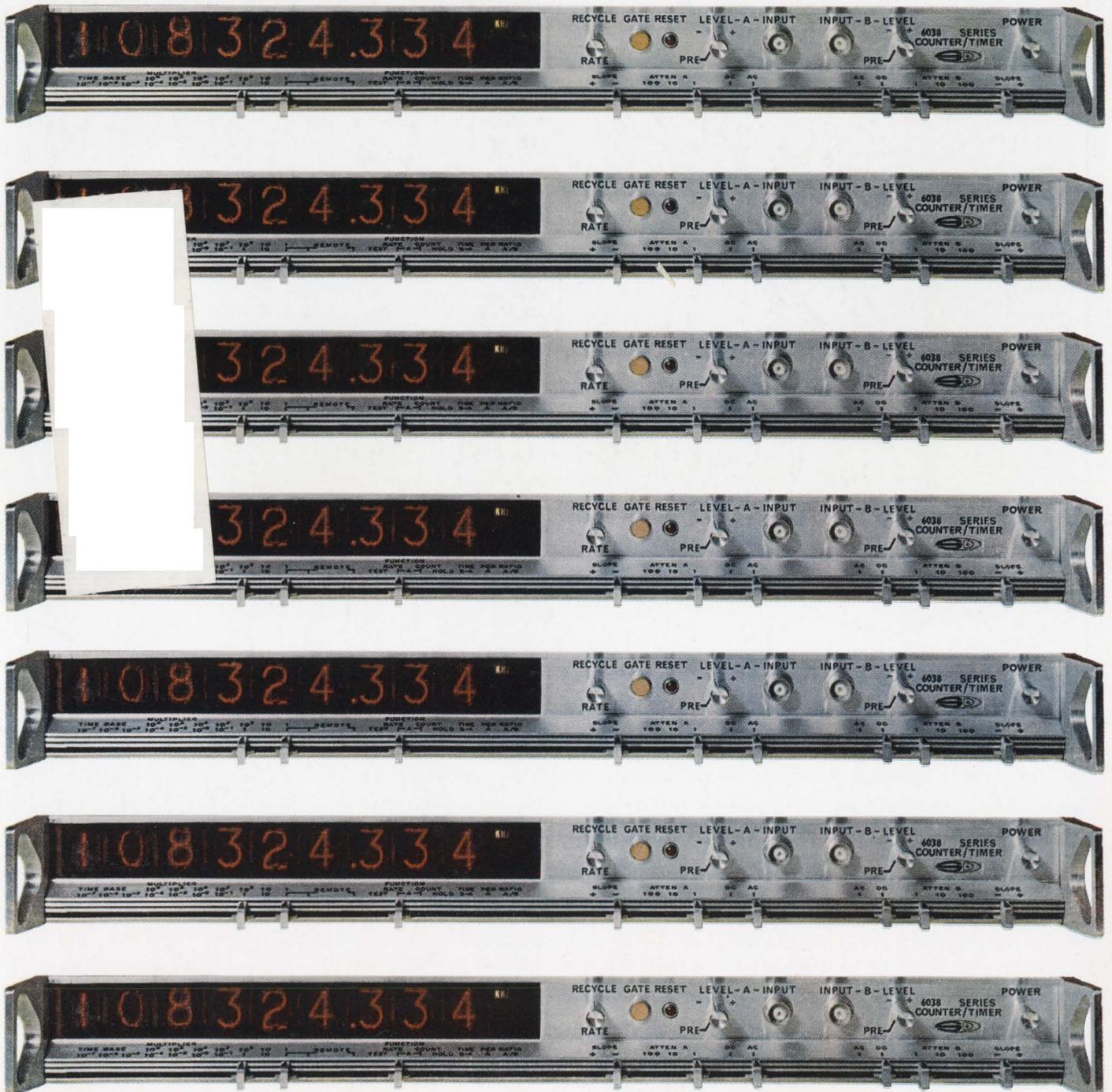


# Electronic Design 5

Just another counter? No, this new thin-line digital counter is a member of an entire family of counter/timers spanning 5 MHz to 12.4 GHz with six models.

The units feature many integrated circuits, high-frequency capability, slide-switch front-panel controls and 9-digit readouts. For a full line on the thin-lines, see p. 114.



**TRW ANNOUNCES  
NEW MILITARY MYLARS**



14-59

**Up to 72% smaller than MIL-C-25C paper capacitors!**

MIL-C-19978B/2 reduces capacitor size drastically—down to .125" diameter by 1/2" long. At the same time electrical characteristics are upgraded sharply.

MIL-C-19978B/2 hermetically sealed mylar\* capacitors are available now from TRW with immediate delivery in production quantities.

- **REDUCED SIZE**—35% to 72% smaller than MIL-C-25C.
- **VOLTAGE CHOICE**—30V, 50V, 100V, 200V, 600V, 1000V.
- **CAPACITANCE CHOICE**—.001 mfd through 10.0 mfd.
- **TOLERANCE CHOICE**—±10%, ±5%, ±2%, ±1%.

For full information contact: TRW Capacitors, 112 W. First St., Ogallala, Nebraska. Phone: 308-284-3611

These capacitors—when designated TRW Type 693—are available to high reliability specifications, and in custom capacitances and tolerances beyond the range of MIL-C-19978B/2.

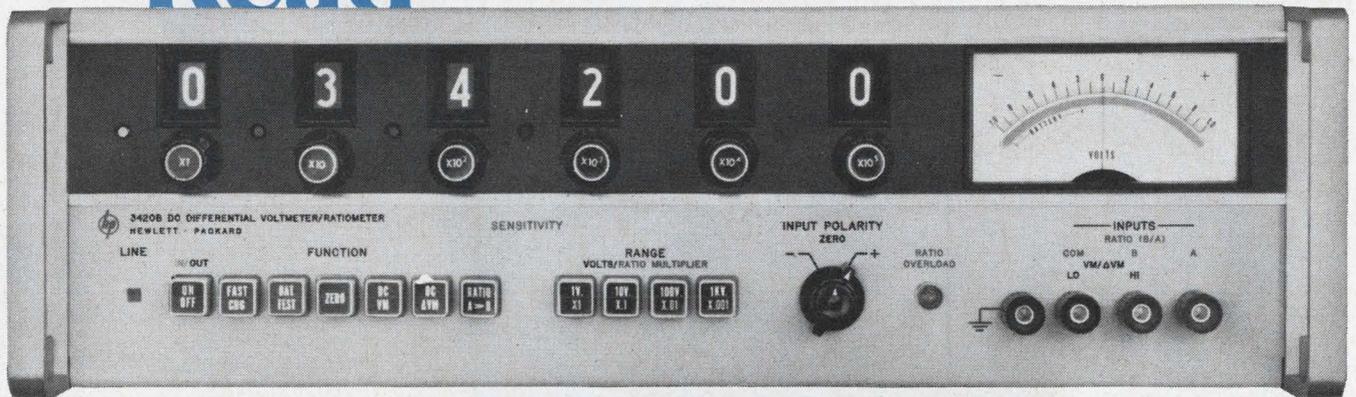
\*Du Pont registered trademark

**TRW**

ON READER-SERVICE CARD CIRCLE 202

# Push Null Read

Accuracy: 0.002% of reading + 0.0002% of range  
Highest resolution (0.2 ppm of range) —1, 10, 100, 1000 v ranges  
Stability: 1 ppm/hour, 5 ppm/day, 30-day calibration cycle  
RATIO measurements: four ranges with 6-digit resolution  
True isolation, battery operation



hp 3420A/B

## for today's most accurate dc differential volt/ratio meter measurements!

**accuracy** Here's the most accurate dc voltmeter available today, backed by a minimum 30-day calibration cycle and temperature coefficient of 4 ppm/°C. With a sensitivity of  $\pm 10 \mu\text{v}$  full scale, six-digit resolution is meaningful for measurements in standards and calibration labs, design labs . . . and all areas (physics, biomedical, electro-chemical, university, processes, control) where high precision and stability are essential.

**ratio** Then add *four ranges* of ratio capability with 0.002% accuracy and make both resistance and voltage ratio measurements. The customary precision voltage source required for resistance ratio is no longer necessary.

**isolation** A line/battery operated model permits true "floating" measurements and provides portability not available at this accuracy level before.

There is 10% overranging on all voltmeter functions, with overload recovery of less than three seconds, and immunity

to damage by overload. The recorder output at  $\pm 1$  volt and 1 milliamp will drive any recorder.

**ease of operation** Pushbutton function and range selection, plus a full in-line six-digit readout, permits convenient and time-saving measurements. Six discrete decade dividers with concentric null sensitivity pushbuttons now make nulling very simple. The zero pushbutton disconnects the input source and decades, and internally shorts input terminals . . . no need to return decades to zero.

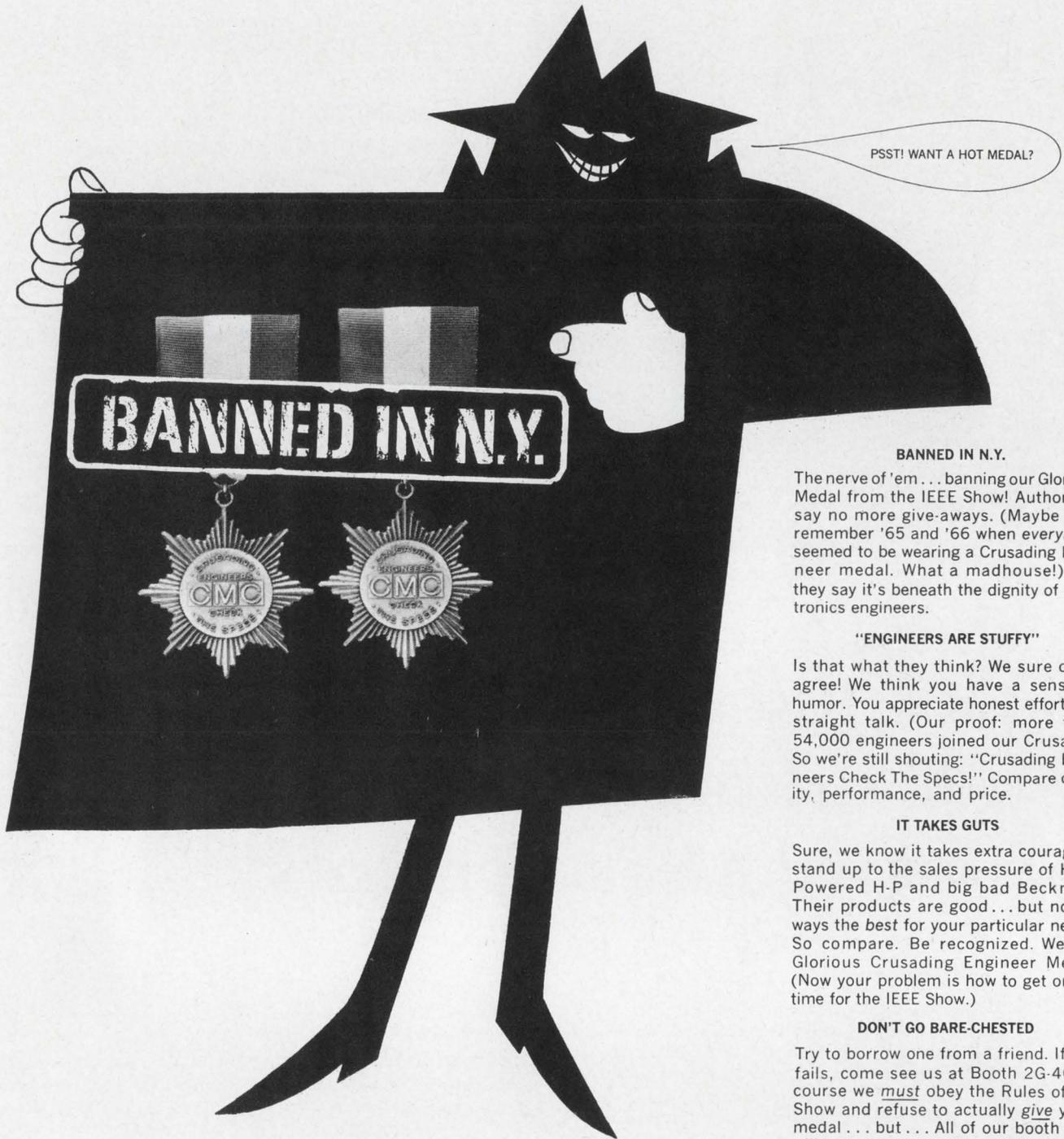
All silicon solid-state, with plug-in circuit board design for easier maintenance in both the 3420A (line operated) at \$1175, and the 3420B (line/battery operated) at \$1300.

Ask for a demonstration by calling your Hewlett-Packard field engineer. Or get complete specifications with the same call or by writing Hewlett-Packard, Palo Alto, Calif. 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

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

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ON READER-SERVICE CARD CIRCLE 2



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The nerve of 'em . . . banning our Glorious Medal from the IEEE Show! Authorities say no more give-aways. (Maybe they remember '65 and '66 when everybody seemed to be wearing a Crusading Engineer medal. What a madhouse!) But they say it's beneath the dignity of electronics engineers.

#### "ENGINEERS ARE STUFFY"

Is that what they think? We sure don't agree! We think you have a sense of humor. You appreciate honest effort and straight talk. (Our proof: more than 54,000 engineers joined our Crusade.) So we're still shouting: "Crusading Engineers Check The Specs!" Compare quality, performance, and price.

#### IT TAKES GUTS

Sure, we know it takes extra courage to stand up to the sales pressure of High-Powered H-P and big bad Beckman. Their products are good . . . but not always the best for your particular needs. So compare. Be recognized. Wear a Glorious Crusading Engineer Medal. (Now your problem is how to get one in time for the IEEE Show.)

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Try to borrow one from a friend. If that fails, come see us at Booth 2G-40. Of course we must obey the Rules of The Show and refuse to actually give you a medal . . . but . . . All of our booth staff will be wearing their own medals (loosely pinned). So if you snatch one, we won't exactly chase you down the aisles.

#### NO-SHOW?

Can't fly to New York this time? You still can get a medal. Just write us. We'll mail you a medal, and a new condensed catalog so you can earn your medal by checking specs.

Then, next time you talk to an H-P or Beckman salesman, wear your medal. You'll see grown men cry.

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COMPUTER MEASUREMENTS COMPANY IS A LEADING DESIGNER AND MANUFACTURER OF ELECTRONIC INSTRUMENTATION TO COUNT, MEASURE, AND CONTROL.

ON READER-SERVICE CARD CIRCLE 3

# Electronic Design

VOL. 15 NO.

# 5

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

MARCH 1, 1967

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Computer-aided design, microwave ICs and silicon-on-sapphire memories are main topics of discussion.
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Reader Service card inside back cover

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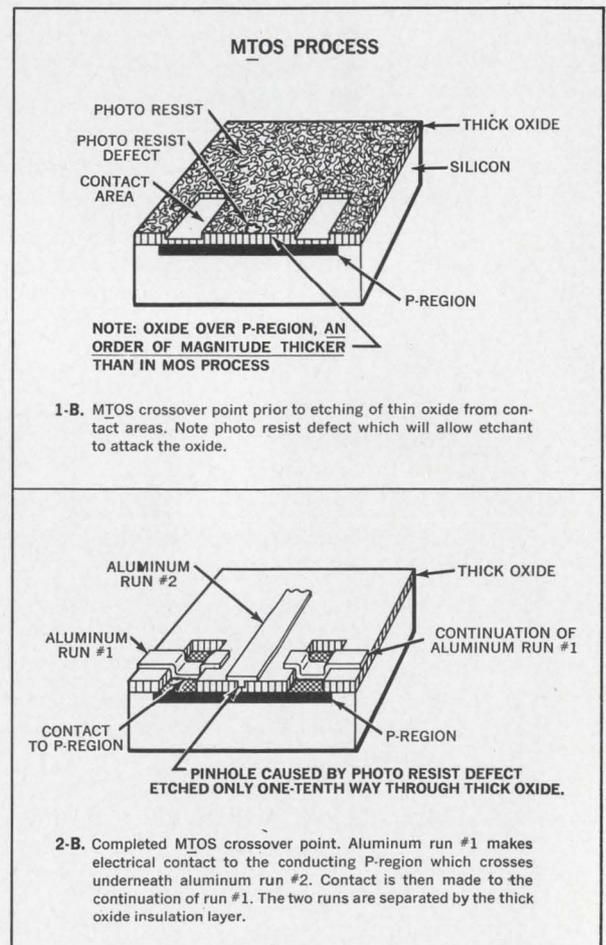
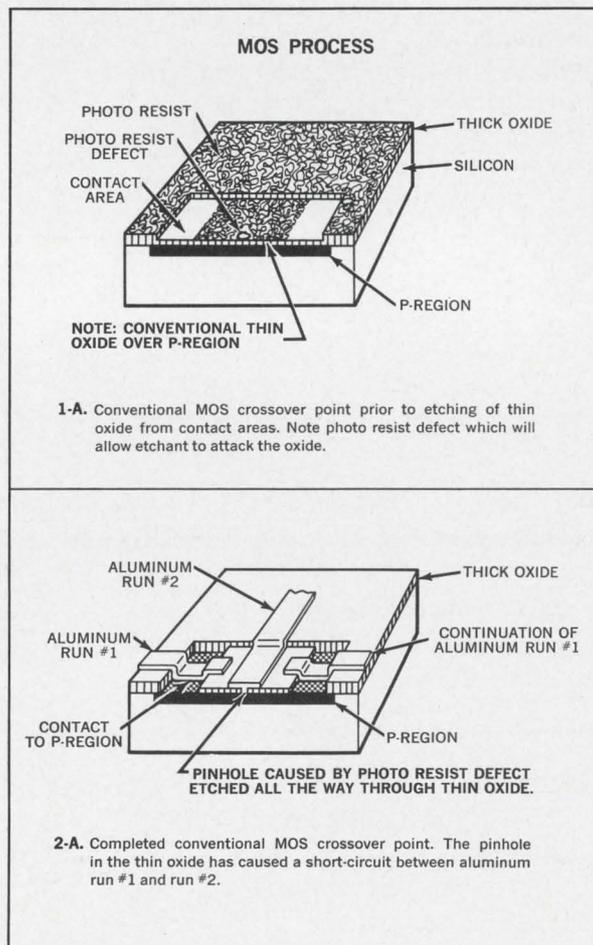
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# announcing...

An exclusive thick-oxide process that now makes possible major progress in Large Scale Integration.

With the introduction of MTOS, Metal-Oxide-Silicon technology has now moved into the second generation of its development. This breakthrough is significant because it makes realizable major progress in Large Scale Integration through reliability and cost parameters that

can now be achieved for the first time. The exclusive General Instrument MTOS (Metal-Thick-Oxide-Silicon) manufacturing process produces circuits of a substantially higher order of reliability, performance, circuit complexity and yields.



# MTOS

## Second Generation MOS Technology

MTOS is a process for the manufacture of integrated circuits in which thick oxide is grown over the entire chip, except for the gate regions. The MTOS process produces an oxide layer ten times as thick over the P-regions as any other known process employed in the

manufacture of MOS devices. This strengthened thick-oxide layer over the P-regions, and the sequence of steps used in the MTOS process, eliminate pinholes that could occur at crossover points, a major cause of failure in integrated circuits. Further, the thick oxide over the P-regions also minimizes the possibility of electrical short-circuits caused by the breakdown of the oxide resulting from a flaw in the oxide layer.

Parametric enhancement is an additional benefit accruing to the user due to the MTOS process. Crossovers occurring over the thick oxide reduce stray capacitance, thereby offering higher frequency performance and faster switching speeds.

The inherently higher yields resulting from the thick-oxide process will reduce the cost per function to the user as well as offer greater complexity per chip area.

This advance in the art of MOS processing creates not only new standards of reliability, performance, circuit complexity and product availability, but is also of prime importance to the position of leadership held by General Instrument in the technology of Large Scale Integration.

MTOS devices are in stock and immediately available from your authorized General Instrument Distributor.

Write for full information.

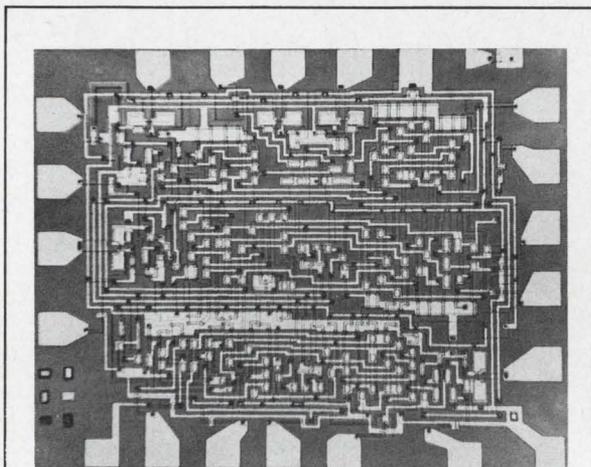


Photo above is of the MTOS Digital Differential Analyzer (MEM 5021), one example of General Instrument's LSI accomplishments (a single chip 86x70 mils contains 244 MOSFETS), and one of a complete line of MTOS ICs and single devices available from General Instrument in production quantities. Below is a listing of some of the more popular MTOS devices also available.

MEM 3050 . . . . .	Dual 25-Bit Shift Register	MEM 2008 . . . . .	Series Shunt Chopper
MEM 3021/3021B . . . . .	21-Bit Shift Register	MEM 1008 . . . . .	Dual Exclusive OR/NOT Gate
MEM 3020 . . . . .	20-Bit Shift Register	MEM 1005 . . . . .	R-S-T Flip-Flop
MEM 3016-2 . . . . .	Dual 16-Bit Shift Register	MEM 1002 . . . . .	Dual 3-Input NOR-Gate
MEM 3012 SP. . . . .	12-Bit Serial In/Parallel Out Shift Register	MEM 1000 . . . . .	Dual Full Adders
MEM 3008 PS. . . . .	8-Bit Parallel In/Serial Out Shift Register	MEM 551 . . . . .	Dual P-Channel MOSFETS
MEM 2009 . . . . .	6-Channel Multiplexer	MEM 550 . . . . .	MOSFETS
		MEM 520 . . . . .	P-Channel MOSFETS
		MEM 517/517A . . . . .	
		MEM 511 . . . . .	
		2N4353 . . . . .	



GENERAL INSTRUMENT CORPORATION  
600 WEST JOHN STREET, HICKSVILLE, L. I., NEW YORK

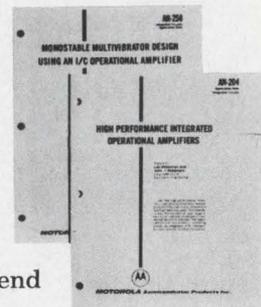
**“Who said integrated circuit Op Amps had to be expensive?”**

Now — from Motorola — you can get what we think is the *most* op amp for the *least* money. Would you believe \$8.00 (100-up) for an integrated circuit operational amplifier that provides specifications like these:

CHARACTERISTICS	MC1430G & F	MC1431G & F
Price (100-up)	\$8.00/\$10.00	\$9.50/\$11.50
Power Dissipation	150 mW	150 mW
Operating Temperature Range	0 to 75°C	0 to 75°C
Open Loop Voltage Gain $A_{vol}$ (min)	3,000	1,500
Input Impedance (typ)	15 K	600 K
Output Voltage Swing	$\pm 5$ V	$\pm 5$ V
Input Offset Voltage	2 mV	5 mV
Output Impedance	50 $\Omega$	50 $\Omega$

If your application calls for a low-frequency, limited-temperature-range op amp that can function as a summing amplifier, integrator or amplifier with operating characteristics as a function of the external feedback components, our MC1430-31 should be your best answer. Nowhere else can you get top performance for so little money!

Motorola Application Notes 204 and 258 discuss the use of integrated circuit operational amplifiers in 20 different applications — including monostable multivibrator design — a key example for our MC1430-31. Both of them can be valuable additions to your library of I/C information. Send for them today!



where the priceless ingredient is care!



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ON READER-SERVICE CARD CIRCLE 5

ELECTRONIC DESIGN 5, March 1, 1967

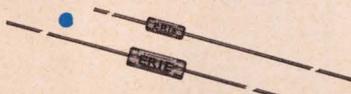
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**HERMETICALLY SEALED-IN-GLASS MONOBLOCS**



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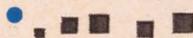
**NEW HIGH VOLTAGE MONOBLOCS**  
1400 pF. at 3 K Volts...  
in only .003 cu. in.



**NEW BUTTON-TYPE MONOBLOC FILTER-CAPACITORS**



**MONOBLOC CHIPS**  
Any SIZE and shape available



**WORLD'S MOST COMPACT TRIMMER CAPACITOR...**  
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In today's microcircuitry, Erie's unique MONOBLOC Ceramic Capacitors provide the answer to difficult packaging problems... particularly where high capacitance, demanding stability, great reliability and severe environmental conditions are deciding factors.

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Advanced Components Through Increased Volumetric Efficiency



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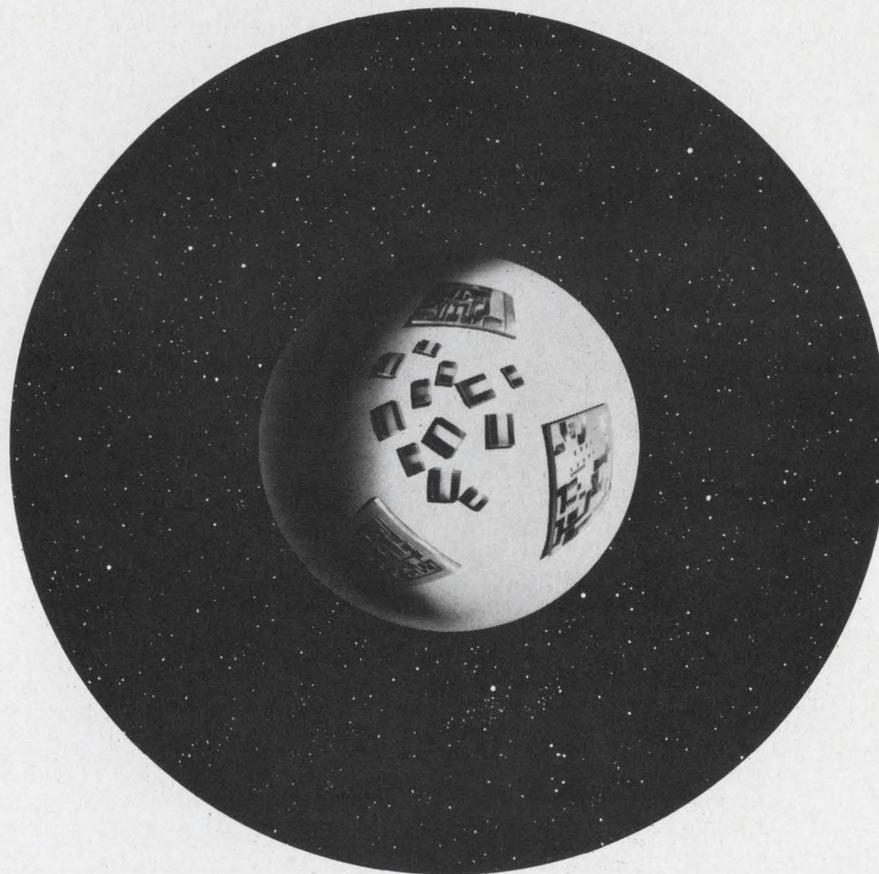
**PRODUCTS, INC.**



Erie, Pennsylvania

ON READER-SERVICE CARD CIRCLE 6

# MICROCIRCUIT CHIPS



## SPACE AGE CAPACITORS

S-CAP 100 A NEW CERAMIC CHIP CAPACITOR DESIGNED FOR THE NEW WORLD OF MICROCIRCUITS. Offering capacitance values ranging from 10 Pf through 0.22 Mf in five optional case sizes (beginning with a chip  .080 X .050 X .050) and four optional dielectrics, all utilizing proprietary method of monolithic construction, the S-Cap 100 Series gives the designer the ultimate in quality — reliability — and flexibility.

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Write today for the S-Cap 100 Technical Literature. For information pertaining to other Scionics products, ask for our General Catalog.

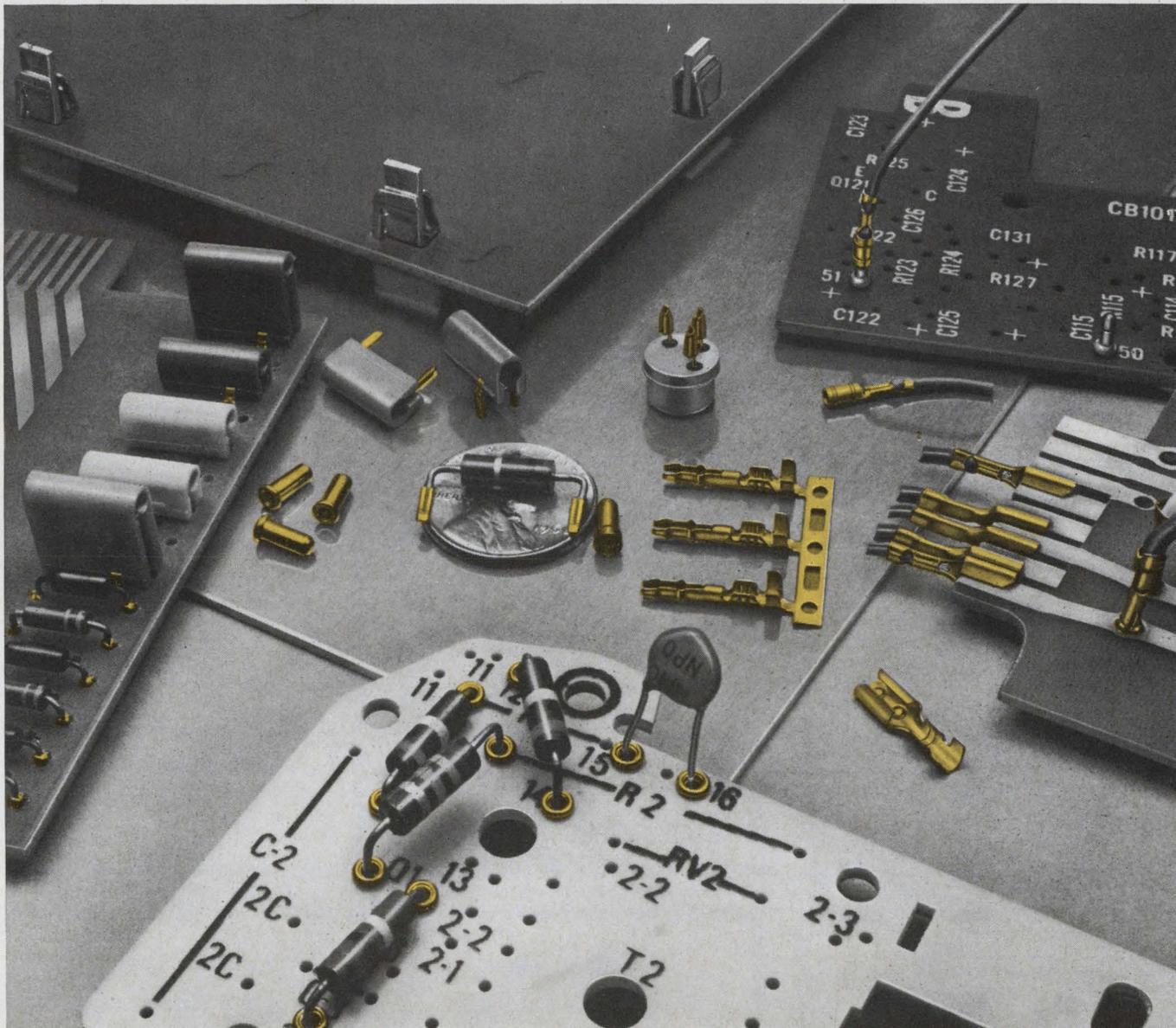
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THE SCIONICS CORPORATION — 8900 Winnetka Avenue, Northridge, California/213-341-5500/TWX 213-341-7559

**SCIONICS**<sup>®</sup>

SCIONICS — SCIENCE AND ELECTRONICS FOR INDUSTRY AND DEFENSE  
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ON READER-SERVICE CARD CIRCLE 7



## Small size. Small price. Big printed circuit convenience.

These little time-savers can help simplify, economize, and automate your printed circuit board production. Specifically designed for users of printed circuit boards, they each incorporate AMP's quarter century of development and experience in precision solderless techniques. One or more can benefit you if you use printed circuit boards.

For example, AMP-IN\* Printed Circuit Pins (A) may be attached at rates up to 4,000 an hour; snap-in design holds leads in position for easy solder dipping. With AMP's handy Test Probe Receptacles (B), test points may be provided anywhere on printed circuit boards. Color coded for quick location; double-ended probe entry. The AMP-EDGE\* Single Circuit Edge Connector (C) is a quick disconnect contact that fits an edge slot in printed circuit boards from .040" to .093" thick. Its wiping action pre-cleans board contacts. AMP's Printed Circuit Board Disconnect (D) comprises a staked pin and a receptacle which is crimped to the lead. This enables you to bring a variety of wires to a printed circuit board and to disconnect them at will.

Components are held in place during assembly with CIRCUITIP\* Terminals (E), which also pro-

mote uniform solder fillets; machine-applied at rates of 7,200 an hour. The many ways to use AMP's Reusable Component Test Receptacles (F) include testing, breadboarding, and modular connector design. One size accepts leads from .018" to .040" in diameter; eliminates soldering. The newest product for printed circuit boards is AMP's Printed Circuit Board Fastener (G), which speeds up the process of assembling a printed circuit board to a chassis and greatly aids servicing. Includes types which facilitate component mounting and power input connections radio, TV, Hi-Fi, vending, and commercial control products. Write today for full information about any of these useful printed circuit board aids. Or, let us help solve your special printed circuit problem.

\*Trademark of AMP INCORPORATED

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**INCORPORATED**  
 Harrisburg, Pennsylvania

A-MP\* products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • Mexico • Spain • West Germany

ON READER-SERVICE CARD CIRCLE 8

# Did you know Sprague makes a wide variety of components for industrial control equipment?

## TRIGATE<sup>\*</sup> PULSE TRANSFORMERS



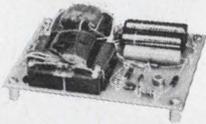
for low-cost SCR triggering  
Balanced pulse characteristics. Increased energy transfer efficiency. Minimum saturation effect permits increased pulse widths. Fast pulse rise time. Increased current capability prevents SCR di/dt failure.

ASK FOR BULLETIN 40,003

<sup>\*</sup>Trademark

ON READER-SERVICE CIRCLE 891

## FAST RISE TIME SCR GATE DRIVES

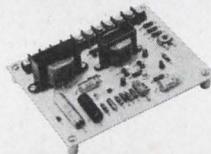


Rise time less than 1  $\mu$ S. Full 180° phase shift for inductive load. Fail-safe— if contact signal is lost, SCR gate pulse is instantly suppressed.

ASK FOR BULLETIN 85,525

ON READER-SERVICE CIRCLE 892

## PROPORTIONAL TEMPERATURE CONTROLS

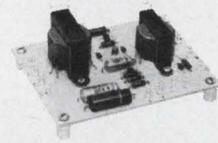


Feature temperature control to  $\pm 1/2^\circ$ . Conductive only when anode voltage goes through Zero. EMI-free. Also available for on-off applications.

ASK FOR BULLETIN 89,000

ON READER-SERVICE CIRCLE 893

## ZERO VOLTAGE SWITCHES



Low-cost EMI-free device for use as on-off switch, proportional temperature control, motor speed control, circuit breaker, etc. Controls resistive or inductive loads. No mechanical contacts to wear, no points to burn.

ASK FOR BULLETIN 87,500

ON READER-SERVICE CIRCLE 894

## MOLDED-CASE TRIGGER TRANSFORMERS



Molded construction for superior humidity resistance. Rated for operation where line voltages range up to 550 volts a-c. Decreased coupling capacitance reduces likelihood of false triggering by line transients.

ASK FOR BULLETIN 40,004

ON READER-SERVICE CIRCLE 895

## COMMUTATING CAPACITORS for SCRs



High capacitance, capable of delivering large peak currents with fast rise time at high repetition rates. Low inductance, low dissipation factor. Available with paper, metallized paper, film, or metallized film dielectrics.

ASK FOR BULLETIN 2875

ON READER-SERVICE CIRCLE 896

## CLORINOL<sup>®</sup> CAPACITORS for A-C Applications



Askarel impregnant has low power factor, high dielectric constant, high dielectric strength. Drawn metal cases— no soldered seams to leak. Available in ratings to 660 V, 60 cy a-c.

ASK FOR BULLETIN 4500C

ON READER-SERVICE CIRCLE 897

For additional data, write Technical Literature Service, Sprague Electric Co., 347 Marshall St., North Adams, Mass. 01247, indicating the Engineering Bulletins in which you are interested.

### SPRAGUE COMPONENTS

CAPACITORS  
TRANSISTORS  
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THIN-FILM MICROCIRCUITS  
455C-6150

PULSE TRANSFORMERS  
INTERFERENCE FILTERS  
PULSE-FORMING NETWORKS  
TOROIDAL INDUCTORS  
ELECTRIC WAVE FILTERS

CERAMIC-BASE PRINTED NETWORKS  
PACKAGED COMPONENT ASSEMBLIES  
BOBBIN and TAPE WOUND MAGNETIC CORES  
SILICON RECTIFIER GATE CONTROLS  
FUNCTIONAL DIGITAL CIRCUITS

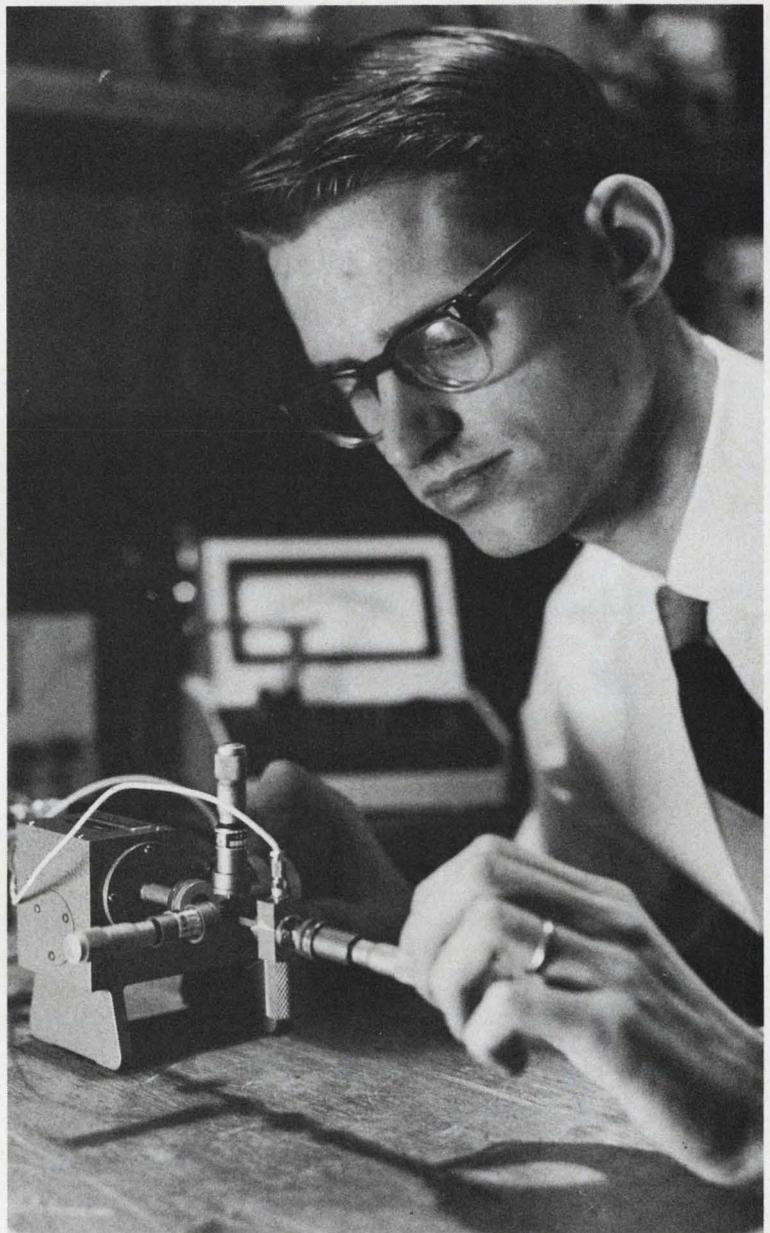
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THE MARK OF RELIABILITY

<sup>\*</sup>Sprague and <sup>®</sup> are registered trademarks of the Sprague Electric Co.

# News



**One-man consoles ease seamen's tasks** aboard automated freighters. Page 26



**LSA-operated GaAs diode was a highlight** in papers read at the Solid-State Circuits Conference. Page 17

## Also in this section:

**CRT is still the leader** among large-scale display devices. Page 33

**Phototransducer converts narrow laser pulses** into oscilloscope patterns. Page 37

**Electronic beam welds computer memories** on the assembly line. Page 42

**News Scope**, Page 13 . . . **Washington Report**, Page 31 . . . **Editorial**, Page 55

# You Can Get All These Microcircuits from Sprague Electric:

## \*SERIES SU300, LU300 UTILOGIC\*



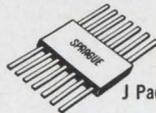
K Package

For use in commercial, industrial, ground support applications. Available in two operating temperature ranges,  $-20^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ , and  $+10^{\circ}\text{C}$  to  $+55^{\circ}\text{C}$ . Propagation delay of 15 to 40 nanoseconds.

\*Trademark of Signetics Corp.

ON READER-SERVICE CIRCLE 883

## \*SERIES SE400, NE400 LOW POWER LOGIC



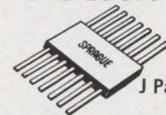
J Package

Operating temperature ranges:  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ , and  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ . For use in Aerospace and other applications where low power drain is required. Optimized speed, noise margin.

ON READER-SERVICE CIRCLE 884

## \*SERIES SE100, NE100, US700 DTL LOGIC

(Signetics CS700)



J Package

Eighteen functions in two operating temperature ranges:  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  and  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ . 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 SE500 LINEAR AMPLIFIERS

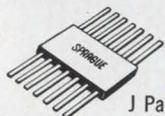


K Package

Operating temperature range:  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ . Two linear circuits available in 10-lead low silhouette TO-5 case. SE501K is a video amplifier, SE505K is a general purpose differential amplifier.

ON READER-SERVICE CIRCLE 885

## \*SERIES SE800, NE800 TTL LOGIC

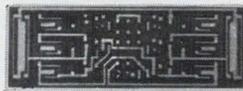


J Package

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

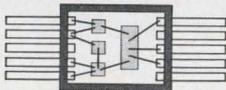


TO-5 Case

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# News Scope

## Computer makers strive to cure software ills

Delays in putting some new-generation computers into full operation have been occasioned by difficulties in preparing advanced-system software (programs). Such shortcomings have brought no joy to the hardware (computer) manufacturers, who have managed to avoid similar snags.

Spokesmen for several smaller firms are sympathetic toward the plight of the giants, Control Data Corp., General Electric and IBM. They note that in this fast-paced field it is inevitable that situations will occur where the hardware will momentarily outstrip the programs. But they add that these problems can be "solved in time," provided that the companies are willing to meet the costs.

The difficulties stem from the manufacturers' attempts to produce software for advanced processing control. These programs include those that optimize computer operation by managing the processor, memory and files, and minimizing delays; and those that permit multiple access for as many as 30 users.

These system programs relate to the over-all ability of the machine to organize and use its own re-

sources. Problems with them, therefore, affect all users of the computer. Troubles with applications programs, on the other hand, affect only the tasks to which they refer.

Most advanced, general-purpose digital computers now have many more system-control or supervisory programs than earlier models.

A spokesman for Control Data Corp., Minneapolis, admitted that his company had experienced difficulties with software for large-scale processing more than a year ago. But he said, "we have now solved most of our problems."

"We still have problems in matching our software with our advanced hardware," a spokesman for GE's Phoenix, Ariz., computer facility commented. He said that the problems related to the operating supervisor of just one family of GE's 600 series machines. He also stated that recent layoffs of computer engineers and assemblers were in no way associated with the software issue; they were a result of what he termed "administrative adjustment."

An IBM official reported that IBM is expending considerable effort to solve problems with the advanced programming of its latest 360

series machines.

"It is often necessary to complete a machine and work with it to prove out the programing," he said. This is not unusual in view of the complexity of the programs and their requirements.

"Unfortunately," he said, "these problems are visible to customers and individuals outside of the computer industry, but represent only a fraction of the total computer manufacturing effort."

## Viet war spurs military R&D

The Vietnam war has given the Pentagon an unparalleled opportunity for intensive research into the special problems of limited, guerrilla-type combat (see "Electronics needed for guerrilla warfare," ED 18, Aug. 2, 1966, pp. 36-47). For the past two years, R&D efforts have ranged wide, from adapting commercial products such as Teflon to military uses, to producing special matériel to withstand a jungle climate and terrain.

One of the biggest projects has been development of offensive and defensive devices to locate the enemy. *The Army Digest* reports: "A wide range of sensors—infrared, radar, gamma rays, seismic, acoustic and others—are being investigated for target acquisition from both ground and air."

Some devices installed in aircraft are so sensitive that they can detect the heat of enemy campfire, even through a jungle canopy. Others can hear the sound of a footfall transmitted through the ground.

An infrared "fence" to protect ground installations is under study. It would sound an alarm as soon as a body intercepted an infrared beam projected at a photoelectric cell. Very fine wires strung between control boxes the size of a cigarette package perform the same function when broken by an intruder.

## Computers may store legal precedent

Computers may revolutionize the practice of law, according to an educator from the University of Southern California.

Vaughn C. Ball, professor of law in USC's Law Center, foresees the day when a lawyer will write his



Computers are suffering from software troubles.

# News Scope

CONTINUED

own computer program, transmit it from his office directly to a computer center, and have an answer to a legal question in seconds. The fantastic increase in legal literature, rising at the rate of 70 million words a year, will make the use of computers for information retrieval an absolute necessity, says Ball.

The problems of developing a computer system are manifold. Ball anticipates resistance to the idea of using computers from the legal profession itself. There may likewise be difficulties in securing funds to meet the tremendous development costs and in resolving disputes that may arise over the use of copyrighted literature.

A basic problem in developing a computer program is that of indexing legal material. Ball is examining three methods at present.

The first is a "semantic code" system in which documents are represented by key words. This system could be considered a mechanization of the kind of indexing presently used in books and printed-matter search aids.

In the "point of law" system, cases are analyzed and the points of law in them identified. The user looks over a master list of points and calls for materials under an appropriate heading.

The "statistical" or "probabilistic" system is based on the theory that a user can identify a document if he knew what words occur in it with highest frequency.

Ball is conducting a research program of computerized simulations of judicial decisions under a National Science Foundation grant.

## You can feel it in your bones

Piezoelectricity may be the secret of growth, hearing and feeling in living creatures, according to two New York scientists.

They report that many tissues, such as human skin and bone, display a piezoelectric effect under stress. Dr. Morris Shamos, chairman of the department of physics at New York University, and Dr. Le-

roy S. Lavine, chief of orthopedic surgery at Downstate Medical Center, Brooklyn, N.Y., suggest that piezoelectricity may be a property of "most, if not all, tissues in the plant and animal kingdoms."

In an account of their experiments in the British scientific journal *Nature*, they say that pressure put on the ends or sides of the long fibers of protein molecules in bone caused nothing electrical to happen. But a diagonal stress generated a negative charge on the inside, compressed curve of the fiber, and a positive charge on the outside of the bend. The attraction of bone-building materials to the negatively charged side might explain the tendency of a bone under stress to grow straight, they propose.

They found that human skin, in which connective tissue fibers run in two directions, showed a dual piezoelectric effect—one for each fiber direction. The same effect was also observed in callus and cartilage in a series of experiments that were the first to demonstrate piezoelectricity in soft tissue. Other researchers have already measured it in hair, wool and cellulose.

Drs. Shamos and Lavine hypothesize that piezoelectric impulses might be what are transmitted through the nervous system to the brain as a sense of touch. And the vibration of the hair cells in the cochlea—of the inner ear by sound waves may generate the impulses that the brain perceives as sound.

## Comsat asks for plans for new satellite stations

Communications Satellite Corp. (Comsat) has asked for proposals for architectural and engineering services for three new earth stations for satellite communications.

These high-capacity stations, to be erected in California, West Virginia and Puerto Rico, would handle all types of commercial communications by satellite—multichannel telephone, television, high-speed data, telegraph and so forth.

The exact sites for the stations, which will bring to six the number operating in the U.S., have not yet been chosen. They will resemble the one at Brewster Flat, Wash. The other two that are already functional are at Andover, Me., and Paumotu, Hawaii.

Comsat's request to 35 design-engineering firms to submit proposals by Feb. 20 was filed with the Federal Communications Commission. Construction of the stations is slated for completion by 1968.

The stations will tie in with the global satellite network that is due to be operational by next year to provide communications between all the United States and the Caribbean, South America, Africa, Europe and Asia.

## Hidden mikes protect schools against vandals

A new warning system that can differentiate between normal and suspicious noises protects schools against vandals. A significant noise causes a light to flash on a control panel installed, say, in police headquarters. The policeman can press a button and listen in to the particular area and determine whether a patrol car should be sent.

The system, built by the Dukane Corp.'s Communications Systems Div. in St. Charles, Ill., functions by turning classroom loudspeakers into sensitive microphones.

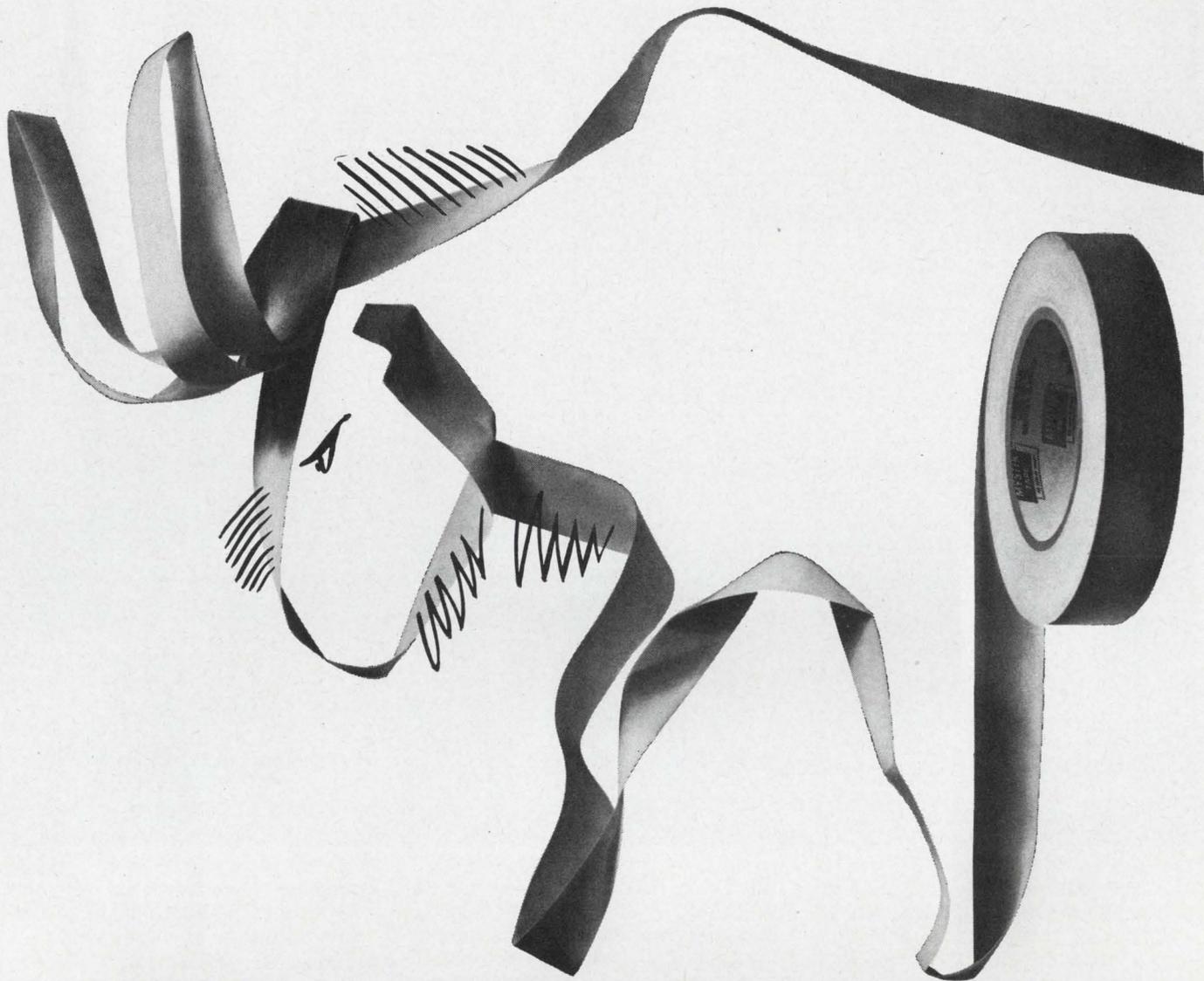
A lock-out circuit prevents false alarms from such things as thunder, overflying jets, or noisy heating or air-conditioning systems. An electronic evaluator computes the frequency and continuity of any alarm impulse before activating the control panel. Only steady noise of several seconds' duration or three alarm impulses within a preset time-span trigger the warning light.

## Systems research center set up by IBM in Europe

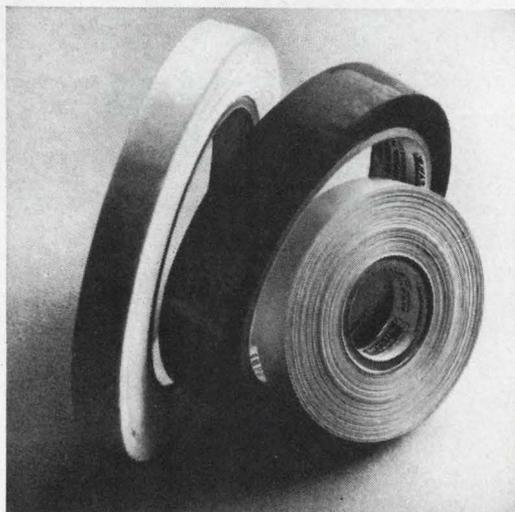
IBM World Trade Corp. has established in Geneva an institute for advanced computer research and education at postgraduate professional levels.

The IBM European Systems Research Institute will promote studies of computer theory, and offer research opportunities and courses in advanced mathematics and the design and operation of computers.

About 80 top European IBM systems engineers will be accepted this year by the institute, which will have its own permanent teaching staff as well as visiting lecturer from European universities and IBM foundations in the U.S.



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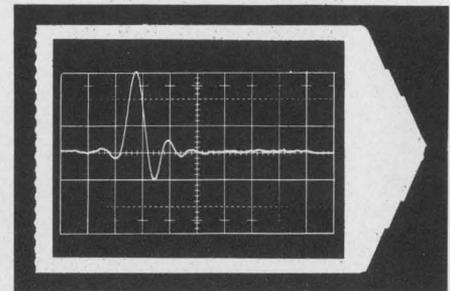
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Typical Photograph of Crosscorrelation Function of Input and Output Signals of Complex Passive Network Driven by White Noise.

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# New technology keys Solid-State Circuits show

## Computer-aided design, a new type of GaAs diode and silicon-on-sapphire memories spark interest

Ralph Dobriner  
Chief News Editor

Progress in microwave solid-state technology and computer-aided design highlighted this year's International Solid-State Circuits Conference held recently in Philadelphia. In-depth coverage of the many panel sessions will appear in the March 15 issue. In summary, the outstanding developments described at the conference were:

- A 1.5-to-6-GHz unilateral varactor quadrupler that eliminates the need for isolators.

- A new mode of operating gallium arsenide semiconductors at peak pulse powers approaching those of klystrons.

- A technique for designing by computer.

- A silicon-on-sapphire complementary MOS memory.

When varactor multiplier stages are cascaded, isolators are often needed to improve circuit stability. The use of unilateral multipliers eliminates the need for such isolators.

A 1.5-to-6-GHz varactor quadrupler has been developed that uses a unilateral circuit concept for even-order harmonic generators to

achieve low sensitivity to output mismatch. A balanced diode-pair hybrid-circuit configuration reduces circuit complexity and circuit loss.

The multiplier, reported by R. D. Brooks and J. W. Gewartowski of Bell Telephone Laboratories, delivers 2.5 watts at 50% efficiency and has a maximum input  $v_{swr}$  of 1.6 for all conditions of load impedance.

The quadrupler efficiency is diode-limited, not circuit-limited, with only 0.5 dB attributable to circuit losses out of its 3.0-dB conversion loss.

The basic concept of the circuit is shown in the illustration where the 1.5-GHz input signal is split into two equal amplitude signals,  $90^\circ$  out of phase, by means of a 3-dB,  $90^\circ$  hybrid. As long as the output arms of the hybrid are terminated in identical impedances, reflected power ends up in the matched termination on the conjugate port of the hybrid. Thus, the input always looks matched. The two equal amplitude signals are fed into two identical quadrupler arms.

Since the phase angle of the 6-GHz output signal is four times the phase angle of the input signal, the two quadrupler arms have output phase angles of  $0^\circ$  and  $360^\circ$  and the

outputs may be combined directly.

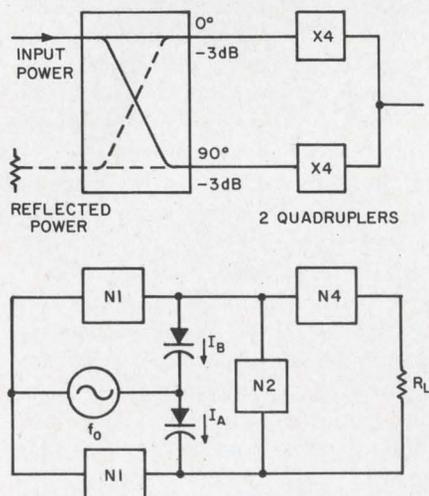
Each quadrupler arm uses two varactor diodes in a balanced hybrid circuit. As shown in the schematic of a center-fed balanced-pair 1-2-4 quadrupler, the input network  $N1$  provides a match between the diodes and the source at 1.5 GHz and blocks all other frequencies.

The advantage of the balanced diode-pair, according to the authors, is that it separates the even and odd harmonics by means of symmetry without filters. Only the unwanted even harmonics in the output and the unwanted odd harmonics in the input need be blocked.

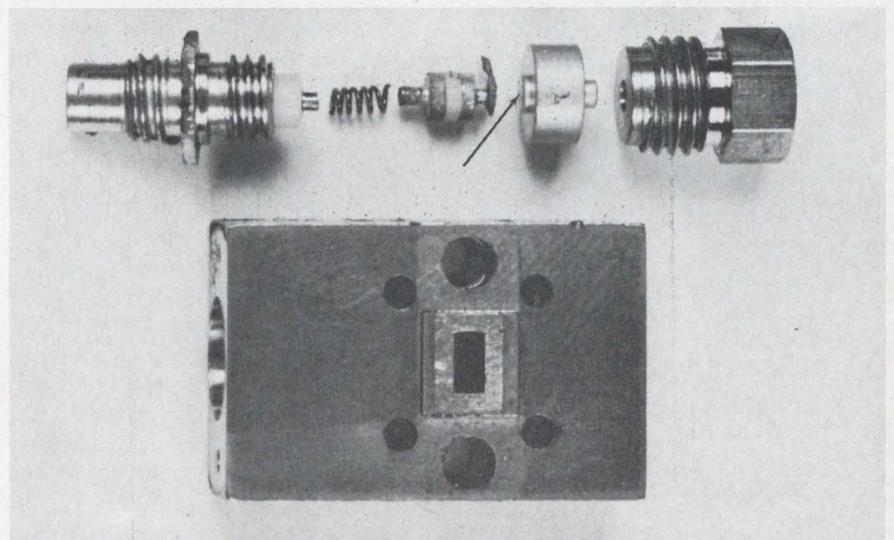
### Gunn effect boosted by LSA

A new mode of oscillation in n-type bulk gallium arsenide was reported by Bell Laboratory scientists (see "New bulk-effect device offers 400 kW in X-band," ED 3, Feb. 1, 1967, p. 14). These diodes can now be made to operate at frequencies in the microwave and millimeter wavelength regions and at peak pulse power levels heretofore achieved only by klystrons.

Called limited-space charge accumulation (LSA), the new mode of diode oscillation was reported by Bell scientist John Copeland. In LSA operation, the accumulation of electrons that form in Gunn-effect



Unilateral quadrupler circuit (above) contains a center-fed balanced-pair quadrupler in each arm. Each is fed from a  $90^\circ$ , 3-dB hybrid.



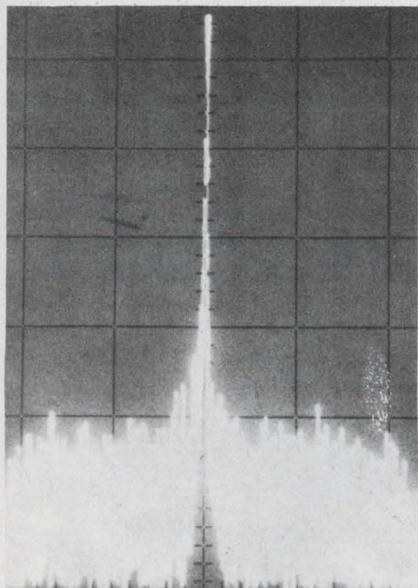
LSA waveguide circuit—less waveguide short and E-H tuner—is shown with inner components. Arrow shows GaAs mounted on heat sink.

(solid-state circuits, *continued*)

diodes is suppressed. The operating frequency generated in Gunn-effect diodes depends on the thickness of the device, since a space charge takes some finite time to travel through the material from one contact to another. Suppression of the space charge makes the frequency independent of transit time and hence of the GaAs's thickness. The frequency is thus determined primarily by an external resonant circuit or cavity. Because frequency is not related to device thickness, the diodes could conceivably be made hundreds of times thicker than the Gunn-effect devices; so a proportionately higher voltage can be placed across the material and power output can be considerably greater at all frequencies. LSAs have operated with cross sections 20 times larger than those of Gunn devices of equal frequency. The waveguide cavity dimensions determine oscillator frequency, which can vary 20% to 50% for a given crystal doping.

Copeland reported that he has achieved 33 watts of pulsed power at 10 GHz and 0.7 watts with 0.7% efficiency at 51 GHz. A continuous output of 20 mW has been obtained at 88 GHz with 2% efficiency, he said.

The scientist noted that the LSA diode operating at 51 GHz was at least as quiet as Gunn and IMPATT



Spectrum of 51-GHz LSA oscillator shows noise level about 40 dB down. This diode is about as quiet as a klystron source.

diodes (see spectrum photo).

Copeland said that LSA diodes operating at 50.4 GHz have been successfully incorporated into an experimental millimeter guided-wave PCM transmission system.

Cornell University, which has also investigated LSA operation, reports having achieved 33-W, 0.5- $\mu$ s pulses at 10 GHz from a GaAs diode.

### Computer designs circuits

As in many other areas of technology, computer-aided design is now invading the microwave circuit designer's discipline.

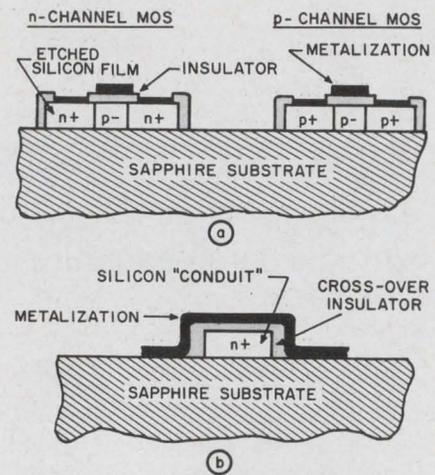
A technique that uses a computer to design, analyze and optimize high-frequency linear amplifiers was described by H. F. Cooke and G. J. Policky of Texas Instruments Inc., Dallas.

The authors discussed programs that were used to design a 2.2 GHz transistor amplifier that was fabricated on alumina. Lengths of shorted, open and series microstrip transmission lines were used for the tuning and matching elements. They also described the design of a video amplifier circuit that was breadboarded on Teflon fiberglass board using 0.25-W resistors and ceramic capacitors.

In the design procedure, an accurate representation of the active device is obtained by measuring small-signal and noise parameters at a number of points—12 in this case—over the frequency band of interest. The parameters are fitted with a least-squares curve-fit versus frequency, so that an empirical representation of the passive circuit elements can be represented by equations, equivalent circuits or measured parameters. These elements may be either fixed or variable.

For computation purposes, all circuit and device elements are converted into either Y- or ABCD-matrix representation with appropriate voltage or current noise generators. The elements are then arranged into a suitable circuit configuration. Values are given to the fixed circuit elements and bounds and constraints are given to the variable circuit elements.

The technique is especially useful, say the authors, in the design of broad-band amplifiers where de-



Isolation between complementary transistors is achieved by selective removal of silicon (a). The same technique is used to leave interconnection conduits for crossovers.

vice parameters change significantly over the frequency range used.

The computer technique is now being expanded, so that several different quantities such as noise figure, parameter sensitivity, gain, etc. may be simultaneously optimized.

They noted that at microwave frequencies there are some fairly straight-forward geometrical relationships between circuit parameters and the physical circuit itself. Thus, they contemplate using a computer to make a complete thin-film microstrip circuit layer.

### Complementary-pair memory

The advantages of the complementary MOS approach to designing computer memories have been known for some time. They are low quiescent power dissipation, loose device parameter tolerances and high-speed operation.

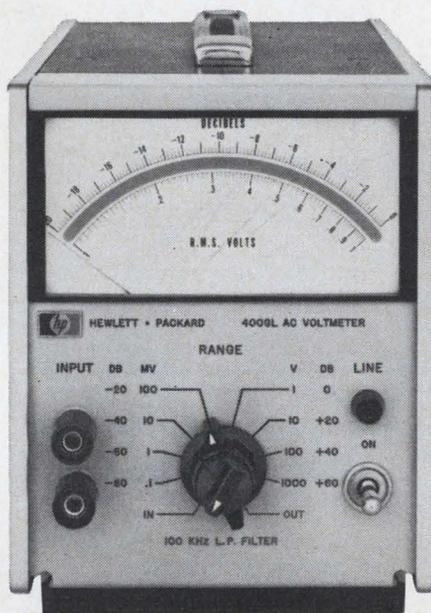
The practical development of such integrated memory systems has been limited by difficulties in isolating the n- and p-channel transistors on a bulk silicon substrate while maintaining high speed of operation.

Scientists at RCA Laboratories, Princeton, N. J., reported development of a 10-transistor, complementary-MOS, one-bit memory cell using thin-film single-crystal silicon films deposited on a sapphire substrate.

RCA scientists J. F. Allison, J. R. Burns and F. P. Heiman stated that the cell exhibited a complementary-pair delay of less than 12 ns with a

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CL34, CL35 85 C polarized plain-foil  
CL36, CL37 85 C non-polarized plain-foil

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## RECTANGULAR TANTALUM CAPACITORS TO MIL-C-3965C



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## NEWS

(solid-state circuits, continued)

stand-by power dissipation of 10  $\mu$ W. The cells have been integrated into a 9-bit word on an 80-mil-square chip.

As shown in the figure, isolation between units is achieved by selectively removing the silicon between n- and p- channel transistors. The same technique is used to leave isolated bars of silicon within the circuit to be used as interconnection conduits for cross-overs.

The p-channel transistors are of the deep-depletion type requiring the starting material to be high-resistivity p-type (1 to 2 microns thick). The n-channel units are of the standard n<sup>+</sup> pn<sup>+</sup>-junction design. All diffusions are done by the standard oxide-masked window diffusion technique and are driven into the silicon until the diffusion front reaches the sapphire surface. This reduces the drain-to-channel capacitance to only that of the diffusion side wall, thus increasing the operating speed of the circuit.

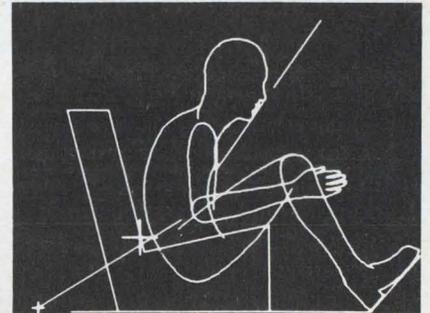
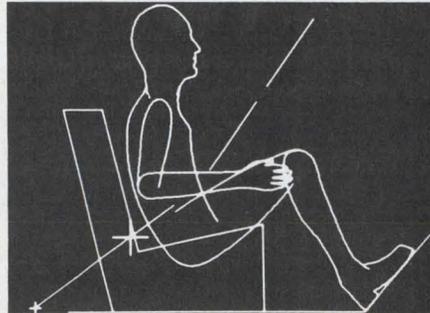
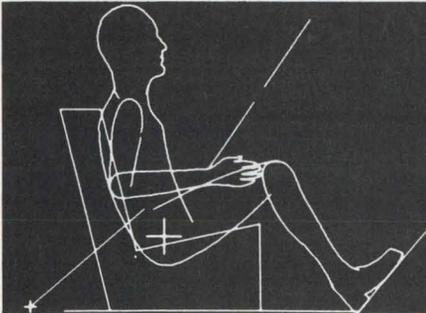
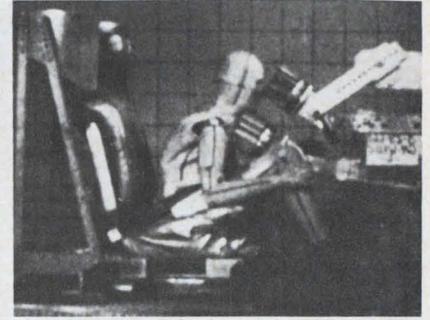
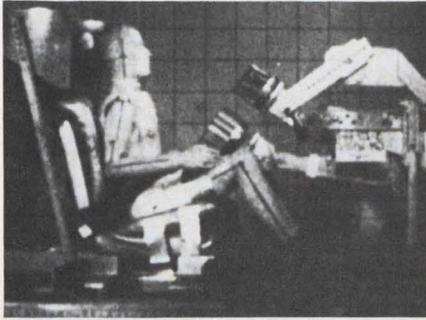
The threshold voltages for the transistors are: +1.0 volt for the n-type and -0.5 volt for the p-type. The oxide thickness is 1000Å. Only one layer of metalization is required for the circuit as crossover conduits were formed during the n<sup>+</sup>diffusion.

The scientists reported stand-by currents are 1 to 10  $\mu$ A, giving a total power dissipation of 10 to 100  $\mu$ W per storage cell. Improved technology and reduction in transistor size are expected to reduce the pair delay to less than 5 ns and the stand-by power dissipation to less than 1  $\mu$ W per bit, they said.

More complex arrays can be fabricated by the same techniques as that for the single-bit cell, it was noted. The scientists fabricated a nine-bit word formed from nine interconnected single-bit cells. The stand-by power dissipation for the entire 90-transistor circuit was 90  $\mu$ W. The 80-by-80-mil chip can be packaged in a conventional 14-lead flat pack.

For a complete digest of technical papers, send \$6 to H. G. Sparks, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa. 19104. ■ ■

# Computer simulates effects of head-on car crash



Computer representation of an auto collision enables scientists to reconstruct what happens immediately after impact. From the left the driver's body at 0.002 seconds, 0.054 seconds and 0.100 seconds after the crash.

Computers have been used to simulate the performance of aircraft, missiles, even the outcome of hypothetical wars. The Cornell Aeronautical Laboratory has found still another use: it has programmed an IBM 7044 to determine the effects of a head-on auto crash on a driver.

The simulation, developed by the university's Aeronautical Laboratory, uses an 11-degree-of-freedom nonlinear mathematical model of a human dummy, a belt-restraining setup, surfaces in the auto's interior that are likely to be hit in a

crash and a test-sled compartment. System response is calculated from recordings of the forces, accelerations, velocities and displacements at various points. In addition detailed energy distribution within the system is calculated from the data.

The technique is being used to evaluate the efficiency of lap and shoulder harnesses in a frontal impact.

The mathematical model in the computer simulation is based on a general subroutine for calculating nonlinear load deflection for each

of the major system forces (restraint belts, contacted interior surfaces and cart-stopping devices). The load-deflection relationship for increasing load is represented by general polynomial functions of deflection and velocity of deflection. For decreasing load, the load deflection is represented by a parabolic function of deflection.

The test program is being supported by an injury-control program of the U. S. Public Health Service. Side and rear collisions can also be stimulated. ■ ■

## ILLIAC IV development goes to Burroughs and Illinois U.

The Advanced Research Projects Agency (ARPA) of the Dept. of Defense has selected the Burroughs Corp. to perform the engineering development of an experimental parallel-processing computer to be known as ILLIAC IV.

Data-processing speeds from 500 to 700 times greater than that of present computers and over 100 times faster than any computer known to be in development are claimed for the new computer. The basic reason given for this large increase in computational speed is

parallel processing. This form of processing involves the simultaneous performance of computational operations by a number of arithmetic units tied in to a single computer, unlike current computers which use a single arithmetic unit under control of a single control unit.

### LSI will be used

ILLIAC IV will have four control units, interacting with more than 250 arithmetic and data

units. Using this arrangement with a 4-MHz clock rate, the computer will be capable of performing one billion calculations per second.

### New software concepts needed

The major consideration in realizing the ILLIAC IV's speed of operation is development of software. New software techniques will be required to permit the partitioning or breakdown of problems into separate pieces that can

**(ILLIAC IV, continued)**

be handled simultaneously by the various arithmetic processing units.

While hardware development will be done at Burroughs' Defense, Space and Special Systems Group in Paoli, Pa., software development will be handled by the project's prime contractor, the University of Illinois. There the ILLIAC IV project will be directed by Prof. Daniel Slotnick.

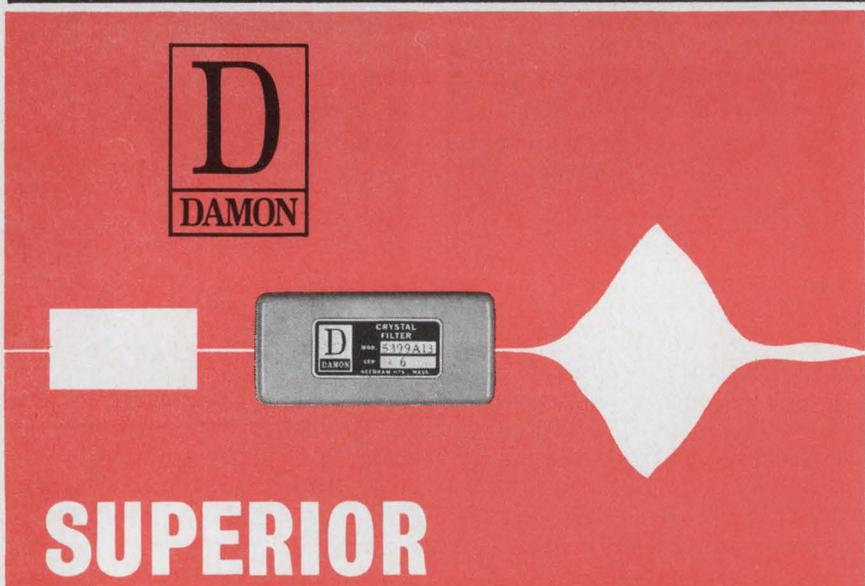
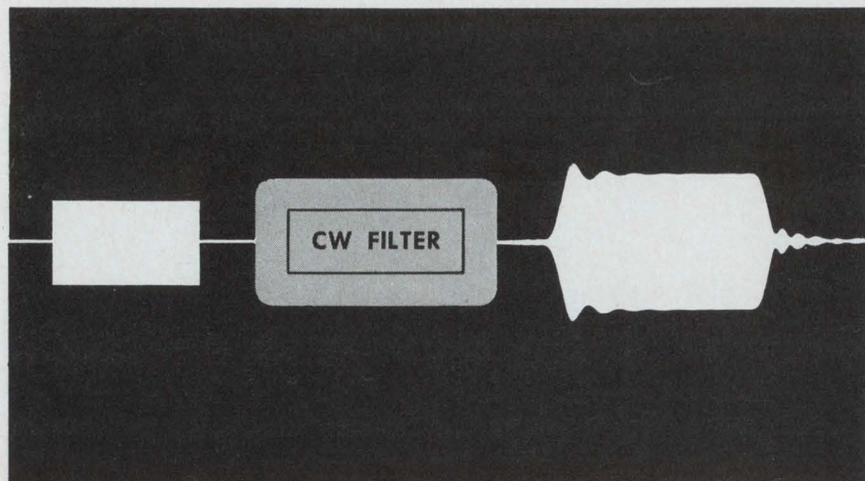
According to Burroughs' president Ray W. MacDonald, "We consider ILLIAC IV to be the most significant undertaking in the field of electronic computer design in the past several years. The techniques which will be employed, including the use of large-scale arrays of integrated circuits combined with extremely high-speed, thin-film memory storage, will have important effects upon the design of systems of the future. The large-scale arrays of integrated circuits will be developed by Texas Instruments, Inc."

According to one industry source "ILLIAC IV may be to large-scale integration what Minuteman was to integrated circuits." The use of LSI can help provide an improvement in system speed by shortening the propagation delays that were experienced with earlier forms of integrated circuits, which required a larger number of interconnections.

**Complex simulation feasible**

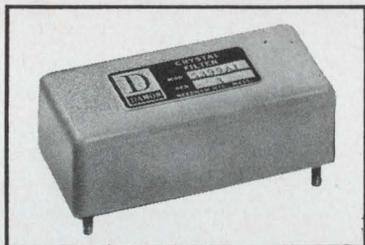
Some proposed applications of the ILLIAC IV are the simulation of the atmosphere for weather prediction, the modeling of large economic systems, and the simulation of large and extremely complex military-logistics problems.

The use of large-scale integrated circuits (see "LSI chips away at computer hardware costs," ED 28, Dec. 6, 1966, pp. 17, 18) will enable hardware designers to build complete program segments on a single chip, thus reducing the need for special-purpose software. The use of LSI is also thought by some industry sources to be the big difference between existing third-generation computers and future fourth-generation machines. ■ ■



# SUPERIOR PULSE RESPONSE

with Matched Crystal  
Filters by DAMON



Matched Crystal Filter Model 5399A  
Center Frequency: Every 10 KHz  
from 5000 KHz to 5150 KHz  
Size: 3" L x 1" H x 7/16" W

Optimization of the signal-to-noise ratio of a pulse receiver is now possible with the Damon Matched Crystal Filter.

The illustration, above, compares the response of a conventional crystal filter with that of a Damon Matched Crystal Filter. The Damon Matched Crystal Filter not only minimizes overshoot and ringing, but since the filter is matched to the transform of the input pulse, maximum signal-to-noise ratio is also achieved.

Solutions to complex pulse modulation crystal filter designs cannot be "picked from a chart". Consultations between circuit designers and Damon engineers are the best route to proper filter selection. As a starter, may we invite you to write for our Technical Bulletin on Matched Crystal Filters. Damon Engineering, Inc., 240 Highland Avenue, Needham Hts., Mass. 02194 (617) 449-0800.

## DAMON

# Introducing... RCA Solid-State GaAs Optical Devices



- Injection Lasers with 1- to 50-W outputs at *room temperature* and threshold currents *below 15A*
- Miniature IR Diode Emitter with focused light output

	TA2628 laser	TA2930 laser	TA7008 IR diode
Peak Power Output (min) @ 27°C	1 W @ 30 A	50 W @ 30 A	0.6 mW @ 0.1 A
Threshold Current	15 A	15 A	120 mA
Output Wavelength	9050 Å ±50	9050 Å ±50	9100 Å ±50
Line Width	5—10 Å	60—100 Å	600 Å ±50
Operating Temp.	-196 to 50°C	-196 to 50°C	-73 to 85°C
Pulse Width/Repetition Rate	0.2 μs/1000 pps	0.2 μs/1000 pps	.CW

RCA's wealth of semiconductor experience introduces a new dimension of practicality to solid-state lasers and light diodes. Available now in sampling quantities, each of these optical devices represents an important new tool for the field of electro-optics.

Check these performance benefits of RCA's TA2628 and TA2930\* laser diodes: *Practical Power Outputs*—conservative peak power rating from 1 to 50 W at room temperature.

*Practical Pulse Current*—lasing action begins with threshold currents below 15 A.

*Practical Circuit Usage*—Inexpensive semiconductor pulse circuits can be used without cryogenic hardware.

*Practical Size*—hermetically sealed in modified TO-5 and TO-46 packages.

RCA's new laser diodes are ready now for your evaluation in applications such as secure communications, intrusion alarms, traffic control, instrumentation, ranging and field illumination.

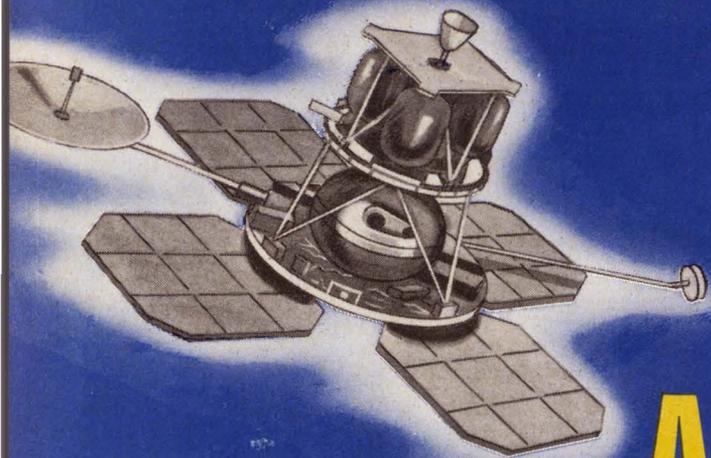
And RCA's new TA7008 IR emitter is equally exciting. Featuring a miniature but highly efficient parabolic reflection system, this tiny device provides a new source of focused light for applications such as card-reading.

Call your RCA representative today for more information on RCA's new family of developmental optical devices. For data sheets and application note on laser power supplies, write RCA Commercial Engineering, Section IC3-1 Harrison, N J

RCA Electronic Components and Devices



The Most Trusted Name in Electronics

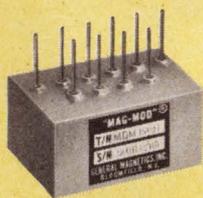


**G/M COMPONENTS** have proven to be superior in function and reliability of operation in thousands of military, space and commercial applications, including aircraft automatic flight control, guidance, weapon systems, fire control, missile and space vehicle flight and stabilization control, pressure-volume-temperature control of gases and liquids. They conform to MIL-T-27 and MIL-E-5400 specifications, and provide a ready solution to problems involving solid state—integrated or micro circuit—analog computer design. Call or write for Bulletins.

# Analog Computing

## Magnetic Division Modules

ACCURACY OF 1% OR BETTER!

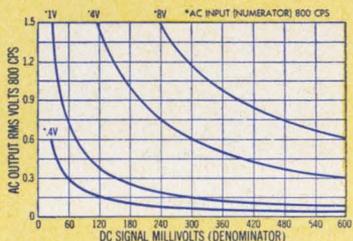


**FEATURES:**

- Micro-miniature Size
- Completely Solid State
- Low Power Consumption
- Wide Numerator and Denominator Ranges

REQUEST BULLETIN MM 110

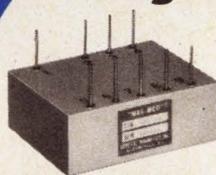
These Analog Division Modules employ a concept which eliminates high gain operational amplifiers and logarithmic circuitry used in electronic dividers. The result is fewer components, excellent stability, micro-miniature size, lower cost. The combination of magnetic and semiconductor circuitry results in analog division accuracy of 1% or better.



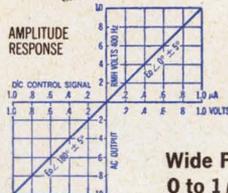
NANO AMP LEVEL

## Current Sensing Magnetic Modulator

ULTRA LOW LEVEL—HIGH STABILITY!



This G/M extremely low level signal current magnetic modulator operates from 0 to  $\pm 1 \mu\text{a}$  DC full scale with a frequency response of 0 to 100 cps minimum for a carrier excitation of 400 cycles. Excellent zero point, amplitude and phase angle stability with respect to line voltage, frequency and temperature range.

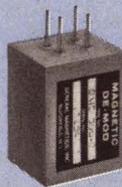


- Wide Frequency Response (over 100 cps)
- 0 to  $1 \mu\text{a}$  DC Full Scale Input
- Drift: Less than 10 Nanoamps referred to Input Terminal
- Input Resistance 1 Megohm
- Complete Solid State Magnetic Rugged, Unlimited Life

**FEATURES:**

## Magnetic Demodulators

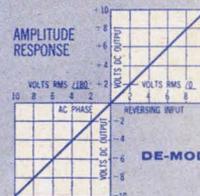
HIGH RELIABILITY—SMALL SIZE!



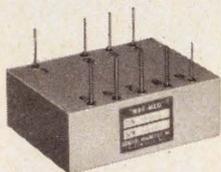
The new G/M Magnetic Demodulator is a solid state circuit for converting phase reversing AC signal voltages into phase detected polarity reversing DC voltages. The amplitude and polarity of the DC output are directly proportional to the phase and amplitude of the AC signal. High reference impedance results in very small reference power requirements.

**FEATURES:**

- Output as High as  $\pm 10 \text{ v. DC}$  in Present Units
- Very Low DC Offset Null Voltages (As low as 0.1% of full scale)
- Operation Over Wide Environmental Conditions
- Completely Solid State—No Moving Parts



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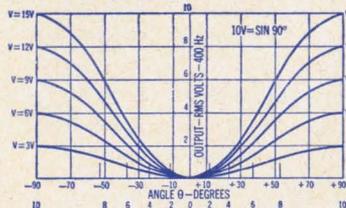
**$E_o = V \sin^2 \theta$**

EQUATION SOLUTION  
ACCURACY—2% fs

A micro magnetic multiplier and squaring block assembled with appropriate semiconductor-transfer gain to solve the indicated expression. Micro miniature, solid state microblock design features high accuracy, extremely stable operation through the application of micro magnetic stages in cascade circuitry.

**FEATURES:**

- Operates over Wide Environmental Ranges
- Unlimited Life, Low Milliwatt Power Level
- Wide Frequency Range
- Wide Dynamic Computing Range



REQUEST DESCRIPTIVE LITERATURE

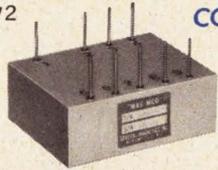
THERE IS NO SUBSTITUTE FOR RELIABILITY



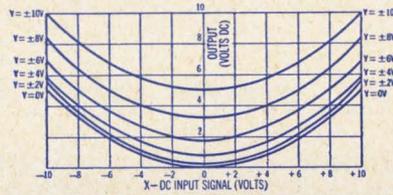
Circuit and Fundamental Principles of Magnetic Modulators are covered by U. S. Pat. No. 2758162

$$E_o = x^2 + y^2$$

The algebraic sum of two magnetic squaring blocks feeding a switching Demodulator, delivers the indicated DC analog output. Input and output data may be either AC or DC, depending on system requirements.



### COMPLETELY SOLID STATE



Extremely Broad Range of Voltage, Current Impedance Levels may be handled

Computing Accuracy to 3% f.s. over temperature range of -55°C to +85°C

Completely Solid State

Low Milliwatt Power Requirements

# with Magnetic Microblocks

## Micro "Mag Mods"®

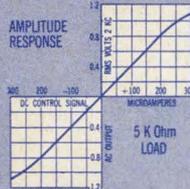
SINE WAVE OUTPUT, NO TUNED FILTERS!



"MAG MODS"® provide four quadrant operation, extreme stability with negligible change of phase, gain and zero position over a wide temperature range. Design is simple, featherweight and rugged—with no vacuum tubes, semiconductors or moving parts to limit life. These Modulators are

available in micro, miniaturized and standard sizes depending on requirements, and feature an essentially drift-free, wide-band width circuit with superior phase and gain stability.

- Greatest Reliability, Unlimited Life
- Repeatable Data over Years of Continuous, Unattended Operation
- High Shock and Vibration Proof
- Low Milliwatt Power Consumption
- Wide Band Width
- Clean Sine Wave Output without Resonant Filtering



REQUEST BULLETIN MM 101X

## Analog Voltage Multiplier

WORLD'S SMALLEST, MOST RELIABLE!



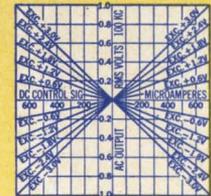
Available as small as 0.1 cubic inch and weighing as little as 0.1 ounce, Micro Magnetic Multipliers feature extreme stability with negligible change of product over wide temperature range, high shock and vibration proof. Band-width may be extended into the kilocycle range. Low milliwatt power consumption; four quadrant operation.

### FEATURES:

Four Quadrant Multiplication or Squaring Monolithic Micro Circuit Block for Analog Voltage Multiplying of DC/AC Voltages

Addition, Subtraction, Multiplication, Division and Extracting a Root of Many Voltage Variables may be Handled by one G/M Magnetic Microblock

Product Accuracy of up to 0.5% of Full Scale, with very slight Derating over a Wide Temperature Range



REQUEST BULLETIN MM 109

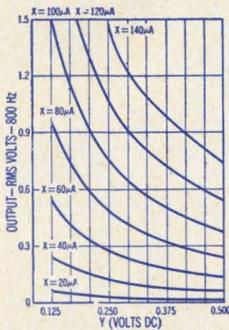
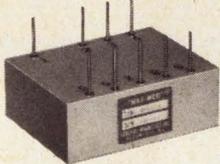
$$E_o = \frac{x^2}{y}$$

EQUATION SOLUTION ACCURACY—2% fs

The micro magnetic squaring block and division module are assembled with semi-conductor operational amplifier for the solution of the indicated equation. Completely magnetic, solid state microblocks constitute the most reliable, space-saving analog voltage computing circuits available.

- Equation solution accuracy—2% fs
- Low Milliwatt Power Consumption
- Completely Solid State Magnetics
- Wide Dynamic Range

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BLOOMFIELD, NEW JERSEY 07003

Telephone: (201) 743-2700

# Electronics eases work on the high seas

## Automation above and below decks is permitting operation of cargo ships from one-man consoles

Neil Sclater  
East Coast Editor

Solid-state components are destined to change the seaman's life on U.S. merchant ships from one of tedious tasks on deck and in the engine room to placid dial-watching and button-pushing.

Automated electronic controls for maneuvering vessels, monitoring and controlling the power plants, and handling cargo are being incorporated in new ship designs. Gener-

al Electric and Westinghouse Electric are among the major producers of the new systems.

The latest system uses solid-state electronics to permit one man to control the propeller speed from the bridge. In the engine room, the same system has an information display that enables one man to monitor from a single console the ship's propulsion machinery and such utility services as electric power and water evaporation.

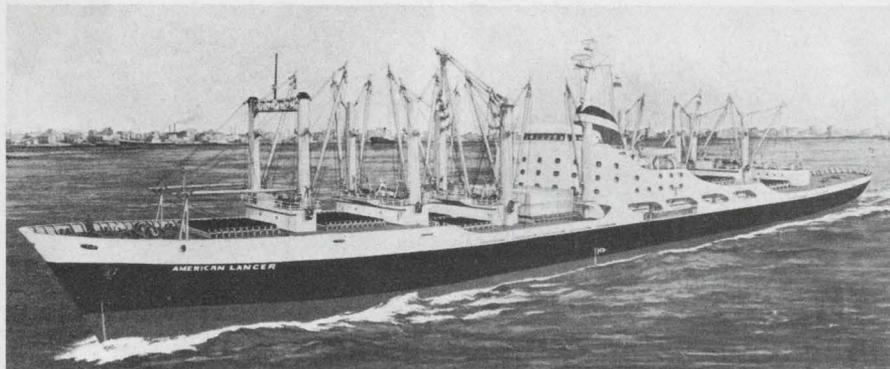
The system, built by GE's Industry Control Dept. of Salem, Va., includes program controls, subloop controls, data-logging and communication between the bridge and engine room.

A United States Lines freighter launched last month at the Sun Shipbuilding and Drydock Yard in Camden, N. J., is being equipped with the GE propulsion-control system, as well as with other automated systems to control climate in cargo holds, to detect and extinguish fires and to improve navigation.

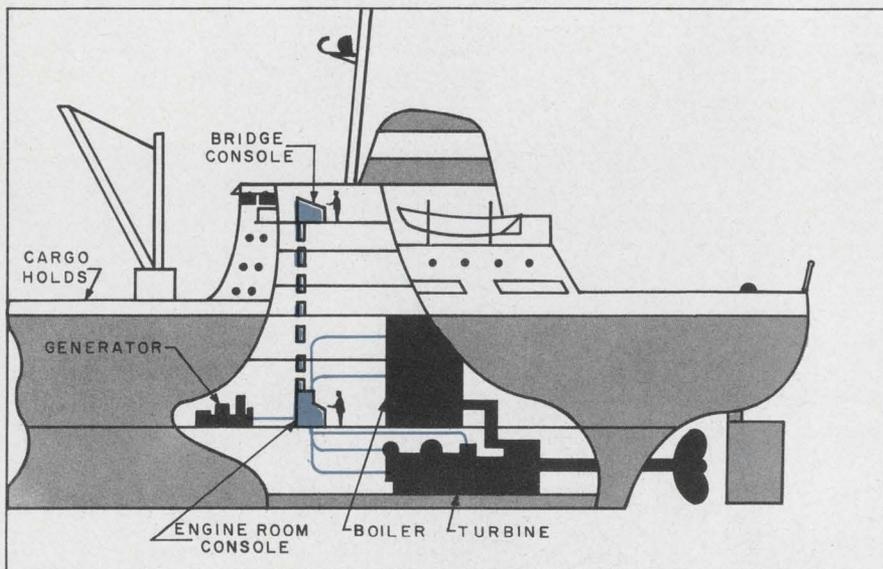
The ship, the 11,400-gross-ton American Lancer, is an example of the newest trend toward automation in merchantmen.

Lancer's propulsion-control system is a second-generation version, improved with all-solid-state components. Previous versions, which used vacuum tubes and cannot perform as many functions, are now installed on five U.S. Lines vessels.

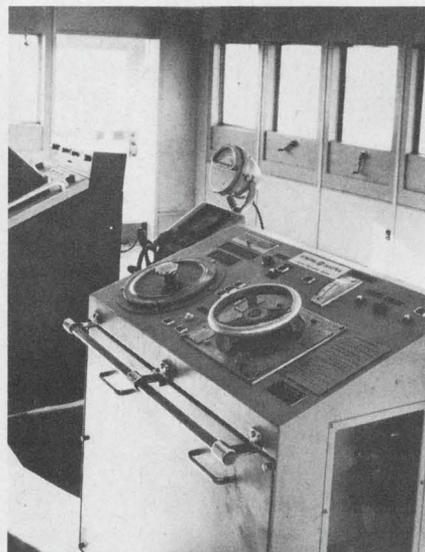
Printed-wiring boards in the solid-state engine-room console contain logic elements that are grouped in modular racks in building-block fashion. Each module performs a single function, such as amplification and switching for sub-



Artist's view of the American Lancer, recently launched automated cargo ship. The vessel will have a propulsion-control system that makes use of solid-state logic modules that can withstand the rough, damp sea conditions.



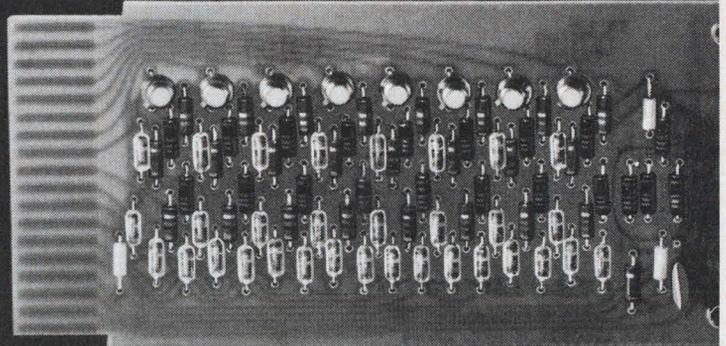
Centralized control of ship's power plant is maintained from two points: the bridge and engine-room consoles. Dotted line is the main interconnection between consoles. Solid lines indicate loops to sensors and actuators.



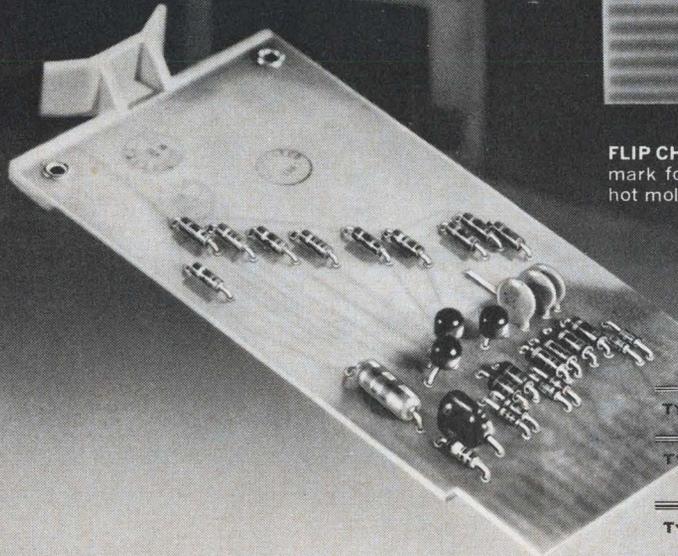
Bridge console in General Electric system allows complete control of the ship's propeller speed from "full ahead" to "full astern."

"When we use A-B hot molded resistors instead of some other make, it's one less component we have to worry about"

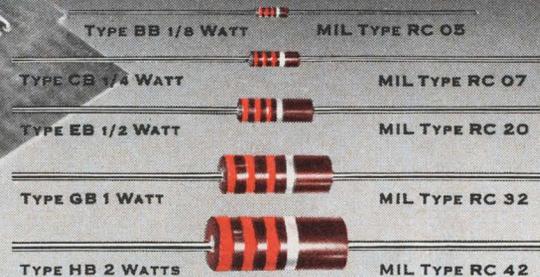
Digital Equipment Corporation



**FLIP CHIP T.M. Modules**—The Digital Equipment Corporation trademark for a new kind of digital system module uses Allen-Bradley hot molded resistors exclusively.



Digital Equipment Corporation's PDP-8 programmed data processor, in which these modules are used, is a compact general purpose digital computer with a high speed, random-access, magnetic-core memory for engineering, scientific, and educational applications.



**HOT MOLDED FIXED RESISTORS** are available in all standard EIA and MIL-R-11 resistance values and tolerances, and can usually also be furnished in values above and below standard limits. Shown actual size.

■ Allen-Bradley hot molded resistors have established such a consistently superior performance record over the years that Digital Equipment Corporation uses them exclusively in their computers—with no substitutes permitted under any circumstances!

While Allen-Bradley quality is the number one reason for this standardization, Digital reports that *excellent service* from Allen-Bradley is an advantage of vital importance to them, too. For example: "Recent expansion of FLIP CHIP production to meet the demand for PDP-7 and PDP-8 computers quadrupled our component needs. With Allen-Bradley's help there wasn't a single hitch in the production speedup."

The unvarying quality of Allen-Bradley resistors—million after million, year in and year out—results from an *exclusive* hot molding process. The precision automatic

equipment developed and used only by Allen-Bradley produces such uniform properties that long term resistor performance can be accurately predicted. Please note, Allen-Bradley hot molded resistors have never been known to fail catastrophically in service.

For complete specifications on Allen-Bradley hot molded fixed and variable resistors, please write for Technical Bulletin 5050: Allen-Bradley Co., 1344 S. Second Street, Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Ave., New York, N.Y., U.S.A. 10017.



**ALLEN-BRADLEY**

QUALITY ELECTRONIC COMPONENTS

ON READER-SERVICE CARD CIRCLE 17

**(ship automation, continued)**

loop control. Silicon transistors and diodes are reported to permit operation at ambient temperatures from 32° to 131° F.

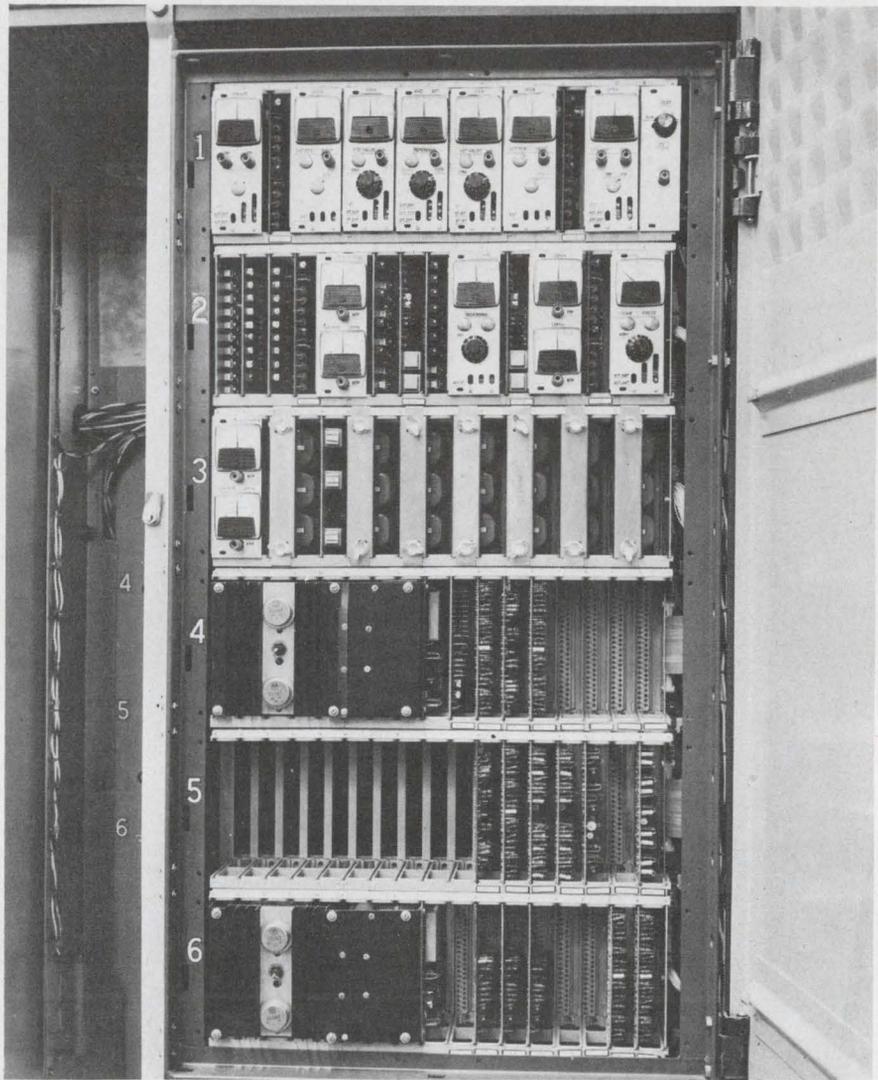
The modules are coated for protection against the sea air (relative humidity as high as 100 per cent) and need be cooled only by forced air instead of separate air-conditioning, as the earlier systems required.

The engine-room console has three sections: a data logger, utility-services control, and propulsion and boiler control. Information for the watch stander is displayed in several forms: continuous or demand, monitor and alarm, and logged data on a typewriter.

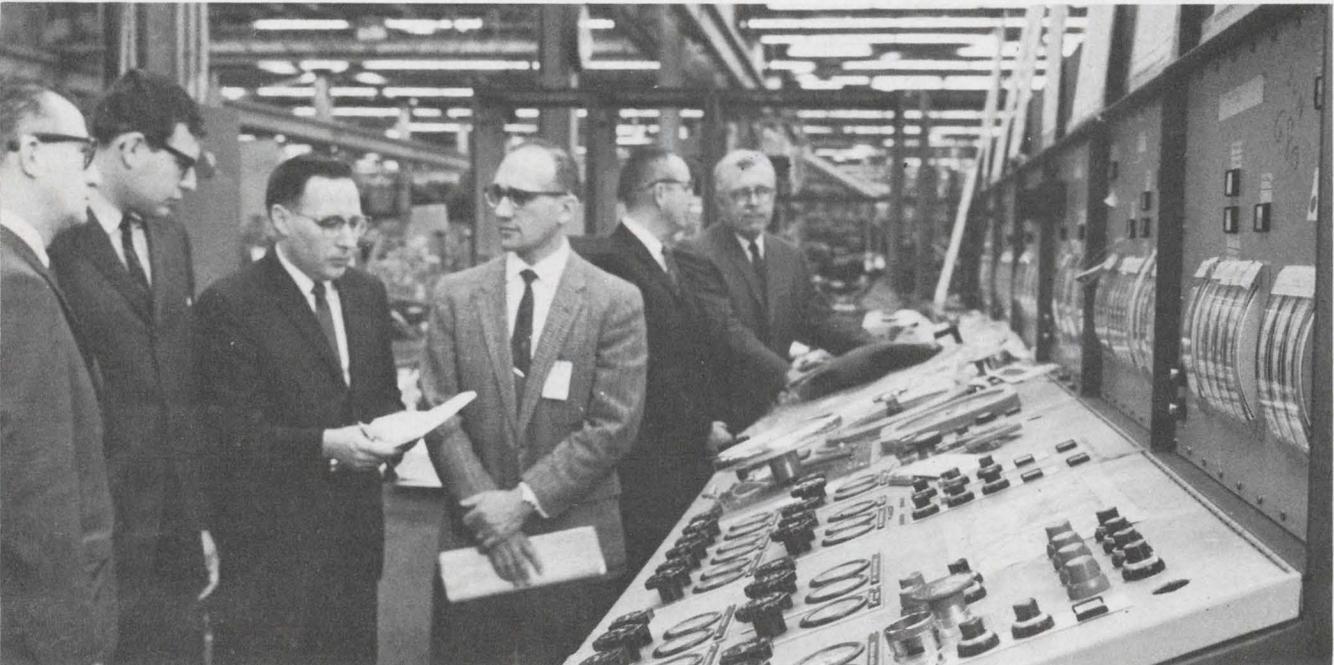
The bridge console contains only essential displays and a wheel that communicates the propeller-speed changes to the engine room.

Westinghouse Electric Corp.'s marine systems engineering group at East Pittsburgh, Pa., has also designed and built a solid-state engine-room control system. It has been installed in the 11,500-gross-ton freighter *Louise Lykes*, operated by the Lykes Bros. Steamship Co.

Savings in manpower and operating expenses are inherent with the automated systems. GE estimates that its system "can pay for itself in 1.6 to 3.8 years." ■ ■

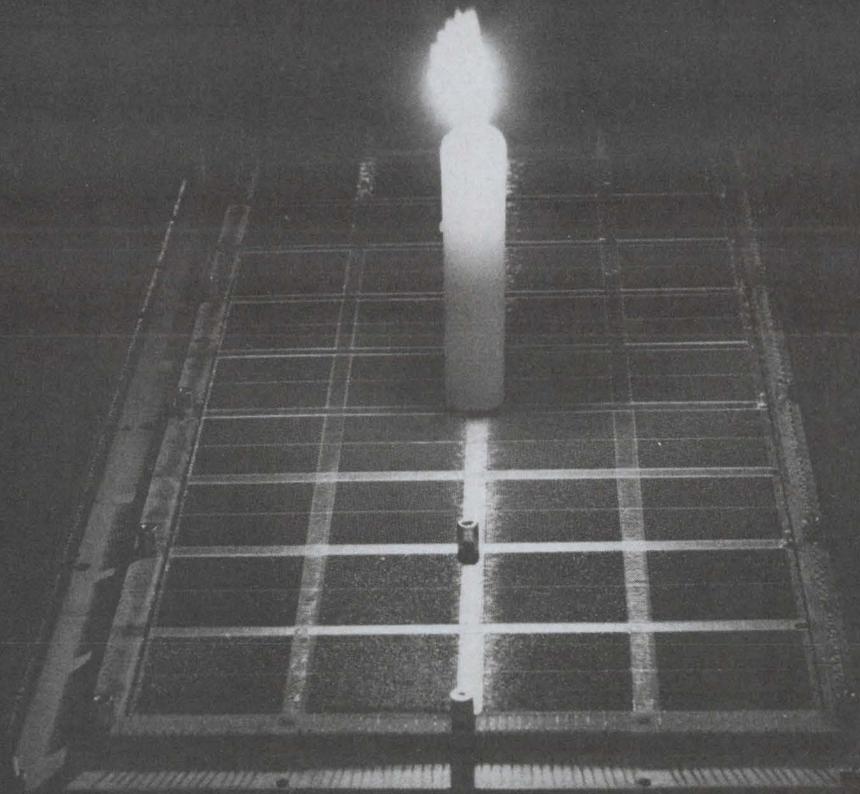


Solid-state control components, as they appear at the back of the engine-room console, are attached to plug-in printed-circuit boards.



Engine-room console that will be installed in the American Lancer has three sections: data logging, ship's utility-

services control, and propulsion and boiler control. It is shown at the GE factory after completing tests.



**in a memory system somewhere, one of our  
2½ D stacks is celebrating its first birthday**

After we shipped that one, we started delivering stacks at the rate of nearly one a day. Several hundred to date. Capacities ranged from 4,096 to 16,384 words of 8 to 25 bits. Cycle times went from 900 to 650 nanoseconds. Some were off-the-shelf designs, some slightly modified.

All had wide operating margins and low system noise.

But one of the most important specs was reliability. Redundant reliability whereby one design technique or assembly procedure enhanced the other. For example, we rimmed the drive circuitry around the edge of the stack so we could use short connectors. By doing this, the internal stack connections were reduced by 80% which

greatly improved the Mean Time Between Failure. Then one more thing — with the drive lines so short, the operational speed was extremely dependable.

With a brand new design, that first birthday is very very significant. Infant mortality has plagued many an engineer. Now we're confident any one of our stacks could be around for a golden anniversary.

There's a new four-page brochure waiting to be requested. It has all the specs. Write for Litpak 2E.

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# SEMICONDUCTORS

NEW IDEAS IN APPLICATION AND DESIGN

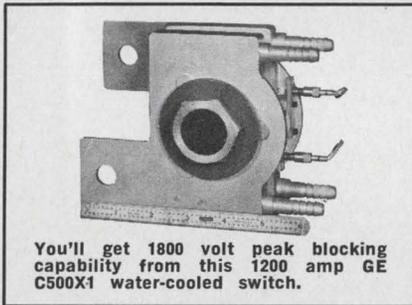
## ■ PROVEN PERFORMER FOR HIGH POWER SWITCHING: GE C500X1 WATER-COOLED SWITCH

Even welding locomotives doesn't tax the high power capability of these SCR's.

For seven months one GE C500X1 water-cooled switch has been in use at a large locomotive plant. It operates at 900 amperes RMS and 480 volts, with an on-time of 1.5 seconds and a 25% duty cycle for resistance welding.

The same plant has been using a second C500X1 for five months and expects to install more of them in the future.

C500X1's are also now in use for automotive welding. Other possible applications include particle accelerator power supplies, primary transformer control, static switching, and control of large lighting loads. (Three C500X1's could theoretically control all the lighting in a 60,000-seat stadium.) The C500X1 is rated at 1200 amps



You'll get 1800 volt peak blocking capability from this 1200 amp GE C500X1 water-cooled switch.

RMS with peak blocking capability to 1800 volts in both directions. Surge ratings are 4000 amperes peak for ten cycles and 7000 amperes for one cycle. The device can be used directly in 440 or 550 volt a-c service. Circle number 811.

These are just a few examples of General Electric's total electronic capability. For more information on all GE semiconductor products, call your GE engineer/salesman or distributor. Or write to Section 220-53, General Electric Company, Schenectady, New York. In Canada: Canadian General Electric, 189 Dufferin St., Toronto, Ont. Export: Electronic Components Sales, IGE Export Division, 159 Madison Ave., New York, N.Y., USA.

## Lots of new application ideas at GE's IEEE seminars

New application ideas for both standard and exotic semiconductors—ideas that can enhance your solid-state circuitry—will be presented at GE's Semiconductor Products Department IEEE seminars on March 21 at the Barbizon-Plaza Hotel Theater, New York City.

The morning session, titled "Innovations for Industrial Semiconductor Circuits," starts at 9 a.m. and features these subjects and speakers:

### The complementary unijunction . . .

Bob Muth discusses new IC fabrication techniques and characteristics of this ultra-stable threshold for timers and oscillators.

### Tunnel Diodes revisited . . .

Rick Spofford introduces the first truly low-cost planar tunnel diode.

### Opto-electronics . . .

Dick Stasior examines the principles and applications of lasers, light emitting diodes, detectors, light-activated SCR's, and SCS's.

### Sophisticated functions using GE's newest p'astic semiconductors . . .

Joe Byerly presents some of the new, low-cost circuit approaches now possible with advanced plastic encapsulated semiconductors.

The afternoon seminar (1:30), "Semiconductor Control and Power Conversion Applications," features:

### The widening wor'd of the fast recovery rectifier diode . . .

John Hey discusses the unique advantages of fast recovery diodes for both low and high frequency power conversion equipment.

### Design/application assistance case histories . . .

Tom Penkalski uses actual cases to illustrate symptoms, analysis, and solutions of semiconductor application problems.

### Increased current ratings from PRESS PAK semiconductors . . .

Bernie Jalbert shows how new mounting methods increase power handling capability without increasing pellet size.

### Primary phase control of transformer coupled loads . . .

Forest Golden examines trigger circuit and transformer requirements in three phase applications.

### Economy control circuits and modules for light industrial and consumer applications . . .

Andy Adem discusses a variety of low-cost reliable motor and temperature controls, and power switching circuit modules.

### Low-cost precision power control module using zero-voltage switching . . .

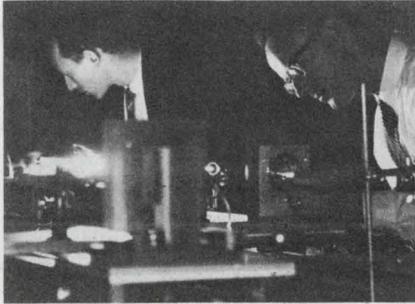
Jim Galloway presents a compact control with 3600 watt capability for a variety of open and closed loop control systems.

You'll also be interested in GE's computer time sharing demonstration. Just feed simple design or specification problems into one of the four consoles at the exhibit and the pre-programmed computer will recommend a solution.

All this and more is waiting for you from GE's Semiconductor Products Department at the IEEE show.

# GENERAL ELECTRIC

DOD double-take on laser weapons?



### Laser weaponry due for Pentagon speedup

Dr. Peter Franken, the new deputy director of the Pentagon's Advanced Research Projects Agency (ARPA), is a laser specialist—a fact that Pentagon officials seem to make much of. As with chemical and biological warfare in the late Fifties and early Sixties, the Defense Dept.'s attitude toward public discussion of laser weaponry has been on and off. Now it's back on, thanks largely to Soviet antimissile-missile deployment. Recently, nearly all Washington statements managed to work in something to the effect that our missiles could overcome Soviet antimissiles. Now the same sorts of statements indicate that we might be able to deploy a laser-based A-ICBM system better than the Soviet system. The hope is that the U.S.S.R. will stop its construction.

Dr. Franken was moved into the ARPA after his predecessor, Dr. Robert Frosch, had served but a short time. Frosch is now Navy Assistant Secretary for R&D. Franken, of the University of Michigan, was a member of a research group that made some of the first laser studies and later helped to develop lasers for communications, measuring and weapons-aiming. He has served on the optical masers group of the Director of Defense Research and Engineering Advisory Group on Electron Devices.

### FBI crime center is only a start

The FBI's System/360-based National Crime Information Center is only the beginning of a much larger center that the Government expects to have in a few years. Right now, one of the two IBM Systems/360 model 40s is simply a back-up available in case of the other computer's failure. Most of the time it is kept busy on routine FBI administrative work. For the present pilot program, the system stores 40,000 stolen vehicle reports, 20,000 records of stolen license tags, 20,000 reports on firearms, 5000 reports on

# Washington Report

S. DAVID PURSGLOVE,  
WASHINGTON EDITOR

other stolen articles, and 10,000 records of wanted persons. Vehicle and stolen-articles records run up to 125 characters long, and reports on wanted persons reach 340 characters. The program contains some 25,000 instructions and handles problems at a rate of 580 characters a second. The system presently connects Washington with 15 state and city police departments and the FBI's Denver field office. Before long, according to an enthusiastic spokesman for J. Edgar Hoover, the information stored will be upped from 95,000 records to 131,000 and the number of police agencies served will increase to 25.

### Fingerprint reader needed

The most ambitious program in the computer battle against crime is the FBI's effort to develop a fingerprint classification system and a computer program to automate fingerprint identification remotely and rapidly. Over a year ago the FBI privately asked electronics firms for help, and early in 1966 the agency formally issued requests for proposals. Result? At press time, the outlook was so dismal that the FBI was no longer even asking for specific proposals. It will be happy just to hear about a company's qualifications for talking on the subject. Capability statements should be sent to J. P. Moore at Rm. 5262, FBI, Justice Dept., Washington, D. C. 20535.

### Report says labs have "in" groups

In every research and development laboratory there's a fellow who recognizes a good idea when he hears it, who knows what to do with it and who can be counted on to carry it "upstairs" for action if it is presented to him. And, just like London's "Establishment," every laboratory has an "in" group that can influence decisions and projects as much through the groups' social interrelations as through its members' real authority.

# Washington Report

CONTINUED

These findings of a Government-sponsored study are hardly surprising, but they do confirm what has long been suspected by every designer who has ever engaged in laboratory politics. The study was made by T. J. Allen and S. I. Cohen, of MIT's Alfred P. Sloan School of Management, for NASA and the National Science Foundation. A copy is available at \$3.00 (65¢ in microfiche) from the Commerce Dept. Clearinghouse, Springfield, Va. 22151. It is entitled *Information Flow in an R and D Laboratory*, No. PB-173 524.

The 28 pages seem to say that the best way to sell an idea is to identify the fellow everybody seems to turn to most for advice and who seems to maintain the widest informal contacts outside the laboratory. He will be the same guy that top management is really listening to. The hypothesis was tested for the government and found to work in an unidentified "small R&D laboratory" working on "materials and devices in the fields of direct energy conversion and solid-state electronics."

## Admiral by short circuit?

People who have long cast doubts on military officer-promotion systems and claim that some officers were awarded their stars by clerical error are raising eyebrows at a new Navy research project. The Office of Naval Research's Cdr. Robert Marion is looking for an electronic voting machine to be used by officer-promotion boards. He wants some firm to develop a simple, accurate and easily maintained unit that will tabulate weighted voting by panels of from nine to 27 personnel-review officers. What Marion (Rm. 1714 Arlex, Washington, D. C. 20370) wants right now is a statement of qualifications from interested companies.

## New sonar fire control for submarines

The Navy may soon announce a new sonar-actuated torpedo and Subroc fire control system. The Naval Ordnance Laboratory is trying to use items already developed wherever possible, but new electronic design contracts may be in the offing. Much depends on results of a definition study that Pennsylvania Research Associates, Philadelphia, is making on

interfaces between sonar units and fire control units.

## Which "poverty" program is which?

Everybody in Washington seemed to be asking which was the *real* poverty program at the time the Fiscal 1968 budget message went to Congress. Both the Labor Department and the Department of Health, Education and Welfare appeared to be claiming major new roles in the poverty program while the Office of Economic Opportunity's Sargent Shriver was doing a real old-fashioned poor-boy performance at a special OEO press briefing. Only the electronics industry, apparently, sorted the wheat from the chaff and knew the real score. That was that somewhere in the poverty program there is still some money for computer-assisted teaching, automated records-keeping and even for running Job Corps camps.

The roster of electronics industry officials who signed up to meet with Shriver last month and discuss industry's role reads like a *Who's Who of Smart Money*: Thomas J. Watson, board chairman, IBM; Ned Garrity, senior vice president, ITT; Andrew Conrad, president, and J. F. Murray, vice president, RCA Service Corp.; James G. Hodgson, industrial relations director, Lockheed Aircraft Corp.; Francis Keppel, board chairman, General Learning Corp.; Morton Long, vice president, Philco-Ford Corp.; Peter C. McColough, president, Xerox Corp.; Nicholas Petrou, president, Westinghouse Defense and Space Center; and Charles B. Thornton, board chairman, Litton Industries, Inc. All of the firms represented either operate Job Corps centers or are major suppliers of specialized equipment.

## Instrument imports to be simplified

The Commerce Dept.'s Business and Defense Services Administration (BDSA) has begun implementing the Florence Agreement under which many scientific and educational materials may be brought into the U.S. free of duty. Included are many items in electronic, optical and medical fields. Free entry is available for nonprofit educational and research institutions if no equipment of equivalent scientific value is made in the U.S. Application forms are available from the Bureau of Customs, Treasury Dept. But preliminary help in determining eligibility and in oiling the appropriate wheels can be had from the BDSA Office of Scientific and Technical Equipment, Commerce Dept., Washington, D. C. 20230.



141A OSCILLOSCOPE

Technical Data hp Sampling Scopes

HEWLETT • PACKARD

TRACE  
ALIGN



BEAM  
FINDER



CALIBRATOR  
10V



IV



**PUT THIS NEW WINDOW IN YOUR LAB  
— SEE OUT TO 12.4 GHz AND BEYOND**

POWER

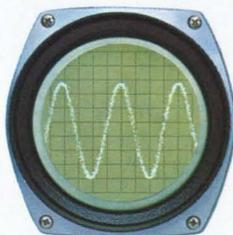


ASTIGMATIS

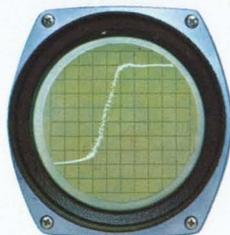


WRITING RATE

12.4 GHz bandwidth



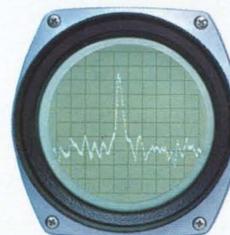
28 psec rise time



Delayed sweep



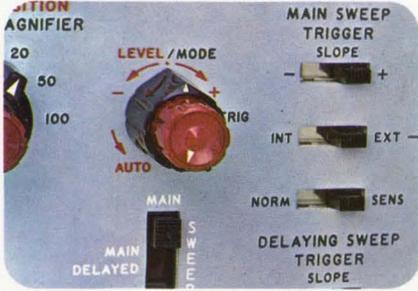
40 psec TDR



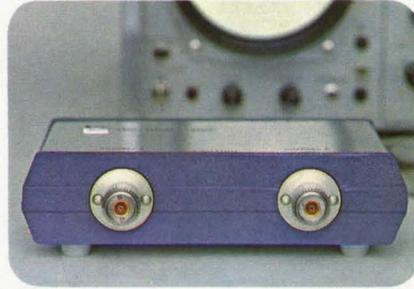
Hewlett-Packard has developed a radically advanced sampling system that lets you see through X band and make oscilloscope

measurements never before possible. Turn the page and see how much easier high-frequency circuit analysis has suddenly become.

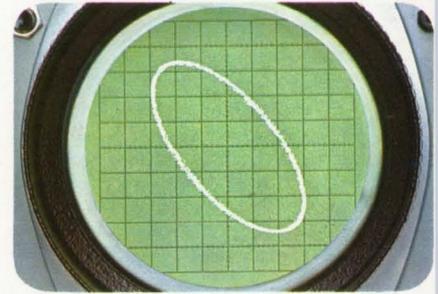
Automatic triggering for fast, easy trace set-up.



Remote sampler permits measurement at test point, eliminates lossy cables.



Accurate phase measurements: less than 10° phase shift between channels at 5 GHz.



New hp Sampling Scope System enables you to

# SIMPLIFY MICROWAVE DESIGN

- DC to 12.4 GHz at 1 mv/cm, dual channel
- 28 psec rise time
- Delayed sweep through full bandwidth for complex waveform examination
- Less than 20 psec jitter for clear displays
- TDR resolutions down to less than 1 cm
- Feed-through inputs for minimum signal disturbance

For the first time, you can see through X band, observe CW signals beyond 12.4 GHz, and see fast pulses with a 28 psec response capability. You can also use TDR measurements to resolve discontinuities down to less than 1 cm in the design of cables, coaxial components, connectors and strip lines. In addition, you can utilize delayed sweep to get displays of pulse segments that leave conventional sampling scopes blurred. Choose from these solid-state plug-ins to get the system that meets your particular requirements:

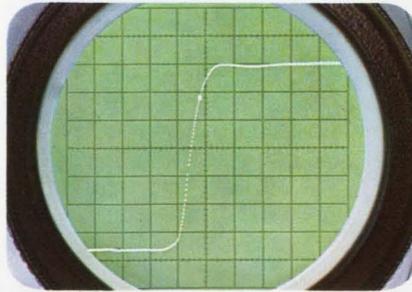
**A NEW 1425A TIME BASE & DELAY GENERATOR** is the first sampling plug-in with delayed sweep, which permits detailed examination of complex signals and pulse trains—even in the presence of high rate jitter. It has maximum sweep speeds of 10 psec/cm, triggering to 1 GHz, and delay times as long as 5 ms. It is also easy to use. Control nomenclature and layout are comparable to those of conventional high-frequency scopes. Automatic internal triggering puts a baseline on the screen in the absence of an input signal, gets a trace displayed sooner. When you want to set up a magnified trace, an intensified dot locates the expansion point for you. You also get push-button return to X1 magnification so that you can take a quick look at the unmagnified trace.



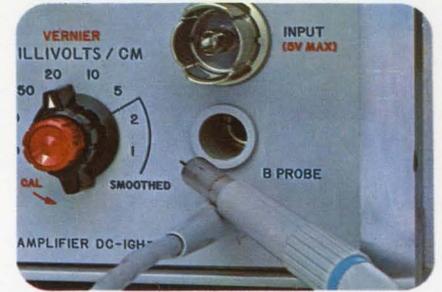
Optional variable persistence mainframe (141A) with trace storage capability.



Intensified dot simplifies magnification & setting delay times.



High-impedance probes and 50-ohm inputs with internal triggering—on one scope.



# AND LOGIC CIRCUIT TESTING!

**B** NEW 1424A SAMPLING TIME BASE is similar to the 1425A (above) but does not have delayed sweep. It is easy to use and features triggering to 5 GHz, calibrated sweeps as fast as 10 psec/cm, low jitter and direct readout of sweeps, even when expanded. A calibrated marker position control permits accurate time interval measurements.

**C** NEW DUAL CHANNEL 1410A SAMPLING VERTICAL AMPLIFIER provides 1 mv/cm sensitivity at 1 GHz, and combines in a single instrument the convenience of high-impedance probes for circuit measurement plus 50-ohm inputs with delay lines for internal triggering—both with the full 1 GHz bandwidth. Both give less than 100 ps time difference between channels for accurate phase measurements in the A vs. B mode, and for precise dual trace time comparisons. Accessories include 10:1 and 100:1 Dividers, Isolator, Blocking Capacitor, 50-ohm Tee Connector and adapters.

**D** NEW DUAL CHANNEL 1411A SAMPLING VERTICAL AMPLIFIER plug-in provides dual-channel performance, front-panel recorder outputs, and A vs. B mode for X-Y scope presentations—plus the capability to function with any one of three remote samplers. Sensitivity ranges from 1 mv/cm to 200 mv/cm—with bandwidth up to 12.4 GHz.

**NEW REMOTE SAMPLERS** represent true state-of-the-art advances made possible by exceedingly fast switching diodes developed specifically by Hewlett-Packard for sampling applications. You can choose from three new samplers in order to optimize your system for best pulse response, flat bandwidth and low VSWR, or low-cost study of signals through 4 GHz:

**E** 28 ps risetime with optimum pulse response for accurate measurements on fast-rise pulses, and sensitivity of 1 mv/cm, dual channel. Capable of resolving discontinuities as close as 1 cm apart when used with 1105A/1106A 20 ps pulse generator. Model 1430A.

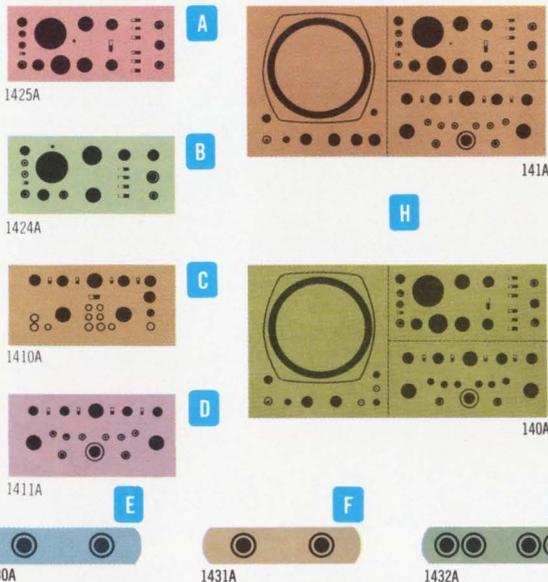
**F** 12.4 GHz bandwidth. This unit has an extremely flat bandwidth for CW measurements, 10 ps time difference between channels for accurate phase measurements, and a low VSWR of 1.4:1 from DC to 8 GHz (2:1 at 12.4 GHz). Model 1431A.

**G** 4 GHz with 90 ps risetime at 1 mv/cm and feed-thru inputs permit accurate measurements of CW, fast pulses and TDR. Model 1432A.

**H** VERSATILE hp 140A/141A MAINFRAMES are general-purpose units whose frequency and sensitivity characteristics accommodate sampling plug-ins (as well as 13 other hp 1400 series plug-ins) so that you can cover virtually the entire spectrum of oscilloscope measurements. The 141A mainframe provides the additional benefits of variable persistence and storage capabilities.

**COUNTDOWN AND PULSER.** The 1104A/1106A Countdown Supply and Tunnel Diode Mount combination provides versatility to the new sampling system by extending triggering capabilities to 18 GHz. The unit counts down from 1 GHz to 18 GHz with an output of about 100 mv at 100 MHz. A 20 psec pulse, ideal for fast circuit testing on high resolution TDR, is provided by the 1105A/1106A Pulse Generator Supply and Tunnel Diode Mount combination.

Build your sampling scope with these plug-in units



# S P E C I F I C A T I O N S

## 1425A SAMPLING TIME BASE AND DELAY GENERATOR

### Main Sweep:

**Range:** 13 ranges, 1 ns/cm to 10  $\mu$ s/cm in a 1, 2, 5 sequence. Accuracy  $\pm 3\%$ .

**Magnifier:** X1 to X100. Increases fastest calibrated sweep speed to 10 ps/cm. Push button returns magnifier to X1.

**Magnified Position:** 10-turn control with intensified marker that indicates sweep expansion point.

### Triggering: (For both Main and Delaying Sweep)

Internal triggering is available on the displayed signal with 1410A vertical amplifier.

**Automatic:** Baseline displayed in the absence of an input signal.

**Pulses:** At least 100 mv amplitude required (75 mv for internal triggering) of pulses 2 ns or wider for jitter  $< 30$  ps.

**CW:** Signals from 200 Hz to 300 MHz require 50 mv for jitter  $< 10\%$  of input signal period. (Usable to 1 GHz with increased jitter.)

### Level Select:

**Pulses:** At least 50 mv amplitude required (100 mv for internal triggering) of pulses 2 ns or wider for jitter  $< 20$  ps.

**CW:** Signals from 200 Hz to 1 GHz require 50 mv for jitter  $< 1.5\%$  of input signal period + 10 ps. Jitter is  $< 50$  ps for signals of 10 mv at 1 GHz. (For internal triggering, required signal increases to 400 mv at 1 GHz for jitter  $< 1.5\%$  of input signal period + 10 ps.)

**Slope:** Positive or negative.

**External Trigger Input:** 50 $\Omega$ , ac coupled (2.2 $\mu$ f) coupled; signal out of jack  $< 10$  mv in sensitive and  $< 5$  mv in normal.

**Jitter:** Less than 10 ps on 1 ns/cm range, and  $< 20$  ps (or 0.005% of unexpanded sweep speed, whichever is larger) at 2 ns/cm and slower, with large amplitude signals having rise times of 1 ns or faster.

### Delaying Sweep:

**Range:** 15 ranges, 10 ns/cm to 500  $\mu$ s/cm in a 1, 2, 5 sequence. Accuracy  $\pm 3\%$ .

**Delay Time:** Continuously variable from 50 ns to 5 ms.

**Accuracy:**  $\pm 3\%$ , except  $\pm 5\%$  on two slowest ranges. Linearity 0.5%. Time jitter is  $< 1$  part in 20,000 or 20 ps, whichever is greater.

**Sweep Functions:** Main sweep, delaying sweep, main sweep delayed.

**Scanning:** Internal, manual, record and single scan operation.

### Sync Pulse Output:

**Amplitude:**  $> 1.5$ v into 50 $\Omega$ . **Rise Time:** Approx 1 ns. **Overshoot:**  $< 5\%$ . **Width:** Approximately 1  $\mu$ sec. **Relative Jitter:**  $< 10$  ps. **Repetition Rate:** One pulse per sample.

**Weight:** Net 7 lbs. (3.2 kg). Shipping, 11 lbs. (5 kg).

**Price:** \$1600.

## 1424A SAMPLING TIME BASE

Direct triggering to 5 GHz. Sweep ranges from 10 ps/cm to 500  $\mu$ s/cm. Price: \$1200. Available mid 1967.

## 1410A DUAL-CHANNEL VERTICAL AMPLIFIER

**Rise Time:** Less than 350 ps (Bandwidth, DC to 1 GHz). **Overshoot:** Less than 5%.

**Deflection factor (Sensitivity):** 8 calibrated ranges from 1 mv/cm to 200 mv/cm; accuracy  $\pm 3\%$ .

**Operating Modes:** Channel A only; B only; A & B; A & B added algebraically; A vs. B.

**Isolation Between Channels:** Greater than 40 dB to 1 GHz.

**Input Impedance:** Probes, 100K ohms shunted by 2 pf, nominal; GR type 874 inputs, 50 ohms  $\pm 2\%$ .

**Noise:** Approx. 1 mv, 5 mv/cm to 200 mv/cm.

**Dynamic Range:**  $\pm 2$  volts.

**Drift:** Less than 3 mv/hr. after warm-up.

**Triggering:** Internal or external when using 50-ohm inputs.

Internal triggering selectable from Channel A or B.

External triggering necessary when using probes.

**Time Difference Between Channels (for probes or 50-ohm inputs):** Less than 100 ps.

**Recorder Outputs:** Front panel outputs provide 0.1 v/cm from a 500-ohm source.

**Accessories provided:** 10:1 dividers, blocking capacitors, adapters, isolators.

**Weight:** Net, 10 lbs. (4, 5 kg). Shipping, 15 lbs. (6, 8 kg).

**Price:** \$1600.

## 1411A DUAL-CHANNEL SAMPLING VERTICAL AMPLIFIER (when used with 1430A, 1431A, or 1432A)

Deflection factor (Sensitivity), Operating Modes. Isolation Between Channels and Recorder Outputs same as 1410A.

**Weight:** Net, 10 lbs. (4, 5 kg). Shipping, 15 lbs. (6, 8 kg).

**Price:** \$700.

## 1430A 28 psec SAMPLER (when used with 1411A)

**Rise Time:** 28 ps (DC to approx. 12.4 GHz).

**Overshoot:** Less than 5%.

**Noise:** Less than 8 mv, 5 mv/cm to 200 mv/cm.

**Dynamic Range:**  $\pm 1$  volt.

**Low Frequency Distortion:** Less than  $\pm 3\%$ .

**Input Characteristics:** 50-ohm feed-thru with Amphenol APC-7 precision 7 mm connectors on input and output. VSWR less than 3:1 at 12.4 GHz.

**Time Difference Between Channels:** Less than 5 ps.

**Connecting Cable Length:** 5 ft.

**Weight:** Net, 4 lbs. (1, 8 kg). Shipping, 9 lbs. (4, 1 kg).

**Accessories Provided:** Two type N adapters, two 50-ohm loads.

**Price:** \$3,000.

## 1431A 12.4 GHz SAMPLER (when used with 1411A)

**Bandwidth:** DC to greater than 12.4 GHz (approx. 28 ps rise time).

**VSWR:** DC to 8 GHz, 1.4:1; 8 to 10 GHz, 1.6:1; 10 to 12.4 GHz, 2.0:1.

**Noise:** Less than 7 mv from 5 mv/cm to 200 mv/cm.

**Dynamic Range:**  $\pm 1$  volt.

**Low Frequency Distortion:** Less than  $\pm 3\%$ .

**Input Characteristics:** 50-ohm feed-thru with Amphenol APC-7 precision 7 mm connectors on input and output.

**Phase Shift Between Channels:** Less than  $10^\circ$  at 5 GHz, typically less than  $2^\circ$  at 1 GHz.

**Connecting Cable Length:** 5 ft.

**Weight:** Net, 4 lbs. (1, 8 kg). Shipping, 9 lbs. (4, 1 kg).

**Accessories Provided:** Two type N adapters, two 50-ohm loads.

**Price:** \$3,000.

## 1432A 90 psec SAMPLER (when used with 1411A)

**Rise Time:** Less than 90 ps. Bandwidth, DC to 4 GHz.

**Overshoot:** Less than 5%.

**Noise:** Less than 3 mv from 5 mv/cm to 200 mv/cm.

**Dynamic Range:**  $\pm 1$  volt.

**Low Frequency Distortion:** Less than  $\pm 3\%$ .

**Input Characteristics:** 50-ohm feed-thru with GR type 874 connectors.

**Time Difference Between Channels:** Less than 25 psec.

**Connecting Cable Length:** 5 ft.

**Weight:** Net, 4 lbs. (1, 8 kg). Shipping, 9 lbs. (4, 1 kg).

**Accessories Provided:** Two 50-ohm loads.

**Price:** \$1,000.

## 1104A/1106A 18 GHz TRIGGER COUNTDOWN

### Input:

**Frequency Range:** 1 GHz to 18 GHz.

**Sensitivity:** Signals 100 mv or larger up to 12.4 GHz, produce less than 20 ps of jitter (200 mv required to 18 GHz).

**Input:** 50-ohm Amphenol APC-7 input connector.

**Signal Appearing at Input Connector:** Less than 250 mv step whose top is flat within 2% for 1 ns.

**Output:** Center Frequency, approximately 150 MHz; amplitude, typically 100 mv.

### Weight:

1104A: Net, 2 lbs. (0, 9 kg). Shipping, 4 lbs. (1, 8 kg).

1106A: Net, 1 lb. (0, 5 kg). Shipping, 3 lbs. (1, 4 kg).

**Price:** 1104A, \$200; 1106A, \$550.

## 1105A/1106A 20 psec PULSE GENERATOR

### Output:

**Rise Time:** 20 ps.

**Overshoot:** Less than 5%.

**Drop:** Less than 3% in first 100 ns.

**Width:** Approximately 3  $\mu$ s.

**Amplitude:** Greater than +200 mv into 50 ohms.

### Output Characteristics:

50 ohms  $\pm 2\%$ , Amphenol APC-7 precision 7 mm connector.

### Triggering Requirements:

Amplitude,  $\geq 0.5$  v peak; Rise Time, less than 20 ns (jitter less than 15 ps when triggered by 1 ns rise time sync pulse from 1424A or 1425A).

**Width:** Greater than 2 ns.

**Input Impedance:** 200 ohms, AC coupled through a 20 pf capacitor.

**Repetition Rate:** 0 to 100 kHz; free runs at 100 kHz.

### Weight:

1105A: Net, 3 lbs. (1, 4 kg). Shipping, 8 lbs. (3, 6 kg).

1106A: Net, 1 lb. (0, 5 kg). Shipping, 3 lbs. (1, 4 kg).

**Price:** 1105A, \$200; 1106A, \$550.

**Mainframes** include 140A with standard CRT (\$595), and 141A with variable persistence and storage (\$1275).

**THE CLEARLY SUPERIOR PERFORMANCE** of this new sampling scope system derives from many hp sampling innovations: first general purpose sampler, first unit with a magnifier, first high-impedance probes, first to 4 GHz—and now, first with delayed sweep and first to 12.4 GHz. Get complete data from your hp Field Engineer, or write to Hewlett-Packard, Palo Alto, California, 94304. Call (415) 326-7000.

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## CRT is still leader in large-scale display

The cathode-ray tube is unlikely to be displaced by competing large-screen display schemes in the next ten years, according to a U. S. Air Force scientist.

While acknowledging progress in many techniques for displaying information on wall-sized panels, the scientist, Dr. Carlo Crocetti, said: "The cathode-ray tube still offers the system designer the most flexibility and a relatively inexpensive solution to virtually any problem."

Dr. Crocetti, associated with the Display Techniques branch of the Rome Air Development Command, Rome, N. Y., stated his view before the IEEE Winter Convention on Aerospace and Electronic Systems held recently in Los Angeles.

He said that most research and development in large-screen displays is directed at refining existing methods rather than creating new ones.

The scientist said that most development falls into four general classifications: electromechanical scribing, silver halide systems, oil-film light valves and cathode-ray projection schemes.

The most recent scheme involves the use of lasers to write information on a screen, but Dr. Crocetti said that the problems of scanning while maintaining the necessary bandwidth and optical efficiency have still to be overcome.

Electroluminescent, gas discharge and magneto-optical phenomena are being exploited for large-screen displays. These approaches, still in the experimental stages, have not yet advanced beyond sample prototype demonstration models. These discrete independent elements or cells are to be assembled into large assemblies or matrices with high character definition.

Either light emitters or reflectors, the basic modules are said to offer higher reliability because of their solid-state construction and low power consumption.

Recently attention has been given to the integration of display modules with digital computers. ■ ■

CONTAMINANT-FREE

# THIN FILM COATINGS

AUTOMATICALLY

TEMESCAL CONTINUOUS HIGH-VACUUM SYSTEMS ASSURE:

■ Consistent high-quality coatings ■ Complete freedom from contamination ■ Rate-controlled uniform deposition ■ Programmed automatic control ■ Minimum maintenance ■ Reliable high productivity ■ Evaporation, sputtering and glow-discharge cleaning can now be accomplished automatically in a continuous, contaminant-free, high-vacuum environment. Temescal continuous and fast-cycle thin-film coating systems are designed to maintain coating-chamber pressure as low as  $10^{-7}$  Torr for more than a thousand cycles between each maintenance clean-up. Substrates are simply moved in and out of the coating chamber through vacuum locks. ■ Coatings produced in this type of environment are exceptionally pure because of the continuous vacuum and because the evaporant remains completely outgassed. Uniformity throughout the production run is assured by Temescal's new rate monitor which remains free of coatings during long production runs. ■ Systems range in size from the Model FC-1100 (shown here), to megawatt systems with coating chambers large enough to coat 10-x 12-foot substrates.

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for details



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Telephone (415) 841-5720

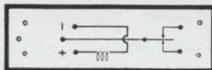


# Adlake Mercury Wetted Relay — Application Data

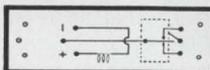
## Capacitance of Adlake Mercury Wetted Contact Relays Applicable for Low Signal Applications

**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.

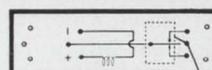
Abbreviation COMM. stands for the Combination of the Armature and Normally Closed Contact. N.O. is the abbreviation for Normally Open Contact; whereas the symbol # is the mean average for the 5 relays. Graphs are available on other styles of Adlake Mercury Wetted Contact Relays upon request. (Please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



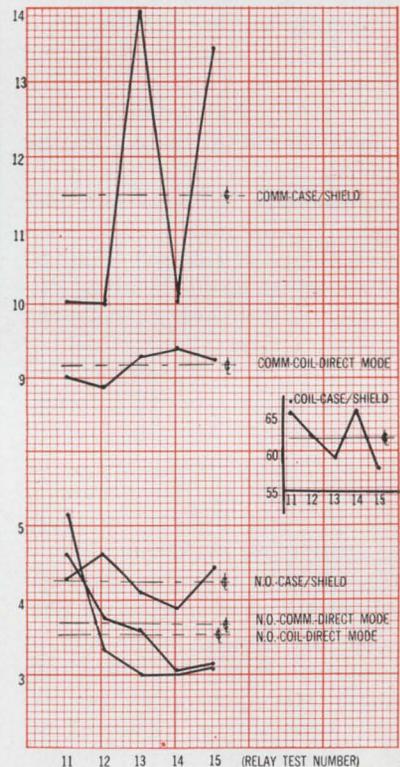
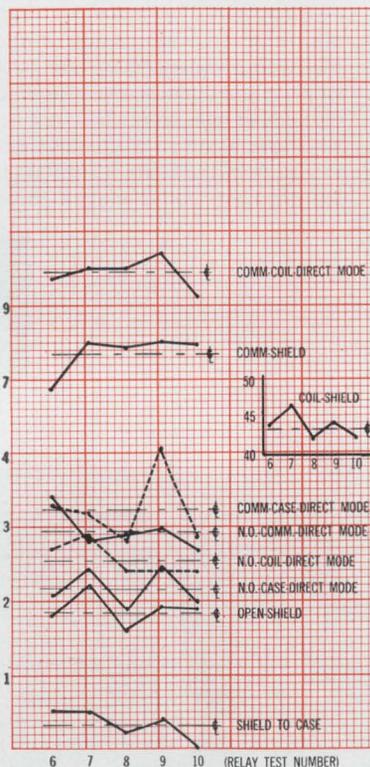
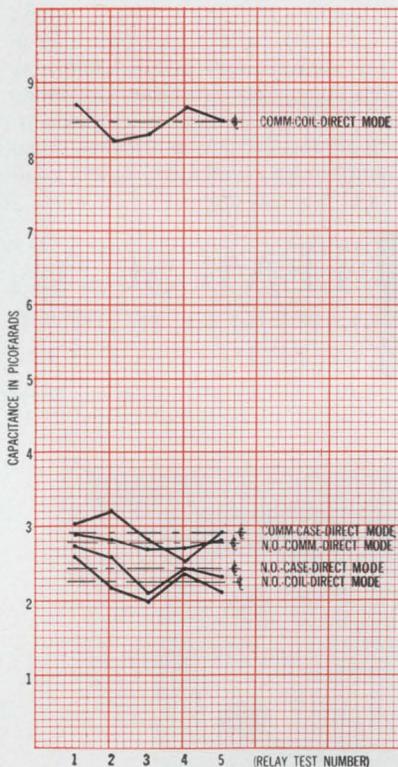
**AWCA 16011-S**  
Fig. 1



**AWCA 16016**  
Fig. 2



**AWCA 16018**  
Fig. 3



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

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

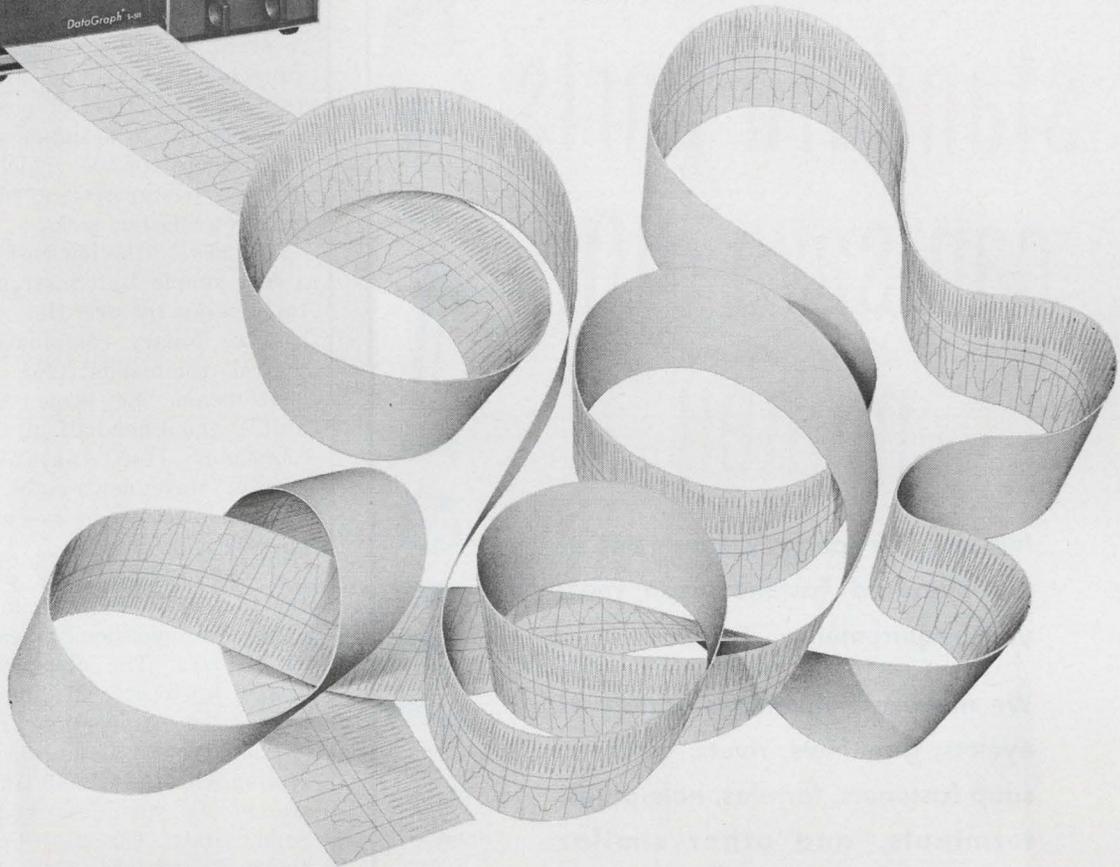
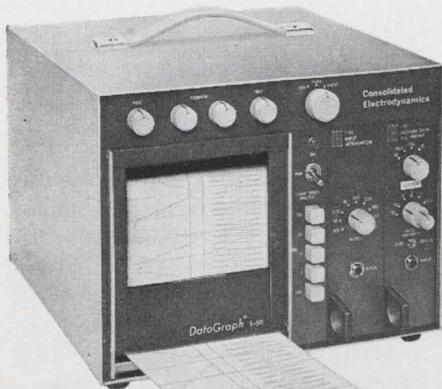
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# CEC

DATAGRAPH PRODUCTS

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ON READER-SERVICE CARD CIRCLE 21

## Low-cost crt units for time-sharing

Crt-display units capable of working with a remote computer can be built for less than \$10,000 each according to designers at Bell Telephone Labs. Inc., Murray Hill, N. J.

The system, which has been built in prototype form, would provide a 10-inch-square viewing area with a 1024-square matrix of possible display points. A designer could use this remote console, which also includes a teletypewriter, to perform numerous design tasks.

The key to the low-cost design is a very simple 4-bit instruction code for driving the crt. Half of the 16 possible binary combinations give control commands (for example: 0011 means "Set scale to move 1 unit.") the other half give drawing commands (for example: 1011 means "Move down-right."). Each such instruction is executed in a microsecond.

A one-head-per-track disc memory is used in the system to store picture information for each 16 to 32 displays. The displays can be located up to several thousand feet from this supporting memory.

The console was designed for operation with the GE645 time-shared system. It was described at the Solid State Circuits Conference held in Philadelphia, Feb. 15-17. ■ ■

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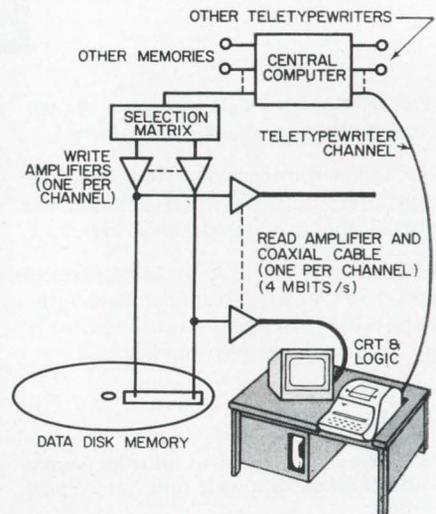
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Remote display consoles for time-shared systems, like the one shown schematically here, could be built for less than \$10,000 each, according to the Bell Telephone Laboratories engineers who designed it.

## Narrow laser pulses captured on scope

A new phototransducer converts powerful laser pulses with picosecond rise times and nanosecond durations into oscilloscope patterns.

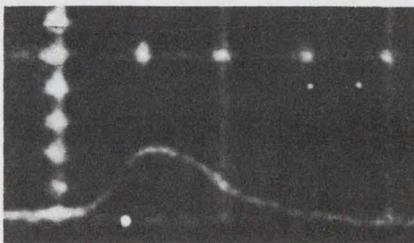
United Aircraft Research Laboratories, East Hartford, Conn., reports that the converted high-power pulses can be observed on currently available oscilloscopes. The phototransducer, the company says, will be useful in studying thermonuclear fusion; in developing optical radars, computers and components; and in medical research.

The new device has a biplanar vacuum photodiode detector. This is mounted in the impedance-matching structure, which is connected to the oscilloscope input terminals. The device is packaged in an eight-inch-long rectangular case.

The researchers say that it can reproduce extremely short, fast-rise-time pulses without going into oscillation. This has been achieved, they say, with the associated detector circuitry, which includes strip-line capacitors. An oscilloscope with a response time of 3 GHz is said to give the best results.

The device is reported capable of displaying optical pulses with peak powers that exceed a billion watts and are less than one-half nanosecond wide at the half-power points. Optical energy between 3000 Å and 11,500 Å can be readily detected.

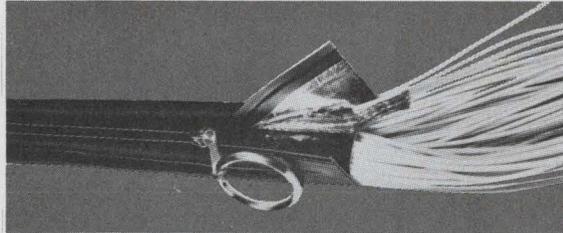
The photodetector will give a one-volt output when detecting 100 watts of incident optical power from a pulsed ruby laser (6943 Å). It will also provide one watt from a 500-watt pulsed neodymium-doped glass laser (10,600 Å). ■ ■



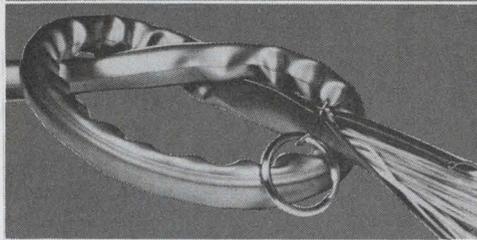
**Oscillograph of a pulse** from a doped glass laser with a rise time of 287 ps obtained with a United Aircraft Research Laboratories phototransducer. The time scale is 1 ns per major division.

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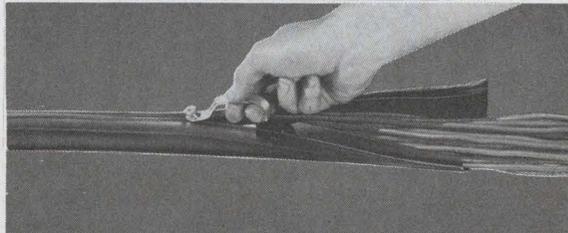
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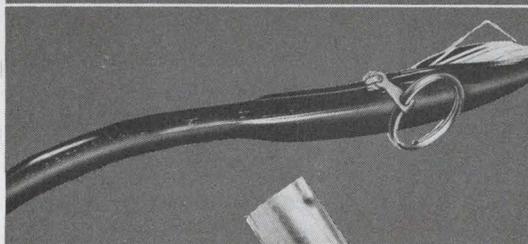
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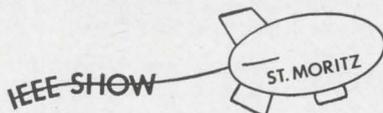
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# the connector thing

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



# WIN

## THE BROOKLYN BRIDGE!

Every March, rumblings of wanderlust begin to stir within the breast of every true electronic engineer. It is time for the IEEE convention. It is time once more to bend one's lance against the Visigoths of New York: waiters, cab drivers, mods on Bleeker Street, the maitre d' at 21, bilious brokers of theater tickets, the subway and just plain people who use words like "chic," "fabulous" and "devastating."

### EVERYBODY WINS

In honor of all those beautiful people, simple of soul, broad of brow, and intrepid of heart, who stem from the provinces, Microdot is offering a genuine, invalid DEED OF TRUST TO THE BROOKLYN BRIDGE printed on equally invalid parchment. Or, if you prefer, Microdot will send you a handsome, invaluable booklet entitled NEW YORK DIETARY LAWS or How to Eat Dinner at the King Henry IV Without Floating a Loan from Chase Manhattan. Nothing to do.

You only get one of these, so choose carefully. There is a way you can get both. Patient reading will tell you how.

### THE BEST CONNECTIONS IN NEW YORK! (PL. 5-5800)

Microdot makes connectors, as a matter of fact, the best microminiature coax connectors in the industry. Whether you're talking about the some 6000 standard off-the-shelf items or the high density, multi-pin MARC 53, Microdot has some rather surprising answers to connector problems. Of course, some of you will not have the advantage of exposing yourselves to the invectives of the hotel clerk in the St. Moritz for the IEEE show. Don't be sad. This is what you would have seen,

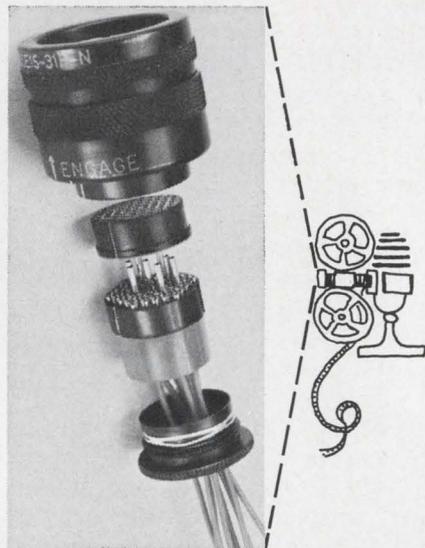
Really



**LEPRA/CON** is Microdot's newest ultraminiature series of coax connectors. The screw-on has an OD of only 1/8 inch with a mated length of only one inch. Packaging can be reduced by as much as 50%. New versions of the LEPRA/CON include the slip-on, multi-pin and rack and panel based on the TWIST/CON concept. See below.

**TWIST/CON** is a concept as much as a product...the most economical microminiature pin and socket in the history of electronics. TWIST/CON permits high density packaging of contacts on .050" centers, up to 420 contacts per square inch.

There are also the Microcrimp, Golden Crimp, Mini-Noise coaxial cable and those 6000 standards we were talking about.



**MARC 53** is the world's smallest, high-performance circular connector with as many as 61 crimp contacts in a tiny 1/8 inch receptacle shell. "Posilock" push-pull coupling mates easily with no danger of damage and eliminates accidental disconnect. "Posiseal" guarantees an interfacial seal. *The new rear-insertable version of the MARC 53 is a revolution—field assembly without special insertion or extraction tools.* We will have a sound color film at the St. Moritz during IEEE which explains all about the MARC 53.

### SEE US AT THE ST. MORITZ!

Microdot will not have a booth at the IEEE show. Instead it has set up a Bessarabian Harem at the St. Moritz, one of the finest combined inns and watering holes in the world. Here, any of you making the trek to Gotham can get all the hot Microdot news first hand. And while you are there you can pick up (free!!!!) at the St. Moritz BOTH your Brooklyn Bridge Deed and your copy of the New York Dietary Laws. By the way, we did say it was a watering hole.



**MICRODOT INC.**

Microdot Inc., 220 Pasadena Avenue, South Pasadena, California 91030

Dear Mr. Microdot:

- Please send me my personal Deed of Trust to the Brooklyn Bridge. I can understand people leaving Brooklyn to come to New York. But going to Brooklyn?
- Although I am a personal friend of David Rockefeller and could get a Chase Manhattan loan easily, I still want my free copy of the New York Dietary Laws.

*NOTE: Only one of the above is available per person unless you visit the Microdot Pasha's suite at the St. Moritz in New York. Both will be sent only to those people who state in 25 words or less (1) why they are a hardship case and (2) why Microdot makes the best connectors in the world.*

- Send me information on all those things like MARC 53 and TWIST/CON, etc. I am going to New York, but I have better things to do.

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ON READER-SERVICE CARD CIRCLE 24

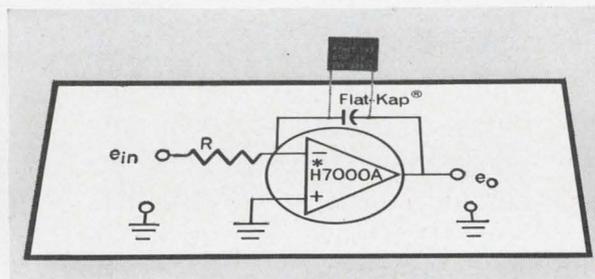
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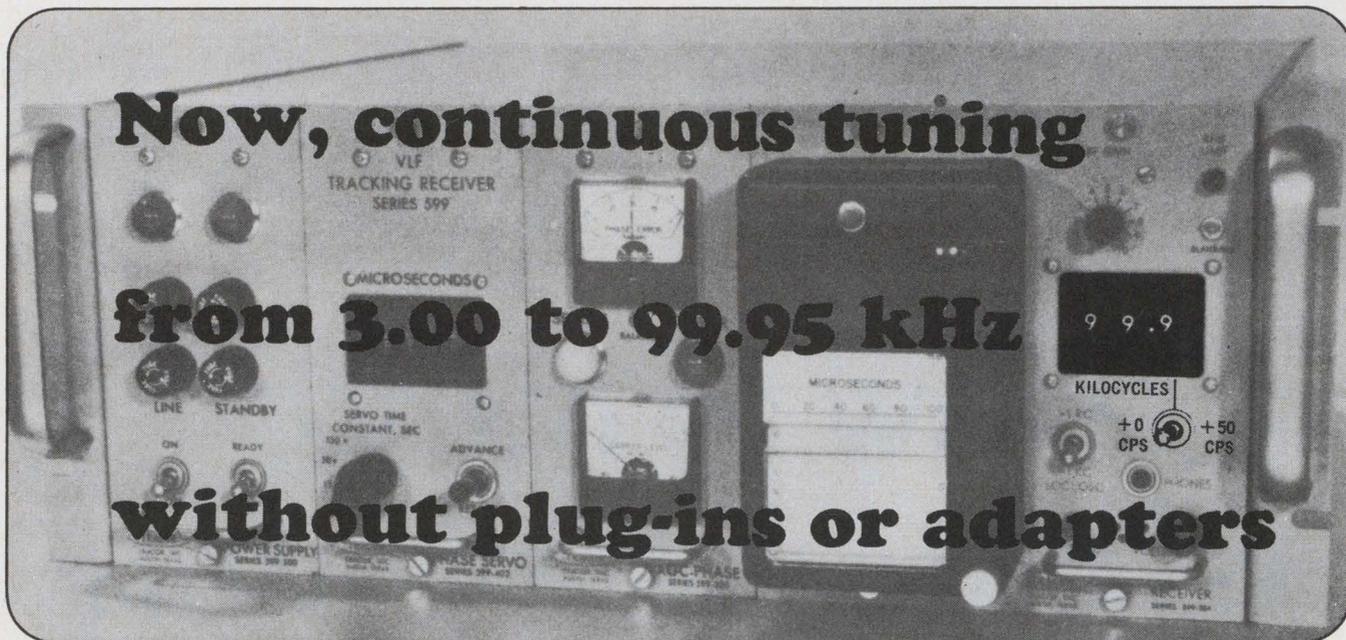


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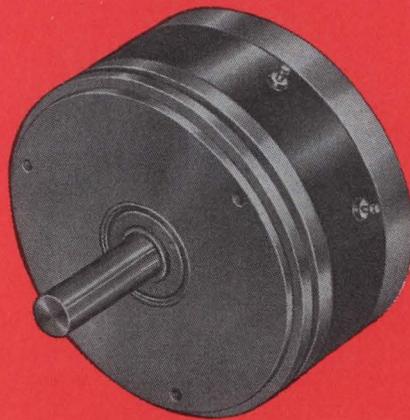
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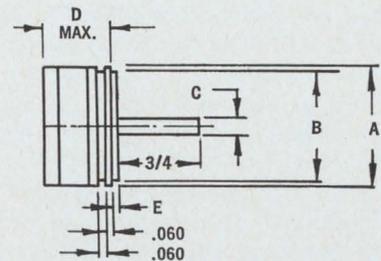


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Model	A	B†	C†	D	E	FUNCTION	RESISTANCE	LIN./CONF.
78	.875	.7500	.1250	.635	.04	LINEAR	1K, 5K	0.25%
105	1.093	1.0300	.1250	.635	.04			
205	2.000	1.8750	.2500	.985	.06		10K, 50K	
106	1.093	1.0300	.1250	.635	.04	SINE	1K, 10K	1.0%
206	2.000	1.8750	.2500	.985	.06	COSINE	20K	0.25%

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## 'Window shade' solar-cell array is tested for spacecraft use

A retractable solar-cell array that can be furled and unfurled in space like a window shade is being tested for possible use on spacecraft. It would save weight and eliminate the inertia problems created by fixed or folded rigid arrays when a spacecraft is put through midcourse maneuvers, according to NASA.

The ability to retract a solar array is also useful for giving instruments a clearer field of view and for regulating the array's power capability by adjusting the number of exposed cells.

The flexible, thin-film solar array was developed by the Hunter Spring Div. of Ametek, Inc., Research Center in Cleveland.

When fully extended, it forms a strip seven feet long and more than three feet wide. It contains 378 cadmium sulfide photovoltaic cells produced by the Clevite Corp. of Cleveland. The thin-film cells, each less than four-thousandths of an inch thick, are three-inch-square sandwiches of active and passive laminations.

Cadmium sulfide is deposited on silvered plastic film, one-thousandth

of an inch thick. A barrier layer of copper sulfide is applied over the cadmium sulfide, and a copper screen current-collecting grid is attached to this layer. A transparent plastic film is used to seal the assembly. The edges of the copper screens are then soldered together to form a continuous sheet. Ametek engineers say that arrays several hundred square feet in area are practical.

Two self-extending booms of spirally wound, stainless steel strip are the main structural supports for the array. Stored on two spools, the strips can be extended or retracted as tapered spiral tubes. Electric motors inside the spools control the extension of the two parallel booms during the deployment of the array and, when reversed, rewind the strip material on its spools. The array moves out and back on a drum under spring tension.

The prototype under test at the Lewis Research Center is not intended for actual flight. It has been successfully extended and retracted more than 500 times. Ametek engi-



Thin-film solar panel that can be unfurled and furled in space is a possible spacecraft power source.

neers say that only minor changes are needed to convert the prototype into flight hardware.

A spokesman for Clevite says that the conversion efficiency of the thin-film solar cells in the array is 5 per cent. ■ ■

## Electronic beam welds computer memories on assembly line

A sharply focused electron beam is being used to weld 9000 external electrical terminals on a computer memory—36 terminals at a time.

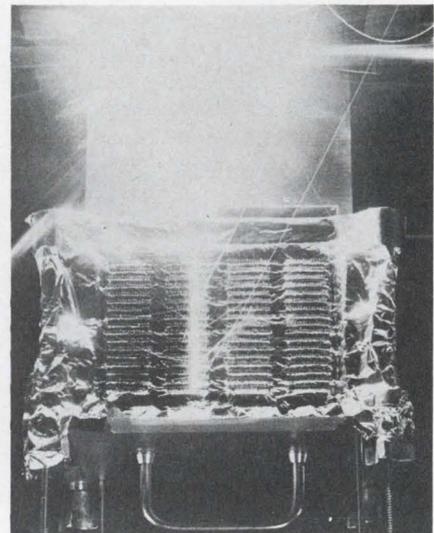
The beam welds the connections of parallel ferrite-core planes on a production line at the International Business Machines Corp.'s Kingston, N. Y., computer plant. With conventional resistance-welding techniques, it would be necessary to join each terminal individually, and the quality of the welds would not be so good, according to IBM.

The ferrite-core planes are stacked in a fixture, and the terminals are carefully aligned. The assembly is then positioned in the electron-beam welder's vacuum chamber, so that the tips of a column of 36 electrical terminals line up precisely.

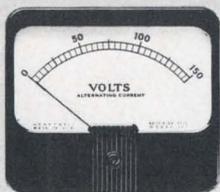
The arrays index past the electron beam automatically in sequence, so that the beam strikes an entire row of terminals simultaneously, approximately 0.015 inch from the tip of each terminal. This process is repeated until all four sides of the array are welded.

When the laser beam strikes the end of the terminal it melts the metal into a spherical glob. The shape of the glob indicates the quality of the weld. Welds should have a uniform ball shape, IBM engineers report. Any distortions in the shape of the weld make them subject to individual inspection to determine their quality.

The welder was made by the Hamilton Standard Div. of the United Aircraft Corp., Windsor Locks, Conn. ■ ■



Electron beam welds a row of terminals in an IBM ferrite memory plane. The arrays move past the beam automatically on the production line.



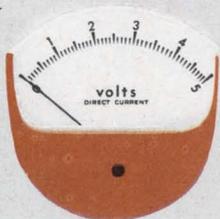
Time's up:

Honeywell now has a taut-band meter that actually goes for even less than a pivot-and-jewel meter.

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We designed every single unnecessary part right out of it. (Fewer parts: fewer things to go wrong.)

And we make this meter by machine. (This not only gives us a very good cost advantage. It also gives you a more reliable meter.)

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out special calibrating because it's self-shielded.

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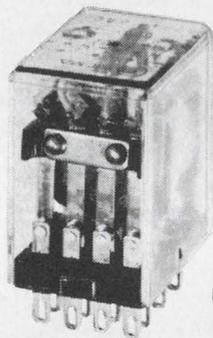
But don't make up your mind yet. Take a look at our catalog first. Write Honeywell Precision Meter Division in Manchester, N.H. 03105.

# Honeywell

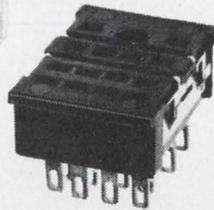
## How long have you waited for a low-cost taut-band meter?



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New Sigma Series 67 4PDT 3 amp AC-DC relays are not only priced lower than competitive types but will outperform them four ways:

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**Need fast delivery? The Series 67 is available off-the-shelf from your Sigma distributor.**

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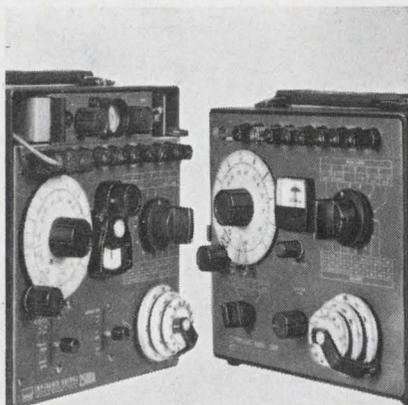
ON READER-SERVICE CARD CIRCLE 29



**Happiness is an Acopian power supply . . .  
because it's shipped in only 3 days.**

Whether your application is op amps, ICs, logic circuits, relays, lamps or electronic measuring equipment, look to Acopian to meet your needs for AC to DC plug-in power supplies. Acopian's new catalog lists over 62,000 different supplies . . . all available for shipment within 3 days. Get your 16 pages of happiness by writing or calling Acopian Corp., Easton, Pennsylvania (215) 258-5441. 





## The old master has met its match.

For more than twelve years, our 250 DA Universal Impedance Bridge ruled supreme in its field. No instrument could match its measurement performance.

Now along comes a serious challenger—our new 250 DE (at right). It has all of the reliability and accuracy of the classic model. As you can see, they look alike from the outside.

But inside, we've made many improvements. The new 250 DE is completely self reliant on its four flashlight batteries. It has a new solid-state detector with greatly improved sensitivities: better than 20 microvolts on DC, 10 microvolts on AC. For simplicity, there is a single meter null detector on the front panel. And for versatility, some useful front terminals have been added.

Why did we improve on the old master when it has delighted so many thousands with its performance in countless plants, laboratories and schools? Well, we figured eventually somebody would make a truly portable impedance bridge even better than the 250 DA. And we wanted it to be us. ESI, 13900 NW Science Park Drive, Portland, Ore. (97229).

### 250 DE Portable Universal Impedance Bridge Specifications

#### Range:

Resistance: 0 to 12 Megohms  
 Capacitance: 0 to 1200 Microfarads  
 Inductance: 0 to 1200 Henrys  
 Resistance: 0.1% + 1 dial division  
 Capacitance: 0.2% + 1 dial division  
 Inductance (Series and Parallel):  
 0.3% + 1 dial division  
 Sensitivity: Better than 20 microvolts  
 DC, 10 microvolts AC  
 Frequency: 1 kc internal  
 (External terminals provided.)  
 Batteries: 4 D size flashlight batteries  
 provide 6 months of normal service.  
 Weight: 12 lbs. Price: \$470.00

Note: The 250 DA features exactly the same accuracy specifications as the 250 DE. However, the 250 DA is AC line-operated. Price: \$495.

Electro Scientific Industries **esi**

ON READER-SERVICE CARD CIRCLE 31

## Fluidic gyro built for spacecraft use

A fluidic gyroscope that uses moving patterns of air to determine the change in a spacecraft's attitude has been developed.

Scientists at the Honeywell Systems and Research Center, St. Paul, Minn., are perfecting a strapdown gyro system that detects spacecraft motion about a single sensitive axis by noting changes in the pattern of moving air. Extremely sensitive pressure sensors are able to detect the air-pattern changes.

Proportional beam-deflection fluidic amplifiers convert pressure differences in a chamber into meaningful signals that are analogs of rotation rate.

The chamber, consisting of a porous metal ring with two end caps that have opposing exhaust stems, is the major element of the gyro. Air is continuously drawn through the opposing stems. When no motion occurs about the sensitive axis, the air drawn through the porous ring moves radially toward the center, dividing evenly as it moves out of

the opposing end stems.

When motion occurs around the sensitive axis, the air pattern changes to a spiral, and a vortex is formed in the center of the chamber. The change in the flow pattern is proportional to the motion of the craft.

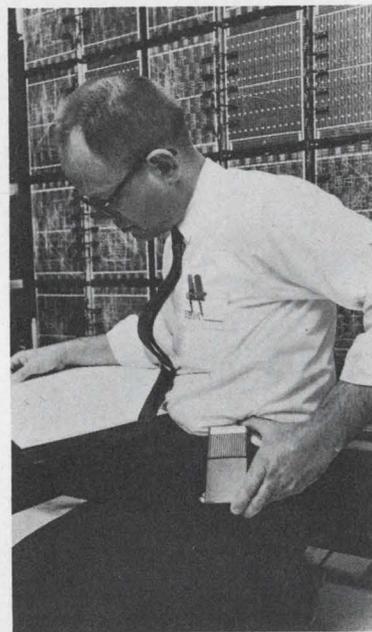
A Honeywell spokesman says that tests have already proved the practicality of this device and that a stable platform could be constructed with three fluidic gyros placed along the three principal axes of motion.

The Honeywell development program is being sponsored by the Army's Harry Diamond Laboratories, Washington, D. C. ■ ■



A sensitive air chamber in a fluidic gyro responds to motion changes by forming detectable vortical patterns.

## Fast, fast relief



IBM is speeding the installation and servicing of its data-handling systems by giving its field engineers pocket-sized radio receivers. The men can be paged over the Motorola units and assigned instantly to emergency calls. The service is being extended by the end of this year to over 200 branch offices of the International Business Machines Corp. across the country. The transistorized pagers receive toned beeps or voice instructions.

# 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<sup>3</sup>/<sub>8</sub> inches long and is 2<sup>3</sup>/<sub>8</sub> 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.



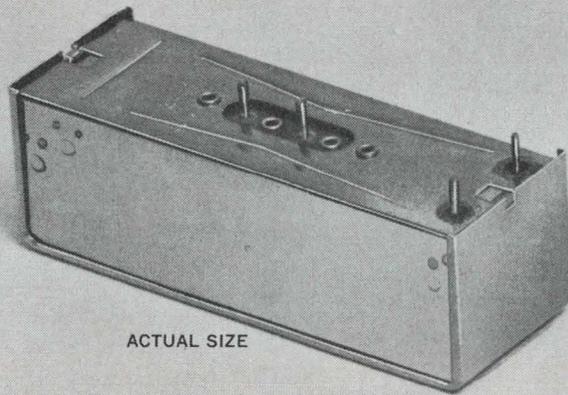
**Microwave Electronics** 3165 Porter Drive, Palo Alto, California  
 Visit us at the **ESSEX HOUSE** during **IEEE**  
 ON READER-SERVICE CARD CIRCLE 32

a division of Teledyne, Inc.

# This NEW G-V

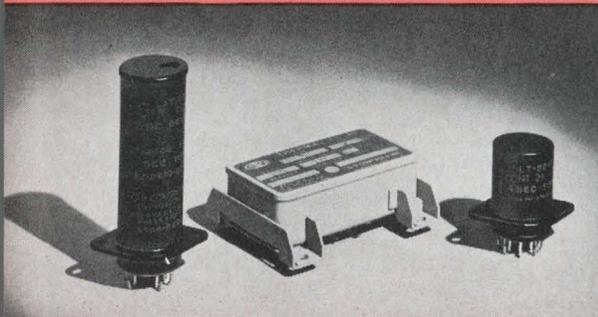


## THERMAL TIMING RELAY...



ACTUAL SIZE

### SEALED THERMAL TIME DELAY RELAYS

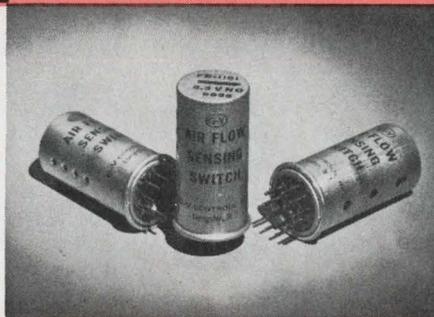


G-V is the largest source and offers the widest variety. Several types are hermetically sealed and still adjustable. All meet requirements of Mil-R-19648. Available in a wide variety including: sub-miniature, miniature, octal and missile types. **Features:** delay time, 0.1 sec. to 3 min.; heater voltages to 230 V; ambient operating temp.,  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ; vibration to 2000 Hz; shock to 50g.

**G-V**

ON READER-SERVICE CARD CIRCLE 132

### AIR FLOW SENSING SWITCH



A new design concept and technique is utilized to monitor presence of air flow. When air flow drops below a safe level, it operates an alarm or automatic shut-off. Used in electronic equipment, cooling packages, air conditioners, computers, etc. **Features:** Operates in any plane, no moving parts. No special adjustments.

only from **G-V**

ON READER-SERVICE CARD CIRCLE 133

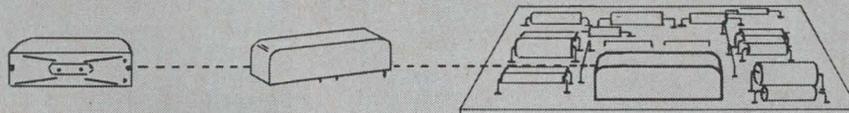
### SEALED ELECTRICAL THERMOSTATS



**Cartridge Type:** Series C8 hermetically sealed and still adjustable. Contact rating up to 5 amps. **Crystal Can Size:** Series VE-2 hermetically sealed. Contact rating up to 3 amps. **Features:** Rapid rate of response; minimal differential; operating range,  $-65^{\circ}$  to  $+300^{\circ}\text{F}$ ; vibration to 2000 Hz; shock to 50g.

**G-V**

ON READER-SERVICE CARD CIRCLE 134



# mounts directly on PCB boards!

**UNIQUE DESIGN ELIMINATES NEED FOR SPECIAL ADAPTERS OR SOCKETS...**

*it's from G-V*

This new G-V Thermal Timing Relay, JT Series, is the only one specifically designed for mounting directly on printed circuit boards without the need for adapters or sockets. This unique design approach improves assembly integrity, reduces assembly time, eliminates hand wiring, reflects a cost saving and increases reliability.

The JT Series mount flat, as compared to the standard upright mounting configuration. This exclusive G-V design conserves space, reduces weight, and allows greater packaging densities for the PCB's. These G-V Thermal Timing Relays are housed in a shatter-proof, dust-proof metal enclosure and feature stainless steel mechanisms and encased heaters. Operating specifications include: Time delays, 2 to 180 seconds; Contacts, SPST, NO or NC; Heater Voltage, 6.3 to 230 V. AC or DC; All units are temperature compensated and will operate in any orientation.



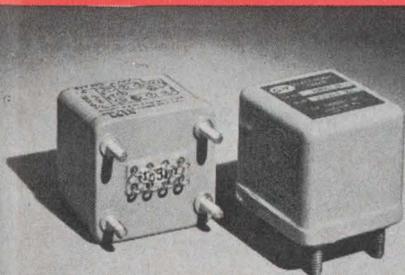
**G-V CONTROLS INC.**

LIVINGSTON, NEW JERSEY 07039

(201) 992-6200

ON READER-SERVICE CARD CIRCLE 131

## SOLID STATE TIME DELAY



Series 900-064 has been accepted as a standard for many military and aerospace applications where high quality, reliability and cost are requirements. **Features:** hermetically sealed; fixed or adjustable time delays 0.1 to 60 sec.; solid state or relay output; vibration to 2000 Hz; shock, 50g.



ON READER-SERVICE CARD CIRCLE 135

## INSTANT RESET THERMAL TIMING DEVICES



Instant reset during or after timing is available, by combining G-V's unique instant reset timing element with a magnetic relay. Widely used in communication systems and data processing equipment. **Features:** Delay time, 2 sec. to 5 min.; ambient operating temp., 32°F to 185°F.

only from 

ON READER-SERVICE CARD CIRCLE 136

## DIRECT-LINE FIELD ENGINEERING SERVICE

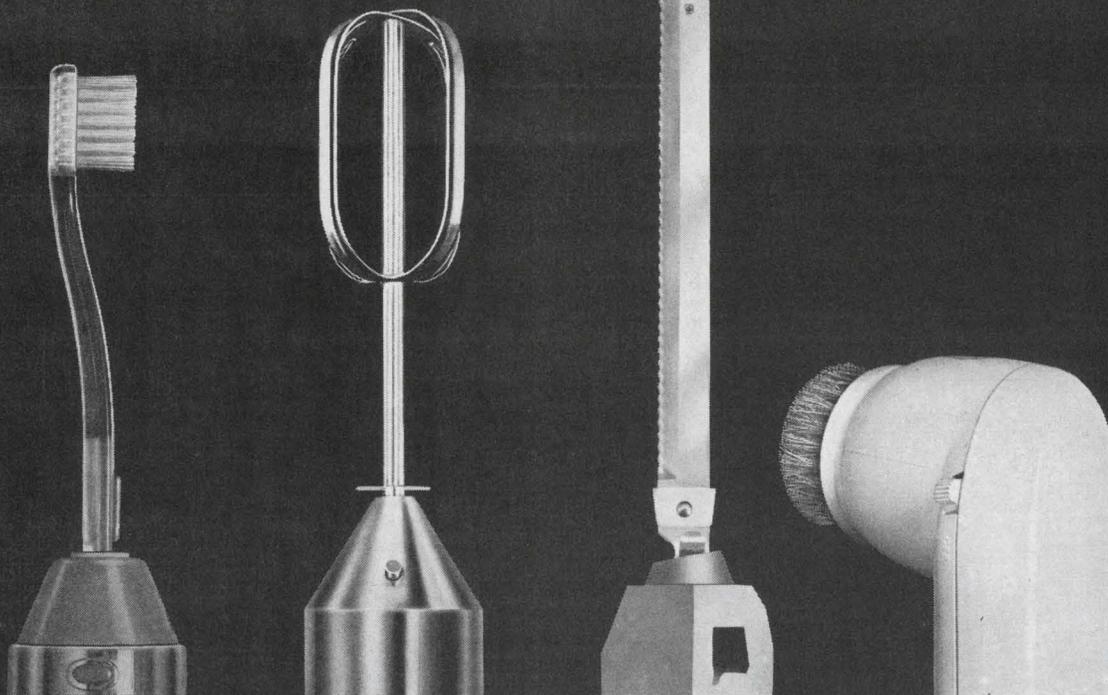


G-V assistance is always available to help you design and produce a better product. G-V Regional Field Engineers in your area will assist you and your design group in new applications and proper selection of your controls. G-V Product Engineers will help you with special applications. When you require experience, products and services in electro-mechanical and solid-state controls . . . call your man from G-V.



ON READER-SERVICE CARD CIRCLE 137

# The top name in portable power



## is at the bottom of it all.



### Sonotone rechargeable nickel-cadmium sealed cells, of course.

Whenever the need for portable, rechargeable power is indicated, you'll find Sonotone nickel-cadmium sealed cells playing a powerful supporting role.

Pioneer in the development of low weight, constant voltage, sintered-plate nickel-cadmium batteries, Sonotone today is a leader in the production of rechargeable portable power cells.

Produced in more than 27 shapes and sizes, Sonotone sealed cells provide the dependable, continuous voltage output needed to turn motors, light lights, activate switches, power electronics . . . in everything from Titans to cordless carving knives.

If you need any better indication of Sonotone's

capabilities in the rechargeable sealed cell field, just tell us your problem. We'll help you with whatever technical data or engineering aid you require. And probably just the cell you need, whether you're looking for 1 or 1 million. If not—we'll make it.

No idle claim. Sonotone has more technical experience in designing, developing and producing nickel-cadmium cells and batteries than any other manufacturer around!

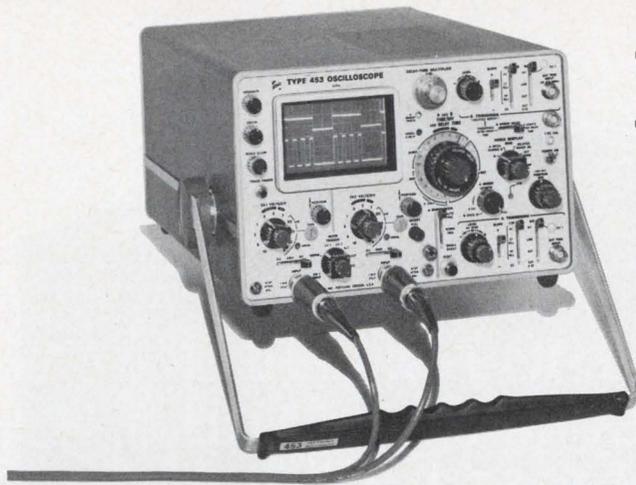
**Sonotone Batteries** 

portable power—from Titan to toothbrush

SONOTONE CORPORATION, BATTERY DIV., ELMSFORD N. Y. 10523

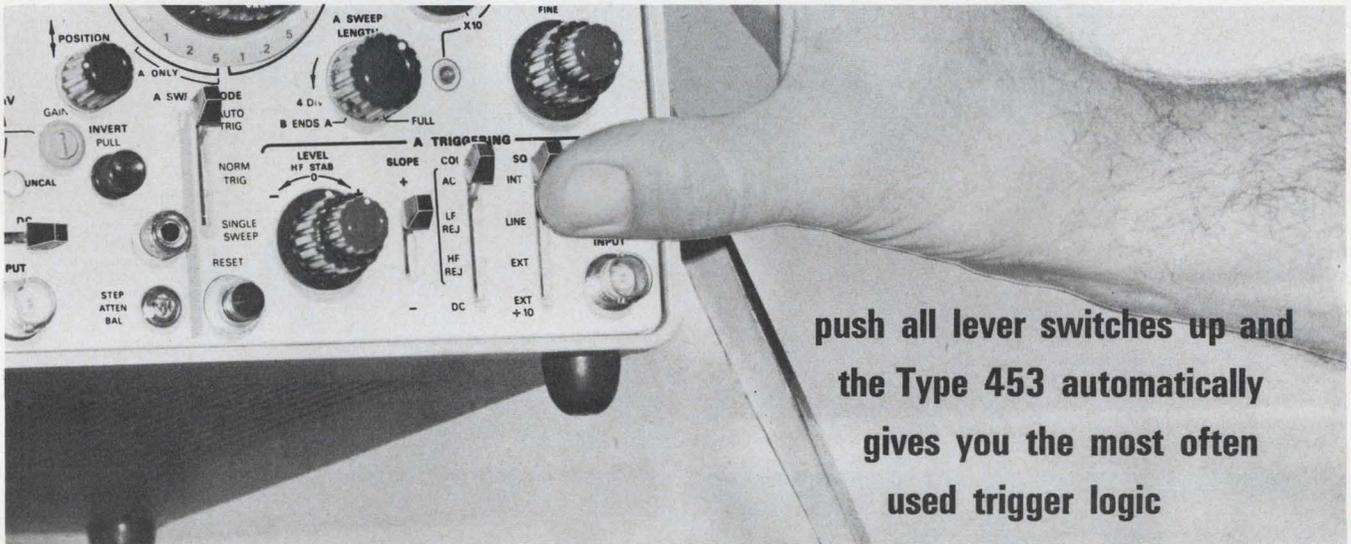
**Aircraft, Missile and Satellite Batteries • Power Supplies • Battery Charger/Analyzer**

Looking for a more challenging opportunity? Join Sonotone's fast-growing engineering team in the sky-rocketing field of nickel-cadmium battery design and development. *An equal opportunity employer.*



# Tektronix Type 453 portable oscilloscope

## takes the guesswork out of triggering



push all lever switches up and  
the Type 453 automatically  
gives you the most often  
used trigger logic

The Type 453 provides the following features when all lever switches are up: automatic triggering that allows discrete trigger level selection with the presence of a signal and provides a bright base line at all sweep speeds when no signal is present; + slope triggering; AC coupling that gives positive triggering regardless of vertical positioning; and internal triggering that makes full use of the vertical amplifier gain and the compact internal delay line. The Type 453 will trigger to well above 50 MHz and a green light gives a positive indication of a triggered sweep.

The Type 453 is a portable instrument with the built-in high performance and environmental capabilities normally found only in multiple plug-in instruments.

The vertical amplifier is specified at the probe tip and provides dual trace, DC to 50 MHz with 7 ns risetime at 20 mV/div. (DC to 40 MHz, 8.75 ns  $T_r$  at 5 mV/div.) Full sensitivity X-Y and 1 mV/div measurements may be made easily.

You can operate the delayed sweep with ease. Lever control to the right and **HORIZ DISPLAY** switch to **A INTEN**

**DURING B** gives delayed sweep operation. Setting the **B TIME/DIV** and the **DELAY-TIME MULTIPLIER** to meet your requirements and switching to **DELAYED SWEEP** allows complete measurements to be made.

The Type 453 is a continuation of the Tektronix tradition of quality workmanship. Its design and layout make it easy to maintain and calibrate. Transistors plug in and are easily removed for out-of-circuit testing. An accurate time ( $\pm 0.5\%$ ) and amplitude ( $\pm 1\%$ ) calibrator permits quick field calibration.

The front panel protection cover carries all the accessories with the complete manual carried in the rain/dust cover. The Type C-30 Camera and a viewing hood that fits in the rain cover also are available.

Type 453 (complete with probes and accessories) . . .	\$1950.00
Type C-30 Camera . . . . .	\$ 390.00
Collapsible Viewing Hood . . . . .	\$ 7.50

U.S. Sales Prices, FOB Beaverton, Oregon

## Tektronix, Inc.



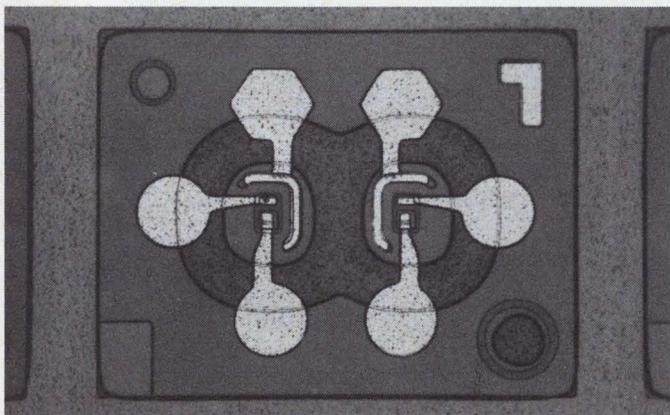
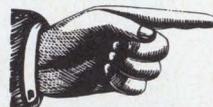
For complete information, contact your nearby Tektronix field engineer or write:  
Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005

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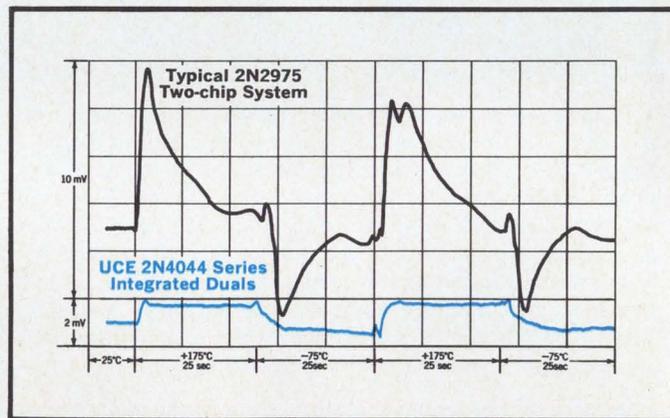
ON READER-SERVICE CARD CIRCLE 35

USE THIS DATA SHEET!  
IT GUARANTEES YOU  
THE BEST AVAILABLE  
IN INTEGRATED DUALS!

TEAR OUT FOR FILE



MONOLITHIC INTEGRATED dual transistors with dielectric isolation. Common substrate for better thermal and electrical characteristics.



THERMAL RESPONSE COMPARISON. UCE integrated duals are very closely matched and track within narrow voltage band over entire temperature range. Typical two-chip system varies widely in response under the same conditions.

**LOWER UNIT COST.** UCE integrated duals will cost you less per unit than matched pairs of discrete transistors.

**CHECK THE SPECS** for yourself, and then sample these devices. You'll find the dielectric process for true isolation, and Union Carbide Electronics' device design yields

low noise transistors with the lowest voltage and current drift, highest betas at low collector current, and high  $f_r$ 's.

**USE THESE DUALS** for low level front end amplifiers, differential amplifiers, comparators, operational amplifiers, integrators, sample and hold and A/D converters.



ELECTRONICS



ELECTRONICS

2N 4042-45 • 2N4099-100 • 2N4878-80

# MONOLITHIC DUAL TRANSISTORS

## NPN • SILICON • PLANAR

### 2N4042 • 2N4043 • 2N4044 • 2N4045

### 2N4099 • 2N4100

### 2N4878 • 2N4879 • 2N4880

Monolithic construction • electrical isolation by dielectric layers • very high dc gain • very low capacitances • high frequency response at low collector currents • very low noise • close parameter match over 10  $\mu$ A to 1 mA collector currents • excellent thermal transient tracking

#### MAXIMUM RATINGS

at 25°C (UNLESS OTHERWISE NOTED) (Note 1)

	SYM.	2N4042	2N4878	2N4099	2N4879	2N4043	2N4880	2N4044	2N4100	2N4045	Units
Dissipation at 25°C Case Temperature											
Each side (Note 1)	$P_D$	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	watt
Both sides	$P_D$	0.5	0.5	0.5	0.5	0.5	0.5	0.75	0.75	0.75	watt
Derating Factor											
Each side		1.7	1.7	1.7	1.7	1.7	1.7	2.3	2.3	2.3	mw/°C
Both sides		2.9	2.9	2.9	2.9	2.9	2.9	4.3	4.3	4.3	mw/°C
Voltage											
Collector to Base	$V_{CBO}$	60	60	55	55	45	45	60	55	45	volts
Collector to Emitter	$V_{CEO}$	60	60	55	55	45	45	60	55	45	volts
Emitter to Base (Note 2)	$V_{EBO}$	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	volts
Collector to Collector	$V_{CCO}$	100	100	100	100	100	100	100	100	100	volts
Collector Current	$I_C$	10	10	10	10	10	10	10	10	10	mA
Storage Temperature	$T_S$	-65 to +200	°C								

#### MATCHING CHARACTERISTICS

at 25°C (UNLESS OTHERWISE NOTED)

SYM.	2N4042		2N4099		2N4043		Units	CONDITIONS
	Min.	Max.	Min.	Max.	Min.	Max.		
DC Current Gain Ratio (Note 3)	$h_{FE1}/h_{FE2}$	0.9	1.0	0.85	1.0	0.8	1.0	$I_C = 10 \mu A$ to 1.0 mA, $V_{CE} = 5.0$ V $I_C = 10 \mu A$ , $V_{CE} = 5.0$ V
Base-Emitter Voltage Differential	$V_{BE1} - V_{BE2}$	3.0		5.0		5.0		mV $I_C = 10 \mu A$ to 1.0 mA, $V_{CE} = 5.0$ V $I_C = 10 \mu A$ , $V_{CE} = 5.0$ V
Base Current Differential	$I_{B1} - I_{B2}$	5.0		10		25		nA $I_C = 10 \mu A$ , $V_{CE} = 5.0$ V
Base Voltage Differential Change with Temperature	$\Delta (V_{BE1} - V_{BE2})$	3.0		5.0		10		$\mu V/^\circ C$ $T_A = -55$ to $+125^\circ C$ $I_C = 10 \mu A$ , $V_{CE} = 5.0$ V
Base-Current Differential Change with Temperature	$\Delta (I_{B1} - I_{B2})$	0.3		0.5		1.0		nA/°C $T_A = -55$ to $+125^\circ C$ $I_C = 10 \mu A$ , $V_{CE} = 5.0$ V

- ① Maximum ratings are limiting values above which devices may be damaged. These ratings give a maximum junction temperature of 200°C.
- ② The reverse base-to-emitter voltage must never exceed 7.0 volts and the reverse base-to-emitter current must never exceed 10  $\mu$ amperes.
- ③ Lower of two  $h_{FE}$  readings is defined as  $h_{FE1}$ .

### SMALL SIGNAL CHARACTERISTICS

Parameter	SYM.	TYPICAL VALUE	Units	CONDITIONS
Input Resistance	$h_{ib}$	28	ohms	$I_C = 1 \text{ mA}, V_{CB} = 5 \text{ V}$
Voltage Feedback Ratio	$h_{rb}$	4.3	$\times 10^{-4}$	$I_C = 1 \text{ mA}, V_{CB} = 5 \text{ V}$
Small Signal Current Gain	$h_{fe}$	250		$I_C = 1 \text{ mA}, V_{CE} = 5 \text{ V}$
Output Conductance	$h_{ob}$	0.6	$\times 10^{-7}$ mhos	$I_C = 1 \text{ mA}, V_{CB} = 5 \text{ V}$
Input Resistance	$h_{ie}$	9.6	K ohms	$I_C = 1 \text{ mA}, V_{CE} = 5 \text{ V}$
Voltage Feedback Ratio	$h_{rc}$	4.2	$\times 10^{-4}$	$I_C = 1 \text{ mA}, V_{CE} = 5 \text{ V}$
Output Conductance	$h_{oe}$	12	$\mu\text{mhos}$	$I_C = 1 \text{ mA}, V_{CE} = 5 \text{ V}$

### ELECTRICAL CHARACTERISTICS

at 25°C (UNLESS OTHERWISE NOTED)

Parameter	SYM.	2N4878		2N4879		2N4880		Units	CONDITIONS
		2N4042	2N4044	2N4099	2N4100	2N4043	2N4045		
		Min.	Max.	Min.	Max.	Min.	Max.		
DC Current Gain	$h_{FE}$	200	600	150	600	80			$I_C = 10 \mu\text{A}, V_{CE} = 5.0 \text{ V}$
DC Current Gain	$h_{FE}$	225		175		100			$I_C = 1.0 \text{ mA}, V_{CE} = 5.0 \text{ V}$
DC Current Gain (-55°C)	$h_{FE}$	75		50		30			$I_C = 10 \mu\text{A}, V_{CE} = 5.0 \text{ V}$
Emitter-Base On Voltage	$V_{BE(\text{on})}$		0.7		0.7		0.7	Volt	$I_C = 10 \mu\text{A}, V_{CE} = 5.0 \text{ V}$
Collector Saturation Voltage	$V_{CE(\text{sat})}$		0.35		0.35		0.35	Volt	$I_C = 1.0 \text{ mA}, I_B = 0.1 \text{ mA}$
Collector Cutoff Current	$I_{CBO}$		0.1(A)		0.1(A)		0.1(B)	nA	$I_E = 0, V_{CB} = 45 \text{ V(A)}, 30 \text{ V(B)}$
Collector Cutoff Current (150°)	$I_{CBO}$		0.1(A)		0.1(A)		0.1(B)	$\mu\text{A}$	$I_E = 0, V_{CB} = 45 \text{ V(A)}, 30 \text{ V(B)}$
Emitter Cutoff Current (Note 2)	$I_{EBO}$		0.1		0.1		0.1	nA	$I_C = 0, V_{EB} = 5.0 \text{ V}$
Collector-Collector Leakage	$I_{C1, C2}$		5.0		5.0		5.0	pA	$V_{CC} = 100 \text{ V}$
Current Gain Bandwidth Product	$f_T$	200		150		150		MHz	$I_C = 1.0 \text{ mA}, V_{CE} = 10 \text{ V}$
Current Gain Bandwidth Product	$f_T$	20		15		15		MHz	$I_C = 10 \mu\text{A}, V_{CE} = 10 \text{ V}$
Output Capacitance	$C_{ob}$		0.8		0.8		0.8	pF	$I_E = 0, V_{CB} = 5.0 \text{ V}$
Emitter Transition Capacitance	$C_{TE}$		1.0		1.0		1.0	pF	$I_C = 0, V_{EB} = 0.5 \text{ V}$
Collector-Collector Capacitance	$C_{C1, C2}$		0.8		0.8		0.8	pF	$V_{CC} = 0$
Collector-Emitter Sustaining Voltage	$V_{CBO(\text{sust})}$	60		55		45		Volts	$I_C = 1.0 \text{ mA}, I_B = 0$
Narrow Band Noise Figure	NF		2.0		3.0		3.0	dB	$I_C = 10 \mu\text{A}, V_{CE} = 5.0 \text{ V}$ $f = 1 \text{ Kc}, R_G = 10 \text{ K}\Omega,$ $BW = 200 \text{ cps}$
Collector Base Breakdown Voltage	$BV_{CBO}$	60		55		45		Volts	$I_C = 10 \mu\text{A}, I_E = 0$
Emitter Base Breakdown Voltage (Note 2)	$BV_{EBO}$	7.0		7.0		7		Volts	$I_E = 10 \mu\text{A}, I_C = 0$

### COLLECTOR CHARACTERISTICS • COMMON EMITTER

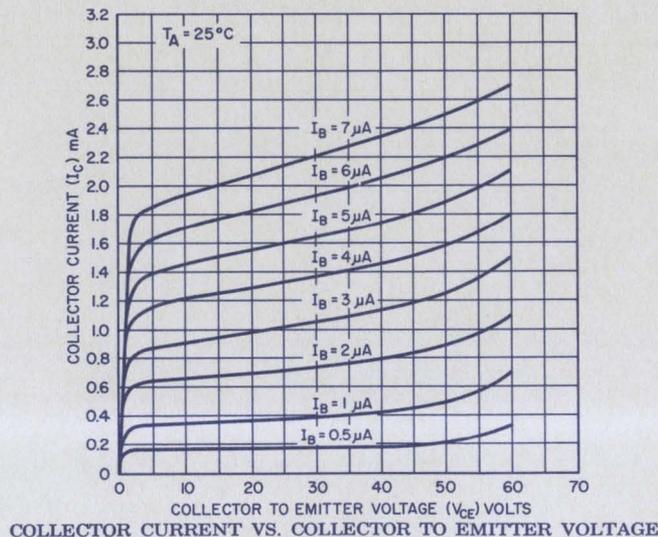


FIGURE 1

## CAPACITANCE CHARACTERISTICS

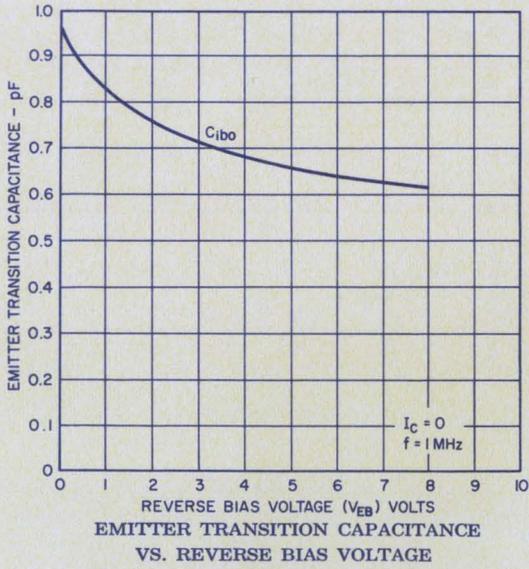


FIGURE 8

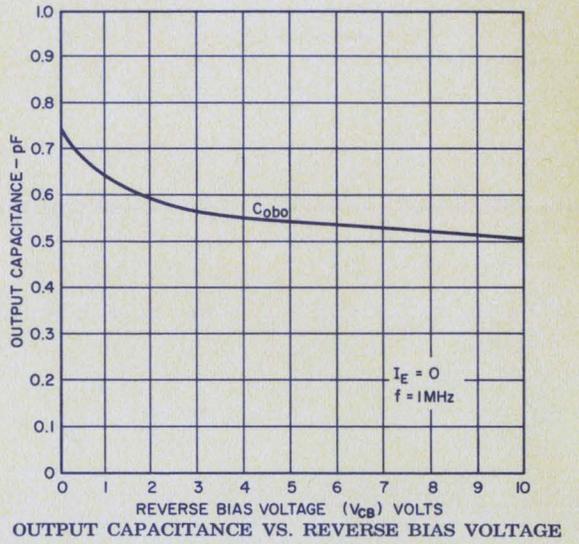


FIGURE 9

### COMMON BASE CHARACTERISTIC

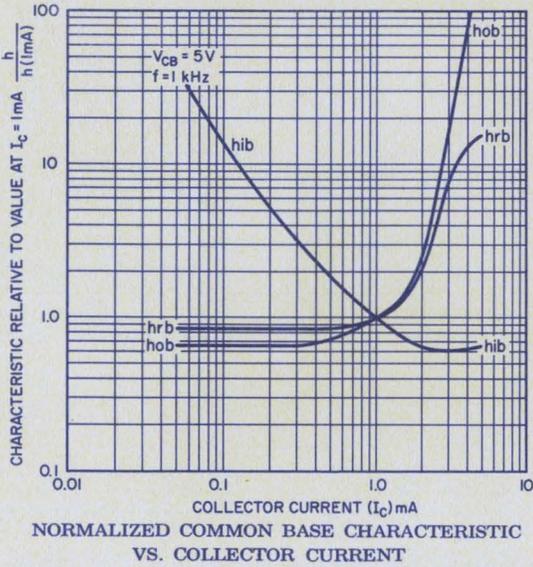


FIGURE 10

### COMMON EMITTER CHARACTERISTIC

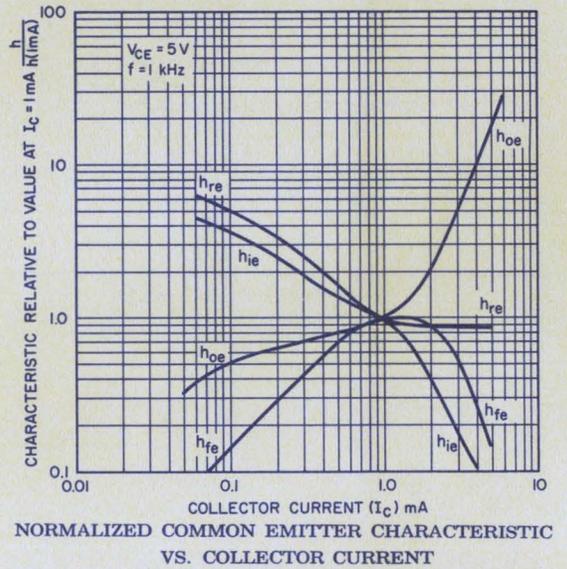


FIGURE 11

### COMMON EMITTER CHARACTERISTIC

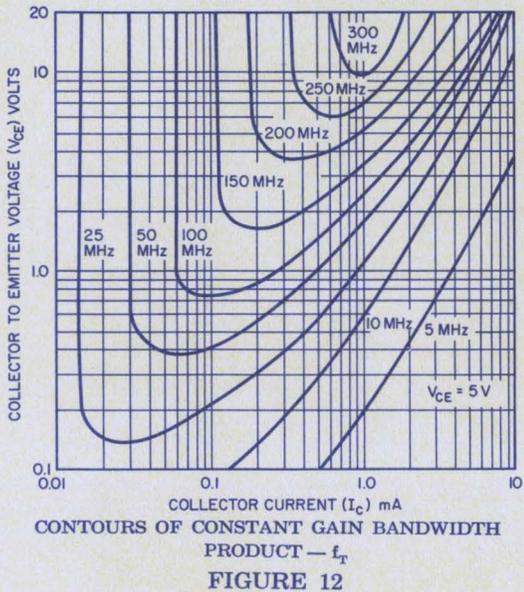


FIGURE 12

### LEAKAGE CHARACTERISTIC

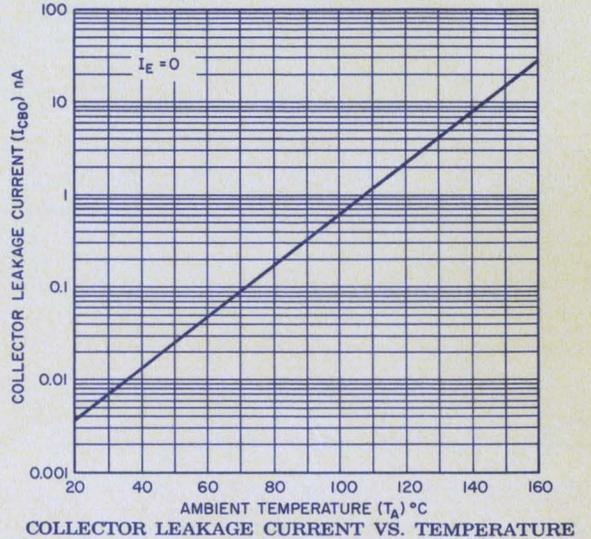
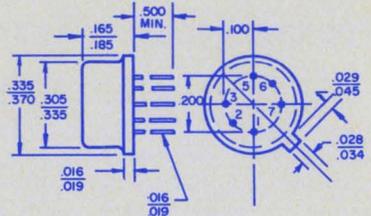
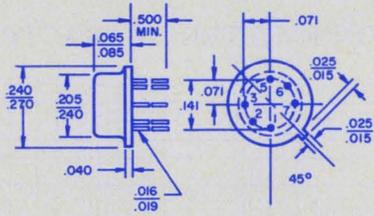


FIGURE 13

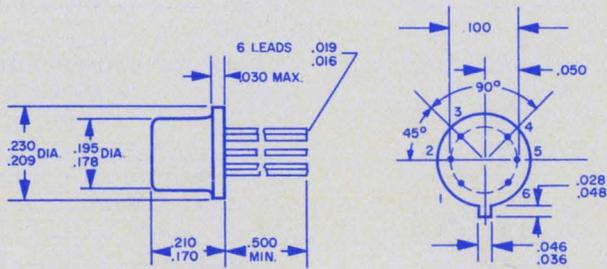
**TERMINAL CONNECTIONS**

Lead 1, Collector 1                      Lead 5, Emitter 2  
 Lead 2, Base 1                          Lead 6, Base 2  
 Lead 3, Emitter 1                      Lead 7, Collector 2  
 Case: All leads insulated from the case



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 2N4043  
 2N4099

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 2N4044  
 2N4045  
 2N4100



JEDEC TO-71 (six-lead TO-18)  
 2N4878  
 2N4879  
 2N4880

## COLLECTOR CHARACTERISTICS • COMMON EMITTER

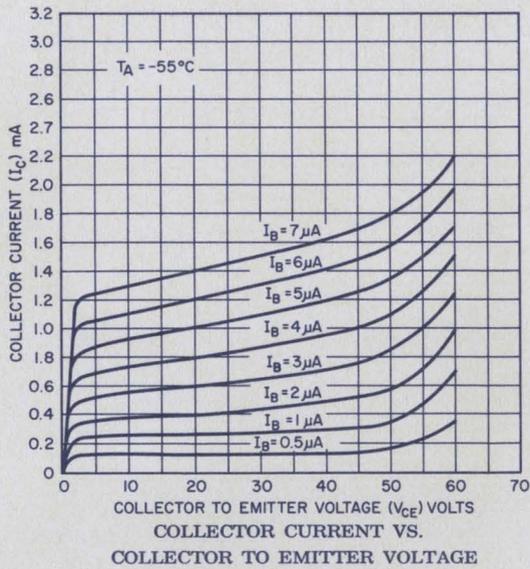


FIGURE 2

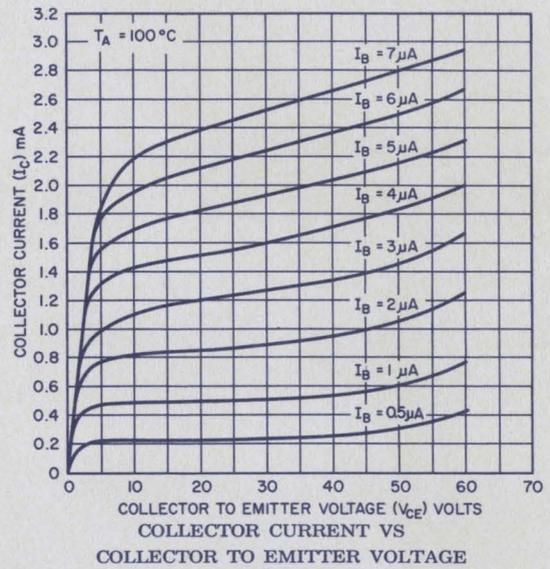


FIGURE 3

## COLLECTOR CHARACTERISTICS • COMMON EMITTER

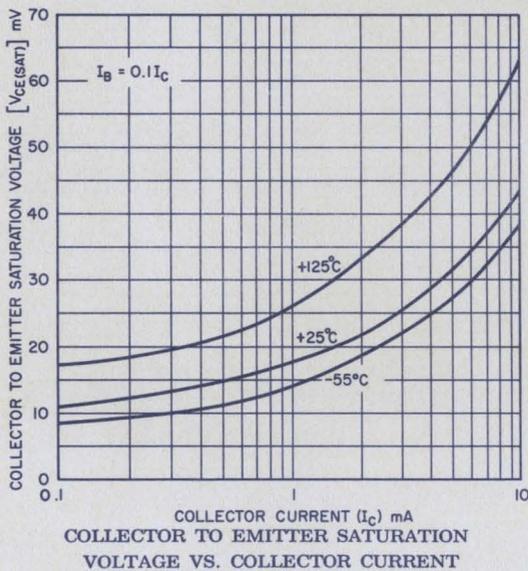


FIGURE 4

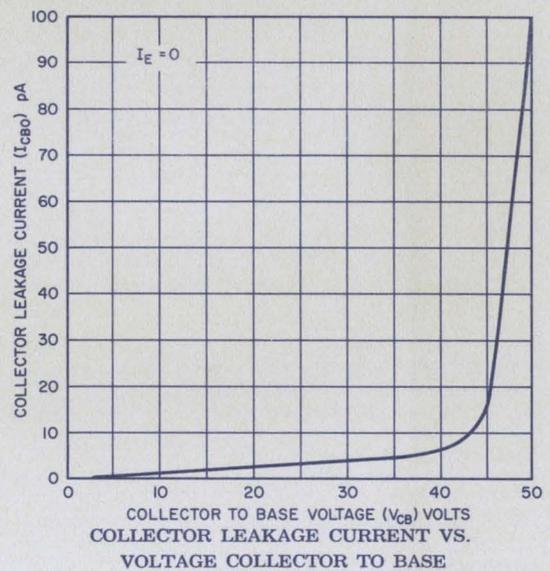


FIGURE 5

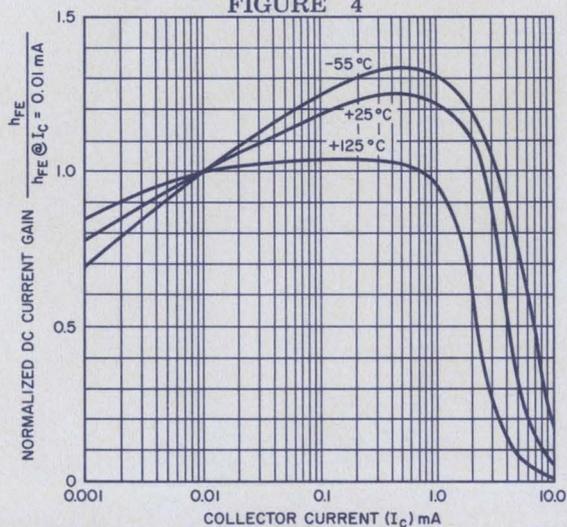


FIGURE 6

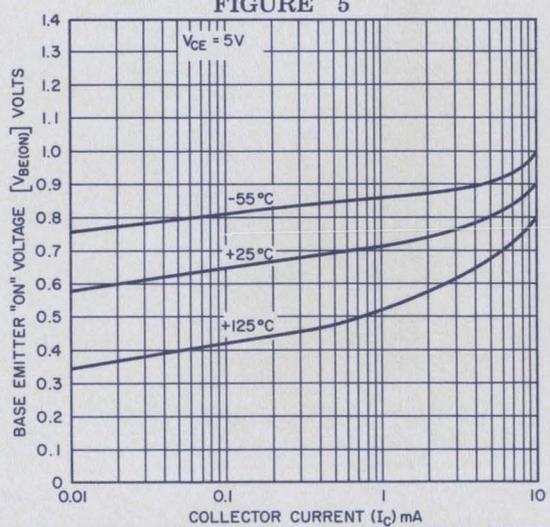


FIGURE 7

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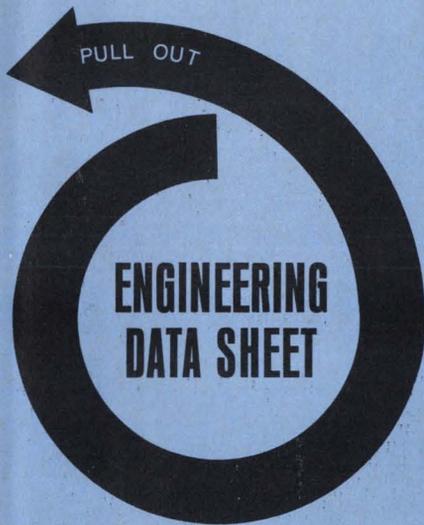
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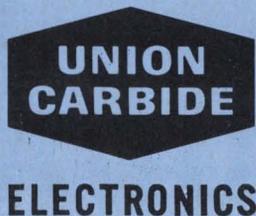
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## Letters

### Humor separates men from mere machines

Sir:

I was rereading a July issue of ED [ED 17, July 19, 1966, p. 38] and ran across a letter criticizing ED for "frivolity" in reference to a tree receptacle for electric cars. I say hurrah for ED for having a little variety in presentation and allowing those capable to see some humor with the technical content.

I applaud all technical magazines that add a touch of humor and cartooning to avoid being just another sterile volume of data. While it may be more "efficient" to do away with humor and all personal touches, this eventually reduces people to the point where they become merely machines digesting the information fed to them.

Some people would perhaps like to have the material presented to them on a set of microfilm IBM cards. While this type of presentation may be suitable for machines and for reference, I feel that the technical magazine is not a medium that should be without character.

Phil Erdman  
Sr. Electronic Engineer  
Mountain View, Calif.

### Bugs should not be outlawed

Sir:

Congratulations on your editorial, "Don't make them throw all those bugs away" [ED 1, Jan. 4, 1967, p. 67]. Obtaining warrants for bugging should be permitted using the same guidelines under which search warrants are issued, and any evidence obtained under that warrant should be admissible in court. A search warrant cannot be issued unless a good reason is given—random searching of houses is definitely forbidden. So be it with bugging. The law-abiding citizen has nothing to fear from bugs.

Bugging or electronic eavesdrop-

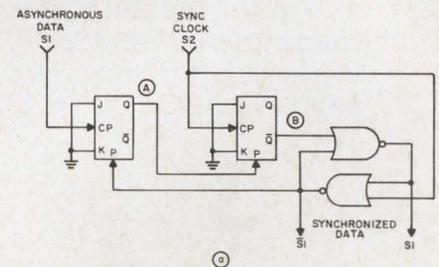
ping has become so tainted in the public eye, I feel a new term should be coined for such activities. I propose "electronic intelligence."

Fred Carlson

Applications Engineer  
Somerville, N. J.

### Accuracy is our policy

In "Integrated dual-storage system solves synchronization need," ED 21, Sept. 13, 1966, pp. 88-90, author Jay Freeman notes that all solder dots were omitted from the published schematic. It is reproduced below with the solder dots inserted. He also notes that in the published waveshapes, the label *sync data* was misplaced. It should be alongside the second *S1* waveshape, so that it is clear that it applies to all the latter three waveshapes.



In "Use integrated circuits in process controls," ED 1, Jan. 4, 1967, pp. 118-121, author Roland Best has drawn attention to two inaccurate statements.

On p. 119, left-hand column, lines 13-16, the sentence should read: "To minimize this interference, the operating frequency is selected in the region where the closed-loop gain of the control system is much less than unity," not "... where the gain of the process transfer function is at its lowest." Mr. Best notes that, in most processes, gain is lowest at infinite frequency, but infinite switching frequency is a meaningless concept.

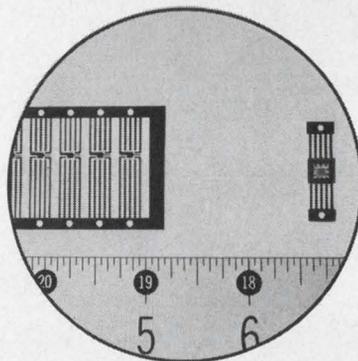
The caption under Fig. 3 on p. 120 should read: "To prevent this interference, the pulse, at a 50% duty cycle, should have a frequency outside the pass-band of the control system." It cannot be the pass band of the operational amplifier, as printed, because the switching waveform is generated by the operational amplifier itself.

# We are not trying to sell you anything...

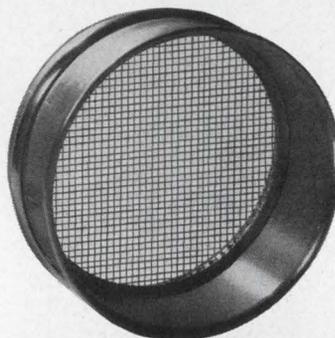
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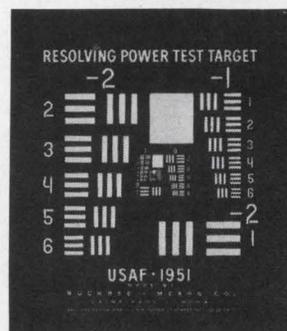
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## EDITORIAL



## And where are the Steinmetzes of today?

During the first quarter of this century, the name General Electric was almost synonymous with alternating current, and alternating current synonymous with a misshapen hunchback who clenched a fat, black cigar in the molars of his grizzly jaw. Through the dense, bluish-grey smoke that encircled the little man's big head shone the twinkling eyes of Charles Proteus Steinmetz.

That cigar went wherever Steinmetz went, and at General Electric, Steinmetz went where he pleased. As he hobbled through a laboratory, fumes from his cigar curled round delicate equipment as well as "no smoking" signs. His company never complained. On the contrary, General Electric gave Steinmetz something it never gave any of its presidents: a blank check. He could do what he pleased, do it when he pleased, hire whomever he pleased and buy what he pleased. If Steinmetz wanted a laboratory (or even a home) in a certain place, General Electric bought it for him. And if it couldn't buy it, it built it. Behind that twinkle, Steinmetz had a marvelous mind, and everyone knew it.

Yet an encyclopedia published in 1923, the year of Steinmetz's death, devoted a page to Thomas Alva Edison's search for a good filament but not a single line to Steinmetz. The hunchback wasn't the poor American boy who made good. He was an ugly, deformed man who was forced to flee Germany because he was a Socialist.

Where is the Steinmetz of today? If he looks presentable, he might be moving up the management ladder in your company. If he doesn't, he might be looking for a job. Perhaps he suffers neither fate. He could, for example, work at a university or for the Federal Government. There should be a place in industry where he can create and flourish. A few large corporations have research laboratories, removed from the production line, which maintain an academic atmosphere.

But are the Murray Hills, Princetons and Yorktowns really enough? Where can those engineers work who are, say, half a Steinmetz or a fourth of a Steinmetz?

Each engineer should be encouraged to launch great ideas from the desk he now occupies. And each firm, if it aspires to the twenty-first century, must ensure adequate advancement opportunities for those who love to create, as well as for those who are inclined to manage creative people.

Look around you! The Steinmetz of our generation may be sitting at the next desk. He might be a pimply youngster fresh out of college. He might be a distinguished gentleman with greying temples. He might even be a little hunchback with a cigar in his mouth and a twinkle in his eye.

ROGER KENNETH FIELD

# Here's A PNP Silicon RF Transistor That's Going To Change The Polarity of A Lot of Present Designs!



TO-72

3.0 dB max. Noise Figure } @ 450 MHz  
17 dB min. Power Gain }  
1200 MHz min  $f_T$

An easy modification of the bias arrangement of your NPN circuit — by simply reversing dc polarity, or grounding the emitter circuit instead of collector circuit (or vice versa) — and you're ready to plug in the far superior performance of the new Motorola silicon PNP 2N4957-9 VHF/UHF transistors.

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What's more, with these PNP devices you can have

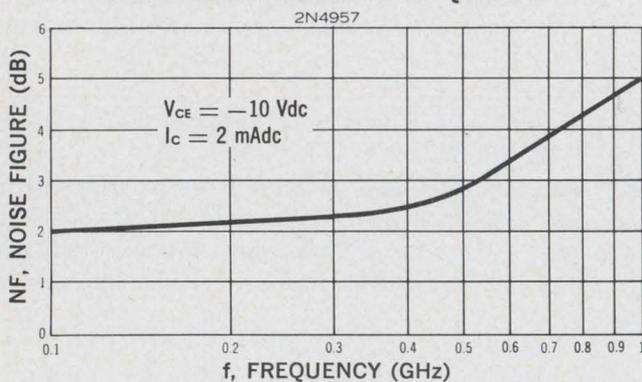
silicon noise figures that are comparable to low-noise PNP germanium at prices as low as \$4.50 (100-up lots)! (Incidentally, Motorola also can supply NPN devices 2N2857 and 2N3839 if that's what you're presently using!)

These "state-of-the-art" devices are available at low prices, too:

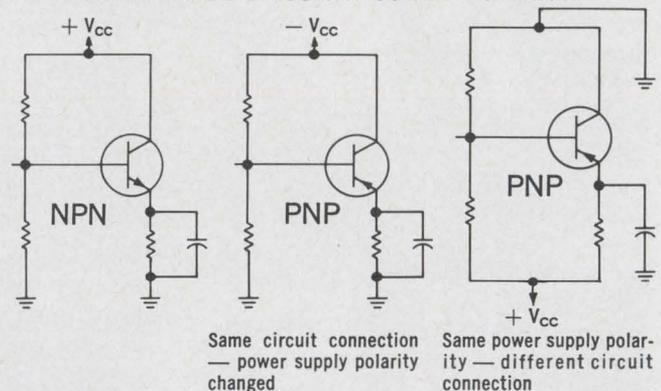
Type	100-up
2N4957	\$13.50
2N4958	6.90
2N4959	4.50

For evaluation units and application information, see your Motorola sales representative. For detailed data sheets, write Motorola Semiconductor Products Inc., Box 955, Phoenix, Arizona 85001.

TYPICAL NOISE FIGURE vs. FREQUENCY



CHANGING DC CIRCUITRY TO PNP POLARITY:

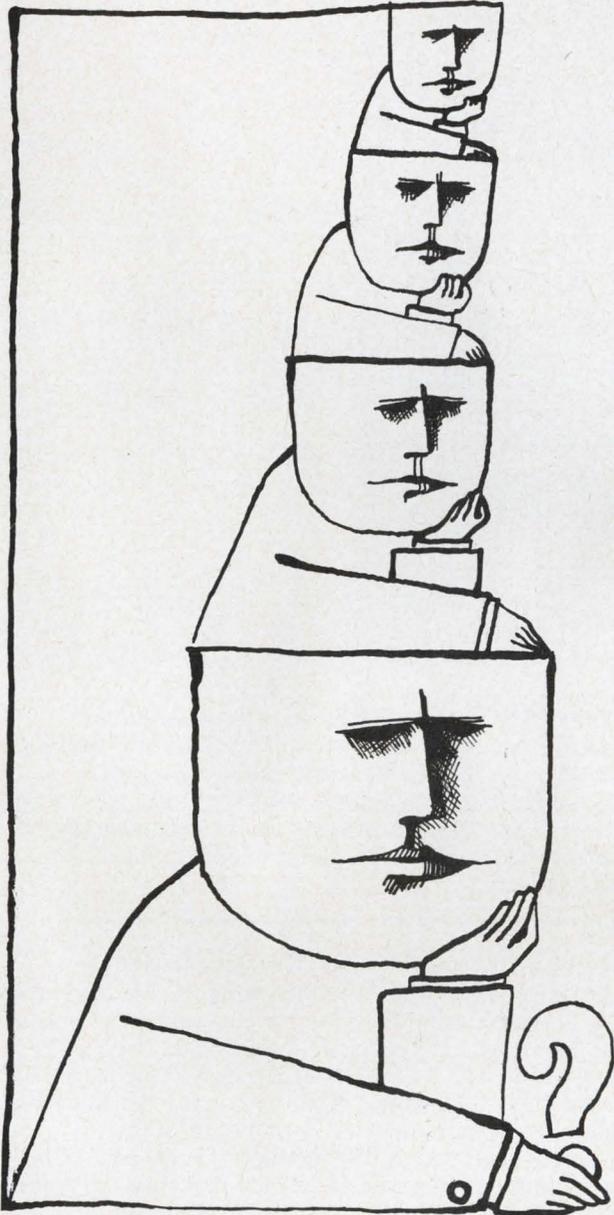


— where the priceless ingredient is care!

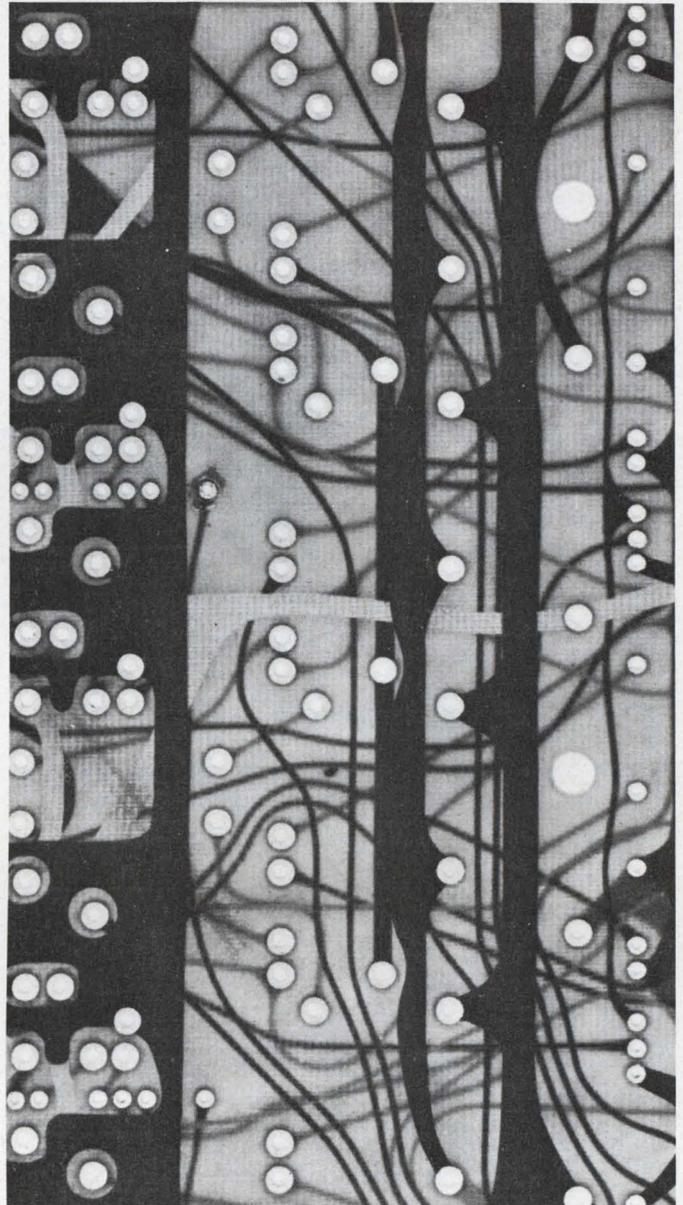


**MOTOROLA**  
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# Technology



Pass personality tests with flying colors by answering what they want to hear. Page 92



Choice of the proper prepreg is a vital point in the design of good multilayer boards. Page 70

## Also in this section:

Digital techniques and curve-fitting yield accurate function generators. Page 59

Field-effect transistors give better FM performance than bipolars. Page 63

Design black boxes so that they fit systems without needing to be modified. Page 76

Relays and semiconductors together hike circuits' power-handling ability. Page 84

# New 18 MHz wave analyzer system

Ideal for lab and production use  
Ideal for communications systems



**It's precise...** Digital frequency readout with 10 Hz resolution and 2 ppm/week stability.

Amplitude measurements to  $< -110$  dBm with  $\pm 0.2$  dB flatness to 10 MHz,  $\pm 0.5$  dB to 18 MHz.

AFC locks analyzer to signal; frequency indicator displays any signal drift.

**It's versatile...** Flexible input selection—wide range of impedances, balanced or unbalanced, bridged or terminated; or use 0 dB-loss probe.

Three selectable bandwidths—200 Hz, 1000 Hz, 3000 Hz—for all measurement needs; and with high selectivity ( $> 60$  dB down when only 2.2 times 3 dB bandwidth).

## High Accuracy Wave Analyzer

Measure all frequency components from 10 kHz to 18 MHz with the HP 312A Wave Analyzer. High selectivity lets you separate the input components, and high sensitivity, plus wide dynamic range, lets you measure the fundamental, harmonics and intermodulation products. The digital frequency indicator pinpoints signal frequencies exactly, with no errors from tuning backlash, dial nonlinearities and the like.

The 312A's wide frequency coverage, its high stability, sensitivity, selectivity, and its wide selection of all common input impedances make it outstanding for maintaining multiplex communications systems. Such measurements as distortion, attenuation, crosstalk and frequency response are made quickly, easily and accurately.

Price: HP Model 312A Wave Analyzer, \$3900

## Full Test System with HP 313A Tracking Oscillator

When you combine the 313A Tracking Oscillator with the 312A Wave Analyzer, you have a complete "closed-loop" measurement system operating at the frequency setting of the 312A. The 313A Tracking Oscillator delivers up to +10 dBm output with  $\pm 0.1$  dB full range frequency response, and has a precision 100 dB attenuator calibrated in 0.1 dB steps. The 312A/313A combination can measure frequency response of circuits having 100 dB gain, with amplitude resolution approaching 0.02 dB.

The 313A can also be operated separately as a wideband (10 kHz-22 MHz), flat ( $\pm 0.1$  dB) signal generator with its precision 100 dB output attenuator.

Price: HP Model 313A Tracking Oscillator, \$1250

For complete data, call your HP field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

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# Generate time functions digitally.

Used with curve-fitting, digital techniques produce accurate and drift-free function generators.

Accurate function generation is required in many instrumentation and simulation systems. Certain systems require the generation of "unique" functions of time; for example, the generation of antenna patterns, target positions, etc., for electronic warfare simulators.

Some of these functions can essentially be described only graphically; others, such as cubic, reciprocal and parabolic functions, have a definite mathematical relationship. The curves that define these time functions can be approximated to any required degree of accuracy by straight line segments, as shown in Fig. 1. The higher the frequency components in the signal being generated, the more line segments have to be used over a given interval of time to achieve the desired precision.

The use of curve-fitting and digital techniques for function generation offers two important advantages:

- Accuracy is very high.
- Adjustments are unnecessary—that is, no zeroing or calibration is needed. The system is thus drift-free.

With these techniques digital functions are generated instantaneously and an analog equivalent is obtained easily and at low cost. If some sort of analog-function generation is used, the digital equivalent would be more difficult and costly to obtain.

A digital function generation system is shown in the block diagram of Fig. 2. The heart of the system is an up-down counter, which stores the function of time in a digital form. A digital-to-analog converter gives the generated function in analog form. Interval-determining cells control which line segment of the approximated curve is being generated at any particular time. Frequency-division cells generate the counter clocking rate. The clocking rate is the absolute value of the slope of the line segment for a particular interval.

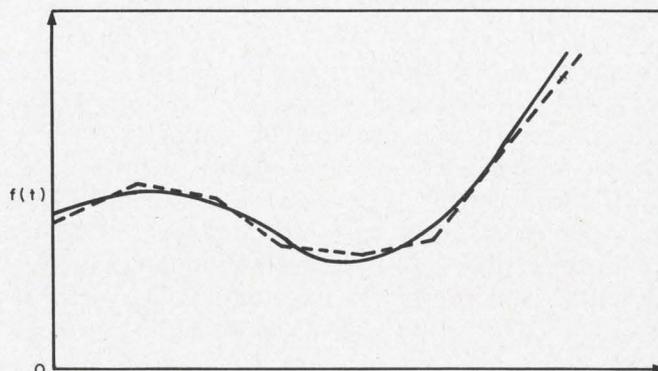
If the slope of the line segment is positive, the counter is counting up at the clocking rate; if the slope is negative, the counter is counting down at the clocking rate.

Operation of the digital function generation system is initiated by a start signal. The start signal resets the up-down counter, interval-determining cells, and frequency-division cells. The system clocks along the initial line segment until the counter reaches the particular value where the second line segment is to start. This value is detected by the interval-determining cells, which command the frequency-division cells to switch to the appropriate clocking rate. This action continues until a predetermined time is reached, a predetermined level is reached, or until a pulse is received by the system.

Three general classes of function generation are possible with this system: periodic, one-shot and start-stop.

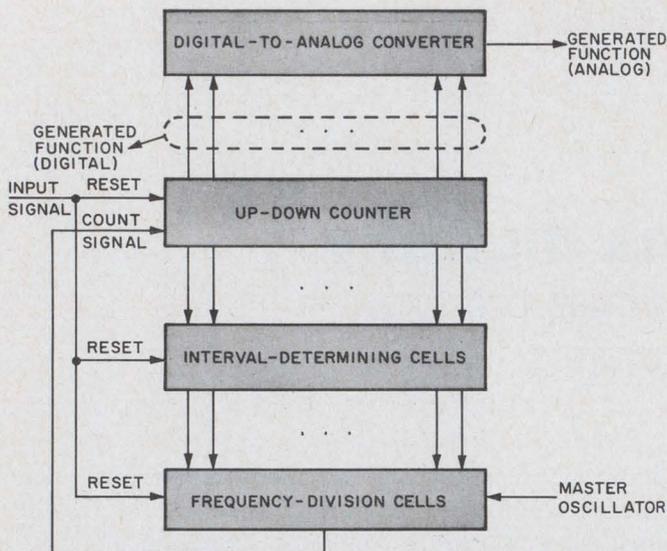
*Periodic generation* produces a portion of the time function (a quarter cycle of a sine wave, for example) repetitively. All the counting, reset and set pulses are generated internally during operation. Periodic generation, triggered by a start signal, continues until a stop signal is received by the generator.

*One-shot function generation* is also initiated by a start signal. In this case, the counter counts for



1. Straight-line segments can be used to approximate a nonlinear function of time. As straight-line segments are made smaller, the approximation becomes more accurate.

Roy A. Griffis, Manager, Data Handling Division, and Charles W. Skinn, Project Engineer, Systems Research Laboratories, Inc., Dayton, Ohio.



2. Time functions can be generated digitally with a system such as this. Flip-flops are used for both interval-determining and frequency-division cells.

some predetermined time or until some predetermined level is reached and then holds. The time function is thus generated only once.

*Start-stop generation* generates a particular function. The time function is generated from the moment the start signal is received until a stop signal is received.

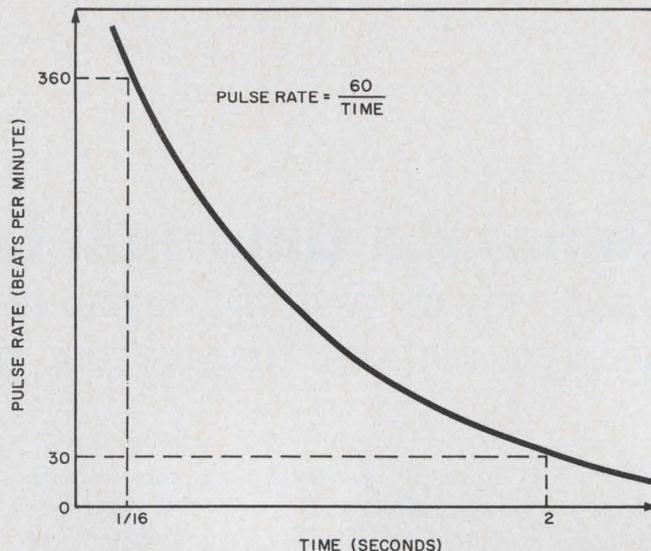
### Cardiotachometer proves technique

Employing the concept of digital function generation, a cardiotachometer was designed, built and tested. This cardiotachometer, an example of start-stop generation, is an instantaneous, beat-to-beat measuring device that gives continuous readout. No averaging is done.

In this application, only the corresponding pulse rate between two incoming pulses is of interest, not the entire reciprocal relationship. Therefore, the block diagram of Fig. 2 is modified by the addition of a memory unit between the counter and readout. Every time a pulse enters the cardiotachometer, the pulse rate corresponding to the time between the previous pulse and the one that has just entered is transferred to the memory unit and displayed visually.

Pulse rate versus time is shown in Fig. 3. Pulse rate is a reciprocal function of time,  $R = 60/t$ , where the pulse rate  $R$  is measured in beats per minute and time,  $t$ , is measured in seconds. The range covered by the cardiotachometer was 30 to 360 beats a minute. With a minimum of hardware, the pulse rate curve was approximated to within one count (beat) by use of 11 straight-line segments.

As given above, the true pulse rate is  $R_T = 60/t$ . The approximated pulse rate is  $R_A = mt + R_I$ , where  $m$  is the slope of the segment and  $R_I$  is the



3. Pulse rate is plotted as a function of time. Digital techniques can be used to produce an accurate record of this curve. Actual data obtained are shown in the Table.

zero intercept. Thus the error,  $\epsilon$ , can be expressed as:

$$\begin{aligned} \epsilon &= R_A - R_T \\ &= mt + R_I - 60/t. \end{aligned}$$

By differentiating the above function  $\epsilon$ , the maximum error  $\epsilon_M$  is found to occur when  $t = [60/(-m)]^{1/2}$ :

$$\epsilon_M = -(-240m)^{1/2} + R_I.$$

With the criterion that the approximation is to be within one beat per minute over the range of 30 to 360 beats per minute, the initial point picked is  $360 - 1 = 359$  beats per minute at  $t = 1/6$  second.

$$\begin{aligned} \therefore 359 &= m(1/6) + R_I, \\ R_I &= 359 - m/6, \\ \epsilon_M &= 359 - (-240m)^{1/2} - m/6. \end{aligned}$$

Set  $\epsilon_M = +1$  beat per minute.

$$\therefore m = -1847 \text{ beats per minute per second.}$$

$\epsilon_M$  will be less than 1 beat per minute if  $m < -1847$ ; so to keep hardware to a minimum, a "nice" value of  $m = -2000$  is chosen. Thus the clocking rate of the first line segment will be 2000 Hz.

$$\begin{aligned} R_I &= 359 - m/6 \\ &= 359 - (-2000)/6 \\ &= 692.3 \end{aligned}$$

Since a full period occurs before the counter counts down a count, the initial stored count should be the integer lower than 692.3. Thus the initial value stored in the counter (binary-coded decimal down-counter) is 692.

When  $\epsilon = -1$ , the first line segment will terminate.  $\epsilon = -1$  when  $R_T = 333.3$ . At this point,  $R_A = 332.3$ . Therefore, the first segment will end at the integer higher than 332.3, or 333 beats per minute. The second segment starts at the point where  $R_A = 333$  and  $t = (333 - 692)/(-2000) = 0.180$  seconds. This previously described math-

**Table. Cardi tachometer response**

Time (ms)	True readout (beats per minute)	Measured readout (beats per minute)
165	364	363
170	353	353
175	343	343
180	333	333
185	324	324
190	316	316
200	300	301
210	286	286
220	272.5	273
230	261	261
240	250	250
260	231	231
280	214	214
300	200	201
320	187.6	188
340	176.5	177
360	167	167
380	158	159
400	150	151
440	136	136
480	125	126
520	115	116
560	107	107
600	100	101
700	86	86
800	75	76
900	67	68
1000	60	60
1200	50	51
1400	43	44
1600	37.5	38
1800	33	34
2000	30	30

emational process is continued until 30 beats per minute is reached.

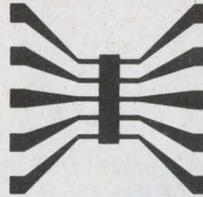
The master oscillator frequency has to be a multiple of the least common multiple of the 11 clocking frequencies required. In this case, 24 kHz was the least common multiple and was the frequency used.

The frequency division cells are reset each time a count signal is generated. Therefore there is no asynchronization between one line segment and the preceding or following line segments. There is an asynchronization between the input signal and the master oscillator, which can produce a start-stop error of up to one beat per minute. This error can be essentially eliminated by making the oscillator frequency much greater than any required clocking frequency—that is, 24,000 >> 2000.

Two digital cardi tachometers were fabricated, and the time response data (see Table) obtained for each instrument were identical. ■ ■

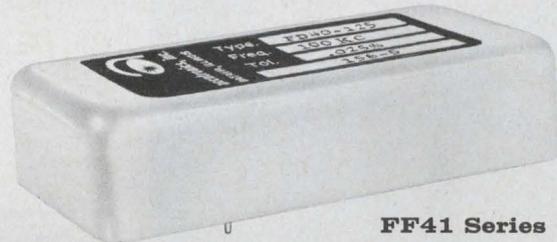
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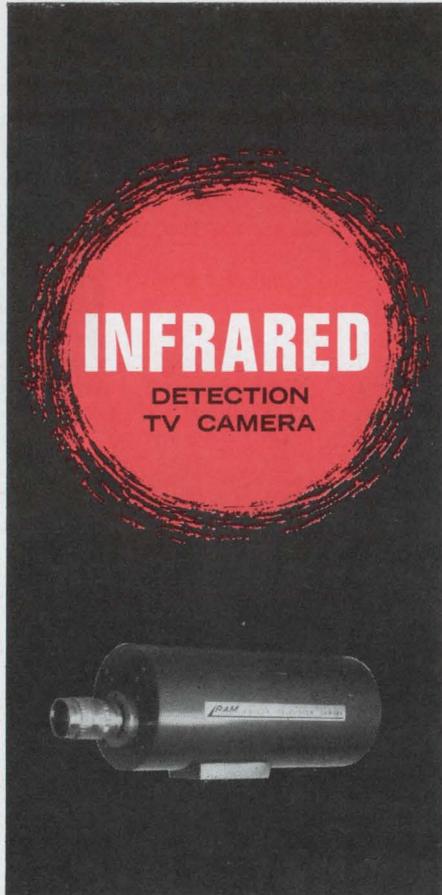
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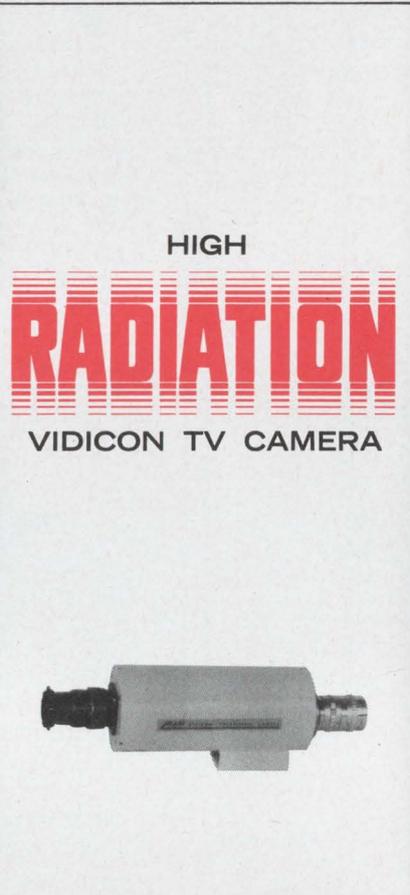
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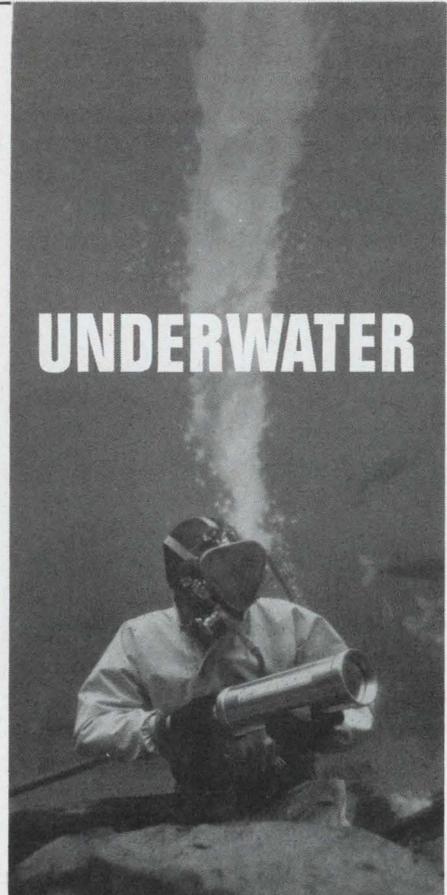
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# Improve FM performance with FETs.

Point-by-point comparison of three FM tuners indicates FETs' superiority to bipolars.

It is well recognized that the field-effect transistor's nearly perfect square-law transfer characteristic makes it an almost ideal mixer, as far as spurious-response immunity is concerned. But in this application, less conversion gain can usually be obtained from it than from the bipolar transistor. What is less well recognized, however, is that the FET is a superior RF device to the bipolar and *no* performance sacrifices have in fact to be made.

Three practical FM front-end circuits demonstrate how the performance of junction-FETs compares with that of bipolar transistors. The first circuit has a FET RF amplifier, FET mixer, and a bipolar-transistor local oscillator. The second circuit has a FET RF amplifier, a bipolar-transistor mixer, and a bipolar-transistor local oscillator. The third circuit has bipolar transistors in all three places.

Each of the three front ends was designed to be compatible with economical high-volume manufacture; for example, slug-tuned, practical size coils were used. At the expense of tracking difficulty, spurious-response rejections could have been improved, had extremely high-*Q* coils been used. Moreover, a three-section tuning capacitor was selected rather than a more expensive four-section capacitor. All parts for the three circuits are listed in the box.

In each case performance data were taken with the same moderate-gain, unneutralized, three-stage IF amplifier, so that the signal-to-noise performance of front ends with different power gains could be properly compared. Use of a high-gain three- or four-stage IF amplifier that causes limiting to occur at a few microvolts will significantly improve the signal-to-noise performance of an FM receiver. With a high-gain IF amplifier, usable sensitivities of less than  $2 \mu\text{V}$  are easily achieved for each of the three front ends.

Comparison of the performance of the three circuits show that:

- All three circuits provide nearly the same signal-to-noise performance.

- The junction-FET mixer has lower conversion gain than does the bipolar-transistor mixer.
- The junction-FET mixer exhibits far superior spurious rejection than the bipolar-transistor mixer.
- The over-all performance of the FET RF amplifier is much better than that of the bipolar-transistor RF amplifier.

## Improve spurious-response rejection with FETs

In Fig. 1a, the RF amplifier is an n-channel silicon TIS34 in the unneutralized common-source configuration with a single-tuned input and

### PARTS LIST

#### Parts for the circuit of Fig. 1a

- L1: 3T, #18 bus, 7/16 in.-length, tapped at 0.5T and 1.5T, wound on 1/4-in. paper form with powdered iron core (Arnold A1-13J)
- L2: 2.7T, #18 bus, 3/8 in.-length, tapped at 1.2T, wound on 1/4-in. paper form with powdered iron core (Arnold A1-13J)
- L3: 2.5T, #18 bus, 5/8-in. length, tapped at 0.4T, wound on 1/4-in. paper form with powdered iron core (Arnold A1-13J)
- C1: 6-21 pF
- 10.7 MHz IF transformer:
  - Primary:  $Q$  (uncoupled) = 72  
CT = 33 pF
  - Secondary: designed as part of IF amplifier

#### Parts for the circuit of Fig. 3a

- L1: Same as for Fig. 1 except tapped at 0.5T and 2.5T.
- L2: Same as for Fig. 1 except tapped at 0.8T.
- L3: Same as for Fig. 1 except no tap.
- C1: Same as for Fig. 1.
- 10.7 MHz IF transformer: Same as for Fig. 1.

#### Parts for the circuit of Fig. 4a

- L1: Same as for Fig. 1 except tapped only at 0.8T.
- L2: Same as for Fig. 1 except tapped at 0.6T.
- L3: Same as for Fig. 1 except no tap.
- C1: Same as for Fig. 1.
- 10.7 MHz IF transformer: Same as for Fig. 1.

David N. Leonard, Texas Instruments, Inc., Dallas.

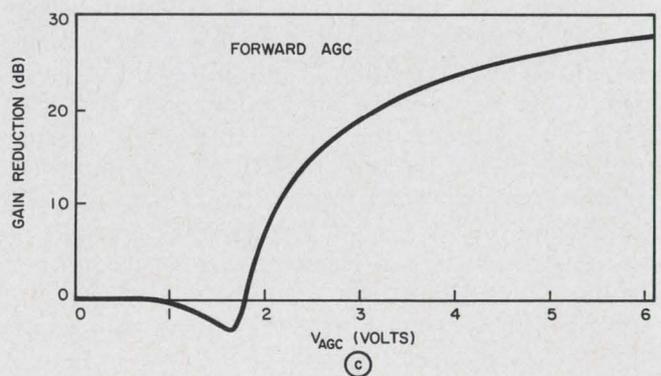
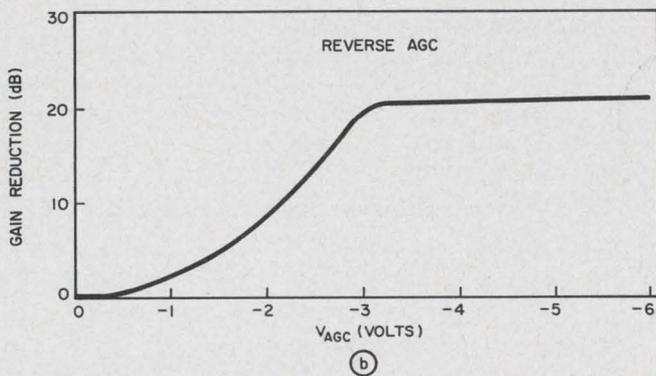
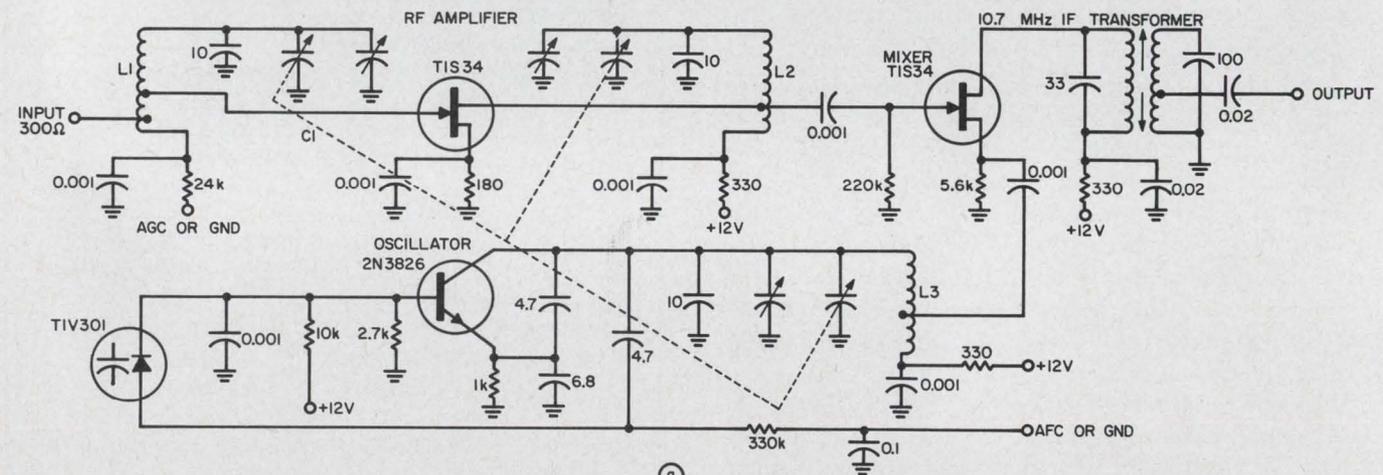
single-tuned output. The device is self-biased to a drain current of approximately  $I_{DSS}/2$  as an adequate compromise between device interchangeability, spurious-response rejection and gain.

Since the junction-FET is normally operated with the gate-source diode reverse-biased (that is, in the depletion mode), it is customary to turn the device off to obtain agc action. This may be classified as "reverse agc" (Fig. 1b). The gain reduction is primarily the result of decreasing forward transadmittance. The advantages of reverse agc are that very little agc power is required and the over-all selectivity of the RF stage remains almost unchanged. However, not only is "forward agc" possible, but in some respects it is better than reverse agc.

Forward agc (Fig. 1c) is realized by forward-biasing the gate-source diode. The gate current is restricted to a safe value by the 24-kilohm resistor. A very low impedance is presented to the antenna tank when the gate-source diode becomes forward-biased. Also, as the drain current increases, more voltage is dropped across the 180-ohm source biasing resistor and the 330-ohm drain circuit decoupling resistor. The drain-to-source voltage,  $V_{DS}$ , is thus made to decrease. When  $V_{DS}$  is small, output impedance is low. Furthermore, with sufficient gate current, the forward transadmittance becomes quite small.

More agc action can usually be obtained with forward agc than with reverse agc. A drawback of forward agc is that the reduced RF stage selectivity degrades spurious-response rejection. This is not a problem, though, if the agc is delayed until fairly strong signals are being received. The reverse and forward agc characteristics appear in Figs. 1b and 1c, respectively. The forward agc characteristic may be altered by changing the values of the gate bias resistor, source bias resistor, or drain circuit decoupling resistor. Contrary to what might be expected, almost no detuning of the front end is observed with reverse or with forward agc.

The mixer in Fig. 1a is another TIS34. The mixer is biased at a low drain current ( $I_D \approx 0.3$  mA) for best conversion gain. Biasing the drain current at  $I_{DSS}/4$  would result in better large-signal-handling capability and significantly better spurious-response rejection at the expense of conversion gain. Input signal is fed into the gate, while 440 mV of oscillator voltage is injected into the source. Injecting oscillator voltage into a terminal different from the signal results in almost no tuning interaction between the RF tank and the oscillator tank. The desired amount of oscillator injection is mostly dependent on the mixer's gate-source quiescent bias point. For the bias in Fig. 1a, increasing the oscillator injection



1. FETs in RF and mixer stages of an FM tuner improve the over-all performance. Forward agc gives more gain

reduction (c). Note the use of the inexpensive three-section tuning capacitor (a).

**Table. FM Front end performance comparison.\***

	Figure 1a	Figure 3a	Figure 4a	Units
1. Sensitivity for 30-dB(S+N)/N at $\pm 22.5$ -kHz deviation	4.0	3.5	4.5	$\mu V$
2. Sensitivity for 30-dB(S+N)/N at $\pm 75$ -kHz deviation.	2.7	2.5	3.0	$\mu V$
3. Tuner power gain neglecting 14-dB loss of 10.7-MHz IF transformer secondary	17.8	35.8	31.8	dB
4. Tuner 6-dB bandwidth	400	425	450	kHz
5. Image rejection (119.4 MHz)	57	53	52	dB
6. Number of spurious responses less than 85 dB	3	16	73	
7. Reverse agc action	21	28	30	dB
8. Forward agc action	30	45	45	dB
9. Afc pull for $\Delta V_{AFC} = \pm 1V$	125	125	125	kHz
10. Oscillator injection voltage	440	100	110	mV

\*Note the difference in the number of spurious responses less than 85 dB.

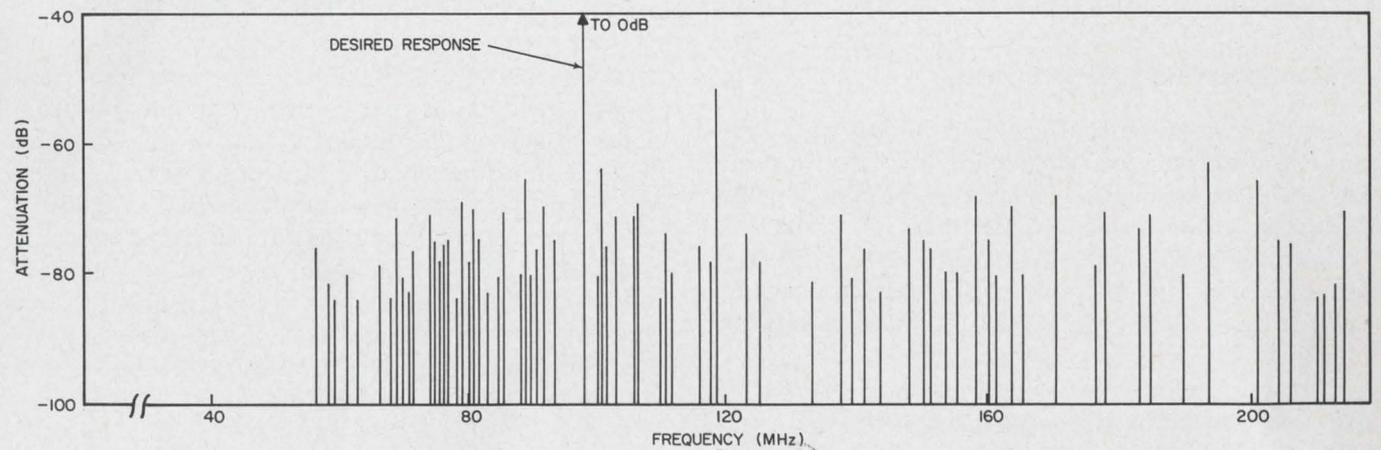
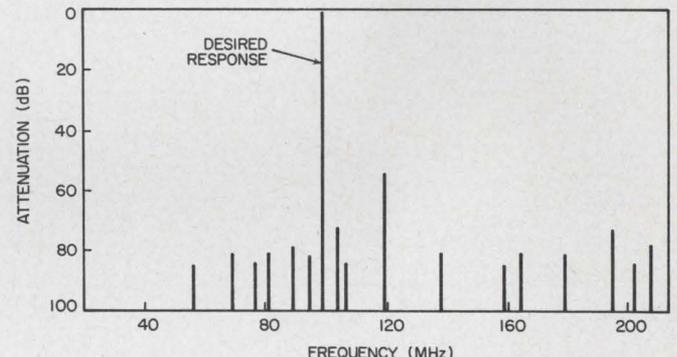
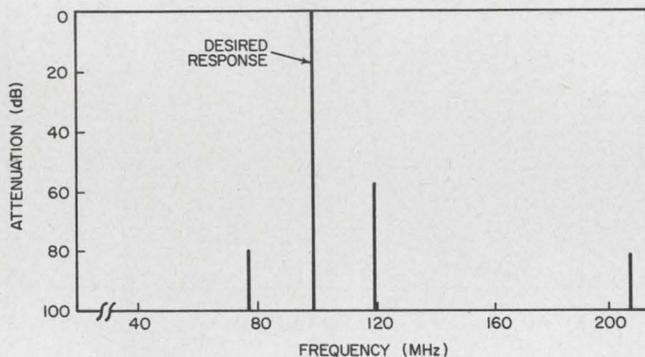
to 560 mV increases the conversion gain by 1.5 dB, but reduces  $(f_o + IF)/2$  rejection from 88 dB to 78 dB. Coupling from the RF tank to the mixer with a fairly large capacitor ( $0.001 \mu F$ ) eliminates the need for a 10.7-MHz trap at the mixer input.

The spectrum of spurious responses is shown in Fig. 2a. The receiver was tuned to 98 MHz and a reference audio output was established at the ratio detector output with a  $3.5\text{-}\mu V$  input signal. The input signal was then increased to a value greater than  $65,000 \mu V$  and the generator frequen-

cy was varied from 54 MHz to 216 MHz. All spurious responses (excluding those caused by generator spurious responses) that were less than 85 dB down from the  $3.5\text{-}\mu V$  input level were recorded.

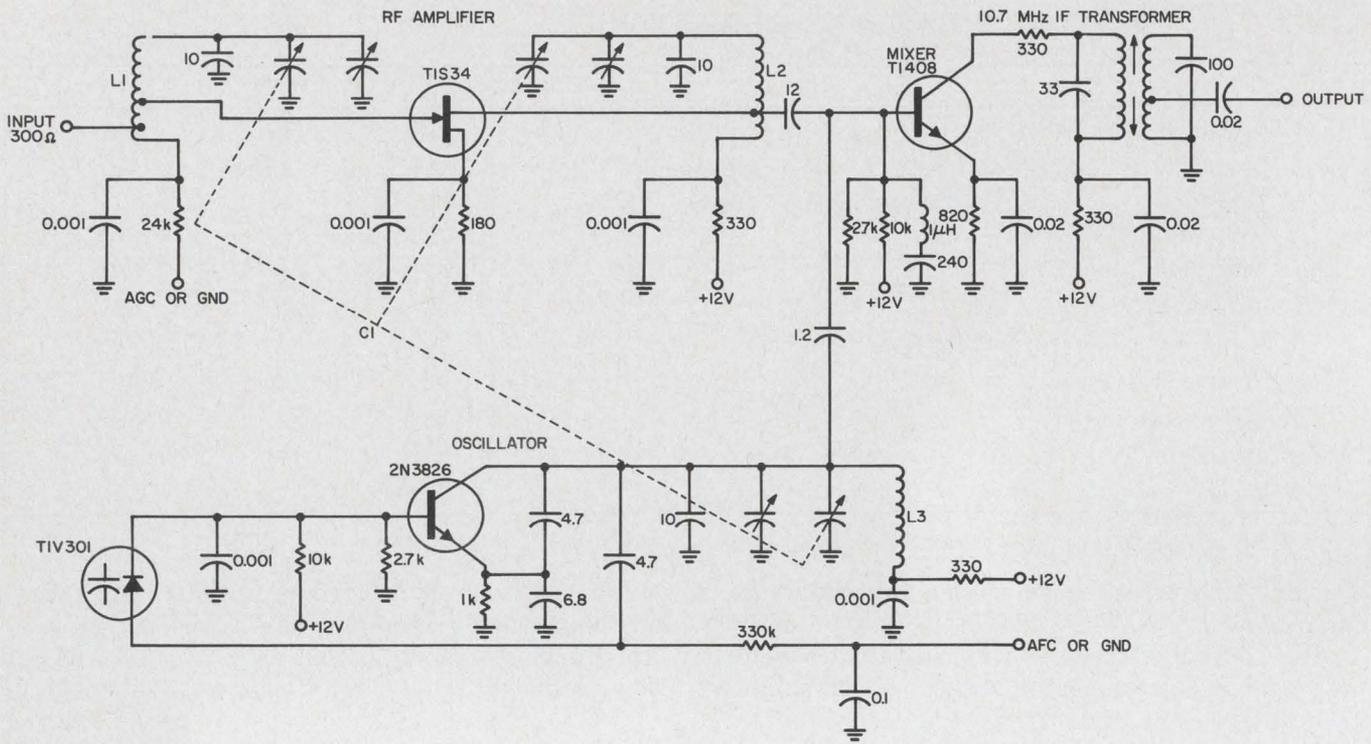
The oscillator is a low-cost, silicon, bipolar transistor in the conventional common-base Colpitts configuration. Performance of the FET-RF-Amplifier, FET-mixer and bipolar oscillator circuit is summarized in Table I along with similar data for the other two front end circuits.

(continued on p. 66)

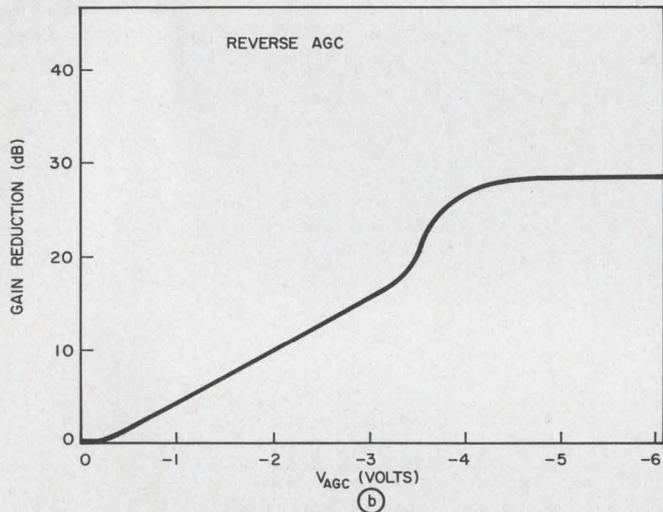


2. Only three spurious responses below 85 dB were observed with the FET-RF and FET-mixer tuner (a). This

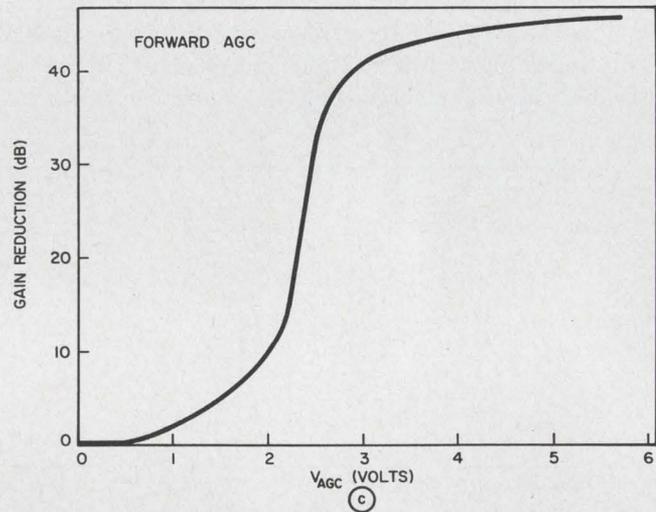
compares with sixteen responses with only FET-RF (b) and with 73 responses with a purely bipolar tuner (c).



(a)



(b)



(c)

3. Replacing mixer FET with a bipolar results in worse tuner performance. Both reverse (b) and forward (c) agcs

give more gain reduction than those of the circuit of Fig. 1, but spurious response rejection (Fig. 2b) is worse.

### Bipolar mixer lowers performance

In the next circuit (Fig. 3a), the RF amplifier and the oscillator are almost identical to those of Fig. 1a. The mixer, however, is a silicon, bipolar transistor biased at about 2.3 mA.

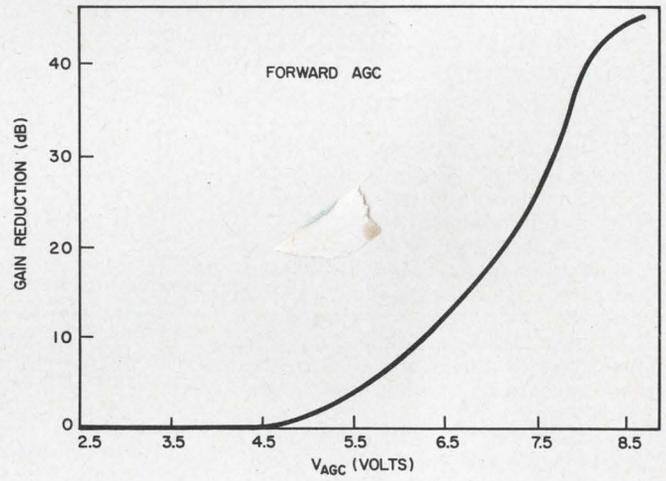
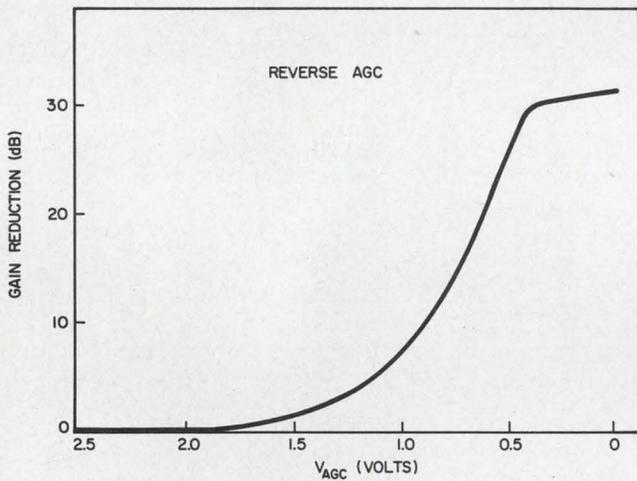
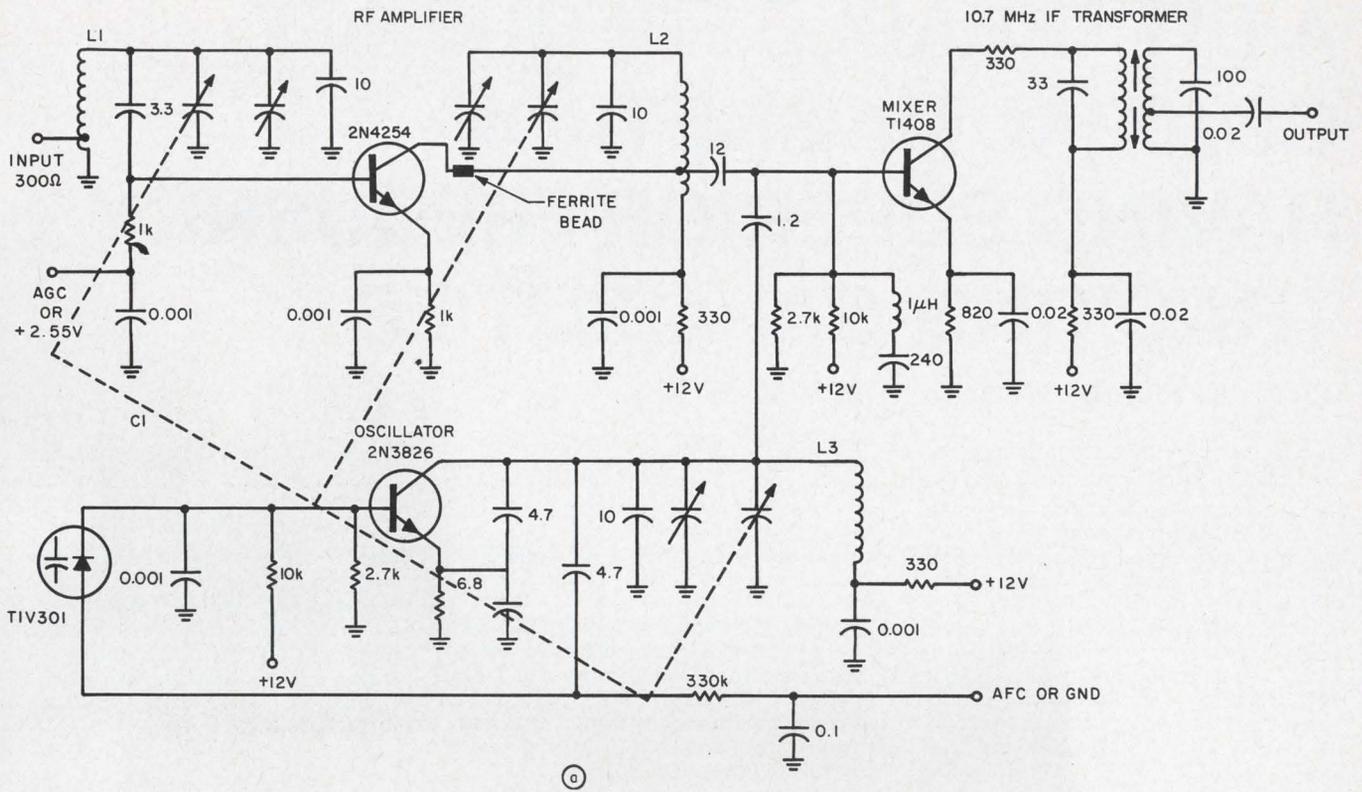
Both forward- and reverse-agc characteristics are shown in Figs. 3c and 3b, respectively. As in the last case, more gain reduction is achieved with forward than with reverse agc.

The spurious-response spectrum is illustrated in Fig. 2b. In comparison with the FET-RF and FET-mixer front end previously discussed, Fig. 2b and Table I indicate that the bipolar-transistor mixer gives lower spurious-response rejection, but

provides about 18 dB more conversion gain. The logical question at this point is whether the oscillator injection, the mixer's bias, or the driving-source impedance of the bipolar mixer can be so modified that some or all of the additional conversion gain can be traded for spurious-response rejection that will be equal to that of the FET mixer. Experimental data (not included here) indicate that the magnitude of the spurious responses can be improved by several dB but is still inferior to that of the FET mixer.

### All bipolar tuner is the worst case

The last of the three circuits is shown in Fig.



4. The over-all tuner performance is degraded even more when all FETs are replaced by bipolars. Note that the agc

curves did not change appreciably compared with the circuit of Fig. 3 (FET-RF, bipolar mixer).

4a. Except for the RF stage, this front end is the same as the previous one. The RF device is a good, high-frequency, silicon, bipolar transistor biased at about 1.8 mA.

from 16, when using a FET RF device, to 73, when using a bipolar RF device! The fact that image rejection (119.4 MHz) is almost identical from one circuit to the next is a good indication that the RF selectivity is very nearly the same for both circuits.

The reverse and forward agc characteristics are shown in Figs. 4b and 4c, respectively. The agc characteristics of the all-bipolar front end are fairly similar to those of the previous two.

A close inspection of the spurious-response spectrum of the FET RF-bipolar mixer (Fig. 2b), with the spurious-response spectrum of the bipolar RF-bipolar mixer (Fig. 2c) shows that several of the spurious responses are unchanged, and hence must be generated by the bipolar-mixer transistor. Some of the other spurious responses, however, are improved by as much as 16 dB simply by use of a FET for the RF amplifier. ■ ■

The performance data of Table I show that, compared with the previous case, the power gain and signal-to-noise performance of the bipolar RF amplifier are only slightly worse than those of the FET RF amplifier. The spurious-response spectrum of Fig. 2c shows, however, that the number of spurious responses less than 85 dB has risen

# A DITHERABLE FREQUENCY, COAXIAL MAGNETRON HAVING SUPERIOR FREQUENCY TRACKING CAPABILITIES

BY JOHN HORRIGAN AND JOHN R. MARTIN

Frequency agility is attracting wide attention today as a means of improving radar range and detection probability in modern radar systems. The technique of providing sufficiently rapid tunability to permit successive transmitted pulses on differing frequencies has been shown to greatly reduce sea, ground, and foliage clutter. This provides radar resolution of targets that would otherwise be obscured by background interference. Also, reduced bearing error in search radar and improved aiming accuracy in fire control radar have been reported.

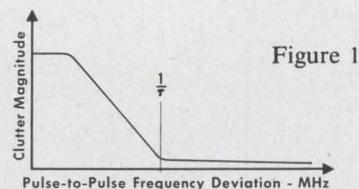
## HOW FREQUENCY AGILE SYSTEMS WORK

Target fading or scintillation occurs as a result of multi-path interference or variations in target cross-section due to changes in aspect. Excessive radar clutter results from the frequency sensitive reflective characteristics of varying targets such as foliage or the sea. As the radar characteristics of individual points within the total illuminated area change with time, the returns from these points to a fixed frequency radar vary from very small to very large. In fact, they may appear larger than the desired "hard target" within the radar scan. Because of this, desired targets, such as submarine periscopes at sea or military vehicles and guns in jungle foliage, are rendered indistinguishable to the radar operator from the background clutter.

For quite some time it has been generally known that the use of a frequency agile radar, i.e., a radar capable of changing its transmitted frequency on a pulse-to-pulse basis, would greatly reduce the problems of scintillation and clutter. The question was, what is the minimum frequency deviation necessary to obtain a satisfactory degree of clutter "decorrelation." Tuning rates

and frequency excursions larger than necessary for adequate decorrelation are undesirable because the greater the pulse-to-pulse frequency shifts required, the more complex and expensive become the mechanisms for producing these shifts.

Recently, numerous theoretical analyses and practical experiments have been conducted to determine the effect of frequency shift on clutter reduction. One significant determination that has resulted from these efforts may be summarized by reference to Figure 1.



This figure shows a plot of clutter magnitude versus pulse-to-pulse frequency shift. The point at which the clutter reduction was considered to be "optimum" occurred at a pulse-to-pulse frequency difference equivalent to  $1/\tau$ , where  $\tau$  is the transmitted pulse duration. Deviations less than  $1/\tau$  resulted in increased clutter while deviations greater than  $1/\tau$  did not afford the operator any measurable performance improvement. The greater deviations were not deemed worth the increased cost or the reduced system reliability that are likely to accompany them.

It was also shown that clutter decorrelation is an integration process. To be effective, the target returns from a series of pulses must be integrated to obtain the signal presented to the read-out unit. It was demonstrated that from 20-30 independent samples should be included within each scan to permit the most effective integration. This implies that 20-30 pulses, each separated by  $1/\tau$  in frequency, are required for optimum performance. In addition, both experiment and theory show that the degree of performance improvement is roughly proportional to  $\sqrt{N}$ ; where  $N$  is the number of independent pulses in the frequency train, to a maximum of 20-30 pulses.

Summarizing the above, a microwave source is needed that will tune rapidly enough to permit a frequency separation between pulses of  $1/\tau$  at the desired radar repetition rate and will tune

broadly enough to allow 20-30 pulses at separate and distinct frequencies.

## SYSTEM CONSIDERATIONS

Since we are defining an "ideal" microwave source from the system designers' viewpoint, we should list all of the desirable characteristics which we consider important before examining the various devices that are available for systems use. The "ideal" microwave source should:

1. Tune rapidly and broadly enough to satisfy the frequency shift and minimum integrated pulse requirements.
2. Afford the systems designer a ready method of local oscillator tracking with a minimum of additional external circuitry, such as servo amplifiers, control loops, etc., that may reduce the overall system MTBF.
3. Have demonstrated high reliability.
4. Maintain a high degree of frequency stability during the pulse (spectral purity) so that the radar receiver bandwidth may be maintained within reasonable limits.
5. If possible, afford an ease of retrofit for existing systems to permit ready addition of frequency agility at a minimum cost to the user.

## CONSIDER THE ALTERNATIVES

The BOMAC Division of Varian Associates and S·F·D Laboratories, Inc., a subsidiary of Varian Associates, jointly programmed a study of the possible alternatives in an effort to provide a device that would satisfy the requirements shown above. This study resulted in the choice of the CEM® Coaxial Magnetron as a starting point. This class of tube has already demonstrated a vast improvement over its conventional counterpart with regard to life expectancy, frequency stability, and cost per operating hour. In opposition to

**John Horrigan** is manager of Development Engineering at Varian's BOMAC Division. In this capacity, he supervises the development work done on ditherable magnetrons, and has played an important role in advancing the state-of-the-art in magnetron design.



**John R. Martin** is a Product Sales Manager at S·F·D Laboratories, Inc., a Varian subsidiary. As coordinator of magnetron marketing operations, he is thoroughly familiar with the many varying customer requirements that affect magnetron design.



amplifier type devices, the magnetron has long been known for its simplicity, efficiency, compact size, and light weight. These factors indicated convincingly that the CEM Coaxial Magnetron was the best base from which to develop a frequency agile source.

Accurate local-oscillator tracking appeared as the most formidable problem to overcome, based upon the efforts of others to provide similar devices. In one of these other efforts, it was determined that the only way to ascertain the operating frequency of the tube was to sample the cold resonant frequency of the device prior to each pulse. This required the use of elaborate swept-frequency, FM-discriminator, and control-loop circuitry.

Another approach was to detect the linear position and velocity of a tuning shaft and relate this information to frequency. This represents an improvement over the first method, but the device requires extensive servo control-loop circuitry to stabilize the output frequency during vibration. Hence, the ultimate frequency readout accuracy that may be attained, though adequate, does not permit the use of a very simple AFC circuit.

Neither of the above approaches satisfies the "ease of retrofit" parameter. Both necessitate the addition of extensive circuitry and prevent the use of existing reflex klystron local oscillators.

#### VARIAN DITHERABLE COAXIAL MAGNETRON

The BOMAC/S·F·D Laboratories dithered-frequency magnetron was conceived to satisfy most of the performance parameters previously shown. First and foremost, the device is simple and reliable. No attempt has been made to incorporate pseudo-features that do not improve the actual system performance, such as extremely broad frequency shifts at unnecessarily high speeds. The frequency tuning rate of 20,000 MHz established for the Varian dithered coaxial magnetron has been chosen to satisfy the broad range of character-

istics found in modern radar systems. Dither frequency excursions and rates may be selected within this limit according to the needs of the particular system.

Basically, the tube is a standard coaxial magnetron, not unlike similar tubes already delivered in large production quantities from both our Union, New Jersey and Beverly, Massachusetts facilities. The rapid tuning mechanism is entirely outside the vacuum envelope and consists simply of a high-speed motor driving the tuning element in the tube through a crankshaft type coupling. The frequency readout is obtained by indexing directly off the motor shaft with an angular detector. Experience has shown that frequency readout error can be maintained to better than 0.01%. Note that both mechanical tunability over the full radar band as well as narrow band dithering are obtainable simultaneously from these tubes. These factors are entirely independent and the loss of one operating mode will not affect the function of the other. In other words, should a dither mode failure occur, the system could still perform satisfactorily as a mechanically-tunable type, thereby further enhancing system reliability considerations.

The philosophy of a dithering mechanism entirely outside the vacuum envelope of the tube is very significant and warrants added comment. The coaxial magnetron is well known for its frequency stability, extremely long life, and rugged construction. It also has broader tunability at higher peak power outputs than can be attained with conventional magnetron types. It was considered essential that the frequency-agile feature be provided in such a way that the performance integrity of this device was not violated in any way. The external dithering mechanism fully satisfies this requirement and also permits ready addition of frequency agility to any existing coaxial magnetron with a minimum of effort and expense. Also, rotating-type dithering elements located within the vacuum envelope are par-

ticularly susceptible to damage from high currents passing through mechanical bearing surfaces during any intermittent high voltage arcing. These high currents contribute to shortened tube life and reduced reliability.

The "ease-of-retrofit" objective also has been virtually assured by the Varian design. In many cases, the magnetron itself provides a frequency readout signal sufficiently accurate for use directly in existing AFC circuits. Finally, since only minor mechanical changes to the basic tube are required to add the agility feature, existing system hardware usually need not be modified.

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## Varian dither-tuned magnetrons

BOMAC Division, Salem Road, Beverly, Mass. / S·F·D Laboratories, Inc., 800 Rahway Avenue, Union, N. J.

Type	Frequency (GHz)	Tuning	Dither About Center Frequency (MHz)	Peak Power Output (Typ.) (kW)	Peak Anode Current (A)	Peak Anode Voltage (kV)	Duty Cycle	Weight (lb.)
SFD-354	8.5 - 9.6	Tunable	±20	200	27.5	23	0.001	12.0
SFD-363	9.10 - 9.65	Tunable	±12.5	70	15	15	0.0012	9.5
BLM-181	16.0 -17.0	Tunable	±15±5	70	15	15	0.0007	7.5
BLM-180	16.0 -17.0	Tunable	±15±5	45	11	12	0.0008	6.25
SFD-355	34.5 -35.2	Tunable	±60	100	21	21	0.0005	15.0
SFD-340	34.512-35.208	Fixed	±60	50	14	15	0.0005	9.25

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ON READER-SERVICE CARD CIRCLE 43

# Pick the proper prepreg for multilayer board assemblies. Here are the prepreg selection criteria and processing steps for multilayer boards.

Part 3 of a three-part series.\*

Etched circuit patterns on thin laminates are packaged together by interleaving them with layers of epoxy glass prepreg (a woven fiberglass cloth that has been impregnated with epoxy resin and only partially cured). This assembly is then placed in a jig and laminated together to form a solid package. The choice of prepreg influences layer thickness, tolerance control and bonding effectiveness. Prepreg selection is thus extremely important in multilayer board design.

The conventional approach leading up to the laminating process is as follows:

- Design the circuit layout (see Part 1). Include the master guide holes that fall outside the circuit area. These guide holes are for lining up art work, pinning during laminating, and locating holes for machining and drilling.

- Etch the circuits, clean them thoroughly and dry them by baking for about an hour at 225°F.

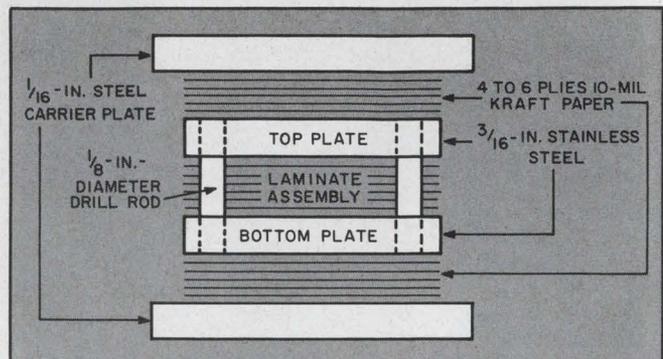
- Assemble the layers of circuitry on the pins of the jig in their proper sequence, interleaving them with the correct number of plies of prepreg. (The pressed thickness of the prepreg should be 1-1/2 to 2 times that of the thickness of the copper to be buried in it.) The top plate is then closed over the assembly and it is ready for laminating (see Fig. 1).

## Factors affecting jig design

For short-run programs, aluminum or mild steel can be employed, but these will wear in pin areas, tend to creep and become damaged. A hard stainless steel should be used for lengthy production runs. The plate should be about 3/16 inch thick and the locating pins should be drill rod stock about 1/8 inch in diameter. They should be a

\*Part 1 (ED 3, Feb. 1, 1967, p. 54) detailed design steps and Part 2 (ED 4, Feb. 15, 1967, p. 84) discussed laminate properties.

**Benson Zinbarg**, Vice President, New England Laminates Co., Inc., Stamford, Conn.



1. Multilayer assembly ready for laminating includes kraft paper to allow uniform heat to be applied from the carrier plate to the laminate assembly.

tight fit in the base plate (about 0.0003-inch clearance) so that they are firm and yet can be knocked out readily. The holes in the top plate, however, should be oversized by about 0.003 inch to 0.005 inch, so that the top plate can ride up and down freely without binding.

All surfaces of the plates and pins should be coated with a reliable nonsilicone-base mold release agent, and should have the release baked into the pores of the metal. Mild applications of release should then be applied after each laminating cycle to protect the laminates from being ruined by sticking to the jig surface.

The press should be hydraulically pumped to maintain a steady pressure. Pressures of 5 to 500 psi should be available on any given laminate area that will fit the platen sizes (the platen is the metal plate that exerts pressure). Normally the working area on a platen is about 18 inches square. The platens should be guided by four posts to provide parallelism.

The platens should be steam-heated and water-cooled. Steam provides uniform heat that is easily monitored and, assuming it is available in the plant, very economical. Many presses, however, employ electrical heat because of local legal and financial difficulties relating to the use of a steam-generating plant. When electricity is used for heating, the press operator must know when and if an individual heater malfunctions.

## Cold-press technique designed for high production

There are two common methods of using either type of press to produce multilayer laminates. The first and older method is to preheat the press to the laminating temperature of about 340°F, and quickly insert the jig containing the assembly into the open press. The press is then closed and a minimum of pressure is applied (about 5 to 25 psi) for a short period of time (about 1 to 5 minutes). Next, full laminating pressure of 200 to 300 psi is applied on the laminate; the material is kept in this cycle for 30 to 60 minutes. Finally the laminate is cooled under pressure.

The second method is the cold-press technique. Here the press is kept at room temperature while the jig or jigs are being loaded into the press. The press is then closed to the full laminating pressure of 200 to 300 psi and kept at that pressure constantly until opened. After the pressure is applied, the heat is introduced into the laminate slowly at about 10° to 13°F per minute. Once the laminate reaches 280° to 290°F, the platens can be quickly brought to 340°F, or the heat can be soaked into the laminate at the same 10° to 13°F per minute until the laminate reaches 340°F. It is allowed to dwell for 30 minutes and is then permitted to cool under pressure.

The cold-press method has the following advantages over the preheated approach:

- It is usual to use kraft paper as lagging and additional steel plates to act as carrier plates and protectors to the laminating jigs (see Fig. 1). The protection afforded by the carriers and paper prolongs tool life and also helps to cushion the load.

- The press cycle is simple. It requires no complex timing or setup adjustments; thus the capital outlay for a cold press is small and little skill is required of the operator.

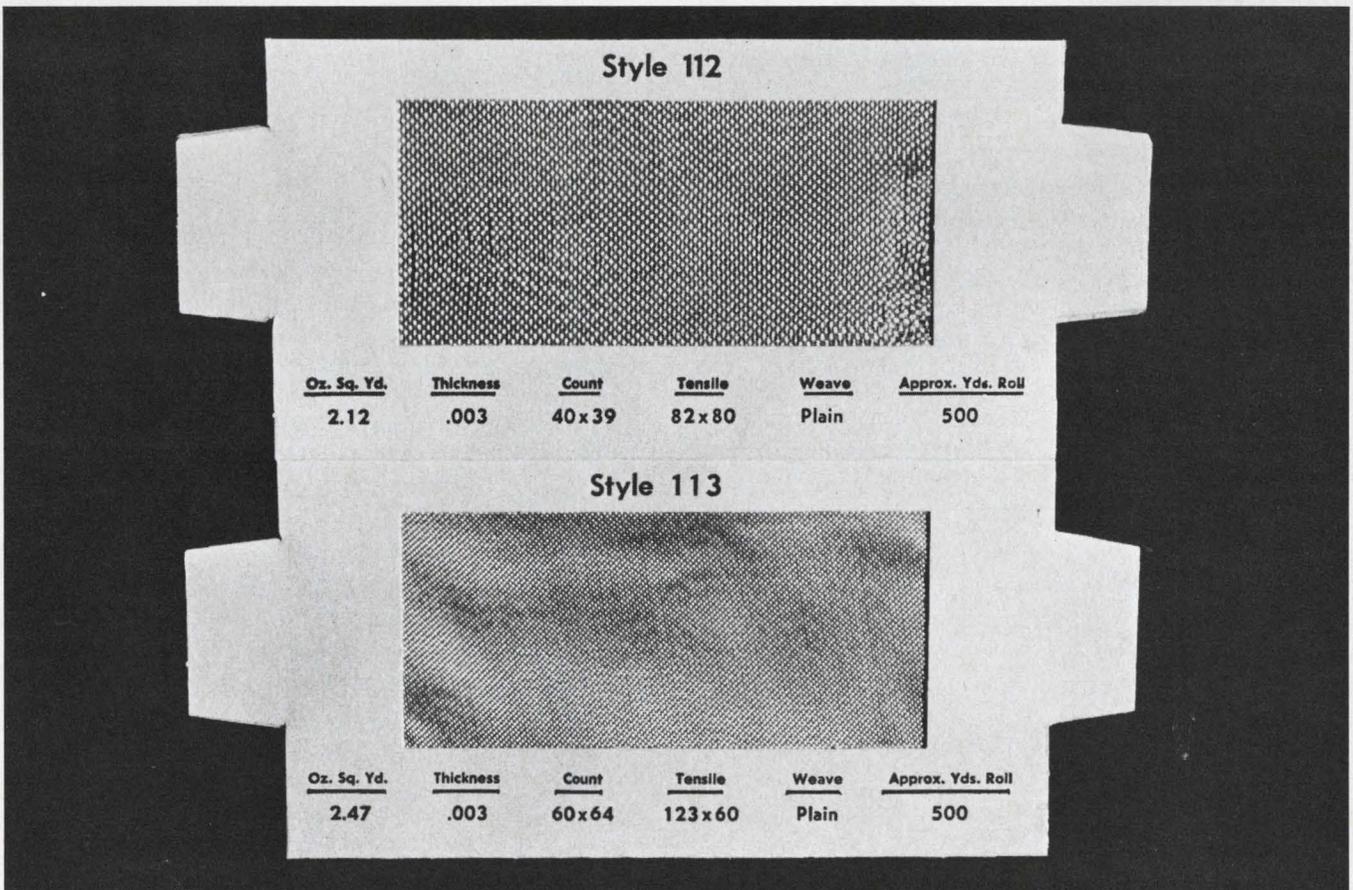
- Since there is one steady clamping pressure, the circuits are held firmly in place and are less apt to "float."

- Owing to the slow temperature rise, the prepreg is melting and flowing for a long time; this tends to produce uniform laminate thickness.

- Since the press is cold during loading, many assemblies may be loaded into a multiple-opening press. This gives high production efficiencies.

## Four parameters influence prepreg design

Epoxy glass prepreg is used to bond the circuit layers together because it is compatible with the base laminates, is easily handled, is efficient in evacuating air, bonds well, and helps to obtain



2. Tighter weave fiberglass (style 113) will resist movement while looser weave (style 112) may tend to move

when pressure is applied. Both fabrics are 0.003 inch thick. Other fabrics are listed in the Table.

close-tolerance laminations. The four basic parameters involved in prepreg design are:

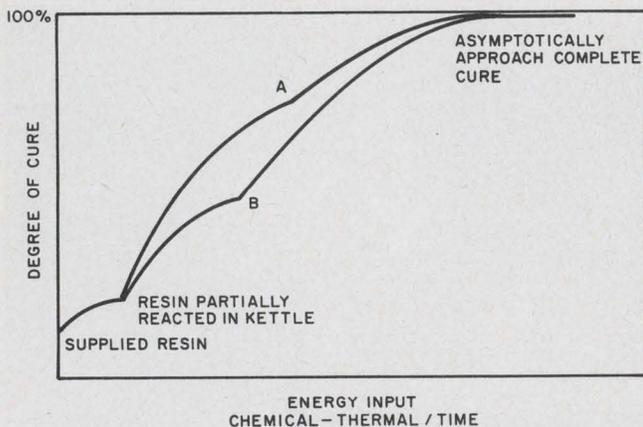
- Glass fabric style—thickness, yarn count and yarn type.
- Resin content—quantity and formulation.
- Degree of cure—gel time, or the more complex flow parameter that is based upon degree of cure, resin content and melt viscosity.
- Degree of dryness—volatile content.

The first variable will be most influential in determining the thickness of the layer and contributes heavily to tolerance control. It can be seen from the Table that many thicknesses of fabric are available, and at some thicknesses more than one fabric. Some fabrics are tighter in weave and allow less nesting; others are more loosely woven and can be moved readily under pressure, if this is desired (Fig. 2). Even changes in the yarn and filament construction can affect the workability and final production of the prepreg.

The resin system that is applied to the cloth must be similar to that used in the base laminate, so that the prepreg will adhere to the circuit boards satisfactorily and produce nearly identical electrical values. The amount of resin applied to the fabric should be large and uniform. Proper resin contents for various common fabrics are shown in the Table. The test to determine this value is as follows.

At least three specimens, weighing  $25 \pm 2.5$  grams or with a minimum area of  $1 \text{ ft}^2$  (if  $1 \text{ ft}^2$  weighs less than 25 grams), are bias-cut from the center and not less than 1 inch from each selvage of the full-width strip or sheet of prepreg. All loose particles and projecting fibers are cleaned off the specimens. Each specimen is weighed in a balance to the nearest decigram in a previously weighed crucible.

Crucible and specimen are then placed in a muffle furnace or equivalent, and ignited to constant weight at  $900^\circ\text{--}1100^\circ\text{F}$ . After this, the



3. The epoxy polymer can be brought to a high degree of cure (A) in the treating oven or left relatively "green" (B) for improved storage characteristics.

glass-fabric residue should be entirely white; if it is some shade of gray, all the carbon has not been removed. Moreover, the glass-fabric residue should show no sign of fusion. The residue and crucible are allowed to cool to room temperature in a desiccator and reweighed to the nearest decigram.

$$\text{Resin content (wet) by weight, per cent} = \frac{\text{Loss in weight} \times 100}{\text{Orig. weight of specimen}}$$

The degree of cure is best described by Fig. 3, which depicts the stages of cure. The starting point is that at which the resin supplier furnishes the epoxy polymer. The next level of cure is reached in the reaction vessel as the hardeners and accelerators are added. Then comes the critical phase where the fabric has been impregnated and the resin is being advanced in the treating oven. It can be brought to a uniformly high degree of cure (portion A on curve) or it can be left relatively "green" (portion B of the curve). Generally a more cured or mature polymer chain has better flow characteristics and produces a better multilayer package. The last level of cure, or final cure, takes place in the laminating press.

The degree of cure is defined by the gel time—the time that it takes the resin to change from a solid to a liquid and back to a solid again. This can be checked by the following method.

Bias-cut enough 2-inch-by-2-inch squares of prepreg to produce a sample stack weighing as nearly as possible 15 grams, align the plies and fasten them together with a staple. Prepare the press platens by preheating them to  $340^\circ \pm 5^\circ\text{F}$  and applying a mold release agent to them. Place the sample stack in the center of press and very rapidly apply approximately 500 psi for 10 seconds. A stop watch should be started as soon as pressure is applied. After 10 seconds, quickly open the press fully, and push the glass cloth off the lower platen. Take a wooden probe (a small tongue depressor or coffee stirrer) and before the stop watch has marked 25 seconds, gather a bead of the exuded resin together. Begin to stroke it back and forth, while keeping it in contact with the hot platen. Movement should be confined to a one-inch-diameter area. Continue to stroke the resin to and fro steadily until it stops moving when pushed. This is the end point and the time is recorded in seconds.

The end point is preceded by a thickening of the fluid resin. It will become very viscous, but still be in the fluid state. The gel point is the exact moment at which the resin turns from a viscous liquid into an elastomer with a memory.

A second method commonly employed to evaluate this degree of cure is to check the percentage of flow. This is done in the following manner.

Bias-cut at  $45^\circ$  to the fiber orientation the number of 4-inch-by-4-inch squares of prepreg

# Table. Epoxy prepreg characteristics.

Vendor's ident. no.	Glass cloth style no.	Cloth thickness (inches)	Prepreg thickness nominal (inches)	One or two pressed layers thickness average (inches)	Resin (wet) content range* (per cent)	Resin flow (per cent)	Gel time (seconds)	Volatile content maximum (per cent)	Flammability of prepreg (seconds)	Flammability of laminate (seconds)
Nelco 10-3205-4	104	0.001 ± 0.0002	0.0015	0.001 to 0.0015	75 ± 5	35 ± 5	95 ± 10	0.5	2 max	5 max
Nelco 10-3205-8	108	0.002 ± 0.0002	0.0035-0.004	0.0025 to 0.0030	60 ± 5	30 ± 5	95 ± 10	0.5	2 max	5 max
Nelco 11-3205-2	112	0.003 ± 0.0003	0.004	0.0035 to 0.004	54 ± 5	26 ± 5	95 ± 10	0.5	2 max	5 max
Nelco 11-3205-3	113	0.003 ± 0.0003	0.0045-0.005	0.0040 to 0.0045	53 ± 5	25 ± 5	95 ± 10	0.5	2 max	5 max
Nelco 11-3205-6	116	0.004 ± 0.0004	0.006	0.005 to 0.0055	50 ± 5	25 ± 5	95 ± 10	0.5	2 max	5 max
Nelco C-3205-6	Caliper ply 116	0.004 ± 0.0006	0.009	0.005 to 0.007	60 ± 8	35 ± 8	100 ± 10	0.5	2 max	5 max
Nelco 12-3205-8	128	0.007 ± 0.0007	0.008	0.0065 to 0.0075	42 ± 2	20 ± 2	95 ± 10	0.5	2 max	5 max
Nelco C-3205-8	Caliper ply 128	0.007 ± 0.001	0.020	0.0075 to 0.012	50 ± 8	25 ± 8	115 ± 10	0.5	2 max	5 max

\*Resin uniformity tolerance is ±1% across the web of the fabric.

that is required to give a total sample weight nearest to 20 grams. The bias-cut square plies are taken from the center of the strip of sheet and not less than 1 inch from any selvage. All loose particles and projecting fibers are cleaned off the specimens. Align the plies and fasten together when necessary with a staple of self-sticking printed-circuit tape. Weigh all the specimens together to the nearest decigram. Specimens and caul plates are maintained at a standard temperature of 75° ± 10°F before test. Adjust press temperature to 340° ± 5°F. Place the specimens in the center of the 1/16-inch-thick steel caul plates, which are maintained at the standard temperature. Insert the assembly of plates and specimens into the preheated press in the center of the opening. Close the press and apply pressure of 200 ± 25 psi within 5 seconds or less, and maintain this pressure. Cure the laminate sample. Remove the epoxy resin flash, being careful not to remove any glass. The laminate sample should be approximately 4 inches square after resin removal. Reweigh the sample to the nearest decigram.

$$\text{Resin flow, by weight, per cent} = \frac{\text{Loss in weight} \times 100}{\text{Original weight of specimen}}$$

This percentage of flow takes into account not only the degree of cure but also the resin content, melt viscosity and degree of dryness. Therefore it is a complex parameter, and to assess its value is difficult.

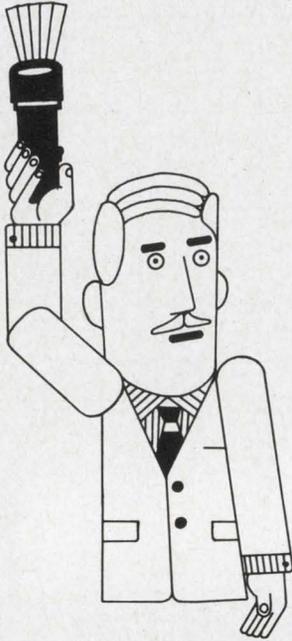
Finally, the amount of volatile matter in the prepreg must be known, and a limit set upon it. The Table shows such values and the following is the method to determine it.

Prepare and weigh samples as in the test for resin content, except weigh to the nearest milligram. Drive off volatiles by hanging the specimens in an air-circulated oven at 325° ± 5°F for 15 minutes. Cool in a desiccator and reweigh.

$$\text{Volatile content, by weight, per cent} = \frac{\text{Loss in weight} \times 100}{\text{Orig. weight of specimen}}$$

From the above discussion it can be seen that many variations in pressing techniques are employed, and many prepreps can be used to obtain a reliable and economical lamination of a multilayer printed-circuit board. The basic criteria are that the final product should be uniformly translucent and clear of flaws, withstand thermal shock, and provide proper electrical values. ■ ■

# COMPUTER



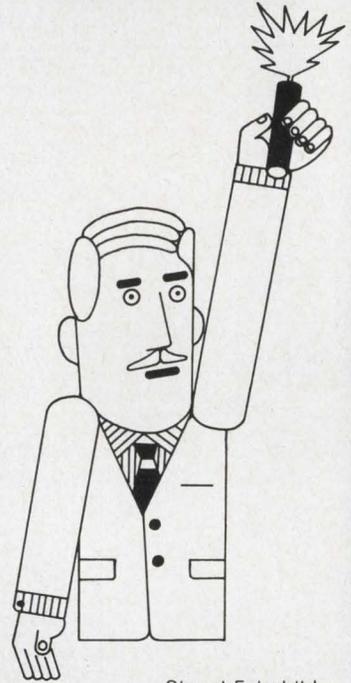
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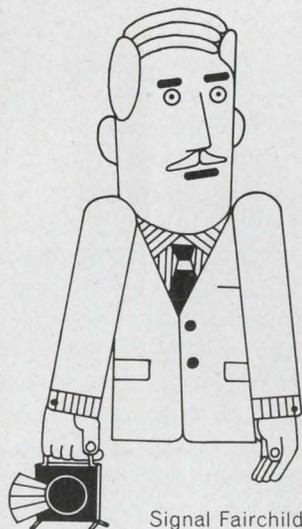
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ON READER-SERVICE CARD CIRCLE 44

# Design black boxes for systems integration right from the start and spare users the headache of modifying them to make them fit.

"We'll have the machine shop modify the unit so it'll fit the rack."

This statement is heard far too often in systems departments, where too much time and money is spent on modifying mechanical problems engendered by "black box" designers. These range from the need to relocate a few holes to repackaging entire units to make them "fit the space."

Some of the more flagrant examples of design incompatibility are units that are practically impossible to mount on equipment slides, units that have hot spots where ventilation is impractical, and units with blinding lights that signal everything from "oven on" to "alarm." Such mechanical and human factors deficiencies can sometimes render almost worthless what from a circuit standpoint is an excellent piece of equipment.

To avoid problems, whether they are immediately obvious or come to light only in the long run, certain general criteria can be established for black-box design. Meeting these criteria is not expensive, and can insure high system compatibility for any black box. The bases of the following criteria, although they apply specifically to ground-based equipment, are universally applicable.

## Over-all configuration is first consideration

As a general rule the proper design of black boxes requires a knowledge of the eventual application. On the more specific level, equipment for rack-mounting should be designed for installation into the generally accepted relay rack. Practically all equipment-mounting racks are constructed to conform with the simple and innocuous government specification, MIL-STD-189.

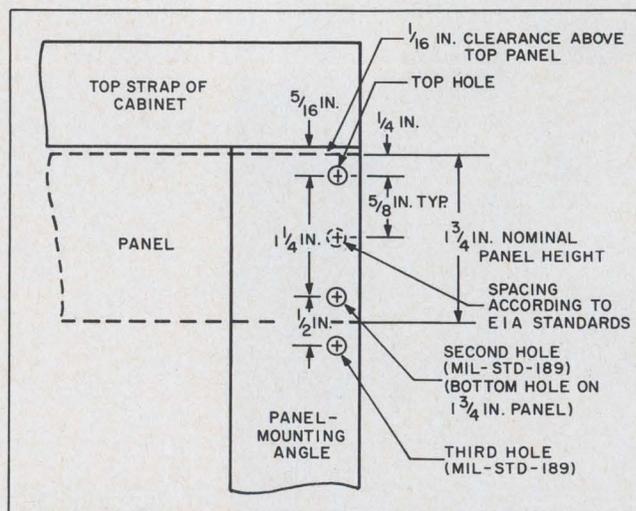
The portions of that specification that will mostly concern a black-box designer are those for panel mounting holes, over-all panel height, and slot details. Of these, the panel mounting-hole dimensions are the most important in a new design.

The basis for panel-mounting-hole spacing is

the 1-23/32-inch panel (panel size A in Table 1). All subsequent panel heights are multiples of this nominal 1-3/4-inch panel. The top hole of the panel-mounting angle is located 5/16-inch below the top strap of the cabinet; this allows approximately 1/16-inch clearance above the top panel (Fig. 1). The second hole in the panel-mounting angle is 1-1/4-inch  $\pm$  1/64-inch below the top hole. (Some equipment-rack manufacturers place an additional hole, according to EIA Standards, halfway between these two holes.) The bottom hole or slot on a 1-3/4-inch panel is placed 5/16-inch from the bottom edge of the panel. The bottom edge will thus come approximately halfway between the second and third holes specified in MIL-STD-189. This is the key to black-box design for system integration: the top and bottom abutting edges of each front panel, regardless of height, must lie approximately halfway between the 1/2-inch-spaced holes in the rack panel-mounting angles.

With this established, the problem of deciding where to mount equipment slides on all black boxes is reduced to simple arithmetic. Table 2 gives the dimensions for the proper placing of slides for the panel heights most frequently used.

In addition to standardizing mounting holes, a



1. Panel mounting holes must be positioned carefully if a black box is to fit properly into a standard relay rack.

Charles H. Daniel, Systems Engineer, Defense Electronics, Inc., Rockville, Md.

**Table 1. Panel mounting-hole spacing**

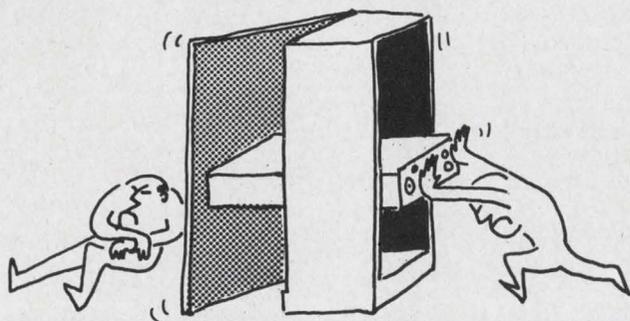
Panel size	Nominal height (in.)	Height (in.)	Distance from first slot to bottom of panel (in.)	Distance between first and second slot (in.)	Distance between second and third slot (in.)	Distance between third and fourth slot (in.)
A	1-3/4	1-23/32	15/64	1-1/4	—	—
B	3-1/2	3-15/32	15/64	3	—	—
C	5-1/4	5-7/32	1-31/64	2-1/4	—	—
D	7	6-31/32	1-31/64	4	—	—
E	8-3/4	8-23/32	1-31/64	1-3/4	2-1/4	1-3/4
F	10-1/2	10-15/32	1-31/64	2-1/4	3	2-1/4
G	12-1/4	12-7/32	1-31/64	1-3/4	5-3/4	1-3/4

standard panel thickness should also be selected for all units. The 3/16-inch panel is the most popular size in use among equipment manufacturers. Open or closed slots may be used for panel-mounting screws, depending on fabrication equipment available, but open slots are preferable because they allow more leeway for aligning units.

Chassis width behind the front panel should not exceed 17-1/2 inches for mounting on 16- or 18-gauge equipment trays. For 1/8-inch chassis-mounting angles, the width should not exceed 17-3/8 inches. Maximum width should take screw head protrusion into account. The small detail of screw heads is often overlooked by designers.

For slide-mounting, select a reliable slide and, if possible, select only one thickness for this slide. The total weight of units designed to mount on slides determines the slides' ruggedness and can easily be estimated. A well-manufactured slide that will support up to 75 pounds is available with 1/2-inch maximum thickness. Using this as a guide, the maximum black-box width for slide-mounting should be 16-3/4 inches.

Chassis depth should be based on the popular 24-inch-deep rack and make allowance for rear connectors and cabling. The rear door of the rack should close without damaging anything. Selection of a 30-inch-deep rack should be weighed against the alternative of increasing chassis and panel height.



Knobs, switches, meters and indicators should not extend more than 1-1/2 inches from the front panel, and should be protected by installing handles. If it is necessary to place the unit face down for servicing, the handles will protect any protruding part. In the same manner, blocks should be permanently installed on the rear apron to protect connectors, fuses, and cabling.

Chassis height, including dust covers and screw heads, should be selected to give a minimum clearance of 1/4-inch between the chassis and the top edge of the panel, and the same clearance from the chassis to the bottom edge of the panel. On units designed for radio frequency interference (RFI) shielding, a minimum lip at least 3/8-inch wide should be provided to prevent interference with the RFI bar placed across the rack.

**Front panel should be functionally designed**

Front-panel and rack paint is usually stipulated in the black-box's specification by a numbered color defined by FED-STD-595. In the absence of control by this Federal Standard, paint should be selected for abrasion- and chipping-resistance. A color as near as possible to a FED-STD-595 color chip should be chosen. Glossy paints should be avoided, if possible, in order to minimize reflections. A semigloss finish is attractive and functional. Most flat colors should be avoided

**Table 2. Equipment slide locations**

Panel size	Nominal height (in.)	Center line of slide to bottom of panel (in.)	Alternative position (in.)
A	1-3/4	not recommended	—
B	3-1/2	1-1/2	1-3/4 *
C	5-1/4	1-3/4	3-1/2
D	7	3-1/2	—
E	8-3/4	3-1/2	5-1/4

\*This position applies to racks with 2 panel-mounting angles, one immediately behind the other.

because they show dirt and fingerprints quickly.

Control functions, scales, and other pertinent designations should be carefully engraved or photo-etched on the front panel and filled with a contrasting color (or different colors if several scales are involved). Silk-screened panels are attractive, but since they are not as durable as engraved ones they should generally be avoided. For low-cost or one-of-a-kind black boxes, however, silk screening can provide a cost saving.

All handles should be of best-quality chrome plate or stainless steel, and durable smooth-acting latches should be installed on units subject to frequent withdrawal from the rack.

#### Rear apron should give ready access to black box

One of the most exasperating experiences for a systems engineer is to purchase equipment for rack-mounting and discover, when it is delivered, that all connections must be made on the front panel. He is then forced to modify the unit by adding parallel connectors on the rear or, alternatively, fabricating a "feed-thru" panel, if space permits.

The rear apron should be regarded as a means of getting into or out of a black box—as a patch panel, so to speak. All available inputs and outputs that could conceivably be used should be terminated there at a connector. A BNC type is easy to connect and disconnect, and functions well with all but the more critical signals.

Each connector should be labeled with both the function that it provides and a number by which it can be identified on the equipment schematic. Silk-screened or stenciled labels are practical for the rear apron since it is not subjected to constant use and abuse.

#### Operational convenience must be borne in mind

In the design of functional front panels, emphasis should be placed on good human-engineering standards. A useful guide in this respect is MIL-STD-803A-1 (USAF).

If the black box has several functions, all controls and indicators for a sequence or related activity should be grouped together. Units that have a single function should have the front panel layout designed for fast and efficient setup by an operator.

Controls and indicators identified by legends are preferable to those having only a color association with a function. The use of legends enables inexperienced operators to master the equipment in a minimum of time. When colors are used to indicate functions, they should follow the recommended criteria outlined in MIL-STD-803A-1 (see Table 3). Blue should be used only as an advisory light, and in general should be avoided if at all possible.

All labeling should be immediately adjacent to the control, indicator, or switch to which it refers. The use of abbreviations to eliminate overlapping of legends between controls or because space is not available for longer words should be determined by the general acceptance of the abbreviation. Acceptable abbreviations are outlined in MIL-STD-12.

In cases where several identical black boxes may be combined in a system, identification of the individual units becomes important and may be accomplished by one of several methods. Metal ID-strip holders can be used to hold identifying cardboard labels. Another possibility is an indicator-type plug-in number that can be wired into the input power or internal power supply to provide

**Table 3. Indicator color coding**

Indicator size & type	Red	Amber	Green	White	Blue
1/2-in. diameter or smaller Steady illumination	Malfunction Action stopped Stop action Failure	Delay Check Recheck	Ready Go ahead In tolerance Acceptable	Functional or physical position Action in progress	As advisory light only (avoid if at all possible)
1-in. diameter or larger Steady illumination	Master summation (system or subsystem)	Extreme caution (impending danger)	Master summation (system or subsystem)	—	
1-in. diameter or larger Flashing 3 to 5 times per second	Killer warning (personnel or equipment)	—	—	—	



integral part of a system, the designer should study heat dissipation within the unit itself. Today's solid-state electronics ease the problem, but some units must still rely on tubes and large, heat-producing components.

In the majority of system installations, equipment air conditioning is disregarded; heavy emphasis is placed on individual rack blowers. For every 5 watts dissipated in a black box there is about a 10°C increase in air temperature within the box, if the forced-air cooling is delivering 1 ft<sup>3</sup>/min of air over the equipment. Figure 2 shows the relationship between wattage dissipation and blower capacity. The curves are somewhat idealized but give the designer an insight into the heat problems facing him. A reasonable ambient temperature on which to base calculations is 40°C.

Air flow within a rack must be exploited to the full. Any hot spots that may occur in a unit should therefore be located close to the rear of the rack. Rack construction and chassis depth combine to form a natural chimney at the back. For extra cooling, fins added to the black box (placing additional surface area in the forced-air stream) will alleviate hot spots. In extreme cases, a small muffin fan should be designed as an integral part of the black box to force air over or pull air across heat-generating components.

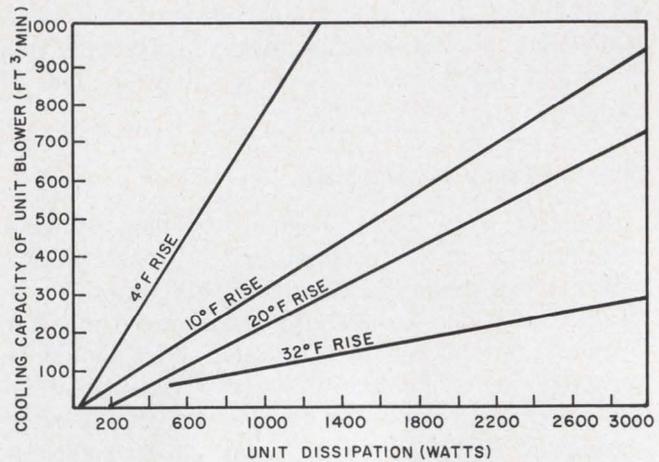
Although actual system operation will seldom demand that a black box be exposed to extreme humidity, it is good practice to use components and mechanical parts that will operate reliably at relative humidities up to 95%. Moreover, since a designer cannot anticipate the environment his product will encounter during shipping and storage, his black boxes should be designed to operate properly after storage or air transportation at temperatures as low as -54°C or as high as +54°C.

#### RF compatibility should be ensured

The black-box designer must realize that his unit will very likely be just one of several combined into a complete system. Therefore, if his unit generates radio frequency interference or is affected by extraneous signals, he should incorporate in his design features that minimize such interference. Techniques include effective filtering of primary power and other unshielded wiring, the use of single point grounds together with separate signal and power grounds, and proper shielding of components.

#### Complete instructions should be provided

It is practically impossible to provide a clear and concise operation and maintenance manual before a black box is designed and tested. The designer should, however, prepare advance information on his unit, and include sufficient details to enable systems personnel to install the box proper-



2. Temperature inside a black box increases about 10°C (18°F) for every 5 watts dissipated when the blower delivers 1 ft<sup>3</sup>/min of air over the equipment. These curves are based on this approximate relationship.

ly into a system. A neatly drawn engineering sketch is adequate, if it furnishes outline dimensions of height, width, and depth; location of connectors and their type (noting whether mating connectors will be supplied); pin numbers of connectors and their functions; a representative front panel layout and control designations; cooling recommendations, if hot spots make this necessary; primary power requirements; precautions that should be observed during installation; the unit's weight; details of special test equipment that may be required or special tools that may have to be acquired; and a description of how to use any special accessories supplied with the black box as well as of any accessories available as optional extras.

Final documentation in the form of an operating and maintenance manual should be supplied to the purchaser as soon as possible. It should be standard practice to include one manual with each black box. This will assure the designer that his unit will be installed and put into operation in the manner which he has recommended. In many cases, it will eliminate improper operation and possible return of the unit to the manufacturer.

A list of required parts and recommended spares for 2000 hours of operation, along with a prediction and the basis of this prediction for mean time between failure, should round out the required documentation.

One final word to the black-box designer. He should make every effort to visit a systems assembly department either in his plant or in his area. Many plants welcome inspection teams, and a talk with the supervisor of systems assembly will be most enlightening to an interested designer. Two major areas to investigate are the construction of relay racks and the minor adjustments that can be made when using them. ■ ■

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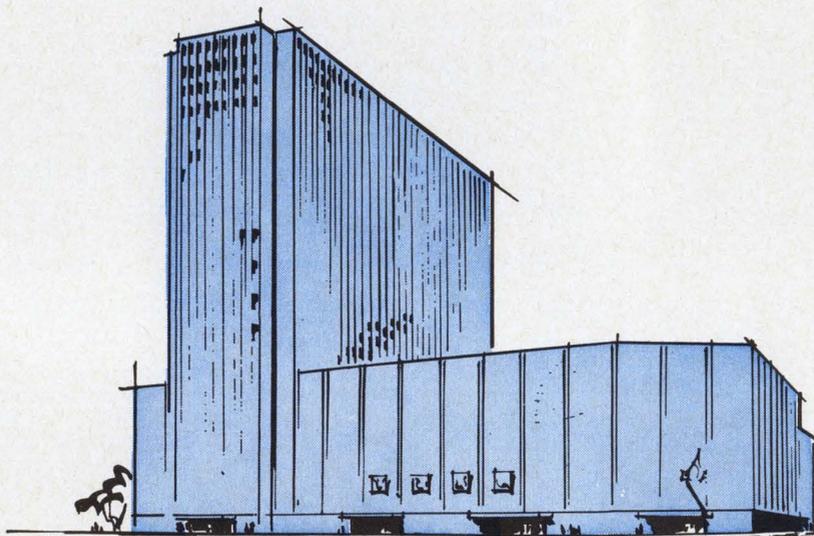
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# Marry relays and semiconductors

and improve performance by cashing in on the best power-switching characteristics of both devices.

Relays and semiconductors are often considered bitter rivals. Yet, in many power switching applications, a truly elegant solution can only be found by the open-minded designer who has no prejudice against either device.

Such "hybrid" circuits can offer the following advantages over purely solid-state or electromechanical ones:

- Higher current-surge-handling ability.
- Higher steady-state load-driving ability.
- Mutual protection.
- Longer life for both types of device.

Three of these circuits are to be described in this article.

## Relays and semiconductors are complementary

Relay contacts, on the one hand, can usually carry much higher currents continuously than they can switch. Semiconductors, on the other, can withstand much higher transient currents than continuous ones. Furthermore, the heating of a semiconductor in continuous operation also reduces its resistance to transient current surges.

This, then, is the source of the complementary nature of relays and semiconductors. That is to say, if one uses relays for heavy continuous duty, and semiconductors to absorb transient current surges and for light continuous duty where proportional control is desired, circuits of considerably higher power-handling capability can be designed.

A relay, for instance, can afford semiconductor switches "crowbar" protection during fault-current occurrences in the circuits shown in Figs. 1 and 2.

In both cases the relay is operated by a current-sensing coil in series with the load and has its normally open contacts connected in parallel with the semiconductor switch. The relay coil is designed such that normal load current does not cause the contacts to close. A fault current that exceeds normal current by a given margin (2:1,

say) will cause the contacts to close and thus bypass the semiconductor switch.

This circuit has been used with high-wattage tungsten-lamp loads, to bypass the semiconductor switch when the lamp is first energized and the low resistance of the cold filament produces a very high surge current for a few cycles of the applied line voltage. After the filament is heated, current is reduced and the contacts open, returning control of the circuit to the semiconductor.

The circuit of Fig. 1 is useful for ac control work, while the circuit of Fig. 2 is suitable for operation from a dc power supply.

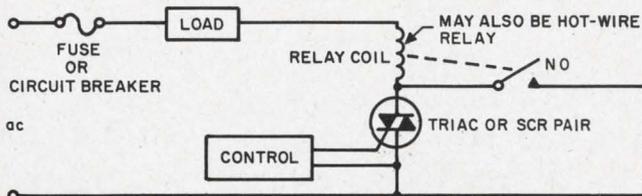
In the circuit of Fig. 2, connecting the normally open contacts of the relay directly in parallel with the SCR provides the surge current protection. The contacts, however, can only be opened when current has decreased to an appropriate drop-out level. If the contacts are connected in the alternative position shown by the dotted lines, closing the contacts causes the current to bypass both the relay coil and the semiconductor switch. This action de-energizes the relay and causes the contacts to reopen. With the proper RC network to limit the rate of change of voltage that builds up across the SCR, the SCR can be commutated, or turned off, by the momentary removal of current. The circuit will then revert to the off state.

## Semiconductors improve contact performance

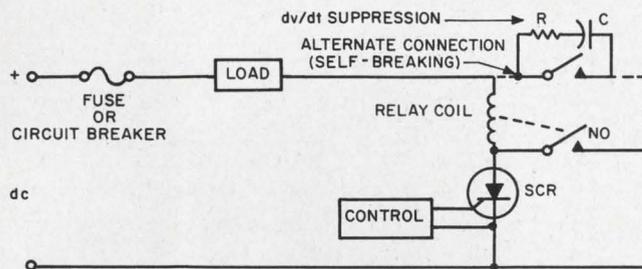
Where relatively slow switching of high currents is required, the semiconductor's rapid, bounceless switching and its high short-term-surge-current capability can augment the performance of mechanical contacts. The circuit of Fig. 3 shows the use of a Triac for protecting the contacts of a mechanical relay operating a high current load from an ac supply. The semiconductor switch is energized by the same signal that energizes the relay coil. The semiconductor begins conducting load current before the mechanical contacts can close. Thus, the voltage across the mechanical contacts at the time of closure is limited to approximately 1 volt.

Since this voltage is too low to support an arc between the two contacts, the usual bouncing that occurs on closure will result merely in current

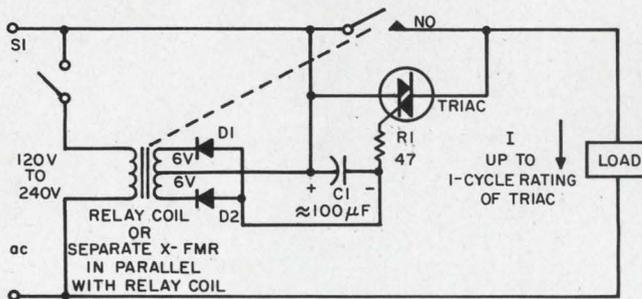
E. Keith Howell, Manager, Light Industrial and Consumer Controls Application Engineering, Semiconductor Products Dept., General Electric Co., Auburn, N. Y.



1. Relay protects Triac when the load current exceeds some predetermined value in an ac circuit.



2. SCR is protected by relay contacts in a dc application.



3. High transient currents are switched without bounce by the Triac while the relay contacts take on the continuous operation. Voltage drop across the contacts is only about 1 volt during both closure and opening. For inductive loads RC arc suppression in parallel with Triac should be employed.

transfer back and forth between the Triac and the contacts with no arcing. The continuous supply of gate current to the Triac ensures that the Triac will always be in the conducting state at any time that the contacts bounce open. When the relay coil is de-energized, energy stored in capacitor  $C_1$  will continue to maintain gate current in the Triac for sufficient time to permit the contacts to open. The resultant surge current will then be absorbed by the still conducting Triac.

The relay contacts in the circuit of Fig. 3 can handle a much larger current than normally assigned to a given size, because the Triac takes on all the making and breaking duty. Likewise, the Triac can turn on and turn off a much larger current than it could handle in the steady-state condition, because the relay contacts provide the steady-state path for the current. In using this circuit, the relay contacts must be kept in good working condition, clean and unpitted, since their failure to lead the current around the Triac will result in rapid failure of the Triac. ■ ■

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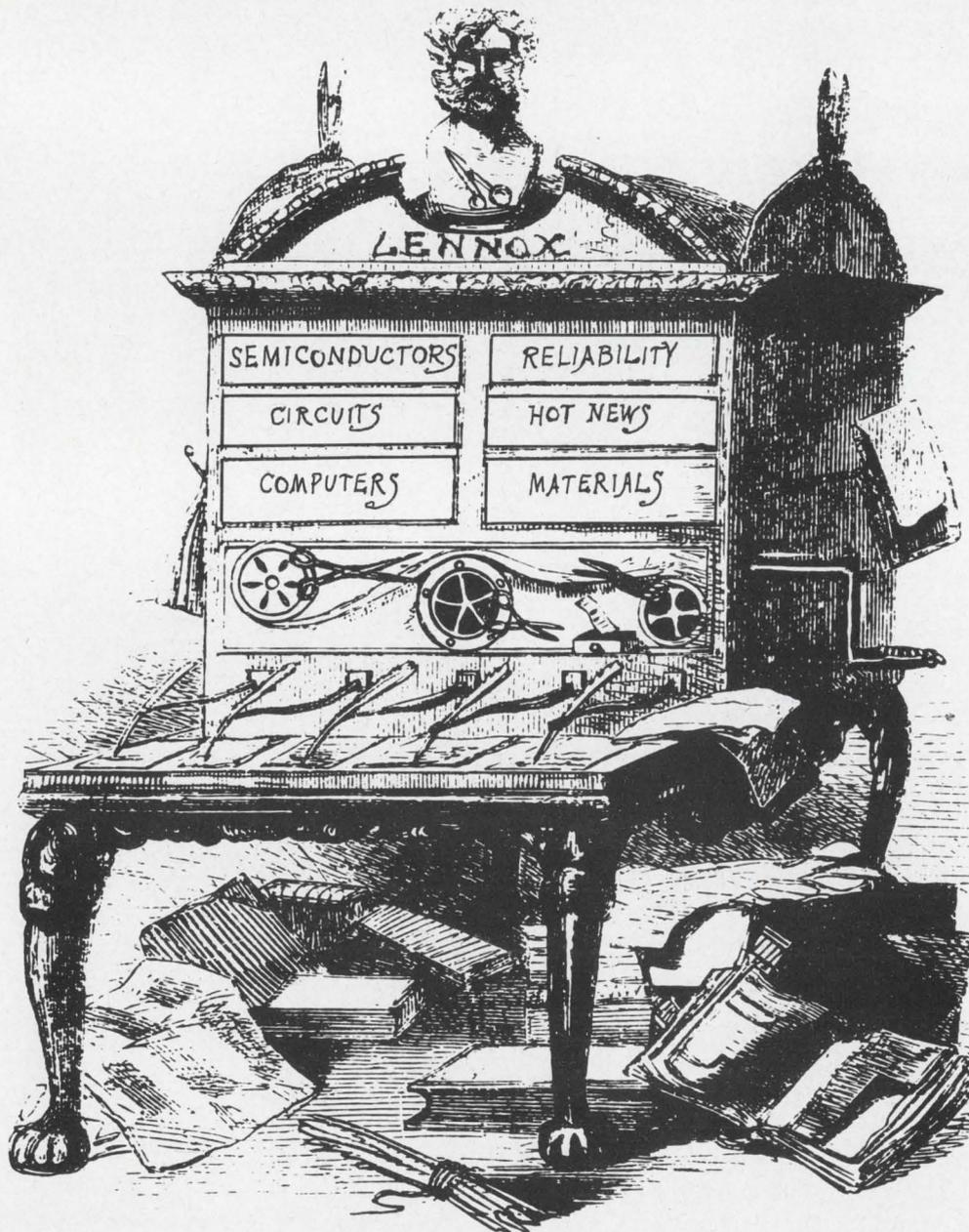
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# Study the trade-offs for synthesizers

on this simple chart. Prepared for digital types, it quickly reveals many subtle design points that lead to top performance.

Thanks to the advent of low-cost, high-speed digital microcircuits, digital synthesis has become competitive with mixing techniques to obtain accurate discrete frequencies. Here is a simplified design chart that enables the design engineer to derive parameters for the digital synthesizer rapidly. It also gives a clearer and faster evaluation of design trade-offs than the mathematical approach.

The basic block diagram for the digital frequency synthesizer is shown in Fig. 1. The output of the voltage-controlled oscillator (VCO) is divided by a fixed ratio,  $K_1$ , and then supplied to a divide-by- $N$  counter, which is manually programmed by the channel selector. The factor  $N$  is an integer which is established by manually setting shafts that determine the counter logic. In some applications this may be performed by remotely programmed serial or parallel digital codes.

The output of the divide-by- $N$  counter is fed to a phase comparator which has a fixed reference frequency,  $F_c$ , as its other input. This reference frequency is obtained from a precision crystal oscillator through a fixed scaler counter having a dividing factor of  $K_2$ . The phase comparator's output produces a correction voltage if its two inputs are not identical in frequency and phase. Hence the VCO's frequency is automatically set so that the divide-by- $N$  input signal to the phase comparator is phase-locked to the divide-by- $K_2$  input. At the end of each counting period of  $F_c$ , the counter  $N$  is reset and the counting process is repeated. Figure 2 illustrates the basic waveforms associated with the block diagram.

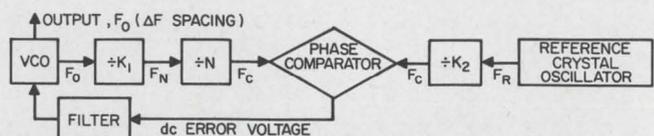
In a typical synthesizer, the input counting frequency,  $F_N$ , to the divide-by- $N$  counter will be limited to a practical maximum frequency, determined by the speed of the digital circuits. If, for

example, the maximum  $F_N$  is chosen to be 15 MHz, a VCO with a required frequency range of 40 to 60 MHz would need a fixed scaler division of 4, which is the factor  $K_1$ .

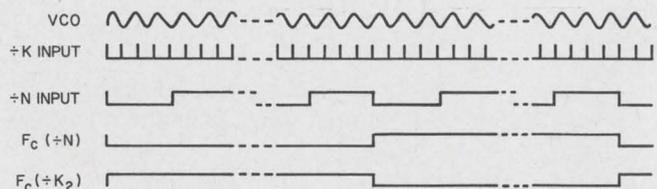
One of the inherent drawbacks in the use of digital synthesizers in certain applications stems from the rate at which frequency corrections can be made to the VCO when  $F_c$  is at a low frequency. For example, when a phase comparator frequency of 1 kHz is used, the error corrections to the VCO cannot be at a rate in excess of 1 kHz, and any disturbances of the VCO at this rate or higher cannot be electronically corrected through the action of this feedback loop. It is, then, in the designer's interest to raise  $F_c$  to the maximum possible comparison frequency and improve short-term stability with a wide-band loop.

## Equations yield exact values

The following mathematical relationships exist  
(continued on p. 90)

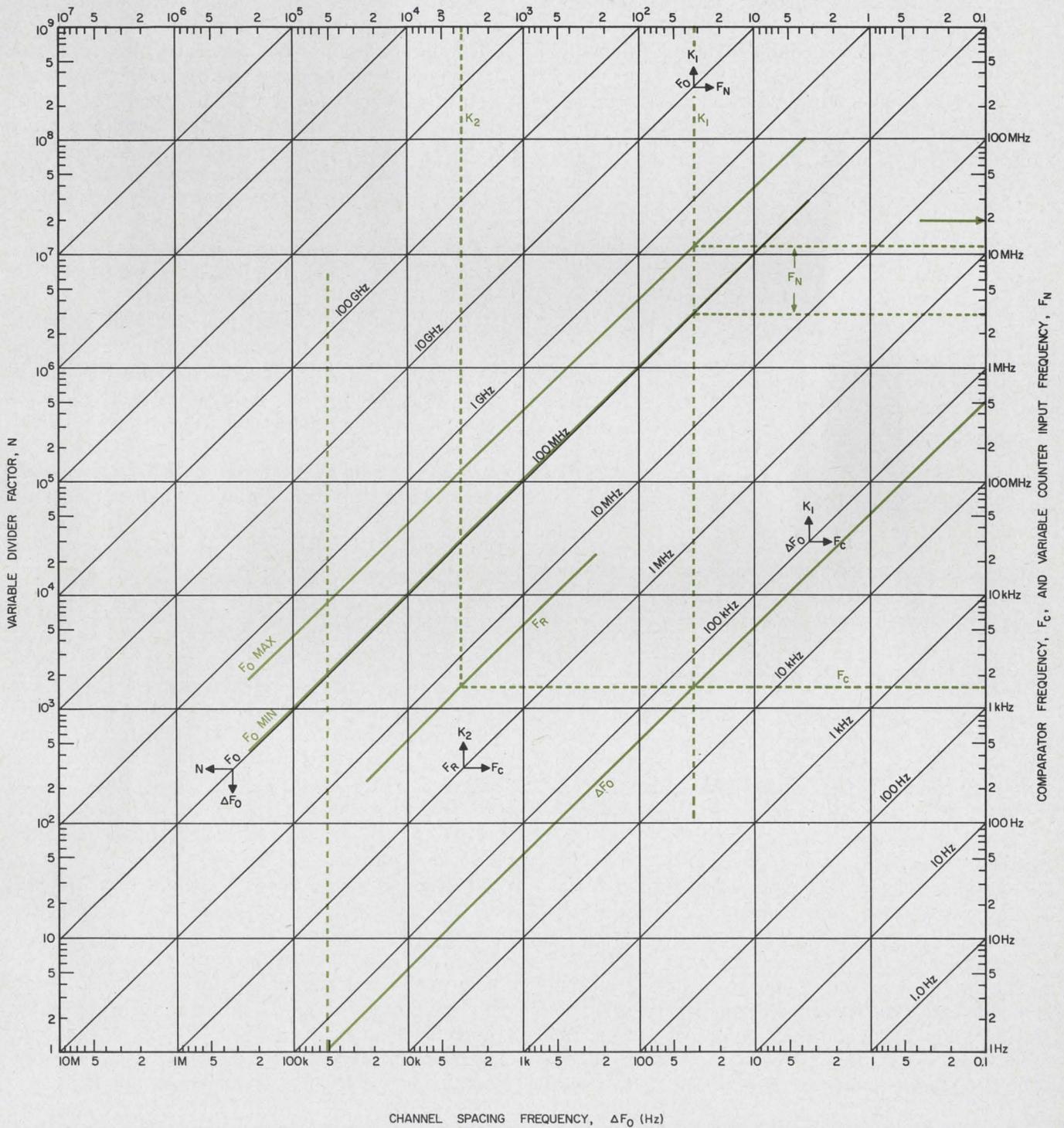


1. Digital frequency synthesizer detects errors in frequency and phase through the phase comparator. The dc error voltage is fed back to the VCO for precise control of the output signal.



2. Waveforms associated with stages of the digital frequency synthesizer show phases of generation of the error voltage. The rate of error correction is determined by  $F_c$ ; therefore it should be as high as possible.

FIXED DIVIDER FACTORS,  $K_1$  AND  $K_2$



3. Design chart gives quick parameter values and trade-off possibilities. It yields the range of  $N$ , the range of  $F_N$ , phase comparator frequency  $F_c$  and the fixed scales,  $K_1$  and  $K_2$ . The example, in color, is worked out in the text.

in the frequency synthesizer:

$$F_o/K_1 = F_N, \quad (1)$$

$$F_N/N = F_c, \quad (2)$$

$$F_R/K_2 = F_c, \quad (3)$$

where

$F_o$  = output frequency of VCO,

$F_N$  = input frequency to divide-by- $N$  counter,

$F_c$  = output of divide-by- $N$  counter after lock-up and also output of divide-by- $K_2$  counter,

$F_R$  = reference crystal oscillator frequency,

$K_1$  = fixed scaler counter factor following VCO,

$K_2$  = fixed scaler counter factor following reference crystal oscillator, and

$N$  = counter factor, which is programable.

The output frequency may be expressed as a function of  $K_1$ ,  $N$  and  $F_c$  by a combination of Eqs. 1 and 2:

$$F_o = K_1 N F_c. \quad (4)$$

When the divide-by- $N$  count is changed by the smallest integer increment of 1, the output frequency is increased by its minimum amount,  $\Delta F_o$ . This is expressed as:

$$\begin{aligned} F_o + \Delta F_o &= K_1(N+1)F_c \\ &= K_1 N F_c + K_1 F_c \\ &= F_o + K_1 F_c. \end{aligned} \quad (5)$$

It is evident from Eq. 5 that:

$$\Delta F_o = K_1 F_c, \quad (6)$$

and the combination of Eqs. 4 and 6 results in:

$$\Delta F_o = F_o/N. \quad (7)$$

The above equations are important for obtaining precise values of  $K_1$ ,  $N$ ,  $F_c$  and  $K_2$ , when  $F_R$ ,  $F_o$  and  $\Delta F_o$  are known.

### Chart yields approximate answers quickly

A design chart enables the designer to take short cuts to approximate values and to derive trade-offs among these various values prior to obtaining precise figures with a desk calculator.

Consider a typical problem of a frequency synthesizer that must meet the following requirements:

Output frequency,  $F_o$  . . . . . 100 to 400 MHz  
Incremental frequency spacing,  $\Delta F_o$  . . . . . 50 kHz

Reference crystal oscillator,  $F_R$  . . . . . 5 MHz

The design constraint on the circuitry is the criterion that the frequency of the input signal to the programable counter  $N$  shall not exceed 20 MHz.

The designer now must find the range of the divide-by- $N$  factor,  $N$ ; the range of frequency,  $F_N$ , which feeds the divide-by- $N$  counter; the phase comparator frequency,  $F_c$ ; and the fixed scaler

factors,  $K_1$  and  $K_2$ .

The step-by-step procedure using the chart of Fig. 3 is the following:

Draw diagonal lines (color) for each of the frequencies:  $\Delta F_o$ ,  $F_R$ , and the minimum and maximum values of  $F_o$ .

Draw a vertical line at  $\Delta F_o = 50$  kHz (color dashed) and a second vertical line (color dashed) from the upper  $K$  scale, which intersects the maximum  $F_o$  line at a frequency below 20 MHz (the design constraint). In this case, it is below the limit just enough to make  $K_1$  equal to 32, which is a binary number and readily obtainable in a simple divider.

The intersection of the vertical  $K_1$  line with the  $F_o$  diagonal line indicates the divide-by- $N$  counter input frequency and is read off from the right-hand scale. This range is from 3 to about 12 MHz. Note that if scale factor  $K_1$  were chosen to be 16,  $F_N$  would have a maximum value of 24, which exceeds the desired counter input frequency.

The extension of the  $K_1$  vertical line intersects the  $\Delta F_o$  diagonal line at 1.6 kHz, according to the right-hand scale. This is the value of  $F_c$ .

Now draw a horizontal line (dashed) through the  $K_1$  and  $\Delta F_o$  intersection until it intersects the diagonal  $F_R$  line. The vertical line (dashed) from this intersection indicates the fixed scale factor  $K_2$  on the upper scale. This value is about 3200.

Thus, the following approximate data have been obtained through the simple graphical construction:

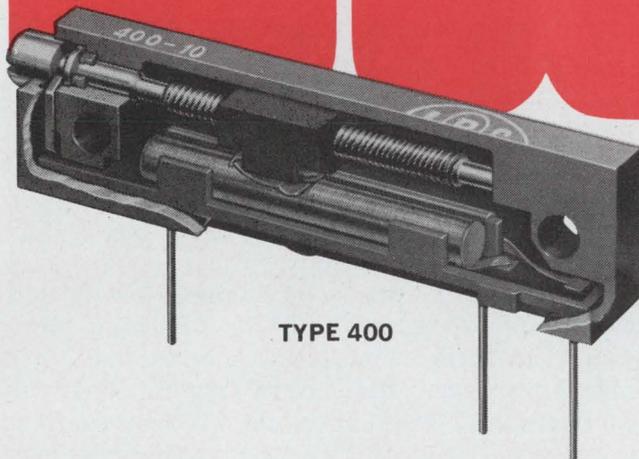
$$\begin{aligned} K_1 &= 32 \\ K_2 &= 3200 \\ F_N &= 3 \text{ to } 12 \text{ MHz} \\ F_c &= 1.6 \text{ kHz} \\ N &= 2000 \text{ to } 8000. \end{aligned}$$

With these values the designer can evaluate the expected performance of his synthesizer. The phase comparator frequency of 1600 Hz will limit the loop bandwidth to some value below this frequency. Vibrational effects, which show up in the VCO as incidental FM noise, will not be removed by the feedback action at frequencies above the loop bandwidth.

By moving the  $K_1$  line to the right to a value of 10, for example, the designer can raise phase comparator frequency  $F_c$  to 5 kHz, but at the same time he will need an input frequency of 40 MHz to the programable counter. He must weigh the benefits of having a higher phase comparator frequency against the added difficulty of performing his counting and reset logic in the divide-by- $N$  counter at the higher frequency of 40 MHz.

Similarly, with a straight edge he may examine on the chart the effects of shifting any of the other lines over which he has control. ■ ■

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ON READER-SERVICE CARD CIRCLE 49

## Cheat on personality tests by giving the tester what he wants. Here is a guide that will enable you to decipher the exam and adopt a fitting guise.

*As most engineers associated with large electronic firms know, the organization has ways of picking and advancing its employees. Personality tests represent one method of determining, at least in part, which engineer is best suited to what job. If you find even one such perplexing examination standing between you and advancement, you will be a lot better prepared to reach that new position if you give the tester precisely the answers for which he looks. In the case of an electronic design engineer, the appropriate image might include some introversion and affinity for visual and mechanical problems. Certainly the personality profile of the ideal designer would be quite unlike that of a salesman. In reading the following, keep in mind both what you are and what you aspire to be. And if you are tempted by levity, remember this: The tester is probably a nervous little man who does not like problems, not even yours. Don't shake him up. Just get the job.*

—THE EDITORS OF ELECTRONIC DESIGN

The important thing to recognize is that you don't win a good score: you avoid a bad one. What a bad score would be depends upon the particular profile the company in question intends to measure you against, and this varies according to companies and according to the type of work. Your score is usually rendered in terms of your percentile rating—that is, how you answer questions in relation to how other people have answered questions in relation to how other people have answered them. Sometimes it is perfectly all right for you to score in the 80th or 90th percentile; if you are being tested, for example, to see if you would make a good chemist, a score indicating that you are likely to be more reflective than

ninety out of a hundred adults might not harm you and might even do you some good.

By and large, however, your safety lies in getting a score somewhere between the 40th and 60th percentiles, which is to say, you should try to answer as if you were like everybody else is supposed to be. This is not always too easy to figure out, of course, and this is one of the reasons why I will go into some detail in the following paragraphs on the principal types of questions. When in doubt, however, there are two general rules you can follow: (1) When asked for word associations or comments about the world, give the most conventional, run-of-the-mill, pedestrian answer possible. (2) To settle on the most beneficial answer to any question, repeat to yourself:

- (a) I loved my father and my mother, but my father a little bit more.
- (b) I like things pretty well the way they are.
- (c) I never worry much about anything.
- (d) I don't care for books or music much.
- (e) I love my wife and children.
- (f) I don't let them get in the way of company work.

Now to specifics. The first five questions in the composite test (p. 93) are examples of the ordinary, garden variety of self-report questions.<sup>1</sup> Generally speaking, they are designed to reveal your degree of introversion or extroversion, your stability, and such. While it is true that in these "inventory" types of tests there is not a right or wrong answer to any one question, cumulatively you can get yourself into a lot of trouble if you are not wary. "Have you enjoyed reading books as much as having company in?" "Do you sometimes feel self-conscious?"—You can easily see what is being asked for here.

### Stay in character

The trick is to mediate yourself a score as near

This article is taken from "The Organization Man," by William H. Whyte, Jr. It is reprinted with the consent of the publisher, Simon and Schuster, Inc.

### Self-Report Questions

- (1) Have you enjoyed reading books as much as having company in?
- (2) Are you sometimes afraid of failure?
- (3) Do you sometimes feel self-conscious?
- (4) Does it annoy you to be interrupted in the middle of your work?
- (5) Do you prefer serious motion pictures about famous historical personalities to musical comedies?

Indicate whether you agree, disagree, or are uncertain:

- (6) I am going to Hell.
- (7) I often get pink spots all over.
- (8) The sex act is repulsive.
- (9) I like strong-minded women.
- (10) Strange voices speak to me.
- (11) My father is a tyrant.

### Hypothetical Question—Dominance Type

- (12) You have been waiting patiently for a salesperson to wait on you. Just when she's finished with another customer, a woman walks up abruptly and demands to be waited upon before you. What would you do?
  - (a) Do nothing
  - (b) Push the woman to one side
  - (c) Give her a piece of your mind
  - (d) Comment about her behaviour to the salesperson.

### Opinion Questions: Degree of Conservatism

Indicate whether you agree or disagree with the following questions:

- (13) Prostitution should be state supervised.
- (14) Modern art should not be allowed in churches.
- (15) It is worse for a woman to have extramarital relations than for a man.
- (16) Foreigners are dirtier than Americans.
- (17) "The Star-Spangled Banner" is difficult to sing properly.

### Word Association Questions

Underline the word you think goes best with the word in capitals:

- (18) UMBRELLA (rain, prepared, cumbersome, appeasement)
- (19) RED (hot, color, stain, blood)
- (20) GRASS (green, mow, lawn, court)
- (21) NIGHT (dark, sleep, moon, morbid)
- (22) NAKED (nude, body, art, evil)
- (23) AUTUMN (fall, leaves, season, sad)

### Hypothetical Situations—Judgment Type

- (24) What would you do if you saw a woman holding a baby at the window of a burning house:
  - (a) Call the fire department
  - (b) Rush into the house
  - (c) Fetch a ladder
  - (d) Try and catch the baby
- (25) Which do you think is the best answer for the executive to make in the following situation:  
Worker: "Why did Jones get the promotion and I didn't?"  
Executive:
  - (a) "You deserved it but Jones has seniority."
  - (b) "You've got to work harder."
  - (c) "Jones's uncle owns the plant."
  - (d) "Let's figure out how you can improve."

### Opinion Questions: Policy Type

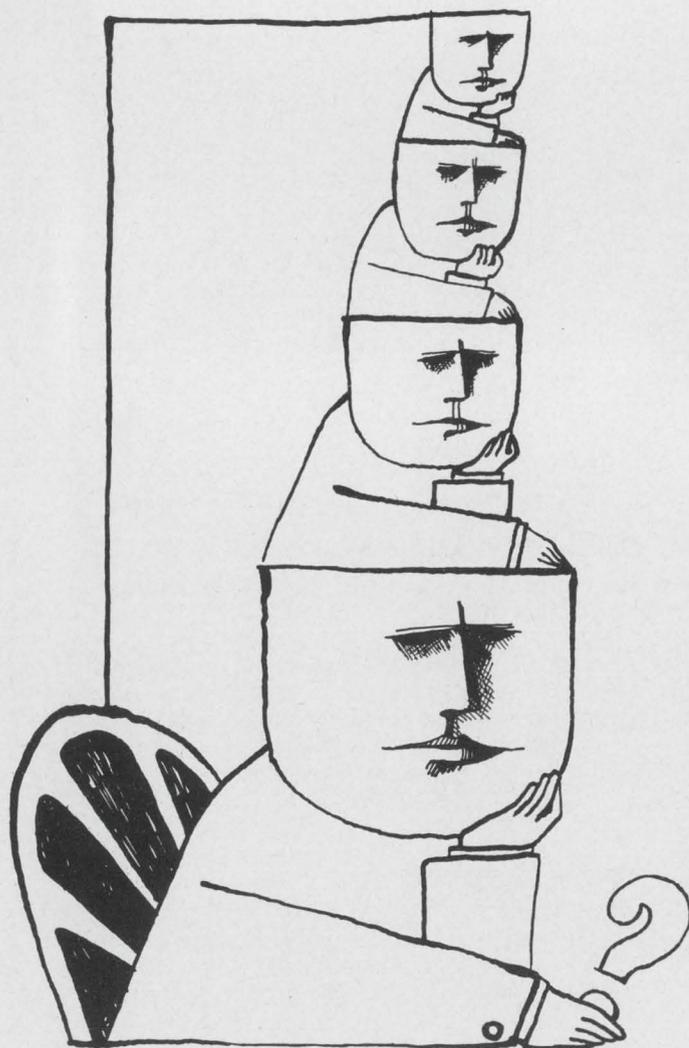
- (26) A worker's home life is not the concern of the company.  
Agree ..... Disagree .....
- (27) Good supervisors are born, not made.  
Agree ..... Disagree .....
- (28) It should be company policy to encourage off-hours participation by employees in company-sponsored social gatherings, clubs, and teams.  
Agree ..... Disagree .....

### Opinion Questions: Value Type

- (29) When you look at a great skyscraper, do you think of:
  - (a) our tremendous industrial growth
  - (b) the simplicity and beauty of the structural design
- (30) Who helped mankind most?
  - (a) Shakespeare
  - (b) Sir Isaac Newton

the norm as possible without departing too far from your own true self. It won't necessarily hurt you, for example, to say that you have enjoyed reading books as much as having company in. It will hurt you, however, to answer every such question in that vein if you are, in fact, the kind that does enjoy books and a measure of solitude. Strive for the happy mean; on one hand, recognize that a display of too much introversion, a desire for reflection, or sensitivity is to be avoided. On the other hand, don't overcompensate. If you try too hard to deny these qualities in yourself, you'll end so far on the other end of the scale as to be rated excessively insensitive or extroverted. If you are somewhat introverted, then, don't strive to get yourself in the 70th or 80th percentile for extroversion, but merely try to get up into the 40th percentile.

Since you will probably be taking not one, but a battery of tests, you must be consistent. The tester will be comparing your extroversion score on one test with, say, your sociability score on another, and if these don't correlate the way the tables say



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Your score is compared with those of others.

they should, suspicion will be aroused. Even when you are taking only one test, consistency is important. Many contain built-in L ("lie") scores, and woe betide you if you answer some questions as if you were a life of the party type and others as if you were an excellent follower. Another pitfall to avoid is giving yourself the benefit of the doubt on all questions in which one answer is clearly preferable to another, viz.: "Do you frequently day dream?" In some tests ways have been worked out to penalize you for this. (By the same token, occasionally you are given credit for excessive frankness. But you'd better not count on it.)

#### Answer the test maker

Question five asks:

"Do you prefer serious motion pictures about famous historical personalities to musical comedies?" If you answer this question honestly you are quite likely to get a good score for the wrong reasons. If you vote for the musical comedies, you are given a credit for extroversion. It might be, of course, that you are a very thoughtful person who dislikes the kind of pretentious, self-consciously arty "prestige" pictures which Hollywood does badly, and rather enjoy the musical comedies which it does well. The point illustrated here is that, before answering such questions, you must ask yourself which of the alternatives the test maker, not yourself, would regard as the more artistic.

#### Choose your neurosis

When you come across questions that are like the ones from 6 to 11—"I often get pink spots all over"—be very much on your guard. Such questions were originally a by-product of efforts to screen mentally disturbed people; they measure degrees of neurotic tendency and were meant mainly for use in mental institutions and psychiatric clinics. The Organization has no business at all to throw these questions at you, but its curiosity is powerful and some companies have been adopting these tests as standard. Should you find yourself being asked about spiders, Oedipus complexes, and such, you must, even more than in the previous type of test, remain consistent and as much in character as possible—these tests almost always have lie scores built into them. A few mild neuroses conceded here and there won't give you too bad a score, and in conceding neuroses you should know that more often than not you have the best margin for error if you err on the side of being "hypermanic"—that is, too energetic and active.

#### Don't be too dominant

Question 12, which asks you what you would do

if somebody barged in ahead of you in a store, is fairly typical of the kind of questions designed to find out how passive or dominant you may be. As always, the middle course is best. Resist the temptation to show yourself as trying to control each situation. You might think companies would prefer that characteristic to passivity, but they often regard it as a sign that you wouldn't be a permissive kind of leader. To err slightly on the side of acquiescence will rarely give you a bad score.

### Incline to conservatism

Questions 13 through 17, which ask you to comment on a variety of propositions, yield a measure of how conservative or radical your views are.<sup>2</sup> To go to either extreme earns you a bad score, but in most situations you should resolve any doubts you have on a particular question by deciding in favor of the accepted.

Similarly with word associations. In questions 18 through 23, each word in capitals is followed by four words, ranging from the conventional to the somewhat unusual. The trouble here is that if you are not a totally conventional person you may be somewhat puzzled as to what the conventional response is. Here is one tip: before examining any one question closely and reading it from left to right, read vertically through the whole list of questions and you may well see a definite pattern. In making up tests, testers are thinking of ease in scoring, and on some test forms the most conventional responses will be found in one column, the next most conventional in the next, and so on. All you have to do then is go down the list and pick, alternately, the most conventional, and the second most conventional. Instead of a high score for emotionalism, which you might easily get were you to proceed on your own, you earn a stability score that indicates "normal ways of thinking."

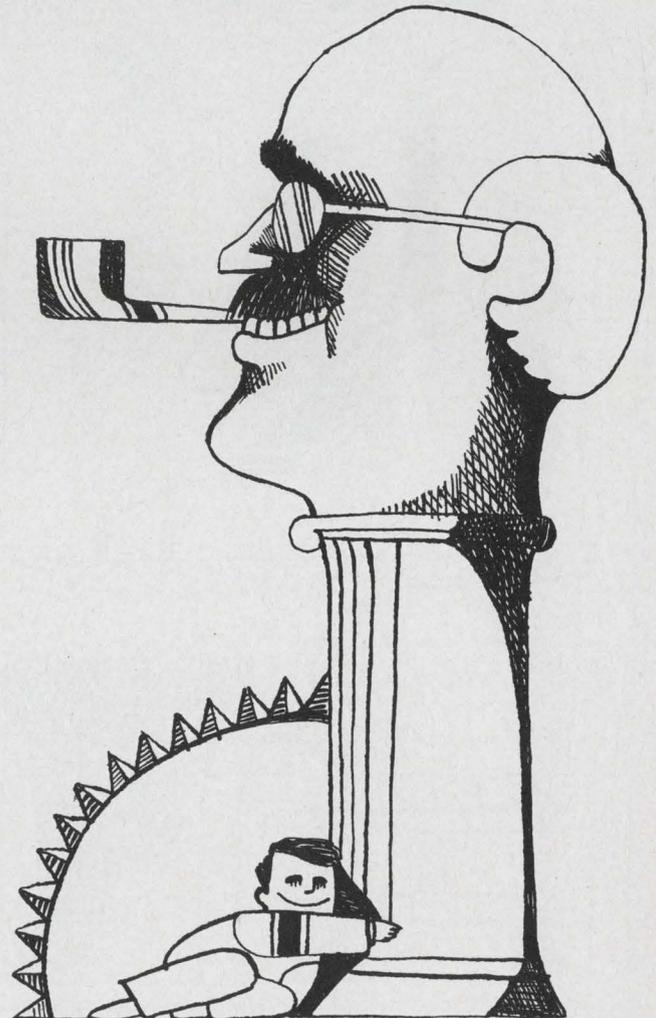
### Don't split hairs

When you come to hypothetical situations designed to test your judgment, you have come to the toughest of all questions.<sup>3</sup> In this kind there are correct answers, and the testers make no bones about it. Restricted as the choice is, however, determining which are the correct ones is extremely difficult, and the more intelligent you are the more difficult. One tester, indeed, states that the measurement of practical judgment is "unique and statistically independent of such factors as intelligence, and academic and social background." He has a point. Consider the question about the woman and the baby at the window of the burning house. It is impossible to decide which is the best course of action unless you know

how big the fire is, whether she is on the first floor or the second, whether there is a ladder handy, how near by the fire department is, plus a number of other considerations.

On this type of question, let me confess that I can be of very little help to the reader. I have made a very thorough study of these tests, have administered them to many people of unquestioned judgment, and invariably the results have been baffling. But there does seem to be one moral: don't think too much. The searching mind is severely handicapped by such forced choices and may easily miss what is meant to be the obviously right answer. Suppress this quality in yourself by answering these questions as quickly as you possibly can, with practically no pause for reflection.

The judgment questions from 25 through 28 are much easier to answer.<sup>4</sup> The right answers here are, simply, those which represent sound personnel policy, and this is not hard to figure out. Again, don't quibble. It is true enough that it is virtually impossible to tell the worker why he didn't get promoted unless you know whether he was a good worker, or a poor one, or whether



I loved my father a little more.

Jones' uncle did in fact own the plant (in which case, candor could be eminently sensible). The mealy-mouthed answer d)—“Let's figure out how you can improve”—is the “right” answer. Similarly with questions about the worker's home life. It isn't the concern of the company, but it is modern personnel dogma that it should be, and therefore “agree” is the right answer. So with the question about whether good supervisors are born or made. To say that a good supervisor is born deprecates the whole apparatus of modern organization training, and that kind of attitude won't get you anywhere.

### Know your company

Questions 29 and 30 are characteristic of the kind of test that attempts to measure the relative emphasis you attach to certain values—such as



Don't quibble about the multiple choices.

aesthetic, economic, religious, social.<sup>5</sup> The profile of you it produces is matched against the profile that the company thinks is desirable. To be considered as a potential executive, you will probably do best when you emphasize economic motivation the most; aesthetic and religious, the least. In question 29, accordingly, you should say the skyscraper makes you think of industrial growth. Theoretical motivation is also a good thing; if you were trying out for the research department, for example, you might wish to say that you think Sir Isaac Newton helped mankind more than Shakespeare and thereby increase your rating for theoretical learning. Were you trying out for a public relations job, however, you might wish to vote for Shakespeare, for a somewhat higher aesthetic score would not be amiss in this case.

There are many more kinds of tests and there is no telling what surprises the testers will come up with in the future. But the principles will probably change little, and by obeying a few simple precepts and getting yourself in the right frame of mind, you have the wherewithal to adapt to any new testing situation. In all of us there is a streak of normalcy. ■ ■

### References:

1. Outstanding example is the *Minnesota Multiphasic Personality Inventory*, Revised Edition, by Starke R. Hathaway and J. Charnley McKinley. Published by the Psychological Corporation, N.Y. 495 questions. This yields scores on hypochondriasis, depression, hysteria, psychopathic deviation, masculinity and femininity, paranoia, psychoasthenia, schizophrenia, hypomania. It also yields a score on the subject's "test-taking attitude," with a score for his degree of "defensiveness-frankness." If the subject consistently gives himself the benefit of the doubt, or vice versa, the scoring reveals the fact. This is not a test for the amateur to trifle with.

2. An example of this kind of testing is the *Conservatism-Radicalism Opinionnaire* by Theodore F. Lentz and Colleagues of The Attitude Research Laboratory. Published by Character Research Association, Washington University, St. Louis, Mo., Dept. of Education. 60 statements are given; the subject indicates whether he tends to agree or disagree. His score is obtained by checking the number of times he sides with the conservative statement side vs. the radical one.

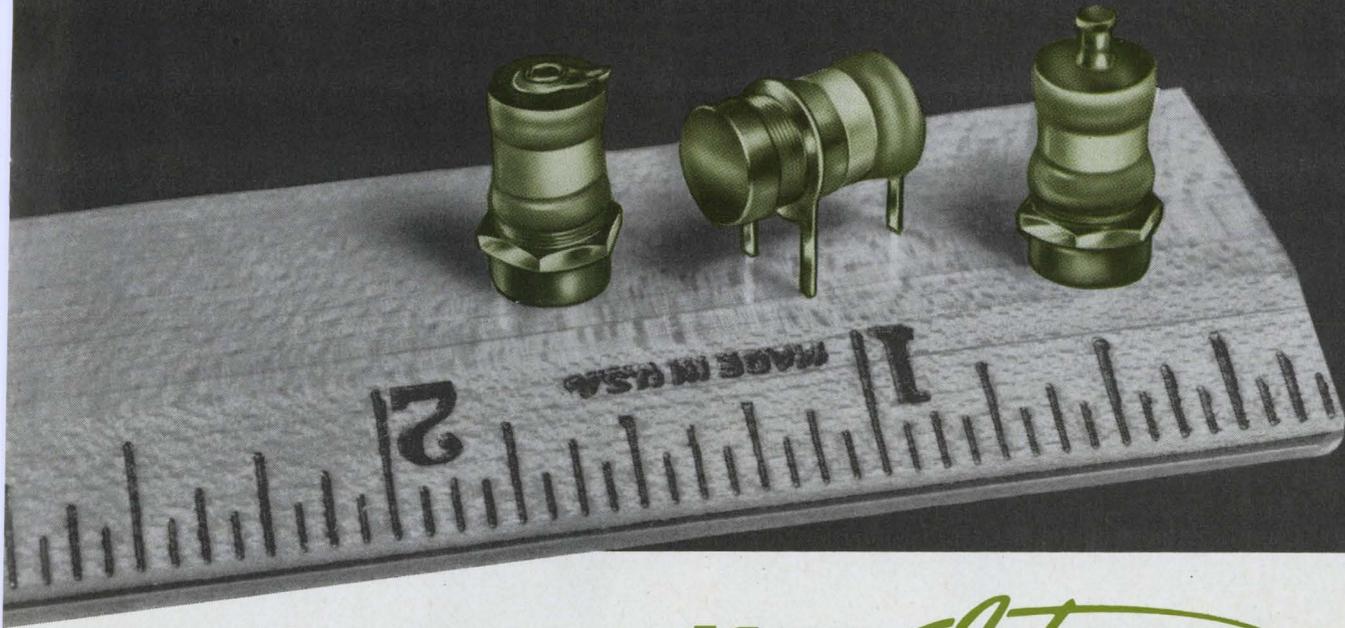
3. Two tests of this type are:  
*Test of Practical Judgment* by Alfred J. Cardall, N.B.A., Ed.D. Published by Science Research Associates, Inc., Chicago, Ill. 48 forced-choice questions "designed to measure the element of practical judgment as it operates in everyday business and social situations." How were the "best" answers chosen? "Rigorous statistical analysis was supplemented by consensus of authority."

*Practical Social Judgment* by Thomas N. Kenkins, Ph.D. Copyright by Executive Analysis Corporation, N.Y. 52 questions about hypothetical situations; subject must choose the "best" and the "poorest" of given answers.

4. An example of this kind of test is *How to Supervise?* by Quentin W. File, edited by H. H. Remmers. Published by the Psychological Corporation, N.Y. Copyright by Purdue Research Foundation, Lafayette, Indiana. 100 questions on management policy and attitudes.

5. *A Study of Values, Revised Edition*, by Gordon W. Allport, Philip E. Vernan, and Gardner Lindzey. Copyright by Gordon W. Allport, Philip E. Vernan and Gardner Lindzey. Published by Houghton, Mifflin Co. 45 forced-choice questions. Answers are scored to give a measure of the relative prominence of six motives in a person: theoretical, economic, aesthetic, social, political, and religious. A profile is charted to show how he varies from the norm on each of the six.

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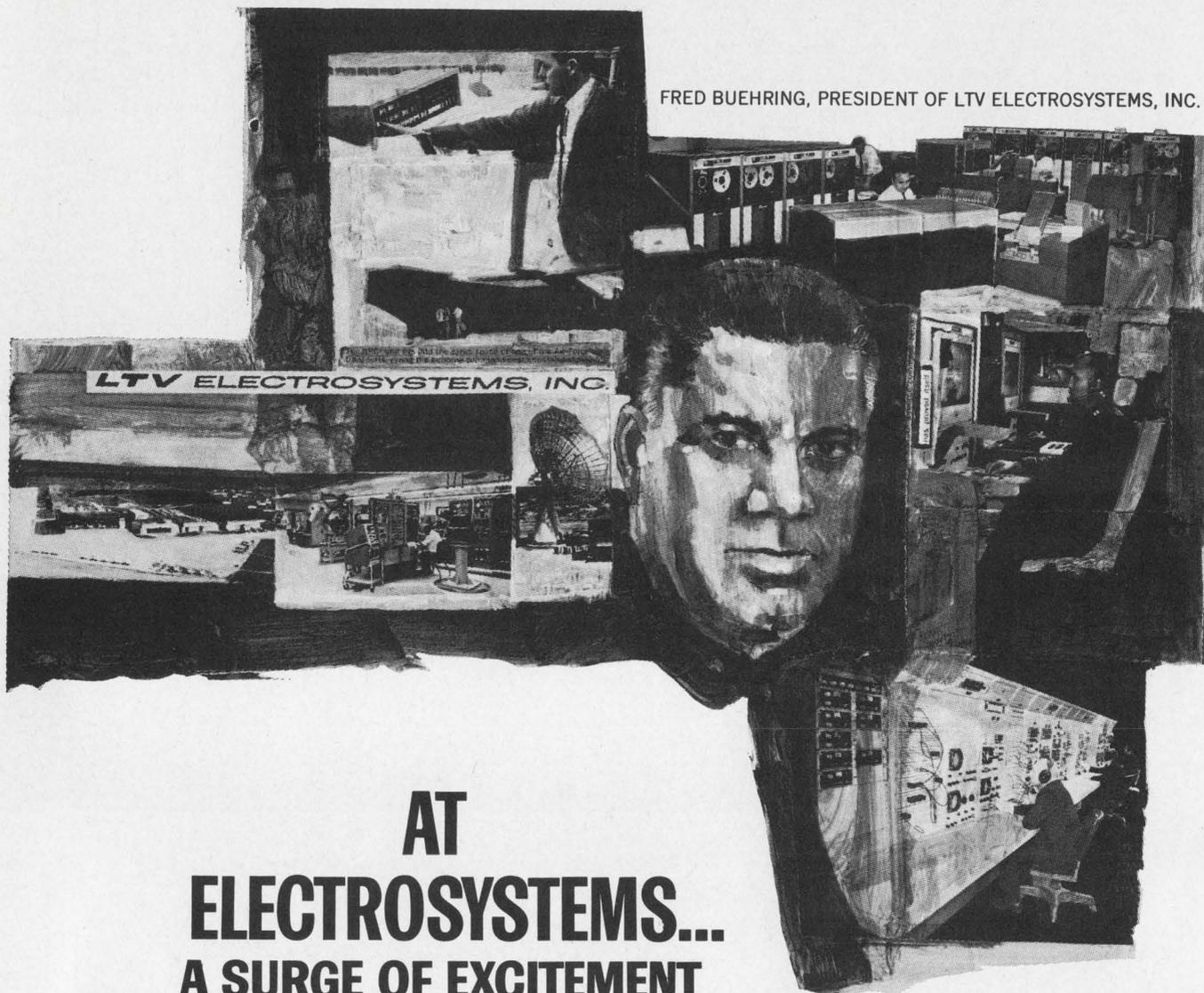
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		to	
		to	
		to	

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			to
			to

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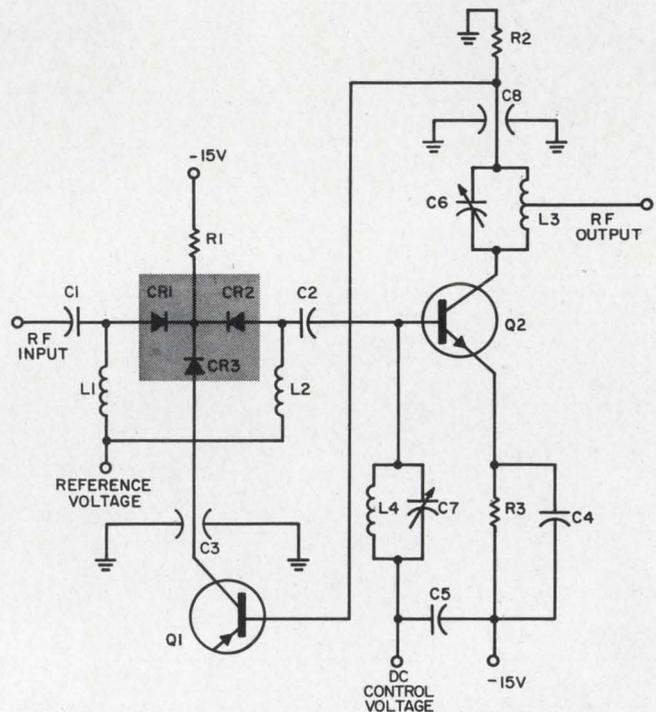
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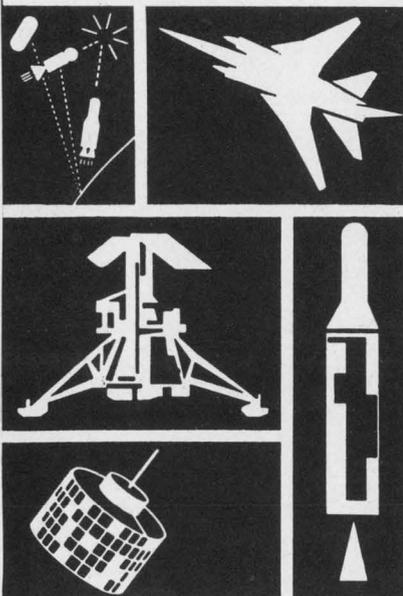
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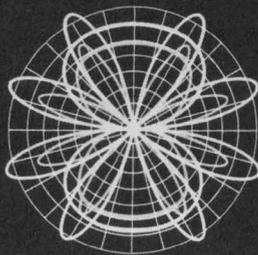


# Book Reviews

## radio handbook

seventeenth edition

William I. Orr, W6SA1



### Here's a new edition of one of the classics

*Radio Handbook*, ed. William I. Orr, W6SA1: (17th ed.; Editors and Engineers, Ltd., New Augusta, Ind.), 847 pp. \$12.95.

If any book can be said to have "universal" appeal and application, the *Radio Handbook* is certainly such a book. Almost anyone interested in radio communications will find much useful information here.

Aimed primarily at the radio amateur, this book should prove equally useful to the practicing engineer. Practical general design procedures for receiving and transmitting equipment, both vacuum-tube (that's the little bottle with the light in it) and solid-state, are given in considerable detail.

The newer amateur communication modes, such as radio teletype and single sideband, are treated along with amplitude modulation and manual radio telegraphy. Equipment designs for these modes are included for those who want to do it themselves.

Propagation and antennas are presented both in theoretical and practical form. As in the other sections of the handbook, the theme here might also be said to be "understand, design, build."

Basic test and measurement techniques and instruments are very nicely covered. The chapter devoted to the oscilloscope is an excellent treatment of this versatile instrument, covering the basic operation of the device as well as a number of applications.

The last two chapters in the book are entitled "Workshop Practice" and "Radio Mathematics and Calculations," respectively. The latter starts with basic arithmetic, moves through algebra, logarithms and vectors, and ends with a section on how to prepare nomographs!

The *Radio Handbook* is one of the most informative and useful reference works available.

—Joseph J. Casazza

## Computer language

*A FORTRAN IV Primer*, Elliott I. Organick (Addison-Wesley, Reading, Mass.), 263 pp. \$4.95.

This introduction to computing techniques and to FORTRAN IV and its sister dialects is designed as a text for courses in computer programming, but it is equally useful for individual study. The concepts treated concern computers, algorithms, FORTRAN IV programming language and processors, flow charts, input-output, and real and integer arithmetic. Emphasis is placed on variations and evolutionary changes in FORTRAN IV in order to make the reader receptive to future innovations or to the use of other algebraic languages. Flow charts, example problems with their actual computer solutions, and an abundance of exercises are included as aids to study.

## Radiation and electronics

*Radiation Effects on Electronic Systems*, Henning Lind Olesen (Plenum Press, New York), 234 pp. \$16.50.

This introduction to the effects of nuclear radiation on electronic and electrical equipment was written to meet the needs of the electronic engineer unfamiliar with nuclear terminology who must design equipment hardened against radiation damage. It describes thoroughly the creation of the radiation environment and its interaction with electronic and electrical circuitry, and

discusses problems of design against radiation damage and interference. Topics discussed include radiation effects on semiconductors and other materials, passive and active radiation shielding, and recommended experimental methods and simulation facilities for design testing.

### RF enclosures

*Contemporary RF Enclosures*, Erik A. Lindgren (Erik A. Lindgren, Chicago), 108 pp. \$12.50.

An unbiased, comprehensive discussion of construction and materials, this report provides research and engineering information on improvements made in RF enclosures. The author outlines the five factors that determine the degree of attenuation to be expected from different types of rooms and the material used in their construction. With the information given and the tables shown, the attenuation that will be obtained can be predicted with considerable accuracy for each type of room.

### Communications and noise

*Noise and its Effect on Communication*, Nelson M. Blachman (McGraw-Hill, New York), 205 pp. \$13.50.

Here is a concise, unified treatment of the pertinent fundamentals of random processes and their spectra, the effect of nonlinear transformations upon a signal and noise, the statistical theory of detection, and information theory. Although the noise dealt with is primarily the Gaussian noise that arises in every electrical circuit and limits the sensitivity of electronic equipment, the approach used and many of the results obtained are general enough to apply to other types of noise as well. Suitable for reference as well as self-study, this book includes among its special features many facets of information theory not found even in more specialized books.

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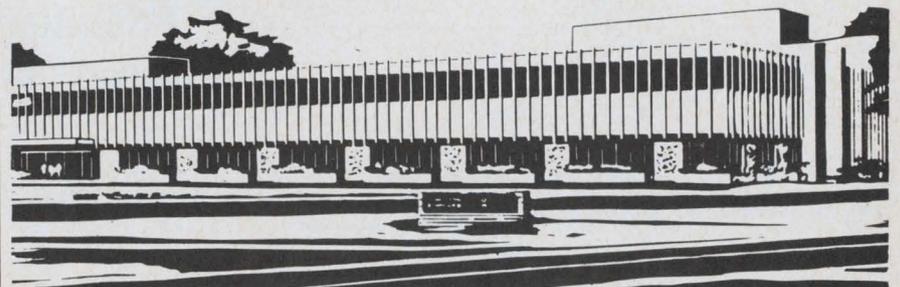
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ON READER-SERVICE CARD CIRCLE 904

# LC oscillator tank circuit built with just one FET

The tank circuit of a FET LC oscillator is no problem to put together because the FET presents negligible loading on the tank circuit. The desired feedback of the tank circuit can be a simple design if a capacitor is used in series with the coil (see schematic).

The design equations are:

$$F = 1/[2 \pi (LC_t)^{1/2}],$$

where  $F$  is frequency and  $C_t$  is the capacity to resonate  $L$  at the desired frequency.

$$C_2 C_3 = G_m R C_t^2,$$

where  $G_m$  is the FET transconductance and  $R$  is coil loss.

$$1/C_t = 1/C_1 + 1/C_2 + 1/C_3.$$

The designer must choose either  $C_2$  or  $C_3$ , and solve for the other. For the case when  $C_2 = C_3$ :

$$C_2 = C_3 = C_t (G_m R)^{1/2}.$$

The derivation of these equations is the following. For high  $Q$ , the impedance of the illustrated network is approximated by:

$$Z = (C_t/C_2)^2 R, \quad (1)$$

where  $C_t$  is the capacity of  $C_1$ ,  $C_2$  and  $C_3$  in series. This can be seen by assuming that the capacitors in series act like the turns ratio on a transformer where the impedance ratio is equivalent to the turns ratio squared.

The gain of a FET is given by:

$$A = G_m Z. \quad (2)$$

The transfer function of the tank circuit is given by:

$$B = -(C_2/C_3). \quad (3)$$

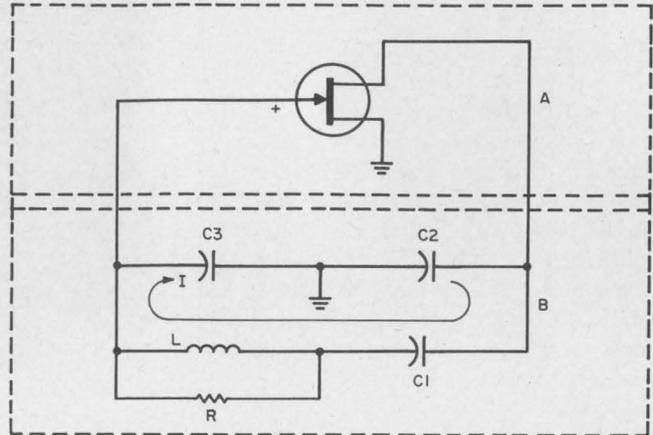
This can be seen from the fact that current  $I$  circulating in the tank circuit goes through both  $C_1$  and  $C_3$ .

A condition necessary for oscillation is that the loop gain be at least 1, or:

$$AB = 1. \quad (4)$$

Combining Eqs. 1 and 2 gives:

$$A = -G_m (C_t/C_2)^2 R. \quad (5)$$



FET oscillator tank circuit uses capacitor in series with the coil.

Substituting Eqs. 3 and 5 into Eq. 4 gives:

$$AB = 1 = G_m R C_t^2 / C_2 C_3. \quad (6)$$

Rewriting Eq. 6 gives:

$$C_2 C_3 / C_t^2 = G_m R. \quad (7)$$

Equation 7 can be interpreted as: The ratio of  $C_2$  and  $C_3$  does not change the feedback as long as the product of  $C_2$  and  $C_3$  stays constant.

This has been demonstrated in practice for ratios up to ten.

For the case when  $C_2 = C_3$ , Eq. 7 can be rewritten into the form in which it has already appeared among the design equations:

$$C_2 = C_3 = C_t (G_m R)^{1/2}. \quad (8)$$

Solving for  $C_1$  when  $C_2 = C_3$  gives:

$$C_1 = 1/(1/C_t - 2/C_2). \quad (9)$$

*Rudy Stefenel, Design Engineer, Microwave Laboratories, Hewlett-Packard, Palo Alto, Calif.*

VOTE FOR 110

## Potentiometer serves to vary ramp generator output linearly

A three-transistor ramp generator of wide usefulness can be designed with provision to adjust linearity for changes in output impedance. It can be used for the transfer function measurement of integrated circuits and data plotting of X-Y graph recorders; it can also be applied in the

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PLAXIAL CABLE DEPT.

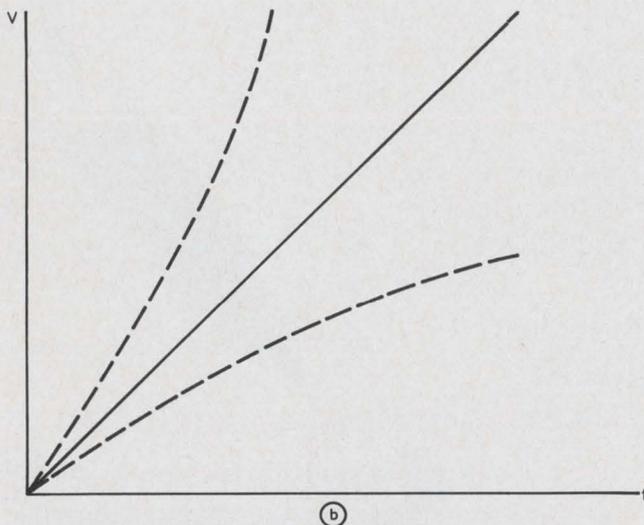
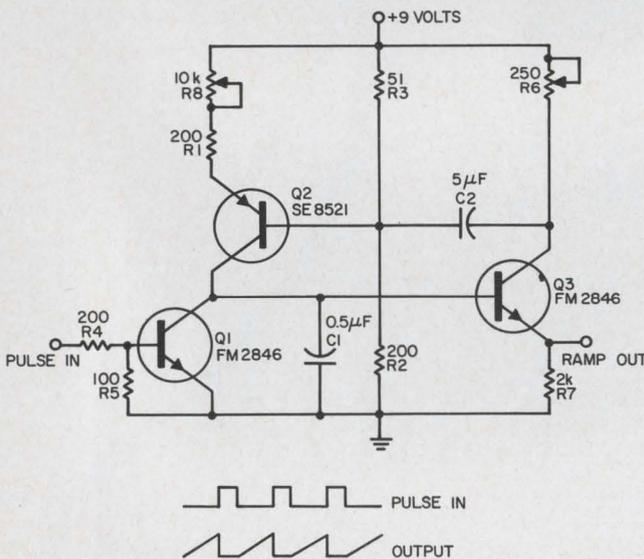
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ramp method of analog-to-digital conversion and the so-called Class-D amplification system. The method outlined here (Fig. 1a) is to charge a good-quality capacitor from a constant-current source, and provide an emitter-follower output for low output impedance.

Resistors  $R_2$  and  $R_3$  establish the bias for the constant-current source,  $Q_2$ ,  $R_1$  and  $R_8$ , which linearly charges capacitor  $C_1$ . Another transistor,  $Q_3$ , provides a low-impedance discharge path for this capacitor.

Transistor  $Q_3$  is an emitter-follower with a small collector resistor for positive feedback for the constant-current source. Since this transistor appears as a finite impedance to capacitor  $C_1$ , the charge is slightly nonlinear. This signal is invert-



Potentiometer  $R_6$  in the output stage of the ramp generator (a) is used to vary ramp linearity as demonstrated in (b).

ed at the collector of  $Q_3$  and applied to the constant-current source, which varies the charging current slightly to compensate for the nonlinearity. Linearity can be varied by  $R_6$  as shown in Fig. 1b. These variations are dependent on the output load impedance.

Timing can be varied over a wide range if care is taken to choose realistic values for  $C_1$  and  $R_1$  and  $R_8$ . Resistors  $R_2$  and  $R_3$  should be relatively small in order to provide a stable voltage source at the base of  $Q_2$ .

Capacitor  $C_2$  is 5- to 10- $\mu$ F electrolytic for good feedback at low frequencies. Input requirements are a single positive power supply and a positive pulse of sufficient amplitude and width to saturate  $Q_1$ . The repetition frequency of the ramp is determined by the input pulse; this should be borne in mind during selection of  $R_1$ ,  $R_8$  and  $C_1$ . For the values given in Fig. 1a, the input pulse repetition rate is 1 Hz, pulse width 10  $\mu$ s and amplitude 5 volts.

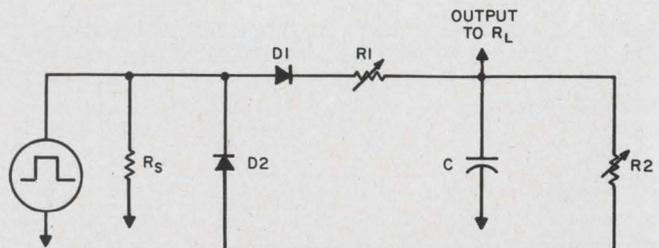
Orville L. Lykins, Applications Engineer, Fairchild Semiconductor, Mountain View, Calif.  
VOTE FOR 111

## Pulse rise and fall times varied independently

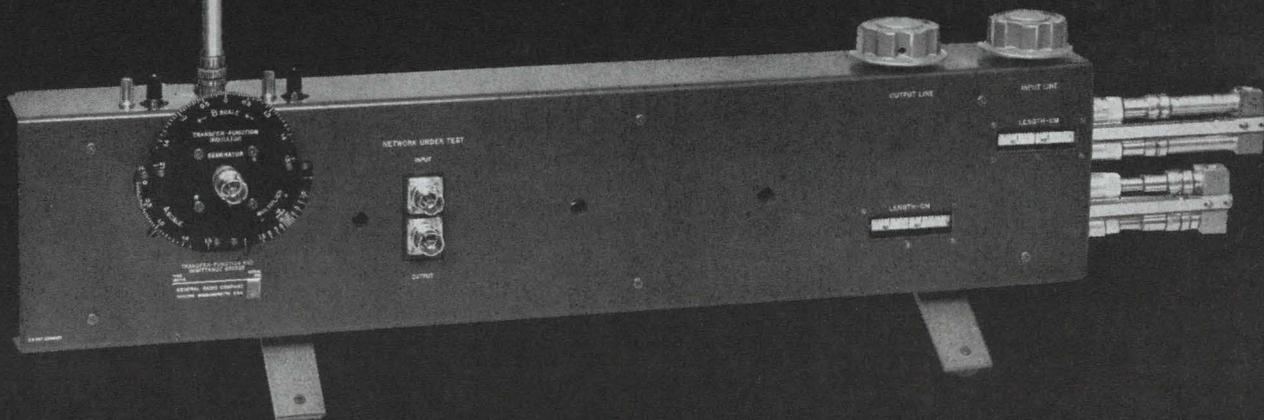
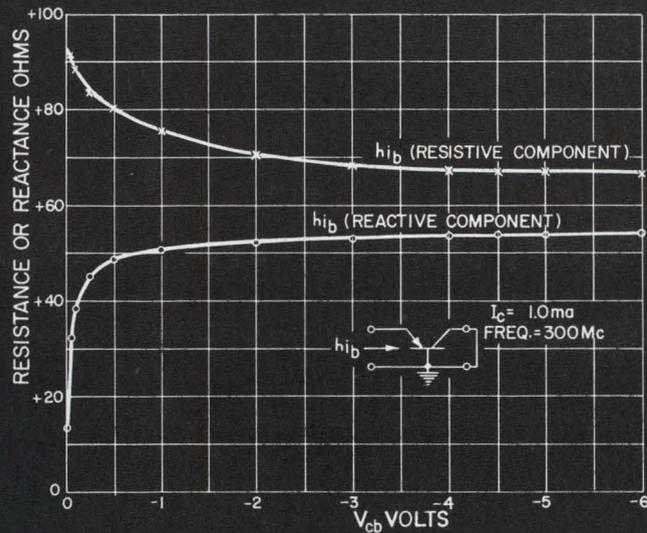
The rise and fall times of a pulse can be controlled independently with this simple circuit.

A positive-going input voltage charges capacitor  $C$  through diode  $D_1$  and variable resistor  $R_1$ . If the voltage across  $C$  is taken as the output, then the rise time is controlled by  $R_1$  since diode  $D_2$  is back-biased. When the input voltage goes to zero (or negative)  $D_1$  is back-biased, and capacitor  $C$  discharges through  $R_2$ ,  $D_2$ , the source impedance  $R_s$  and the load impedance  $R_L$ . If  $R_L$  is chosen to be much larger than  $R_{2max}$  and  $R_s$  is made on the order of  $R_{2min}$ , then the output fall time is controlled by  $R_2$ . The roles of  $R_1$  and  $R_2$  are reversed for negative-going pulses.

This technique permits continuous control of rise and fall times independently of each other



Switching  $D_1$  and  $D_2$  with the input pulse permits independent rise-and-fall-time control.



## Measure transistor $h$ and $y$ parameters directly without resorting to the "New Math."

If you use  $h$  and  $y$  parameters in your design work, you can measure them directly with the 1607-A Transfer-Function and Immittance Bridge. You can measure  $h_{ob}$ ,  $h_{oe}$ ,  $h_{fb}$ ,  $h_{fe}$ ,  $h_{ib}$ ,  $h_{ie}$ ,  $h_{rb}$ ,  $h_{re}$ ,  $y_{ob}$ ,  $y_{oe}$ ,  $y_{fb}$ ,  $y_{fe}$ ,  $y_{ib}$ ,  $y_{ie}$ ,  $y_{rb}$ ,  $y_{re}$ , as well as all open-circuit impedance parameters directly, without using mathematical transformations that could degrade data accuracy. These measurements can be made over a broad 25-MHz to 1.5-GHz range.

Since the 1607-A uses adjustable lines settable to half and quarter wavelengths, both open- and short-circuit conditions can be easily established. Eight specially designed, electrically invisible mounts for almost all popular transistor configurations provide a readily defined reference plane for measurements. No measurement corrections need be made for the mounts. Even transistors with

2-inch leads can be measured without correction (the mount "swallows" the leads). The transistor can even be mounted with some of its lead length exposed to simulate its eventual connection in the circuit. In this way, the parasitic effects of the leads can also be considered.

Price of the 1607-A is \$1995; transistor-mount prices range from \$65 to \$115. For a complete description of the 1607-A, request our Engineering Reprints E107 and E109. Write General Radio Company, 22 Baker Avenue, W. Concord, Massachusetts 01781; telephone (617) 369-4400; TWX 710 347-1051.

**GENERAL RADIO**

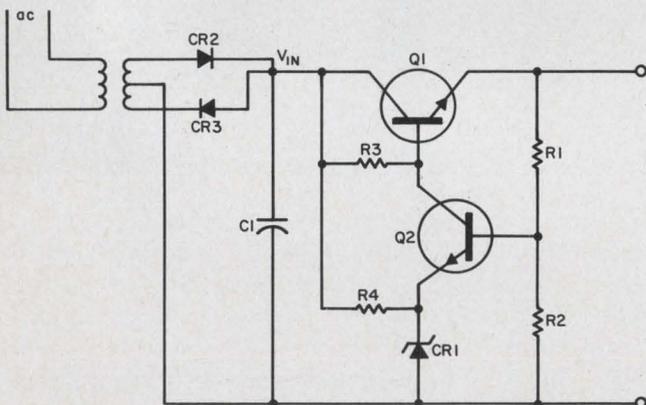
over a very wide range. In particular, it enables the fall time to be adjusted so that it is much greater than the rise time, or vice versa. Capacitors can be switched in parallel with  $C$  to change the range in fixed steps. A typical application for this circuit is in a communications receiver to provide separate adjustment of age attack and decay time constants.

*Craig Moore and Wilfred Hand, Designers, Sylvania Electronics Systems, Williamsville, N.Y.*

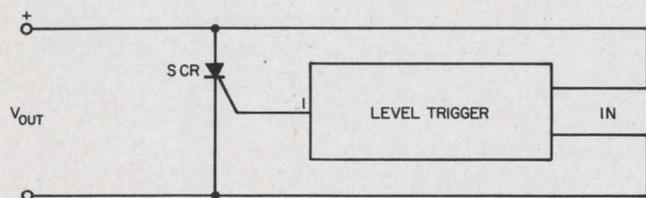
VOTE FOR 112

## Protect ICs against power supply failure

A simple power supply component failure can destroy thousands of dollars' worth of ICs. For example, consider the circuit shown in Fig. 1. If used as a regulated supply for a large IC system, a collector-to-emitter short in  $Q1$  will cause the output voltage to rise to  $V_{in}$ . As this voltage is, in general, higher than the maximum rating of the integrated circuits, an entire system may be destroyed. A failure of any other regulator component may cause the same catastrophic result. While this problem is not restricted to IC systems, the characteristics of integrated circuits make the



1. A collector-to-emitter short in  $Q1$  will cause  $V_{in}$  to appear at the supply output terminals, destroying an entire IC system.



2. A level trigger and an SCR placed across the power supply terminals will short out, whenever the supply voltage rises above some preset value.

situation uncommonly hazardous, as the ICs have a ratio of maximum to operating supply voltage of about 1.6:1. Discrete component circuits, on the other hand, typically have a ratio of more than 4:1.

It is not difficult to design a power supply in which the ratio of  $V_{in}$  to  $V_o$  is less than 4:1 and which is, therefore, fail-safe for systems using discrete components. Unfortunately, power supply design in which the ratio does not exceed 1.6:1 for worst-case line, load and transformer variations involves serious compromises in cost and performance. The problem is further compounded by the low current drain of ICs, which allows a single power supply to feed a very large system.

A partial solution may be effected by the inclusion of current-limiting circuitry in the power supply. However, a far higher degree of safety may be realized with the circuitry shown in Fig. 2 in conjunction with current-limiting circuitry.

In operation, this circuit is connected across the supply output. If for any reason  $V_o$  rises above the safe level, the level trigger goes to the 1 state which causes the SCR to conduct. This shorts-circuits the output, which will then blow the primary fuse. With suitable thermal design, this system can protect the integrated circuits against any power supply failure.

This approach has been successfully applied in a working power supply system that is produced by the Data Technology Corp.

*Phil Wasserman, Director, Instrument Development, Behlman-Invar Electronics Corp., Santa Monica, Calif.*

VOTE FOR 113

## Three lamps yield seven colors

By use of the same projected-color technique as that employed in colored-television receivers, a three-lamp pilot light (Microswitch Data Sheet 199A, or equal) can project as many as seven different colors ranging through the full color spectrum.

This may be useful, either to indicate seven separate conditions, or for a gradually increasing operation, such as a temperature rise, where the spectrum colors from cool to hot could be simulated.

The pilot light assembly employs a white translucent screen. Each lamp has either a red, green or blue silicone rubber color cap over it. Maximum brightness will be obtained with 6-volt lamps, type no. 328. Each lamp must project over the entire screen.

*(continued on p. 110)*

*We asked 20 of your fellow engineers*

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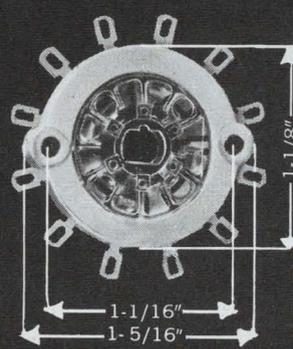
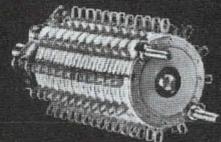
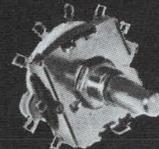
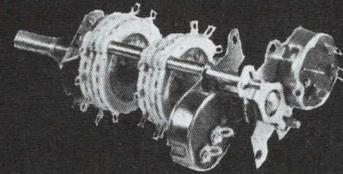
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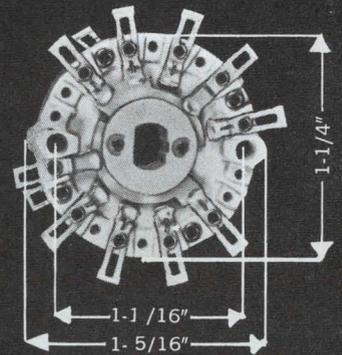
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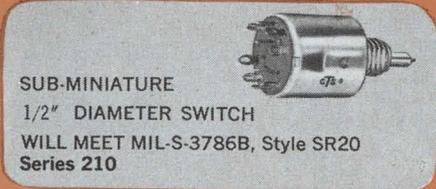
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Because 1, 2, or 3 lamps are used to obtain the color combinations, variations in brilliance will be experienced. Low ambient-light contrast will augment the screen intensity.

Color Chart

Projected color on screen	Primary color lamps		
	Blue	Green	Red
Purple	X		X
Blue	X		
Turquoise	X	X	
Green		X	
Yellow		X	X
Red			X
White	X	X	X

Marshall K. Kessie, *Atomics International, Canoga Park, Calif.*

VOTE FOR 114

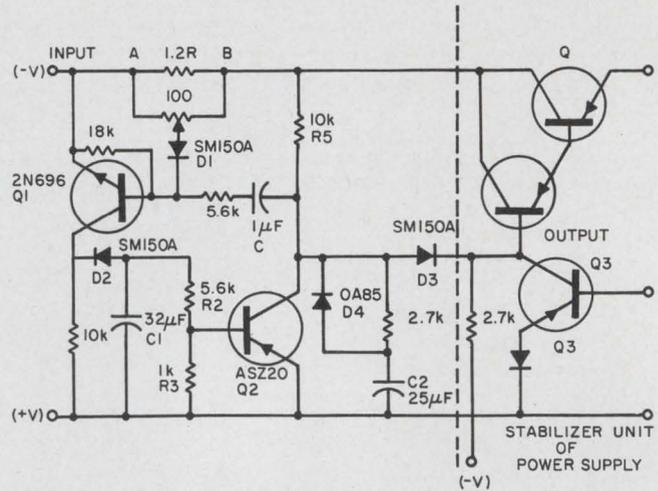
## Protect power supply against overloading

The wide use of power supplies has created a need for automatic safety circuits that will protect these supplies from overloadings and short circuits. These circuits should also allow the supplies to return to normal functioning as soon as the faults disappear. They should function for either resistive or capacitive loads, and accomplish all this at the lowest possible cost.

The accompanying circuit works as a safety device for the stabilizer unit of a power supply by switching output transistor *Q* when the current exceeds a predetermined value.

The stabilizer unit is adjusted to supply a current of 1 amp maximum. When this current acquires a higher value because of overloadings or short circuits, point *B* of resistor *R* becomes more positive than point *A* and transistor *Q1* is switched on through diode *D1*. Capacitor *C1* then starts charging through diode *D2* and transistor *Q2* is switched on. The voltage swing (positive swing) at the collector of *Q2* is applied through *C* to the base of *Q1*, whereupon the latter becomes more conductive. With this feedback through *C*, the safety circuit becomes faster.

The voltage drop at the collector of *Q2* makes *D3* conductive and the voltage at the collector of *Q3* approaches zero. As it is this latter voltage that drives *Q*, its low value causes *Q* to switch off. Now, the current flowing through *R* drops below 1 amp whereupon the circuit returns to its initial state.



Power supply output current is monitored by *R* and triggers protective circuitry whenever the current exceeds a predetermined value.

If the overloading or short circuit still persists, the cycle just described is repeated until the fault disappears.

Diode *D2* allows *C1* to discharge through *R2* and *R3*, thus increasing the off time of *Q*. Capacitor *C1* delays the switching on of *Q*. Potentiometer *R* permits adjustment of current value at which the safety circuit is to operate. Capacitor *C2* is used in case of capacitive load.

In such a case, when the power supply is switched on, the voltage that drives *Q* increases with a delay caused by the time constant *R5C2*. The output voltage of the power supply increases similarly and the capacitive load is charged progressively, causing no trouble to the power supply.

Resistor *R4* protects *Q2* when *Q2* is made capacitive by the discharging of *C2*; *D4* short-circuits *R4* when *C2* is charged.

### Reference:

Jack Takesuye, "Tunnel Diode Sensor Protects Regulator from Short Circuit," *Electronics*, XXXVIII, No. 25 (Dec. 13, 1965), 75-76.

Daniel Panayotis, *Electronic Engineer, Piraeus, Greece.*

VOTE FOR 115

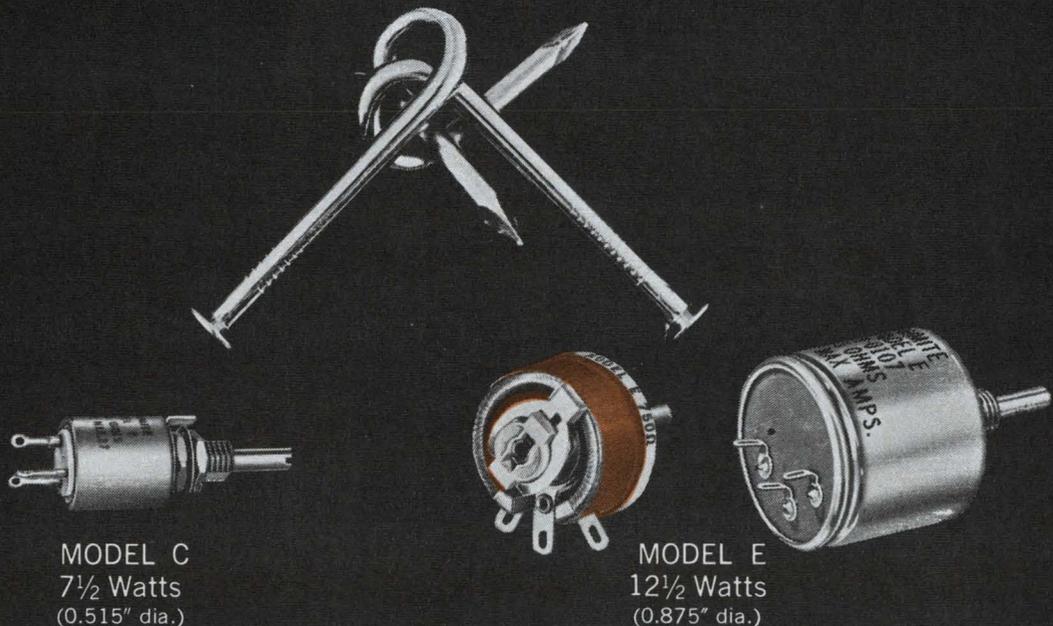
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Alex. W. Adler, President, Radio Research Co., Rockaway, N. J.

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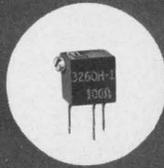
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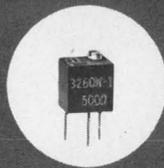
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ON READER-SERVICE CARD CIRCLE 54

# Now! All the Features of Larger Size Potentiometers — Except Larger Size!



New TRIMPOT® Potentiometer Model 3260H  
ACTUAL SIZE



New TRIMPOT® Potentiometer Model 3260W  
ACTUAL SIZE

- 1 Dimensions: 1/4" x 1/4" x 0.17"
- 2 Multi-turn adjustment
- 3 Damage-proof clutch action
- 4 Indestructible **SILVERWELD®** termination
- 5 Standard resistances from 10Ω to 20K
- 6 20 ppm wire
- 7 Two configurations available

Write today for complete technical data

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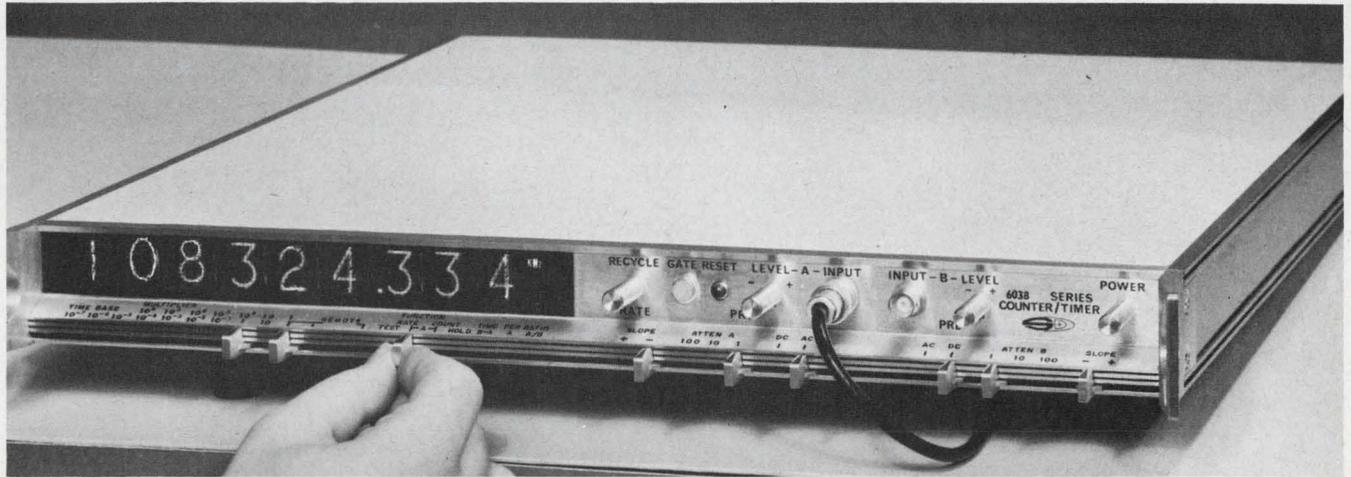


BOURNS, INC., TRIMPOT DIVISION  
1200 COLUMBIA AVE., RIVERSIDE, CALIF.  
PHONE (714) 684-1700 · TWX: 714-682 9582  
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MANUFACTURER: TRIMPOT® & PRECISION POTENTIOMETERS, RELAYS; TRANSDUCERS FOR PRESSURE, POSITION, ACCELERATION.

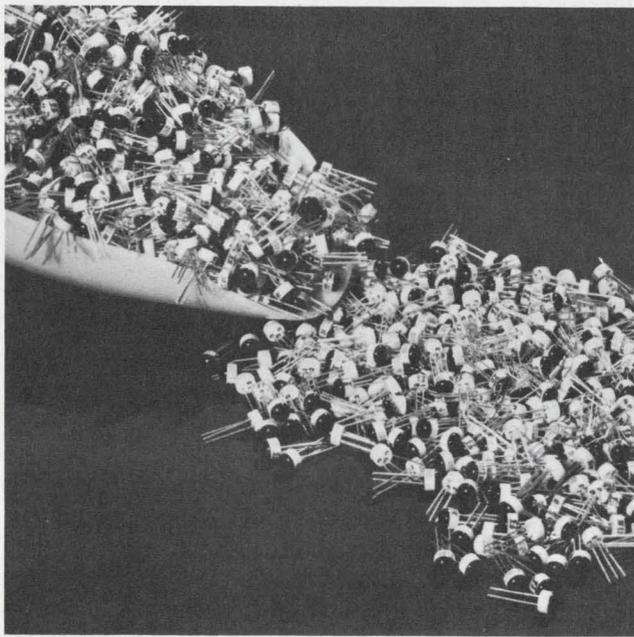
PLANTS: RIVERSIDE, CALIFORNIA; AMES, IOWA; TORONTO, CANADA

# Products

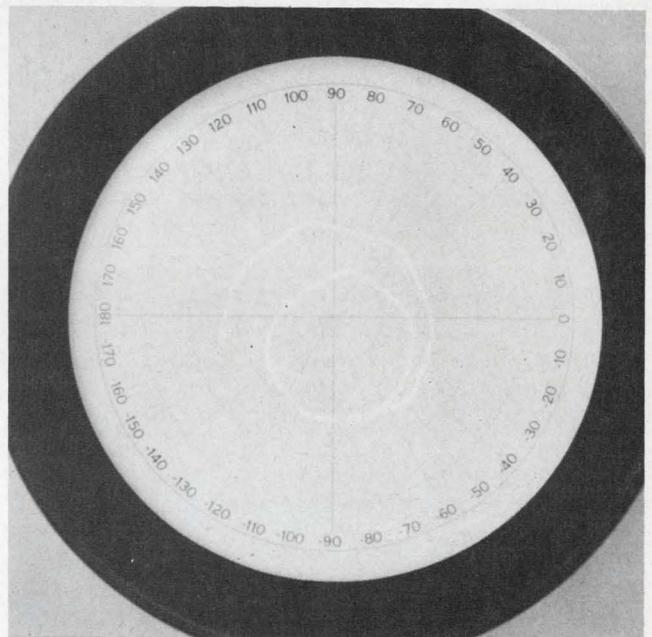


Frequency counter stacks up 1-3/4 inches tall. Using front-panel slide-switch controls

and many ICs, a full line of thin-lines covers 5 MHz to 12.4 GHz in 9 models. Page 114



Epoxy FETs cost less. N-channel field-effects are priced under 50¢ in quantity. Page 120



Read network parameters directly on swept polar displays or on Smith charts. Page 116

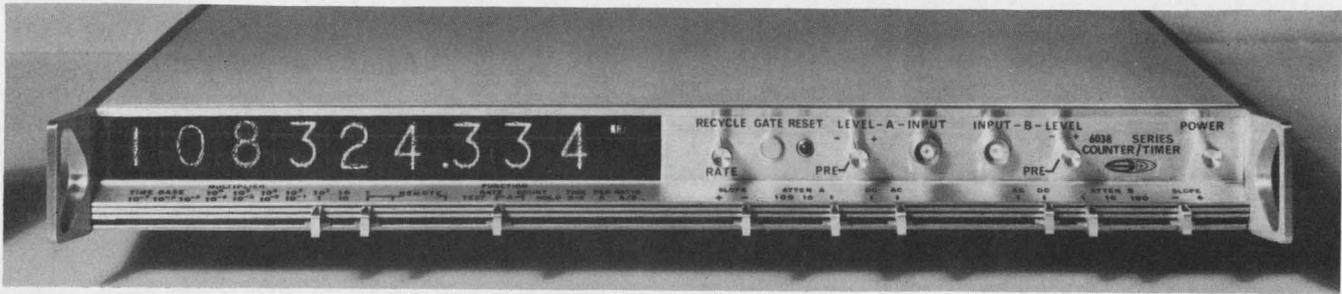
## Also in this section:

**Solid-state regulators** adjustable from 1.8 to 36 volts. Page 120

**Magnetic material** outdoes nickel-iron alloys. Page 122

**'Wedge-action' brush** keeps tiny potentiometer quiet. Page 126

**Design Aids**, Page 146 . . . **Application Notes**, Page 148 . . . **New Literature**, Page 150



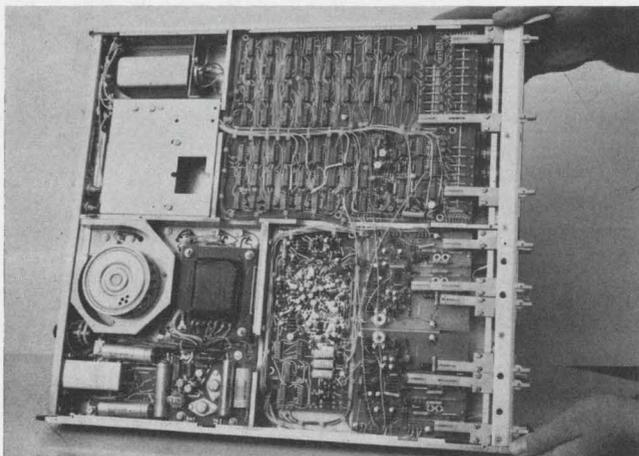
## 'Thin-line' counters measure 1-3/4 inches tall with 9-digit readout, slide-switch controls

*Systron-Donner, 888 Galindo St., Concord, Calif. Phone: (415) 682-6161. P&A: \$1000 (5-MHz counter) to \$4450 (microwave units), \$3350 (6038), \$1850 (counter/DVM); 4 to 6 months.*

Don't mistake these frequency counters for stereo tape decks for your car—despite their 1-3/4-inch panel height. Systron-Donner, by integrating their counter/timers, has cut panel height three-fold, added fingertip slide-switch controls, yet still managed to squeeze in a ninth Nixie for readings of one-part-per-billion resolution.

Extensive use of ICs and horizontal mounting of the boards have cut panel height to one-third that of transistorized models. Even the squirrel-cage blower and transformer fit the "thin-line" package.

Along with the package redesign, the slide-switch controls are radically new. The switches permit uncluttered selection of function, time base and input adjustments. Setting indications are at an angle to the panel face for easy reading.



**How to cut panel height.** Horizontally mounted board (upper right) holds all ICs. Even the squirrel-cage blower and the transformer (lower left) fit the 1-3/4-inch-high package. Tabs extending in from right are switch leaves for the slide switches.

The readout extends by one digit the present 8-digit readout of available counters. Resolution is thus up to one part per billion. The readout includes an automatic decimal point and units annunciator.

Featured in the line is a direct 100-MHz counting range. This dc-to-100-MHz range is available in two models: model 6018 is a 100-MHz frequency meter and model 6038 is a 100-MHz counter/timer for frequency measurements as well as time-interval, ratio and multiple-period measurements.

Microwave counters that cover S-, C- and X-bands (300 MHz to 12.4 GHz) are also available. The measuring technique is performed automatically by means of a built-in automatic computing transfer oscillator (termed ACTO). Counter accuracy is maintained over the entire range since the counter is phase-locked to the input signal.

Perhaps most unusual is a 5-MHz counter/integrating DVM, model 6413. This combination permits direct frequency measurements from dc to 5 MHz and voltage measurements over four selectable ranges (1, 10, 100 and 1000 volts). Resolution is 1  $\mu$ V on the one-volt range. Automatic polarity indication, floating inputs and selectable filters are featured.

The full line comprises a 10-MHz frequency and period meter, 5- and 100-MHz counters, 10- and 100-MHz counter/timers, 0.3-to-3-GHz, 2.96-to-8.2-GHz and 8.2-to-12.4-GHz microwave counters and the 5-MHz counter/DVM combo.

Two options are offered: A "super high-stability" oscillator with an aging rate of 5 parts in  $10^{10}$  per 24 hours and remote programing for local and remote control of major operating controls.

The finished product is a team effort from Systron-Donner. Engineering manager Norman Perlmutter and industrial designer Richard Dunlop are responsible for the package, while engineers Richard Hall and Richard Voyles collaborated on the electronics.

CIRCLE NO. 159

# These three NIXIE<sup>®</sup> tubes will fill 80% of your digital-readout requirements



STANDARD RECTANGULAR



MINIATURE RECTANGULAR



LOW-COST SIDE-VIEWING

The most popular readout ever made—Type 8422. Combines *readability* (maximum viewing distance of 30 feet), *compact* size (0.6" character in a 1.0" x 0.8" end-reading rectangular envelope) and *high reliability* (MTBF of 1 million hours at 90% confidence level). Also available in a decimal-point version, Type B-59956. For high-density packaging (0.7 cu. in.) and minimal instrument height, it's the choice of virtually every important manufacturer of digital instrumentation.

Small wonder this readout (Type B-4998) is chosen when a combination of *compact* size (0.3" character in a 0.47" x 0.63" rectangular envelope), *long life* (200,000 hours dynamic life) and *readability* (maximum viewing distance of 14 feet) are needed. For the smallest electronic readout with BCD decoding and memory, use the B-4998 with the Burroughs BIP-9401A module. Small wonder, indeed!

Our new side-viewing NIXIE tube, Type B-5440. Combines *long-life* (average life of 600,000 hours) with *low cost* (\$4.95 in 1000 quantity). Tube has low profile and narrow width for minimum panel-area opening (you can line them up on less than 0.80" centers), and its new socket is especially designed for pc-board mounting. Independently-operable decimal points are optional at slight extra cost (Type B-5441).  
**Call or write for full information.**

(and we've got the  
NIXIE tubes for that  
other 20%, too!)

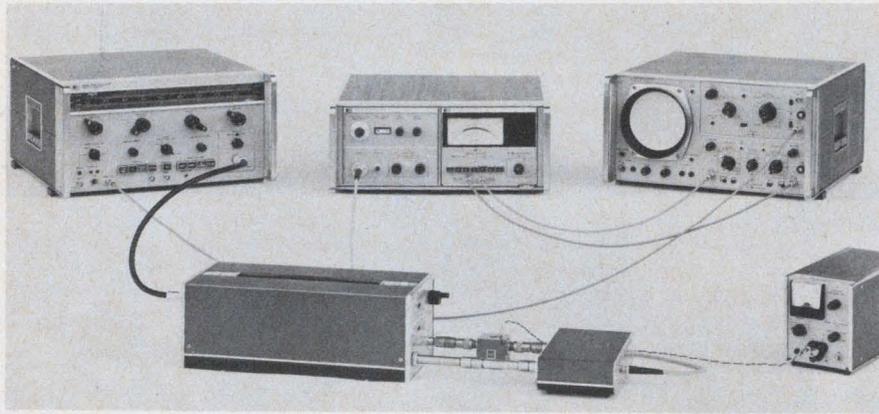
IEEE Booths 2H25-31

Only Burroughs manufactures NIXIE Tubes



**Burroughs Corporation**

ELECTRONIC COMPONENTS DIVISION  
PLAINFIELD, NEW JERSEY 07061



## Read network parameters on a meter or Smith chart

*Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: From \$825 to \$2200; 12 to 16 wks.*

A network analyzer system, consisting of seven laboratory units, provides easy reading of the full characteristics of broad-band devices, active and passive, singly or in arrays.

The system coherently samples test signals transmitted through, or reflected from, microwave devices under test. It produces 20-MHz IF replicas of the test signals, and processes them for display.

A harmonic frequency converter generates the 20-MHz IF replica. The network analyzer main frame processes the replicas for measurement and display. A plug-in display unit, which may be either a phase-gain indicator or a polar display unit, gives the readout.

The phase-gain unit indicates phase-magnitude relations on a meter, and produces analog outputs that can be fed to a standard two-

trace oscilloscope. This makes possible a simultaneous calibrated display of sweep response, phase and magnitude versus frequency, with a 60-dB dynamic range.

The polar display unit gives a three-dimensional CRT display of swept-frequency test signals, with amplitude proportional to the distance from center, phase displayed as an angle, and frequency indicated by intensity-modulated pips. Reflection test signals are read directly, with Smith chart overlays provided for calibrated readout.

In one arrangement of units shown above, a YIG filter is tested for amplitude and phase response versus frequency in the X-band range. Interconnections of the complete system for transmission or reflection tests are shown.

In transmission measurement, the harmonic frequency analyzer compares two signals from the sweep oscillator through the transmission test unit, one channeled directly and one through the device to be tested. In reflection measurements,

the reflection test unit replaces the transmission test unit; both comparison channels are direct. The device under test is plugged into the reflection test unit as shown.

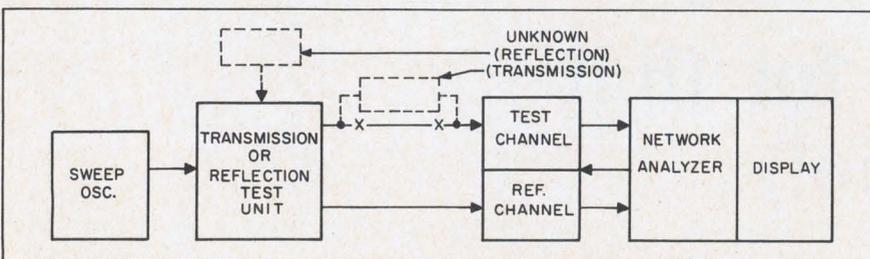
Two reflection test units cover the ranges from 110 MHz to 2 GHz, and 2 to 4 GHz, respectively. Each is equipped with a dual-directional coupler and a calibrated variable reference plane extension. The incident and reflected signals are fed to the harmonic frequency converter. Amplitude and phase may then be analyzed either as complex impedance (or admittance), as reflection coefficient and angle, or as return loss and angle.

By means of the reference plane extension, measured impedance or admittance may be referred to the RF testing device, or to any point as much as 15 centimeters beyond. In this way, manual Smith chart replotting is greatly reduced.

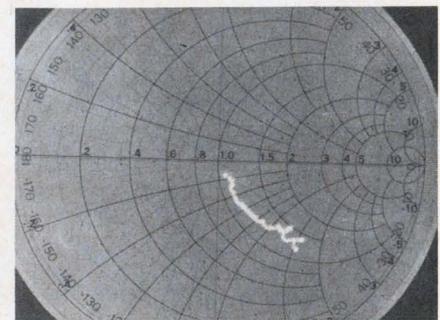
With swept display of phase and amplitude simultaneously vs frequency the transmission characteristics of such devices as filters are readily understood. Bandwidth, insertion loss, resonances, and any spurious responses are immediately visible. The phase display directly indicates the number of complex poles, phase linearity, and slope through resonance. This information immediately implies the equivalent circuit of the device, and predicts its behavior in any system. Tests of this kind may be made just as easily to determine the suitability of active devices, such as high-frequency transistors.

Component by component, complete tests with the network analyzer can simplify and speed systems work.

CIRCLE NO. 158

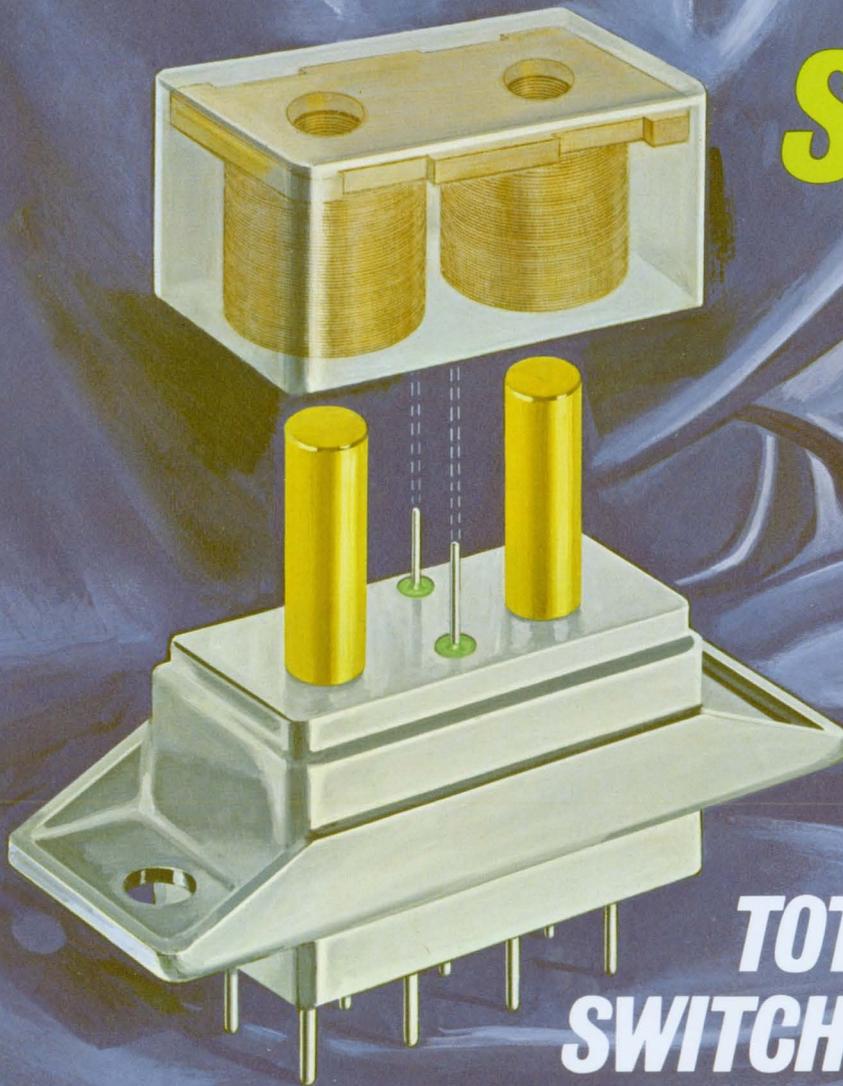


1. Block diagram of the complete network analyzer system adapted for either transmission or reflection measurement of microwave devices.



2. Smith chart overlay with trace shows impedance characteristics of microwave pellet transistor with common-emitter configuration.

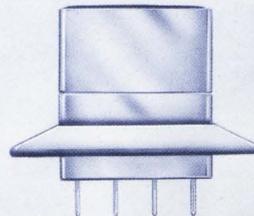
# ***FILTORS INTRODUCES SUPER-J***



***THE  
WORLD'S  
FIRST  
CRYSTAL-CAN  
RELAY  
WITH A  
TOTALLY-SEALED  
SWITCHING MODULE!***

# FILTERS INCOMPARABLE SUPER-J

ELIMINATES CONTACT  
INCONSISTENCY



Actual Size (Crystal Case)

## A Product of Filtors New Ultra-Rel Technology

Filtors, the leader in Hi-Rel Relays, now leads the way with SUPER-J, a switching device featuring a unique, sealed switching module. The switching module is an hermetically-sealed contact chamber, devoid of all organic compounds...achieving a degree of cleanliness never before attained in the switching industry.

### **SUPER-J's Unique Design Ends Contact Contamination**

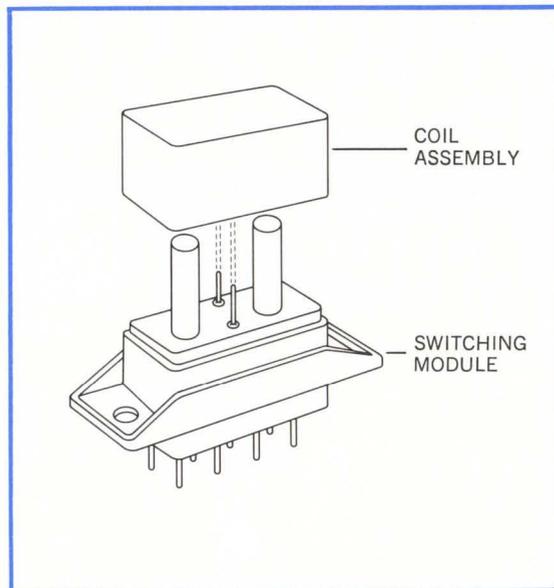
By mounting the coil assembly on the outside of the relay, gaseous organic contaminants are dissipated into the surrounding atmosphere...not enclosed within the relay housing to contaminate contact interfaces. SUPER-J is impervious to contamination...provides consistent performance...maintains low contact resistance.

### **SUPER-J's Unique Design Advances Manufacturing Technologies**

Because the organic coil assembly is absent during fabrication, Filtors can now subject the switching module to higher bake-out (degassing) temperatures and more active cleaning solvents. These two Filtors manufacturing innovations reduce contamination to a level never before achieved in the relay industry.

### **SUPER-J's Unique Design Affords Unsurpassed Delivery**

The SUPER-J concept enables Filtors to stock completely adjusted and sealed switching modules ready to accept coils according to your specifications.



More and more, your critical relay applications demand the high performance and low contact resistance provided only by Filtors SUPER-J. The in-house manufacturing capability exclusively at Filtors makes possible this significant advance in relay technology. SUPER-J is the first of Filtors new Ultra-Rel Series.

**YOUR CRITICAL APPLICATIONS MAY REQUIRE THE ULTRA-RELIABILITY OF FILTERS SUPER-J. IF SO, TELL US. A COMPLETE SUPER-J INFORMATION KIT WILL BE SENT TO YOU IMMEDIATELY.**

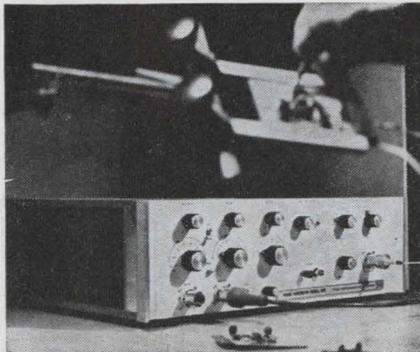
See Us At IEEE Booth 4C30



**FILTORS INC. RELAYS**

East Northport, New York 11731 / (516) ANDrew 6-1600

### Audio to RF pulser has independent baseline



Texas Instruments, Inc., 3906 Buffalo Speedway, Houston. Phone: (713) 526-1411. P&A: \$1800; stock.

A pulse generator with a controlled pulse repetition rate of 1 kHz to 100 MHz features an independent baseline adjustment, and a jitter-free synchronizing feature for high pulse repetition frequency oscilloscope display.

Pulse amplitude and baseline controls are made independent of each other by putting the offset current source after the attenuator, and by using a load-compensating resistor network to maintain a constant 50-ohm load impedance.

Baseline control may be adjusted to  $\pm 2$  V (with no attenuation) without affecting pulse amplitude or waveshape. At full attenuation, variation is  $\pm 1$  V.

The independent baseline control is an asset also in emitter-coupled logic design, where baseline amplitudes of the same order as the pulse amplitudes are required.

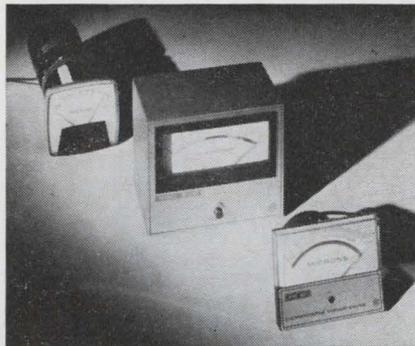
Jitter is virtually eliminated from displays at the higher frequencies by synchronizing at a lower rate. When the prf is greater than 3 MHz, a square wave is produced which synchronizes the high-frequency pulse display once for approximately every thirty pulses.

Pulse repetition rate is controllable over six ranges. Pulse amplitude is adjustable from 30 mV to 5 V, in both vernier and step attenuation.

Pulse width is adjustable from 3 ns to 100  $\mu$ s in five ranges. The unit is applicable to testing of medium-speed RTL and highspeed ECL circuits.

CIRCLE NO. 160

### Gauge controls have low thermal drift



Norton Co., 160 Charlemont St., Newton, Mass. Phone: (617) 332-5800. Price: \$75 to \$195.

Vacuum thermocouple gauge controls are offered with temperature compensation, line-voltage regulation, and solid-state circuitry throughout. A thermistor is an integral part of the measurement circuitry. This component compensates for the natural thermal drift of thermocouple gauge sensitivity resulting in pressure indications that are independent of ambient temperatures.

CIRCLE NO. 161

### Hipot testers are self-protecting

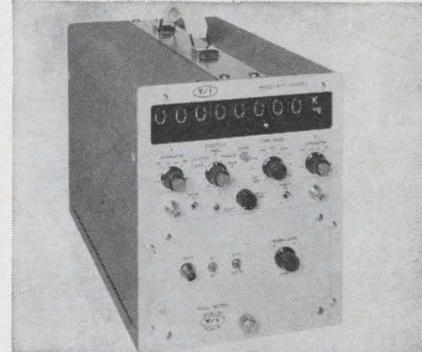


Peschel Instruments Inc., P. O. Box 47A, West Pawling, N. Y. Phone: (914) 855-9881. P&A: \$140 to \$300; stock.

Portable ac and dc hipot testers are offered for production and maintenance testing of electrical components, rotating machinery, appliances, or for use as simple power supplies. The units range from 2 to 30 kVdc or 2 to 20 kVac. Features include adjustable output, output metering, and complete surge and short protection.

CIRCLE NO. 162

### Dual-channel counter measures ratios, periods

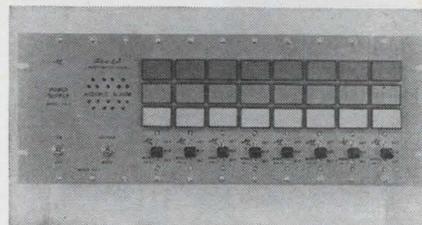


Transistor Specialties, Inc., 120 Terminal Dr., Plainview, N. Y. Phone: (516) 935-8700. P&A: \$2890; stock.

Model 600 counter features all-silicon circuitry. It makes direct frequency measurement to 100 MHz, period measurement to 1 MHz and multiple period to 20 MHz. Ratio measurements are made to 100 MHz/1 MHz and multiple ratio to 100 MHz/20 MHz. Time interval and frequency extender plug-ins are available to 2.5 GHz. Time base stabilities as high as 1 part in  $10^9$  per 24 hours are also featured.

CIRCLE NO. 163

### Detection system is visual and audible

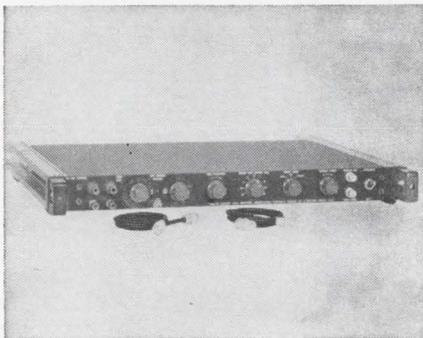


Astro Lab, 9371-D Kramer Ave., Westminster, Calif. Phone: (714) 839-0741. P&A: from \$39.50; stock to 6 wks.

Both visual and audible alarm are provided by this all solid-state detection system. There are no moving parts or adjustments. It contains a memory that indicates a momentary interruption of the sensor. Individual channel rejection for defective or out-of-service sensors is included. The system works on pressure, temperature, air-flow and other sensors.

CIRCLE NO. 164

## Sweeper for use with frequency synthesizers



General Radio Co., West Concord, Mass. Phone: (617) 369-4400. Price: \$495.

A sweep and mark generator is available for use with the manufacturer's family of frequency synthesizers. It supplies a control voltage for their continuously adjustable decade, and also supplies center frequency and side markers for visual monitoring of the frequencies generated. A synchronized constant-amplitude sweep voltage is also available for horizontal deflection of the display device.

CIRCLE NO. 165

## Eddy current tests in building-block form



The Budd Co., Instruments Div., P. O. Box 245, Phoenixville, Pa. Phone: (215) 933-8965.

A building-block approach for on-the-job assembly of custom electromagnetic testing and inspection systems affords high-speed detection of surface and subsurface flaws in tubing, bar stock, wire and related shapes. This unit is designed as a general purpose eddy current instrument for both laboratory and production uses.

CIRCLE NO. 166

## Charge your Ni-Cd cells in less than 1 hour



Dutchess Design & Development, 32 Van Wagner Rd., Poughkeepsie, N. Y. Phone: (914) 471-5420.

Nickel-cadmium cells can be charged in less than an hour. Constant current discharge rates up to 10 A and end-point voltages are programable. When the cell reaches the end-point voltage it is removed from the discharge circuit to avoid reverse charge. A print-out occurs simultaneously to indicate cell number, discharge time and date.

CIRCLE NO. 167

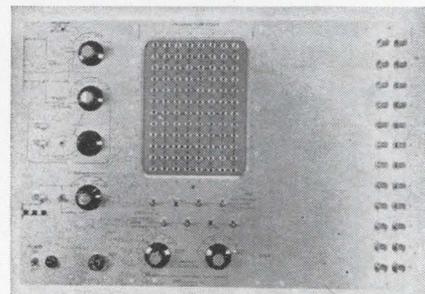
## Phase angle standard self-calibrating

Dytronics Co., Inc., 5566 N. High, Columbus, Ohio. Phone: (614) 885-3303. P&A: \$3450; 1 wk.

Model 312 is a completely solid-state primary phase angle standard for operation over the frequency range from 4 to 500 kHz. It will produce precise phase shifts over a 360° range, and will measure the phase shift through an unknown device or between two signals. Absolute accuracy is  $\pm 0.05^\circ$  from 4 to 10 kHz;  $\pm 0.02^\circ$  from 10 to 50 kHz, with slightly decreasing accuracy to 500 kHz. Output impedance is 1.6  $\Omega$ .

CIRCLE NO. 168

## Pulse generator has 8-by-12 matrix



Adar Associates, Inc., 73 Union Square, Somerville, Mass. Phone: (617) 623-3131. P&A: \$3000; stock.

A multiple pulse generator that operates at stepping rates from 10 MHz to 1 kHz has 12 parallel output channels on an 8-by-12 program matrix board and solid-state circuit logic. Eight time steps make a single pass through the program. The program is repeatable a given number of times under a variable delay control prior to re-initiation.

CIRCLE NO. 169

## Transistorized oscillator capacitance-tuned



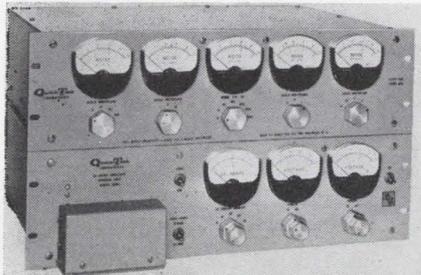
Dranetz Engineering Labs., Inc., 1233 North Ave., Plainfield, N. J. Phone: (201) 755-7080. P&A: \$160; stock.

Series 380 oscillators, for use in laboratories and OEM applications, are fully transistorized. The laboratory model is available ac or battery powered. The oscillator produces a sine-wave voltage from 5 Hz to 500

CIRCLE NO. 211

Don't forget to return your **ELECTRONIC DESIGN** renewal card.

## Noise analyzer for active, passive devices

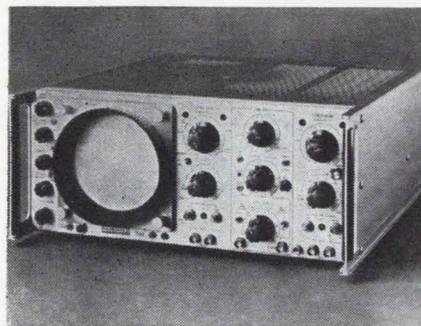


Quan-Tech Labs., 43 S. Jefferson Rd., Whippany, N. J. Phone: (201) 887-5508. Price: (Control Unit) \$1495.

Noise can be measured in anything from a 10-k $\Omega$  resistor to a complete amplifier with 50-dB or more gain with this IC noise analyzer. The unit has two low-noise power supplies, one positive and one negative, independently variable from 0 to 30 V, at 100 mA for biasing ICs and op-amps. A 50-dB step-and-continuous attenuator compensates for gain of the test device.

CIRCLE NO. 212

## Dual gun scope doesn't share time



Fairchild Instrumentation, Div. of Fairchild Camera & Instruments, 475 Ellis St., Mountain View, Calif. Phone: (415) 962-2076. Price: \$1045.

Using two identical vertical amplifiers and a non-time-sharing, dual-gun CRT, this oscilloscope has a sensitivity range of 10  $\mu$ V to 10 V/cm in 19 steps of 1, 2, 5 sequence. It also features dc or ac stabilized amplifiers, 6-x-10-cm viewing area for each beam with a 5-kV high-intensity CRT and a selectable band-pass.

CIRCLE NO. 213

ELECTRONIC DESIGN 5, March 1, 1967

# Ballantine Sensitive AC-DC Digital Voltmeter



Model 355  
Price: \$620

## Measures Wide Range of AC or DC Voltages in one Economical Package

Ballantine's Model 355 accurately measures a wide range of ac or dc voltages with a versatility that makes it ideal for production or quality control applications.

### FEATURES:

- ★ Replaces analog instruments to reduce personnel errors and to speed up production
- ★ Maximum sensitivity of 10 mV f.s. ac, and 100 mV dc
- ★ Frequency range of 30 Hz to 250 kHz
- ★ Accuracy, % f.s., to 500 V: ¼%, 50 Hz — 10 kHz; ½%, 30 Hz — 50 kHz; 1%, 50 Hz — 250 kHz
- ★ Servo-driven, 3 digit counter with over-ranging to 4, plus ability to interpolate for additional digit. This feature is not possible with electronic digital displays
- ★ Well-lighted readout, illuminated decimal point. Indicator warns against over-ranging or wrong polarity
- ★ An optional foot-operated switch for retaining readings speeds up successive readings

Write for complete technical data today

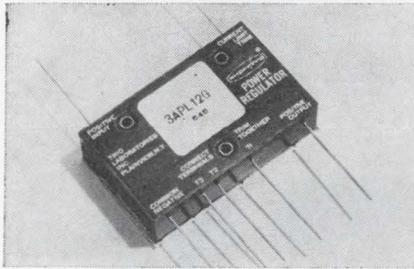


**BALLANTINE LABORATORIES INC.**  
Boonton, New Jersey

CHECK WITH BALLANTINE FIRST FOR DC AND AC ELECTRONIC VOLTMETERS/AMMETERS/OHM METERS, REGARDLESS OF YOUR REQUIREMENTS. WE HAVE A LARGE LINE, WITH ADDITIONS EACH YEAR. ALSO AC/DC LINEAR CONVERTERS, AC/DC CALIBRATORS, WIDE BAND AMPLIFIERS, DIRECT-READING CAPACITANCE METERS, AND A LINE OF LABORATORY VOLTAGE STANDARDS FOR 0 TO 1,000 MHZ.

ON READER-SERVICE CARD CIRCLE 58

### Solid-state regulators give 1.8 to 36 V, 3 A



Trio Laboratories, 80 Dupont St., Plainview, N. Y. Phone: (516) 681-0400. P&A: \$59.50, \$69.50 (with current limit); 10 days.

A line of miniaturized, solid-state, encapsulated dc voltage regulators comprising 13 models has nominal output voltage ratings in the range from 2 to 33 Vdc. All are capable of providing output currents up to 3 A. Output voltages are adjustable up to  $\pm 10\%$  without derating. Adjustable automatic current limiting is featured. Output impedance of 2 to 7 m $\Omega$  permits obtain-load regulation on the order of 0.01%. The 3 AP series regulator is an encapsulated flat-pack, 2.5-in. long, 1.5-in. wide, and 0.6-in. thick, one face of which is an integral copper heat sink. It may be mounted on a PC board with the sink exposed to free air; a metal fin may be bolted to the copper face for increased dissipation of internally generated heat, or the unit may be mounted in direct contact with a chassis, finned sink, or cold plate to achieve the full 80-W dissipation rating of the device. The units are available with nominal output voltage ratings of 2, 3, 4, 5, 6, 8, 10, 12, 15, 18, 22, 27 and 33 volts.

CIRCLE NO. 214

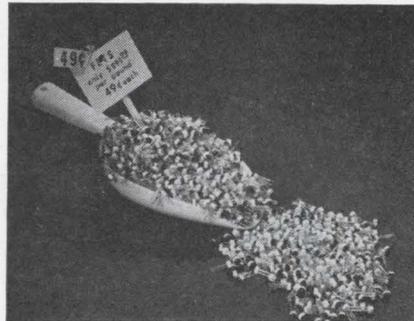
### 1/2-A silicon transistors have ratings to 800 V

Industro Transistor Corp., 35-10 36th St., L. I. C., N. Y. Phone: (212) 392-8000.

A line of 1/2-A silicon npn transistors with voltage ratings from 100 to 800 are available in both TO-5 and MD-14 packages. The transistors have an  $h_{fe}$  of 15 min at an  $I_C$  of 500 mA and a  $V_{CE}$  of 10 V. Power ratings are to 15 W.

CIRCLE NO. 215

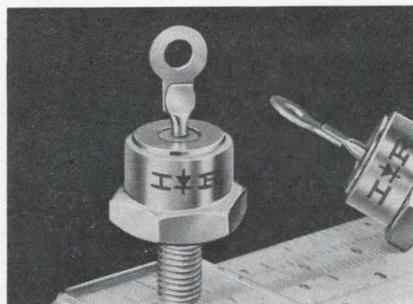
### Plastic n-channel FETs cheaper by the pound



Siliconix Inc., 1140 W. Evelyn Ave., Sunnyvale, Calif. Phone: (408) 245-1000. P&A: 49¢ to 92¢ (1000 lots); stock.

Epoxy-encapsulated n-channel junction FETs are priced as low as 49¢ in 1000 quantities. For industrial and consumer applications including amplifiers, choppers and variable resistors, the series offers low leakage (10 pA at 20 V) and a low noise figure (1.8 dB typical). Other characteristics include 50-V typical gate-to-source breakdown voltage and a 5:1  $I_{DSS}$  and  $V_P$  spread for types E101, 102 and 103. The E100 is a more broadly specified lower-cost version. Maximum reverse transfer capacitance is 3 pF. Lead configuration is TO-18.

CIRCLE NO. 216



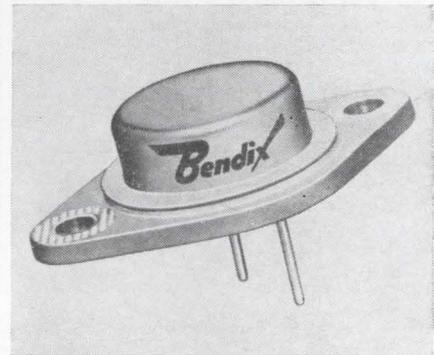
### Rectifier line has high PIV

International Rectifier, 233 Kansas St., El Segundo, Calif. Phone: (213) 678-6281. P&A: \$0.80 to \$7.20 (100 to 999); stock.

This series of rectifiers is rated at 40 A and from 50 to 1000 V max repetitive PIV. They are available in both standard (cathode to stud) and reverse (anode to stud) polarities.

CIRCLE NO. 217

### Transistors built for high-speed switching

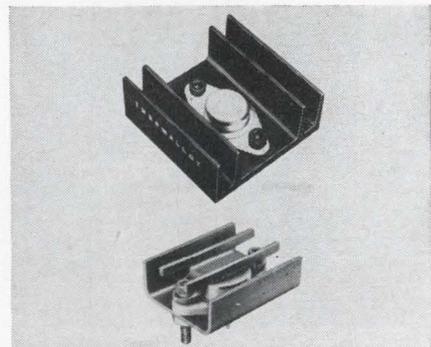


Bendix Corp., Semiconductor Div., Holmdel, N. J. Phone: (201) 747-5400. P&A: \$2 to \$8 (100 to 999); stock.

A line of 25-A diffused alloy power germanium pnp transistors is specifically designed for high-speed, high-current switching and amplifier applications. The devices are designed for secondary breakdown protection in all kinds of circuitry. Mechanical dimensions conform to the JEDEC TO-3 outline.

CIRCLE NO. 218

### Two heat sinks for TO-66 cases

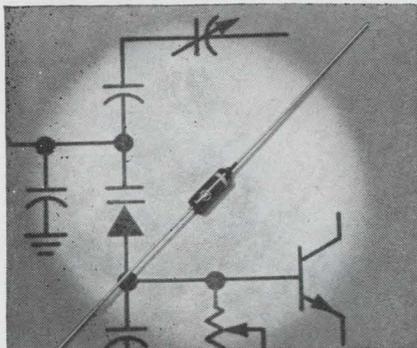


Thermalloy Co., 8717 Diplomacy Row, Dallas. Phone: (214) 637-3333. P&A: 2-piece, 35¢; 1-piece, 55¢ (12 to 99); stock.

Two heat sinks for the TO-66 case are available. A 2-piece stamped aluminum sink for restricted board space has a thermal resistance of 11°C/W and comes in insulated black anodize or chromate. A single-piece sink for larger board space has a thermal resistance of 12°C/W, has 4 fins and comes in black anodize only.

CIRCLE NO. 219

## Varactor diodes offer high Q, tuning ratio



Motorola Semiconductor Products, Inc., P. O. Box 955, Phoenix. Phone: (602) 273-6900. P&A: \$4.90 (100 to 999); stock.

Voltage-variable capacitance diodes feature the combination of high Q and high tuning ratio. MV1720 through MV1750 silicon Epicaps cover a capacitance range of 6.8 to 100 pF with 10% tolerance and a reverse breakdown voltage of 30 V. The epitaxial, passivated DO-7 diodes are designed for vhf and uhf tuning applications. The MV1720 has a nominal diode capacitance of 6.8 pF at a reverse bias voltage of 4 Vdc and at 1 MHz. Tuning ratio is a minimum of 2.7 to 1 with a minimum Q of 500 measured at 50 MHz with 4 V of reverse bias. The MV1750 has a nominal diode capacitance of 100 pF with a minimum tuning ratio of 3.2 to 1 and a minimum Q of 250.

CIRCLE NO. 220

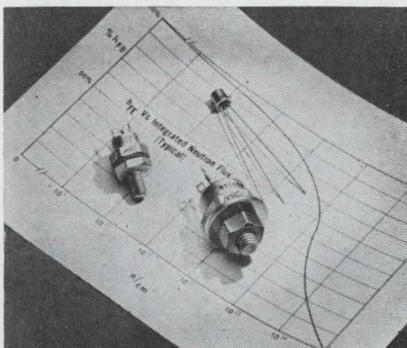
## Silicon transistors for high voltage

Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. Phone: (305) 848-4311.

Additions to a line of high-voltage silicon power transistors feature  $V_{CE0}$  sustaining voltages from 150 to 325 V. They are offered in the TO-66 package and have a frequency response of 50 MHz and  $C_{OBO}$  of 150 pF. They are capable of dissipating up to 25 W. They are suited for use in high voltage inverters, switching regulators, and all line voltage switching and amplifier applications.

CIRCLE NO. 221

## Silicon transistors are radiation-resistant

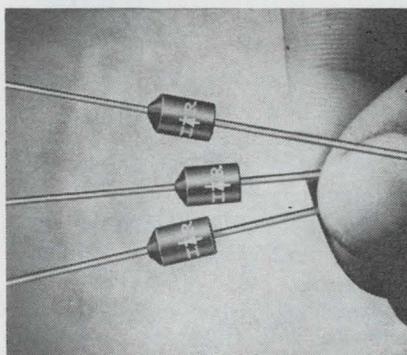


National Semiconductor Corp., Danbury, Conn. Phone: (203) 774-0060.

Three npn silicon transistors have been designed to operate in environments subjected to atomic weapon neutron bombardment. Neutrons are known to cause extensive permanent deterioration in semiconductors. The new radiation-resistant devices are silicon epitaxial planar transistors, designed for regular and power applications. They are packaged in TO-18, TO-60 and TO-61 cases.

CIRCLE NO. 222

## Plastic silicon rectifiers rated at 1.5 and 2 A



International Rectifier, 233 Kansas St., El Segundo, Calif. Phone: (213) 678-6281.

A double series of DO-27 plastic silicon rectifiers are available. One series, the IR/20A, is rated at 2 A, while the JEDEC series, 1N4816 through 1N4822 and 1N5052 through 1N5054, is rated at 1.5 A. Both are offered in the plastic DO-27 package at ratings from 50 to 1000 volts. The high operating and surge currents of these devices permit maximum circuit flexibility.

CIRCLE NO. 223

# LC Filters?

# We'll try anything!

If you have a tough, tricky or unusual problem in LC filters, try Bulova first! Bulova has built a reputation for being willing to "try anything". Even jobs that other companies "can't be bothered with"!

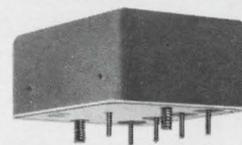


Are we crazy? Like foxes! Fact is, we can do things others can't—and that's the way we win friends and customers!

We'll custom-design units to solve your unique problems. We'll supply prototypes when you need them—in 2 weeks or less! We'll schedule production units to meet your schedule—and give you solid proof we can do it!

And what a range! High pass, low pass, band pass, lumped constant delay lines, IRIG filters—you name it! Frequencies from DC to 50MHz! Sharpest shape factors! Just tell us your requirements—when you need it—and let us tackle it. Our hot engineering group will show you why you should "Try Bulova first"!

For more information, write to us at Dept. ED-25.



# Try Bulova First!

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ELECTRONICS DIVISION  
OF BULOVA WATCH COMPANY, INC.

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WOODSIDE, N.Y. 11377, (212) DE 5-6000

ON READER-SERVICE CARD CIRCLE 59

*Looks like Krohn-Hite hit the jack pot again. Read on!*

*All this in a 5 1/4" high panel! Finally—a filter for "Time Domainers," too. I'll be glad to see a clean pulse, for a change.*

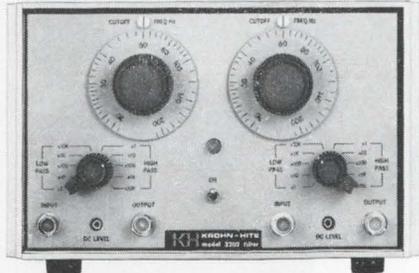
*Let's see—I can even have a Band Pass with Butterworth at one end and R-C at the other—how about that?*

*48 db/octave—that's no roll off—that's a chop off!*

*Where's that Bingo Card?*

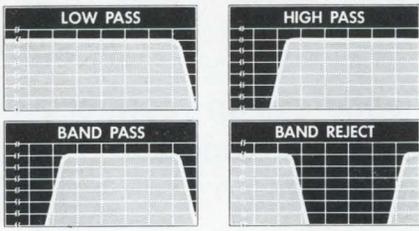
*See it at IEEE Booths 2H11-2H13*

WITH **KH** ALL-SILICON MULTIFUNCTION VARIABLE FILTERS YOU GET MORE THAN HIGH-PASS and LOW-PASS PERFORMANCE



MODEL 3202 provides continuously adjustable high-pass, low-pass, bandpass and band-reject functions over frequency range of 20 Hz to 2 MHz. Two-channel bench unit shown; 5 1/4" x 8 5/8" x 1 5/4"-rack units available.

The unlimited flexibility of the K-H Multifunction Variable Filters is essential for complex frequency- or time-domain measurements. Don't settle for limited single-function capability when you can take advantage of K-H's two-channel Model 3202 or the one-channel Model 3200. See functions, below.



These responses are fully adjustable and may be set independently. This performance typifies the extra value you get from modern Krohn-Hite electronic instruments. Other values increase user confidence further by providing simpler, faster and lower-cost operation.

**Functions:** Low-pass—direct coupled with low drift. High-pass—upper 3 db at 10 MHz. Bandpass—continuously variable. Band rejection—Variable Broad Band or Null.

**Two Response Characteristics:** (1) fourth-order Butterworth or (2) simple R-C (transient free)

**Zero-db Insertion Loss:** all-silicon amplifiers provide "lossless" passband response. Steep (24 or 48 db per octave) attenuation slopes extend to at least 80 db.

**90-db Dynamic Range:** Low hum and noise (100 microvolts) eliminates costly preamplifiers.

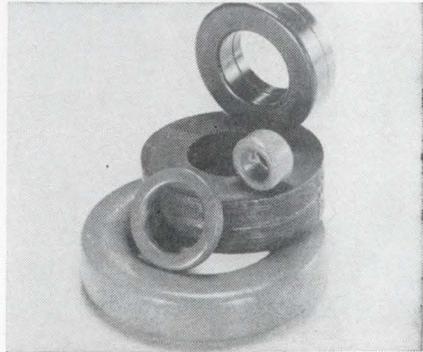
**Output Impedance:** 50 ohms, or lower. There's more in K-H Data Sheet 3200/3202. Write for a copy.

**KH KROHN-HITE CORPORATION**  
580 Massachusetts Avenue, Cambridge, Mass. 02139  
Telephone: 617/491-3211

ON READER-SERVICE CARD CIRCLE 60

MATERIALS

Magnetic material outdoes nickel-iron



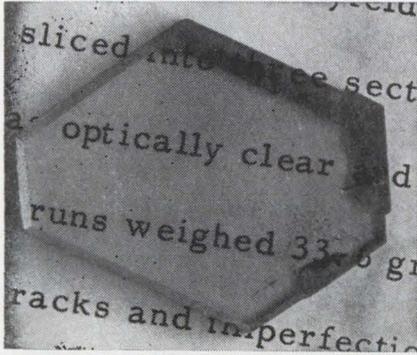
Inter-Technical Group, Inc., Irvington-on-Hudson, N. Y. Phone: (914) 591-8822.

A new material in the form of toroidal cores wound from 0.002, 0.004 and 0.008-inch strip extends the normal nickel-iron alloy magnetism curve up to a saturation flux density of 15,000 gauss. Losses are approximately one quarter those of silicon iron over the whole operating range of flux density up to 13,000 gauss, and the magnetizing force required over this range is also one quarter that required for silicon iron. Initial and maximum permeabilities are approximately 65,000 (at 0.005 Oe) and 240,000, respectively, and coercive force is 0.025 oersteds. Satmumetal applications include small distribution transformers, instrument transformers and ground leakage protective devices, where electrical losses and magnetizing forces need to be minimized. It also is of interest for small chokes, high-gain magnetic amplifiers, dc polarized transformers and high-efficiency low-level inverters and converters. Its properties also are suited for Hall-effect multipliers and other components controlled by dc magnetic fields like yttrium garnets. Cost for the material is comparable to nickel-iron alloys. Other savings in size, accuracy and sensitivity are claimed.

CIRCLE NO. 224

Remember to return your ELECTRONIC DESIGN renewal card. Don't miss any issues in '67.

## Zinc oxide crystals for microwave delay

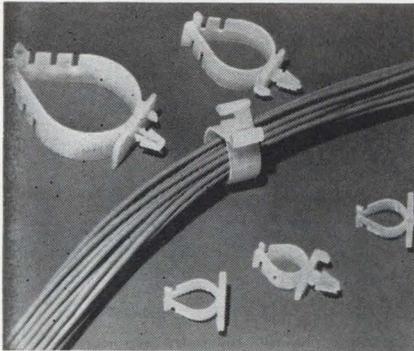


Airtron Div. of Litton Industries, 200 E. Hanover Ave., Morris Plains, N. J. Phone: (201) 539-5500. P&A: \$25 to \$50 per gram (cut); 1 to 2 wks.

Hydrothermally grown single crystals of zinc oxide are available with resistivities from 1 to  $6 \times 10^9$  ohm-centimeters. Applications include microwave delay lines and amplifiers, IF or RF filters, transducers for pressure, force and displacement, and temperature gauges.

CIRCLE NO. 225

## Nylon routing clamps lock in 3 positions

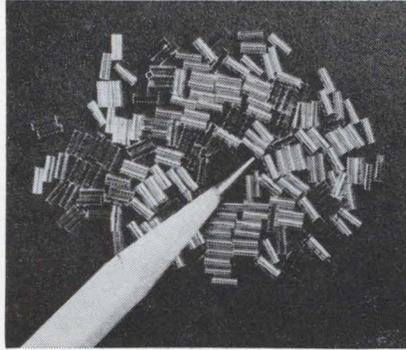


The Thomas & Betts Co., 36 Butler St., Elizabeth, N. J. Phone: (201) 354-4321.

Routing clamps for temporary routing of wires or for clamping of permanent wiring can be used for control wiring in panels and are completely reusable. The clamps are locked by means of slots. They can be locked in either of three positions to permit adjustability for varying diameters. They are fabricated of nylon and are available in four basic sizes: 1/2, 1, 1-1/2 and 2-inch diameters.

CIRCLE NO. 226

## Alkali-free glass has high resistivity



Hanibal Glass, Inc., 1639 E. Edinger St., Santa Ana, Calif. Phone: (714) 542-4794.

Alkali-free sealing glass for use with Kovar or molybdenum has high lead content providing much greater resistivity at elevated temperatures, and a longer working range. The absence of alkali is necessary with new diode designs to prevent parameter changes from the presence of sodium ions. Resistivity in log ohms is 11.8 at 250°C and 10.2 at 350°C and softening point is 683°C. The glass is available drawn and cut to any diameter up to 0.1 inch.

CIRCLE NO. 227

## Mica-based insulation withstands 1400°F

Industrial Mica Div., Columbia Technical Corp., 223 S. Van Brunt St., Englewood, N. J. Phone: (201) 568-7200. P&A: \$1.69 to \$2.86 (10-x-36-in. sheet); stock.

High-temperature resistant mica-based insulating material is made of natural mica platelets, bonded with boron-based silicone resins. It closely approximates natural mica with regard to electrical, mechanical, chemical and thermal properties. Owing to its high-temperature resistance (1400°F intermittent use) and stable insulation of high mechanical strength, Indomica is recommended for use as a self-supporting carrier of coils in appliances and industrial apparatus, and as washers, gaskets and substrates. It is available in thicknesses from 15 to 40 mils.

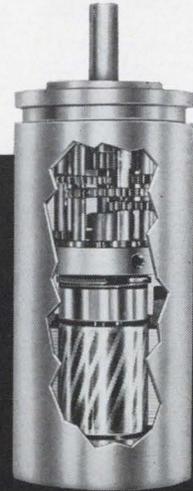
CIRCLE NO. 228

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## SERVO MOTORS

## GET HOT

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PLAYS IT COOL**

One continuous stainless steel case houses both motor and gearhead in Harowe integral-gear servo motors. There are no joints to block heat flow; no dissimilar metals to expand unevenly. Result is cooler motor operation and excellent thermal stability.

Harowe builds motors and gearheads together to work together . . . and to give you one-source responsibility and industry's fastest deliveries.

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ON READER-SERVICE CARD CIRCLE 61

## Epoxy powders for transfer molding



Emerson & Cuming, Inc., Canton, Mass. Phone: (617) 828-3300. Price: 90¢ to \$4.50/lb.

A new group of epoxy powders have been added to Emerson & Cuming's line of transfer molding compounds. Ecomold HD-110T is a high-thermal conductivity encapsulating material for use where good heat dissipation is desired. Ecomold SC-41T is designed for semiconductor application and features high thermal conductivity and temperature capabilities to 600°F. Ecomold LD-80T contains hollow silica microspheres to give a low density material for airborne applications. Ecomold M-100T is a magnetic molding powder with high attenuation over the full microwave frequency range. It is useful for molding waveguide terminations, attenuators and loads. Ecomold 20T is a low pressure, long flow, high-strength encapsulant for coils and transformers.

CIRCLE NO. 229

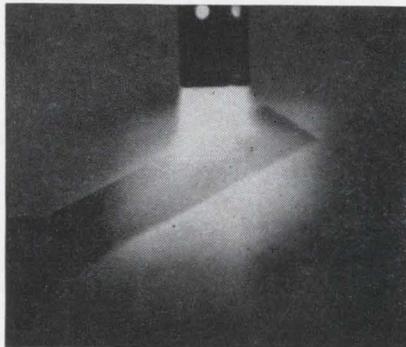
## Transfer molding powder for delicate components

Hysol Corp., Olean, N.Y. Phone: (716) 372-6300.

Soft-flow characteristics of MG6 epoxy Hyflo molding powders suit them for encapsulation of delicate components such as solenoid coils, modules, glass diodes, relays and semiconductor devices. The material is characterized by extreme toughness, low shrinkage, excellent moisture and thermal shock resistance, high dielectric strength and chemical resistance.

CIRCLE NO. 230

## Paint-on ceramic coating extends service life



Lithoid Corp., Lima, Pa. Phone: (215) 566-9502.

Composition coatings of inorganic materials (produced of 100% ceramics) extend the service life of aluminum, stainless steel and mild steel subject of extremes of heat, corrosion, abrasion and oxidation. Designed to withstand temperatures up to 2500°F, the coatings provide a harder surface than steel (extend life of metals up to 600%), never fade or weaken, and have high electrical properties.

CIRCLE NO. 231

## Adhesive film produces high bonding strengths

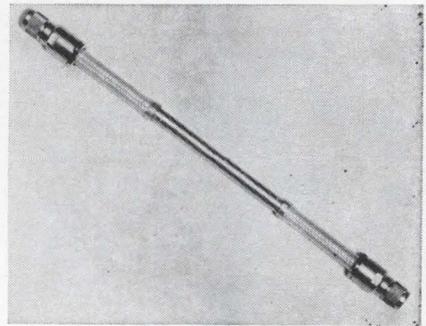


nelco, Inc., 481 Canal St., Stamford, Conn. Phone: (203) 324-4181.

Thermoset adhesive bonding films produce bond strengths in excess of 20 lbs per inch for use in multilayer PC board applications. The 0.001-inch thick elastomerized epoxy resin system bonds to most smooth, untreated metal foil surfaces with extremely low flow and no volatile by-products. Metal surfaces of copper, nickel, Kovar, aluminum and steel require no preparation, other than degreasing.

CIRCLE NO. 232

## Cable assembly handles high power at low vswr



Times Wire & Cable, Hall Ave., Wallingford, Conn. Phone: (203) 269-3381.

Semiflexible cable assemblies are capable of handling high peak powers at low vswr, with enough flexibility to facilitate alignment. Copersol is manufactured with a solid Teflon dielectric and a tubular copper outer conductor. Flexibility is achieved by the creation of 3-inch flexible sections at the end of the cable without the use of a splice connector. The assembly has been designed for special application with various connector interfaces, and is usable to X-band.

CIRCLE NO. 233

## Square-cut lead wire keeps high tolerance

Art Wire & Stamping Co., 227 High St., Newark, N. J. Phone: (201) 621-7272.

Square-cut straightened lead wires offer very tight tolerances. Within certain wire diameters and depending on the over-all length and the material to be straightened and cut, tolerance on the over-all length of the wire can be held to  $\pm 0.002$ , flatness of the cutoff to within 0.0003 and cutoff burr to a maximum of 0.0005. The surface may be cut by as much as 80%. These features are important in assuring a solid bond where welding with automatic equipment is to be done.

CIRCLE NO. 234

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prediction:

**Centralab  
push button  
switches  
will  
revolutionize  
your  
switching  
designs**

One button selection of function provides user convenience, operational simplicity, and visual appeal. Now you can incorporate push button switching in your products, within present pricing parameters.

**Competitive Price • Great Versatility • Miniature Size • Simple Connection and Mounting**

For additional information circle number 125  
SEE IT AT IEEE BOOTHS 4H 19-23

# Centralab push button switches\* will revolutionize your switching designs

New from Centralab! A low-cost push button switch that's small, easy to wire, easy to mount and twice as versatile as any you now use!

**PRICES** are competitive with multiple position rotary types for many applications, much lower than other push button switches. And our new modular design facilitates same day price quotations.

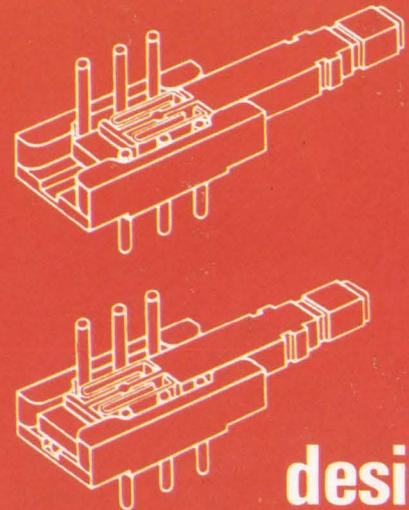
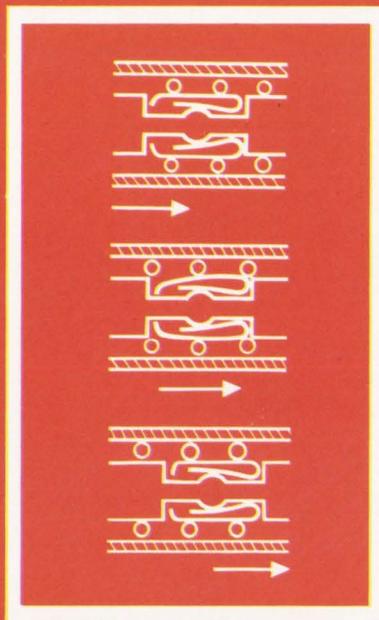
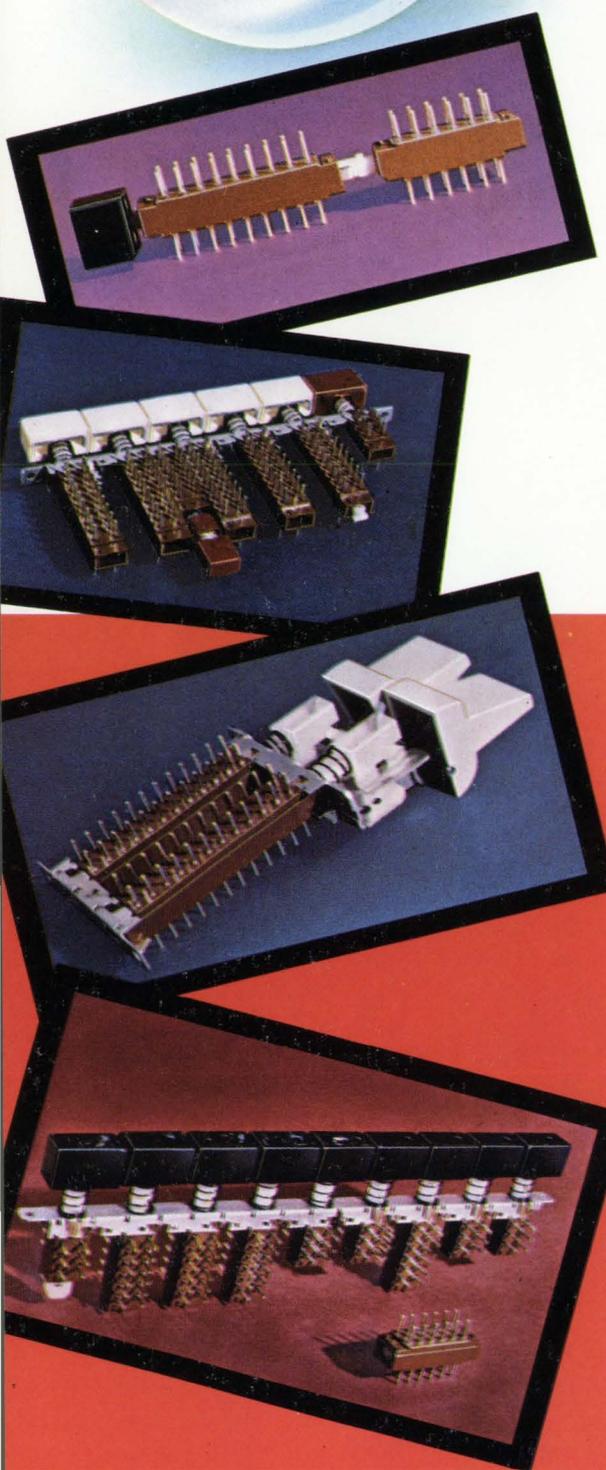
**SIZE** of these new switches is so small that there's room to spare in printed circuit or conventionally wired chassis. Centerline spacings are 25/64" (Model 10), 19/32" (Model 15) and 29/32" (Model 20).

**VERSATILITY** is exceptional. Switch action may be momentary, independent, push-push, row latching or even a combination of these anywhere in the same row! A zero block which releases the other blocks from the latching assembly is also available. Each switch can have two, four, six or eight double throw functions and a ganging arrangement permits up to 14 pole double throw action when required. Up to 19 switches may be ganged side-by-side on the same mounting bracket! A rear coupling is available for any switch. A line switch can be included in the assembly.

**WIRING** is particularly easy. Use standard dip or wave soldering methods with printed circuits. You can also make connections to the OTHER side of the switch with a pc board! In wired chassis, the design permits easy hand wiring and is ideal for automatic wire wrapping.

**MOUNTING** is simplified because Centralab provides a complete family of integrated hardware. Typical is a low-labor-content tab lock front mounting bracket.

Find out how you can revolutionize your designs with push button switches by writing to Centralab, The Electronics Division of Globe-Union Inc. at 5757 North Green Bay Avenue, Milwaukee, Wisconsin 53201.



## design principles

Centralab's new push button switches are completely machine-made of injection molded plastic. Even the contacts are inserted automatically for machine-secure quality control.

The unusual contacts provide excellent wiping action for electrically reliable performance. Their mechanical configuration assures even pressure on both fixed con-

tacts, eliminates local high stress points in the contact for long failure-free life. The sketches show the simplicity and self-aligning characteristics.

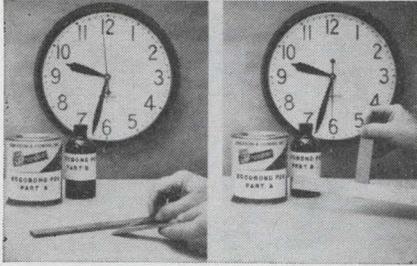
Smooth switch action is assured by the low friction plastic slider which holds the moving contacts. The switch body completely encloses the switch contacts for protection from solder and dust.

P-6615

\*Isostat licensed.

For additional information circle number 125

## Epoxy adhesive cures in a minute



Emerson & Cuming, Inc., Canton, Mass. Phone: (617) 828-3300. P&A: \$3 to \$4/lb.; stock.

Eccobond PDQ is a two-part epoxy adhesive that sets within one minute after mixing. It is useful for joining metal, glass, ceramics and many plastics, where bonding speed is important. Cure does not take place until the two parts are stirred together. The mix ratio is 4 parts of A to one part of B by weight. Tensile shear strength on aluminum to aluminum is 900 psi.

CIRCLE NO. 235

## Mounting kits are pre-matched

Tor Mfg. Co., 16329 E. Arrow Hwy., Irwindale, Calif. Phone: (213) 334-4907.

For over 80% of standard transistors, a line of mounting kits provide the most efficient heat transfer and optimize transistor performance. The components of these kits are pre-matched and individually packaged for instant use. Hardware included are insulating washers, busings, mounting screws, or nuts and solder lugs.

CIRCLE NO. 236

## Flexible PVC conducts when necessary

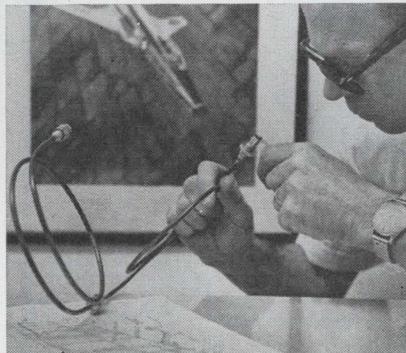
Monsanto Company, 800 N. Lindbergh St., St. Louis. Phone: (314) 993-1000.

A polyvinyl chloride compound, Abbey No. 100, is a flexible thermoplastic with the ability to conduct or "bleed off" electrical charges where required for reasons of safety or interference. Conductive vinyl

is used in cable shielding, antistatic devices, electronic systems and hospital operating room equipment. It offers several benefits over conventional shielding materials. The vinyl affords 100% coverage as a conductor. It is also lighter in weight and easier to fabricate, according to Monsanto. Resistance values can be varied to meet requirements. It can be formed by extrusion, molding, calendaring or lamination.

CIRCLE NO. 237

## Coax cable withstands re-entry temperature



Electronic Specialty Co., 4561 Colorado Blvd., Los Angeles. Phone: (213) 246-6767.

A high-temperature coaxial communications cable has been designed to withstand the heat generated during spacecraft re-entry into the earth's atmosphere. In aircraft it may be routed through the engine compartment where temperatures of 2000 degrees are generated. The cable weighs only 1 oz per ft.

CIRCLE NO. 238

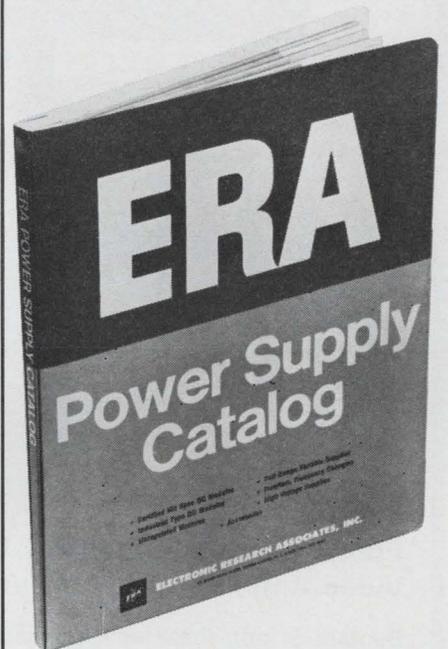
## Stripping agents handle organics

Miller-Stephenson Chemical Co., Inc., Route 7, Danbury, Conn. Phone: (203) 743-4447.

Two strippers are offered for softening and removing most organic resins. The strippers are said to be effective in removing epoxies, phenolics and polyurethanes without attacking metal surfaces. MS-110 is applied by spray-gun or brush. MS-111 removes organics by soaking. Both can be removed from the component by water rinse.

CIRCLE NO. 239

# Buying Power?



Here's the new, single source for all your power needs.

- Certified Mil Spec Transpac® DC Modules
- New Low-Cost Silicon Transpac DC Modules
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- Inverters, Frequency Changers
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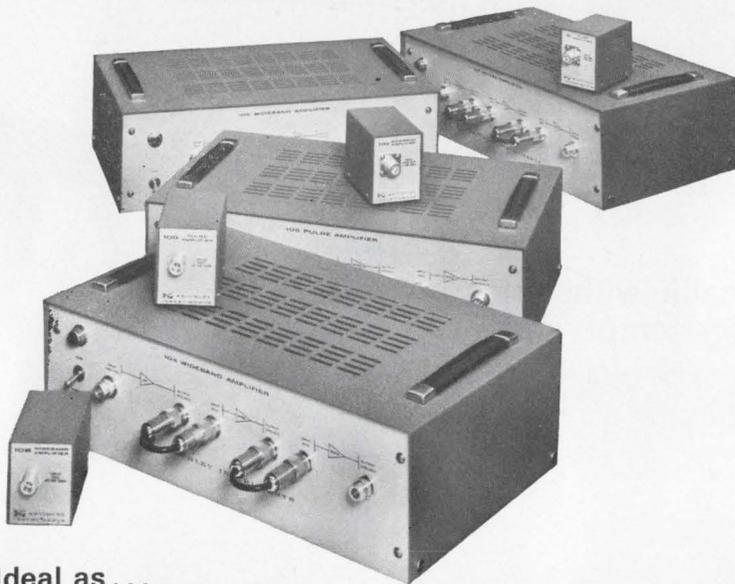


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ON READER-SERVICE CARD CIRCLE 108

# WIDEBAND OR PULSE here are eight better ways to AMPLIFY YOUR SIGNALS



Ideal as . . .

**Photomultiplier Amplifiers, Oscilloscope Preamplifiers,  
Video Amplifiers . . . or what have you**

Bantam or not, these ac amplifiers are made to handle your most stringent applications. And do it with low noise.

Use our wideband-tuned models where constant gain for sinusoidal signals is most important and for amplifying from audio to 180 mc. Try their pulse-tuned companions to enjoy unmatched waveform fidelity. Each has less than 3 nanoseconds rise time; overshoot of less than 3%.

Models with decade gains to 1,000 or with unity-gain for impedance matching are available. The decade amplifiers feature 50-ohms input impedance, less than 35  $\mu\text{v}$  rms noise (8 db) and a maximum output of 1.4 volts, p-p. Our unity-gain models, with an input impedance of 1 megohm, 10 pf or 10 megohms at 12 pf, feature protection from ac overloads of 100 v, p-p, and dc overloads of 400 v, p-p.

No matter which amplifier you choose, you'll get overload recovery within 50 nanoseconds and a delay time of less than 5 nanoseconds. Plus gain accuracy better than 2%.

What more can you ask for? Only our technical engineering notes or an in-plant demonstration. Why not write or call now.

WIDEBAND TUNED			PULSE TUNED		
	Gain			Gain	
Model 104	1-10 <sup>2</sup>	\$695	Model 105	1-10 <sup>2</sup>	\$695
Model 106	10-10 <sup>3</sup>	\$695	Model 107	10-10 <sup>3</sup>	\$695
Model 108	10	\$195	Model 109	10	\$195
Model 110	1-10 <sup>3</sup>	\$245	Model 111	1-10 <sup>3</sup>	\$245



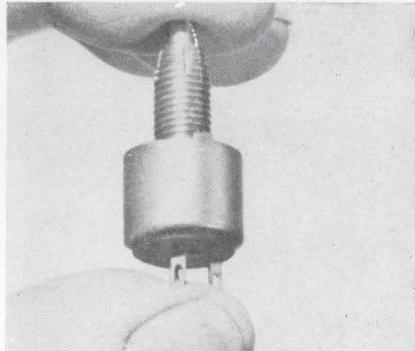
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ON READER-SERVICE CARD CIRCLE 62

## COMPONENTS

### 'Wedge-action brush' keeps tiny pot quiet



Reon Resistor Corp., 155 Saw Mill River Rd., Yonkers, N. Y. Phone: (914) 965-9850.

A positive "wedge-action" brush assembly, which reduces contact resistance and minimizes dynamic noise levels is incorporated in model B, MIL-type RV6, potentiometer. The design eliminates possibility of variations in potentiometer performance due to dependence on perfect parallel angle conformity, necessary in most brush assemblies. The "wedge action" is positive and independent of angle alignment. It provides maximum setability, with backlash reduced to less than 1%. Performance exceeds MIL-R-94B. The pot is available in all standard MIL bushings and shaft lengths. Non-standard bushings and shaft lengths are available on order.

CIRCLE NO. 240

### Transistor amplifiers for telemetry bands

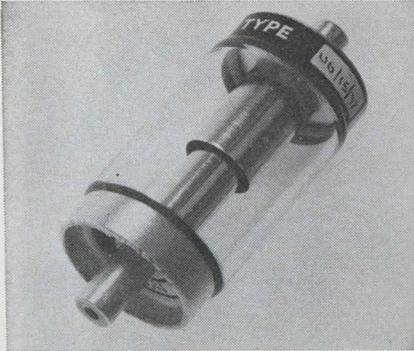
Aerotech, 250 Polaris Ave., Mountain View, Calif. Phone: (415) 967-9492.

Operating in the vhf, S and L bands, this telemetry transistor amplifier has a gain of 20 dB max and a noise figure of 3 dB max. Max vswr is 2, operating temperature is -55 to 70°C.

CIRCLE NO. 241

Remember to return your **ELECTRONIC DESIGN** renewal card. Don't miss any issues in '67.

## Vacuum capacitors in glass or ceramic cases

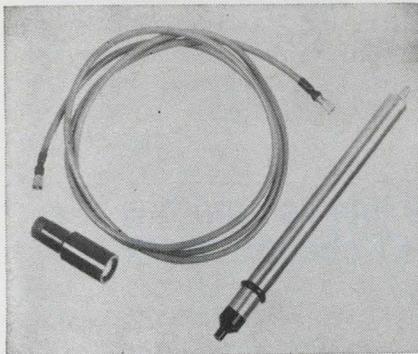


English Electric Valve Co. Ltd., Chelmsford, England. Phone: Chelmsford 53491.

A series of high-vacuum glass envelope capacitors with ratings of 15 kV peak and 7 A rms can be supplied in capacitance values up to 10 pF. Another series, rated at 3 kV and 50 A, is in the capacitance range 500 to 1000 pF. In ceramic envelopes a series rated at 30 kV and 140 A with capacitance values up to 34 pF is available.

CIRCLE NO. 242

## Light pen eliminates fiber-optic bundles

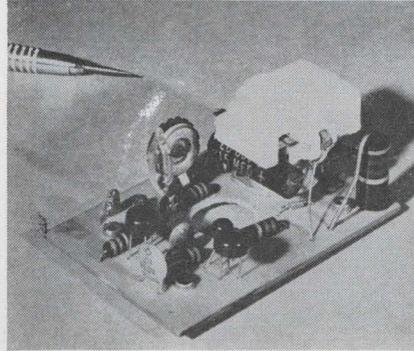


Information Control Corp., Abacus Div., 138 Nevada St., El Segundo, Calif. Phone: (213) 322-6930.

Through the use of a phototransistor as the light sensing element in this light pen, the fiber-optic bundle usually used is eliminated. This results in a unit which is much lighter in weight, has a lighter weight cable, has greater sensitivity, has a broader spectral response and does not require high voltages for a photomultiplier. Spectral response is 4200 to 7000 Å. Power requirement is -20 V at 20 mA.

CIRCLE NO. 243

## Capacitance switches for contact or proximity

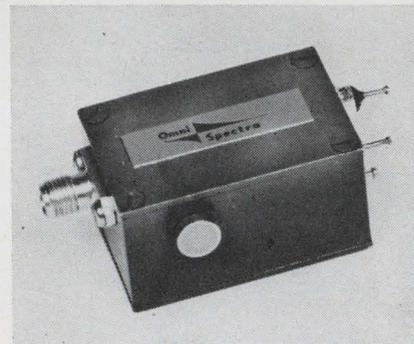


Wagner Electric Corp., 1 Summer Ave., Newark, N. J. Phone: (201) 484-8500.

These two switches can be operated either as contact switches or as proximity switches merely by changing the sensitivity. Stray RF signals will not cause false firing and they have stable operation over a temperature range of -20° to 170°F. The device is basically a relaxation oscillator acting in conjunction with a matched pair of transistors.

CIRCLE NO. 244

## 1-W RF oscillators in 1-oz packages

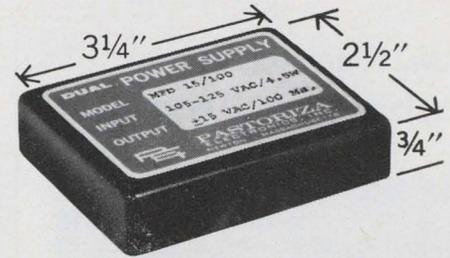


Omni Spectra, Inc., 19800 W. Eight Mile Rd., Southfield, Mich. Phone: (313) 444-8890. P&A: \$155; 60 days.

Power outputs up to 1 W may be obtained from a 1-oz RF oscillator module. Two series of oscillators use silicon high-power, high-frequency transistors and are electrically tunable from 10 MHz to 1 GHz in up to octave bands. Separate modulators are available to drive the pulsed series.

CIRCLE NO. 245

for Operational Amplifiers,  
Instruments and Systems



## Miniature Precision Dual Power Supply

from 110 vac input to  $\pm 15$  vdc at 100 ma output in a package  $3/4$ " high including power transformer.

The Model MPD 15/100 represents the first significant step in power supply miniaturization. This rugged unit provides 0.02% regulation (no load to full load), 0.005% regulation against line, complete short circuit protection and operates in ambients from -25°C to +65°C. There are pin connectors for socket or printed circuit board mounting.

for Operational Amplifiers:

Provides both positive and negative highly regulated dc voltage required by most operational amplifiers. The designer can finally take full advantage of the size reduction in monolithic and hybrid amplifiers.

for Instruments:

Provides high regulation and capacity for precision requirements. Compact form eliminates many mechanical design problems, allowing more flexibility in package design.

for Systems:

This Power Supply becomes another member in the System Designers' Card Library; making possible simplified system design by supplying required power to local circuits.

Write for Bulletin MPD 15/100.

**PASTORIZA**  
ELECTRONICS, INC.

385 Elliot St., Newton Upper Falls, Mass. 02161  
(617) 332-2131

ON READER-SERVICE CARD CIRCLE 63

## New, Tunable (Lock-in) Coherent Amplifier



MODEL 300-A

### For Measurement of Ultra-Low Level Signals in the Presence of Noise

- Continuously tunable from 1.5 Hz - 200 kHz
- Variable Q from broadband to 25
- 160 db gain (100 nV - full scale)
- 0.1 uV equivalent noise voltage
- Plug-in preamplifiers
- Reference channel drives coaxial switch or chopper directly

#### Applications:

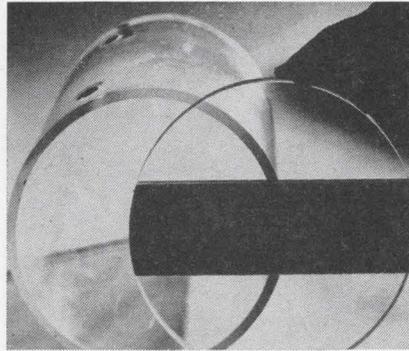
The Model 300-A Coherent Amplifier is useful for detection of effects of biological stimuli, photometric measurements at low S/N ratios, conversion of a communications receiver to sensitive radiometer, magnetic field effect studies, cross-correlation measurements, and general amplification and measurement of low level signals in the presence of noise.

**Write for data on the Model 300-A**  
Price \$1795 (including basic pre-amp)

Also available are: Fixed Frequency Coherent Amplifiers, Coaxial Switches, Radiometric Receivers, and Klystron Frequency Stabilizers.

## COMPONENTS

### CRT faceplate has fiber optic insert

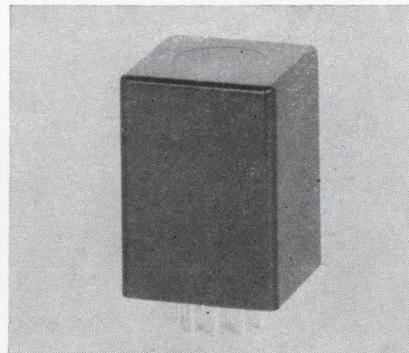


*Chicago Aerial Industries, Inc., 550 W. Northwest Highway, Barrington, Ill. Phone: (312) 381-2400.*

A new CRT faceplate has a fiber optic band across the center of the plate, with clear glass on either side to complete the disc. This provides a cost advantage by limiting the fiber optics only to the area used. The CRT image is brought to the front surface, eliminating parallax. Photo contact prints may be made, or the image may be viewed through an overlay, such as a map on grid.

CIRCLE NO. 246

### Differential frequency from silicon module

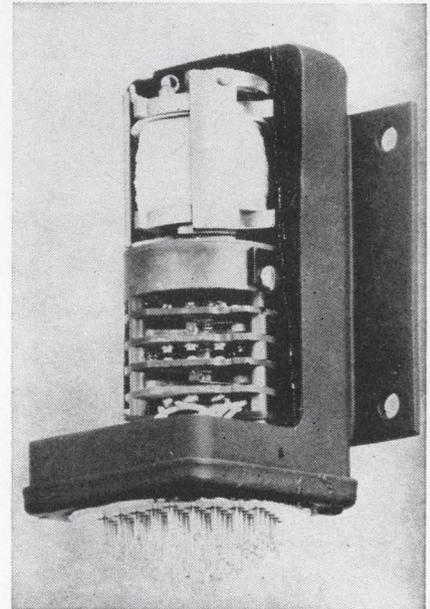


*Solid State Electronics Co., 15321 Rayen St., Sepulveda, Calif. Phone: (213) 894-2271. P&A: \$275; 2 wks.*

This differential frequency module is a solid-state unit designed to provide a continuous output frequency which is the absolute difference between two continuous input frequencies. It requires no separate supply and is activated by the input signals only. Either sine or square waves may be used at either input.

CIRCLE NO. 247

### Stepping relay is hermetically sealed



*Giannini-Volteax, 12140 E. Rivera Rd., Whittier, Calif. Phone: (213) 723-3371.*

Designed to MIL-R-6106, a small stepping relay in a hermetically sealed enclosure is available as a standard with twelve positions and four decks. Special modifications can be made for other output requirements. Standard stepping motor voltages are 6, 12 and 28 Vdc. Contacts are rated at 10-A resistive and 6-A inductive.

CIRCLE NO. 248

### Stable op-amp has FET chopper stage

*Systems Engineering Laboratories, Inc., P. O. Box 9148, Ft. Lauderdale, Fla. Phone: (305) 587-2900.*

This op-amp utilizes a silicon field-effect chopper stage, combined with a self-contained chopper drive circuit to provide best possible drift characteristics in the amplifier. The amplifier has a  $\pm 100$ -V output capability while presenting a high input impedance (10 M $\Omega$  at dc) to the source. Output current is 40 mA.

CIRCLE NO. 249

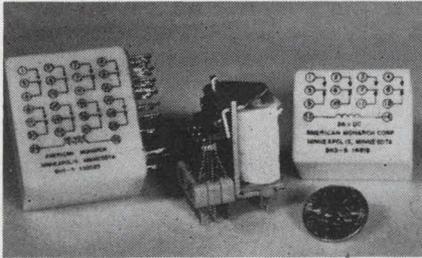
Remember to return your **ELECTRONIC DESIGN** renewal card. Don't miss any issues in '67.

## Teltronics, Inc.

Subsidiary of Roanwell Corporation

23 Main Street, Nashua, New Hampshire 03060  
603-889-6694

## Multipole relays switch more with less power

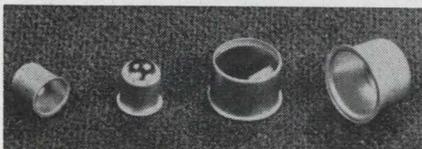


Minneapolis Scientific Controls Corp., American Monarch Div., 2801 37th Ave. N. E., Minneapolis. Phone: (612) 941-2200.

Five-amp telephone type, multipole relays have switching capacity ranging from 4 through 8-pole, while operating power remains at 1.2 to 1.5 W. High, tight-tolerance contact pressures (30-gram minimum NC, 35-gram NO) combine with simple contact members to give maximum contact resistance of 15 mΩ. The BKS-5 relay offers 500,000 electrical operating life, and features a 2-element contact circuit design, eliminating internal wiring, solder connections and pigtailed. Coil voltage options range from 6 to 110 Vdc and contact options are silver-gold, gold alloy, silver cadmium and palladium.

CIRCLE NO. 250

## Photodevice covers hermetically sealed



GTI Corp., Warren, Pa. Phone: (814) 723-8197.

Improved glass-to-metal sealing techniques are used to produce these covers for semiconductor photodevices. The transistor-type enclosures are sealed by resistance welding methods required for hermetically sealed phototransistors and photodiodes. The glass-to-metal seal permits welding in vacuum, inert or special atmospheres. Window covers (flat glass) and lens covers (curved, lens-like glass) to meet customer requirements are available, meeting TO-5 or TO-18 EIA specs.

CIRCLE NO. 251

# A better way to measure Delay

Acton Laboratories, pioneer in transmission delay measurement, has applied eight years of experience in this field to develop the 462B . . . a new delay measuring set that ensures complete compatibility with existing instruments of all types.

Our **all-solid-state 462B** measures transmission delays to accuracies of 2 microseconds up to 552 KHz in channels, groups, or supergroups. Separate packaging of transmitter and receiver makes the set equally suitable for measurements via loop, end-to-end straightaway, or end-to-end return reference techniques.

Model 462B was specifically designed for applications such as **AUTOVON** and **AUTODIN**. This instrument complies fully with **DCA-300-175-2A** and **DCA-375-185-1**. (Acton instruments of this type have been field proven for 2½ years).

The price, including transmitter and receiver with one modulating frequency, is \$3985. Additional modulating frequencies can be provided for \$100 each. Delivery is normally 30 days.

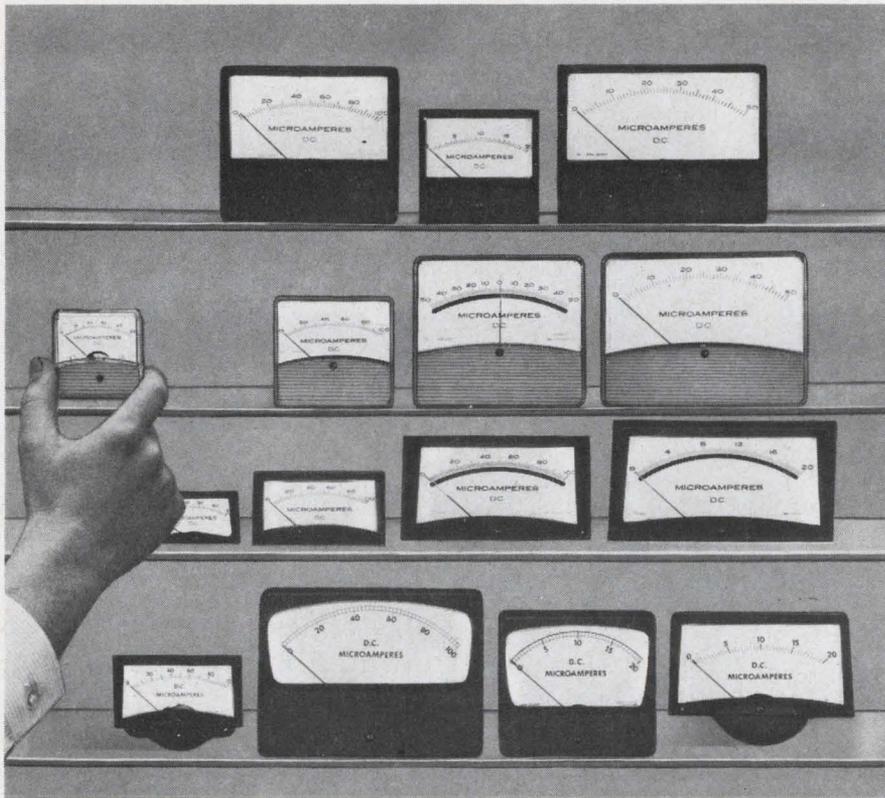
Don't let cost and delivery delay your delay measurements. Specify the Acton 462B. **Your local Acton representative will be happy to demonstrate this instrument; why not give him a call right now.**

See these instruments at IEEE Booth #2J25.

**ACTON LABORATORIES · INC.**  
Subsidiary of Bowmar Instrument Corporation  
531 Main Street, Acton, Mass. 01720 • Tel: (617) 263-7756 (Boston) 542-0284



ON READER-SERVICE CARD CIRCLE 66



# Off-the-Shelf Only from api

- 1% tracking
- taut-band
- no extra charge
- 20 to 100  $\mu$ a

There's extra value, but no extra cost, in API's line of DC panel meters in the 20 to 100 microampere ranges. Tracking of  $\pm 1\%$  is standard. Frictionless taut-band construction produces meters that are the most accurate, sensitive to smaller signals, vibration-proof and durable.

No other manufacturer offers these bonus features at firm catalog prices.

## 15 Models in Stock

You'll get off-the-shelf delivery of the economically priced Panelist, Stylist and black phenolic meters shown above. Choose from these full-scale DC ranges:

**Microamperes:** 0-20, 0-50, 0-100

**Millivolts:** 0-5, 0-10

If ultra-precision tracking is the least you'll settle for, API offers 0.5% tracking at reasonable cost. This "super-calibration" is another API exclusive, again backed by published prices.

**Ask for Bulletin 47.**

*Also stocked nationally by Allied Electronics and Newark Electronics.*

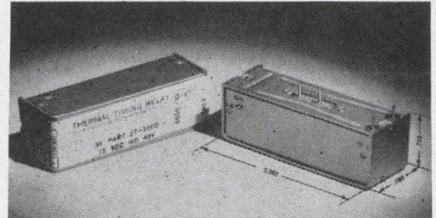
**See these instruments at IEEE Booth 2-G-39.**

**api INSTRUMENTS CO.**  
CHESTERLAND, OHIO 44026 (CLEVELAND-216) 729-1611 • TWX: 810-427-9230

ON READER-SERVICE CARD CIRCLE 72

## COMPONENTS

### Thermal timing relay mounts PC board

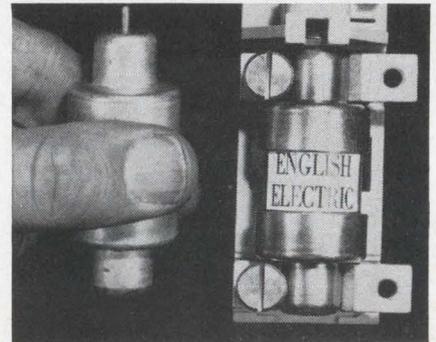


G-V Controls Inc., 101 Okner Pkwy., Livingston, N. J. Phone: (201) 992-6200. P&A: 8.50 (1 to 9), \$5.80 (100 to 249); stock.

Thermal timing relays mount directly on printed circuit boards. By eliminating the need for an adapter, JT thermal relays increase reliability of the circuit and reduce assembly time. Contacts are spst-NO or NC with a life of over 100,000 makes and breaks claimed at rated load. The series offers delays of 2, 5, 10, 20, 30, 45, 60, 90, 120 and 180 seconds with heater voltages of 6.3, 28, 48, 115 and 230 V.

CIRCLE NO. 262

### Current-limit fuses protect SCRs

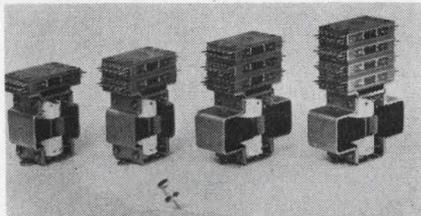


English Electric Corp., 1 Park Ave., New York. Phone: (212) 679-3522.

Fast-acting current-limiting fuses are designed for the protection of SCRs. For inverter application the fuse is rated 350 Vdc. For static switching and phase control application it is rated 1000 Vac PRV. Current ratings are 35, 55, 75, and 100 A rms. Each fuse fits a holder which incorporates a trigger-operated switch. When a fault occurs, the switch is closed by an integrally mounted indicator pin which is ejected by the fuse.

CIRCLE NO. 263

**Latching relays  
available 52pdt, 60pst**

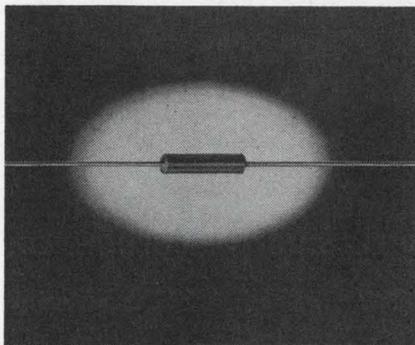


Electronic Controls, Inc., P. O. Box 254, Wilton, Conn. Phone: (203) 762-8351. P&A: \$51.72 (36pdt); 4 to 5 wks.

Latching relays from 12pdt to 52pdt and 60pst are designed for computer, instrumentation, communications and automatic test systems. The pulse-operated units combine high density with shock and vibration resistance. The gold-bonded over fine silver contacts switch dry circuit to 3 A and non-inductive loads. Connectors have crimped, snap-in contacts.

CIRCLE NO. 264

**'Circuit jumper' is  
dummy component**



Erie Technological Products, Inc., 644 W. 12th, Erie, Pa. Phone: (814) 456-8592.

A component-like circuit jumper is designed to replace unsightly jumpers for PC or hand wiring layouts. The submin device looks, feels and loads like a component, and thus is ideal for automatic insertion. It has a black plastic body to distinguish it from other parts. The molded case measures 0.1 in. diameter by 0.26 in. long. Wire leads measure 1-1/4 in. long and are available in 20 or 22 gauge tin-coated wire.

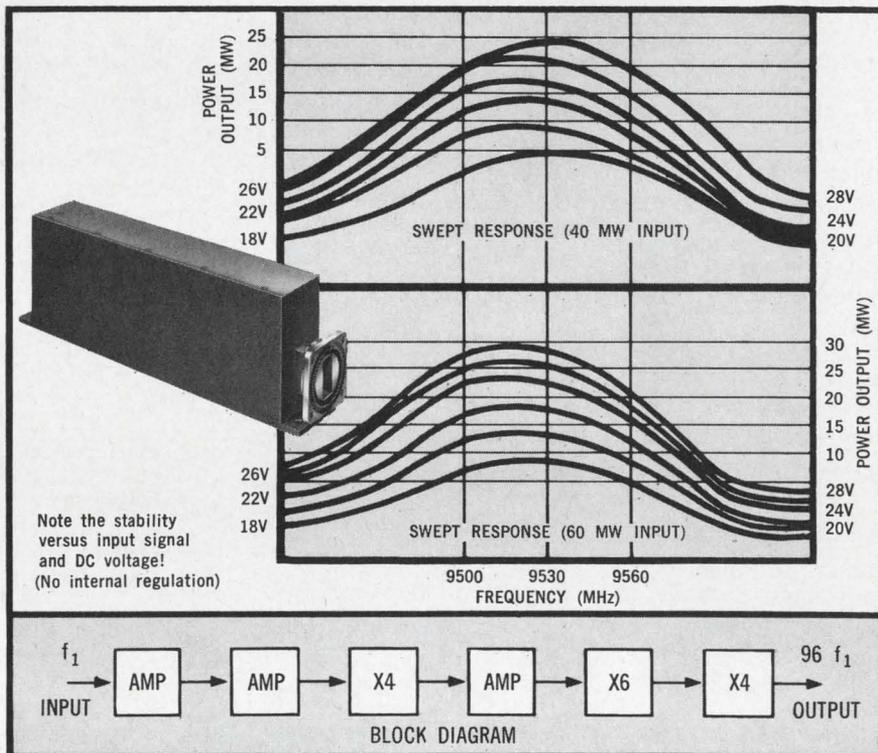
CIRCLE NO. 265

# MATCH THIS PERFORMANCE

IN A X96 FREQUENCY MULTIPLIER

# IF YOU CAN!

(IF YOU CAN'T, COME TO US)



Note the stability versus input signal and DC voltage! (No internal regulation)

**Low spurious outputs • Low AM and FM noise • Efficient operation**

Our Model M-9-1-10-96 Solid State Frequency Multiplier remains stable versus temperature from  $-10$  to  $+60^\circ\text{C}$  and requires only 4 watts DC input to provide a 20 MW output.

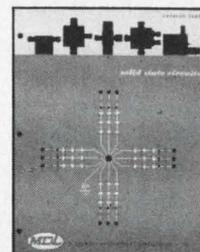
For further information regarding bandwidth, power output, or other trade offs, contact Mr. Joseph Brumbelow, Director of our Solid State Department, at the address below.



WRITE FOR OUR FREE CATALOG ON SOLID STATE CIRCUITS

**MICROWAVE DEVELOPMENT LABORATORIES • INC.**

87 Crescent Road • Needham Heights • Massachusetts 02194  
Telephone: 617-449-0700 • TWX 617-444-2695

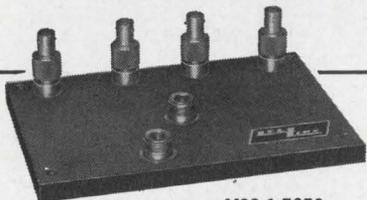


ON READER-SERVICE CARD CIRCLE 73

# IMAGE SUPPRESSION

## MIXERS

or SSBSC Modulators



MSS-1-5650

LEL-Line strip transmission line components offer excellent characteristics at microwave frequencies. **Image suppression mixers**, for example, are quickly available in 11 ranges from 925 to 5900 MHz. When used as SSBSC modulators there is a choice of IF's to 180 MHz. Specifications include:

- 20 dB image suppression
- 9.5 dB noise figure
- 20 dB L.O. isolation
- 10 dB conversion loss and 2:1 VSWR (when used as modulators)

Other standard LEL-Line components include:

**BALANCED MIXERS:** 400 — 5900 MHz

- 7.5 dB noise figure • 20 dB isolation

**SINGLE ENDED MIXERS:** 7 — 18 GHz

- 10 dB noise figure • 20 dB isolation

**DIRECTIONAL COUPLERS:** .25 — 18 GHz

- Coupling tolerance  $\pm 1$  dB • VSWR 1.35:1 • Directivity 20 dB (Typical)

**POWER DIVIDERS:** 200 — 18,000 MHz

- Octave bandwidth • Insertion loss per binary section: 0.4 dB (Max.)
- Split Accuracy  $\pm 0.3$  dB

**HYBRIDS:** 400 — 18,000 MHz

- Isolation 25 dB • Bandwidth 25%
- Insertion Loss: 0.4 dB • VSWR 1.41:1 (Max.)

Call LEL for your receiver requirements including matched component assemblies.



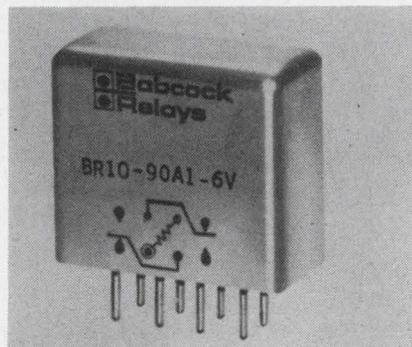
**LEL** DIVISION  
VARIAN associates

AKRON ST., COPIAGUE, L. I., NEW YORK 11726  
(516) AMityville 4-2200/(516) PYramid 9-8200  
TWX Code 516-691-5085

ON READER-SERVICE CARD CIRCLE 69

## COMPONENTS

### Dpdt relay has 'universal contacts'

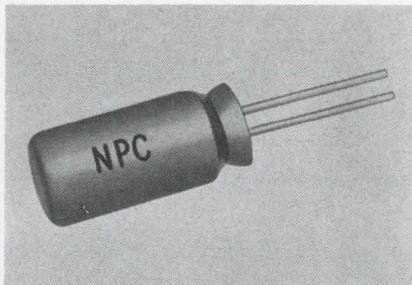


Babcock Electronics Corp., 3501 Harbor Blvd., Costa Mesa, Calif. Phone: (714) 540-1234.

"Universal contacts," said to provide dry circuit to 1-A operation with the same contact set, have been incorporated in model BR10 1/6-size, dpdt crystal can relays. This permits the specification of a single submin relay to meet a variety of low-profile, circuit-board applications. Model BR10 measures 0.4 x 0.23 x 0.5 inch and weighs 0.15 oz. It has a guaranteed life to 150,000 operations. Sensitivity is stated at 80 mW; vibration performance 30 G, 40 to 3000 Hz; operating temperature range, -65 to +125°C.

CIRCLE NO. 256

### Miniature electrolytics for vertical PC mount

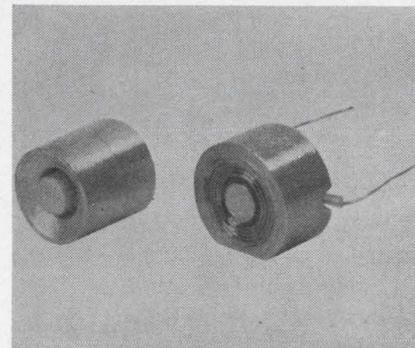


Nucleonic Products Co., Inc., 3133 E. 12th St., Los Angeles. Phone: (213) 268-3464.

Electrolytic capacitors for vertical PC mounting have been designed for transistor circuitry and PC boards. All-welded terminations and high stability electrolytes are used for greater reliability. Capacitance range is 1 to 500  $\mu$ F. Working voltage range is 3 Vdc to 50 Vdc.

CIRCLE NO. 257

### Induction generator for triggering systems

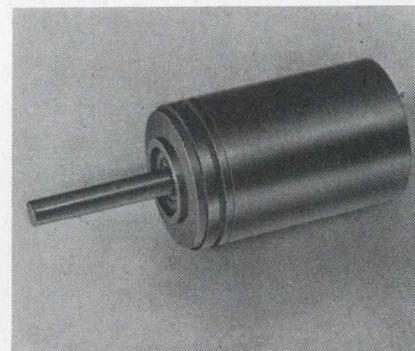


Globe Industries, Inc., 2275 Stanley Ave., Dayton, Ohio. Phone: (513) 222-3741.

Designed for use in triggering systems, this magnetic induction generator has an output energy of  $0.7 \times 10^{-3}$  joules across a 1- $\Omega$  load. In operation, the magnet assembly is displaced from the output coil, causing a change in flux linkage. The resultant voltage is a function of flux linkage, coil design and rate of change of flux linkage with time. The peak output power is 0.4 W.

CIRCLE NO. 258

### Mechanical stop sets from 0 to 20 turns

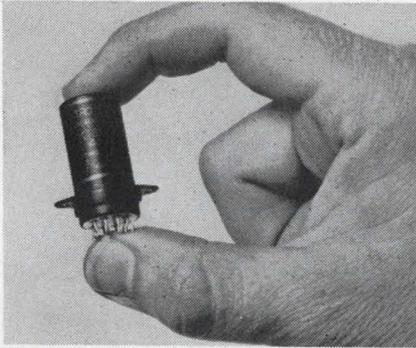


Computer Instruments Corp., 92 Madison Ave., Hempstead, N. Y. Phone: (516) 483-8200.

By simply removing the dust cover from this mechanical stop, an adjustable collar can be set to provide the stop setting desired. It has a completely adjustable range from 0 to 20 turns. All parts are of stainless steel construction, with the exception of a phosphor bronze traveling nut.

CIRCLE NO. 259

## Subminiature relay has self-cleaning contacts

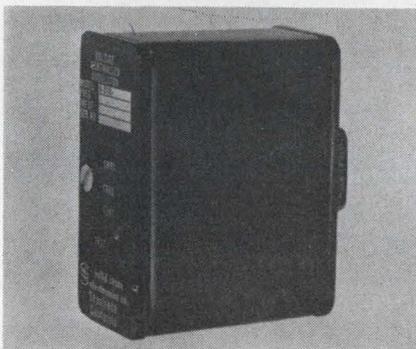


Electro-Tec Corp., P. O. Box 667, Ormond Beach, Fla. Phone: (305) 677-1771.

Self-cleaning wiping action, low contact resistance, and high contact pressure that increases during over-travel are claimed as features of a 2pdt subminiature relay. The unit weighs less than 1 oz and is 0.65 in. diameter by 1.3 in. high. The unit is hermetically sealed and allows the use of one relay for both dry circuit and 2-A applications. Contacts are gold over fine silver.

CIRCLE NO. 260

## Subcarrier oscillator is voltage-controlled



Solid State Electronics Co., 15321 Rayen St., Sepulveda, Calif. Phone: (213) 894-2271.

A VCO has been designed for conversion of varying analog dc voltage to a linearly proportional sine wave frequency. Special consideration has been given to its application within FM-FM telemetering systems and as an analog-to-digital converter. The unit is all-solid-state.

CIRCLE NO. 261

**NEW**

## COMPLETE LINE OF ELECTRONIC ALL SILICON COUNTERS...AS LOW AS \$445.



COUNTER TIMER MODEL CF-500R

If you have a counting application, then you need a counting device. Anadex has a complete new line of counting instruments



VARIABLE TIME BASE COUNTER MODEL CF-501R

for every function: preset counters, counter-timers, bi-directional counters, time interval counters, totalizers, frequency



FREQUENCY COUNTER MODEL CF-503R

counters, and variable time base counters. You have probably looked at other instruments and found they do more than you



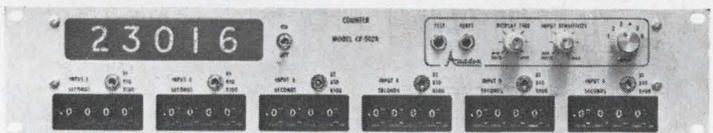
TIME INTERVAL COUNTER MODEL CF-530R

need. And you pay more. It stands to reason that if all you need is an instrument for a specific function, why pay extra dollars



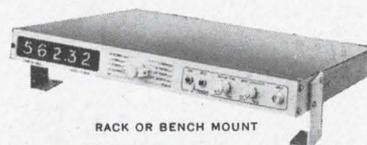
TOTALIZER MODEL DC-500R

for needless frill functions. Anadex counters have in common several unique features: all-silicon solid state, plug-in transis-



MULTI-CHANNEL VARIABLE TIME BASE COUNTER MODEL CF-502R

tors, 1 3/4" high panel space. If your interest is counting and you are tired of paying for things you don't need, Anadex has the instrument for you...you can count on it! Send for our new counter line catalog today.



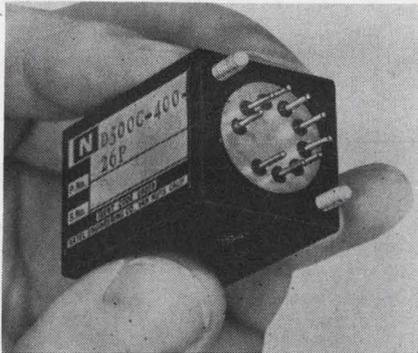
RACK OR BENCH MOUNT



... THE NAME YOU CAN COUNT ON

7833 HASKELL AVENUE, VAN NUYS, CALIFORNIA 91406 PHONE 213-873-6620 TWX 213-781-6811

### Phase-sensitive demod barely a handful

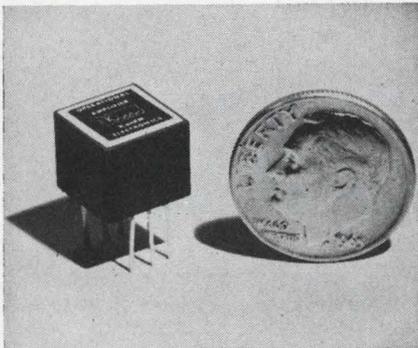


Natel Engineering Co., 7129 Gerald Ave., Van Nuys, Calif. Phone: (213) 782-4161. P&A: \$117 to \$130; 30 days.

For converting phase-sensitive ac signals to linearly proportional bipolar dc voltages, this demodulator measures 1.03 x 1.03 x 1.53 inches and has an input impedance of over 120 k $\Omega$ . It is suited for use in ac/dc closed loop systems and is available with voltage offsets for recording and telemetry applications. Null stability is 1 mV.

CIRCLE NO. 266

### Micromin op-amp is thin-film hybrid

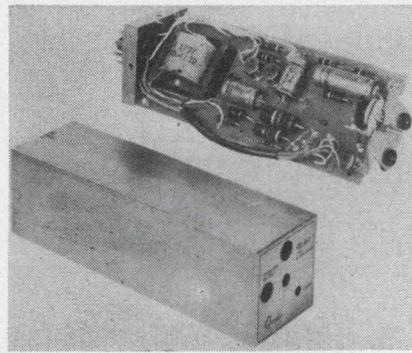


K & M Electronics Corp., 102 Hobart St., Hackensack, N. J. Phone: (201) 343-4518. P&A: \$49.50; stock.

Packaged in a 0.4 x 0.4 x 0.2-inch case, model KM23M op-amp uses thin-film hybrid circuitry. It is designed for use in analog computers, high-gain low-drift servo preamps, high-stability ac amplifiers and voltage comparators. Input impedance is 100 M $\Omega$ , open-loop gain is 200,000 and drift is 10  $\mu$ V/ $^{\circ}$ C.

CIRCLE NO. 267

### Line amplifiers for voice frequencies

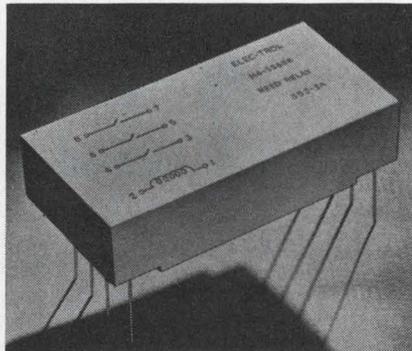


Quindar Electronics, Inc., 60 Fadem Rd., Springfield, N. J. Phone: (201) 379-7400.

Designed to amplify voice frequencies as a repeater or straight amplifier, this line amplifier's high sensitivity also makes it suitable as a microphone preamp. Input and output impedances are 600  $\Omega$  balanced and isolated. A dc feedback system provides temperature stabilization from -22 to 140 $^{\circ}$ F. Signal variation over this range is 0.25 dB. Frequency response is flat within  $\pm$ 0.1 dB between 75 and 15,000 Hz.

CIRCLE NO. 268

### Reed relay for PC or plug-in

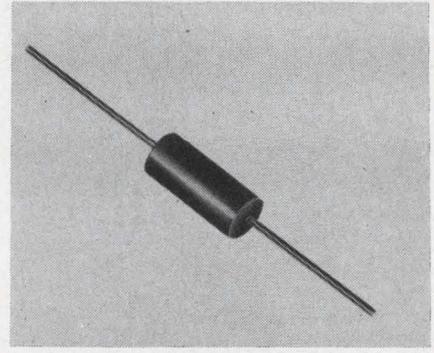


Elec-Trol, Inc., 18828 Bryant St., P. O. Box 304, Northridge, Calif. Phone: (213) 349-0622.

Reed relays designed for PC or plug-in application are available in 4 different load capabilities from dry circuit to 15-A inrush. The relay has 3 standard coil voltages: 6, 12 and 24 Vdc, and comes in 1, 2, 3, 4 or 6 poles. Electrostatic and electromagnetic shielding are available on special order.

CIRCLE NO. 269

### Voltage-variable caps offer high Q

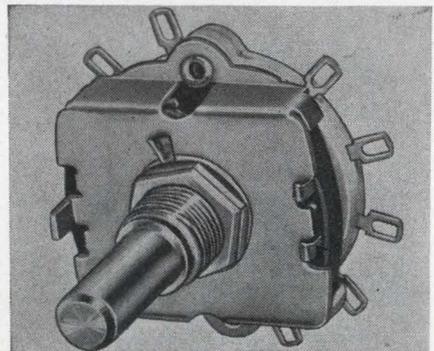


Solitron Devices, Inc., 256 Oak Tree Rd., Tappan, N. Y. Phone: (914) 359-5050.

Voltage-variable capacitors of the VH series offer ratings of 100 volts and Q of 100 in units up to 150 pF. The DO-14 package is rated at 500 mW. Matched pairs and quads are available per customer specification; matching is as close as 0.5% or less over the rated voltage.

CIRCLE NO. 270

### Rotary switches have adjustable stops



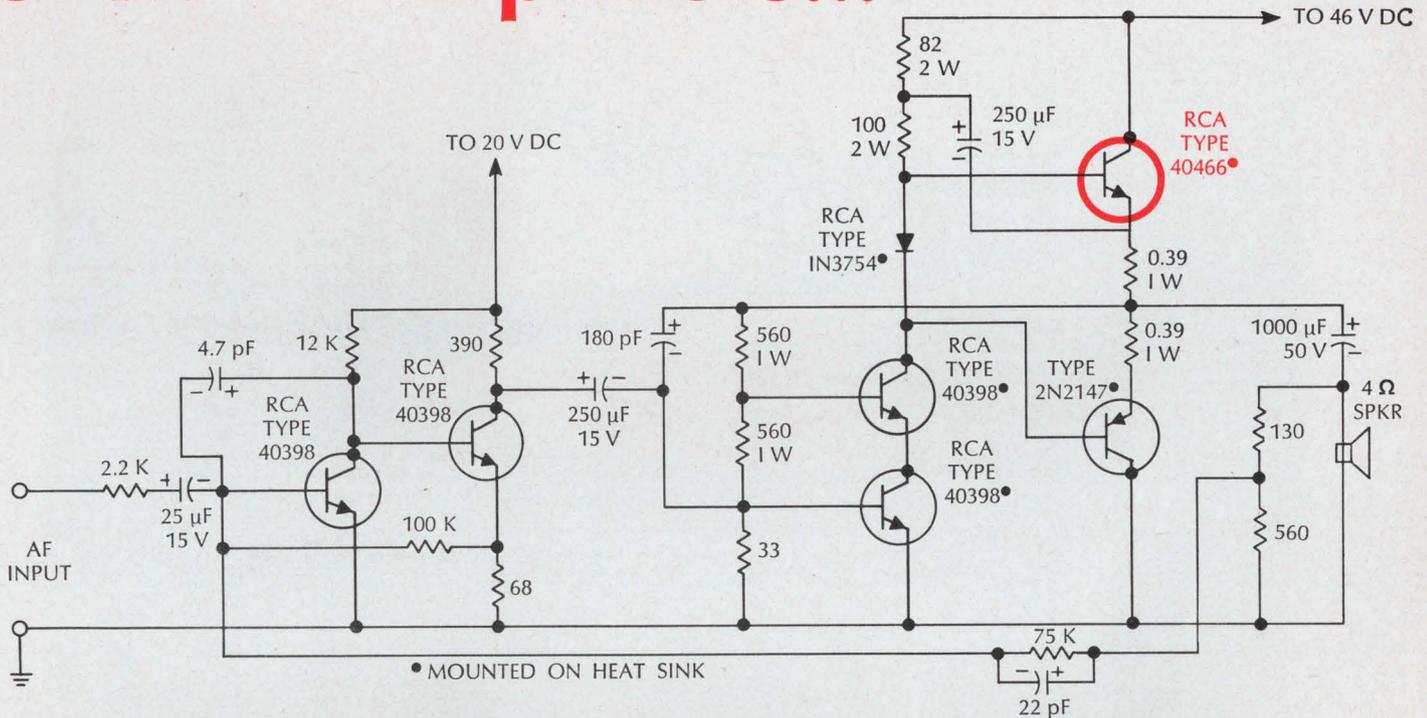
CTS Corp., Elkhart, Ind. Phone: (219) 523-0210.

Adjustable stops, shaft lengths up to 12 in., three torque ranges and special lubrication that prevents the possibility of terminal corrosion are the four features offered in this series of rotary selector switches. A cycle life of 100,000 is claimed.

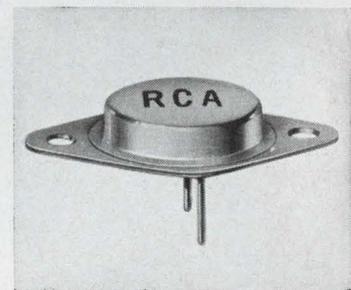
CIRCLE NO. 271

Don't risk missing any issues of **ELECTRONIC DESIGN**. Send in your renewal card today.

# Because RCA's New 40466 Silicon Power Transistor was developed specifically for Hi-Fi Amplifiers...



you can now design economical complementary-symmetry audio power amplifiers with extended high frequency response...simple driver requirements...and low distortion!



Hermetically sealed in a TO-3 low profile metal case

RCA's new 40466 silicon n-p-n power output transistor lets you combine real high fidelity performance with superior electrical ruggedness and the economy of *transformerless design*.

You can get 50 watts music power per channel in the circuit shown when the 40466 is complemented with the high-performing RCA 2N2147 germanium drift-field power transistor. Together they make a low cost output pair.

Response is flat from 10 Hz to 80 Hz...total harmonic distortion at 20 watts with a 1 KHz signal is 0.13%... 0.05% at 1 watt.

Because of its epitaxial base construction, the 40466

also provides virtual freedom from second breakdown. And its high minimum beta of 50 at 2 amperes simplifies driver stage requirements.

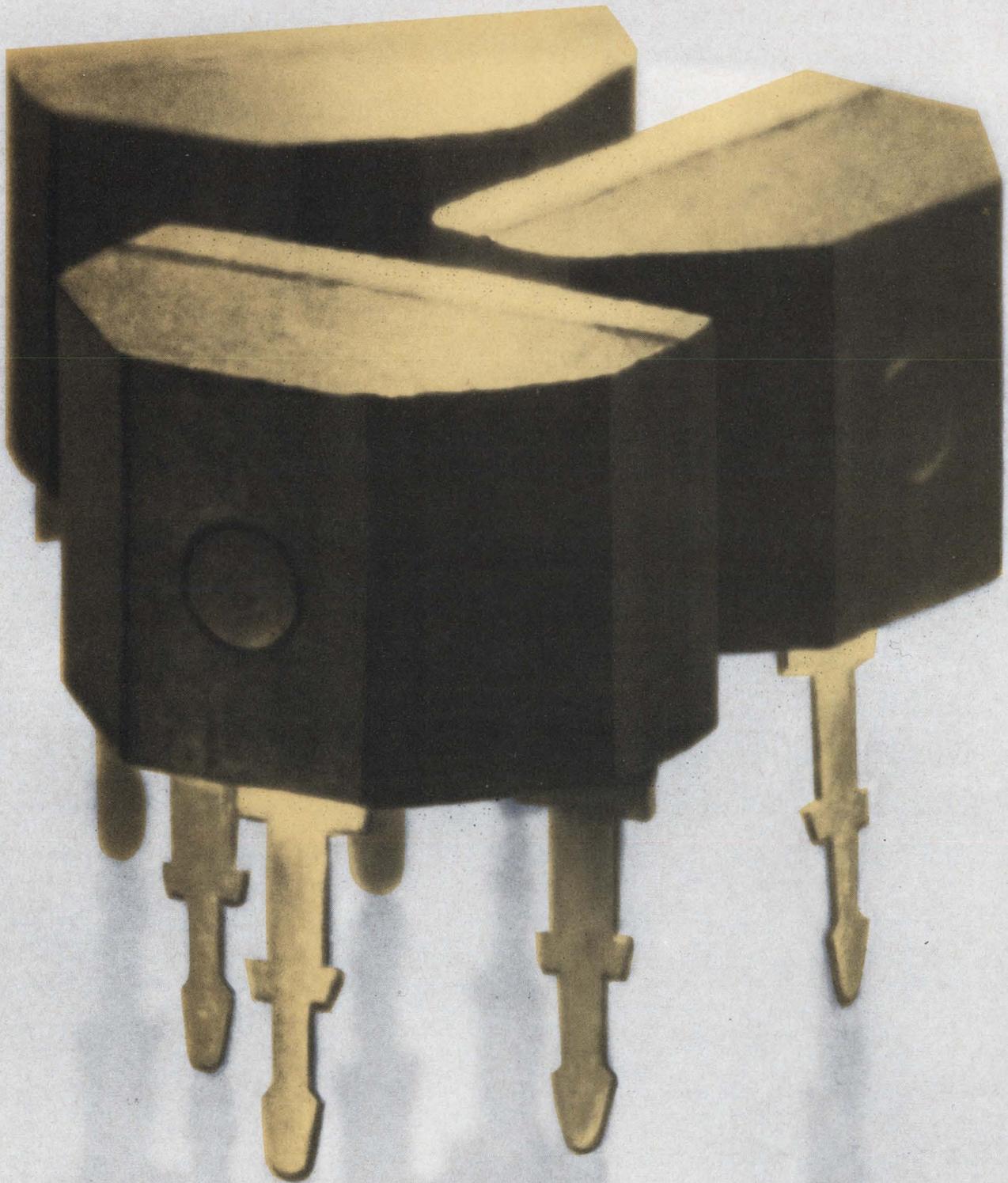
RCA's new 40464 and 40465 silicon transistors are also available for lower power hi-fi stereo circuits. Your RCA Field Representative can tell you the whole story of how these new audio power devices can improve the performance of stereo phonographs, receivers, and tape recorders. He can also give you price and delivery. For a technical data sheet on the RCA 40464, 40465, 40466, write RCA Commercial Engineering, Sec. EG3-1, Harrison, N.J. 07029. ALSO AVAILABLE THROUGH YOUR RCA DISTRIBUTOR

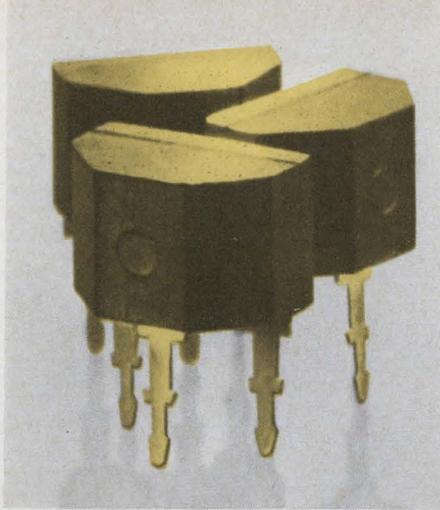
RCA Electronic Components and Devices



The Most Trusted Name in Electronics

Now—the autoserf  
A New Transistor Configuration  
That Permits Automatic Insertion Into  
All Standard PC Boards





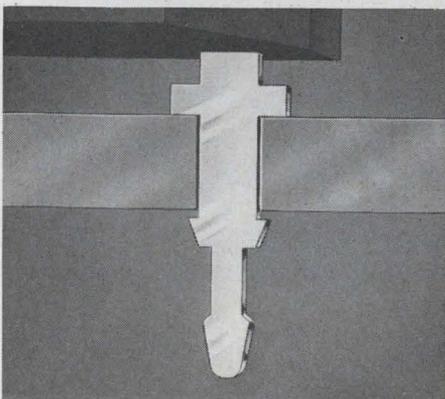
One of today's major unsolved problems in mass-producing electronic circuit boards is automatic insertion of transistors into the boards.

To solve this problem, the transistor should have rigid leads and a shape conducive to mechanized handling; it must fit the industry's standard circuit board hole-pattern and when inserted, it would have to snap in and seat so firmly that no other support is required.

The new Amperex **autoserf** provides all these advantages for automatic (as well as high speed manual) insertion — at plastic transistor prices — without compromise in performance or reliability.

Instead of flexible wire leads, the **autoserf** is terminated in three rigid alloy leads .008" thick, that snap — that's right, snap-into the circuit board holes.

Its unique shape mechanically keys the lead arrangement; the leads are spaced on a 200 mil pin circle eliminating the possibility of solder-bridging. Once inserted into the board, the **autoserf** sits firmly on its own stand-off, its depth of penetration controlled by its rigid leads.



Transistors now available in the new **autoserf** configuration are the RF amplifier types A494 and A495, for AM/FM radio, TV video drivers, sound IF's and sync circuits, CB and mobile communications receivers and types A747, A748 and A749 for general purpose and low level audio-frequency applications.

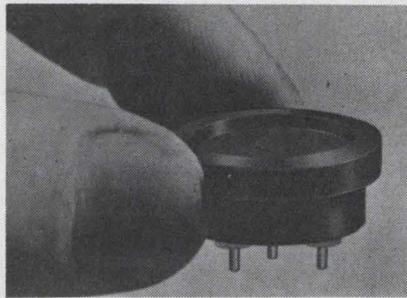
For additional information, write: Amperex Electronic Corporation, Semiconductor & Receiving Tube Division, Dept. 371, Slatersville, Rhode Island 02876.

**Amperex**<sup>®</sup>

TOMORROW'S THINKING IN TODAY'S PRODUCTS

## COMPONENTS

### Position indicator homes in on light spot



*United Detector Technology, P. O. Box 2251, Santa Monica, Calif. Phone: (213) 457-2314. P&A: \$98; stock.*

A sensitive, large area, silicon photodetector is designed for light detection applications involving homing devices, machine control devices, servo systems, light pickoff devices and optical inspection. The PIN-Spot/10 provides two output signals that specify X and Y positions of an input light signal relative to fixed internal coordinates. When the input light spot is at the exact center, no electrical signals are generated. By moving the light spot over the face, continuous signals are provided at the terminals, giving exact position at each instant of time. Spectral response of the PIN-Spot/10 is 3300 to 11,000 Å (three times the range of a photomultiplier). Rise time is less than 10 ns (10 times faster than ordinary silicon pn). The dark current is less than 1 mA while the light current for a few foot-candles illumination is greater than 1 mA.

CIRCLE NO. 252

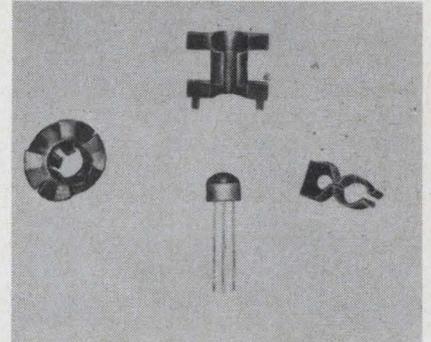
### Power supply adjusts from 0 to 3/4 V at 1.5 A

*Power/Mate Corp., 163 Clay St., Hackensack, N. J. Phone: (201) 343-6294. P&A: \$88; stock.*

Adjustable from 0 to 3/4 volts, 1.5 amperes, this power supply is designed with all-silicon semiconductors to meet MIL-E-5272 environments and can operate up to 71°C. Regulation is to 0.005% or 1 mV; ripple is 250 μV. The units are completely short-circuit proof, and can be operated in series or parallel.

CIRCLE NO. 253

### Heat dissipators for plastic transistors

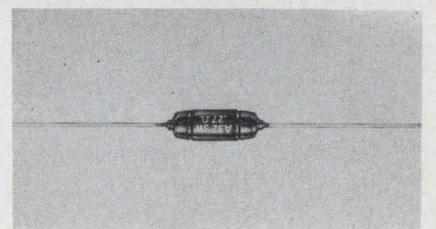


*IERC Corp., Div. of Dynamics Corp. of America, 135 W. Magnolia Blvd., Burbank, Calif. Phone: (213) 849-2481.*

Heat dissipators and retaining devices for plastic transistors are available in models to cool, position and prevent lead-pull. The Fan-Top unit (TO-5, TO-18 and DØ packages) is a dissipator for high-density packaging. The Clip-Type dissipator (TO-5) acts as a retainer, reduces high shock and vibration loads and can be used either as a heat conducting element or as a radiating device. The Spade-Type series positions plastic transistors when automatic soldering techniques are used.

CIRCLE NO. 254

### Metal film resistors available 0.01 to 27 Ω

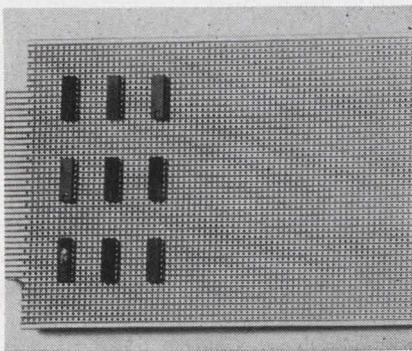


*Welwyn International Inc., 811 Sharon Dr., Westlake, Ohio. Phone: (216) 871-7980.*

Metal film resistors are available in values from 0.01 to 27 Ω. The half-watt size (type A20) is available in 1, 2 and 5%, and the 1-1/2 (type A31) and 3-watt (type A32) sizes are available in 2, 5 and 10% tolerances. The resistors exhibit excellent stability, moisture and temperature coefficient characteristics.

CIRCLE NO. 255

## Breadboard accepts molded dual in-lines

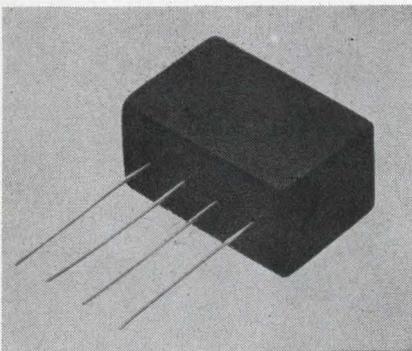


Vero Electronics, Inc., 48 Allen Blvd., Farmingdale, N. Y. Phone: (516) 694-6550. P&A: \$29.95; stock.

Designed for dual in-line molded ICs, this kit of Veroboards are pierced on a 0.1 x 0.1 matrix so that the ICs can plug in at any point on the board. The kit contains a single-sided 18-in.-long board with 34 copper strips on 0.1-in. centers, a plug-in single-sided board with 32 plated contacts, a double-sided plug-in board with strips at right angles and an epoxy-glass plain board pierced at 0.1-in. centers with 0.5-in. holes. There are also 500 terminal pins, a pin insertion tool, a spot face cutter to break the copper strips where required and a 32-contact edge connector.

CIRCLE NO. 272

## IC clock oscillator is temperature controlled

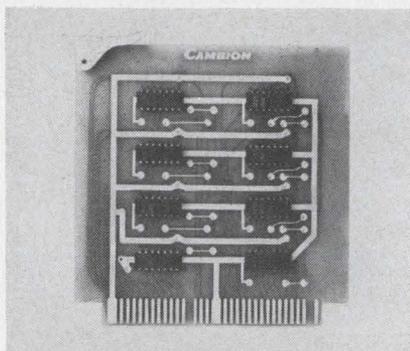


Monitor Products Co., Inc., 815 Fremont, S. Pasadena, Calif. Phone: (213) 682-3761.

A complete IC crystal clock oscillator enclosed in a proportional temperature control oven occupies only 0.84 in.<sup>3</sup>. Frequency range is 701 to 1000 kHz with stability at  $\pm 8$  ppm over a temperature range of  $-55^{\circ}$  to  $60^{\circ}\text{C}$ .

CIRCLE NO. 273

## Digital decoders on PC boards

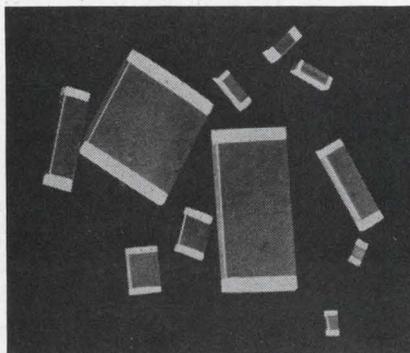


Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. Phone: (617) 876-2800. P&A: \$34.60 (10-49); stock.

A new series of versatile decoders includes binary-to-octal, BCD-to-decimal, 2421-to-decimal, 5241-to-decimal, excess-3-to-decimal and binary-to-hexadecimal decoders. The binary-to-octal card provides conversion from a 3-bit to an 8-bit octal equivalent and is available with options for either a single decoder, a dual decoder, or a decoder with drivers.

CIRCLE NO. 274

## Chip capacitors for hybrid and IC use

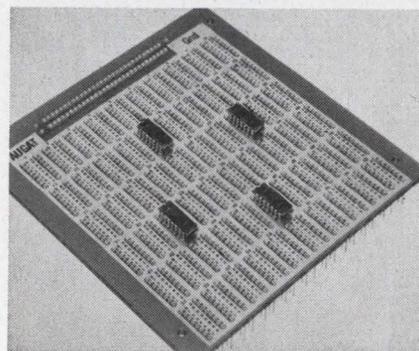


Ultronix, Inc., 461 North 22nd, Grand Junction, Colo. Phone: (303) 242-0810.

Designed for use in hybrid and integrated circuits, and encapsulation in MIL-C-11015 capacitor bodies, these multilayer ceramic elements have a capacitance of 5 pF to 1 mF. They are composed of up to 40 layers of ceramic dielectric and platinum electrodes.

CIRCLE NO. 275

## Packaging panels for 14- and 16-lead plug-ins

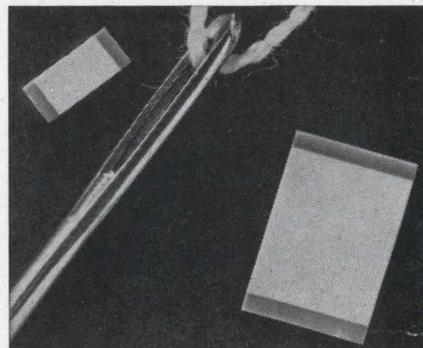


Augat Inc., 33 Perry Ave., Attleboro, Mass. Phone: (617) 222-2202. P&A: about \$1 to \$3/station; 4 to 5 wks.

High-density packaging panels are designed for 14- and 16-lead plug-in integrated circuits. 30 and 60 stations are standard. The PC board is printed on two sides with power and ground takeoffs at each station. Wiping gold-plated contacts insure low contact resistance and high reliability. The panels are furnished with an IC extractor tool.

CIRCLE NO. 276

## Chip cap is stable through thick and thin



Nytronics, Inc., 550 Springfield Ave., Berkeley Hts., N. J. Phone: (201) 464-9300.

Claiming high capacitance-to-volume ratio, this chip capacitor has mounting versatility for outboard mounting on integrated, thick- and thin-film circuitry. Dimensions with tinned terminals range from 0.170 by 0.065 by 0.070 in. with capacitance range of 4.7 to 82 pF, and 0.280 by 0.195 by 0.070 in. for 100 to 1000 pF. Rating is 200 Vdc.

CIRCLE NO. 277

**Only  
Honeywell Offers  
A Family of  
Compatible  
High Speed\*  
I/C Core Memories**

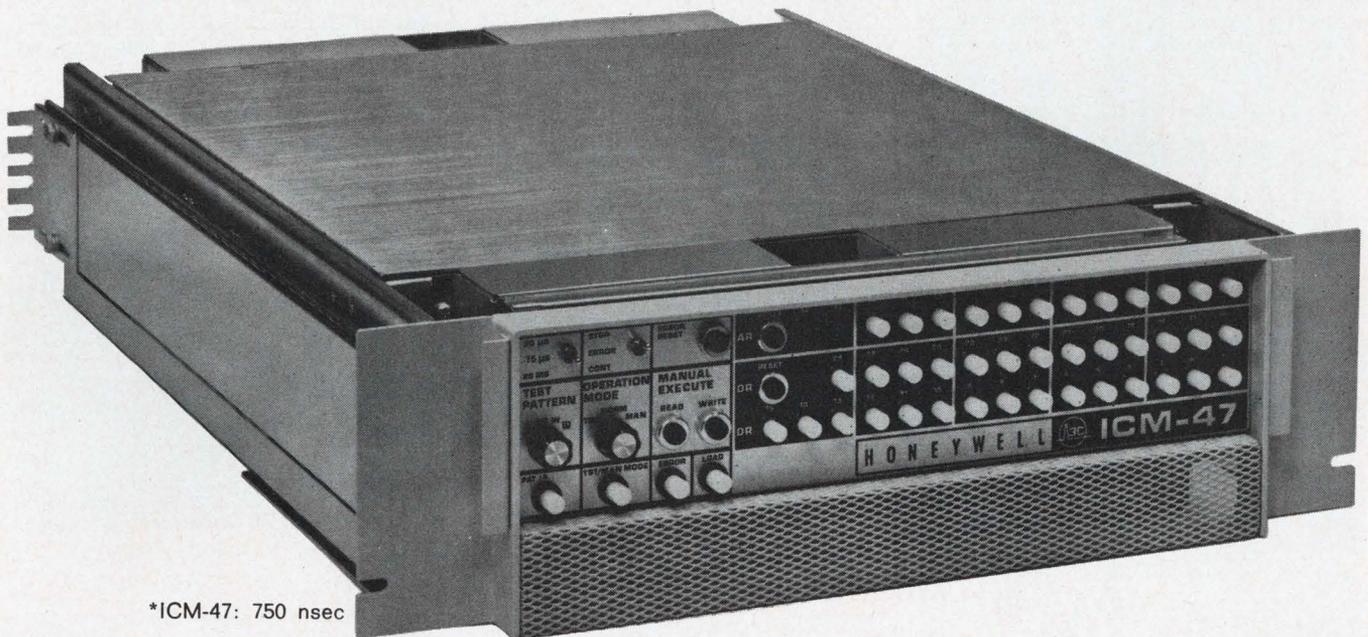
$\mu$ -STORE ICM core memories are fast, reliable, and able to store more words in less space than any other core memories on the market. They are field-proven and in high volume production . . . yet offer a flexible design which meets a wide range of system requirements.

ICM-47 — 750 nanoseconds full cycle time; capacities from 4K to 32K words in a single 5 1/4" high module (like the one shown below). ICM-40 — 1 microsecond full cycle time; capacities from 4K to 32K words. In addition, multiple module capability allows ICM's to be expanded to larger capacities. Both models feature high noise protection, data retention in case of power failure and maximum use of integrated circuits to achieve high reliability. In brief, you'll find the ICM-40 and ICM-47 designed to perform

comfortably in a wide variety of operating environments and to fit easily into almost any system requirement.

Because ICM's come from Honeywell, Computer Control Division, you know they're backed by more than eight years' experience in the design and production of standard core memories . . . and by some pretty intensive special purpose memory systems experience as well. Add to this our I/C capabilities, logic module capabilities, and digital computer capabilities, and you can be sure of dependable support in solving your core memory applications and systems design problems.

Write today! Ask for our  $\mu$ -STORE summary brochure. Honeywell, Computer Control Division, Old Connecticut Path, Framingham, Massachusetts 01701.



\*ICM-47: 750 nsec

**Honeywell**



ON READER-SERVICE CARD CIRCLE 74

# AMPERITE

## GLASS ENCLOSED Thermostatic DELAY RELAYS



Offer true hermetic sealing—

— assure maximum stability and life!

### Delays: 2 to 180 seconds

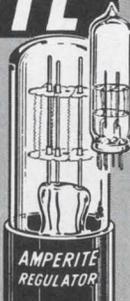
Actuated by a heater, they operate on A.C., D.C., or Pulsating Current... Being hermetically sealed, they are not affected by altitude, moisture, or climate changes... SPST only — normally open or normally closed... Compensated for ambient temperature changes from  $-55^{\circ}$  to  $+80^{\circ}\text{C}$ ... Heaters consume approximately 2 W. and may be operated continuously. The units are rugged, explosion-proof, long-lived, and inexpensive!  
TYPES: Standard Radio Octal and 9-Pin Miniature... List Price, \$4.00  
PROBLEM? Send for Bulletin No. TR-81.

# AMPERITE

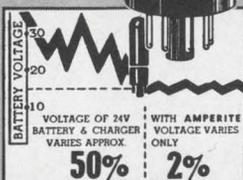
## BALLAST REGULATORS

Hermetically sealed, they are not affected by changes in altitude, ambient temperature ( $-50^{\circ}$  to  $+70^{\circ}\text{C}$ ), or humidity... Rugged, light, compact, most inexpensive.

List Price, \$3.00



Write for 4-page Technical Bulletin No. AB-51

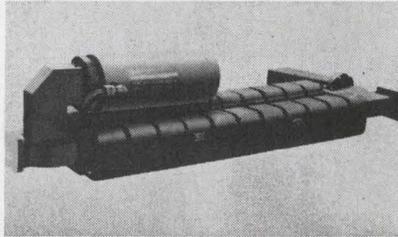


# AMPERITE

600 PALISADE AVE., UNION CITY, N.J.  
Telephone: 201 UNION 4-9503  
In Canada: Atlas Radio Corp., Ltd.,  
50 Wingold Ave., Toronto 10

## MICROWAVES

### Four-port circulator handles high power

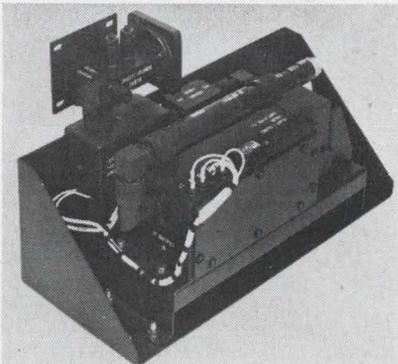


Airtron Div. of Litton Industries, 200 E. Hanover Ave., Morris Plains, N. J. Phone: (201) 539-5500. P&A: \$5000; 4 months.

Model 336180 is a liquid-cooled 4-port circulator capable of handling 20-MW peak power and 20-kW average power while maintaining insertion loss of 0.5 dB. It can also be used as an isolator by terminating the appropriate ports. Operating in the frequency range of 2.8 to 3.1 GHz, it has an isolation of 20 dB and a vswr of 1.2.

CIRCLE NO. 278

### Frequency translator for communications

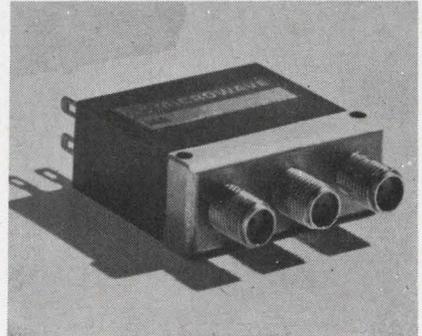


Micro State Electronics, 152 Floral, Murray Hill, N. J. Phone: (201) 464-3000.

A field-transportable mW frequency translator for communications systems converts signal inputs of 7.25 to 7.75 GHz to outputs at 400 MHz with an RF to IF gain of 50 dB and a noise figure of less than 8 dB. Intermodulations and spurious responses are at least 60 dB below the desired output level. Linear amplification is provided to signal levels as high as 9 dBm with a 1-dB bandwidth of 60 MHz min.

CIRCLE NO. 279

### Spdt coax switch weighs 1.25 ounce



Microwave Associates, Burlington, Mass. Phone: (617) 272-3000.

Spdt coaxial switches weigh in at less than 1-1/4 ounces and measure 0.75 in.<sup>3</sup>. The switch has isolation of 60 dB and vswr of typically 1.3 from dc to 12.4 GHz. Switching time is 20 ms and RF power rating is 15 W cw. Actuation is remote by 22 to 30 Vdc. Applications include channel selection in communications and radar equipment where space is limited. The units may be stacked for multichannel and matrix use.

CIRCLE NO. 280

### Solid-state sources provide 250 mW

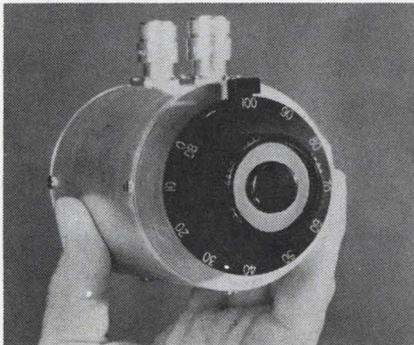


Microwave Products Group, 115 Old Country Rd., Carle Place, N. Y. Phone: (516) 741-1500.

Solid-state fundamental oscillators providing more than 250 mW output power near octave tuning ranges from 30 to 1000 MHz, feature short-term stability of  $10^{-4}$ . Spurious outputs are  $-60$  dB in-band and  $-25$  dB out-of-band. The oscillators are also available in electronically trimmable models, allowing electronic trimming over 10% of any manually tuned setting.

CIRCLE NO. 281

## Rotary attenuator uses individual pi networks

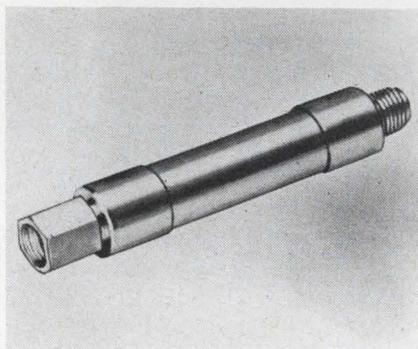


*Telonic Instruments, 60 N. First Ave., Beech Grove, Ind. Phone: (317) 787-3231. P&A: \$140; 30 to 45 days.*

Spanning 100 dB in 10-dB steps, model 8008 rotary attenuator incorporates individual attenuation pads consisting of resistive pi networks. Each pad is positioned in a rotor assembly to maintain 50- $\Omega$  transmission line characteristics throughout the attenuator. The attenuator operates over a frequency range of dc to 1000 MHz with an insertion loss of approximately 0.1 dB at 30 MHz.

CIRCLE NO. 282

## Low-pass filters offer choice of cutoff

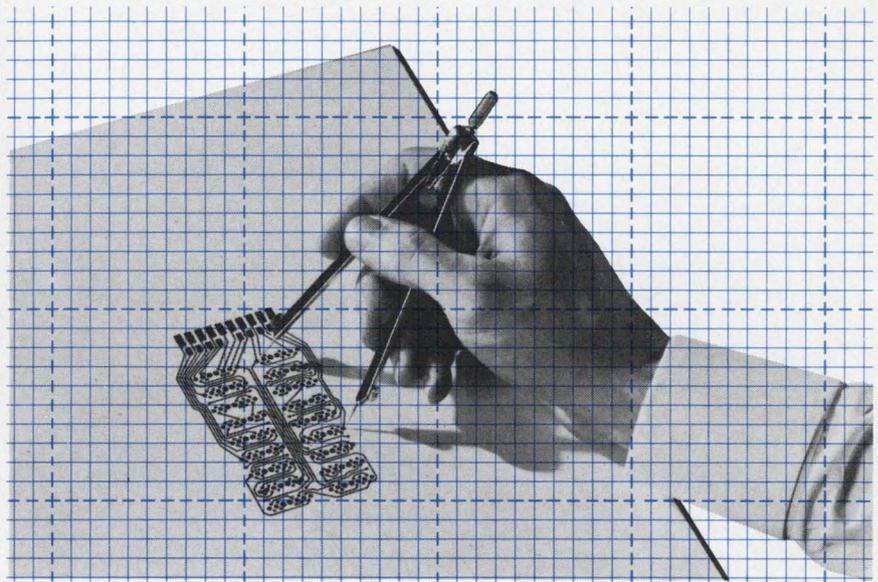


*Microlab/FXR, 10 Microlab Rd., Livingston, N. J. Phone: (201) 992-7700. P&A: \$40; stock.*

Miniaturized coax low-pass filters offer a choice of cutoff frequencies. Models designed to cut off at 3, 4, 6 and 8 GHz have a max vswr of 1.5; models with cutoff frequencies at 10 and 13 GHz have a max vswr of 1.6. All feature MFM male and female connectors.

CIRCLE NO. 283

# Shortest accurate distance between two points...



## \* ASN Grids

\*ACCURATE, STABLE, NON-REPRODUCIBLE

Too many electronic designers spend their time over-designing to compensate for inaccurate graphs and grids. Adapting. Redesigning. Erasing . . . and losing some of the grid lines. These are handicaps the CAPITOL \*ASN grid can eliminate.

Grids may resemble each other. But if your requirements call for  $\pm .0015''$  accuracy, the CAPITOL \*ASN grid is your best buy. The CAPITOL grid is available in two stable grid materials: mylar and glass. The \*ASN mylar grid is provided with either blue line or black line grids. The \*ASN glass grid in blue or black line is unmatched for extremely high accuracy. Either the fifth or the tenth line on \*ASN grids is broken to permit easier interpretation of dimensions. And the CAPITOL grid will not smear or erase.

A designer's time is too expensive to waste on inaccuracies. That's why you need CAPITOL \*ASN grids.

**FREE SAMPLES** Test the accuracy of a CAPITOL \*ASN mylar grid. Circle the reader service card number indicated below.

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SPECIAL PRODUCTS DIVISION

215 East 12 Mile Road  
Madison Heights, Mich. 48071  
Phone (313) 564-4820



ON READER-SERVICE CARD CIRCLE 76

## Hybrid computer is completely integrated



*Electronic Associates, Inc., W. Long Branch, N. J. Phone: (201) 229-1100. P&A: \$200,000-\$250,000; 6 mos.*

A completely integrated, medium-scale hybrid computing system has been designed for application in the aerospace, biomedical, process and education fields. The 690 system comprises a digital computing system, an analog hybrid computing system and a linkage system. Digitally, the system offers a 16-bit instruction and data-word plus protect bit, a protected core memory with a 32,768-word storage capacity, a 1.65-ms memory-cycle time, a repertoire of 62 instructions, multi-level interrupt capabilities and a capacity to communicate with up to 64 peripheral devices. Max I/O rate is 1.2 million 8-bit bytes per second. In the analog portion of the system, the user has at his disposal high dynamic and static accuracy, 500-kHz-bandwidth operational amplifiers, a system prewired for expansion to 156 analog amplifiers, an extensive parallel logic capability, servo-set potentiometers and low (10-volt) power requirements.

**CIRCLE NO. 284**

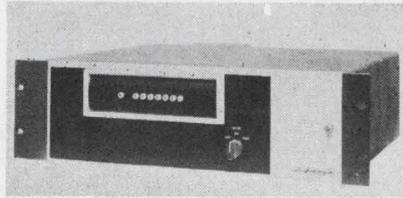
## Digital computer serves as controller

*Interdata, Inc., Farmingdale, N. J. Phone: (201) 681-3800. Price: \$6000 (Model 3); \$6700 (Education unit).*

Applications are seen in process control, real-time counting, sequence control and data acquisition for the Interdata model 3 computer. The small unit can also serve as an educational tool when fitted with a special display panel. Model 3 is a 16-bit system, among the first products of this firm.

**CIRCLE NO. 285**

## Multiplexer-converter has 667-kHz throughput

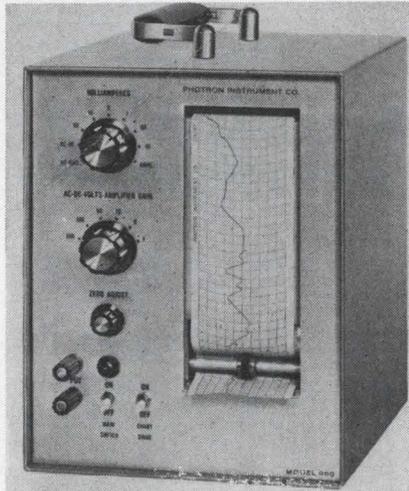


*Adage, Inc., 1079 Commonwealth Ave., Boston, Mass. Phone: (617) 783-1100. Price: \$8780.*

A multiplexer-converter with a total throughput rate of 667 kHz can digitize up to 10 channels of high-frequency data. The unit accepts up to 10 channels of analog data. Each channel is selected and its data digitized in 1.5 microseconds. Resolution is 8 bits including sign, and accuracy is 0.5% of full scale  $\pm 1/2$  least significant bit.

**CIRCLE NO. 286**

## Recording system draws voltage or current curves

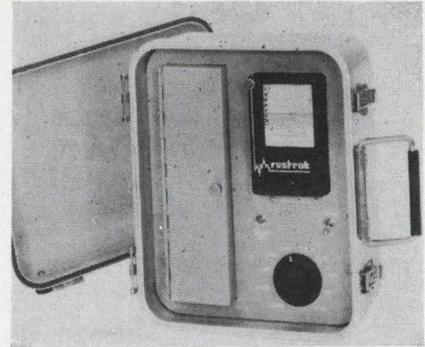


*Photron Instrument Co., 6516 Detroit Ave., Cleveland. Phone: (216) 281-7020.*

Modular construction with plug-in amplifiers and plug-in galvanometer are features of this recording system. Dual attenuator switching provides ac peak voltage, ac rms voltage, dc voltage and ac or dc current as low as 0.1 mA full scale. An independent op-amp for non-recording use is also provided; zero adjustment control permits the positioning of the writing stylus to left-hand margin or center of chart.

**CIRCLE NO. 287**

## Multirange recorder battery-powered

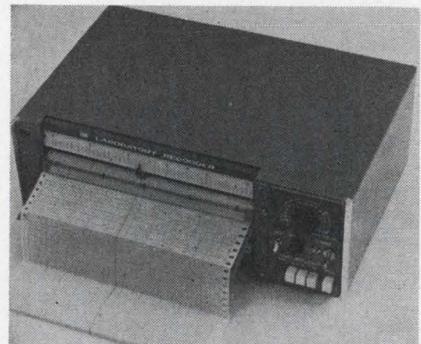


*Rustrak Instrument Co., Inc., Municipal Airport, Manchester, N. H. Phone: (603) 623-3596. P&A: \$439 (steel case), \$479 (fiberglass); stock.*

A portable, multirange dc millivolt recorder is specifically designed for use in electrolytic corrosion control surveys involving pipelines, buried cables and metallic conductors. The instrument uses an inkless, dry-writing process to record differences in potentials, correlated with time on a strip chart. The recorder provides nine ranges with zero center: 2.5 mV to 125 V.

**CIRCLE NO. 288**

## Strip chart recorders for information retrieval



*Yokogawa Electric Works, Inc. 1995 Palmer Ave., Larchmont, N. Y. Phone: (914) 834-3550.*

Solid-state, self-balancing potentiometric strip chart recorders are designed for easy scanning and information retrieval. They are supplied self-contained with up to 14 full scale ranges from 1 mV to 100 V and a wide selection of chart speeds. They are available for bench use or rack panel mounting.

**CIRCLE NO. 289**

# Heat Dissipation Bonus of Beryllia Worth An Extra Two Cents?



Coors Beryllium Oxide Ceramic offers you the bonus of 10 times the thermal conductivity of aluminum oxide ceramic—approximately the heat transfer qualities of aluminum metal. Ordinarily, beryllia is thought to be too expensive, except for designs where maximum heat dissipation is an essential. However, we find the additional cost of using beryllia in small metallized assemblies adds only a few cents to the total cost of the completed part. For an “extra two-cents worth” Coors offers a beryllia-to-metal assembly that allows you to use more power . . . or allows you even further miniaturization than with alumina . . . or gives you longer component life—or a combination of all three. When you design micro-substrate assemblies—Consider Coors Metallized Ceramics—and get the bonus of beryllia’s thermal conductivity. Write for Coors Metallizing Data Sheet 9502, or call the Coors “hot line”—303/279-4533, Ext. 351.

*consider  
Coors metallized  
ceramics*

# Coors

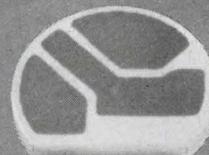
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integrated circuitry

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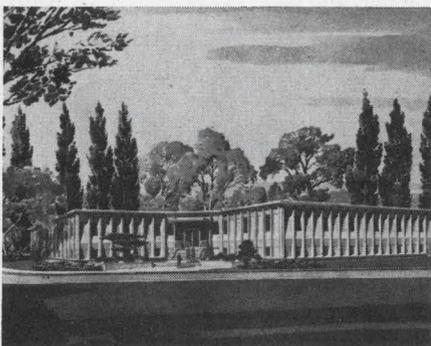
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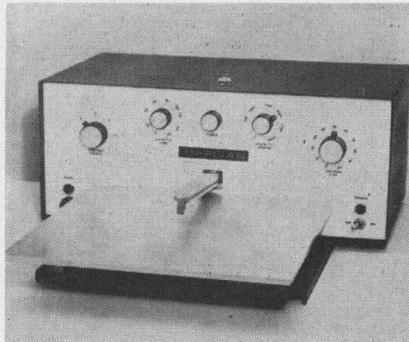
SOMERVILLE, N.J. 08876 tel. 201-722-9500

ON READER-SERVICE CARD CIRCLE 208

144

## PRODUCTION EQUIPMENT

### Reflow solderer for single and multileads

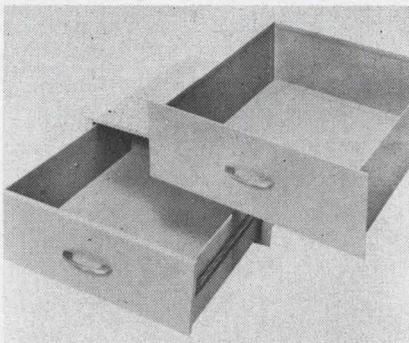


*Sippican Corp., P. O. 139, Marion, Mass. Phone: (617) 748-1160. P&A: under \$900; 8 wks.*

Model 333 permits rapid, simple joining of a variety of materials in a wide range of thicknesses. Using the built-in multiple lead fixture, IC and standard component leads can be soldered to PC and other types of boards. Memory plane terminations and wiring/connector assemblies can also be soldered via the reflow process. The single lead fixture simplifies fine-joining operations in hard-to-get-at assemblies.

CIRCLE NO. 290

### Rack-mount drawers available 60 sizes

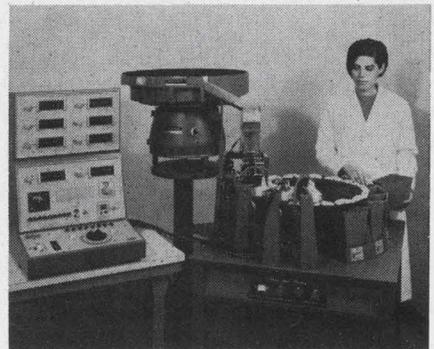


*Zero Manufacturing Co., 1121 Chestnut St., Burbank, Calif. Phone: (213) 849-5521.*

Rack-mounted storage and utility drawers in 19- or 24-inch panel widths fit panel spaces 3-1/2 through 10-1/2-inches in 1-3/4-inch increments per MIL-STD-189. The storage drawer and RFI-shielded utility drawer are formed and welded of 16-gauge cold-rolled steel. The panel frame of the RFI-shielded drawer provides a seal against cabinet rails and divider bars.

CIRCLE NO. 291

### Diodes classified 10,000 per hour



*Teradyne, Inc., 183 Essex St., Boston. Phone: (617) 426-6560. P&A: \$11,200; 90 days.*

D200 diode classifiers will completely classify 10,000 diodes per hour. The two tests of final inspection can be made at 20,000 diodes per hour. The units perform the standard dc forward voltage, reverse current and PIV tests, identify shorts or opens and the polarity of diodes, and permit loading in either polarity. Programming is done at a single switch register on the front panel. Any test may be performed at any position in any sequence of from four to fourteen tests. A front-panel, pin-board matrix translates test results into bin decisions.

CIRCLE NO. 292

### Lead bonder handles cans, flatpacks

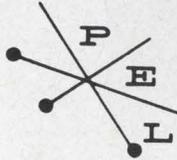
*Hugle Industries, 587 N. Mathilda Ave., Sunnyvale, Calif. Phone: (408) 738-1700.*

An ultrasonic lead bonder handles as many as 600 flatbacks per day with 14 leads of two bonds each. The bonder has an automatic bonding cycle and features two separate channels for post and chip bonding. The 20-W ultrasonic generator and transducer has a temperature-compensated feedback network for operational stability. Model 1200 handles TO-5 and TO-18 packages, with flatpack chucks available.

CIRCLE NO. 293

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# Still the best YIG Filters available



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ON READER-SERVICE CARD CIRCLE 78

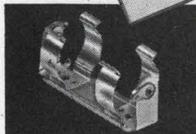
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**GUIDE TO**  
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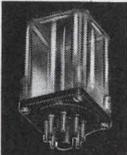
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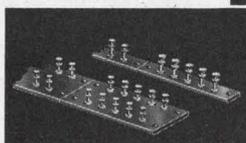
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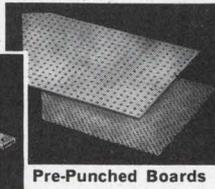
Battery Holders



Plug-in Housings



Terminal Boards



Pre-Punched Boards

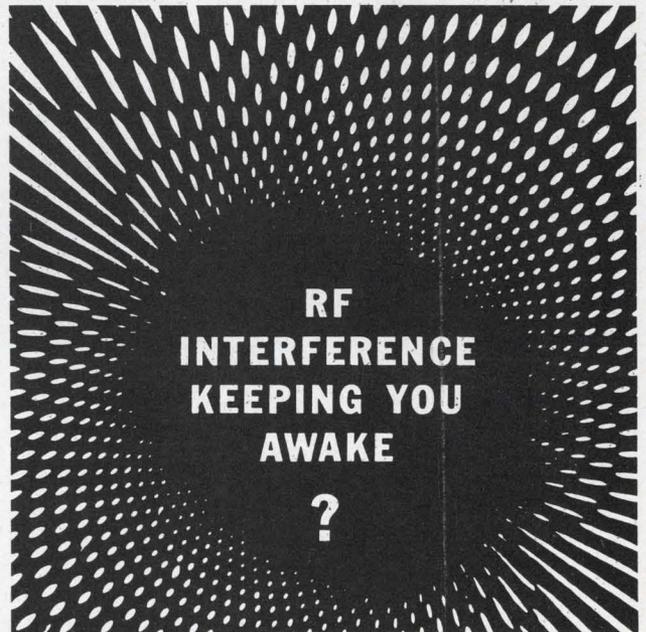


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ON READER-SERVICE CARD CIRCLE 79

ELECTRONIC DESIGN 5, March 1, 1967



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ON READER-SERVICE CARD CIRCLE 80

# Design Aids

**Mathematical Handbook**

An Aid to Every Day Figuring Problems, Tables, Formulas, Arithmetical Rules

## Mathematical handbook

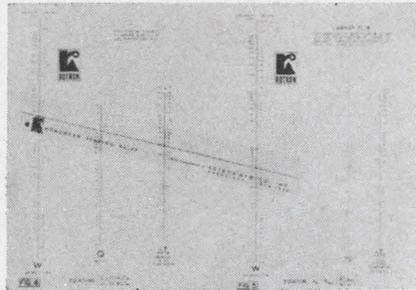
Sixty-four pages of formulas and rules in a pocket-sized handbook are a valuable aid to calculations. The handbook contains powers and roots, logarithms, decimal equivalents, mensuration formulas, weights and measures and conversion factors. Also included are business formulas such as profit and loss, markup, discount, simple and compound interest tables, etc. In addition, general arithmetic rules and formulas are found in this handy manual. Curta Co.

CIRCLE NO. 294

## RF choke and coil selection

A 6-page guide to coil selection contains a 10-point check list of primary considerations for selecting inductors. Descriptions of major types of windings and the advantages of each help the designer when choosing from several coils having the same inductance but different winding configurations. A nomogram which determines effective series resistance for various Q factors is included. General recommendations are given for cores, forms, and wire types for low- (10 to 100 kHz), medium- (100 kHz to 3 MHz), and high-frequency (3 to 300 MHz) use. J. W. Miller Co.

CIRCLE NO. 295



## Heat flow nomograms

A series of 3 charts and 3 nomograms completely determine high-altitude air-cooling problems. The nomograms relate the heat capacity of air, weightflow changes under laminar flow and weightflow to volume flow. A translucent nomogram reading rule is included for convenience. Rotron Mfg. Co.

CIRCLE NO. 296

**Temperature Conversion Table**

SCHWEBER ELECTRONICS

## Temperature conversion

Can't remember those °C to °F conversion formulas? This handy conversion table covers -70 to 200°C and includes interpolation factors. Conversions are possible at a glance. Schweber Electronics.

CIRCLE NO. 297

**BALDWIN**

**Shaft Position Encoders**  
Using the World's Most Accurate Disks

DECIMAL	BINARY	ANGLE	
1	2 <sup>2</sup>	360	DEG.
2	2 <sup>1</sup>	180	
4	2 <sup>2</sup>	90	
8	2 <sup>3</sup>	45	
16	2 <sup>4</sup>	22.5	
32	2 <sup>5</sup>	11.25	
64	2 <sup>6</sup>	5.625	
128	2 <sup>7</sup>	2.8125	
256	2 <sup>8</sup>	1.40625	
512	2 <sup>9</sup>	42.1875	MIN.
1,024	2 <sup>10</sup>	21.0938	
2,048	2 <sup>11</sup>	10.5469	
4,096	2 <sup>12</sup>	5.27344	
8,192	2 <sup>13</sup>	2.63672	
16,384	2 <sup>14</sup>	1.31836	
32,768	2 <sup>15</sup>	39.5508	SEC.
65,536	2 <sup>16</sup>	19.7754	
131,072	2 <sup>17</sup>	9.88770	
262,144	2 <sup>18</sup>	4.94385	
524,288	2 <sup>19</sup>	2.47192	
1,048,576	2 <sup>20</sup>	1.23596	
2,097,152	2 <sup>21</sup>	0.617981	
4,194,304	2 <sup>22</sup>	0.308990	
8,388,608	2 <sup>23</sup>	0.154495	
16,777,216	2 <sup>24</sup>	0.077248	

## Position resolution converter

A pocket-sized plastic chart provides a means of converting decimal shaft angle readings into either binary or radial degrees. The chart extends to 2<sup>24</sup>. Baldwin Electronics, Inc.

CIRCLE NO. 298

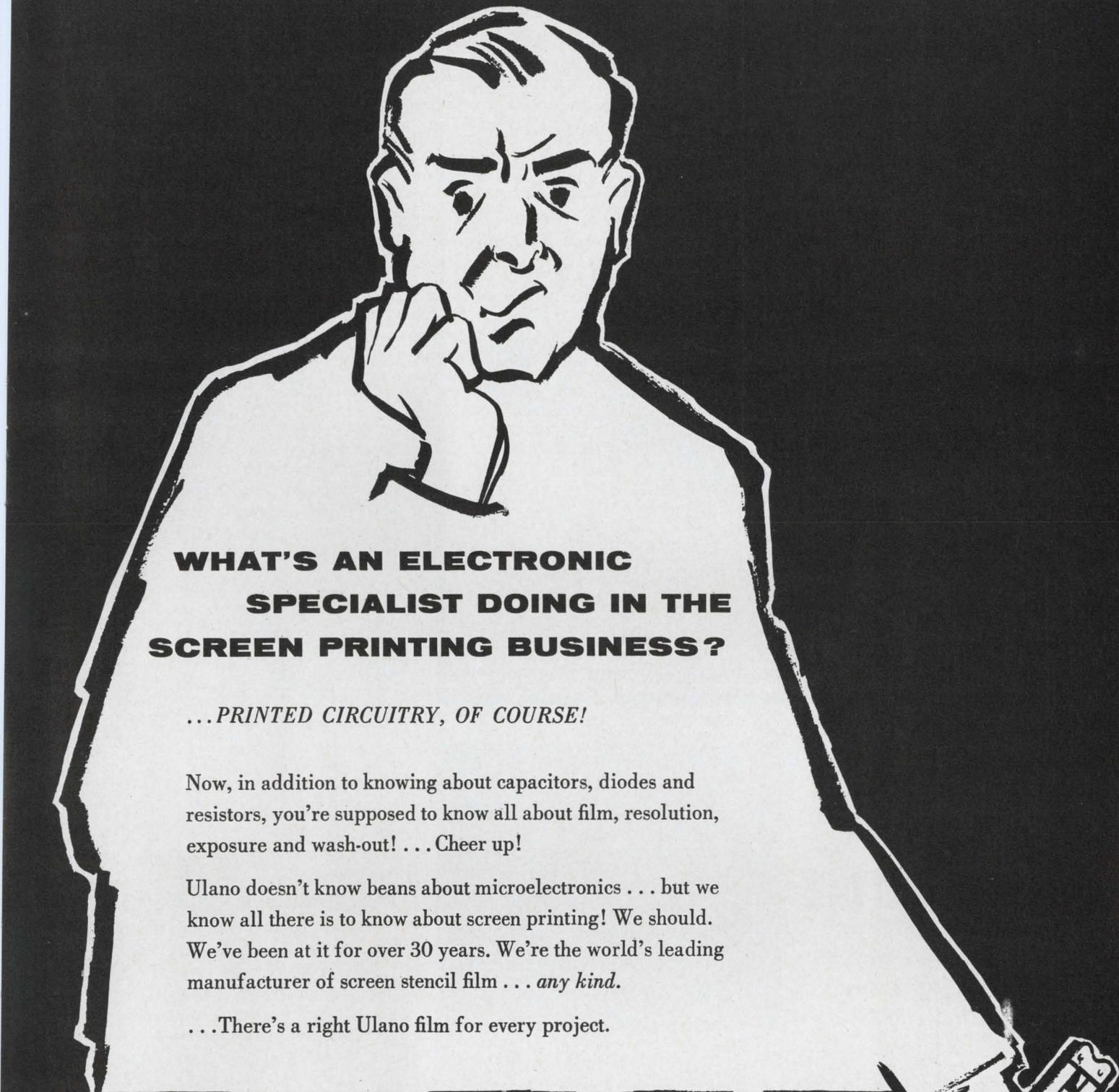


## Steel machining slide rule

Estimate surface or turning speed, feed rate, spindle speed, cycle time and production rate for over 20 stainless steels with this slide chart. The stainless grade is set at an arrow and surface speeds and feeds for 8 machining operations are read at windows. A slide on the other side converts surface speed to spindle speed for rounds and hexagons from 0.03 to 8 inches in diameter. A third slide converts cycle time to production in parts per hour at any efficiency from 30 to 100%. Carpenter Steel Co.

CIRCLE NO. 299

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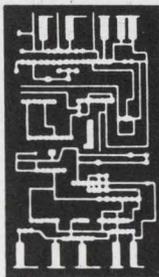
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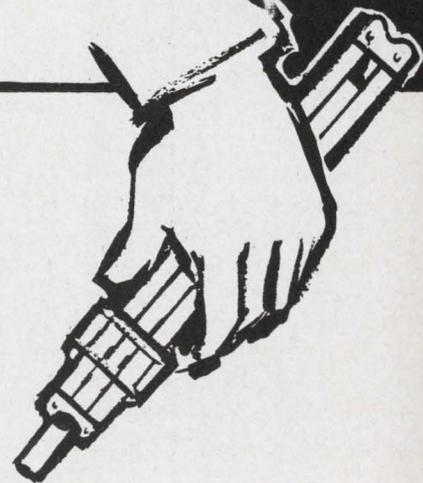
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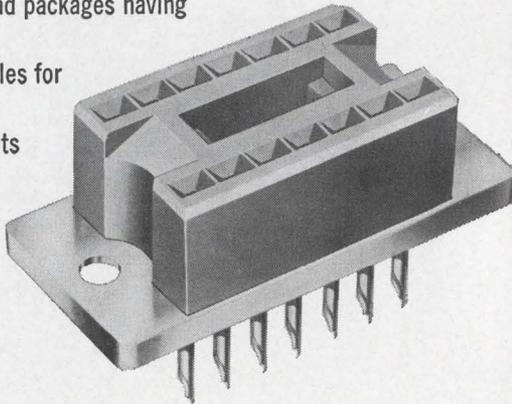


# DUAL-IN-LINE SOCKETS

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LOW COST • HIGH PERFORMANCE • WIDE APPLICATION

- Sockets for 14 and 16 lead packages having flat or round leads
- Large contoured entry holes for easy IC insertion
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ON READER-SERVICE CARD CIRCLE 82

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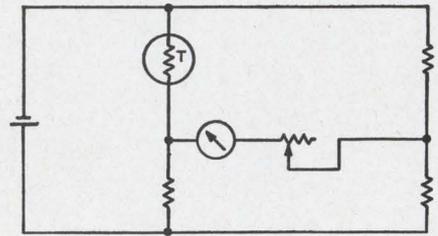


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**WABASH HYDRAULIC PRESS DIV.**  
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ON READER-SERVICE CARD CIRCLE 83

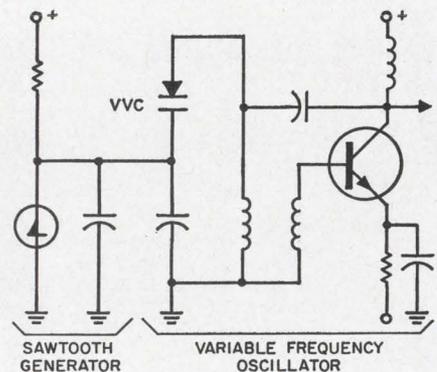
# Application Notes



## Temperature readout

Methods of designing linear temperature readout circuits using thermistors are outlined in five pages of text and schematics. Formulas for selection of input voltage and the meter circuit are included; both short-cut and precision methods are provided. Fenwal Electronics, Inc.

CIRCLE NO. 311



## Voltage-variable capacitors

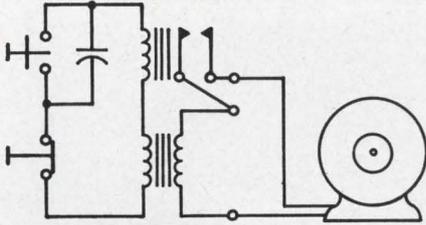
Seven pages of schematics and explanatory material describe applications of variable voltage capacitors to sweep oscillators (shown above), electronically controlled delay lines, remote-controlled tuned circuits, and telemetry and communications FM circuits. Eastron Corp.

CIRCLE NO. 312

## Tuned RF for testing

Applications of a 4.5-W tuned amplifier in the 10-to-500-MHz range to the testing and calibration of receivers and instruments is the subject of a 10-page brochure. Formulas and block diagrams deal with testing of RF receivers, RFI testing, antenna measurements and calibration of RF voltmeters and wattmeters. Hewlett-Packard.

CIRCLE NO. 313



### Isolation relays

A vest-pocket folded sheet gives 28 applications of a step-down isolated transformer and sensitive relay on a common laminated core. Manual switching of 110-V loads is done at a safe low voltage. The circuits supplied can trigger lamps, bells, tape recorders and other devices by means of light, heat, magnetic and other sources, including door keys. Many other applications suggest themselves. Alco Electronic Products, Inc.

CIRCLE NO. 314

### Fans and blowers

Three loose-leaf sheets are devoted to acquainting the electronic designer with the problems of airflow encountered in cooling electronic equipment. Charts and explanatory text facilitate selection of the proper fan or blower. Rotron Manufacturing Corp.

CIRCLE NO. 315

### Program controllers

A discussion of program controllers covers digital programs, optical line followers, long and short programs, curve integration and recorder controllers. Diagrams and text occupy three pages; two more list the manufacturer's sales offices. Hewlett-Packard/Moseley Div.

CIRCLE NO. 316

### Bonding materials

The problems of bonding metals together are discussed in two pages, covering surface preparations, treatment and safety precautions. Various metals, inorganic compounds and plastics are dealt with, and the grade of adhesive indicated. Dielectric Materials Division, Emerson & Cuming, Inc.

CIRCLE NO. 317

# Ceramic Capacitors

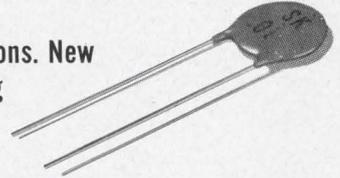
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for computer applications. The ultimate in reliability (failure rate 0.001%/1000 hours at 85° C and twice rated voltage.)



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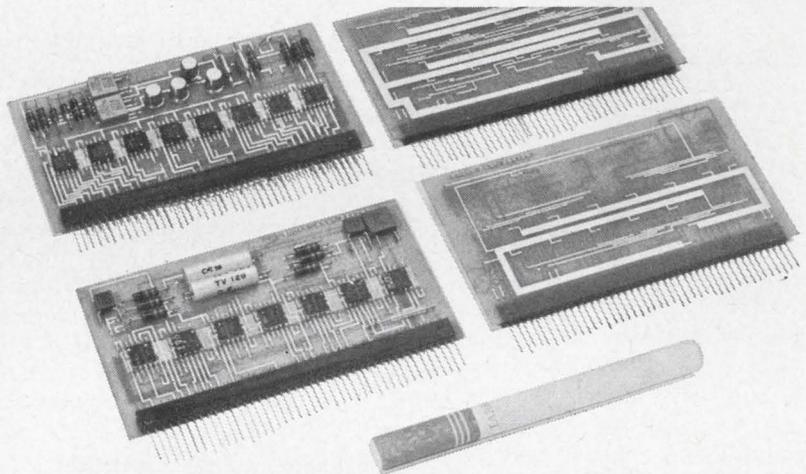


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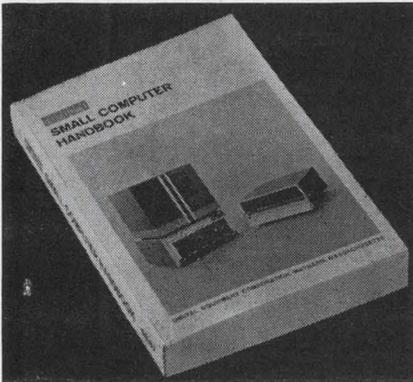


Advanced Instrumentation  
Outer Space to  
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ON READER-SERVICE CARD CIRCLE 85

# New Literature



## 544-page computer book

A 544-page handbook is devoted to the use of small computers. The first 43 pages present in primer form the organization of the computer, the fundamentals of programming, and procedures for feeding data into the computer. The remainder of the book describes a family of machines with the same word length, instructions and programs. Digital Equipment Corp.

CIRCLE NO. 318

## Delay line waveforms

A new engineering bulletin describes magnetostrictive delay line waveforms for various modes of operation. The 2-color brochure illustrates the waveforms for delay lines in the return-to-zero, non-return-to-zero and bipolar modes of operation and discusses the features and applications of each as a guide to the designer. Included are indications of pulse width, polarity and input and output characteristics for the various lines. Sealectro Corp.

CIRCLE NO. 319

## New products supplement

A 48-page supplement to the company's 1967 catalog of electronics components for industry combines the presentation of new products with the latest directory of integrated circuits and semiconductors. The integrated circuit directory quotes current prices on purchases in various quantities of devices from leading manufacturers. Allied Electronics Corp.

CIRCLE NO. 320

## Connector catalog

A 40-page catalog is available on the product line of K circular connectors, which includes complete product information, specifications, and ordering instructions for the connectors. The data include a wide variety of cable- and panel-mounting connectors, with contact arrangements, and accessories. ITT Cannon Electric.

CIRCLE NO. 321

## Precision counters

A 4-page file folder describes electrically operated displays, time and events indicators, navigational counters and custom display assemblies. Reversing angle, decimal, internal pinion, variation, and external pinion counters are discussed and illustrated. Discussion includes applications, variations, and performance specifications. Bowmar Instrument Corp.

CIRCLE NO. 322

## Semiconductor chemistry

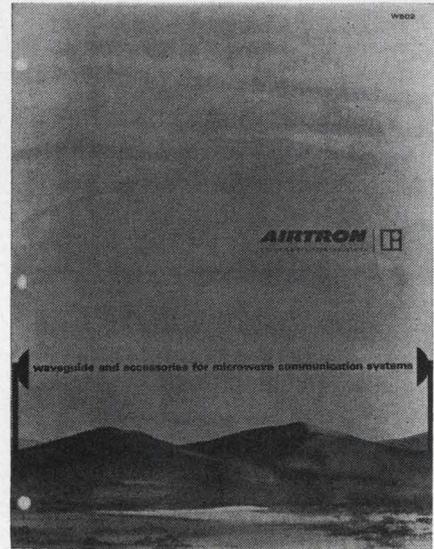
This brochure includes 13 pages of product descriptions and useful technical data pertaining to semiconductor surface stabilization, difusants for pn semiconductor junctions, protective coatings and bonding agents. Electroless nickel, special gold alloy plating solutions, metallization of ceramic materials and high Q dielectric coatings are also discussed. Transene Co., Inc.

CIRCLE NO. 323

## PCM telemetry assembly

A 16-page brochure details step by step how to assemble a pulse code modulation (PCM) telemetry system to meet any specifications. The system designer can select the proper circuit modules from 21 basic types to put together a PCM system that will handle any combination of analog and digital inputs needed. Using the same instructions, the system can be expanded or modified by simple point-to-point wiring changes. Electro-Mechanical Research, Inc.

CIRCLE NO. 324



## Waveguide data

All the components required for a microwave communication waveguide system, from radio equipment output to antenna feed, are described in a 16-page brochure. Component application, complete specifications and detailed ordering information are included. Airtron, Div. of Litton Industries.

CIRCLE NO. 325

## Power distribution

A six-page data sheet describes in detail the function, operation, application and typical specifications of seven commonly used power distribution welded-circuit modules. Included are dc shunt regulators, dc series regulators, dc to ac inverters, voltage and current monitors and limiters, constant current sources, ac to dc converters, and voltage and current indicators. Radix, Inc.

CIRCLE NO. 326

## How to cool it

Design of air circuitry for cooling electronic packages and cabinets is treated comprehensively in a 12-page brochure. Formulas, tables and illustrations showing air-flow directions illustrate the text. Forced-air cooling and heating to stabilize component temperature are also discussed. McLean Engineering Laboratories.

CIRCLE NO. 327

# NEW

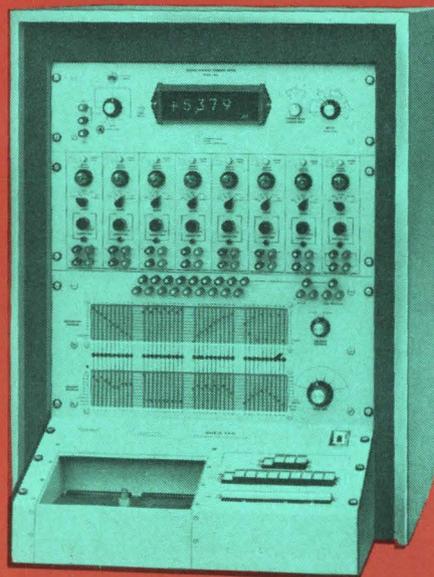
## semi-automatic integrated circuit analyzer

### MICA-150

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Now the integrated circuit user can get all the flexibility and performance of an expensive, large scale IC test system in an accurate and reliable DC bench top analyzer.

**The new MICA-150 Modular Integrated Circuit Analyzer** tests all IC configurations of up to 40 pins with unique programming, fast pushbutton sequencing and built-in DVM readout.

**Fast, Versatile Programming** Two independent 10x40 crossbar switches and rapid pushbutton sequencing provide up to 40 tests on a single device without re-programming. For example, it's now quick and easy to check a 10 pin device using four completely different test programs without resetting any switches to advance the test from pin-to-pin or program-to-program. Additional flexibility allows the built-in DVM to measure current on one pin of the device and voltage on another—all pre-programmed.

**Universal Test Adapters** Through use of universal test adapters, the MICA-150 is designed to check ICs according to the number of pins of a particular package, not device or circuit type. Adapters are available for diode, transistor, TO-5, flat-pack, dual in-line and other package configurations, and can also be provided for Kelvin connections.

**Accurate Digital Readout** Specifically designed for the MICA-150 analyzer, the built-in Digital Volt/Ammeter has a conservatively rated readout accuracy of 0.1% with a four digit display. Other features include automatic ranging and polarity selection, self-calibration, automatic voltage or current readout selection. Measures currents as low as 1 nanoamp, voltages to 1 mv.

**Modular Design** Modular construction allows users to select an economical, customized tester without obsolescence problems. Maximum capacity of eight function generators permits later expansion, including modules for AC and pulse testing, without additional modifications.

**Variable Soak Time** Marginal device operation can be easily detected through use of an adjustable test time control which provides a period for thermal stabilization prior to measurement. A continuous position on the control allows parameters to be varied while observing results.

**Precision, Wide Range Power Supplies** Highly precise supplies utilize multi-turn calibrated potentiometer controls with high resolution and repeatability. Constant current supplies are continuously variable from 0-100 ma with voltage compliance adjustable to 100v. Constant voltage supplies are variable from 0-100v with automatic current limiting to 100 ma to provide device protection.

#### QUICK ACTION REPLY

Detailed technical literature on the MICA-150 will be mailed immediately upon receipt of this request.

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Name \_\_\_\_\_

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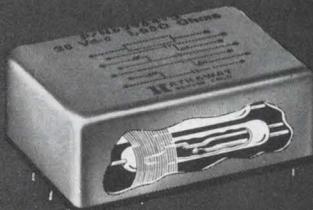
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NEW LITERATURE

**Counter design**

Basic counter design information, covered in an 8-page illustrated brochure, includes counter capability, applications, modular design, logic implementation, input-output, specifications and ordering information. Data Technology, Inc.

CIRCLE NO. 328

**Digital readout**

A line of "optimum contrast" illuminated digital readouts is discussed in a 10-page brochure with photos. Included is a presentation of the operating principles of the seven-segmented bar readout, and a chart of the readout display. Wagner Electric Corp.

CIRCLE NO. 329

**128-page microwave catalog**

A 128-page catalog gives product information and engineering data on antennas. Microwave, uhf, vhf and telemetry antennas, flexible coax cables and elliptical waveguides, switching and pressurization equipment and system accessories such as radomes, positioners and telescoping masts are included. Andrew Corp.

CIRCLE NO. 330

**Bidirectional counters**

A 2-page bulletin describes a line of high-speed 100,000-Hz bidirectional counters, designed to measure dimension, travel or position along one or two axes of motion. Included are application and operating data, and a description of the six single- and double-axis models available. Modular Instrument.

CIRCLE NO. 331

**Environmental data**

Details and operating data on such equipment as full-range temperature-humidity chambers, refrigerated test chambers, air-cooled temperature-humidity cabinets and life-test ovens are given in a 16-page brochure. All use a saturable reactor proportioning control, and a full description of the design and operation of this device is included. Blue M Electric Co.

CIRCLE NO. 332

**Precious metal selection**

An 18-page illustrated booklet, "Characteristics of Precious Metal Electrodeposits for Industrial Uses," is available. The booklet aims to aid in the selection of the correct precious metal for a particular application, and in selecting the most economical metal to meet particular requirements. Metals included are platinum, palladium, rhodium, ruthenium, iridium, osmium, gold and silver. Charts illustrate density, melting point, coefficient of thermal expansion, resistivity, reflectivity and annealed hardness. The International Nickel Co., Inc.

CIRCLE NO. 333

**Instrumentation**

A 16-page condensed catalog describing a test instrument line is divided for convenience into four sections: semiconductor test systems, digital voltmeters, oscilloscopes and components. Test equipment for PCs, ICs and differential op-amps are covered. Fairchild Instrumentation.

CIRCLE NO. 334

**Rotating components**

A 4-page file folder describes servo motors, motor tachometers, stepper motors, synchros, 2-speed gear-changers, gear heads and speed reducers. Dimensions and performance information are given. Bowmar Instrument Corp.

CIRCLE NO. 335

**Microswitches**

A 9-page booklet describes applications of mercury switches in industry. Printed in a two-color, 5-1/2-x-8-in. format the booklet lists a range of sizes, electrical capacities and operating characteristics. Honeywell.

CIRCLE NO. 336

**Vane axial blowers**

Small vane axial blowers, with diameters of the order of 1.5 in., are treated on two sides of a loose-leaf data sheet. Specs, curves and mechanical dimensions are provided. Eastern Air Devices.

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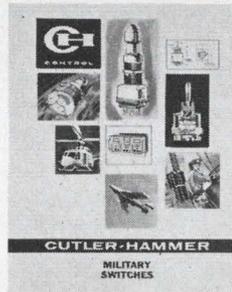
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ELECTRONIC DESIGN 5, March 1, 1967

# What do we know about switches and military relays?

## We wrote the "books"!

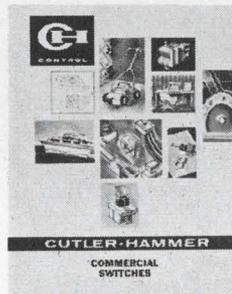
Free: Three new catalogs from Cutler-Hammer—the company with the most versatile line of switches and relays in the industry! Order the ones you want!



### Military Switches

Here is complete descriptive data on the Cutler-Hammer switch line, designed especially for military applications—everything from push-buttons to "Positive Action" switches (nearly everything that flies uses Cutler-Hammer "Positive Action" switches!)

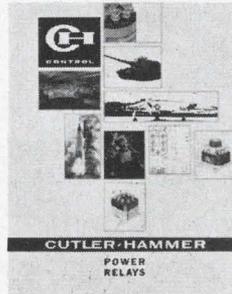
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### Commercial Specialty Switches

New 36-page catalog is filled with detailed information on hundreds of switches for every application . . . appliances . . . power and hand tools . . . photo equipment . . . business machines . . . you name it! Truly a buyer's guide for quality switches.

Reader Service No. 101



### Power Relays

Here is the book on performance-tested relays designed for electrical control on aircraft, space vehicles, ordnance, and ground-support equipment. Contains illustrative photos, engineering data, drawings and ratings on our full line of military power relays. A must!

Reader Service No. 102



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# 10 milliwatts

# 10 AMPS

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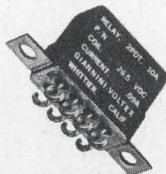


with a self-contained amplifier, has SPST, SPDT, DPST or DPDT outputs to fit your circuit requirements. This miniature package is available with a variety of mounting and terminal configurations compatible with Aerospace requirements. The weight but 1.6 ozs. Dimensions: 1.025" x 1.025" .935".



If you are looking for an extremely *small, lightweight, reliable* 10 Amp relay, but don't need the low input characteristics, consider this versatile series:

**G12 SERIES MODULAR RELAY.** Basically the same as the G15, but without amplifier. Can be supplied as two SPDT relays in the same enclosure, with the same or different coil characteristics.



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## NEW LITERATURE

### High-temp insulation

Insulation material and sleeving designed to withstand high temperatures are covered in twelve illustrated pages. Fiberglass coated with silicone rubber, vinyl and other media are described, and samples of sleeving are included. Bentley-Harris Mfg. Co.

CIRCLE NO. 338

### PC interconnection

Perpendicular or parallel stacking of PC boards is facilitated by a system of posts and receptacles with a selection of contact spacings. The modular interconnecting system and components are described in 8 pages of photos, diagrams and explanatory material. Amp, Inc.

CIRCLE NO. 339

### Thermal switches

Low-cost, miniature thermal switches have been summarized in a new 4-page illustrated folder. Included are operational drawings and descriptions, complete design drawings and dimensions on termination and mountings available from stock, and electrical and thermal ratings. Elmwood Sensors, Inc.

CIRCLE NO. 340

### Power supplies

An 8-page catalog listing more than 250 electronic instruments and components presents specifications, applications and prices for power modules, current indicators and integrators, signal conditioning equipment, pulse filters and related equipment. Elcor Div. of Halliburton Co.

CIRCLE NO. 341

### Instruments for rent

A 16-page instrument rental catalog gives the monthly rates and ordering information for more than 13,000 electronic, industrial and electrical instruments of every make and kind available to industry through rentals by General Electric's Schenectady Instrumentation Service (S.I.S.). The catalog also outlines the calibration, repair and measurement services offered. General Electric Co.

CIRCLE NO. 342

### Silicon rectifier data

A 44-page catalog is available on an entire silicon line which includes diode, power rectifier, high voltage rectifier tube, octal base and encapsulated assemblies. The diodes use a diffusion process that takes full advantage of the avalanche characteristics inherent in silicon. Syntron.

CIRCLE NO. 343

### Temperature controls

This brochure gives description and photos of temperature and pressure controllers, indicators and recorders for a range of applications in industrial plants. The 16 pages cover units from small solid-state thermometers to systems for controlling 5-kW furnaces. West Instrument Corp.

CIRCLE NO. 344

### Stepping relays

Electrical and mechanical specs, curves and dimensional drawings are available in a 16-page catalog on linear dc solenoids. Included are single- and two-coil, single-coil push, and adjustable-stroke models, with force ratings from 0.4 oz to 60 lbs. IMC Co.

CIRCLE NO. 345

### New EIA standards

The EIA has published four new recommended standards: RS 328, Message facsimile equipment for operation on switched voice facilities using data communications terminal equipment; RS 329, Minimum standards for land-mobile communication antennas. Part I—base or fixed station antennas; RD 330, Electrical performance standards for closed-circuit television camera 525/60 interlaced 2:1; and RS 331, Polarization of stereophonic headphones with 3-contact plugs.

Available for \$0.50, \$2, \$1.20 and \$0.50 respectively, from Electronic Industries Association, 2001 Eye St. NW, Washington, D. C.

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## Panel design data

Panel designs using lighted and unlighted push buttons and indicators, switch display matrices, toggle switches and panel meters are described in 12 pages of full-color photos and text. Micro Switch, Div. of Honeywell.

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.

*ICs end the driver gap* (No. 347)  
*General engineering memo #15* (No. 348)

*Achieving high performance in vhf uhf tuned amplifiers* (No. 349)

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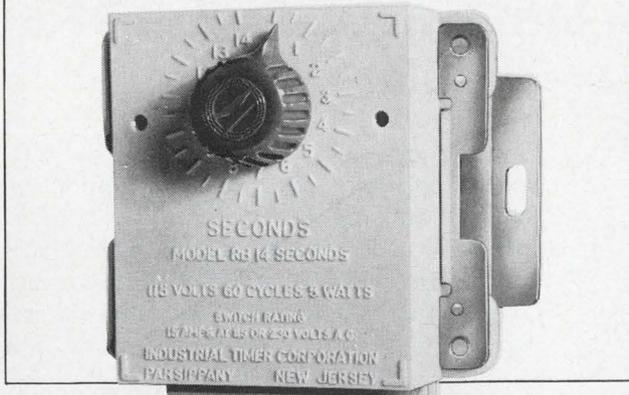
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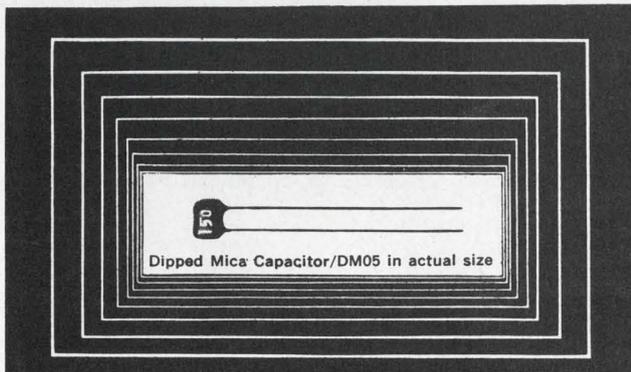


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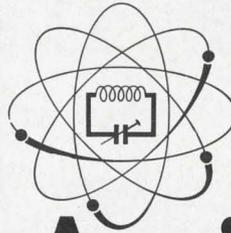
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DM 15 (C.M05)	2000	1200	510	13.0	11.0	6.5	12.5	10.5	6.0	12.0	10.0	5.5
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S	M	T	W	T	F	S	S	M	T	W	T	F	S
			1	2	3	4							1
5	6	7	8	9	10	11	2	3	4	5	6	7	8
12	13	14	15	16	17	18	9	10	11	12	13	14	15
19	20	21	22	23	24	25	16	17	18	19	20	21	22
26	27	28	29	30	31		23	24	25	26	27	28	29

For further information on meetings, use Reader Service card.

## Mar. 20-23

IEEE International Convention (New York City) Sponsor: IEEE; The IEEE, 345 E. 47 St., New York, N. Y. 10017

CIRCLE NO. 353

## Mar. 22-24

International Symposium on Modern Optics (New York City) Sponsor: Polytechnic Institute of Brooklyn, AFOSR, NOR; Symposium Committee, Polytechnic Institute of Brooklyn, 333 Jay St., Brooklyn, N. Y. 11201

## Mar. 29-31

Symposium on Microwave Power (Stanford, Calif.) Sponsor: IMPI; Dr. Donald Dunn, IMPI, P. O. Box 2335, Stanford, Calif. 94305

CIRCLE NO. 354

CIRCLE NO. 355

## Apr. 5-10

International Exhibition of Electronic Components (Paris) Sponsors: Five specialized French professional societies under patronage of the Fédération Nationale des Industries Electroniques (EIA of France); J. Amiel, Air France, 1350 Sixth Ave., New York, N. Y. 10019.

CIRCLE NO. 350

## Apr. 10-15

International Conference on Electronics and Space (Paris) Sponsor: Two specialized French professional societies under patronage of the Fédération Nationale des Industries Electroniques (EIA of France); J. Amiel, Air France, 1350 Sixth Ave., New York, N. Y. 10019.

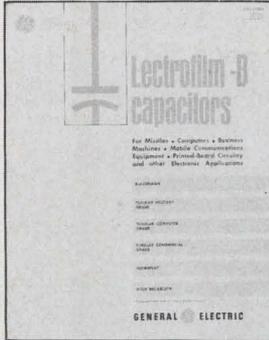
CIRCLE NO. 351

## Apr. 14-21

Mesucora 67 (International Exhibition and Congress on Measuring and Test Equipment and Automation) and Physics Exhibition (Paris) Sponsor: Société Française de Physique (French Physics Society); J. Amiel, Air France, 1350 Sixth Ave., New York, N. Y. 10019.

CIRCLE NO. 352

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# 172

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# 174

## Fairchild Semiconductor Integrated Circuits

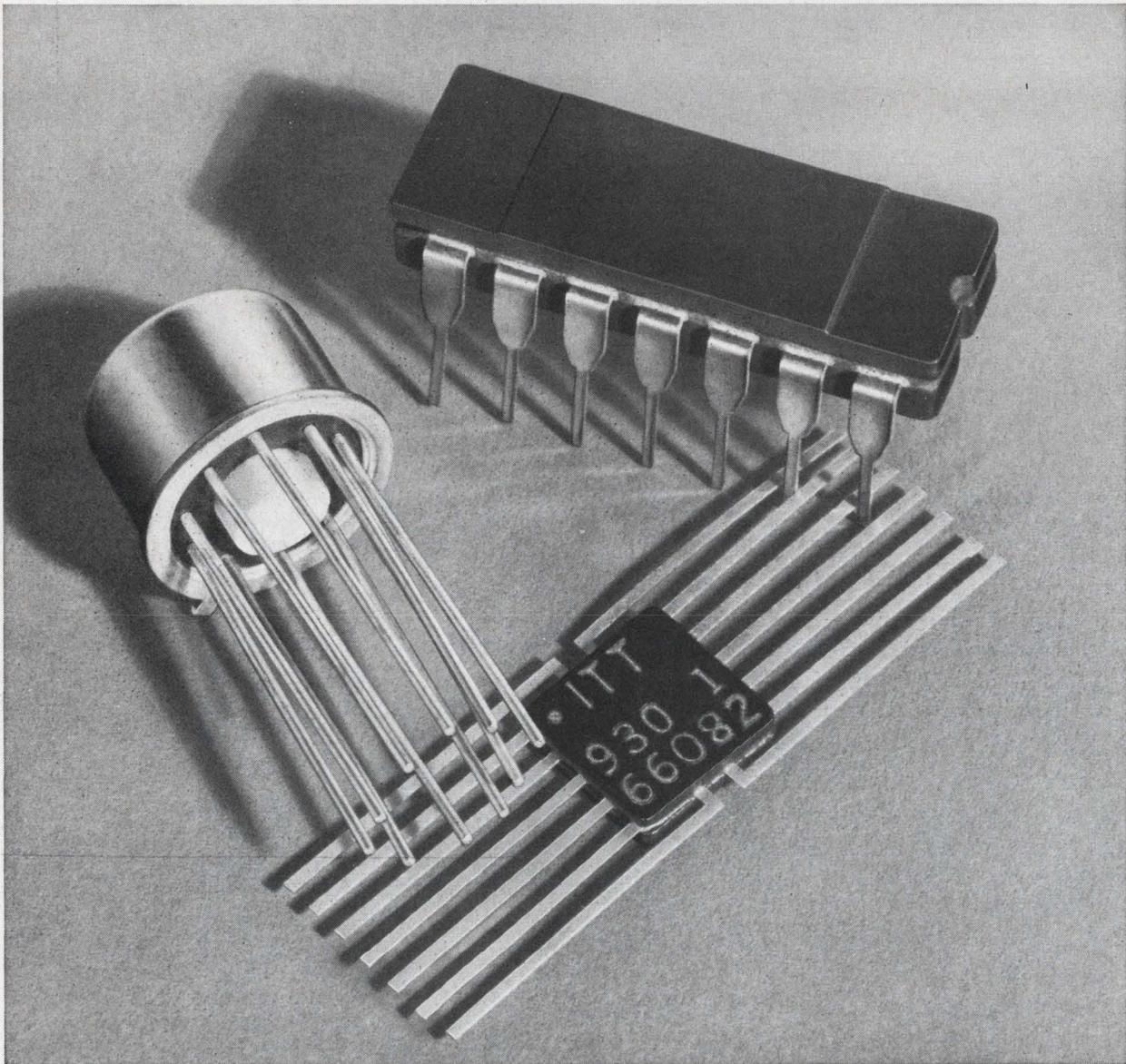


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# 176

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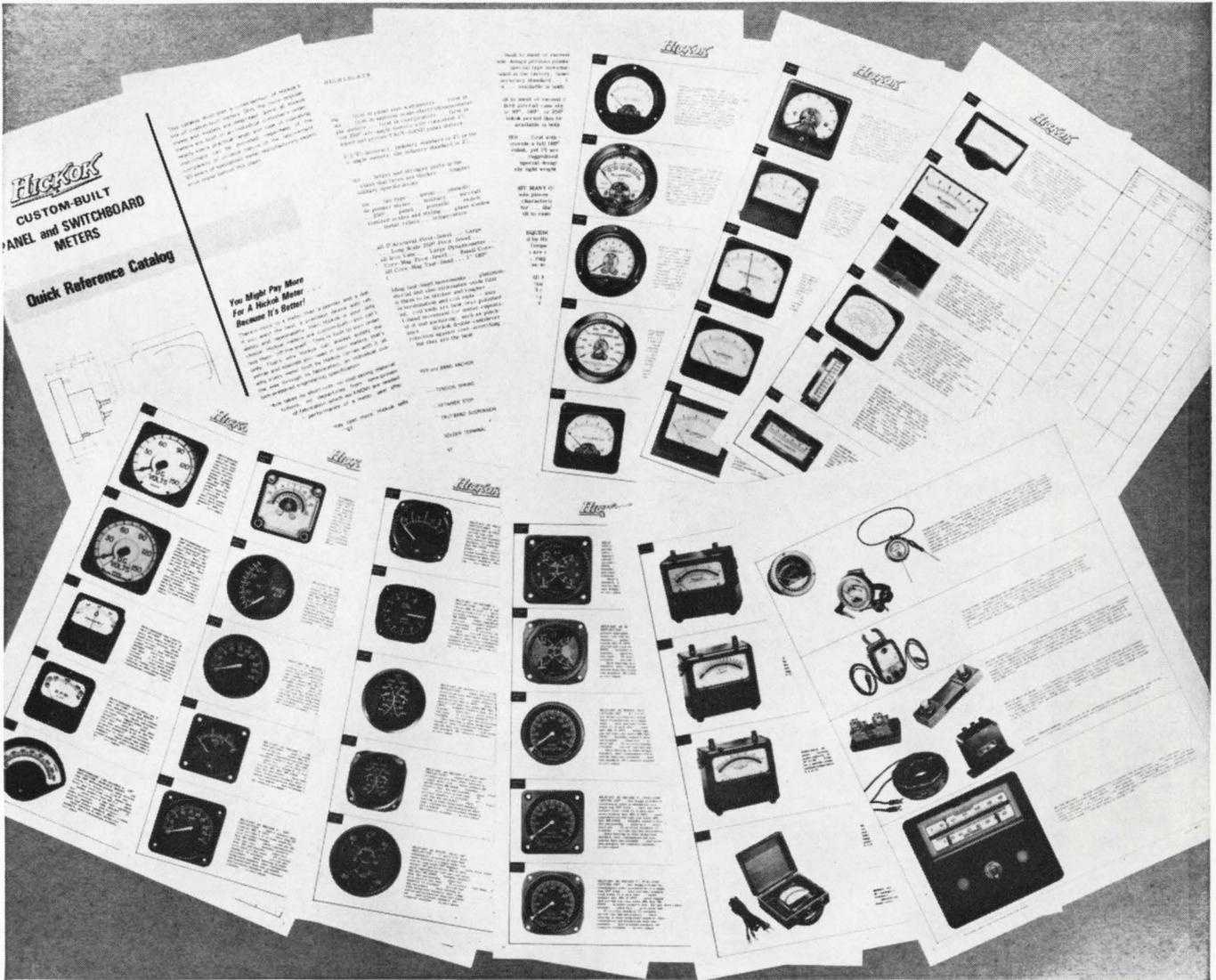
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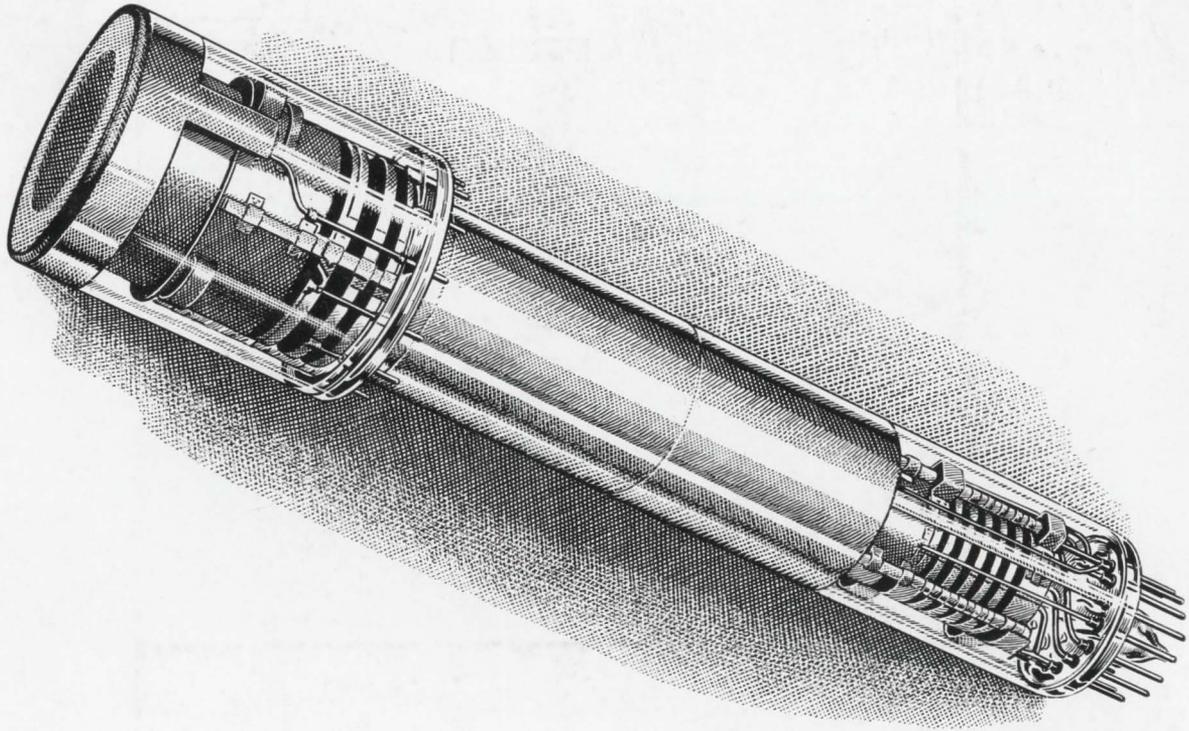


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