8-in. and model EN-99 measures 12-1/2 x 3-3/8-in. Both have metal-banded scale ends and are transparent and laminated. Four slotted openings are provided along with graduations of 10, 50, 20, 40, 30 and 60 decimal parts to the inch. A scale with inches in sixteenths, a millimeter scale and half-scale are also provided.

Available for $0.60 (EN-56), $1 (EN-99) from C-Thru Ruler Co., 823 Windsor St., Hartford, Conn.

Learn why

Please send me a FREE copy of "Transistor characteristics related to circuit performance," along with detailed specifications on ITT strip line transistors.

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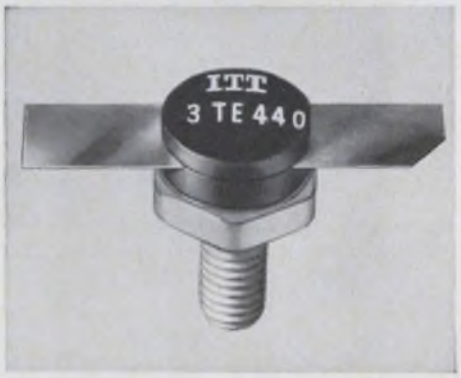
ITT's exclusive strip line packaging makes VHF/UHF transistor circuits work better



The strip line package reduces or eliminates many of the difficulties that were formerly inevitable when working with high-power VHF-UHF transistors.

Consider these advantages: strip line configuration simplifies final tune-up by virtually eliminating instability; low-inductance package means easier matching to driver stages and broad bandwidth. For 400 MHz application, you may select the 3TE440 (15 watts output) or the 3TE450 (4 watts output).

For full details fill in the coupon above. Or see for yourself — sample quantities are available off the shelf from your ITT distributor or factory representative.

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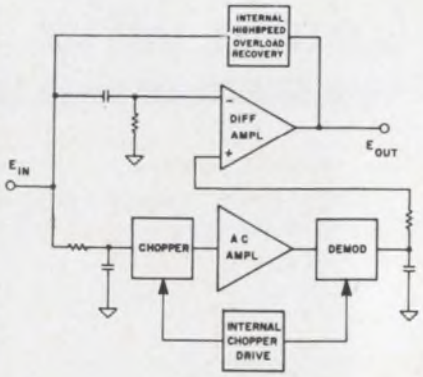
Application Notes



Chopper-stabilized op-amps

Part 5 in Analog Devices' series of application notes is a 12-page handbook covering theory and applications of chopper-stabilized op-amps. The first section details basic principles and shows how the amplifier's drift reduction provides 5 application advantages.

The second section discusses such practical considerations as different methods for adjusting current and voltage drift and offset, techniques for stability when driving highly capacitive loads, use of a small capacitance across the feedback resistor for circuit stability, etc.

With the aid of diagrams, the third section gives circuit applications. Typical circuits covered are inverting, noninverting, summing, integrating and current amplifiers, converters, sources and circuits for measuring the output from Wheatstone-bridge transducers. Analog Devices.

CIRCLE NO. 316

Heat sinking primer

Basic data on heat sinking are presented in the form of four reprinted articles by Wayne Goldman, Wakefield's Applications Engineer. Titles and the subjects covered are: "An Introduction to the Art of Heat Sinking," "Nine Ways to Improve Heat Sink Performance," "How to Measure Heat Sink Characteristics for High Power Application" and "Torque and Thermal Resistance." Wakefield Engineering, Inc.

CIRCLE NO. 317

Measuring systems

The technology and industrial applications of load and displacement measuring systems are described in this brochure. Measurement and calibration techniques used with load cells and position transducers are treated in detail. Lockheed Electronics Co.

CIRCLE NO. 318

Noise and field intensity

Description and applications information on a 1- to 22-GHz noise and field intensity analyzer are given in a 6-page brochure relating to military electromagnetic interference measurements and frequency surveillance. The Singer Co.

CIRCLE NO. 319

Pressure transducer

This report describes a transducer covering the unusually wide range of 10^{-5} to 10^{3} mm Hg and sensitive to absolute pressure, with small size and internal volume, and fast response. Electrical output indicates pressure continuously. Applications include electronic control systems and automatic data recording.

Available for 30¢ from Clearinghouse, U.S. Dept. of Commerce, Springfield, Va.

Microwave procurement

The ninth technical paper in a series being published by Sperry's Electronic Tube Division is entitled "A New Solution for Microwave Source Procurement." The paper discusses the interface problems encountered in matching microwave components and outlines a new approach to simplified system design. Sperry Rand Corp., Electronic Tube Div.

CIRCLE NO. 320

Over 100 prizes—try your luck on p. 232.

New Literature

Relay catalog

A 50-page relay catalog gives complete engineering data, illustrations and dimensional drawings covering 1700 different relays divided into 23 classifications. Contacts, contact arrangements, coil specifications and other pertinent information needed to select or design relay circuits is given. Standard Relay Corporation.

CIRCLE NO. 321

Components catalog

Potentiometers, switches and capacitors available "off the shelf" are described in the "Industrial Distributor Components Catalog 33-I." The 44-page catalog contains information designed to make specification, selection and purchasing a snap for circuit design or component procurement. Centralab, The Electronics Div. of Globe-Union, Inc.

CIRCLE NO. 322

Epitaxial films

This 41-page report deals with thin gold films having the class of defects observable by transmission electron microscopy: dislocations, stacking faults and twins. It also considers gross features such as holes and other discontinuities.

Available for $2 from Clearinghouse, U.S. Dept. of Commerce, Springfield, Va.

Precision optical components

This new 10-page catalog of precision optical components contains descriptions and prices of laser windows, mirrors and prisms, as well as fused silica lenses, cylindrical lenses, flat and concave reflectors, beam splitters and dispersion prisms. Detailed information on coatings is also included. Oriel Optics Corp.

CIRCLE NO. 323

Ferrite and garnet materials

An 8-page catalog lists yttrium iron garnet, nickel ferrite and magnesium ferrite in single polycrystalline forms along with specifications and stock sizes and shapes. A 4-page bibliography on garnet materials is also included. Harshaw Chemical Co., Xtalonix Products.

CIRCLE NO. 324

Cryogenic liquid

The physical properties of liquid nitrogen and the design factors to be considered for its delivery, on-site storage and in-plant distribution are discussed in "Liquid Nitrogen." The 20-page booklet provides comparative data on boiling and freezing points, heat content and density of liquid nitrogen, liquid oxygen, liquid air and other cryogenic fluids. Union Carbide Corp.

CIRCLE NO. 325

Magnetic shielding

A 4-page brochure gives technical data on rust-inhibited "Blue Netic" magnetic shielding foil, with some applications for other magnetic foil shielding, for general and laboratory use. Perfection Mica Co.

CIRCLE NO. 326

Folded-array memory

A miniature folded-array memory, in separate types for commercial, industrial and military applications, is described in an 8-page brochure. Indiana General Corp.

CIRCLE NO. 327

Connector catalog

An 8-page catalog describing a line of connectors for commercial and military applications covers eight different series, with pertinent specifications for each group. Included are connectors for printed circuitry, removable contact, center screwlock and rack and panel applications, power, terminal blocks and special designs. Continental Connector Corp.

CIRCLE NO. 328

Transistor amplifiers

A catalog covering low-noise transistor amplifiers features reliability data in accordance with MIL-HDBK-217. A nomograph is included to facilitate calculation of spurious responses and intermodulation products on both relative and absolute bases. Avantek, Inc.

CIRCLE NO. 329

Semiconductor specs

JEDEC Suggested Standard No. 3, "Standard List of Values to Be Used in Semiconductor Device Specifications and Registration Formats" and JEDEC Publication No. 59, "A Guide to the Preparation of Semiconductor Detail Specifications in MIL-S-19500 Format" have been issued as aids in semiconductor specification writing.

Available for 25¢ (No. 3), and 95¢ (No. 59), from Electronics Industries Association, 2001 Eye St., N.W., Washington, D. C.

Power supply modules

Both single- and dual-output modular power supplies are described in a new 8-page catalog. Thousands of all-silicon models are listed with outputs from 0 to 400 V and output currents to 25 A. Power Mate Corp.

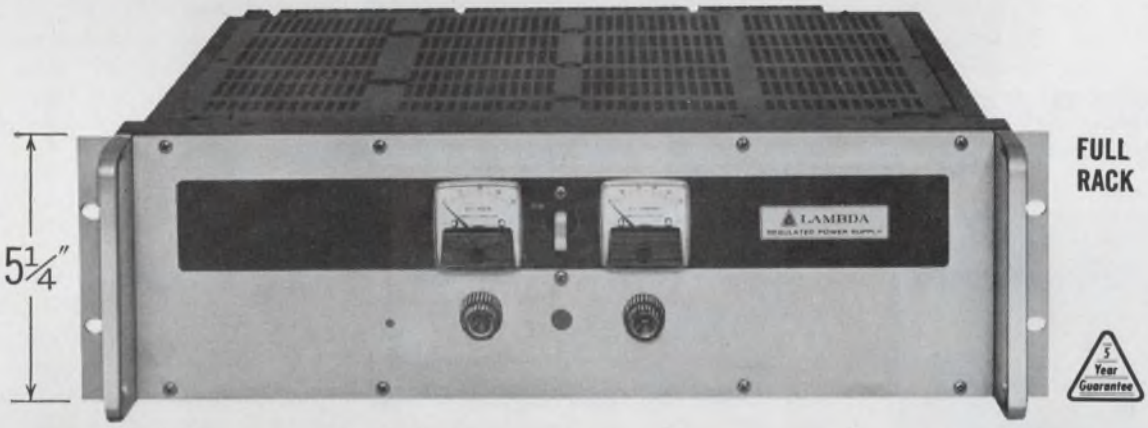
CIRCLE NO. 330

Over 100 prizes—try your luck on p. 232.

NEW

Lambda high current LK Series power supplies

0-20, 0-36, 0-60 VDC • up to 35 amps • 5¼" height • starting at $330.



Features

- **All Silicon**
- **Convection cooled**
- **Remotely programable**
- **Meet Mil-Environment specs**
  Vibration, MIL-T-4807A
  Shock: MIL-E-4970A
  • Proc. 1 & 2
  Humidity: MIL-STD-810
  • Meth. 507
  Temp. Shock: MIL-E-5272C
  • (ASG) Proc. 1
  Altitude: MIL-E-4970A
  • (ASG) Proc. 1
  Marking: MIL-STD-130
  Quality: MIL-Q-9858
- **Remote Sensing**
- **Series/Parallel Operation**
- **Regulation**—.015% or 1 MV (Line or Load)
- **Ripple**—500 uV RMS.
- **Temp. Coef.** .015%/°C
- **Transformer**—designed to MIL-T-27 Grade 6
- **Completely Protected**—Short Circuit Proof—Continuously Adjustable Automatic Current Limiting
- **Constant I./Constant V.** by automatic crossover
- **No Voltage Spikes or Overshoot** on "turn on, turn off" or power failure
- **Wide Input Voltage and Frequency Range**—105-132 VAC, 47-63 cps

RACK OR BENCH USE—rubber feet included for bench use.

3 full-rack models – Size 5¼" x 19" x 16½"

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1]				Price[2]
		40°C	50°C	60°C	71°C	
LK 350	0-20VDC	0-35A	0-31A	0-26A	0-20A	$675
LK 351	0-36VDC	0-25A	0-23A	0-20A	0-15A	640
LK 352	0-60VDC	0-15A	0-14A	0-12.5A	0-10A	650

6 half-rack models – Size 5 3/16" x 8⅜" x 16½"

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1]				Price[2]
		40°C	50°C	60°C	71°C	
LK 340	0-20VDC	0- 8.0A	0- 7.0A	0- 6.1A	0-4.9A	$330
LK 341	0-20VDC	0-13.5A	0-11.0A	0-10.0A	0-7.7A	385
LK 342	0-36VDC	0- 5.2A	0- 5.0A	0- 4.5A	0-3.7A	335
LK 343	0-36VDC	0- 9.0A	0- 8.5A	0- 7.6A	0-6.1A	395
LK 344	0-60VDC	0- 4.0A	0- 3.5A	0- 3.0A	0-2.5A	340
LK 345	0-60VDC	0- 6.0A	0- 5.2A	0- 4.5A	0-4.0A	395

[1] Current rating applies over entire voltage range.
[2] Prices are for non-metered models. For metered models add suffix (FM) to model number and add $30.00 to price.
[3] Overvoltage Protection: Add suffix (OV) to model number and add $70.00 to the price for half-rack models; $90.00 for full-rack models.

LAMBDA ELECTRONICS CORP.
515 BROAD HOLLOW ROAD • MELVILLE, L. I., NEW YORK • 516 MYRTLE 4-4200
A Vesco SUBSIDIARY

LA-173

ON READER-SERVICE CARD CIRCLE 793

NEW LITERATURE

Glossary of instrument terms

The "Glossary of Instrument Terms" is an 8-page booklet which contains 155 technical terms or phrases and their definitions. The terms are peculiar to electronics, electromechanics, theoretical mechanics, biophysics and electrical engineering. The glossary provides a "semantic reference" so that language between instrument manufacturers and users can be more thoroughly understood. Brush Instruments Div., Clevite Corp.

CIRCLE NO. 331

Automatic film reader

A 40-page report treats the development of a method for digitizing oscilloscope data at a faster than usual rate while minimizing human error. The method applies automatic techniques to the digitizing of analog data recorded on positive transparent oscillograms.

Available for $2 from Clearinghouse, U.S. Dept. of Commerce, Springfield, Va.

Condensed diode catalog

Condensed catalog D-1 is a 2-color, 4-page publication giving specs on a complete line of microwave diodes. Tabulated electrical and mechanical data is provided on more than 100 models including mixer and video detector diodes, general purpose varactors and step recovery, paramp, fast switching and pin switching diodes. Alpha Industries, Inc.

CIRCLE NO. 332

Subminiature RF connectors

Submin RF connectors and coax cables are described in Amphenol's 12-page, 2-color catalog. The publication contains specs and illustrations of radial-crimp, quick-crimp and field-serviceable connectors. Complete assembly instructions with step-by-step drawings are included for each type. A cable section covers available dielectric and cable jacket combinations, along with a full listing of electrical characteristics. Easy-to-use reference charts detail compatible connectors and cables. Amphenol, RF Division.

CIRCLE NO. 333

Platinum alloys

"High Tensile Strength Platinum Alloys" outlines the advantages of these alloys and their composition. It covers the unusual characteristics which make them desirable for wirewound pots, galvanometer suspension strips, bridge wires, spring contacts and strain gauges. Also included are tables showing methods for calculating torque and resistance per foot. Sigmund Cohn Corp.

CIRCLE NO. 334

Solid-state electrometer

A solid-state electrometer is described with a range of current measurement of 10^{-12} to 10^{-8} A, for use in a portable radiation survey meter. The device offers high linearity, fast response and low power consumption.

Available for $1 from Clearinghouse, U.S. Dept. of Commerce, Springfield, Va.

Brazing alloys

A line of phosphor-copper and silver alloy brazing fluxes and solders is detailed in this 4-page bulletin. Charts of composition analysis and specification compliances of silver solders and silver brazing fluxes are included. Unibraze Corp.

CIRCLE NO. 335

Electromagnetic compatibility

"Electronic Equipment Enclosures," fourth in a series developed by the EIA Electromagnetic Compatibility Committee, contains material to aid the equipment designer in designing or specifying equipment enclosures to meet radiation and susceptibility requirements. Both analytic and measurement approaches are covered. Information is presented in graphic form to permit quick design decisions. The bulletin contains sections dealing with definitions, shielding theory, shielding materials, RFI leakage, aperture radiation and gaskets.

Available for $2.50 from EIA Engineering Dept., 2001 Eye St., N.W., Washington, D. C.

Magnetic core memories

This 6-page brochure describes a line of memory systems for military, aerospace and commercial applications. Photos and specs are presented for regular and miniature serial, sequential and random access units, and a bit serial core memory system. Di/An Controls, Inc.

CIRCLE NO. 336

General purpose relays

Twenty-three series of relays covering a wide range of duty requirements are described with photos, dimensional drawings and operational data in an 18-page catalog. Data on coils and contacts, mounting dimensions and available enclosures are included. Guardian Electric.

CIRCLE NO. 337

Impact and vibration

A description of elastomeric energy-absorption devices and how they isolate vibration, noise and impact are presented in this 12-page catalog. Also treated are causes, characteristics and effects of free vibration, forced vibration and resonance, with data on the company's energy-absorbing devices. Ohio Rubber Co.

CIRCLE NO. 338

Computer techniques

"New Techniques in Computer Development" is a 16-page brochure describing the design, development and production of the new SDS line. The use of critical-path planning, computer-aided design, standardization programs, automated testing, and semiautomatic quality-control procedures are described fully. Scientific Data Systems.

CIRCLE NO. 339

Illuminated switches

A well-illustrated 19-page catalog presents a broad line of illuminated push-button switches with accessories. It describes the series 10E with ordering data for accessories and required front-panel lens engravings. Master Specialties Co.

CIRCLE NO. 340

Win a free trip to Paris. See p. 232.

ON READER-SERVICE CARD CIRCLE 813 ➤

NEW LITERATURE

Silicon assemblies

An indexed 80-page catalog lists a complete line of silicon assemblies, with ratings and specifications. The catalog describes a line of molded circuit assemblies from low-current, low-voltage bridges through cartridges and tube replacements to high-voltage encapsulated stack rectifier assemblies. International Rectifier.

CIRCLE NO. 341

Clutches and brakes

Design features and operating characteristics of magnetic dry particle clutches and brakes are given in this 16-page catalog. Complete electrical and mechanical data are given for servo sizes 5 through 23, and a simple nomograph is provided for determining heat-rise in any unit. Vibrac Corp.

CIRCLE NO. 342

Terminal junctions

This 4-page brochure describes terminal junctions, a class of interconnection and busing devices in which terminals tool-crimped on leads are inserted in junction modules. The brochure describes the method and presents various junction configurations. Deutsch.

CIRCLE NO. 343

Lamp indicators

Data sheets are available on two additional models of the Replaceable Lamp Button-Lite (RBL) Series, containing full specifications and ordering information. Transistor Electronics Corp.

CIRCLE NO. 344

Precision potentiometers

An 8-page catalog gives the nomenclature, dimensions, specs, photos and price listings of over 25 bush-mount, servo-mount, digital and clock-face precision pots. Also treated are power supplies, voltage sensors, relays, time delays, microcomponents and turns-counting dials. Bourns, Inc.

CIRCLE NO. 345

Enter the "Top Ten" contest on p. 232.

Crystal filters

A 16-page catalog, describing a line of quartz crystals, crystal filters and oscillators, contains illustrations, schematics and a frequency vs bandwidth guide for determining the practicability of crystal filters. Midland-Wright Corp.

CIRCLE NO. 346

Reprints Available

The following reprints are available free and in limited quantities. To obtain single copies, circle the number of the article you want on the Reader-Service Card.

New FETs replace tubes (No. 347)

Measure transistor y-parameters (No. 348)

Need a pedestal-free gate? (No. 349)

Accuracy Policy

It is the policy of ELECTRONIC DESIGN:

To make reasonable efforts to insure accuracy of editorial matter.
To publish promptly corrections brought to our attention.
To reserve the right to refuse any advertisement deemed misleading or fraudulent.

All editorial correspondence should be sent to:

Howard Bierman, Editor
ELECTRONIC DESIGN
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New York, N. Y. 10022

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AMERICAN BUSINESS PRESS, INC. BPA

Design Data from

Quality Fasteners For All Design Applications

This 8-page catalog provides design data on the complete group of DZUS 1/4-turn self-locking fasteners for standard, high speed and panel applications, as well as universal high strength multiple thread fasteners for high tensile and shear stresses. Dzus stud assemblies, wire forms and receptacles offer an exceptional, wide variety of combinations from stock to fit specific fastening requirements. Diagrams and tables give full details for rapid, unlimited design selection. Condensed Catalog No. S-2 or comprehensive Catalog No. D-3 are available on request.

Dzus Fastener Co., Inc.
Division 32
425 Union Boulevard
West Islip, L. I., N. Y. 11795

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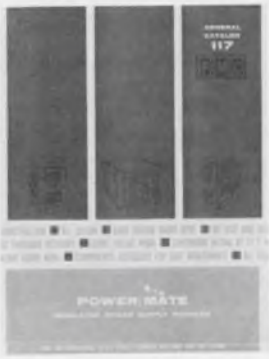
Engineers' Relay Handbook

A definitive work that is fast becoming a standard reference text for the relay user. Prepared and edited by the National Association of Relay Manufacturers, this book is a complete guide to the principles, properties, performance characteristics, application requirements, specifications, and testing of relays. Systems and product engineers will find the *Handbook* an indispensable help in determining the correct types of relays for their applications. For further information about this unique sourcebook, write Dept. ED

Hayden Book Co., Inc.
116 W. 14th Street
New York, N. Y. 10011

173

Thousands Of Power Supply Modules



Thousands of single and dual output all-silicon power supply modules are available from Power/Mate with outputs from zero to 400v • Output currents to 25A • Rated for continuous duty at —20 to +71°C • Modules are short circuit proof, and are designed for automatic recovery • Since they are rigorously inspected and operated full load 71°C for 24 hours prior to shipping, they are sold with a three year warranty • Single units priced as low as $49.95 with discounts on over ten modules • Many available for off-the-shelf delivery • Send for General Catalog 117 for complete details and ordering information.

Power/Mate Corporation
163 Clay Street
Hackensack, New Jersey 07601 (201) 343-6294

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Manufacturers

dvertisements of booklets, brochures, catalogs and data sheets. To order use Reader-ServiceCard.

Piezotron (TM) Quartz Accelerometers

Four-page Bulletin 813106 provides answers to frequently asked questions concerning Kistler's new, easy-to-use, low impedance Piezotron quartz transducers which require only one wire for both signal and power. Subjects covered include power requirements, interface considerations, shock measurements, use with long cables, and environmental characteristics.

Kistler Instrument Corporation
8969 Sheridan Drive
Clarence, N. Y. 14031

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DC Modules Simplify Power Supply Logistics

Data sheets describe three new Universal Power Modules which replace hundreds of slot-range supplies. Discrete output voltages are determined by the mating connector wiring. Interpolation potentiometer (25-turn) provides intermediate settings. Modules mount in any plane, to any surface, without heat sinking or blowers. Model UPM-11 is two independent sources of 0 to 16V, 1 ampere. Model UPM-22 is two independent sources of 16 to 28V, ½ ampere, or 28 to 60V, ¼ ampere. Model UPMD-6 is a 10-ampere source of 3, 4, 5, or 6V.

Power Designs, Inc.
1700 Shames Drive
Westbury, L. I., N. Y.

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New "Tape Lift" Printed Circuit Drafting Aids

No engineer or draftsman should be without the most up-to-date cross-reference guide to better Printed Circuit Drafting Catalog. It is complete with prices and illustrations of over 1200 sizes of "Tape Lift" pads, shapes and other aids for faster, more accurate, distortion-free printed circuit master drawings.

By-Buk Company
4326 West Pico Blvd., Los Angeles, Calif. 90019
Telephone: (213) 937-3511

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Designer's Datebook

JANUARY						
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Jan. 4-7, 1967
Winter Meeting of the National Society of Professional Engineers (San Juan, P. R.) Sponsor: NSPE; Kenneth E. Trombley, National Society of Professional Engineers, 2029 K. St., N.W., Washington, D. C. 20006

Jan. 10-12
1967 Annual Symposium on Reliability (Washington, D. C.) Sponsor: NASA; John E. Condon, Reliability and Quality Assurance (KR), NASA Headquarters, Washington, D. C. 20546

Jan. 19-20
Institute—Computer Aid for Reliability Analysis of Electronics (Milwaukee) Sponsor: University of Wisconsin; C. L. Brisley, Director, Engineering Center for Postgraduate and Professional Development, The University of Wisconsin, 600 W. Kilbourn Ave., Milwaukee, Wis. 53203.

Jan. 31-Feb. 2
Circuit Design by Computer —Tutorial Symposium (New York City) Sponsor: New York University; M. B. Goldin, New York University, University Heights, New York, N. Y. 10453

Feb. 7-9
Winter Convention on Aerospace & Electronic Systems (Los Angeles) Sponsor: IEEE, G-AES; D. Traitel, Electro-Optical Systems, 300 N. Halstead, Pasadena, Calif.

Feb. 14-17
Electronic Packaging Conference (New York City) Sponsor: Society of Automotive Engineers, Inc.; A. J. Favata, SAE, 485 Lexington Ave., New York, N. Y. 10017

Feb. 15-17
International Solid-State Circuits Conference (Philadelphia) Sponsors: IEEE, University of Penn.; Lewis Winner, 152 W. 42 St., New York, N. Y. 10036

Electronic Design's "TOP TEN" CONTEST

FIRST PRIZE

win 2 round-trip tickets between New York and PARIS

VIA AIR FRANCE

- **Select the "TOP TEN" ads in this issue.**
- **All Electronic Design readers are eligible.**
- **Over 100 other valuable prizes!**

1966 "TOP TEN" CONTEST RULES

1. Select the ten advertisements in the January 4, 1966 issue you think will be best remembered by *Electronic Design* readers, as determined by "Recall-Seen" scores in "Reader Recall." On the official entry blank or any reasonable facsimile thereof, enter, for each of the ten advertisements you have selected, the name of the company advertising and the page number(s) on which it appears. Your ten choices need not be in rank order. Ads placed by Hayden Publishing Company, Inc., in *Electronic Design*, should *NOT* be considered among the *top ten* advertisements.

2. If more than one entry is submitted, none will be considered. Entry blank must be filled in completely, or it will not be considered. *Electronic Design* will pay postage for official entry blanks only. Entries must be postmarked not later than midnight, January 30, 1966.

3. To enter, readers must be engaged in electronic design engineering work, either by carrying out or supervising design engineering or by setting standards for design components and materials. Employees of Hayden Publishing Company, Inc., its subsidiary and advertising agency, and members of their families, are not eligible for this contest. Decision of the judges will be final. In the event of a tie, the contestants involved will be asked to participate in a special run-off.

4. First prize is two tourist class, round-trip tickets between New York and Paris via Air France. Transportation to and from point of embarkation in New York or Paris, and any other expenses incurred as part of this trip, are not included in the prize. No cash payments, or other substitutes, will be made in lieu of any prize.

5. Contest void where prohibited or taxed by law. Liability for any taxes on prizes is the sole responsibility of the winners.

"TOP TEN" INDUSTRIAL MANUFACTURER/ADVERTISING AGENCY CONTEST RULES

6. All rules for Reader Contest (above) will similarly apply for this contest, with one exception: readers engaged in electronic design engineering work, as defined in the rules above, are not eligible to participate in this special contest.

7. This special contest is open to personnel at all industrial manufacturing companies and advertising agencies. Those who qualify for the Reader Contest (as defined in point 3, above) are not eligible to enter this contest.

8. Employees of all industrial manufacturing companies and advertising agencies are eligible to enter this contest whether or not their companies or agencies have an advertisement in this issue. However, only those companies (or divisions thereof) advertising in this issue, and the advertising agencies placing such advertisements, are eligible for a free re-run of their advertisement, should a member of their organization win. Entrants from such companies and advertising agencies must clearly indicate the specific advertisement to be re-run (including page number) in the space at the bottom of the entry blank.

2nd PRIZE

HOFFMAN COLOR TV CONSOLE

Hoffman 23" console, featuring 26,000 volts of picture tube power . . . 4"x6" front-firing speaker. 32"x29"x19⅛" cabinet. (Retail value: $600.00.)

3rd–8th PRIZES

BULOVA ACCUTRON® ELECTRONIC TIMEPIECES

The "Spaceview" is an ideal timepiece for electronic engineers. Its clear-view dial reveals transistorized electronic circuit and tuning fork assembly. (Retail value: $150.00.)

PLUS 100 ADDITIONAL PRIZES

MICROELECTRONIC DESIGN — a thorough overview of the field in six sections—has almost 90 outstanding articles. Edited by Howard Bierman. (Retail value: $11.50.)

CONTEST FOR ADVERTISERS, TOO

here's all you have to do to enter:

Rate the ads appearing in this issue of *Electronic Design*. Select the *top ten*—the ads that, in your opinion, will be best remembered by readers. Your choices will be measured against the 10 ads ranking highest in the "Recall-Seen" category of "Reader Recall"—*Electronic Design*'s scientific method of measuring readership. In making your predictions, be sure to consider your 54,000 fellow engineers' interest in the subject matter of the ads, their effectiveness, impact, and attention-getting values.

Entry blanks and complete contest rules appear at right. Don't miss this opportunity to win one of the many valuable prizes. The first prize winner will receive round-trip tickets for two, between New York and Paris, via Air France!

Brand NEW FROM HICKOK

DMS-3200 Digital Measuring System

DMS-3200 Main Frame **$320**
(shown with DP-100)

DP-100
DC Voltmeter
Plug-in
$175

DP-150
1 MC Counter
Plug-in
$195

DP-170
Ohmmeter
Plug-in
$240

DP-200
Capacity
Meter
Plug-in
$240

DP-140
Event Counter
and
Slave Plug-in
$75

HIGHLIGHT FEATURES

■ 3-digit Biquinary Tube Read-out ■ Plug-in Flexibility ■ All-electronic ■ Fully-transistorized ■ Modular Design ■ Fully Field-tested ■ Automatic Polarity Indication ■ Automatic Decimal Point Indication

AS A DIGITAL DC VOLTMETER (DP100 Plug-in)

Range 0.1 millivolts to 1000 volts
Accuracy ±0.1% FS, ±0.1% of reading
True integrating voltmeter design
10 megohms input impedance at all times

AS A DIGITAL 1 MC COUNTER (DP150 Plug-in)

±0.005% accuracy: Resolution 1 part in 10^7
(Overrange capability with sector read-out permits 3-digit display to be equivalent of a 7-digit instrument)
Frequency measurement range 0.1 cps to 1 mc
Period measurement range 0.1 ms to 999 seconds

AS A DIGITAL OHMMETER (DP170 Plug-in)

Range 0.01 ohm to 1,000 megohms
Accuracy ±0.1% FS, ±0.2% of reading

AS A DIGITAL CAPACITY METER (DP200 Plug-in)

Range 1.0 picofarad to 10,000 microfarads
Accuracy ±0.1% FS, ±0.2% of reading

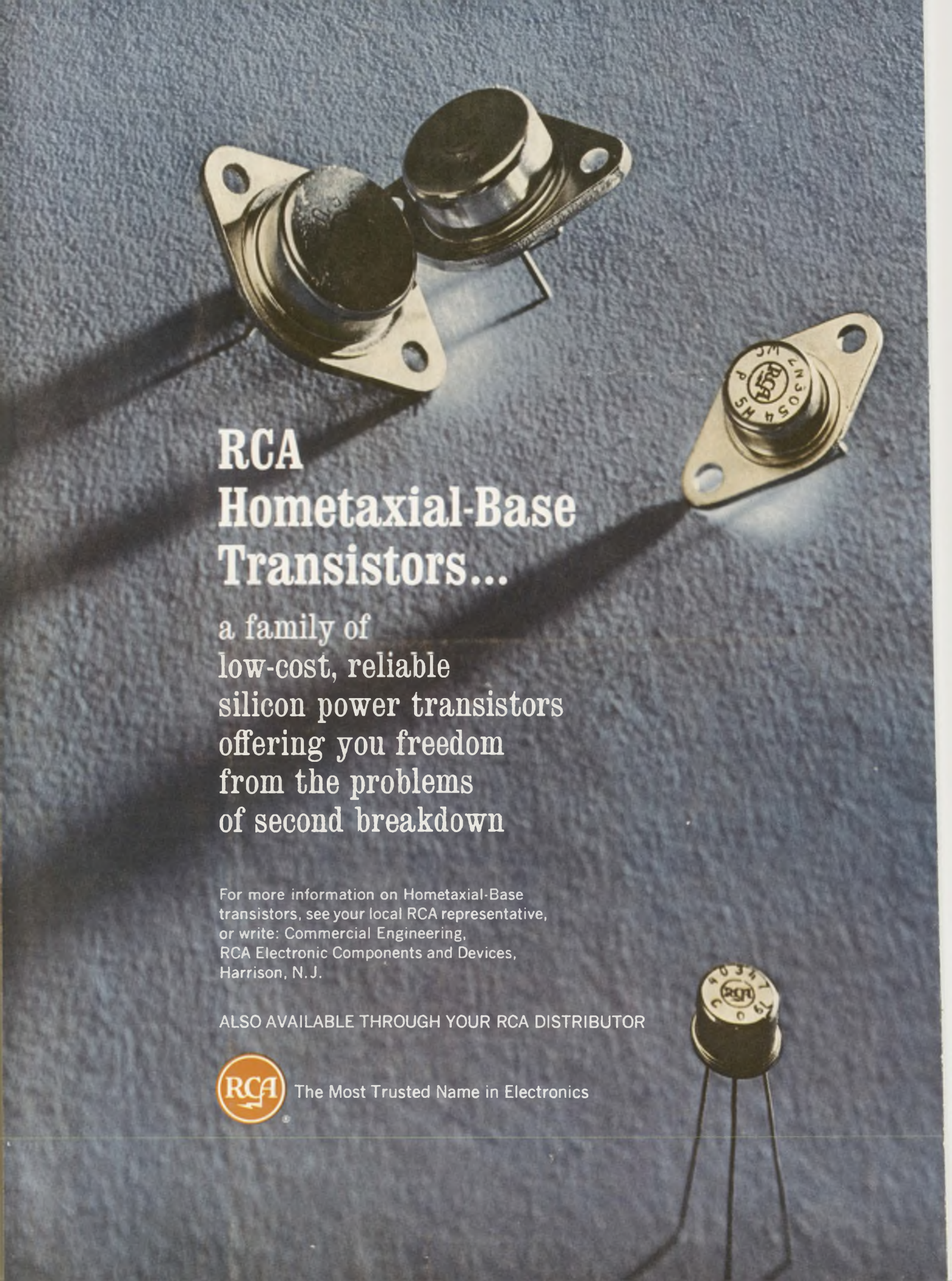
AS AN EVENT COUNTER AND SLAVE (DP140 Plug-in)

Event counting speed: 1,000,000 pps
Alternate use as slave to DP-150 to provide 6-digit display

The DMS-3200 is designed for rugged industrial and laboratory applications. By utilizing a design which has the optimum combination of accuracy capability and number of digit display, the DMS-3200 meets the general purpose measurement needs of industry for reliable, precision digital measurement equipment in the $400-$500 price range.

THE HICKOK ELECTRICAL INSTRUMENT CO. • 10514 Dupont Avenue • Cleveland, Ohio 44108

ON READER-SERVICE CARD CIRCLE 867



RCA Hometaxial-Base Transistors...

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

For more information on Hometaxial-Base transistors, see your local RCA representative, or write: Commercial Engineering, RCA Electronic Components and Devices, Harrison, N.J.

ALSO AVAILABLE THROUGH YOUR RCA DISTRIBUTOR

RCA The Most Trusted Name in Electronics