High-voltage IC's widen design horizons 90
Negative feedback in active filters 96
Nitride lowers MOS thresholds 117

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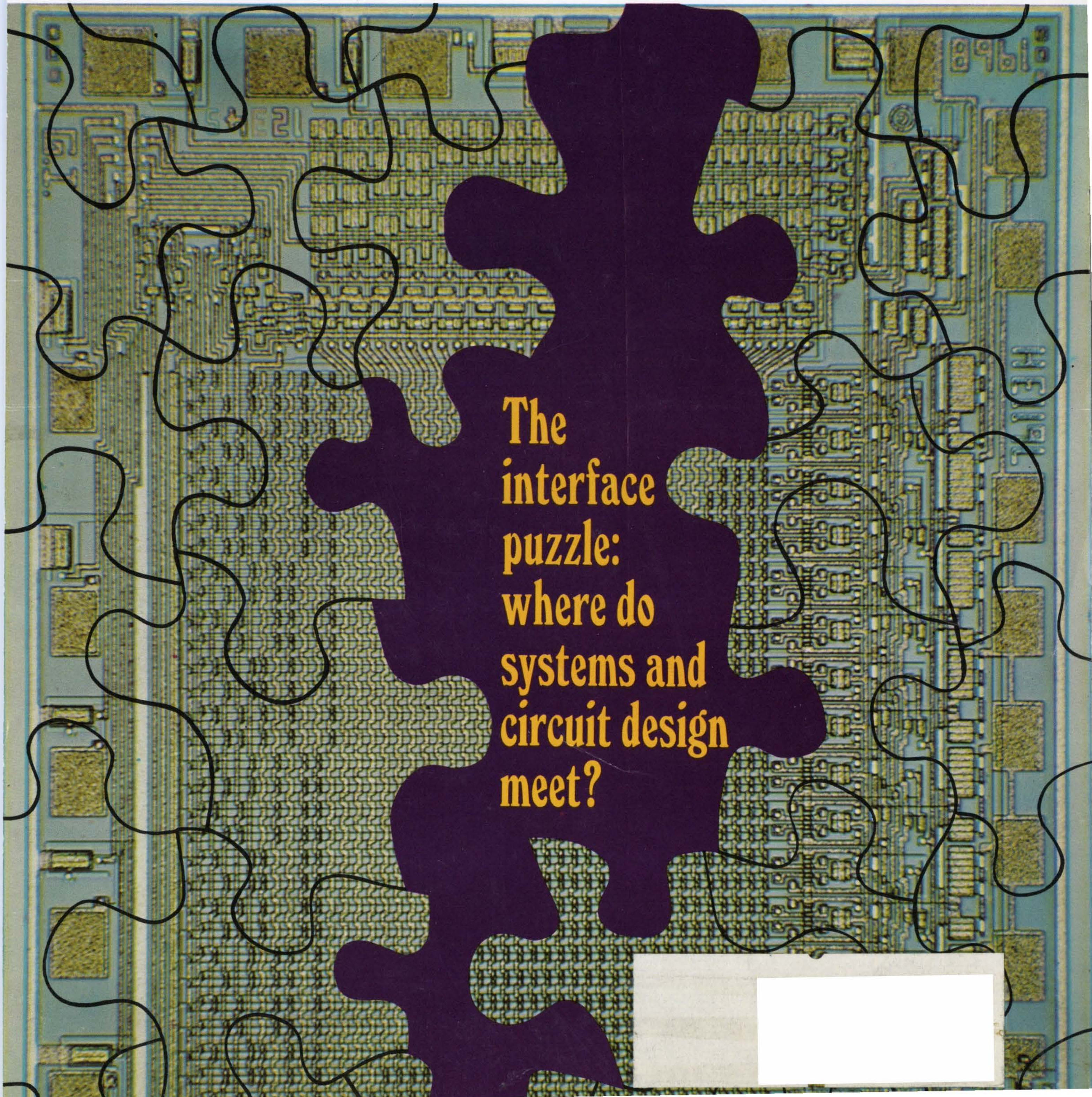
March 31, 1969

Electronics



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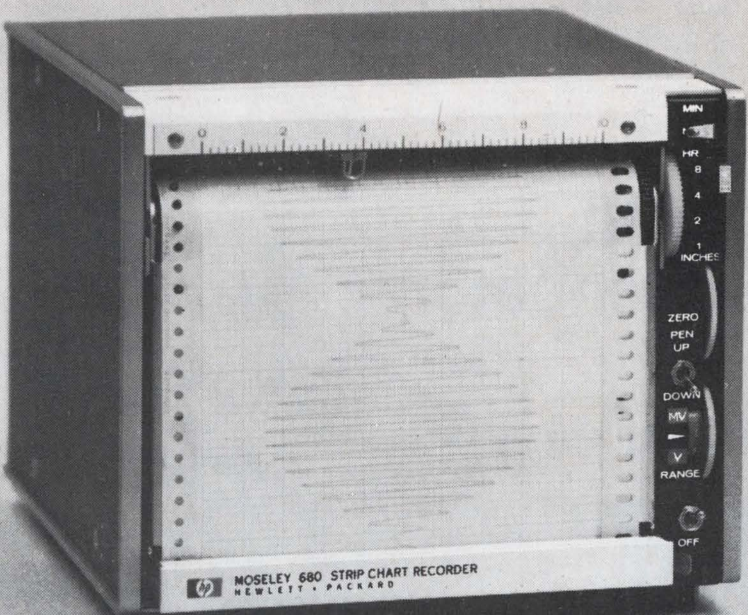

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Let's face it. There are places where even the *best* strip-chart recorder could be improved. Like in the desert, on mountains or undersea. Anywhere there's dust, moisture or high humidity. Jobs that demand wear-free, corrosion-free reliability.

That's why Hewlett-Packard developed a unique photoslidewire (Option 17) for the HP 680 Strip-Chart Recorder. Users around the world tell us it has one outstanding feature: you can leave it alone. The photoslidewire combines a proven null balance technique with optical coupling to eliminate mechanical contacts. A narrow light source on the stylus and HP-made photoconductor strips replace the mechanical slidewire contacts which balance the positioning servos. Photoslidewire (Option 17) cuts down preventive maintenance time and need for trained personnel. Price: Model 680 plus Option 17, $850. And for long-term unattended operation, where a standard pen system is not practical, add HP's exclusive electric writing (Option 15) for crisp, clean, permanent recording, $75. Call your local HP field engineer for details on this extra measure of reliability. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

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GRAPHIC RECORDERS

11814

Circle 1 on reader service card

Electronics

Volume No. 42 Number 7 March 31, 1969

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Readers Comment

Big Brother

To the Editor:

There are at least three items in the Feb. 17 issue of *Electronics* which emphasize the totalitarian trend of our culture. Hardly anyone is concerned nowadays by the fact that Government is regulating and controlling more and more aspects of our nation's private and business activities.

On page 39, the editorial "Heading off IBM" informs us that "the Justice Department wants IBM to change its way of doing business." Why does it want this change? Because IBM "has been so faultless in the way it has planned, manufactured, and marketed computers and computer services that if it merely continues its successful practices, its competitors may be unfairly treated." This statement clearly shows that the intention of the Government is to restrain or punish excellence, because to let those with superior ability, superior energy, or superior effort keep the earned consequences of their superior performance would mean that competitors with inferior performance would be "unfairly treated."

On page 58, the article "Pushing buttons" informs us that the Federal Communications Commission intends to force television-receiver manufacturers to include detent uhf tuners so that "all receivers will have 'comparable ease of tuning' on both vhf and uhf channels." After failing to persuade the industry to do this voluntarily, the FCC proposes a rule and follows up with the comment: "Maybe we won't have to make a ruling. Perhaps the threat will do it."

Such a "persuasion" or ruling will unquestionably result in higher receiver costs. In principle, this requirement does not differ from one that would require all sets to have remote controls for ease of tuning or to display color images and produce stereophonic sound for ease of viewing and listening. The only difference is that the consequences to the purchaser would be a little less obscure in the latter cases.

Finally, on page 71 we are con-

Wet-sintered-anode Tantalex® Capacitors

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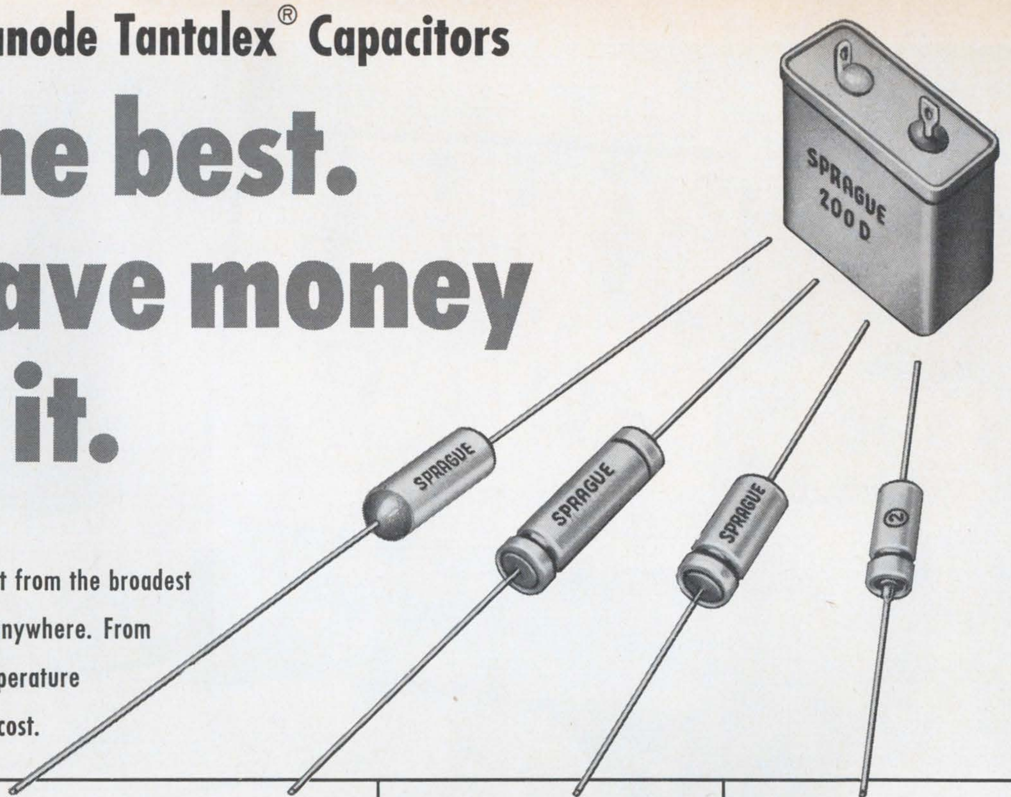

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Select the capacitor type that meets your temperature requirements. That's how to save money. Specify Sprague Tantalex® Capacitors. That's how to get the best.

For complete information on Type 145D Capacitors, write for Engineering Bulletin 3750 (Type 109D, Bulletins 3700F and 3700.2; Type 130D, Bulletins 3701B and 3701.2; Type 137D, Bulletin 3703A; Type 200D and 202D, Bulletin 3705B) to the Technical Literature Service, Sprague Electric Company, 35 Marshall St., North Adams, Mass. 01247.

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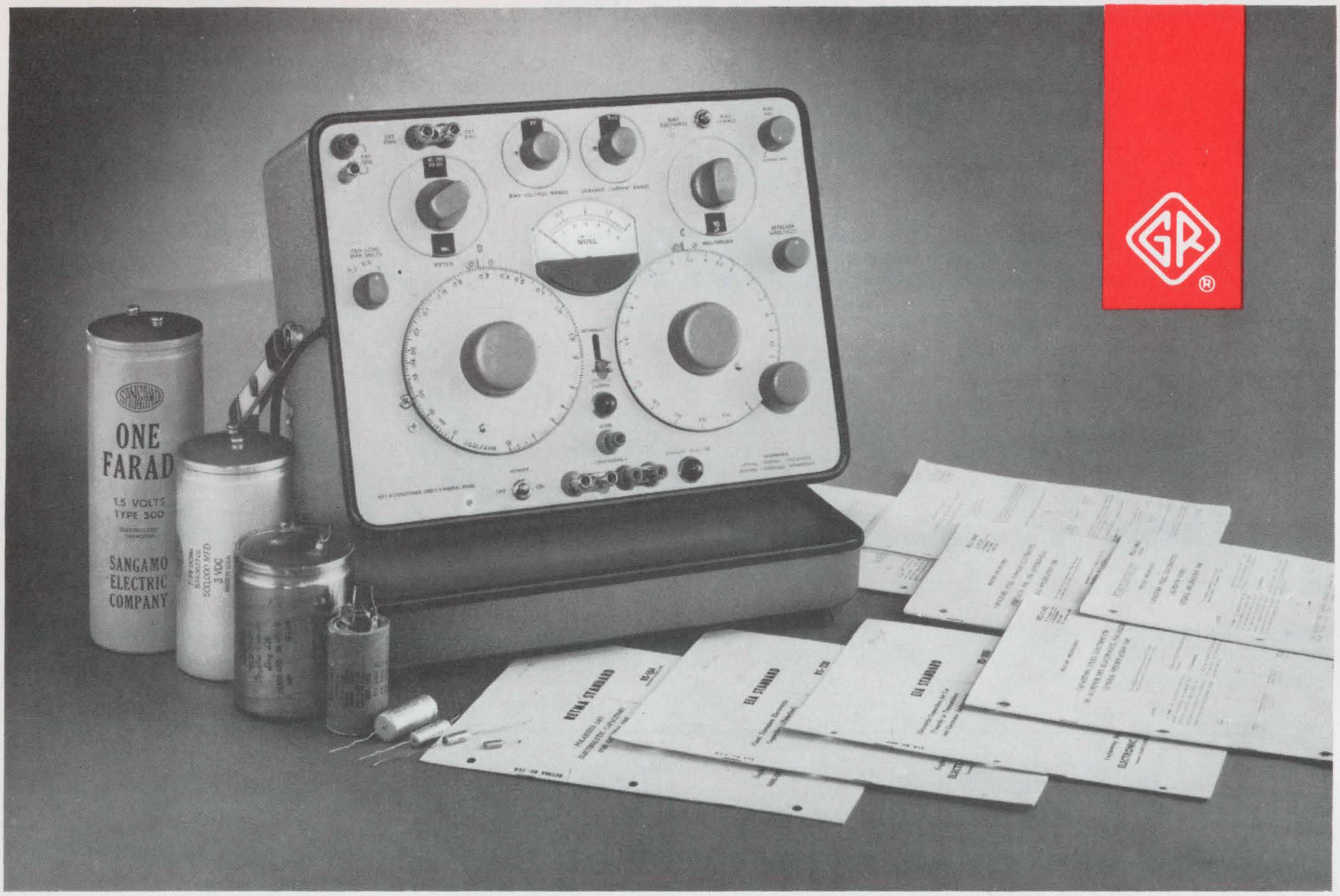

A "system" for testing tantalum and aluminum electrolytics

The Type 1617 Capacitance Bridge is really a system in one package designed specifically to test electrolytic capacitors at 120 Hz per MIL or EIA specifications. However, this 1% bridge can measure any capacitor, including those as large as 1.1 F. Besides having an exceptionally wide C range, the 1617 has many other features that make it an excellent general-purpose bridge for component testing at quality-control and incoming-inspection stations.

WIDE RANGE. C range of 10^{12}, from 1 pF to 1.1 F, with an accuracy of $\pm 1\% \pm 1$ pF and 2% from 0.11 F to 1.1 F. D range from 0 to 10 with an accuracy of approximately $\pm 2\% \pm 0.001$.

CONVENIENCE. The 1617 is completely self-contained; just plug it into a power line and start measuring. It includes a 120-Hz generator, a tuned detector, and an adjustable dc polarizing voltage, all enclosed in a handy, portable, flip-tilt carrying case.

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OTHER FEATURES. The 1617 bridge:

- has a metered, dc polarizing voltage that is adjustable from 0 to 600 volts; external bias up to 800 volts may be applied.
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- can operate at frequencies up to 1000 Hz with an external generator.
- has important safety features, such as warning lights and discharge circuitry, which protect both the operator and the instrument.
- has Orthonull® balance finder to permit rapid bridge balances and eliminate sliding nulls during high-D capacitance measurements.
- has a generator that is phase-reversible to reduce the effects of hum pickup; amplitude is selectable and limited to 0.2 V, 0.5 V, or 2 V.

The 1617 bridge can also measure the capacitance and loss of cables, transformers, insulating materials, and electric motors.

Price: $1250 in the U.S.A. For complete information, write General Radio, W. Concord, Massachusetts 01781; telephone (617) 369-4400. In Europe: Postfach 124, CH 8034 Zurich 34, Switzerland.

GENERAL RADIO

fronted with "Compulsory f-m will get big push." This item tells us that f-m broadcasters "are about to launch a strong drive for a law requiring that all receivers be able to pick up both a-m and f-m. A bill to that effect was introduced last month by Sen. Frank Moss (D., Utah), a member of the communications subcommittee of the Senate Commerce Committee."

In a free country, the citizen, and not the Government, decides what and from whom he does or does not wish to purchase, and he expresses his desires with his dollars.

Ernst F. Germann
Austin
Texas

Scattering light

To the Editor:

In the article on solid state displays in the British IC's series [Feb. 3, p. 100], a description is given of Bragg-angle diffraction by the propagating planes of altered refractive index associated with the sound energy in a moving domain.

It is surprising that 50% to 75% of the light was found to be deflected to the detector. The diffraction pattern of the equivalent transmission grating, as shown in the diagram on page 102, should be symmetrical, with about equal energy in the right and left diffracted beams. In addition, neglecting the energy in the higher-order beams, the zero-order, or undeflected, beam usually has greater intensity than any other diffracted beam.

If 50% or more of the light input is in one deflected beam, the phenomenon is possibly one of total reflection by the domain interface or a refractive effect with bending from some gradient or wedge geometry in the domain.

Leo Mackta
Belle Harbor
N.Y.

▪ Gordon Robertson and C.P. Sandbank of Britain's Standard Telecommunication Laboratories, authors of the article in question, reply:

"The essential difference between a diffraction grating and Bragg-type diffraction is that the former is planar while the latter is many wavelengths in depth. Thus, the zero-order beam can be scattered many times. By introducing the light at the Bragg angle in an ideal system of this type, all the energy would emerge in only one of the first-order beams. Destructive interference occurs in all other directions. The intensity of the scattered light beam is a function of the change in refractive index caused by the acoustic wave—hence, of the intensity of the acoustic wave and of the thickness of the sample. In this case, use of a 1-millimeter-wide crystal is quite sufficient to give substantial scattering.

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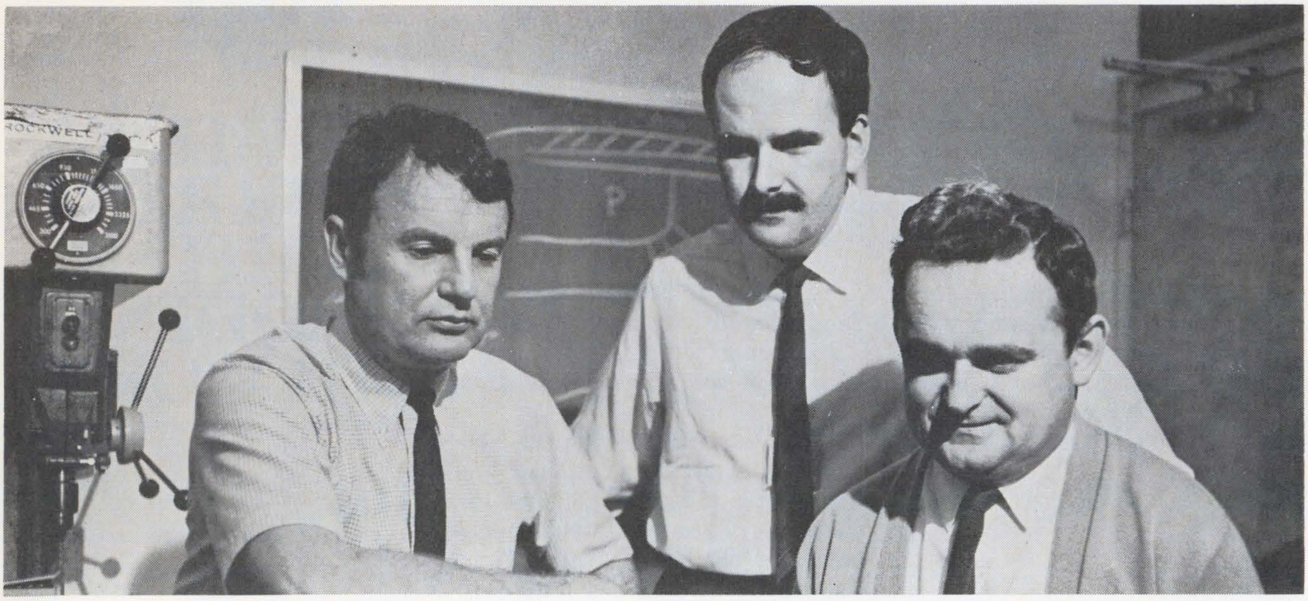

Kocsis Camenzind Polata

Cosmopolitan is perhaps the best word for the Signetics trio who wrote the article on high-voltage IC's (page 90). Joseph Kocsis, who manages the company's microwave and high-frequency research group, was born in Hungary and educated in Britain. Before joining Signetics last year, he spent three years each at the Bell Telephone Laboratories and ITT Semiconductor. He has always been intrigued by novel devices, an interest that led him to investigate surface-controlled breakdown and the use of field plates for IC's.

Hans Camenzind, a native of Switzerland, has been designing linear IC's for the past six years. He is the author of a book, Circuit Design for Integrated Electronics, and is on the faculty of Santa Clara University where he teaches a graduate course on IC design. His main interests center on the development of designs that open up new areas for IC's. Camenzind, who joined Signetics a year ago, was previously with the P.R. Mallory Co. He holds a master's degree from Northeastern University.

Bohumil (Bob) Polata, a Czechoslovakian by birth, joined Signetics early in 1966. His background includes stints with Beckman Instruments and Fairchild Semiconductor's research and development lab in Palo Alto. While at Fairchild, Polata worked on linear IC's using thin-film resistors and on MOS capacitors for space telemetry applications. He also developed a 10-bit a-d and d-a converter system that uses medium-scale integration circuits and tantalum resistor arrays as building blocks.

Active filters have long been a professional preoccupation of Gunnar Hurtig. One of the founders of Kinetic Technology Inc. and now its vice president for operations, he designed the monolithic unit discussed in the article beginning on page 96. Before helping KTI set up shop, Hurtig was a group manager at Western Microwave Labs and president of the Ninic Corp., which was bought by Fairchild Semiconductor. Hurtig stayed on with Fairchild, where he was in charge of the firm's active-filter facility. He received his bachelor's and master's degrees from Cornell.

Hurtig

Semiconductors are a common ground for Karabet Simonyan and Robert Hull, authors of the article of log diodes beginning on page 104. Simonyan, born in Turkey, has a bachelor's degree in applied physics from Hofstra University. He is now vice president of engineering at the Computer Diode Corp.

Hull, who holds a doctorate from MIT was one of the founders of the General Instrument Corp. He later formed a consulting firm that did work for Computer Diode, and has recently started a new company that manufactures semiconductor materials.

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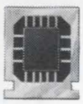
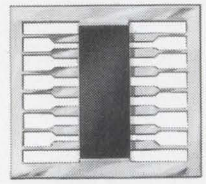


FIRSTLY, we mount the chip on a small, gold-plated grid. After the chip has been provided with a protective lacquer coating we package the assembly in soft epoxy resin. The resin protects the chip against moisture penetration, and prevents thermal fatigue of the bonding wires.

2



SECONDLY, we weld this sub-assembly into the final tin-plated grid structure and package it in the dual-in-line encapsulation. We chose a special ultra-strong plastic for the body of the device, to withstand severe bend-pull stresses on the external leads.
The leads themselves have been specially designed to maintain maximum adhesion to the plastic body. The tin plating on the leads continues right inside the body of the device, ensuring excellent corrosion resistance; it also ensures high-quality soldered connections even after storage under tropical conditions.

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This test gives a good indication of BOND STRENGTH, BULK LEAKAGE, and any degradation of electrical performance under severe thermal stress.

We also check the endurance of RTR-circuits by reverse-biasing the transistor time after time at high ambient temperatures. This is a searching test of lacquer or plastic influence on the CRYSTAL STATE, since it shows the effects of SURFACE CHARGES and SURFACE TRAP DENSITY.
We check production circuits for the same qualities, but with the input diodes reverse-biased and the output transistor dissipating power, again at a constant high ambient temperature.
The reverse-bias test for RTR-circuits, and its counterpart for production circuits, are also carried out under tropical conditions of temperature and humidity.
We test the ability of our circuits to withstand HIGH and LOW TEMPERATURE STORAGE. This is very important, because weaknesses in solder structure, lacquer deterioration, and 'plague' effects can all show up under adverse storage conditions.

We follow this up by storing circuits for weeks at a time under true TROPICAL conditions.
We really try out a digital circuit's SWITCHING capabilities by switching its input at 50% duty cycle under maximum fan-out and temperature conditions.
We carry out full sequential TEMPERATURE TREATMENT tests to MIL-spec requirements.
Our mechanical checks include SOLDERABILITY, the effect of PULLING or TWISTING the LEADS, resistance to SHOCK, ACCELERATION, and VIBRATION.
Finally, STEP STRESS TESTS are carried out to determine the extent of the temperature stress over a number of cycles needed to induce failure. This is a rapid method of detecting potential failure modes which may occur under normal conditions.

*) test device with separate transistor and resistors

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dual NAND gate	FCH121*
	FCH131
triple NAND gate	FCH141*
	FCH161
	FCH151*
	FCH171
quadruple NAND gate	FCH181*
	FCH191
sextuple NAND gate	FCH201*
	FCH211
dual line driver NAND gate	FCH221
	FCH231
single 5-bit comparator	FCH281
single 10-bit parity checker	FCH291
gated 4-bit decoder	FCH301
input expander	FCY101
single JK flip-flop	FCJ101
single JK master-slave flip-flop	FCJ111
	FCJ201
dual JK master-slave flip-flup	FCJ121
	FCJ131
	FCJ191
	FCJ211
quadruple latch flip-flop	FCJ221
monostable multivibrator	FCK101
level detector	FCL101
single decoder NIT driver	FCL111

*Without collector resistors

TTL INTEGRATED CIRCUITS

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(Compatible with the SN74N series)

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dual NAND gate	FJH111
triple NAND gate	FJH121
quadruple NAND gate	FJH131
dual buffer NAND gate	FJH141
dual AND-OR-NOT gate	FJH151
single expandable AND-OR-NOT gate	FJH171
single AND-OR-NOT gate	FJH181
quadruple NOR gate	FJH221
quadruple two input NAND gate	FJH231
single JK flip-flop	FJJ101
single JK master-slave flip-flop	FJJ111
dual JK master-slave flip-flop	FJJ121
dual latch flip-flop	FJJ131
single decade counter	FJJ141
quadruple latch flip-flop	FJJ181
dual JK master-slave flip-flop	FJJ191
dual gate expander	FJY101

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DESIGNATION	TYPE NUMBER
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	FHH101B
dual NAND gate	FHH121A
	FHH121B
quadruple NAND gate	FHH141A
	FHH141B
single expandable AND-OR-NOT gate	FHH161A
	FHH161B
	FHH181A
	FHH181B
JK flip-flop (AND inputs)	FHJ101A
	FHJ101B
JK flip-flop (OR inputs)	FHJ121A
	FHJ121B
AND-OR-NOT expander	FHY101
	FHY121

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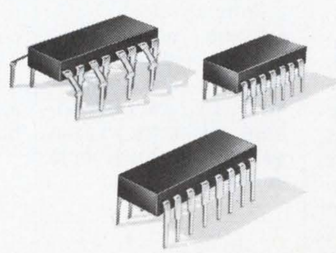

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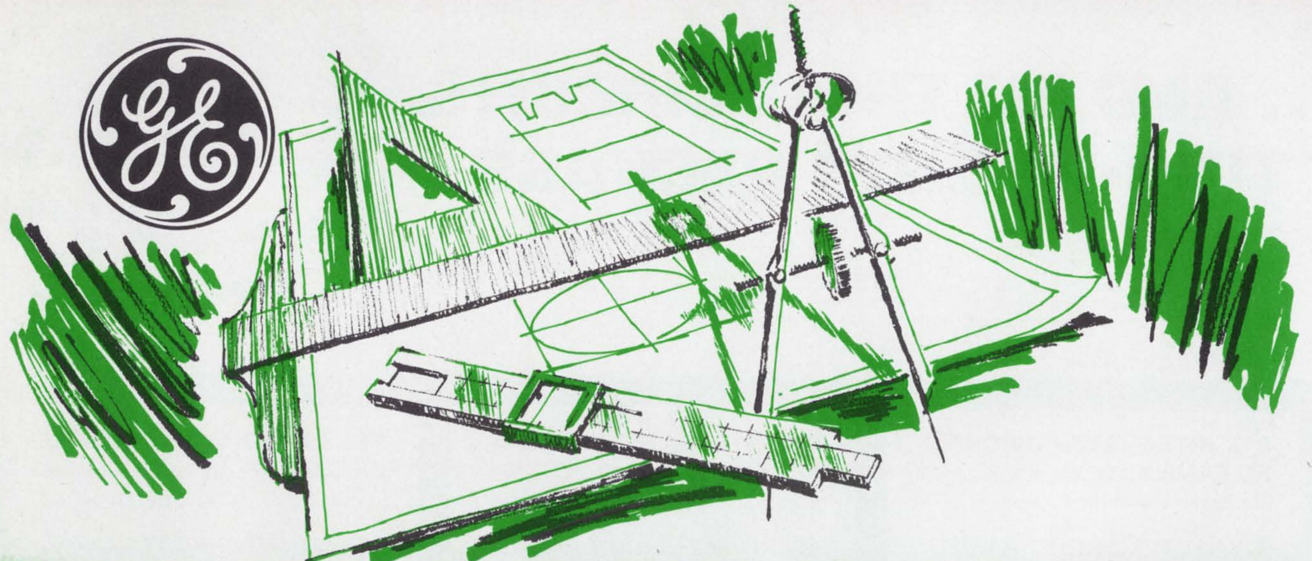

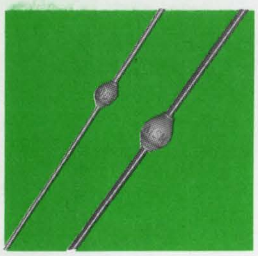

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GE offers a higher rated companion to its field-proved, 1 amp A14 rectifier at a significantly lower cost than stud or other lead mounted units (depending upon configuration). The A15 is rated 3 amps at 70 C and the 200 to 800 volt models are transient voltage protected up to 1000 watts for 20 μS in reverse direction.

A15's dual heat sink design means low thermal impedance and easy adaptation to PC board mounting . . . reduced installation cost.

Both the A15 and A14 are hermetically sealed in an all-diffused, glass passivated junction structure. No internal cavity means more resistance to environmental stresses . . . thus increased reliability.

High-power A15 is now available through GE distributors in quantities up to 9999 for applications including time delay circuits, battery chargers, TV damper diodes, communication equipment and small portable appliances. Circle number 505.

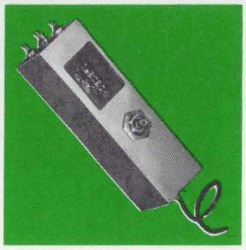
Select your instruments from industry's most complete line

● **Panel meters.** Measure a-c, d-c volts and amps. 1½ to 4½-inch sizes in THE BIG LOOK® style. 2½ to 4½-inch sizes in HORIZON LINE® style.

● **Meter relays and pyrometers.** Indicate, monitor and control temperature or other variables directly or with transducers. BIG LOOK and HORIZON LINE style. 2½ to 4½-inch sizes. "Piggy-back" control module.

● **Edgewise meters.** Measure a-c and d-c volts and amps. Miniature type 185, 2¼ inch or large type 180, 6-inch. Both can be multi-stacked vertically or horizontally. Standard accuracy of 2%, 1% optional.

● **Switchboard instruments.** Measure volts, amps, speed, vars, power factor, frequency, phase angle, other variables. 4½ and 8½-inch sizes. Standard one percent accuracy. For full line information, circle **506.**

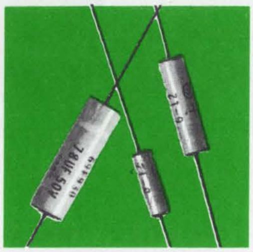


Reduce redesign cycles with reliable GE microwave circuit modules

GE microwave circuit modules (MCM) help reduce design cycles, provide retrofit and lead to improved system performance by optimum integration of active devices. And lower system cost results from circuit simplicity, easy application and longer life.

These rugged GE devices are built to deliver reliable performance in adverse environments of shock, vibration, high altitude and extreme temperatures. MCM's may be designed for use as oscillators, amplifiers, integrated isolators and circulators.

General Electric microwave modules encompass all planar triode and diode uses—from DC to X-band, from milliwatts to kilowatts. For details, circle number **507.**

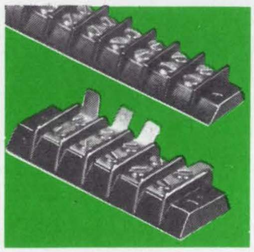


GE wet slug capacitors . . . highest efficiency in half the size

GE 69F900 wet slugs meet high-density application needs with highest volumetric efficiency of any capacitor. We halved the military (CL64) wet slug size, and essentially kept its electrical and performance traits.

The 69F900 has excellent capacitance retention at low temps . . . can be stored to −65 C. Operating range is −55 C to +85 C. It's tough too—withstands vibration to 2000Hz; 15G acceleration!

GE's capacitor is fully insulated; has low, stable leakage current. Ratings are available from 6 to 60 volts; capacitance ranges from 0.5 to 450 μf. For more information, circle magazine reader card number **508.**



New 36 point one-piece Terminal Boards

General Electric has stretched its reliable line of one-piece terminal boards to 36 contact points. And they are available in eight configurations of solder, screw and quick-connect points.

The new expanded line of CR151, Type D1 or D7, is rated 15 amperes with breakdown voltage of 3600. Of course, other designs are still available in ratings up to 30 amperes and breakdown voltage to 7500.

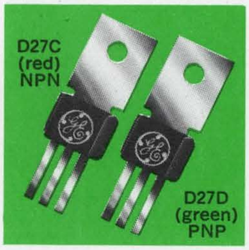
No insulation is required between board and panel because the molded plastic base already provides the protection. Marking strips or stamped markings can be provided on top and/or bottom.

The expanded D1 and D7 boards add just another dimension to what is already the broadest terminal board line on the market. For more information, circle reader card number **509.**

10 more

electronic components tailored for designers

General Electric components are engineered for reliability and cost effectiveness. No other single manufacturer offers such a wide selection of quality electronic components as General Electric. Specify GE in your designs.



Complementary power transistors—up to 20W in audio applications

Complementary D27C/D27D silicone-encapsulated, planar, epitaxial power transistors have low collector saturation voltages and offer a dissipation of 8W total power with tab at 70 C. Their 0.5″ leads can be formed to fit TO-66 and TO-5 configurations.

Key Characteristics

Collector current
3 amps (continuous)
5 amps (peak)
Collector saturation voltage
D27C: 0.5V typ., 3.0A
D27D; -1.0V typ., -3.0A
Collector-to-emitter voltage
30 and 40 volts
Total power dissipation (with tab)
1.7W (free air at 50 C)
2.1W (free air at 25 C)
8.0W (tab at 70 C)
Forward current transfer ratio
120 max., 200 mA
Gain band width product
D27C: 50MHz typ.
D27D: 40MHz

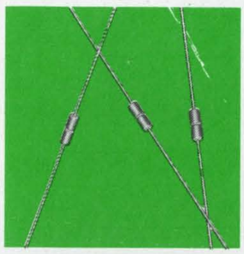
Their small size and power handling capability offer a great variety of applications including drivers, voltage regulators, power switching, audio output for automobile or phono stereo, TV, radio. And they are color coded for identification. Circle number **510.**

Designing a radar? New GE 4-cell tetrode improves bandwidth 300%

Up go electronic bandwidths with GE's unique ZP-1081 "multi-cell" tetrode, a compact, air-cooled transmitting tube that incorporates four high-performance tetrode units in a single vacuum envelope. This innovation leads to very high transconductance and significantly low output capacitance, to provide high gain-bandwidth in amplifier circuits.

Electronic bandwidth of about 120 MHz has been demonstrated under RF power amplifier operation at 475 MHz. Related typical performances includes 70 KW of useful peak power output with a peak drive power of 15KW.

Output efficiency is close to 40%, and low operating voltages are used under RF grid-pulsed amplifier service. Bandwidth achieved is on the order of 200-300% of that available from previous tetrodes and associated circuitry operating at comparable power and frequency. For more information, circle number **511.**



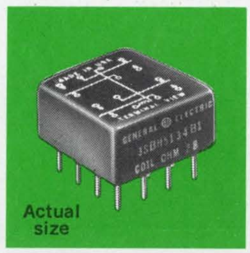
GE's Economy Pack . . . proved thermistors at budget prices

Growing uses of printed circuit boards in new applications have demanded hermetically sealed temperature compensation units at lower cost. And in response to this need, GE has put its proven 1H-Series (negative temperature Coefficient) Thermistors in a new Economy Package.

As low as 16¢ each in OEM quantities, these high-quality units are available in 5%, 10%, 20% and 30% tolerances with Zero-Power Resistance Values from 18K to 56K ohms at 25 C.

1.125 inch gold-plated Dumet leads may be welded or soldered . . . ideal for PCB designs.

Proved quality at lower cost makes GE thermistors the answer to your PCB needs. For more facts on the GE Economy Package, circle number **512.**



Smallest 4-pole relay available anywhere . . . GE's 150 grid

The General Electric 150 grid sealed relay is now a better buy than ever. It's the smallest available. And three years of application experience rank it with the most reliable GE sealed relays ever designed.

Low in price, it is even less than GE's standard 4-pole relay which is 4 times larger.

It meets Mil Spec 5757E, rated 2 amps, 250 MW sensitivity, and has all welded construction. Ask for the best 4-pole sealed relay buy on the market—GE's Type 3-SBH 150 grid.

Circle number **513** for more information.

Instant response for driving computer peripherals

When your equipment calls for instant response—inertial time constants low as 1 millisecond—look to GE's new Hyper-Servo* motor. It can accelerate faster than any previous GE design.

The Hyper-Servo motor makes possible new performance capacity in motor-driven peripheral data processing equipment. It is available in 3.4-, 4.6-, 4.8- and 4.9-inch diameters. And look at these performances: torque-to-inertia ratios in excess of 350,000 rad/sec² and; cont torque ratings from 32 oz-in at 2700 rpm to 326 oz-in at 2800 rpm.

These and other high performance characteristics make the Hyper-Servo motor adaptable to nearly every computer peripheral drive application. Circle magazine inquiry card number **514.**

* Trademark of the General Electric Company.

Look to General Electric—your best source for more in electronic components.

ELECTRONIC COMPONENTS SALES OPERATION

GENERAL ELECTRIC

285-47

Who's Who in electronics

Graham

"The shift to the Houston area is not a short-term answer to a problem," says George Graham, 36, manager of transistor transistor logic for Texas Instruments, who will manage the new plant there. This spring, TI will shift the bulk of its integrated-circuit activities to a 181,000-square-foot plant in the Houston suburb of Stafford, moving nearly 1,000 professional personnel to run the facility [*Electronics,* March 17, p. 36].

The company did such a good job of selling TTL to designers that demand far outstripped supply last year. But Graham says that the capacity situation was already well in hand when the move was decided on. "We made our significant investment, in equipment and people, last year," he notes. "I think I'll be able to supply anything our customers need—certainly by the end of the second quarter. I expect to be on top of the situation long before the transfer is complete; the move is really to make sure that we stay that way."

Future. As plant manager, Graham will be host to TI's so-called TCC (for Technology Customer Center) projects under Charles Phipps. This operation includes the high-technology areas in which TI expects its growth to come: MOS IC's, large-scale integration, and memories. (Phipps will continue to report to Glenn E. Penisten, TI vice president in charge of business development. Graham reports to C. Morris Chang, vice president in charge of IC's.) The inclusion of TCC operations in the shift to Stafford underlines Graham's observation that "TI has realized for some time that it needed another business base for the Components group." The corporation purchased 200 acres in Stafford three years ago; the semiconductor personnel will occupy a building that now houses the Industrial Products division, which makes TI's IC test equipment.

Industrial Products is moving into a new 15,000-square-foot plant next door, and TI will soon begin construction of a third building as large as the existing structure.

Big H. Why Houston? The site seemed a natural to the Texans who will move there. It's only 250 miles from the Dallas headquarters, with frequent plane service; the labor market isn't quite so tight as in Dallas (the housewife market is hardly tapped, Graham says), and there is a good scientific and educational community, with the NASA Manned Spacecraft Center and Rice University. "You go into this with some apprehension, but so far the response has been good," Graham says.

Not too many executives rise to the top through the engineering ranks, but Victor H. Pomper did. In 1950, fresh out of MIT Graduate School, he joined audio manufacturer H.H. Scott Inc. of Maynard, Mass., as a sales engineer; in December Pomper became president.

With no formal business training, he was forced to learn management on the job and admits making mistakes. "There have been frustrations and failures, but all one can do is assemble facts and deal with them objectively," says Pomper.

Right feeling. Pomper must deal with both engineering and management—when and where to apply new technology, carefully weighing a new technique's worth in the marketplace against its cost. But in the end, Pomper says, one often

How a little Rexolite® helps Amphenol plug leaks in microwave lines.

Amphenol RF Division knew they had a tiger by the tail when they set out to come up with a new 7 mm precision connector. And they say their choice of Rexolite 1422 dielectric material had a lot to do with their success.

The challenge — Microwave test equipment and air lines had advanced to the point, particularly in low-signal-strength applications, where equipment manufacturers were calling for a new, stable connecting link that would have almost no loss at all! Current coaxial connectors, producing VSWR's of about 1.35 at 10 GHz wouldn't do.

The solution — Working within parameters established in an IEEE subcommittee, Amphenol developed the precision coaxial connector shown here. It operates to 18 GHz with a maximum VSWR of 1.039.

WHY REXOLITE —

1. The **dielectric constant** of this Brand-Rex material, chosen for the insulation, proved "just right for a coaxial design of 7 millimeters inside diameter" according to Amphenol engineers.

2. Rexolite's **consistency** of properties, piece-to-piece and batch-to-batch was found better than that of other materials considered.

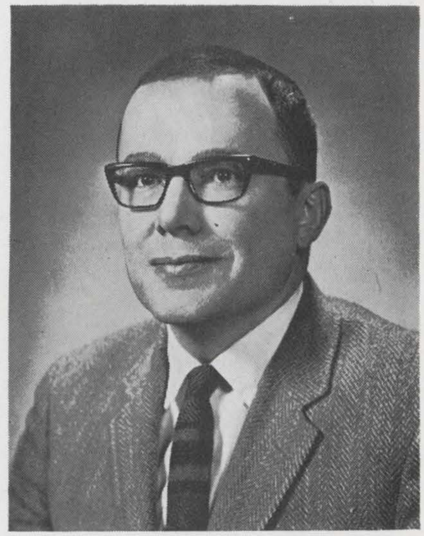
3. And it provided better **stability,** particularly where temperature variations were involved.

4. Finally, Amphenol found Rexolite 1422 **machines beautifully.** The disk is cut from rod stock to within .0002″ tolerance on thickness, I.D. and O.D. And sharp shoulders (.002″ max. radius) are held.

Can you use a real, problem-solver dielectric like this? Write for the facts on REXOLITE clad, rod and sheet stock.

American Enka Corp., Brand Rex Division,
Willimantic, Conn. 06226, Phone: 203 423-7771.

BRAND-REX



Pomper

has to make "risky enterpreneurial decisions on the basis of intuition or guts. You must stick your neck out."

Scott claims to have developed the first hi-fi amplifier, the first wideband f-m tuner, and to have used silicon transistors, field effect transistor's and IC's before most competitors thought them feasible. Now Scott is working with Motorola to develop thick-film circuits; also forthcoming is a new speaker.

Many of Scott's firsts occurred during Pomper's 19 years with the company. Meanwhile, the payroll grew from 12 to 700. Ironically, if Scott had been that large in 1950, Pomper might not have joined. While a co-op student, he had worked at Philco, and this decided him against larger companies.

Hobby. An MIT professor who knew Hermon Scott recommended the young firm to Pomper, whose first reaction was: "It's a hobby, not a company." But he soon decided that Scott held opportunities even though he had never worked with audio equipment.

Pomper recalls: "I worked 70 hours a week at first and had no social life. People thought I was crazy."

But now both Pomper and the corporation are ready for a slower pace. "In the last 15 years we have doubled our business every three years," he says. "Now we'll grow a little more slowly; we want to consolidate before diversifying."

Photographed in Vietnam by Howard Sochurek

When you need a new way to see in the dark...

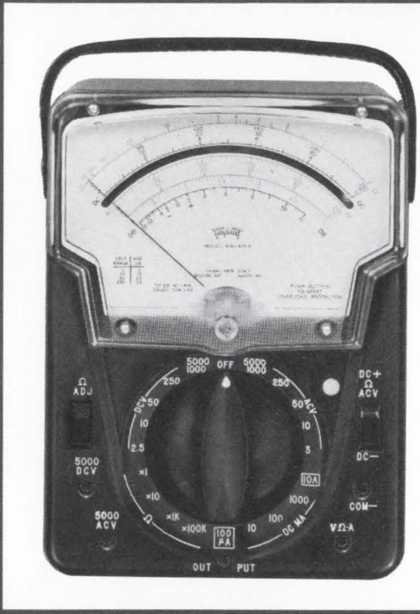
bring ERIE in early.

The jungle night falls fast for a pilot downed behind "Charlie's" lines. But, rescue choppers no longer wait for morning light to find him. The answer? New portable night vision devices that actually intensify available light...even starlight...thousands of times. From the start, those working on this project have relied on the Research Engineers and component capability of ERIE TECHNOLOGICAL. Our new sub-miniature high voltage supply is at the heart of the system. Proof, once again, that whatever your area of electronics, it pays to bring ERIE in early.

ERIE TECHNOLOGICAL PRODUCTS, INC.

644 West 12th Street, Erie, Pennsylvania 16512
Area Code 814-456-8592

Triplett turned to Durez® 11540 to protect both their meters and their customers



Triplett Electrical Instrument Company needed a case for its new portable volt-ohm-milliammeter that could stand up under the rugged bumps of portable use and protect the user against shock.

They found the right combination of physical and electrical properties in Durez 11540 phenolic molding compound.

Its dielectric strength meets the toughest specs, including Mil-M-14F, Type CFG.

Durez 11540 is just one of dozens of Durez compounds that offer you the right choice for electrical applications in almost any environment. If you're trying to solve a problem, let us give you more facts to work with. Write Durez Division, Hooker Chemical Corp., 504 Walck Road, North Tonawanda, N. Y. 14120.

MOLDED PROPERTIES (specimens compression molded at 340°F.)

Durez 11540 Black Phenolic Material	Value		ASTM Method
Specific gravity	1.36-1.38		D 792
Molding shrinkage, in./in.:			
Compression	0.006-0.008		D 955
Transfer	0.009-0.011		D 955
Water absorption, %	0.6	max.	D 570
Impact, Izod, ft. lb./in.	0.35	min.	D 256

Durez 11540 Black Phenolic Material	Value		ASTM Method
Flexural strength, psi	10,500	min.	D 790
Tensile strength, psi	7,000	min.	D 638
Compressive strength, psi	30,000	min.	D 695
Defl. temp., °F., 264 psi	330	min.	D 648
Modulus in tension, psi	1.2×10^6	avg.	D 638
Hardness, Rockwell, E scale	85	avg.	D 785

hooker
DUREZ DIVISION

Flutter measurements have one basic problem...

They're usually wrong.

And wrong measurements are of no value to anyone. Most oscilloscope presentations of flutter give you an inaccurate picture for several reasons: they make you *subjectively* evaluate a composite waveform, and even experts have trouble with this; their economical scope construction often can't compete with lab-quality display devices; they lack uniformity in repetitive flutter readings, or several units of the same model give different readings; and they can't track or measure noise-like waveforms accurately.

That's a lot of places to go wrong.

MICOM gives you highly accurate flutter and wow measurements without forcing you to make "eyeball" readings, yet are simple to operate. The MICOM line of meters accurately measure long-term speed errors or drift, and will quickly locate resonant flutter peaks within the flutter bandwidth. Outputs for scope displays are available. MICOM flutter meters can save you both time and money in evaluating your analog recorder—with the confidence that your equipment will meet published specifications.

So if wrong measurements aren't doing you any good... correct them by selecting the MICOM flutter meter that best suits your needs.

MODEL 8100/8100-W FLUTTER METER—for professional accuracy and flexibility in measuring to NAB and DIN standards. Used in recording stations, production line testing, and lab work in tape recorder manufacturing.

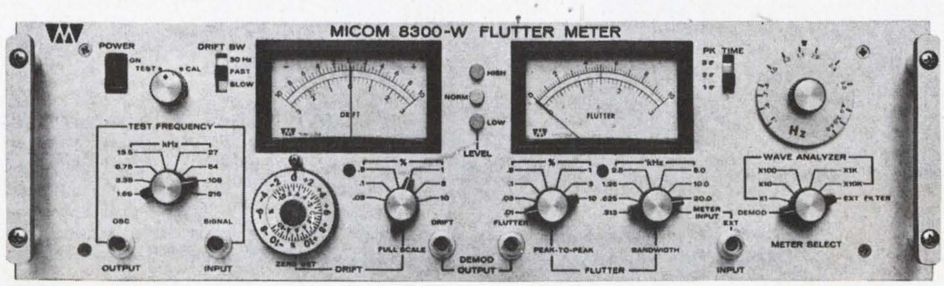
MODEL 8150 FLUTTER METER—for professional accuracy and best economy in radio/TV broadcast stations, service applications, and production line testing. Available in NAB and DIN configurations.

MODEL 8200/8200-W WIDEBAND FLUTTER METER—for highly critical audio or transport design applications where scrape flutter or automatic peak-to-peak measurement to 1, 2, or 3 sigma limits is important.

MODEL 8300/8300-W IRIG FLUTTER METER—meets all IRIG Standard requirements and eliminates subjective "eyeball" analysis and associated errors in the IRIG measurement. Accepted as the industry standard by the major instrumentation magnetic tape recorder manufacturers.

MODEL 9100/9100A FM MODULATOR—for exceptionally low-phase noise, linear modulation over a wide deviation. Also used for calibration of flutter meters.

For more details, contact MICOM, Inc., at 855 Commercial Street, Palo Alto, Calif. 94303. Telephone (415) 328-2961.



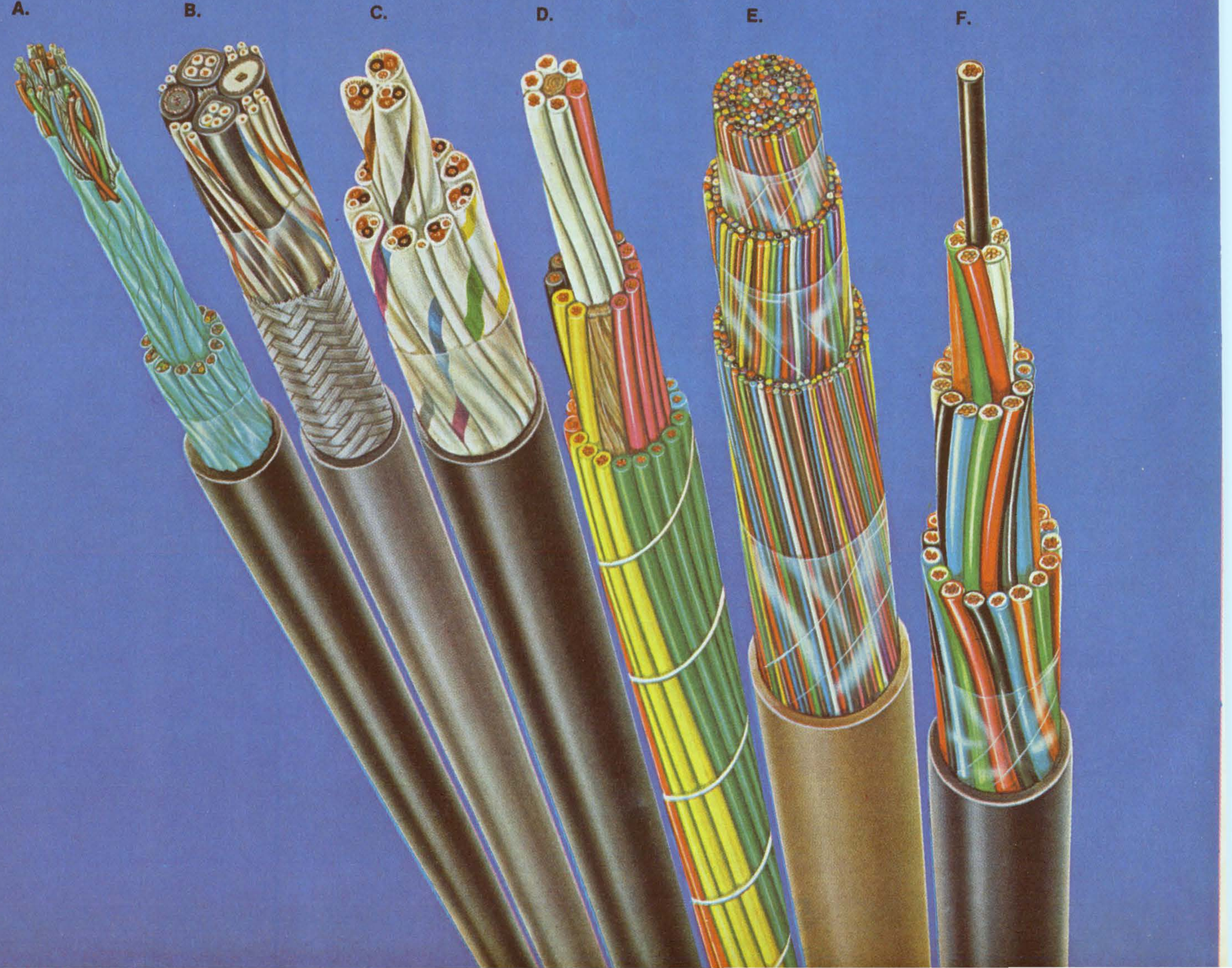
MICOM
A California Corporation

Custom(er) Cable Constructions by Chester

Proof of Chester's ability to produce plastic coated multi-conductor cable construction to customer requirements is reflected in part by the production samples shown on these pages. Though only representative of the thousands of "specials" made for our many customers they graphically prove Chester's ability to translate a wide range of special multi-conductor needs into dependable and practical cable constructions.

When standard cable constructions will not suffice, Chester's vast resources, technical skills and manufacturing facilities are placed at your disposal to manufacture conductors, insulations and jackets to meet your most exacting requirements.

Whatever your multi-conductor cable needs, check first with Chester. We know you'll be more than pleased with the expeditious and thorough handling of your request.



A. RECORDING STUDIO: Audio sound cable: 25 shielded pairs, stranded copper conductors, low loss insulation, twisted with uninsulated drain wire, isolated aluminum tape shields, cabled, PVC jacket.

B. TV CAMERA MFR.: Camera control cable for Audio and Video signals: a composite of PVC and polyethylene insulated conductors, cabled, overall braid shield, PVC jacket.

C. AIRCRAFT SIMULATOR MFR.: Control cable: 12 shielded jacketed, stranded copper conductors, PVC insulated, individual shield jackets color coded, cabled, overall PVC jacket.

D. ELEVATOR MFR.: Control cable: 35 conductors, stranded copper, PVC insulated, conductors coded by colors and printed numbers, cabled with open binder; individual conductors U/L listed.

E. INTERCOM EQUIPMENT MFR.: 250 conductor inter-office communication and signaling cable: solid bare copper, PVC insulation, paired, cabled, PVC jacket; U/L listed.

F. ELECTRIC UTILITY CO.: Station control cable for general use: 37 conductors, stranded, polyethylene and PVC insulated, color coded, cabled, overall tough PVC jacket; per NEMA/IPCEA Specifications.

G. LARGE CITY: Communication cable: 50 pairs, polyethylene insulated, cabled, continuous layer of copper shielding tape, PVC jacket; per spec. IMSA-19-2, 600 volts.

H. LEADING SHIPBUILDER: shipboard cable: stranded conductors, nylon-jacketed PVC insulation, pairs shielded and jacketed, cabled, PVC jacket, and aluminum braid armor overall; per spec. MIL-C-915.

I. U. S. GOVERNMENT: Coaxial cable: type RG-218/U, solid copper conductor, polyethylene insulated, copper braid shield, PVC jacket; per spec. MIL-C-17/79.

J. BROADCASTING COMPANY: Remote control broadcasting cable: stranded conductors, polyethylene insulation, pairs & triples shielded and jacketed, cabled, PVC jacket overall.

K. COMPUTER MFR.: Computer control cable: 55 conductors, stranded copper conductors, PVC insulated, formed into 7 groups of 7 conductors, cabled, PVC jacket; U/L listed.

L. MACHINERY MFR.: Bus drop cable: 3 PVC insulated stranded conductors, with split uninsulated grounding conductor, cabled, overall PVC jacket; U/L listed; per NEC.

CHESTER CABLE CO.

DIVISION TENNESSEE CORPORATION
CHESTER, NEW YORK • 10918
PHONE: (914) 469-2141 TWX (914) 469-9801

A SUBSIDIARY OF CITIES SERVICE COMPANY

from 45 Hz to 1 MHz. This greatly increases the capability previously available in a digital meter. You get true RMS responding measurements on four ranges (1 V to 1000 V). And the 3450A has a ±0.05% midband accuracy!

Adding the ac converter (Option 001) to your basic 3450A provides ac voltage and true four-terminal ac ratio. Price Option 001, $1250.

OHMS and OHMS RATIO (Option 002)

Six ranges (100 Ω to 10000 kΩ) of four-wire ohms measurements at 15 readings/sec are available when you add the ohms converter to the 3450A basic unit. A maximum of 1 mA signal current reduces self-heating in the resistor under test. The ohms converter also adds four ranges of ohms ratio. Price Option 002, $400.

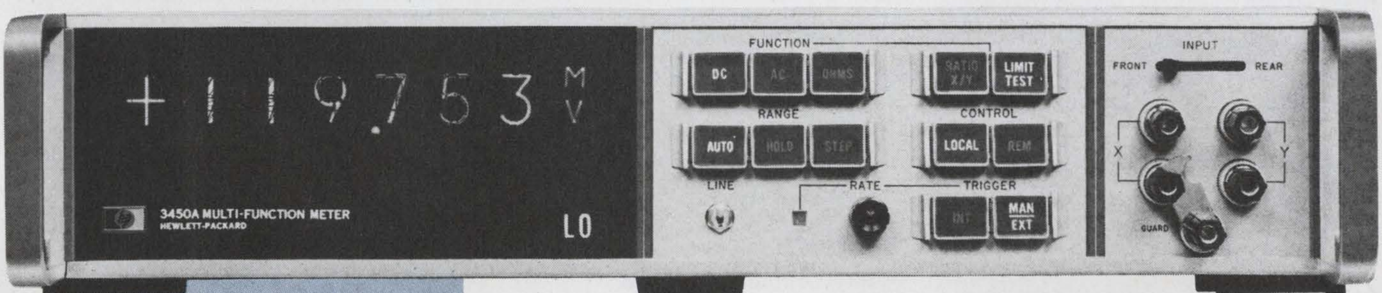
LIMIT TEST (Option 003), DIGITAL OUTPUT (Option 004)

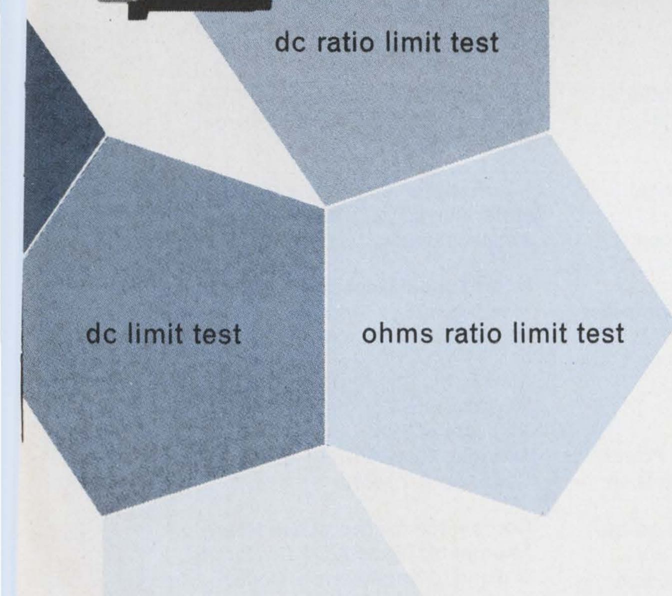
Install the limit test converter in your 3450A. Then you can use contact-closures-to-ground to preset two four-digit limits (with an additional digit for 20% overranging) and polarity for dc and dc ratio limit tests. When your 3450A has ac and ohms capability, plus the limit test option, you have ac limit and ac ratio limit tests, ohms limit and ohms ratio limit tests. HI, GO, LO front panel lights clearly indicate results of a test.

With the digital output (Option 004), you get 9 columns of information including HI, GO, LO limit test decisions in 1-2-4-8 "1" state positive BCD form. Buffered BCD output stores previous reading until printer can record it and allows DVM to immediately make another reading. Price Option 003, $350; Option 004, $175.

THE INCREDIBLE DODECAMETER

Start with the basic meter...Order what you *need* now... Add what you *want* later!





REMOTE CONTROL (Option 005)

For systems applications, remote control option installed in the 3450A allows full programmability. All programmable front panel controls can be locked out in remote operation. Price Option 005, $225.

REAR INPUT TERMINALS (Option 006)

Addition of this option provides a set of rear input terminals and a FRONT/REAR INPUT selector switch on the front panel. Price Option 006, $50.

098/9

HEWLETT *hp* PACKARD

DIGITAL VOLTMETERS

Circle 23 on reader service card

Discrete components fight for survival

More than ever, participants at the Electronic Components Conference are concerned with building a future for the discrete-components industry. The competition from integrated circuits gets heavier every year. [For more on the shifting scene, see p. 78.]

A review of today's status will be given by Bruce R. Carlson, president of the Sprague Electric Co., at the conference banquet. The title of his talk is "Mayday for the Components Industry—Problems of an Industry in Transition." Carlson is expected to discuss the role that the components industry will play in future electronic systems.

The conference, scheduled for April 30 to May 2 in Washington, will also cover the heavy use of hybrid circuits across the entire applications range from military and space systems to consumer products. The importance of hybrids will be underlined in a special evening panel session entitled "Role of Hybrids in the Microelectronic Domain," in which such aspects as interface problems, packaging, and reliability will be discussed by Alfred Levy and Fred Herzfeld of RCA, Harold Larsen of Halex Inc., William C. Littell Jr., of Fairchild Semiconductor, Mick Strief of Beckman Instruments, and George S. Szekely of Aerojet-General.

Microwave. Another evening panel discussion will cover new microwave components, including Gunn and avalanche diodes, microwave integrated circuits, and ferrites. Among the participants will be Harold Sobol of RCA, M. Gilden of Microwave Associates, D.H. Temme of MIT's Lincoln Laboratory, and B.T. Vincent of TI.

The 10 day sessions will cover topics from trimming potentiometers to high-frequency hybrid filters—and almost everything in between.

For further information contact Roger D. Allan, Electronic Industries Association, 2001 Eye St. NW, Washington, D.C. 20006.

Calendar

Quality Control Conference, University of Rochester; Rochester, N.Y., **April 1.**

Numerical Control Society; Stouffer's Motor Inn and Convention Center, Cincinnati, **April 1-3.**

Mathematical Aspects of Electrical Network Analysis, American Mathematical Society; Providence, R.I., **April 2-3.**

International Symposium on Computer Processing in Communications, Polytechnic Institute of Brooklyn; Waldorf-Astoria Hotel, New York, **April 8-10.**

High Frequency and Microwave Power, Radio Standards Engineering Division of the NBS Institute for Basic Standards; Boulder, Colo., **April 14-16.**

Structures, Structural Dynamics, and Materials Conference, American Society of Mechanical Engineers and the American Institute of Aeronautics; Fountainebleau Motor Hotel, New Orleans, **April 14-16.**

Computer Aided Design Conference, IEEE; University of Southampton, England, **April 15-18.**

Joint Railroad Conference, IEEE; Queen Elizabeth Hotel, Montreal, **April 15-16.**

International Magnetics Conference (Intermag), IEEE; RAI Building, Amsterdam, Holland, **April 15-18.**

International Geoscience Electronics Meeting, IEEE; Twin Bridges Marriott Hotel, Washington, **April 16-18.**

Man in his Environment, Technical Meeting and Equipment Exposition, Institute of Environmental Sciences; Anaheim Convention Center, Anaheim, Calif., **April 20-24.**

Conference for Protective Relay Engineers, Texas A&M University College of Engineering; College Station, Texas, **April 21-23.**

Conference on Switching Techniques

(Continued on p. 26)

A-B Type W variable resistor shown about 5 times actual size

The QUALITY is Allen-Bradley—the price is COMPETITIVE! This new Type W variable resistor is a commercial version of the Type G control.

This Type W variable resistor features a solid, hot-molded resistance track for long operating life. Life tests show less than 10% resistance change after 50,000 complete cycles. Noise level is low initially and actually becomes less after normal use. Furthermore, the resolution is essentially infinite, and the low inductance permits operation at high frequencies where wirewound controls are useless.

The Type W control, while only ½ inch in diameter, is immersion-proof. The shaft is sealed with an "O" ring, making it watertight at that point.

Rated ½ watt at 70°C, the Type W can be operated at 120°C ambient with zero load. Nominal resistance values are from 100 ohms to 5.0 megohms.

For complete specifications on tolerances, tapers, and options, please write Henry G. Rosenkranz and request Publication 5212. Allen-Bradley Co., 1201 S. Second St., Milwaukee, Wis. 53204. Export Office: 1293 Broad St., Bloomfield, N.J. U.S.A. 07003. In Canada: Allen-Bradley Canada Ltd.

EC69-1

ALLEN-BRADLEY
QUALITY ELECTRONIC COMPONENTS

*Standard unit with plain bushing and hardware, 20% tolerance in 1,000 piece quantities. Price subject to change without notice.

Meetings

(Continued from p. 24)

for Telecommunications Networks, IEEE; London, **April 21-25.**

Conference and Exhibit, Temperature Measurements Society; Hawthorne, Calif., **April 21-22.**

Spring Meeting, United States National Committee, International Scientific Radio Union, IEEE; Shoreham Hotel, Washington, **April 21-25.**

Symposium on Circuit Theory, Department of Electrical Engineering and Electronics Research Center; University of Texas at Austin, **April 21-22.**

RTCM Assembly Meeting, Radio Technical Commission for Marine Services; Hollenden House, Cleveland, **April 21-23.**

National Telemetering Conference, IEEE; Hilton Hotel, Washington, **April 22-24.**

International ISA Pulp & Paper Instrumentation Symposium, Instrument Society of America; Vancouver, Canada, **April 22-26.**

Relay Conference, National Association of Relay Manufacturers and Oklahoma State University's School of Electrical Engineering; Oklahoma State's Student Union Building, Stillwater, **April 22-23.**

Southwestern Conference & Exhibition, IEEE; Convention & Exhibition Center, San Antonio, **April 23-25.**

Photo-optical Techniques in Simulators, Society of Photo-optical Instrumentation Engineers; South Fallsburg, N.Y., **April 28-29.**

Symposium on Information Processing, Purdue University's School of Electrical Engineering; Memorial Center, Lafayette, Ind., **April 28-30**

Optical electronics, IEEE; Kirtland Air Force Base, Albuquerque, N.M., **April 28.**

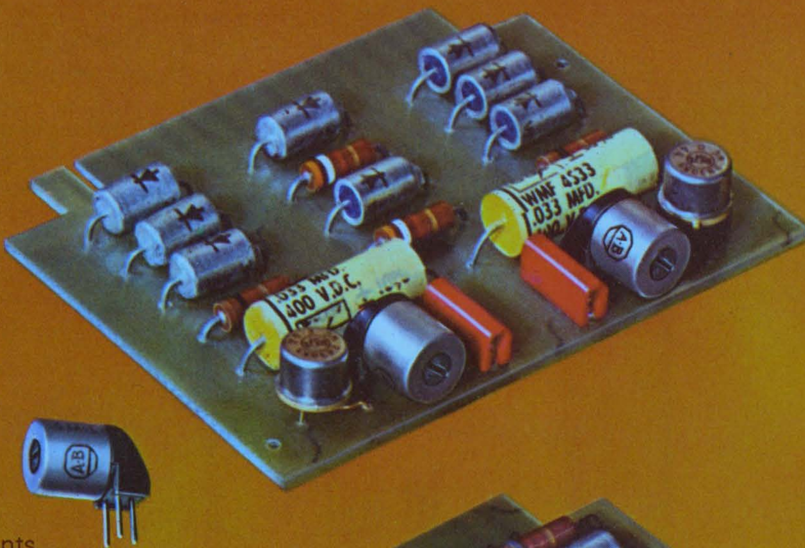
Surface Science, Evaporation and Effusion, American Vacuum Society; Los Alamos Scientific Laboratory, New Mexico, **April 28-30.**

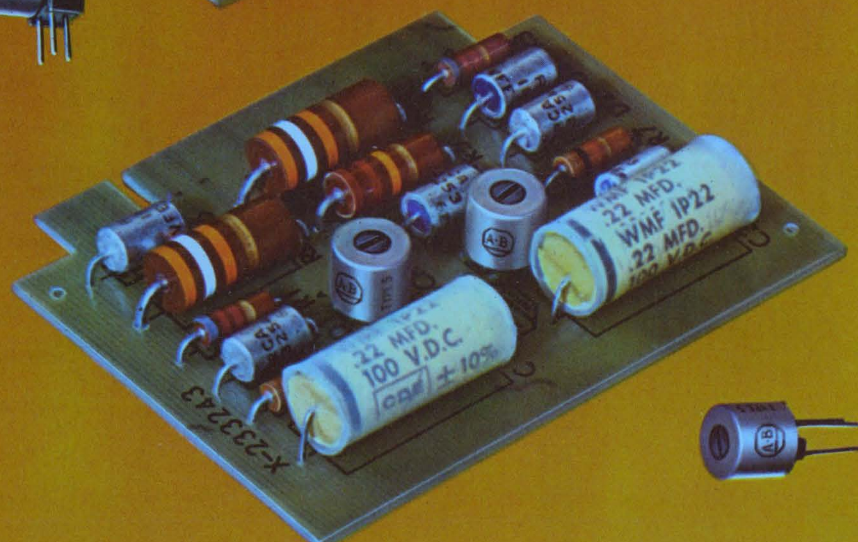
Audio Engineering Society Convention and Exhibition; Hollywood Roosevelt Hotel, Los Angeles, **April 28-May 1.**

Electronic Components Conference, Electronic Industries Association; Shoreham Hotel, Washington, D.C., **April 30-May 2.**

Electronic Components Conference,

(Continued on p. 28)





All components shown actual size

Only the new Allen-Bradley Type S cermet trimming resistors have all these features

Type S
shown twice actual size

for side adjustment

for top adjustment

The Allen-Bradley Type S is a one turn cermet trimmer in which you will find incorporated a wider range of features than in any other trimmer now on the market. Here are a few of the more important features.

- **COMPACT**—body is ⅜" dia.
- **BUILT FOR EITHER TOP OR SIDE ADJUSTMENT**
- **50 OHMS THRU 1 MEGOHM**
- **THE SEALED UNIT** is immersion-proof
- **TEMPERATURE COEFFICIENT** less than 250 ppm/°C over *all resistance values* and *complete temperature range*
- **UNIQUE ROTOR DESIGN** provides exceptional stability of setting under shock and vibration
- **SMOOTH CONTROL,** approaches infinite resolution
- **PIN TYPE TERMINALS** for use on printed circuit boards with a 1/10" pattern
- **VIRTUALLY NO BACKLASH**
- **WIDE TEMPERATURE RANGE** from −65°C to +150°C
- **RATED** ½ watt @ 85°C
- **EXCEPTIONAL STABILITY** under high temperature or high humidity
- **MEETS OR EXCEEDS ALL APPLICABLE MIL SPECS**
- **COMPETITIVELY PRICED!**

You'll find the new Type S trimmer equal to the traditional Allen-Bradley quality. You really ought to know more about the Type S. Won't you write for detailed specifications? Allen-Bradley Co., 1201 S. Second Street, Milwaukee, Wis. 53204. Export Office: 1293 Broad Street, Bloomfield, New Jersey, U.S.A. 07003. In Canada: Allen-Bradley Canada Limited.

567E-6

ALLEN-BRADLEY
QUALITY ELECTRONIC COMPONENTS

Meetings

(Continued from p. 26)

Electronic Industries Association and the IEEE; Shoreham Hotel, Washington, D.C., **April 30-May 2.**

National Instrument Society of America Aerospace Symposium, Instrument Society of America; New Frontier Hotel, Las Vegas, **May 5-7.**

Short courses

Pulse modulation telemetry systems, Purdue University, Lafayette, Ind.; **June 2-6;** $200 fee.

Principles of reliability for engineers, Purdue University, Lafayette, Ind.; **June 9-13;** $160 fee.

Integrated circuits engineering summer institute, University of Arizona, Tucson; Session I, **July 7-18;** Session II, **July 28-August 8;** $1,000 fee for both courses.

Call for papers

National Electronics Conference, NEC; Conrad Hilton Hotel, Chicago, Dec. 8-10. **April 26** is deadline for submission of abstracts to Dr. J. Robert Betten, Department of Electrical Engineering, University of Missouri at Rolla Rolla, Mo. 65401.

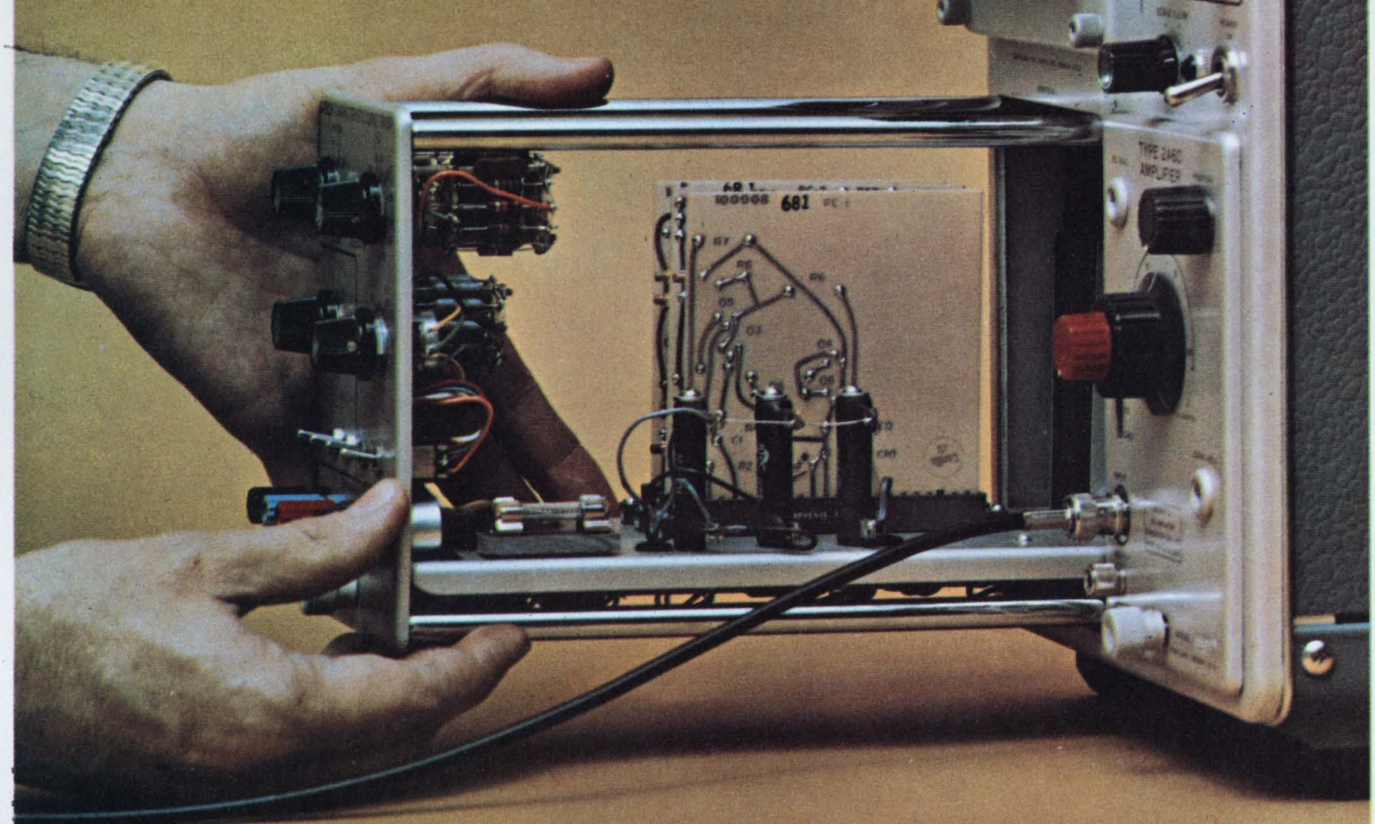
Computerized Electronics, School of Electrical Engineering, Cornell University, Ithaca. N.Y. Aug. 26-28. **May 1** is deadline for submission of abstracts to Conference Committee on Computerized Electronics, School of Electrical Engineering, Phillips Hall, Cornell University, Ithaca, N.Y. 14850.

Symposium on Management and Economics in the Electronics Industry, IEE, University of Edinburgh, Scotland, March 17-20, 1970. **May 1** is deadline for submission of synopses to The Conference Department, The Institution of Electrical Engineers, Savoy Place, London W.C. 2.

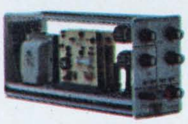
Connector Symposium, Electronic Connector Study Group, Cherry Hill Inn, Cherry Hill, N.J., Oct. 22-23. **May 1** is deadline for submission of abstracts to Technical Papers Committee, Electronic Connector Study Group, P.O. Box 3104, Philadelphia 19150.

Joint Conference on Mathematics and Computer Aided Design, Association for Computing Machinery, Society for Industrial and Applied Mathematics, IEEE; Disneyland Hotel, Anaheim, Calif., Oct. 26-30. **May 1** is deadline for submission of papers to 1969 Joint MCAD Conference, SIAM, 33 S. 17th St., Philadelphia 19103.

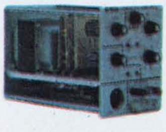
Convert your present scope into a curve tracer: $595.00*



The first plug-in unit that transforms an existing scope into a curve tracer—at ½ to ⅓ the cost!



U-Tech plug-in
Model 681: $595.00*.
For use with Tektronix 560 series **Oscilloscopes.**



U-Tech plug-in
Model 682: $615.00*.
For use with Tektronix 530, 540, 550, 580 series **Oscilloscopes.**

U-Tech Console
Model 683: $625.00*.
For use with any X-Y **Oscilloscope.**

*Prices apply to purchases and shipments within U.S.A. fob Salt Lake City, Utah.

Now you can expand your present Oscilloscope to include curve tracer capabilities. U-Tech plug-in and console units enable any X-Y Oscilloscope to display the dynamic characteristics of both NPN and PNP transistors, N Channel and P Channel junctions, FETs, MOS-FETs, bipolars, unijunctions, diodes, tunnel diodes and SCRs.

So, if it wasn't in the budget before, now it can be, and even if you were planning for a curve tracer, you can now buy two, possibly three, of these units for the price of any other characteristic curve tracer.

Ask your distributor about these U-Tech curve tracer units or order direct.

U-TECH A Division of Industrial Physics and Electronics Company
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☐ Yes, send me curve tracer model ________
Enclosed is: ☐ Check ☐ P.O. ☐ Bill me ☐ Send literature

Name ________ Title ________

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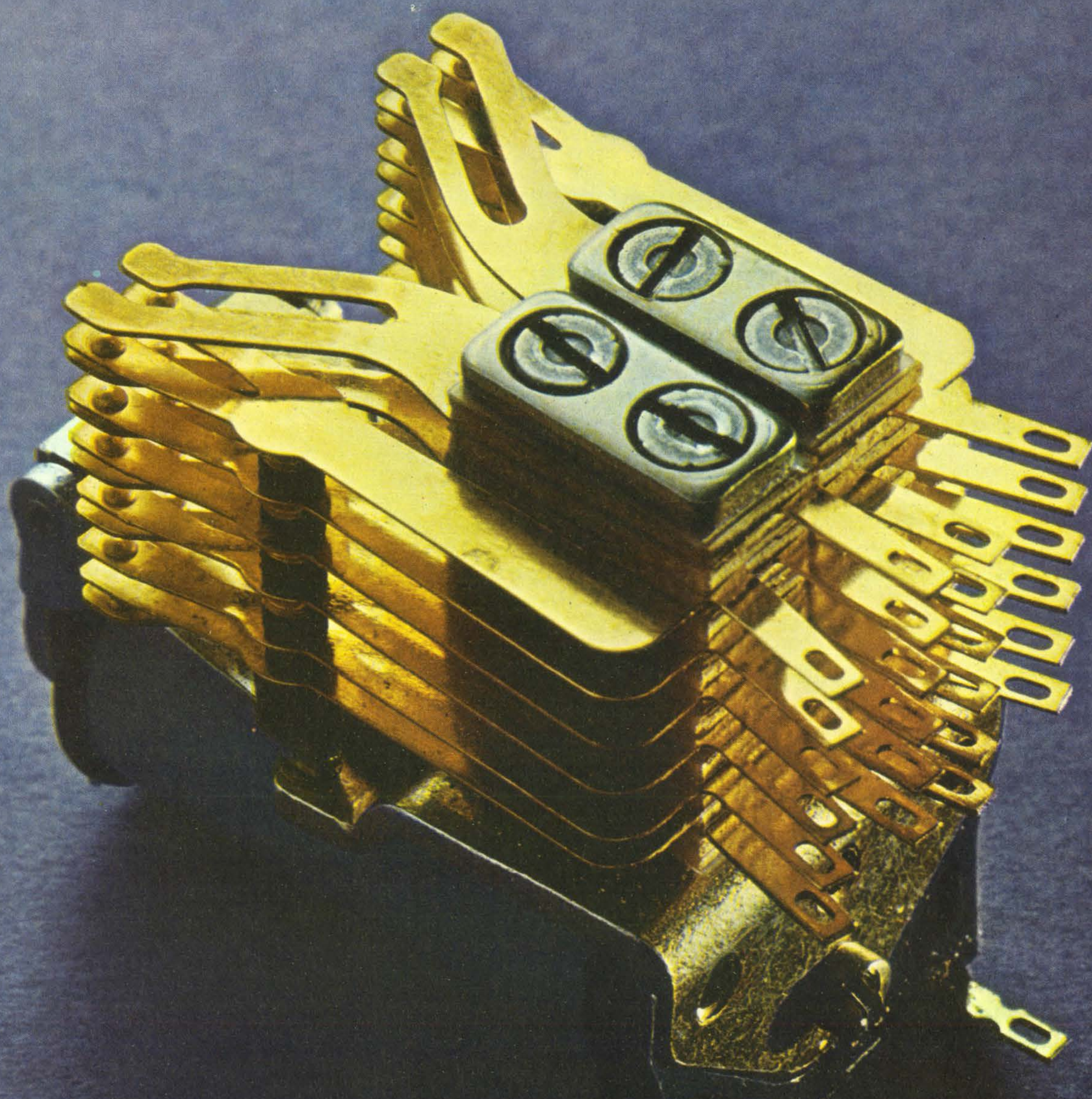
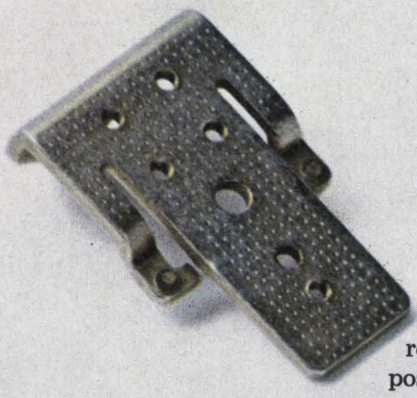
Company Address ________

City ________ State ________ Zip ________

Reliability is six things we do that nobody else does.





We're fanatics.

We build our relays stronger than we have to. That way, they last lots longer than they ever have to. Our Class E relay (shown on the opposite page) is a good example of our way of thinking.

The industry's strongest heelpiece.

We make the strongest heelpiece in the industry. A gigantic machine bangs them out extra fat and extra flat.

Extra fat to carry a maximum of flux. To handle big loads. Extra flat so that once an AE relay is adjusted, it stays adjusted.

Since our backstop is part of the heelpiece, it's just as thick and flat. But, tough as it is, the slightest wear here would throw the entire contact assembly out of whack. So, to be safe, we weld two tiny, non-magnetic pads where the armature arms meet the backstop. You might say we created the no-stop backstop.

Three parts that'll wear like crazy.

When you build a relay like a small tank, you have to think of everything. We try. Right down to the tiniest part. For example, we make our armature arms and bearing yoke extra thick.

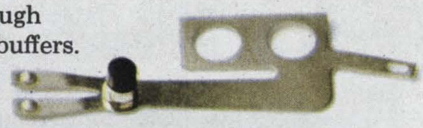
Thicker than years of testing and use say they have to be. Then, to make sure they don't cause wear problems, we insert a hardened shim between the hinge pin and the frame. The pin rides on the shim, instead of wearing into the heelpiece. (You can forget the bearing, it's permanently lubricated.)

Buffers with lots of muscle.

We make our buffers of a special tough phenolic material that lasts. And lasts. And lasts. All without wear or distortion. Another reason why our relays stay in whack.

To make sure our buffers stay in place, we weld the buffer cups to the armature arms. We weld, instead of using rivets, because our lab found that rivets have a habit of falling out.

For the very same reason, we weld buffer cups to the contact springs. And also use the same special tough phenolic buffers.



No, we didn't forget the contact springs.

We have some strong feelings as to what makes a contact spring reliable. Our sentiment is that two contacts are better than one. So, we bifurcate all the springs, not just the make and break. This slotting and the addition of another contact to each spring means you get a completed circuit every time.

We make each set of contact points self-cleaning. The bad stuff doesn't have a chance to build up.

Now, what's different about our bobbin?

Our bobbin is one piece—molded of glass-filled nylon. This provides the maximum in insulation resistance.

Because our bobbin is nylon, we don't have to impregnate with varnish. Moisture and humidity have no effect on the stubborn nylon material. No effect means no malfunctions for you to worry about.

What all this means to you.

What this all adds up to is reliability. The kind of toughness no one else can give you. It means an AE relay works when it's supposed to, longer than it has to.

Isn't this the kind of reliability you really need? Automatic Electric Company, Northlake, Ill. 60164.

AUTOMATIC ELECTRIC

SUBSIDIARY OF GENERAL TELEPHONE & ELECTRONICS

Circle 31 on reader service card

Editorial comment

When it pays to do it yourself

Trying to decide whether a complex integrated circuit is a device or a system is a futile exercise. The arguments on either side generate lots of heat but little light. The answer, of course, is that it's both. And as such, it attracts a proprietary interest at both semiconductor-device makers and large system houses.

Though most systems houses profess no ambitions to compete with device suppliers, more and more of them are setting up their own facilities to make IC's. These are the reasons most frequently given:

- In-house facilities are a source of technical innovation. The designer can immerse himself in the problems of IC design and fabrication. He can develop sophisticated designs impossible with off-the-shelf devices, thereby gaining a competitive advantage for his company.
- Home-based facilities narrow the communications gap between IC designer and manufacturer that usually crops up when outside suppliers are involved.
- By studying IC technology firsthand, systems makers can exert a greater influence on the design and fabrication of devices at a supplier's factory. In fact, such knowledge makes the system designer a more perceptive buyer of IC's.
- An in-house facility can handle those production runs that are too limited for a large semiconductor firm. At Lockheed, for example, an official notes: "A large IC order for satellites is rare. In one case, each of five birds had black boxes containing 20 identical circuits, for a total of 100 circuits." No semiconductor house would touch such an order unless the circuits came close to matching an existing device or at least a device similar to one in research and development.
- An in-house capability permits a systems maker to control its own device delivery times and quality.
- Since the proliferation of IC's tends to chip away at system assembly requirements, some systems manufacturers feel it's necessary to make some of their IC's in-house to retain their share of value added.

In sum, the systems house may maintain its own facility either to help design the IC's best suited to its own applications, or to actually produce a portion of the circuitry it uses.

Those systems makers that follow the second course should heed the advice of Texas Instruments' Jack Kilby and concentrate on IC's that aren't generally available outside or are peculiar to the equipment they build. ■

Toward better communication

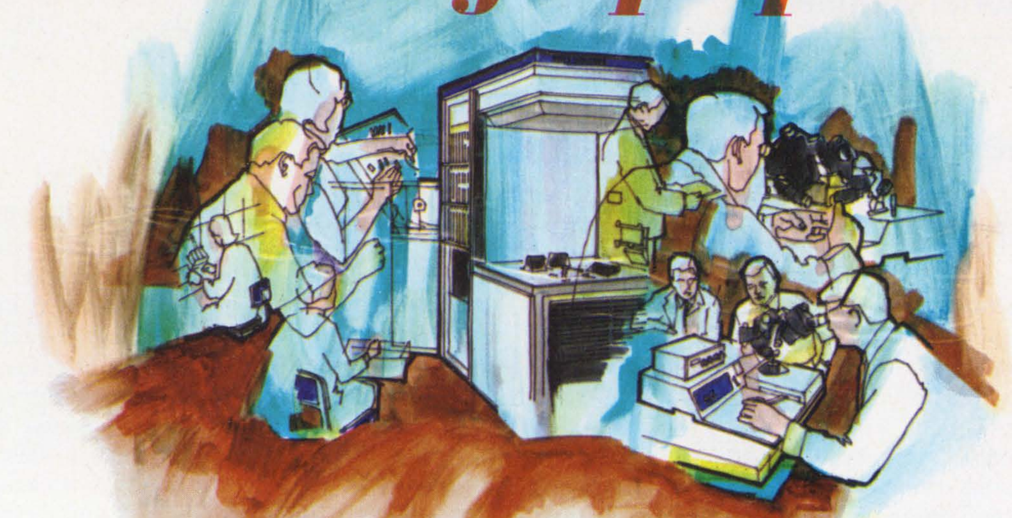
Computer-aided design plays an important part in the development of complex integrated circuits. It comes into play at many stages of the design cycle, from definition of functions to final testing of the circuits. But as Rudolph Thun of Raytheon's Missiles Systems division observes (page 85), the CAD chain must be broken at some point. Here, the systems house steps out of the picture and the device manufacturer takes over.

To ease the division of labor, Thun suggests that semiconductor makers and systems houses adopt a common form of documentation covering software schemes, programs, and formats. And William Dunn of Sylvania's Semiconductor division notes that the semiconductor manufacturer can help by making its wiring rules, specifications, guard bands, and other standards available to customers.

Another approach is being tried by Fairchild Semiconductor, which makes its own CAD programs available to selected systems houses.

The goal of common software is commendable but may prove unattainable. A worthwhile first step, though, would be to unscramble the semantic confusion (by basing IC definitions on MIL/STD 1313, for example). ■

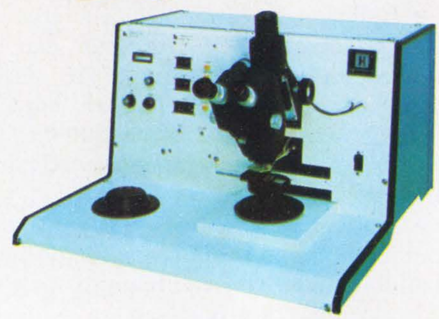
from the leader in assembly equipment



Advanced bonding equipment for every semiconductor assembly requirement.

MODEL 1350 ULTRASONIC WIRE BONDER

- Handles hybrids and LSI IC's up to 3" across
- Stitch bonds continuously at multiple levels
- Bonds wire with automatic feed and cut-off



MODEL 2000 FLIP CHIP BONDER

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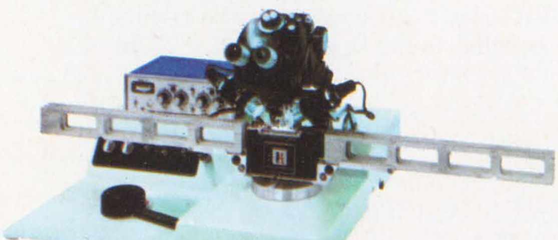

MODEL 1370 RACK FEED ULTRASONIC BONDER

- Hi-speed transistor bonding
- Production bonding of 14 lead IC's
- Bonds up to .020" wire for power device production

MODEL 2100 UNIVERSAL ASSEMBLY MACHINE

- Automatically bonds beam lead devices
- Thermocompression flip chip and die bonding
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Electronics Newsletter

March 31, 1969

Burroughs readies plasma display panel

Burroughs is about to introduce its own plasma display panel, hard on the heels of the Owens-Illinois Digivue [see "Flat display has inherent memory," p. 133]. Both displays are based on work done at the University of Illinois by D.L. Bitzer and H.G. Slottow [*Electronics,* July 22, 1968, p. 39].

Burroughs, unlike Owens-Illinois, has retained the three-layer sandwich design of the Bitzer-Slottow model. Plasma displays—under development at a dozen or so labs around the world—have suffered from a common problem: high voltage punching through the insulation. Owens-Illinois and Burroughs have apparently found solutions, **although both designs require more than 100 volts to operate.**

Two firms ready new processors for digital signals

Two companies will introduce digital signal processors at the Spring Joint Computer Conference May 14. **Both systems perform fast Fourier transforms, convolutions, averaging, and auto- and crosscorrelation.** Applications should range from seismic data processing to speech studies and biomedical research.

Raytheon's Computer division will announce its peripheral processor called ATP (for array transform processor). ATP works with the firm's small 16-bit computers (models 703 and 706); software shunts lengthy, repetitive operations of fast Fourier or other techniques into ATP's hard-wired processor to speed filtering or correlation. **Fast Fourier is said to be 80 times faster with the ATP** than on a Raytheon 703 computer alone. First deliveries are forecast for autumn.

By contrast, Computer Signal Processors' CSS-3 is a stand-alone system with a 4,096-word memory, a built-in 16-bit general-purpose processor, plus teletypewriter input and crt output. According to the company's president, Edmund U. Cohler—designer of Sylvania's ACP-1—the CSS-3 is about a tenth as fast as hard-wired processors, but more flexible because it has a large library of software to suit it to other tasks and to allow further processing of data after such things as filtering and correlation. Deliveries will start in May.

TI's MERA arrays ready for market . . .

Now that MERA solid state phased array is pretty much under control, **Texas Instruments will begin a major program to market the MERA modules and the hybrid integrated circuits from which the modules are built.** TI has spent millions of dollars on the MERA (Molecular Electronics for Radar Applications) program; costs were shared by the Air Force. Next month TI will test a quarter-array of 151 radiation elements. **The full 604-element array will be ready for test by mid-May, the company says.**

Meanwhile, TI has been selling some of the circuits and modules on an evaluation basis. Now it is ready to go all out to sell microwave IC's and recoup the expenses of the painful development period. Difficulties in transferring devices from development to production delayed MERA considerably, but now TI figures it is ahead of the field since it now has a total capability from discrete devices through thin-film fabrication and hybrid IC design.

The MERA circuits include a 500-megahertz intermediate-frequency amplifier, an X-band mixer, a local oscillator multiplier, an S-band small-signal preamplifier, an S-band power amplifier, a transmit and receive switch, and a times-4 multiplier.

TI is also selling microwave sources, both transistor-multiplier and bulk-effect types (the latter for frequencies at X-band and above), and it is making a line of Gunn diodes.

. . . Honeywell places first module order

Honeywell's Aerospace division is among the first to buy the MERA microwave modules. According to John King, the division's manager of contracts, Honeywell has ordered 25 of the thin-film strip line devices for the PRC-95 identification-friend-or-foe Tacan transponder. This is a cigarette-pack-size transponder that downed fliers use to signal for help. Honeywell, according to King, expects to receive the first breadboard models in four months, two prototypes in about six months, and the 25 pilot production versions in about 10 months.

NASA, Air Force weigh joint projects

The heads of the Air Force and NASA have indicated that a major shift in space policy may be in the offing. NASA Administrator Thomas O. Paine has suggested that **a joint NASA-Air Force development program might be pursued for such programs as space shuttlecraft and a shuttle launch complex.** And Secretary of the Air Force Robert Seamans Jr. made a similar proposal at the same Air Force Association meeting.

If NASA and the military do team up on such projects, it would be the space agency's first major leap into military work.

Real-time monitor for DC-10 airbus

What may be the first real-time data acquisition system to monitor new commercial aircraft during certification tests will begin to be installed this summer or fall at the Douglas Aircraft division of McDonnell Douglas and will be used to check out the DC-10 airbus.

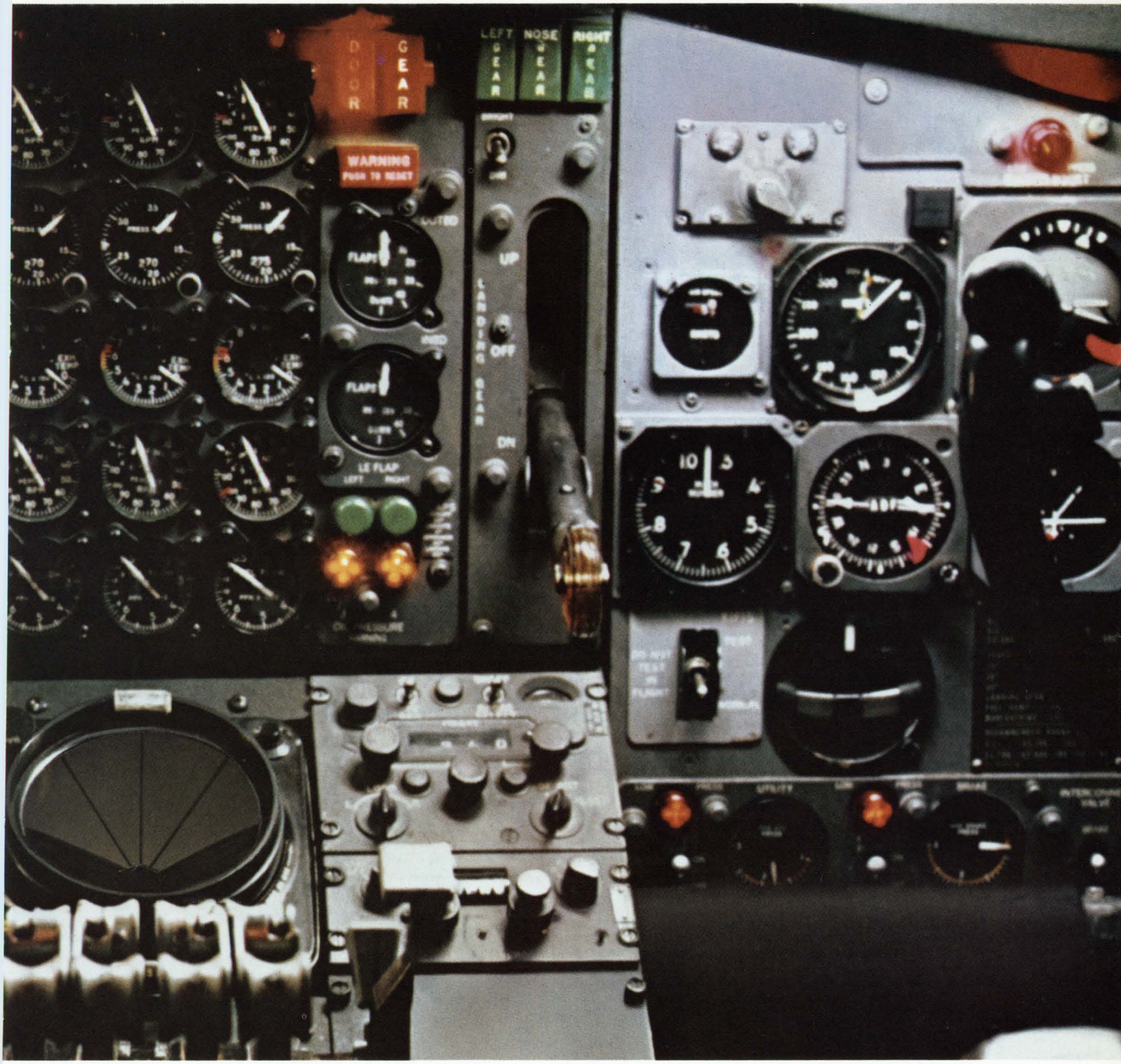
Scientific Data Systems is supplying a Sigma 7 and three Sigma 2 computers for the ground-based flight test data-processing facility at Long Beach, Calif., under a $3.3-million contract. The system is believed to include a pulse-code-modulated telemetry link for aircraft-to-ground data transfer, plus graphic terminals to be provided by Sanders Associates.

NASA aims grants at 'software gap'

NASA's **Electronics Research Center will soon announce more than $400,000 in research grants aimed at narrowing the "software gap."** According to David Van Meter, head of the center's computer research laboratory, hardware production is much faster and better organized than software development. As a result, new machines often stay idle while software problems are solved or use—inefficiently—software designed for earlier computers.

Proposed research areas include unified processor-software design, highly adaptable general-purpose computer languages, computer-assisted software design, and software subdivision to permit both serial and parallel operation in multiprocessors. The program is open-ended, says Van Meter, and the research grants are expected to run for five years or more.

The grants will go to scientists at the Universities of California, Maryland, and Texas; Stanford University, MIT, Case-Western Reserve University, and the Rand Corp.



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in electronics?

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Components manufactured by O/E/N companies are vital in keeping today's jets flying. On the control panel you'll find pushbuttons, indicator lights, thumbwheel and rotary switches. In communications systems...crystal filters and oscillators, and potentiometers. And elsewhere, from the cockpit to the tail . . . relays, solenoids and electronic insulation.

Each component is engineered to provide instant, accurate response, as well as compact, clean and readable visual information. We're in ground control equipment, up in the jets, and even beyond . . . in aerospace. We're a single source of supply for a variety of components used by almost every industry today.

Matter of fact, we're not sure where we'll be next. Our R/D people are a restless lot, never satisfied, always trying to make something better. This constant updating of technology has been O/E/N's driving force.

Here are a few highlights and we'd be pleased to tell you even more about them. Write for individual product literature and/or booklet describing O/E/N, its companies and products.

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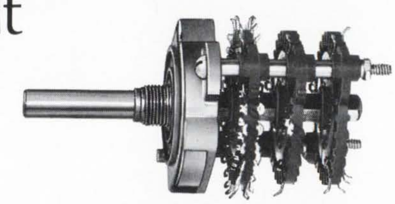


Multidex switches were engineered to meet the increasing demands for flexible and fast designs faced by today's electronic engineers.

This versatile switch line offers an almost unlimited number of variations of the most popular options and features and eliminates much tedious design work for the engineer. In fact, it is his best choice to replace seven older sizes and types of switches. What's more, Multidex switches are smaller and yet provide more contacts (even 32 and 36 positions).

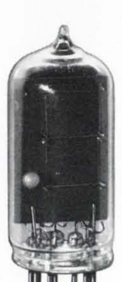
Detent mechanism offering a crisp, uniform action is available in a wide number of throws. Diallyl phthalate insulation is used and Oak-pioneered double-wiping contacts are a further guarantee of dependable operation.

If rotary switch design is your job, you'll want full details on the versatile, new Multidex line of rotaries.

OAK MANUFACTURING CO.
Crystal Lake, Illinois 60014

Reader Service Card No. 311

O.K., now... by the numbers!



Zero to nine (optional decimal point) daylight visible and from wide angles . . . that's LAMP's new filament readout Numeralamp. This 4-volt AC/DC lamp offers 200,000 hours average life. Numerals (0.4" x 0.7") formed by seven tungsten filaments operating at 1800°K., emit 4,000 foot-lambert brightness. Filaments are the type used in Military Standard lamps of high reliability and duration.

Lamps, (2.1" high x 0.83" dia.) sealed in a standard 9-pin vacuum tube base, mount on 1" centers.

LOS ANGELES
MINIATURE PRODUCTS
17000 South Western Avenue
Gardena, California 90247

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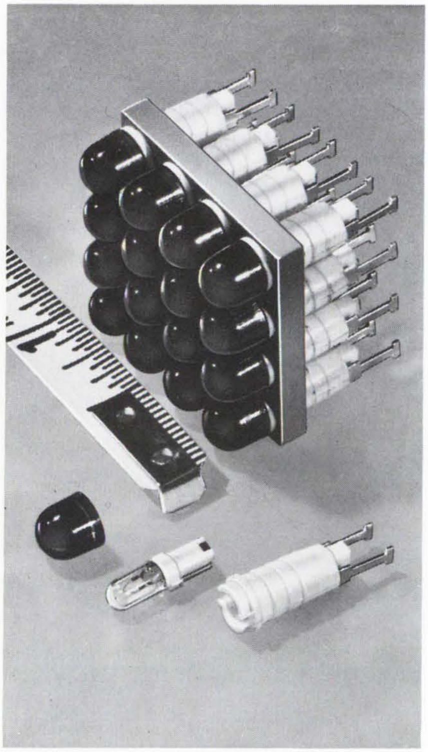


dot-lite lamps aim high

They're a natural for computers, but the extremely small size and high brightness of these bantam-weight indicator lights makes them a logical choice for sophisticated airborne displays as well.

Sixteen of these tiny T-1 units can be mounted in a single square inch of panel space and the lamp base snaps right into the panel mounting holes (without any hardware) on 0.218 centers.

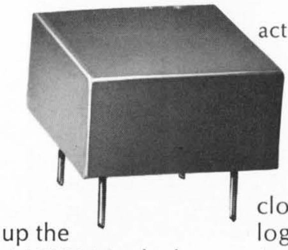
In addition, the T-1 lamp can be replaced in just seconds, from the front of the panel, without tools.

There's no guesswork in replacing lamps either, as far as proper voltage rating is concerned. Lamp ratings range from 1.5 V to 28 V and each base is color-coded for instant identification. Snap-on lens caps are available in a wide choice of colors and shapes.

MARCO-OAK
P. O. Box 4011
207 S. Helena Street
Anaheim, California 92803

Reader Service Card No. 313

midget tick-tock for computers



actual size

Compact, inexpensive, versatile—sums up the reasons for designing McCoy's new MC109A1 clock oscillator into computers and peripheral equipment. It's only 1" square by ½" high, yet offers output over the entire 30 kHz to 50 MHz range. It holds ±150 ppm maximum from −55° to +105°C. over the 30-650 kHz range, ±50 ppm from −55° to +125°C. over the 180 kHz to 50 MHz range. Over smaller temperature ranges, even better stabilities are possible.

With an input voltage of only 5 vdc (±5%), this clock oscillator is compatible with DTL, RTL or TTL logic. Meets all requirements of MIL-E-5400, class 2 (commercial versions also available). While the basic styles give general capabilities, all electrical specifications are variable and can be altered for specific requirements. Delivery time is 2-6 weeks, depending on frequency desired.

McCOY ELECTRONICS COMPANY
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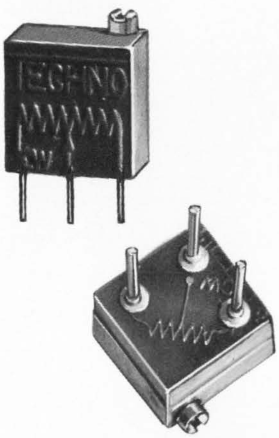

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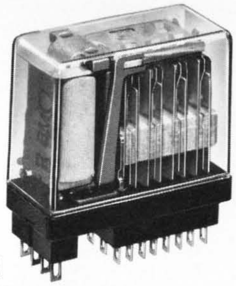

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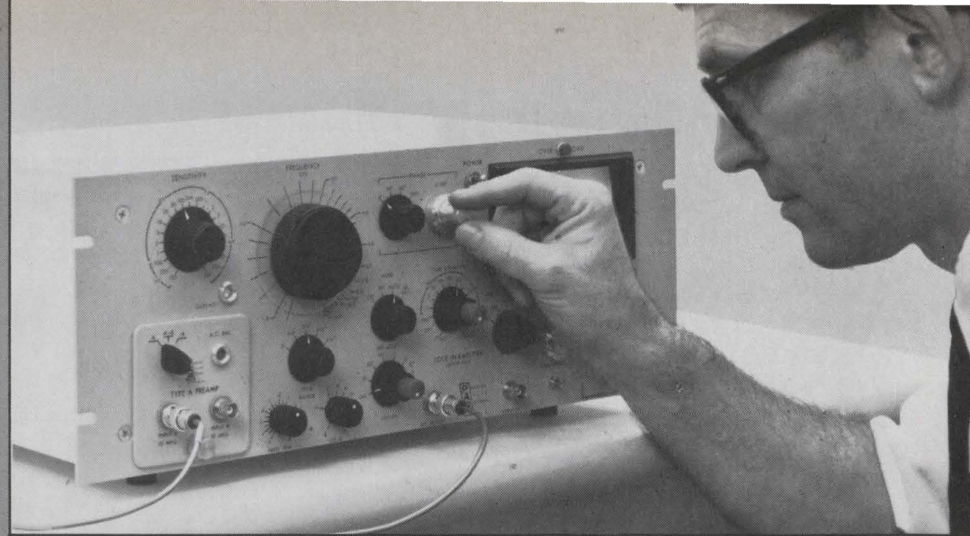

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MEASURE AMPLIFIER CROSSTALK TO ONE NANOVOLT

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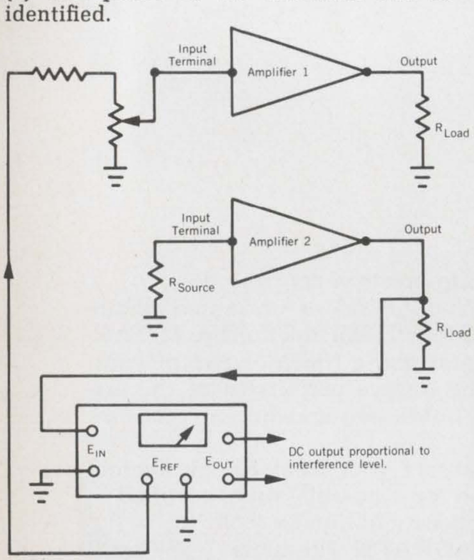

LOCK–IN AMPLIFIER
USED FOR AMPLIFIER CROSSTALK MEASUREMENT

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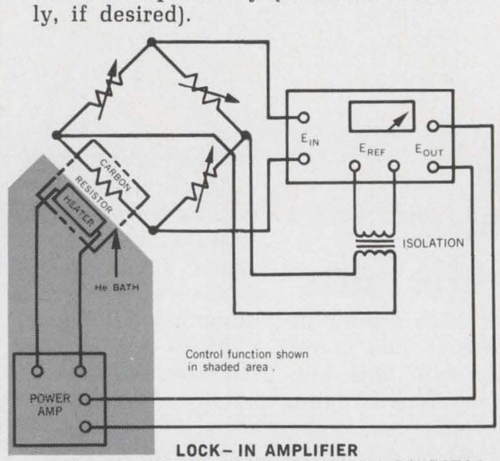

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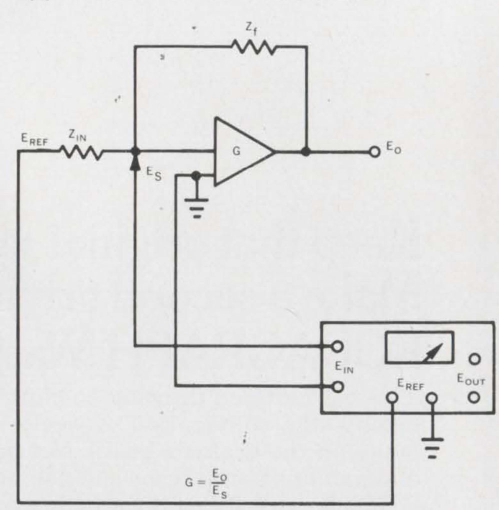

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PRINCETON APPLIED RESEARCH CORPORATION

Phased array's analog method keeps antenna beam shaped up

Ryan technique needs no beam-steering computer, has step recovery diode capable of both frequency multiplication and phase shifting

Most phased-array radars being developed today use ferrite or p-i-n diodes to perform digital phase shifting because simple analog phase shifters haven't been available. One-bit systems shift the phase 180°, two-bit systems shift in 90° increments, three-bit systems in 45° steps, and four-bit units in steps of 22.5°. Thus, if a phase shift of only 20° is desired in a three-bit system, the 45° step limitation can lead to significant phase errors resulting in unwanted sidelobes and pointing problems.

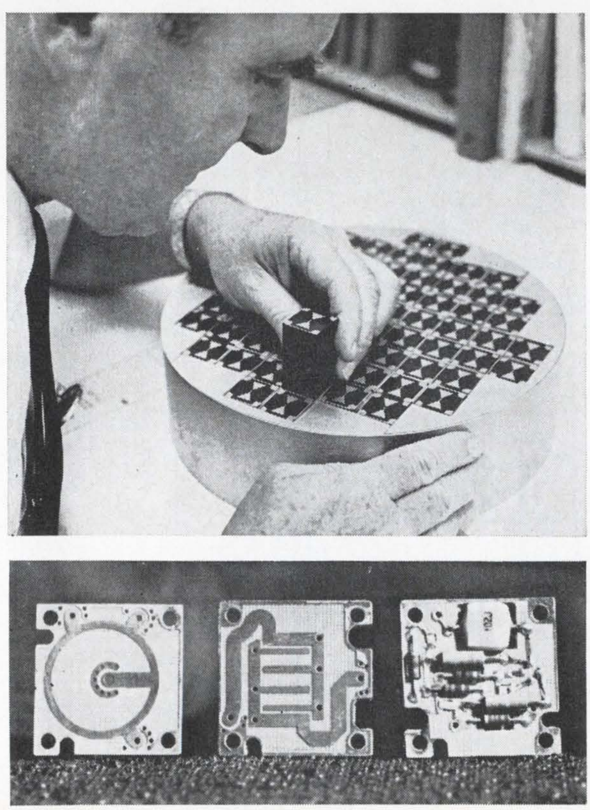
For radars using very large antennas—500 or more elements and gains greater than 33 to 35 decibels —these errors average out to become almost unnoticeable. John Aasted, program manager for phased-array development in electronic and space systems at the Ryan Aeronautical Co., maintains this error averaging is the reason digital phase shifting is so popular in large phased arrays. These systems often use beam-steering computers to help shape the beam. But for smaller systems, in which a beam-steering computer would be an expensive extra, phase errors can become intolerable.

To solve the problem, Ryan has developed a phased array which changes phase by an analog method that combines phase shifting with signal generation in a frequency multiplier, completely eliminating the usual phase shifters [*Electronics*, Sept. 2, 1968, p. 102].

Delivery. Ryan has just delivered a prototype of a combined acquisition and tracking radar incorporating this novel design to NASA's Manned Spacecraft Center. The prototype could be used to assist in rendezvous with a disabled spacecraft, to identify and track space debris, or to track meteorites. The array has 16 elements, each putting out 0.25 watt at C band. Each module is 1 by 1 by 3 inches deep, and contains a "bow tie" antenna, a transmitter, a receiver, and a circulator to isolate transmission and reception on the antenna.

But the part of the unit that Ryan officials believe is unique is a step recovery diode capable of both frequency multiplication and phase shifting. Aasted says its adoption resulted from a search for a way to electronically steer the beam of antennas such as the one the firm provides for its landing radar on the lunar module for project Apollo, which is a fixed-beam unit but not all solid state. Ryan wanted an all solid state system for its next generation of radars. Aasted believes the array just sent to the Manned Spacecraft Center is the first all solid state phased array to be delivered to a Government agency.

As with ferrite or p-i-n diode phase shifters, the Ryan system begins with a master oscillator, splitting the signal to each module in the array. But there the similarity ceases. The signal is generated at about 200 megahertz, boosted in frequency by the step-recovery diode which is used as a 10-times frequency multiplier, "and then we



Steering. Phased-array radar developed by Ryan uses analog techniques, eliminating the phase shifters, which often add errors to the beam steering. Prototype of acquisition and tracking radar has been delivered to NASA. Array contains 16 elements, each emitting 0.25 watt at C band. The module measures 1 by 1 by 3 inches. Shown is earlier 68-element array built for Army.

vary the bias of the diode so that the output is not only multiplied but phase shifted," Aasted explains. One step-recovery diode is used in each module. Ordinarily, in a system using ferrite phase shifters, the shifters would be inserted after the multiplier.

Aasted has no firm cost comparisons for the Ryan method compared with more conventional phase shifting, but he says the Ryan method achieves high gain at a lower cost than a system using transistors to boost the signal, and he maintains efficiency is better. "The cost of transistors at 2,000 Mhz is several thousand dollars, but the step-recovery diode at 200 Mhz is a fraction of that. Besides, we don't need the beam-steering computer."

Solid state

Canned heat

Outside temperature changes can wreak havoc with the performance of electronic circuits, and as a result, sensitive military test and communications equipment must take those changes in stride.

Designers generally try one of two things: let the user sense the temperature and then compensate for the performance change; or build the key circuits into an "oven" to keep them at a constant temperature. But the user method is cumbersome and subject to human error, and the oven takes up weight, space, and power in restricted military environments.

However, Bendix Corp. engineers think they have a better way. They have put the sensitive integrated circuits on a "hot plate" inside a TO-8 or TO-5 can. Besides being a simple and small circuit, the "hot plate" could keep an operational amplifier, for example, within ±0.5°C of the desired temperature over most of the military range of −55°C to +125°C, according to Norman Green, director of the new device development section at the Bendix Communications division in Towson, Md. Prototype r-f voltmeter diode probes using this principle are now being delivered to the Navy for the versatile avionics shop test (VAST) system.

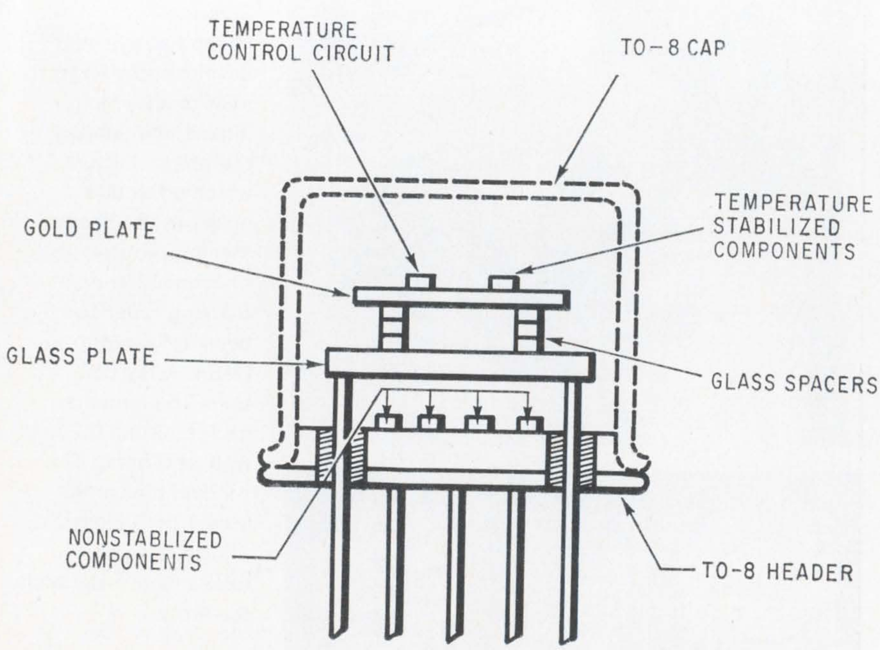
Hot seat. Essentially it's a hybrid bridge temperature-feedback circuit, for which Bendix is applying for patents. The design consists of a proprietary configuration of three transistors, one thermistor, and two diodes acting as a thermostat and heater for a gold substrate, the "hot plate." These in turn are mounted on a glass substrate suspended from the header of the TO-8 can by the leads.

In the bridge, the collector of one of the transistors and the thermistor are mounted on the gold substrate. The collector, by dissipating power through the substrate, becomes the heater. The thermistor provides the feedback to the circuit by keeping its resistance constant, which in turn controls the power the collector dissipates. The four arms of the bridge are composed of the thermistor and the three resistors while the other two transistors sense imbalance in the bridge.

The 100-by-130-mil gold substrate is like a table, which is supported by four 20-square-mil glass legs, about 27 mils above the 20-by-130-by-360-mill glass substrate. The glass legs and substrate act as insulators. Those components that need to be temperature controlled are mounted on the gold table; those that need not be can be mounted on the header.

Flipped out. In the present design the feedback circuit takes up half the area of the hot plate. Bendix has already developed designs where the hot plate can be flipped so that the feedback circuit is underneath and the top of the table is clear for larger audio oscillators or op amps. But Green hints that his group "is working on new geometries which won't even look like this," and won't be as costly.

There are other single-purpose temperature-controlled microcircuits being built. Fairchild Semiconductor, for example, makes a temperature-controlled preamplifier which sets its own temperature. "The Fairchild circuit has its own oven," Green comments. "Ours controls anything that can fit on it."



Hot plate. Bendix's answer to the problem of temperature changes features small heating circuit inside a TO-5 or TO-8 can with component itself.

Optoelectronics

Holograms for cops

Despite the obvious advantages of automatic fingerprint matching and identification systems, most of them have been greeted with blank stares by police agencies. The lawmen have found the systems—some of which have been knocking around labs for a long time—incompatible with present setups and hard to operate.

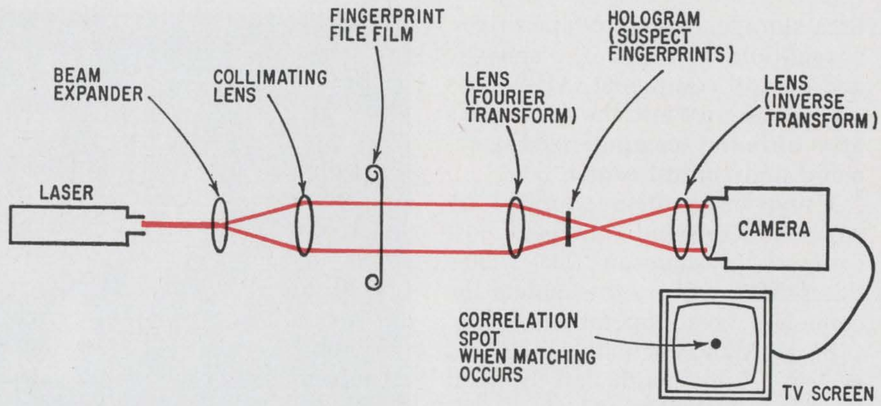
But the Conductron Corp. of Ann Arbor, Mich., thinks it might be able to turn the stares into smiles with its Confess (for Conductron fingerprint electro-optical search system). The company says Confess, currently a lab model, could go through the New York City Police Department's file of about 1.5 million prints in less than two minutes. It now takes 100 employees about 15 minutes to identify a suspect's print.

"It's the only automatic system we've seen so far that looks like it's going to work," said a New York police official. In early April, the department will witness tests by Conductron. "If the tests are successful," says the official, "we'll recommend the system to the Federal Government to try to get a research grant."

Bright spot. The technique, which has aroused the interest of a number of police agencies around the country, is based on the matching of a hologram with a photograpic film containing a library of fingerprints. A print taken at a police station is forwarded to the fingerprint bureau, which makes a transparency of it. A holograph is then made of the transparency and inserted into a holder on an optical bench. On the bench, laser light passes through two lenses that expand and collimate the beam. The film, driven by a servo motor, is run until a bright spot appears on a television screen. This occurs when some print on the film matches the holograph. The film can be rewound by hand to zero in on the correct print.

The technique works because the film print and holograph are complex conjugates of each other. This permits pure laser light to strike the camera aperture, causing the bright spot. The system is analogous to the transferring of maximum power when two networks are complex conjugates of one another. In both cases, the output intensity is maximum.

The phenomenon in optics rests on the Wiener-Kinchin law of cross-correlation. That law deals with the Fourier transform of one function correlating with, or multiplying, the complex conjugate of a second function. In Confess, the second function is the holographic pattern, which is actually a record of the complex conjugate of the suspect's print. It is constructed away from the bench by a filter generator.



Fingerprint matching. Optical correlator bench in Conductron's Confess system. When file print matches sample, reference beam is seen as spot on crt.

The first function is the print pattern. The beam passes through the film, picking up its information, and gets Fourier transformed through a lens. It then goes through the holograph and an inverse transform lens onto the camera lens. When a match occurs, the two patterns multiply as autocorrelations; the beam, carrying no film or holographic information, produces the bright spot.

Headache. Conductron plans to market Confess this year at $750,000. This includes the bench, a transparency generator, and the filter generator, but not the camera and display unit.

The system can't now holograph latent prints on door knobs, weapons, or the like, but Conductron is working on this.

The headache that remains, according to law enforcers, is putting central files onto film. "It would be a helluva job converting the 18 million fingerprints of our criminal file into film" says an FBI official. "Then, too, we'd have to make holograms of each of the 30,000 prints that come into the bureau for identification each day."

The FBI says it isn't interested in Confess now. It is pinning its hopes on another type of optical system—compatible with its inked file—being developed under FBI contract by Cornell Aeronautical Laboratory and Autonetics. The work, due to be completed this summer, is based on flying-spot scanning techniques that can discern certain whorl and loop structures on fingerprint cards and match them with those on file.

Computers

Wild blue data

The Strategic Air Command uses flying command posts designed to ensure control after nuclear attack; these EC-135's are called Paccs, for Post Attack Command and Control Systems. To follow Paccs are the Advanced Airborne Command Post (AACP) and the Airborne Warning and Control System (Awacs)—systems that will make heavy use of on-board electronic data processing gear, which SAC doesn't have yet.

But last week, the Air Force Electronic Systems division of Bedford, Mass., began flight tests of a Paccs aircraft equipped with a data processing system supplied by RCA's Aerospace division, Burlington, Mass.

ADA and VIC. Called ADA for Airborne Data Automation, the system is built around RCA's VIC variable instruction computer [*Electronics*, March 17, p. 36]. Together with five cathode-ray tube display and keyboard consoles, a 100-megabit twin-drum mass memory, core data storage, magnetic tape drives, a real-time clock, and diagnostic and control equipment, ADA turns a Paccs aircraft into the Air Force's first airborne computerized command and control center.

Using information supplied by SAC's underground command post computer system—an IBM 7090—Paccs-ADA will try to simulate the command post's operation aloft.

Paccs-ADA is actually an austere system, built with off-the-shelf hardware, some of which wasn't designed to fly. Thus the Air Force is probing the potential of airborne data processing without paying for specially developed gear. The cost of the two-year Paccs-ADA procurement is therefore estimated at a relatively low $5 million.

Answers. Paccs-ADA is a one-time procurement designed for a specific mission, according to Lt. Col. Robert F. Macko, the project officer. "Paccs-ADA is to determine how effectively a man can use electronic data processing in the air: can he make decisions on the basis of stored data; is the data readily available in a form he can use; is there enough data and can it be properly organized? These are the sort of questions we need answered about the man-machine interface. While we are sure that Paccs-ADA will outperform a nonautomated system, the insight gained in these flights will demonstrate just how much of an improvement computers buy us," says Macko.

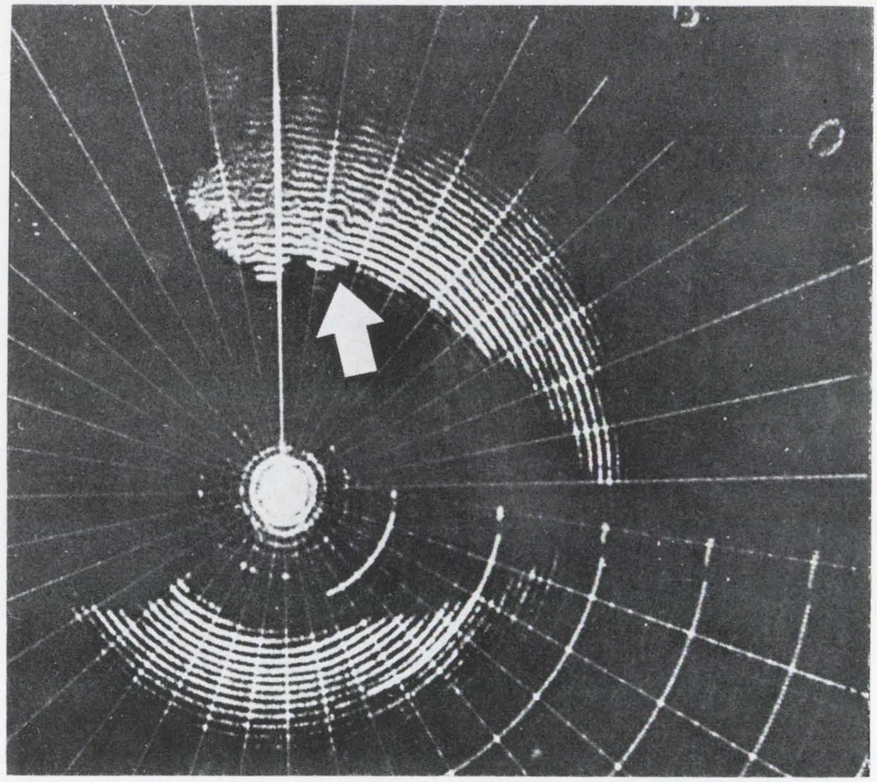
Some of the information will help the Air Force reinforce arguments for AACP and Awacs. And, according to Macko, who is also AACP project officer, "ADA's procurement already has taught us enough about airborne EDP for good estimates of advanced hardware needs."

Mass memory is one example. Later systems are almost sure to take a different tack from Paccs-ADA for a couple of reasons. Paccs-ADA's memory drums spin like gyroscopes and try to process as the aircraft maneuvers. Resulting forces strain bearing structures, distort the drums, and thus could cause loss of data during readout because of head drift.

Weight. The drums are also the heaviest single Paccs-ADA component, weighing 1,490 pounds out of a 4,290-pound total, and Macko says that lighter, smaller systems will probably be a must in future memory systems. Thus it seems that AACP or Awacs might use plated wire, woven wire, etched Permalloy, or thin-film memories. Each of these was investigated by RCA. Some were dropped to keep Paccs-ADA's cost down; others weren't readily available.

Temperature extremes and high humidity have also troubled Paccs-ADA hardware. "After a heat or cold soak, for example, it has taken far longer than desirable to get some parts operating at spec," according to Maj. Albert J. Pikul, the Electronic Systems division's Paccs-ADA flight test director. AACP or Awacs equipment will face tough environmental specs.

The tribulations of hardware procurement for Paccs-ADA may have helped the system meet one of its major goals by supplying data for future advanced system procurements. But some secondary areas can be explored only during the 13 months of test flights.



Turbulence on display. Doppler radar techniques are used to detect wind vortex patterns. Wavy lines in display distinguish the turbulent air from constant wind flow.

Avionics

Shear look

Ground-based doppler radar techniques have been used experimentally to spot shifting storm winds, so hazardous to aircraft, by detecting precipitation or cloud formations. But although these techniques can measure wind speeds, they can't adequately chart dangerous wind vortex patterns—much less plot them in real time on a radar scope.

At the Air Force's Cambridge Research Laboratories, however, researchers are experimenting with an approach that promises to accurately distinguish between turbulence and constant wind flow as well as display the turbulence patterns. Called Plan Shear Indicator (PSI), the new display mode "forgets about wind velocity measurement and concentrates on how the wind is changing in a small space," says Ralph J. Donaldson Jr., a research physicist at the lab. "If the wind speeds are changing in one direction, then they'll change all

the patterns in every direction." PSI indicates disturbed wind patterns along the beam.

The PSI display for a scanning doppler radar uses an ordinary scope in which a coherent memory filter handles intensity modulation. The coherent memory filter performs a frequency analysis at all ranges of the doppler signal returned by precipitation or clouds. When displayed on the scope, the output of the filter allows the operator to distinguish easily between turbulence and constant wind flow. By converting radial measurement to displacement measurement at regular intervals, PSI displays wind pattern in concentric arcs.

Arc types. Thus, radial turbulence, or shear, is indicated by gaps or bunching of the arcs; tangential shear is indicated by wrinkles in the arcs. Turbulence on a scale smaller than measurable wind shear broadens the doppler spectrum and is shown by an increase in the thicknesses of the concentric arcs.

Conventional-pulsed doppler radar uses a range gate at the selected range interval, a boxcar circuit to search the return signal, and a bank of parallel bandpass filters to perform the frequency analysis.

The coherent memory filter provides real time analysis at all ranges. It consists of a summing network; a delay line and associated amplifiers; a single-sideband mixer, the output of which is the sum of the input frequency and the scanning frequency; a frequency generator, the period of which matches the radar pulse width; and an envelope detector, which converts the filter's infrared region to video output. The filter essentially equates a frequency shift with a linear time-varying phase shift.

PSI achieves the real-time capability at the cost of mediocre resolution of ranges and wind speeds. But tests so far with various kinds of storms near the Sudbury, Mass., site show that PSI can make a distinction between turbulence that endangers aircraft and that which doesn't. Effectively, this would give airfields and pilots up to an hour's warning of dangerous approaching storms.

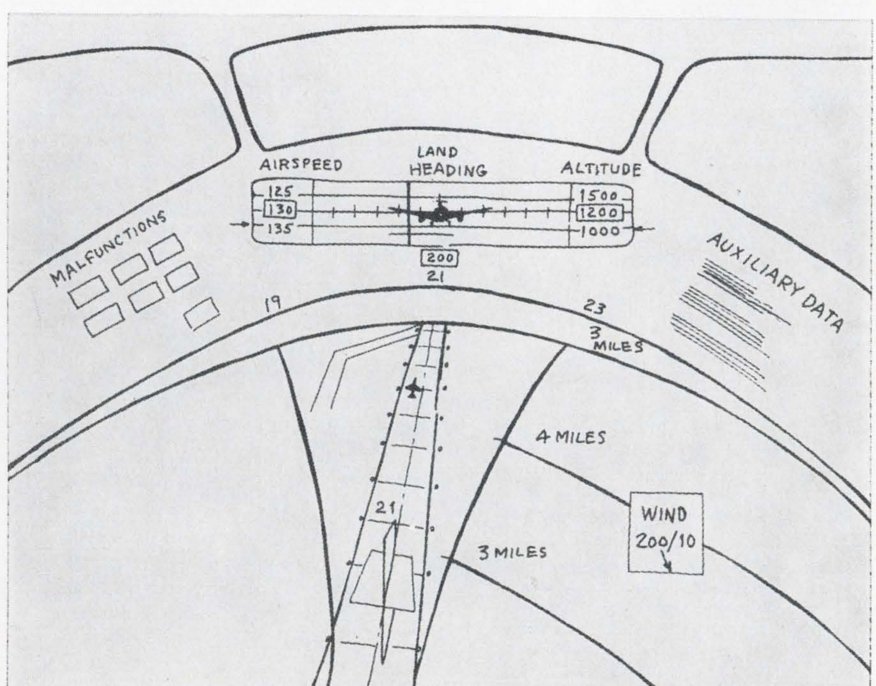
Physicist Donaldson and his research colleague, Graham M. Armstrong, an electrical engineer, plan further storm monitoring. They would like to replace the coherent memory filter with a fast Fourier transform processor, but acknowledge that it would run the cost up to $200,000—a high sum at a time when research budgets are tight.

Flights of fancy

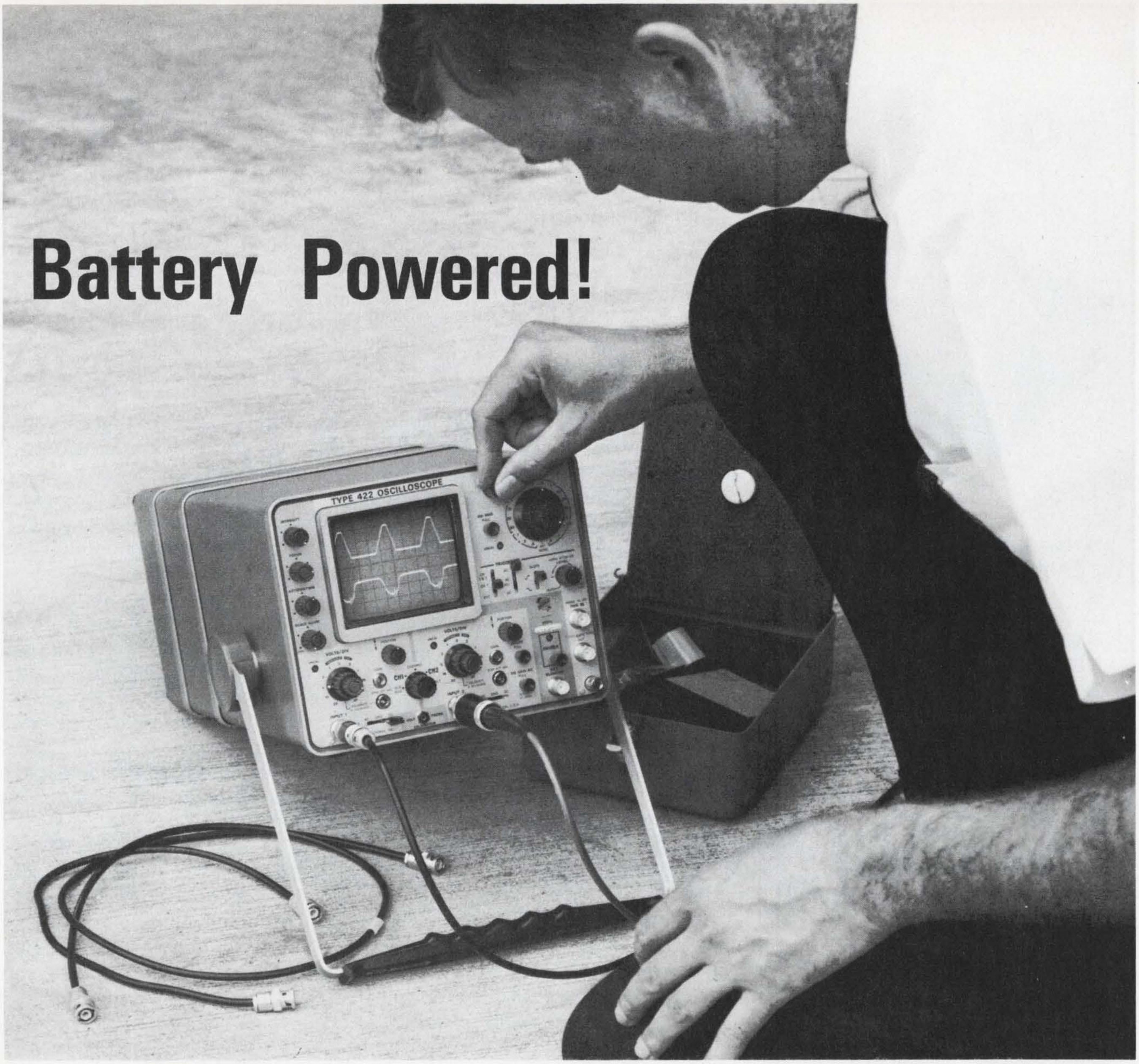
"Running an airplane is like running a corporation," suggests Bernard H. List, director of systems and information at Texas Instruments' research and engineering laboratory. List is quite serious. "Forget the mechanics of flying the plane," he says. "Just take all your inputs—radar, performance indications, and so forth—and imagine that you could let a computer monitor them. If anything went wrong, a light would inform the pilot, and he would be given an indication of the possible corrective actions he could take. Mark Shepherd [president of TI] would love to have a screen on his desk that would light up when the company was in trouble and tell him what his alternatives were."

List is directing parallel studies for Wright-Patterson Air Force Base and the Naval Air Systems Command concerning the nature of avionics systems in the late 1970's and the early 1980's. But avionics itself, in the sense of hardware, hardly enters into the studies at this stage. As far as List is concerned, he's studying "information management systems," and that is the title of the two studies being made by the Dallas company.

Data deluge. List observes that because the complexity of air missions and aircraft is increasing at the same time the size of air crews is decreasing, fliers nowadays must deal with a superabundance of information. Work at Wright-Patterson has led to a concept of avionics in which the goal is to simplify the information presented to the pilot so that he can handle it more efficiently. List notes that the kind of solid state arrays being built for TI's MERA (molecular electronics for radar applications) program can be put anywhere on the plane. Also, the availability of large-scale integrated circuits should lead to airborne computers of great sophisti-



Brainstorm. Here's one possible future cockpit display. The plane is landing, as seen on still-to-be-invented flat-screen crt at center.



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"There are really two classes of problems for the system," List says. "First is the plane still flying? This is a fault-detection and-isolation problem, and we can take advantage of redundancy at every level in dealing with it. Take altitude; let's say you have a radar altimeter that conks out. There'll be terrain-following radar on board, too, and if you used this to read distance and phase angle, you could get a perhaps degraded, but still useful, altitude reading. A lot of black boxes have this capability, but the trick is to connect them to the central processor to provide backup modes. You get more reliable avionics at no extra cost.

Wing and a prayer? "The second class of problem involves loss of information or the incorrect interpretation of information. What happens if the computer itself fails?" List suggests that with the development of semiconductor memories, it might be possible to build modular parallel processing computers that would degrade gradually. "When you get down to the last module, that one gets you home," he says.

The display shown on p. 48 is one product of the TI studies. With this kind of system, the pilot could punch up a cockpit display for any given situation—attacking, landing, cruising. He would then be given a visual display of his attitude and bearing, plus the minimum digital information necessary to make the proper responses.

The flat-screen display at the lower part of the drawing is, of course, only an idea. Besides, List notes, airborne computers aren't yet sophisticated enough to handle the necessary calculations. The TI study deals with conceptual system design only. List warns that "you can go off half-cocked in the concept stage"—meaning that the temptation to come up with blue-sky solutions is strong—but he adds that out of this brainstorming may come some hardware—perhaps the computer for the nation's Airborne Warning and Defense System, which is slated to fly before 1975.

The intention of both the Air Force and Navy studies is to produce enough information so that system design can begin in two years, List says. That warning system for TI's president may have to await more sophisticated business sensors, however.

Space electronics

Quick Exam

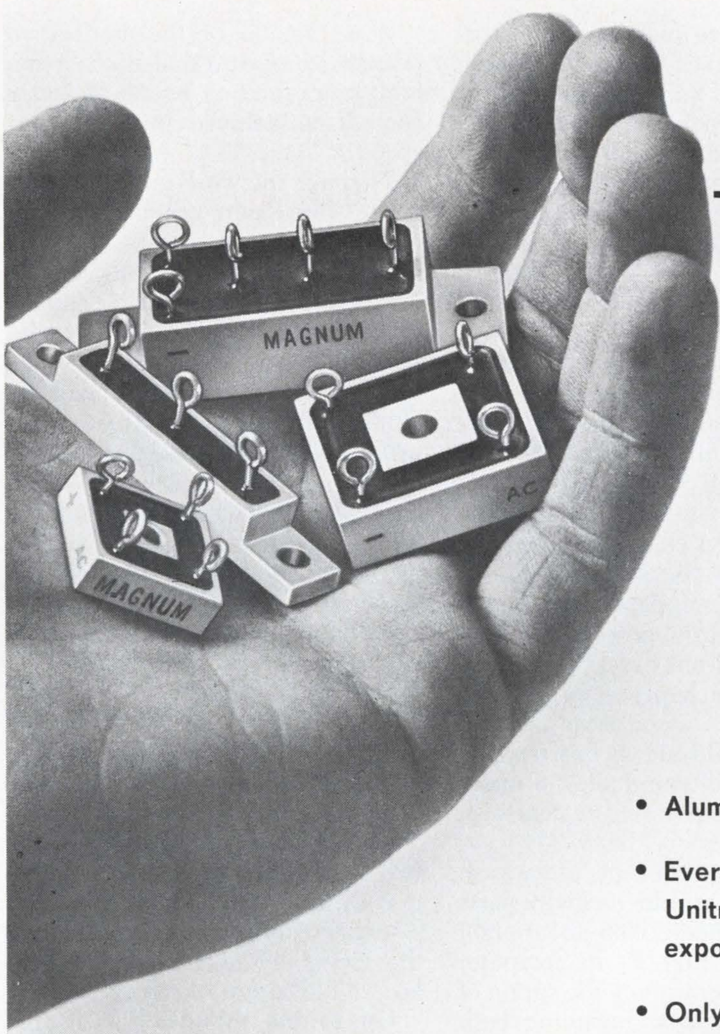
"Even the best components can offer only so much computer speed and reliability," says Gary Y. Wang of NASA's Electronics Research Center. "Soon it becomes necessary to approach dependability and speed on a systems level."

This is what Wang, the center's aerospace computer branch chief, is doing in the Exam project. Exam, for experimental aerospace multiprocessor, is now being developed at the Cambridge, Mass., center as a forerunner of the computers needed for the complex, long space missions of the mid- and late 1970's.

Exam-type computers could use as many as four data processors and four memories interconnected by a crossbar switching system like that in a small telephone exchange. Through the switching system, any one of the processors could access any of the memories, making it possible to continue operation despite failure of other processors. With all processors operating, an Exam computer would provide several channels through which data could be handled simultaneously, thus increasing the machine's capacity for work, or throughput.

Wang says Exam will be modular. More or fewer processors or memory modules could be added, depending on the reliability and throughput needed to perform a mission. "During launch or other critical phases of a mission, we could set all the processors to the same task and compare their outputs in a sort of a vote, with the spacecraft obeying the majority," Wang says. "After launch we could set each working in parallel to boost throughput."

Failure. Multiprocessors have been built before, but their com-



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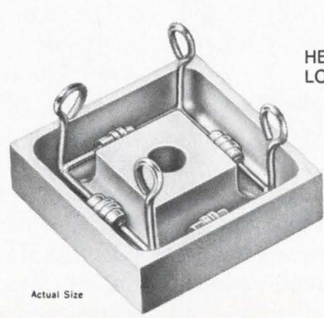

Actual Size

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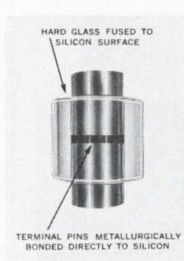

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plex hardware made them expensive. Most have also needed powerful executive software routines to make them operate. They have also been vulnerable to failure of their executive processor, which assigns tasks and priorities among the others. A failure of this single executive section was equivalent to failure of the whole complex system.

Exam is being designed to avoid these problems. Wang feels that the cost should be reasonable, because much of the system is to be made of metal oxide semiconductor large-scale integrated circuits, which he says should be very inexpensive by the mid-1970's.

To overcome dependence on a single executive processor, Exam would parcel out executive authority among each processor in turn. Finally, an associative control memory would aid in this division of responsibility and allow a major reduction in operating system software and memory, he says.

The Exam concept already is about two years old, and with parts deliveries scheduled in about eight months, the first Exam computer should be operating in the spring of 1970, Wang says. Including both in-house and contract efforts, Exam should cost NASA no more than $250,000 to $300,000 through fiscal 1970, Wang adds.

By today's standards, this is a small price, but some of it is buying some pretty fancy hardware. RCA's Electronic Components division, Somerville, N. J., is supplying Exam with a complementary MOS 16-by-16 bit LSI scratchpad as well as a four-bit arithmetic unit capable of addition, subtraction, multiplication, and division, and left-right shift.

Seems fast. Honeywell is working on a p-channel MOS LSI associative memory circuit. It will be 256 by 64 bits, and delivery is scheduled for early 1970.

Wang notes that while the MOS circuits have a relatively low 4-megahertz clock rate, Exam will seem faster because of its parallel processing capability. Thus, a four-processor Exam computer would seem like a 16-Mhz single processor.

It is the job of the associative memory to ensure that each of the four processors is used efficiently enough to achieve this apparent speed.

To make the work go faster, programs for Exam are broken into parts. Some of these may be worked on independently, while others must await completion of earlier sections before they can be started. If this breakdown is done elegantly, each processor will be either working or taking on its next task via the associative memory.

As a processor finishes its job, it checks to see whether any of the others has executive control of Exam. If none has, it can access the associative memory, tell it what's been done (updating the record of work done toward completion of a program), and accept the next task, If another processor has executive control, the first processor gets in a queue and awaits control, normally for a matter of microseconds.

Though rare, it is possible for two processors to demand executive control at the same time, but so-called conflict resolution logic in the switching allows only one to access the control memory.

Up to the minute. All of this could be handled in software, but the result would be a slower computer with a massive, expensive memory. In Exam, the associative memory records the status of all parts of a program as well as ranking the remaining jobs in their priorities. The associative memory is updated each time a new processor assumes executive control. Its data is always up to the minute, and changes in job or processor priority and interrupts are taken in stride.

As a processor accesses the control memory it searches its whole content in a single memory cycle rather than word by word as might be needed with a random-access store. The associative memory fires back the title and location in core memory of the next task in as little as 300 nanoseconds, and uses far less software than is needed to search a random-access memory.

Wang also plans to use the associative memory to control input-output access, for memory paging

Dale Mrazek
National Semiconductor

MOS BRIEF 5

MOS CLOCK SAVERS

Extra effort in the design of MOS clock-drive networks can pay large dividends in power savings and lower component costs. Compared with straightforward designs, component counts and power dissipation often can be cut in half or more by reorganizing the MOS subsystem to reduce operating frequency and duty cycle, by redistributing the clock power with buffers, or by combining these approaches.

The larger the drive network, the more opportunities the designer has to economize if he appreciates the power-frequency-load tradeoffs of MOS devices. For openers, consider the 20,000-bit serial memory in Figure 1. It could be built with 100

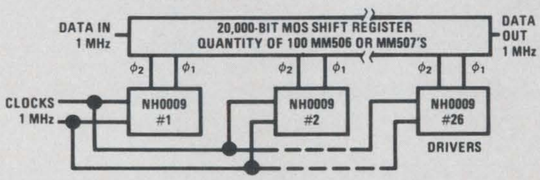

FIGURE 1. Straightforward Drive Network Can Be Costly

MM506 dual 100-bit dynamic shift registers and 26 NH0009 two-phase clock drivers at 70°C. Each MM506 presents a capacitive load of about 80 pF and takes a voltage swing of 16V. At 1 MHz, an NH0009 can drive four MM506's. (If single-phase clocks were preferred, NH0007 or NH0012 drivers could be used.)

A designer could cut the cost and power of the Figure 1 design by reducing operating frequency and data rates. The energy needed to charge and discharge load capacitance is, in any driver,

$$P_{transient} = CV^2 f$$

where C is the load, V the voltage change, and f the repetition rate. If the frequency is halved, for instance, each driver can handle twice the number of MOS devices. At a frequency of 200 kHz, our drivers can handle 80 complex MOS devices in well-designed systems. The savings can be greater than 1:1 because reductions in duty cycle and internal power consumption of the drivers and registers can be made at lower frequencies. Total power dissipation is the sum of load and internal power consumption.

Suppose, though, that a reduced data rate is not acceptable. If the shift registers are rearranged and the data multiplexed as in Figure 2, the operating frequency of the registers can be cut to 250 kHz and each NH0009 can drive many additional MM506's. A suitable clock format can be provided by only two drivers, 24 drivers being replaced by a few bipolar binaries and seven gates, for a considerable savings in power and component costs. The registers will also dissipate much less power. As an alternative, we could keep the drivers (26) and raise the data rate to 4 MHz.

It would be difficult to find a more economical drive network for a large system than Figure 3. Here, a single NH0009 drives remote pnp-npn switches that buffer and distribute the clock signals. If each buffer is made with 2N4142 and 2N4140 transistors, each could do the work of two NH0009's. Transient power would remain the same as in Figure 1, since the load is not changed, but each transistor would dissipate only one-fourth the average DC power of an NH0009. Such a network can synchronously operate a very large MOS memory assembly, whether it is a serial system like Figure 1 or a multiplexed configuration like Figure 2.

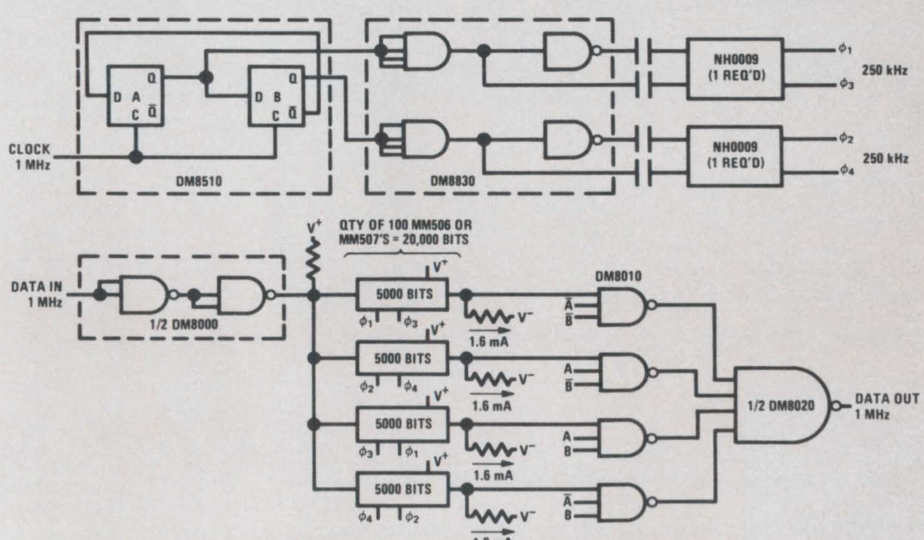

FIGURE 2. Parallel Organization Eliminates 17 Drivers

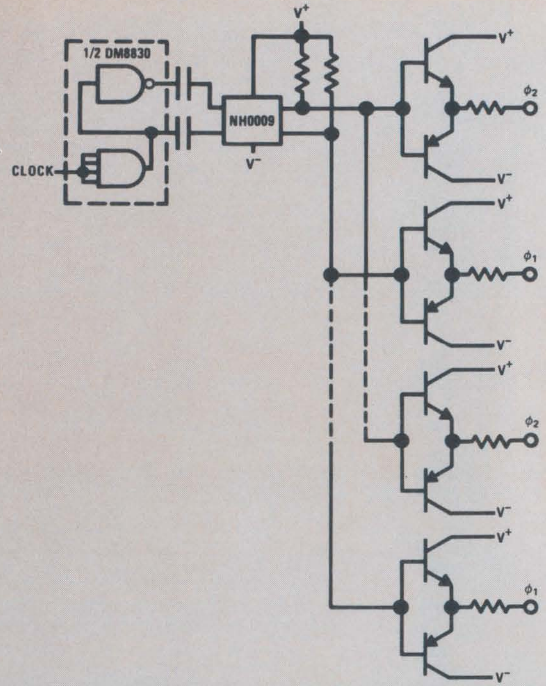

FIGURE 3. Remote Buffers Redistribute Clock Signals

The NH0009 simplifies these examples because it adapts to any practical variation in C, V and f. Discrete-component drivers such as Figure 4 can also do a good job, but clutter up a diagram (as well as PC boards). Figure 5 is a neater subassembly because a voltage translator interfaces the TTL control lines and the buffers. Either of these circuits can drive several MOS devices.

Whatever technique the designer prefers, he must take certain precautions. Since the drivers source and sink large currents into their capacitive loads,

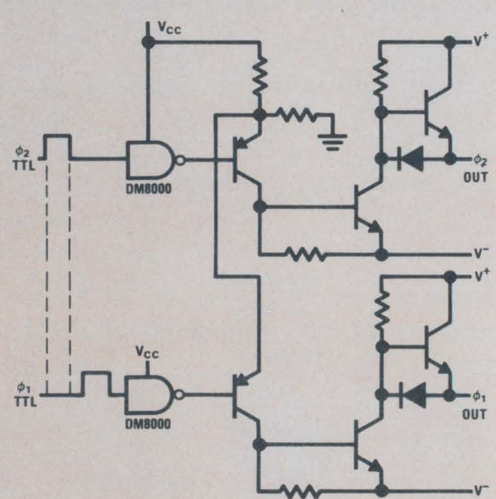

FIGURE 4. Typical Discrete-Component MOS Driver

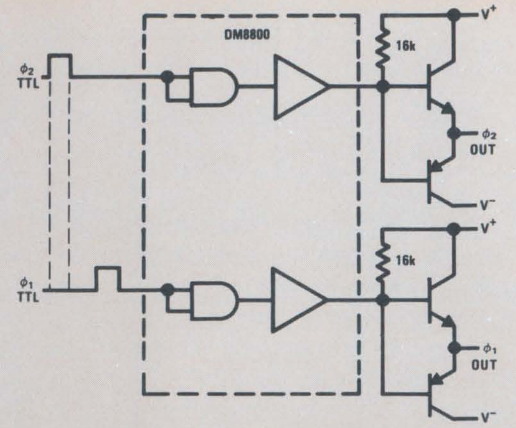

FIGURE 5. Voltage Translator Simplifies Driver Design

they require adequate power-supply decoupling. In large systems, clock-line layouts should be adjusted to avoid excessive clock swinging, of course. Clock lines may have to be terminated to prevent oscillations and noise generation. During positive logic transitions, no clock line should swing more than 0.5V more positive than the most positive bias on the MOS device driven. To avoid malfunctions due to excessive overshoot, the transitions may have to be clamped with a germanium diode, or other low-impedance terminations such as the remote buffer driver shown in Figure 3.

Problems like those are overcome nicely in Figure 3. The long lines between the NH0009 and the buffers carry relatively small currents. The collector-base junctions in the transistors act as clamps and terminations, while the emitter resistors control clock transition time and minimize overshoot. A pullup resistor was added to the NH0009 to maintain the required DC margin and to keep impedance low during the logic "0" state of the buffers.

Overall system costs can be further reduced by techniques—such as a one-resistor TTL/MOS signal interface—that are described in other National Semiconductor literature. Finally, to keep this discussion of savings in perspective, it should be remembered that merely using MOS shift registers, read-only memories, character generators and other large-scale MOS circuits in a digital system will usually make the cost considerably less than an all-bipolar design. No other process is as stingy with valuable silicon "real estate". The register in these examples, the MM506, contains 1240 elements in a 92-by-78-mil chip. And it consumes less than a milliwatt per storage cell.

Data sheets and additional application information on the MOS devices are available upon request.

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and protection, and as a directory, giving the main memory location of any desired data.

The associative memory scheme may also allow internal diagnosis and repair. Even if massive failures were to take place, the Exam computer would try to complete its mission not only by restructuring its pattern of interconnections but also by restructuring the way its programs are divided and the priorities for each division. This self-healing capability will be studied under a contract to be awarded this spring.

Government

Year of the application

NASA's Office of Advanced Research and Technology is planning to spend $35 million on electronics research in fiscal 1970. And the job of convincing the House subcommittee on advanced research and technology that every cent of the total is needed went to Francis J. Sullivan, NASA's director of electronics and control. Sullivan appeared before that group earlier this month and made it clear that NASA's electronics research program is taking a turn for the practical.

As Sullivan came to each program, he noted how it would fit into current needs in space and astronautics. The battle plan calls for an extensive push in aviation electronics with the concentration put on research that will lead to an alleviation of air traffic control problems and the improvement of safety. Among the programs which will be pushed in this area are aircraft satellite radio links (L-band), further work in pilot-warning indicators, phased array antennas for aircraft, electronic clocks for sophisticated collision-avoidance schemes, beacon landing systems, inertially aided instrument landing system, and new techniques in man/machine communications between aircraft and computer. Particular attention is being paid to V/STOL aircraft technology with a major emphasis on inertial and combined inertial-radar systems to permit

U.S. Reports

"blind" V/STOL landings.

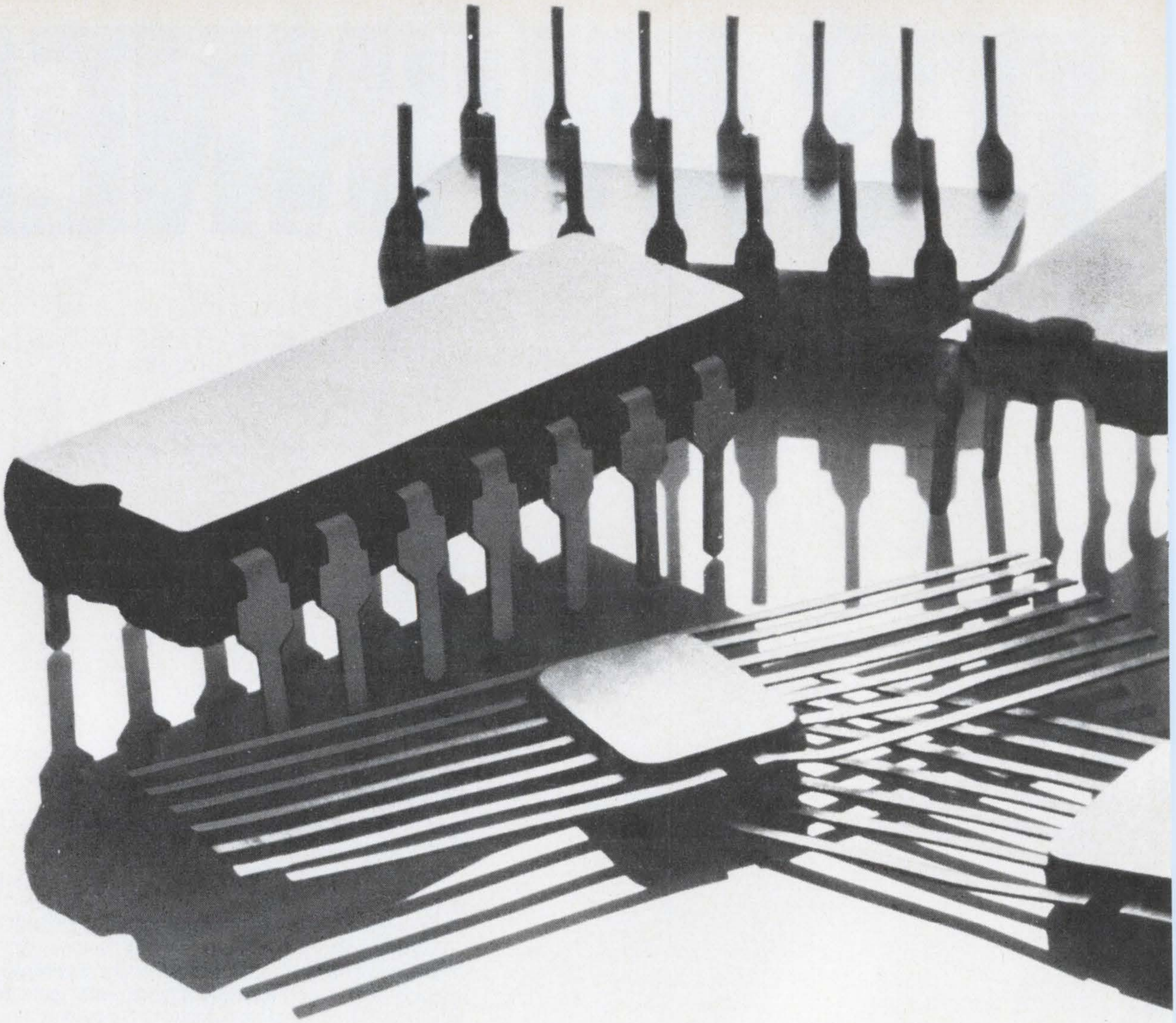
Component research. Specific aircraft instrumentation work which will be in NASA's plan for fiscal 1970 include precision inertial sensors, new techniques in cockpit cathode-ray tube displays, a V/STOL airspeed indicator and a fluidic yaw control system.

For the record

Whither ABM? The Pentagon is keeping the technical details of its newly slimmed down $6 billion-to-$7 billion Safeguard ABM system a secret, but some clues were dropped by Defense Secretary Laird in his testimony before the Senate Armed Services Committee. He said an "improved, longer-range" Spartan missile is under development, that the new system is designed to intercept "at least the first salvo" of submarine-launched missiles, and that the perimeter acquisition radars are being increased (to seven with 11 faces) to cover all approaches including the seaward.

Quick frisk. When the Federal Aviation Administration held a press briefing on what was being done to develop electronic means to thwart would-be hijackers, it proudly displayed three black boxes. But the FAA refused to say what was in them (it turned out they were magnetometers to detect metal objects), who was making them, or how they will be improved (only one worked perfectly during a test demonstration).

Time for a change. The Electronic Industries Association is going to reorganize. Under the proposed changes, members of the EIA's present seven divisions would be allowed to join mutual interest groups the association would form. Initially, four new groups have been proposed: consumer products, Government-industry, passive components, and active components. In addition, each group would have its own autonomous board of directors. The reorganization plan is expected to be approved by the membership at the association's annual convention in Chicago June 23 to 26.



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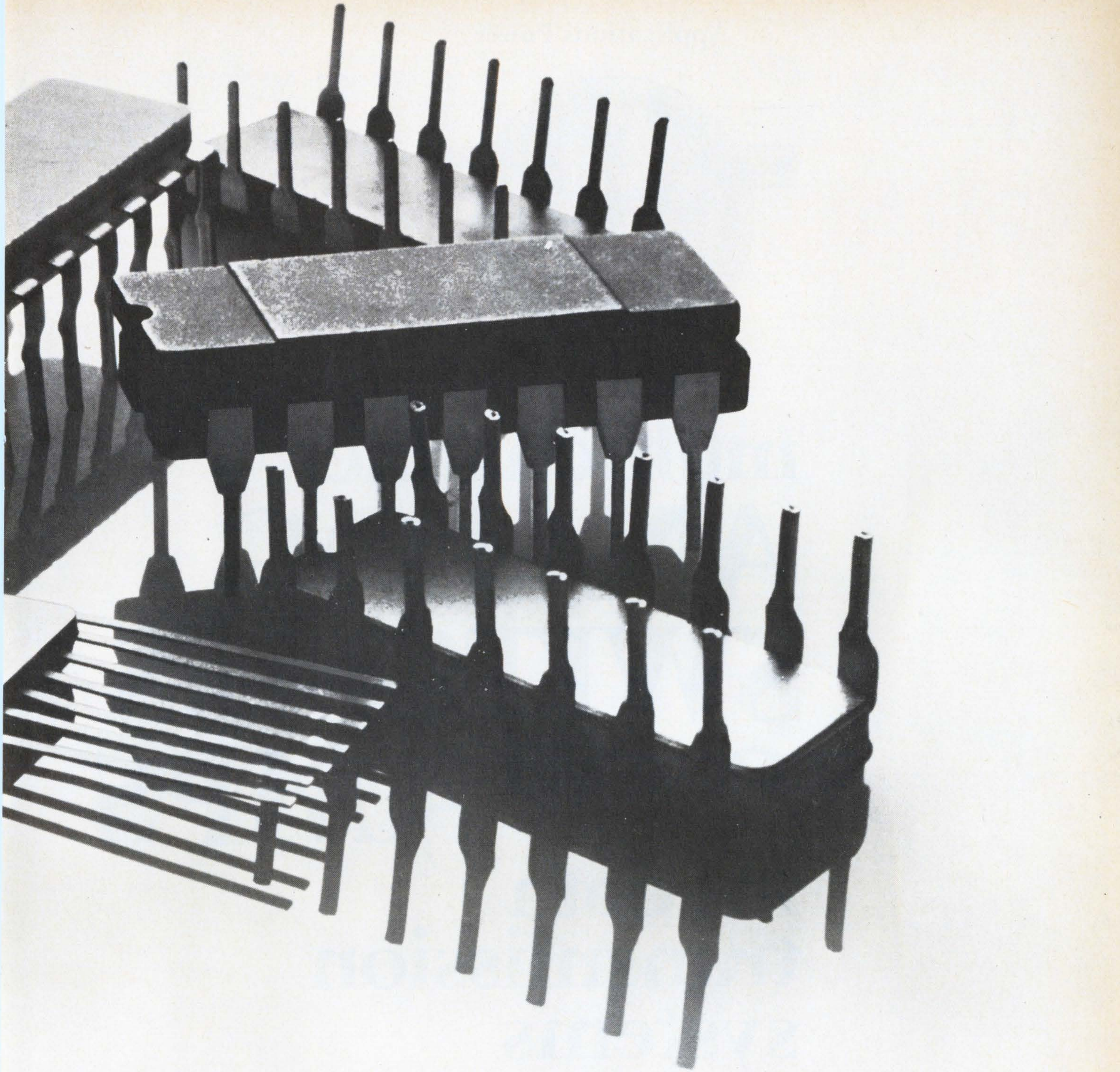

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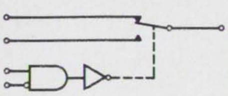
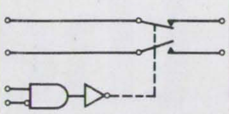
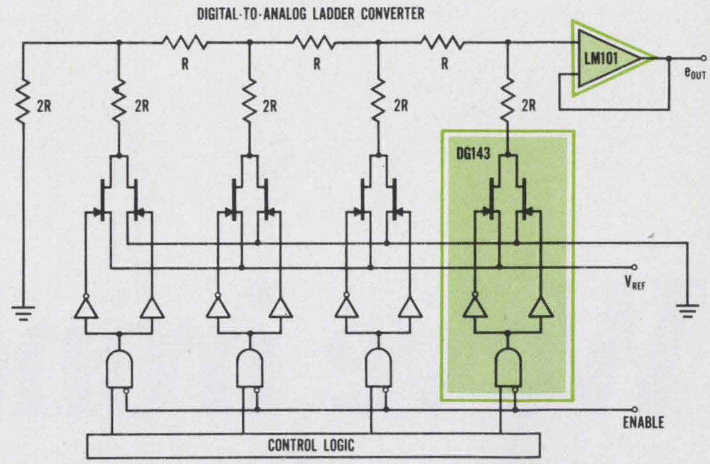
SPDT 1-CHANNEL 	DG136 SI3002	600 600	PMOS NMOS PMOS
SPDT 1-CHANNEL 	DG113 143 144 146	600 80 30 10	PMOS N N N

A number of switches with the ON resistance ranges best suited to your application are available from Siliconix. These driver-switches accept standard DTL, RTL, and TTL logic control inputs.



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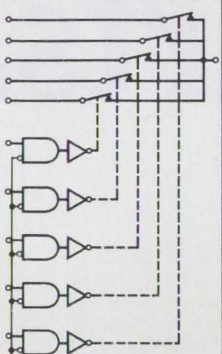
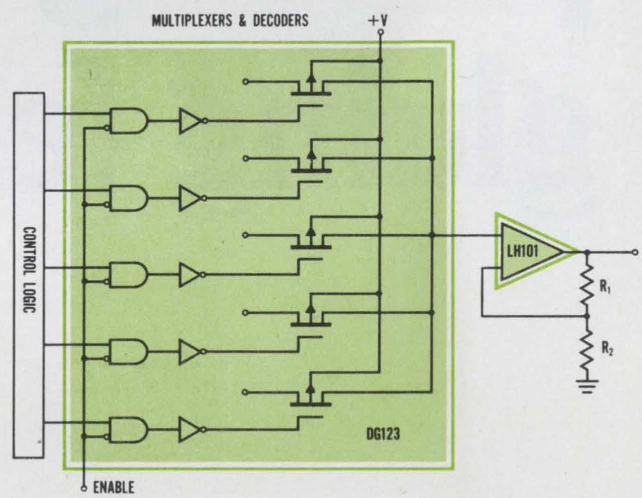
 ENABLE DG123	2	DG102 103 104 110 111 112 133 134 141 147 148	100 100 100 600 600 600 30 80 10 600 40	N N N PMOS PMOS PMOS N N N PMOS PMOS
	4	DG116 118	600 600	PMOS PMOS
	5	DG123 125	600 600	PMOS PMOS

System requirements will dictate which of the above combinations are best for your multiplexer combination.



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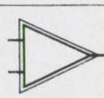
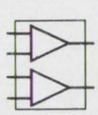
 LM 101 LH 101 (Internally compensated)	6 mV	200 nA	50K	±12V	.25V/μsec.	• Operation from ±5 to ±20V power supplies • Low current drain • Continuous short circuit protection • Same pin configuration as 709 amplifier
 L 120	200 mV	50 pA	100	±12V	20V/μsec.	• Low input leakage • High slew rate • Unity gain stable • Ideal for sample and hold, integrating and fast voltage comparisons

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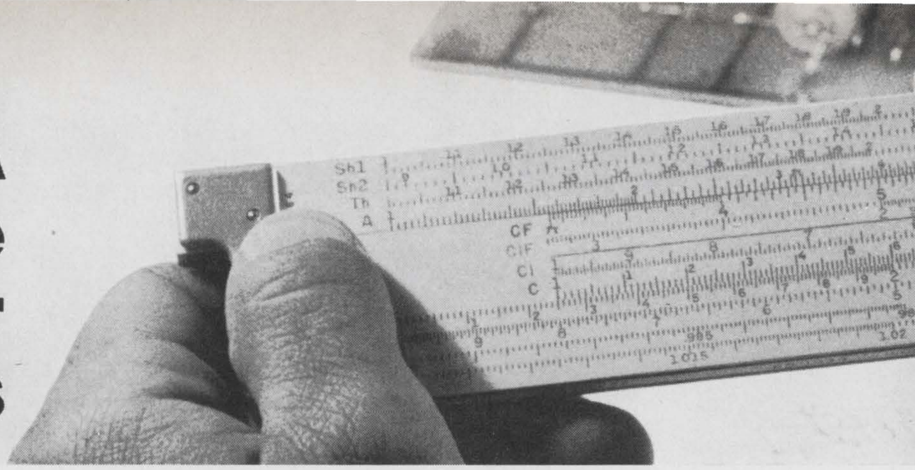

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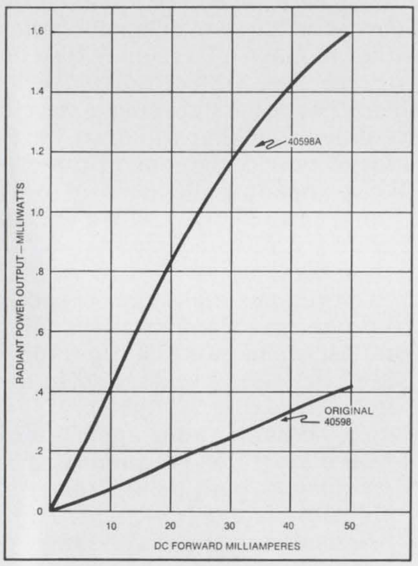

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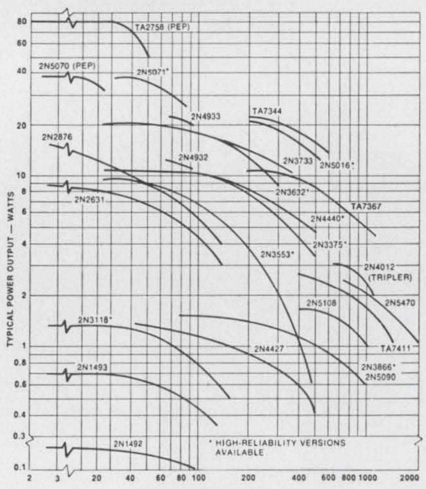

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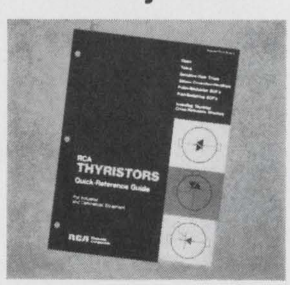

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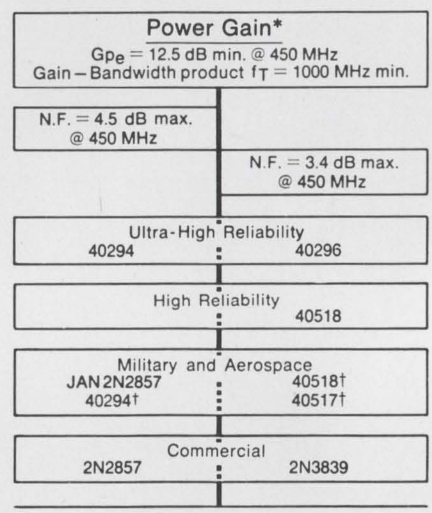

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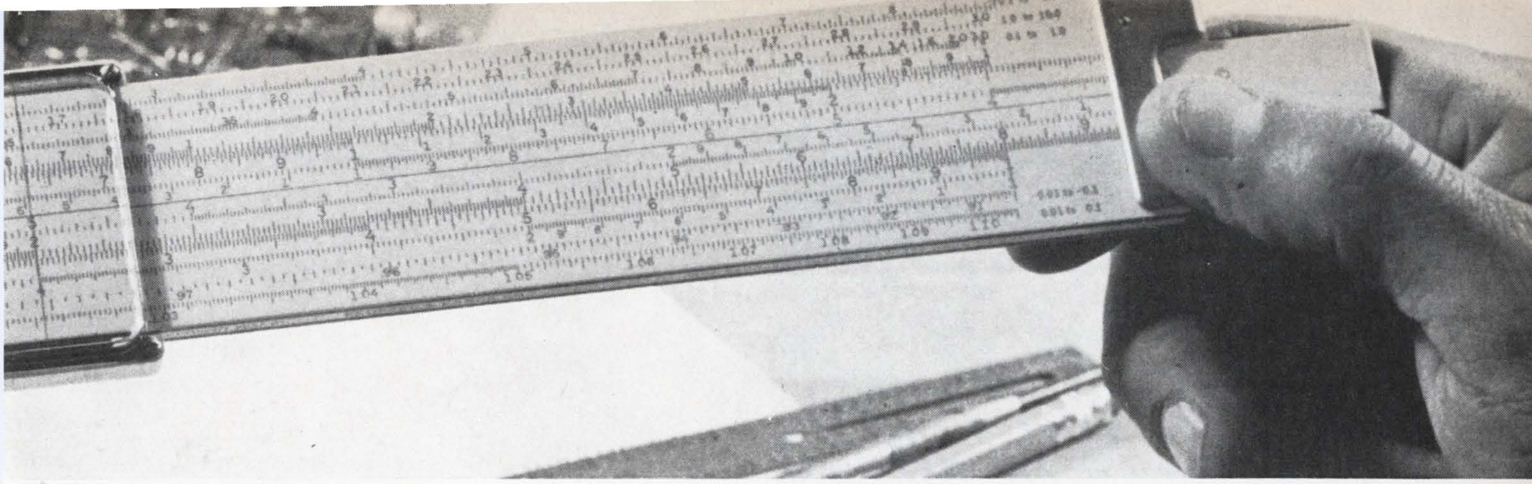

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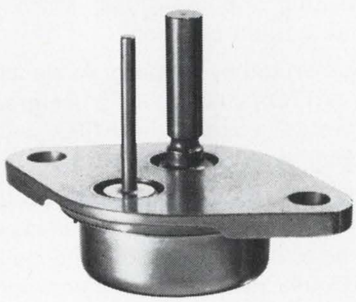

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Characteristic	Test Conditions			2N5575 2N5576 2N5577		2N5578 2N5579 2N5580		Units
	V_{CE} V	V_{BE} V	I_C A	Min.	Max.	Min.	Max.	
h_{FE}	4		40	—	—	10	40	
	4		60	10	40	—	—	
V_{CEO} (sus)			0.2	50		70		V
$I_{S/b}$^▵	25			12	—	12	—	A
$E_{S/b}$*		−1.5	7	0.8	—	0.8	—	J
$\theta_{J\text{-}C}$					0.5	—	0.5	°C/W

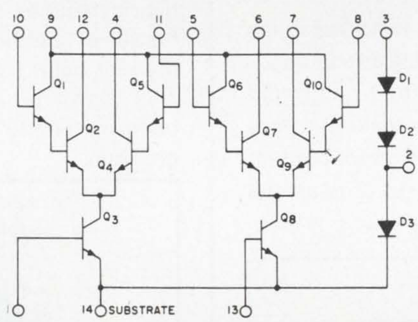
▵With base forward biased

*With base reverse biased and $R_{BE}=10\Omega$, $L=33$mH

Design Delight—Dual Darlington Diff Amp Arrays

RCA-CA3050 and CA3051 offer designers a significant opportunity to work with the inherent device match of monolithic construction PLUS building-block flexibility. On a single chip, in a dual-in-line package, each type offers:

- Independently accessible inputs and outputs
- Diode temperature compensation of constant-current-transistor bias
- High input impedance—460 KΩ typical
- Low input offset current—70 nA max.
- Low input offset voltage—5 mV max.



Get the feel of real design freedom with CA3050 or CA3051 for matched dual amplifiers, dual sense amplifiers, dual Schmitt triggers, doubly-balanced detectors and modulators —and anywhere you want matched device performance.

Prices: CA3050 in dual-in-line ceramic, $2.25 (1000 units); CA3051 in dual-in-line plastic, $1.65 (1000 units).

Circle Reader Service No. 255 for full technical data.

Using 830 and 930 DTL? RCA CD2300 Series Adds 4 Dual Flip-Flops in 3 Package Styles

Directly interchangeable with 830 and 930 series units, there are now 57 types in RCA's CD2300 Series DTL line. New 24-page technical bulletin, File No. 374, now contains information on all types including:

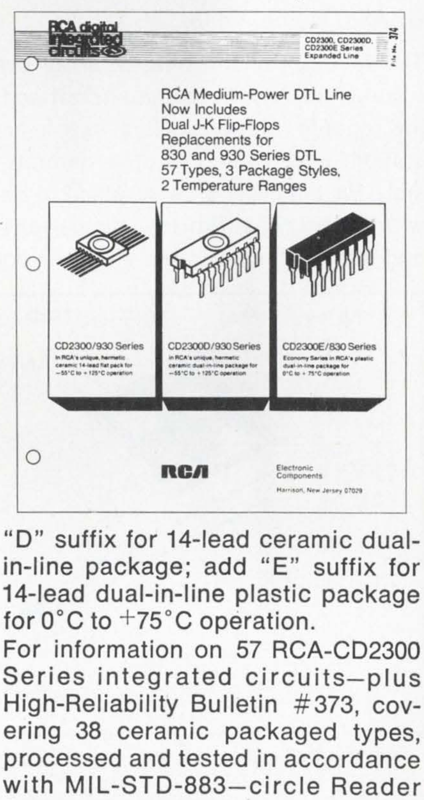
CD2315—dual JK flip-flop; with separate JK, clock, and set inputs, 6 KΩ pullup. For ripple counter applications.

CD2316—same as CD2315 except for 2 KΩ pullup.

CD2317—dual JK flip-flop; with common clock and clear inputs, with separate JK and reset inputs, 6 KΩ pullup. For shift-register and clocked counter applications.

CD2318—same as CD2317 except for 2 KΩ pullup.

Type numbers above indicate −55°C to +125°C ceramic flat pack. Add


RCA digital integrated circuits

CD2300, CD2300D, CD2300E Series Expanded Line

File No. 374

RCA Medium-Power DTL Line Now Includes Dual J-K Flip-Flops Replacements for 830 and 930 Series DTL 57 Types, 3 Package Styles, 2 Temperature Ranges

CD2300/930 Series
In RCA's unique, hermetic ceramic 14-lead flat pack for −55°C to +125°C operation

CD2300D/930 Series
in RCA's unique, hermetic ceramic dual-in-line package for −55°C to +125°C operation

CD2300E/830 Series
Economy Series in RCA's plastic dual-in-line package for 0°C to +75°C operation

RCA Electronic Components
Harrison, New Jersey 07029

"D" suffix for 14-lead ceramic dual-in-line package; add "E" suffix for 14-lead dual-in-line plastic package for 0°C to +75°C operation.

For information on 57 RCA-CD2300 Series integrated circuits—plus High-Reliability Bulletin #373, covering 38 ceramic packaged types, processed and tested in accordance with MIL-STD-883—circle Reader Service No. 256.

For price and availability information on all solid-state devices, see your local RCA Representative or your RCA Distributor. For specific technical data, write RCA Electronic Components, Commercial Engineering, Sec. No. QN3-5, Harrison, N.J. 07029.

RCA

Washington Newsletter

March 31, 1969

Move is on to force U. S. to reshuffle Intelsat delegation

Between now and next November, when delegates to the Intelsat consortium get together again, the White House is going to be pressed to realign the U.S. delegation. Observers both in and out of the Government feel that this country's showing at Intelsat's first session left much to be desired. The U.S. delegates didn't have a definite position on many of the points raised at the meeting, and in some cases didn't agree with one another on the positions that were taken. This divided front reflected a rift between the State Department's representatives and those from Comsat. Explains one observer, "The State Department looks at Intelsat as an arm of U.S. foreign policy and Comsat looks at it as part of its business."

Factions in the Federal Communications Commission, the Office of Telecommunications Management, and Comsat are already pushing for a recomposition of the delegation.

Navy command plane may get a completely automatic radar . . .

The Navy wants to automate the overland operations of the APS-111 radar slated for its E2-C flying command post. In its present form, the computer-based system can automatically track targets over water; over land areas, however, its operator has to manually track targets with a strobe pencil. **The Naval Air Test Center is now working on the problems involved in adding an automatic overland capability, and study contracts have been let to GE and Hazeltine.** The first E2-C planes are scheduled to come off the production line in the fall of 1972.

. . . and will get passive detectors

The electronics shopping list for the E2-C continues to grow. The Naval Air Systems Command is adding a passive detection system that will zero in on enemy radar and communications signals. The Defense Department has approved this highly classified subsystem, which was not in the original plans for the Grumman-built plane.

Because the Navy doesn't want any subsystem to hold up delivery of the E2-C, Grumman has had to reject some state-of-the-art proposals for the system due to the long development times involved. **For the design engineering phase, the company has narrowed the field of potential producers to about four. The first production prototype is due this fall.**

The Navy is also considering the system for its S-3A (VSX) antisubmarine aircraft.

ATS-G will have L-band transponder

NASA has definitely decided to put an L-band transponder on Applications Technology Satellite-G. This means there'll be L-band units on three consecutive ATS satellites, starting with ATS-E [*Electronics*, Nov. 25, 1968, p. 65]. The repeaters planned for each of the three birds will be increasingly powerful. As now foreseen by NASA, the repeater on ATS-E will not be powerful enough for voice tests with practical antennas but will be suitable for data transmission tests.

NASA sees L-band as the hope for efficient aeronautical services satellites, and is moving quickly to prove it's right. The space agency is pursuing two concepts for aircraft L-band antennas—directive slot-array units and hemispherical turnstiles—and two satellite-to-aircraft techniques: multipath and direct.

Washington Newsletter

Five jump gun on ERTS bids

Even though no formal request for proposals has been issued, five firms have given NASA informal proposals for the development of an Earth Resources Technology Satellite. They are General Electric, RCA, TRW Systems, Lockheed, and Hughes Aircraft. The unsolicited proposals are an indication of the eagerness of firms to get a crack at the first two satellites, ERTS-A and -B [*Electronics,* March 17, p. 58].

The formal proposal has been written, but it will probably be at least a month before NASA issues it; a number of Government units, including the departments of Agriculture and the Interior, must first review the proposal.

Marks to head Comsat in May

Leonard Marks, a well-known figure in communications circles, will soon take over as chairman and chief executive officer of the Communications Satellite Corp., according to Washington informants. Marks, who last week resigned as chief of the U.S. Intelsat delegation, will be replacing James McCormick, who is stepping down voluntarily. **The target date for the changeover is said to be sometime in May.**

Before heading this country's delegation to the first Intelsat meeting, where he also chaired the 80-nation conference, Marks was director of the U.S. Information Agency in the Johnson Administration. He was also a member of the President's task force on telecommunications policy.

How Marks' appointment would affect future Comsat policies is not known, but he is said to be vigorously opposed to releasing the telecommunications task force report which recommends, among other things, that Comsat put up a pilot domestic satellite system.

Uhf satellite relays due for a promotion

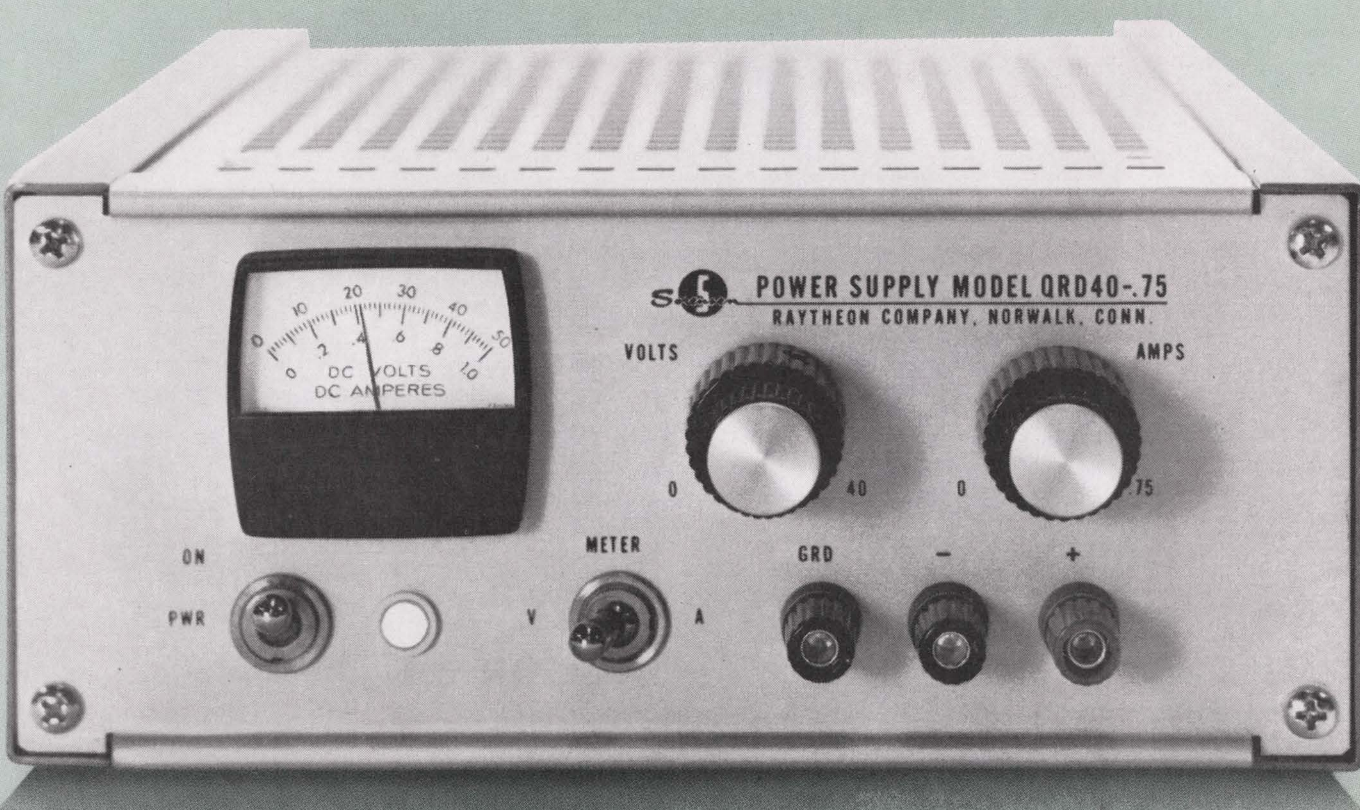
A major push for deployment of uhf satellite relays for military communications will be made at the June meeting of the Armed Forces Communications and Electronics Association.

Speakers at the Washington meeting will stress that the LES-5 and LES-6 satellite relay test programs have established the technical feasibility of using the 225-to-400-megahertz band, and will claim that "highly reliable" intercontinental communications are thus possible with simple and inexpensive antennas and terminals. Present satellite communications systems use the 4-to-6-gigahertz band. Army, Navy, and Air Force speakers will join those from Electronic Communications Inc., which has been running tests with LES-5 and LES-6 uhf satellite relays.

Addenda

Rep. Joseph E. Karth, (D., Minn.), chairman of the House subcommittee on space science and applications, wants NASA to put more money into supporting graduate students at universities. In budget hearings Karth expressed anger at NASA's cutback in such funding: from about $25 million annually in 1965 and 1966 to less than $1 million in the past two years and $1.3 million for fiscal 1970. The congressman was especially upset by the cuts because his committee hadn't been informed about them. **The committee might end up putting more money into the program than NASA asked for the coming year. . . . The FAA's sharpest critic is not satisfied with the agency's proposal to require crash-locator beacons on "air taxis" and small commercial aircraft.** Rep. Richard Ottinger (D., N.Y.), wants the devices on all aircraft—especially commercial airliners [*Electronics*, March 18, 1968, p. 70]. Ottinger, who has submitted a bill to this effect calls the FAA plan "too little and too late."

High-speed programmable dc power supplies $178.00



The QRD Series of precision power supplies is composed of seven off-the-shelf models covering the range of 0-60Vdc at current levels up to 4 amperes.

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Other features include: ■ ±0.005% voltage regulation ■ 200μV r.m.s (3mV p-p) ripple ■ automatic crossover between constant voltage and constant current operation.

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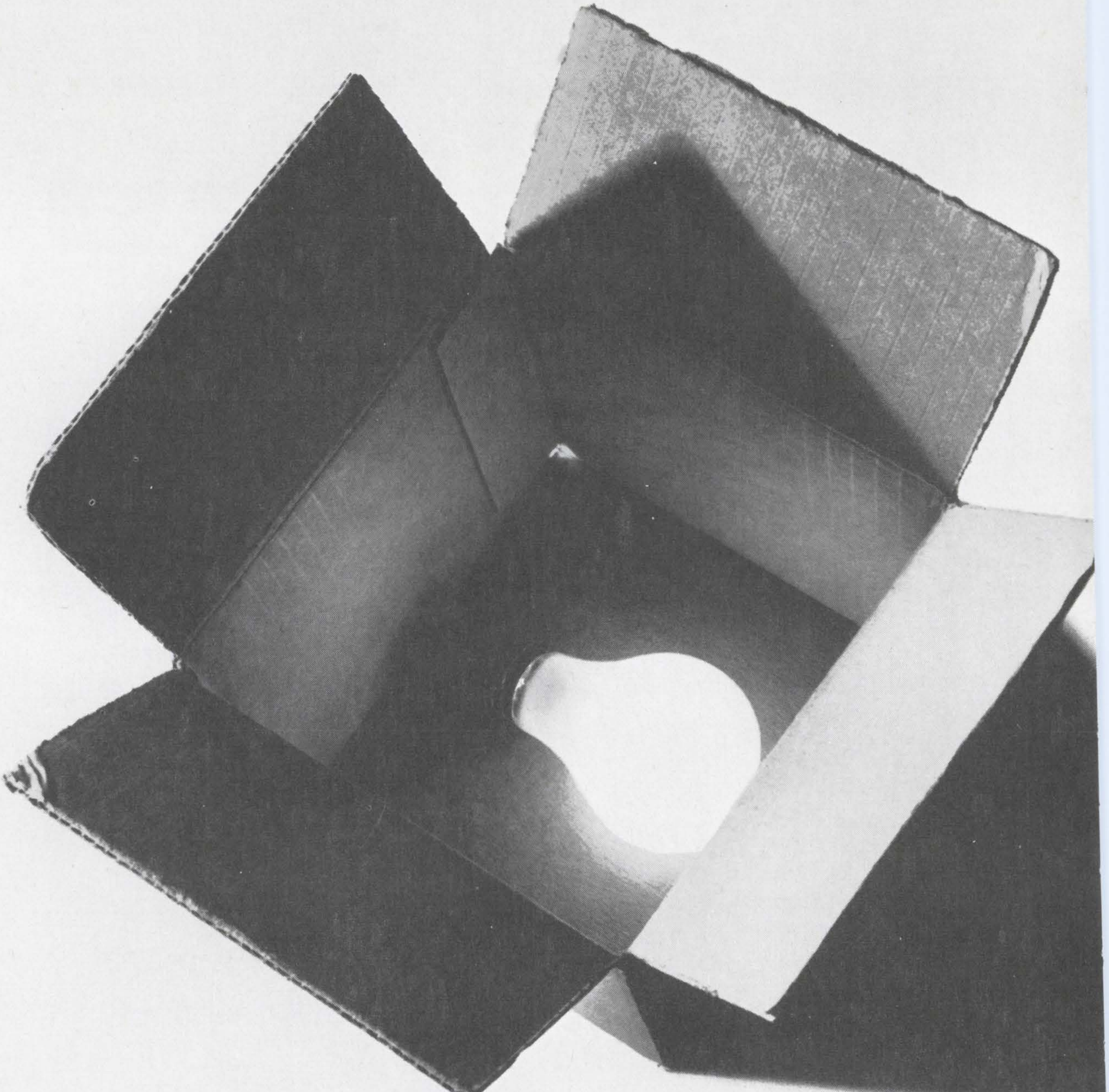


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Burroughs

March 31, 1969 | **Highlights of this issue**

Technical Articles

LSI and systems: the changing interface
page 78

As the discrete-device maker becomes a producer of complex integrated circuitry and, in effect, a subsystem supplier, his relationship with the customer—the systems manufacturer—is undergoing a fundamental shift. Unless LSI logic can be standardized —and there's still a possibility it can—systems houses will insist on playing an increasingly active role in the design and manufacture of IC's. Even at this early stage of the game, such companies are developing in-house facilities at least capable of making prototype circuits. For the cover, art director Jerry Ferguson took a shot of a 2,048-bit MOS read-only memory built by General Instrument and overlaid a jigsaw puzzle to suggest the current flux.

IC's break through the voltage barrier
page 90

Dielectric isolation, which permits the use of high-resistivity substrates, and a field plate that neutralizes positive surface charges make it possible to fabricate integrated circuits with breakdown voltages of better than 300 volts. With this technique, yield is enhanced and components can be more densely packed than is possible in comparable p-n junction circuits. So far as costs, therefore, dielectrically isolated circuits compare favorably with commercial p-n junction units having lower breakdown voltages.

Positive results from negative feedback in active filters
page 96

Active filters to which positive feedback is applied require fewer components than those using negative feedback. Unfortunately, however, such circuits tend to oscillate. But now integrated circuits with many active devices on a single chip are commercially available, making it both practical and economical to design stable negative-feedback filters.

Log diodes can be counted on
page 104

Semiconductor technology has reached the point where diodes with specified logarithmic voltage-current curves can be turned out in quantity. Purchasers can thus use these units in simple circuits to perform computing functions without going through the laborious process of testing and matching them.

Coming

Squeezing size and cost in microwave IC amps

Uhf and microwave power amplifiers can be built with lumped passive elements designed as if they were to operate at lower frequencies where distributed reactances are no problem. The development promises cheaper and smaller circuitry.

LSI and systems | The changing interface

Large-scale integration is turning IC's into subsystems and blurring the separate identities of IC firms and systems houses

By George F. Watson
Associate editor

Go inside many a plant these days and you'll be hard pressed to decide whether you're at a systems house or a semiconductor device manufacturer. There are diffusion furnaces and mask-making equipment at the systems company and systems engineers working with block diagrams at IC firms. Causing this blurring is the ever increasing complexity of the large-scale integrated circuit, as LSI moves farther into the subsystem level.

It's not clear how things will finally shake out, but there's no doubt that the relationship between the IC user and supplier is undergoing a fundamental realignment. Most of the activity is in the big systems house currently, but it's only a matter of time before this changing interface affects every company building equipment.

In some cases, the suppliers are turning over a greater portion of the design task; in others, they are retaining the IC design function but making it easier—by means of computer-aided design—for the systems designer to interface with them. But the most significant response is the trend of systems houses setting up their own IC fabrication facilities.

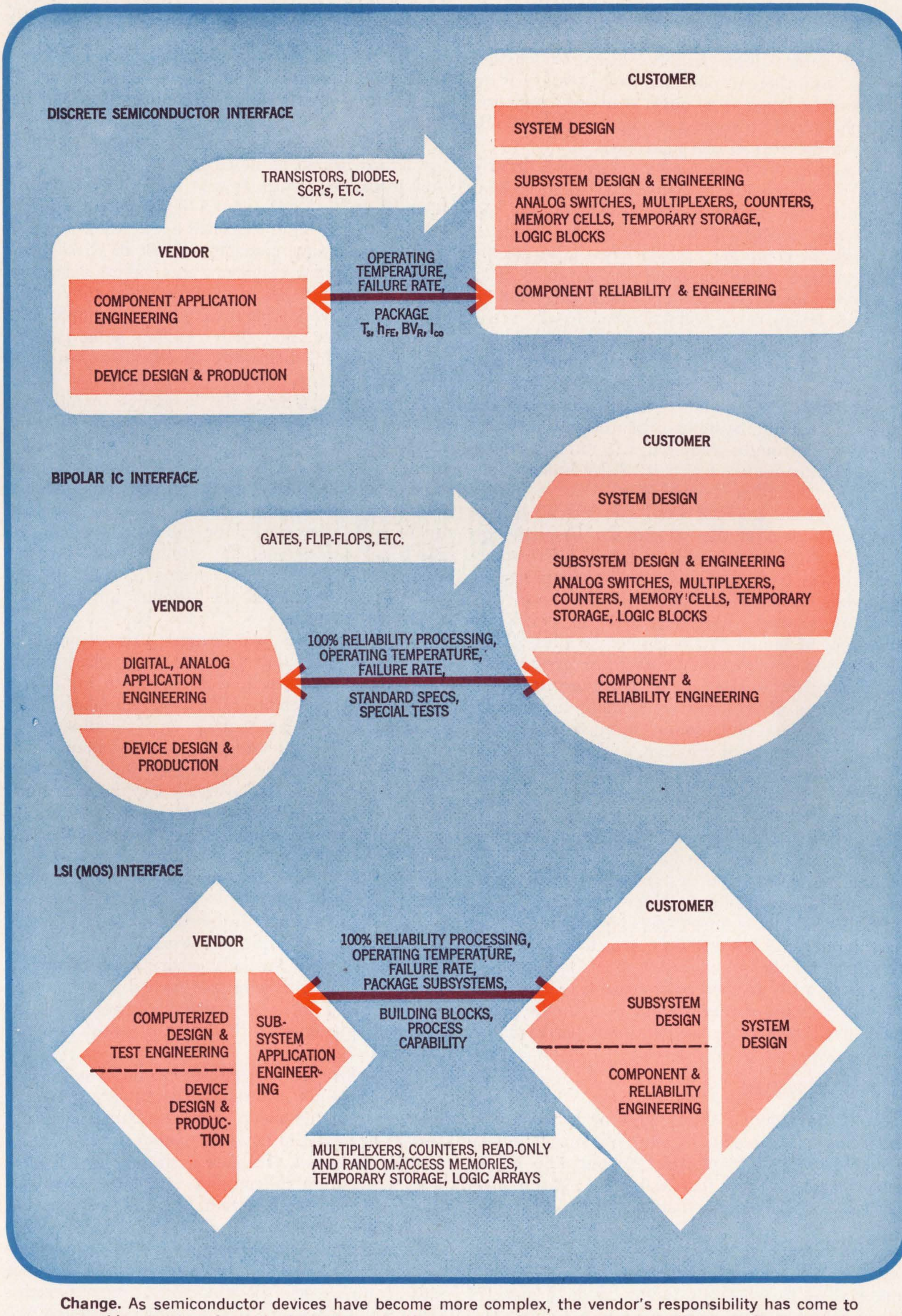
Who should design and fabricate IC's, after all? They are semiconductor devices, and the traditional semiconductor houses tend to feel proprietary toward them. But they are subsystems too, and the systems houses are reluctant to relinquish their traditional prerogative.

The position of the interface depends on the particular combination of user and maker of IC's. In some instances, the design may be done entirely by the IC vendor; the systems house merely furnishes performance specifications. Or the customer may do the entire design, furnishing the supplier with a composite diagram or masks of the IC. Or the systems house may even go so far as to use its own IC production line to make circuits.

The systems houses are now assuming more and more of the responsibility for designing IC's. Whether this trend will persist depends on how successful the IC makers are in developing standard, off-the-shelf LSI circuits and persuading their customers to use them.

So far, only memories and similar repetitive circuits appear to be amenable to standardized LSI. Michael Callahan, director of IC research and engineering at Motorola's Semiconductor Products division, for example, believes that there will be some, but not many, standards in LSI. The general logic control function won't become standardized, he says. "The bulk of computer arithmetic units, for example, will be custom, but memories will become pretty common and fairly standardized, as will shift registers," he asserts. "These have very high component counts and are really LSI devices, but they're used by many customers."

But with the advent of read-only memories—which can be used to perform control logic functions—this could change. ROM's may profoundly influence the design interface, shifting it toward the IC maker again. Robert N. Noyce, president of the Intel Corp., says he is fascinated by the



Change. As semiconductor devices have become more complex, the vendor's responsibility has come to resemble what was formerly the customer's. However, the customer has a much greater influence on the device design—at least in MOS LSI.

ROM approach, although he is not yet sure that it is practical. "Memories are easy to interface," Noyce says. "But what about the rest of the system, the control logic?" In the absence of standard modules, control logic requires expensive custom design. "But there is another route, which is to treat control logic as a huge read-only memory, in which you do microprograming, and then standardize on the rest of the machine".

The goal is to replace random logic with orderly arrays of iterative stages, with each stage leading to a ROM that provides the instruction for the next stage. "Designing the ROM is the same as designing the computer," Noyce says. "You get the wiring pattern of the computer and duplicate it as the ROM. This overcomes my major objection to LSI—that design costs will kill you."

Whatever the role of standardized LSI in the future, LSI is designed and manufactured on a highly customized basis right now. The experience of Richard A. Stokes, manager of planning at Burroughs' Electronic Systems organization, is representative. Burroughs required LSI circuits (more than 100 gates makes a circuit LSI by Stokes' definition) for the Illiac 4 computer.

Stokes' group selected word-axis instead of bit-axis partitioning for the LSI circuits. Even though bit-axis partitioning results in fewer interconnections, Stokes feels that the word-axis approach is preferable because it's cheaper; fewer circuit designs are needed. "We were able to develop a more general family of LSI chips," he says. "Having the semiconductor manufacturer execute the partitioning by making all the necessary interconnections on a given substrate is really a major investment in time and money. In each case, minimizing the number of different kind of chips minimizes the engineering investment." The same applies, of course, to testing.

Pointing out that "we were not sure there was a viable LSI technology available" at that time, Stokes reports, "We started at ground zero and we did an initial logic design—in terms of registers, adders, multipliers, things like that." This logic design was a rough blocking out, since the logic family had not yet been selected. "Then we looked at families" and selected a vendor whose approach to LSI seemed most feasible. The vendor "sent in a group of very capable people who pretty much lived with us as we set about partitioning," Stokes says.

Staying uninvolved

So far so good: "About 80% of it went very fast because the partitions were obvious." But the Burroughs-vendor team spent "about 90% of our partitioning time on that last 20%. The control part of it was the one that we had the problem with."

Nevertheless, the group arrived at an initial partitioning, although it was "completely untried and untested as to what one might do on a piece of silicon," Stokes says. The vendor took the designs, "made a few false starts," spent six months in laying out the masks, and then further developed the chips. "As we found we couldn't do certain things, there was iteration at partitioning, there was iteration at the chip layout," Stokes reports, "and then iterations from the final performance of the chip—from the partitioning back to the logic."

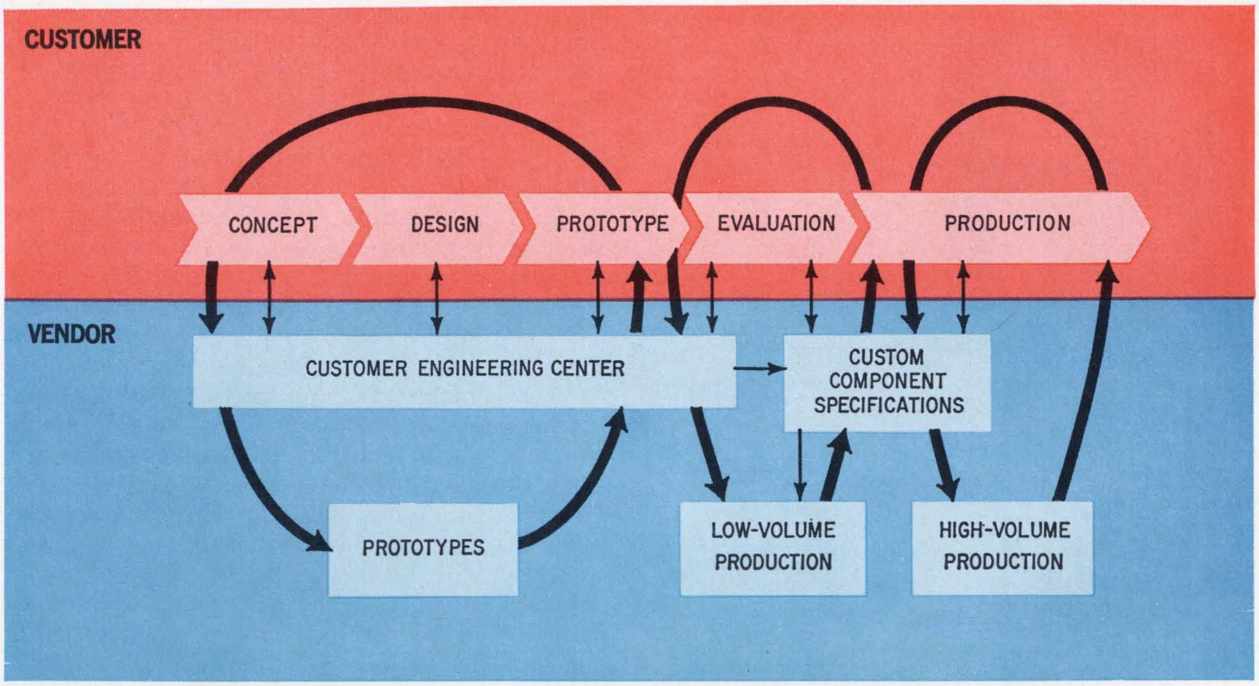
Often the vendor prefers to stay uninvolved in the circuit design as much as possible. The General Instrument Corp. is one such semiconductor manufacturer. GI has about 140 people working on MOS circuit design. According to Art Sidorsky, product marketing manager, "Most of these people were systems engineers and circuit designers who had to learn about devices when they came to GI." They work with the customer to implement his requirement, and their starting point can be a logic diagram, black-box specifications, or anything in between.

But rather than tie up the company's own design personnel, GI likes to have the customer do most of the design, from black-box specs, to logic diagram, to schematic, to operating schematic (containing a generalized layout of the components), to a composite diagram. GI then uses the composite to make the masks for the IC. GI engineers can teach a customer the ground rules for the design—in a few days, according to Sidorsky—so both the customer and the supplier are speaking the same language.

For circuits of its own design, GI uses computer-aided techniques that generate a punched paper tape, which is then used to drive an automatic mask-making machine. (The program that's used to generate the mask-making tape simultaneously generates a tape to program GI's automatic testing equipment.) "The ideal case," says Sidorsky, "would be to have the customer use the same program, so that when he wants a new circuit, he produces a tape that we use to make the masks and test the final product. This will not only speed up the design process but also save the customer money because he's not tieing up our design people with details of the circuit design."

GI now has offices in New York, Salt Lake City, Los Angeles, and Scotland where a customer can have his composite diagrams turned into tapes or masks. The people at these locations can also assist the customer with the chip layout and the composite diagram.

The philosophy at Hughes Aircraft Co.'s Newport Beach, Calif., division is essentially the same as that at GI; engineers give the impression that they're delighted to have the systems house do the bulk of the work. (Hughes is gathering considerable momentum in complex MOS arrays, so the division's viewpoint is that of an IC vendor, not that of a systems house.) Says Jack Hirshon, division manager, "Our philosophy is that the systems people know systems performance characteristics and are in a better position to partition their designs into subsystems that a vendor will make. We



Looped. Texas Instruments uses the three-loop concept in its relations with systems houses. The light-colored arrows represent the typical design cycle through which a system passes in the systems builder's house, from initial concept through production and delivery to the end-user. The dark-colored areas represent activities at TI. The slender arrows show communication between the systems builder and the IC manufacturer. The broad arrows—the loops—indicate the flow of software and hardware between the segments of the customer's and the vendor's activities.

furnish design rules that include line widths, component spacing, and crossover considerations." Hughes also provides a library of building blocks that can be interconnected to form read-only or random-access memories, certain kinds of shift registers, and some random logic.

Texas Instruments' policy of participation with the customer is perhaps more representative of the industry. According to Jack Kilby, manager of the customer requirements center at TI's components group, "Our present mood is to encourage the systems house to participate fully with us. We want them to work closely with us in the actual circuit design. We think this work takes a closer customer-device maker relationship than one of just mailing specifications back and forth. We think this will continue to be our position."

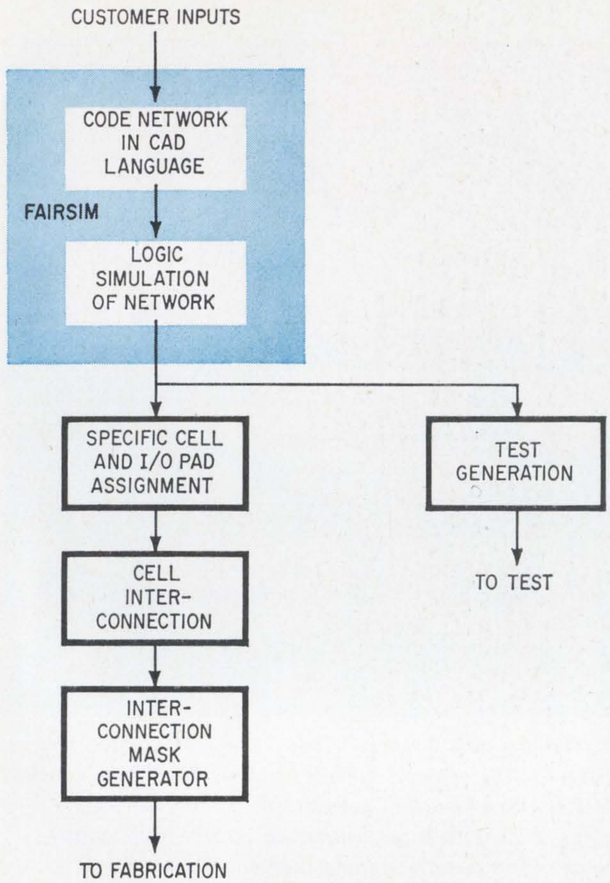
Kilby has reservations, though. The systems house will be content to let the circuit maker devise designs "to the extent that we can save him money while providing him with performance gains." The big thing, he says, is economics; he says the IC maker can now show customers money savings in the beginning on complex custom circuits and extend the lure of even lower costs as orders increase "because we can have more automation." Says Kilby, "That is the key factor."

Rudolph Thun, manager of the microelectronics department at Raytheon's Missile Systems division and technical director of the Components division, describes what he considers an ideal working relationship: "Systems designers should model circuits as best they can to see if they will work." They should then supply the IC maker with a schematic, the models, and full transistor characteristics. Finally, the customer should provide "a set of black-box specs and be prepared to yield a little on design, and perhaps some on performance-cost relations as well."

Hedging bets

Whatever the interface favored by the semiconductor manufacturers, there is no question about the direction in which the systems houses are moving: they are setting up their own microelectronics fabrication facilities. In most cases, the systems houses disavow any intention of competing with the established suppliers. Nevertheless, it's clear that, by learning IC technology first-hand, they intend to exercise greater influence on design and fabrication.

The reasons for establishing in-house capability are varied and complex. Perhaps the most common motivation is simply a desire to get the job done. Lockheed's Missiles and Space division can serve as a good example. Several years ago, when hybrid IC's were considered advanced technology by the component manufacturers, the division needed 300 such circuits built to the company's own specification. Lockheed awarded the contract to one of



Fair similitude. Fairchild's Fairsim program for computer-aided design of LSI and MSI circuits may eventually be linked directly to systems houses.

the large semiconductor firms for less than $50,000—$158 per circuit.

A year later, the semiconductor house was staggering eight months behind schedule. At an emergency conference, an executive vice-president of the semiconductor supplier told Lockheed: "I have no product to sell." Despite $400,000 spent to develop the hybrid quad output driver, the company had to concede that it couldn't build the circuit.

Finally, after three of the big semiconductor firms had tried to make the circuit, a fourth succeeded.

It was about then that Lockheed started to think about getting into microelectronics design and fabrication itself. The company finally took the plunge and it's now firmly committed to prototype and pilot-line production of hybrid and monolithic IC's.

And other companies, such as Martin-Marietta, Autonetics, Boeing, TRW—apparently every major systems house—have found it expedient to encompass a significant part of fabrication within their own organizations.

As with Lockheed's star-crossed circuit, the IC supplier may be unable to do the job technically. Or he may not want to handle a small-quantity order. Engineers at the Lockheed division are particularly nettled at this reluctance of major manufacturers to make limited production runs of custom devices. Lockheed's programs, officials say, are mostly small-quantity; except for Polaris and Poseidon programs, most of Lockheed's work requires only one-of-a-type IC's for each space vehicle or satellite. A large order is rare for satellites; indeed, officials recall only one program that had a "large" order; each of five satellites had two block boxes, and in each box there were 10 identical circuits, for a grand total of 100 IC's. "Now you go to Fairchild or Texas Instruments and ask them to run off 100 circuits for you and they're not really interested," says a Lockheed engineer. "The only thing that will induce them to make this run for you is if the device happens to resemble something they've got going in Research and Development and they think they can get a little subsidy for their R&D work." Therefore the systems house often has no choice; it must do its own development.

Another problem influencing systems houses to develop their own microelectronic capability is the difficulty of two-way communication. The semiconductor houses sometimes just don't understand the user's need, or vice versa. "When you try to be cute with a maker," observes William F. List, manager of molecular systems at Westinghouse's Aerospace division, "and not tell him what the circuit is intended for, you can wind up in trouble. For example, the maker naturally tries to make the circuit cheaper and more efficient and may change the design a little while still meeting specs. He may meet specs, but the device won't plug into the system because it throws the parasitic components off."

Burroughs has found that it works the other way, too; by adhering blindly to specifications, the vendor may impede the development of an IC. In interfacing with a vendor during the development of LSI circuits for the Illiac 4 computer, Stokes was "surprised at the way semiconductor people take certain logic designs as absolute gospel. In many cases, the interconnections you make are very much arbitrary—only one of several ways of doing it." To stick with only one way of designing the interconnections may be contrary to the best interests of the LSI partitioning. In the Illiac 4, of course, circuit speed is critical, and one of the design rules suggested to the IC vendor was that the least significant bits in a word be processed first to minimize delay. But a combinatorial logic unit works backwards: it starts shifting the more significant position first. "You can delay the least significant positions a couple of gates later," Stokes says. When the vendor's engineers got to this kind of circuit, "they agonized over that partitioning because of the delay" that resulted when the least-significant digit priority was observed, "without the knowledge that we could just as easily look at the most significant bits first," Stokes adds. "When that came to the fore, the whole problem was solved."

And the separation of more than 1,000 miles between user and vendor didn't help communication. "I can't overemphasize the need for absolute intimacy," Stokes says.

The systems companies like the short lead time that an in-house microelectronic facility affords. Lockheed, for instance, can get its new circuits fabricated "virtually overnight," according to a spokesman.

"There are a lot of other intangibles" that an in-house facility provides, says Dale Hartman, who is setting up such a facility for Martin-Marietta in Orlando. "For instance, technical image. If you're competing for a big proposal, and have a review team coming in, if you don't have a basic capability in microcircuits today, I feel that your technical image suffers."

Probably, however, the fundamental reason that the big firms are rolling their own is simply that they want to preserve their traditional role and protect against incursions of IC suppliers into the heart of the systems design activity. If this process were carried to its logical conclusion, the microelectronic supplier would assume the task of systems design and the systems house would become merely an assembler.

To prevent this, many companies believe that the design engineer must become personally involved in the new technology; he must go into the lab and make the circuit, because he'll understand only by doing the job himself. "The designer can't really conceive in this business without having a personal feel for it. That's why we've invested in our microelectronics facility at Lockheed," says Julius Y. Kaplan, director of engineering at the Military Systems division of Lockheed Electronics.

One of the by-products of in-house electronics, many systems manufacturers feel, is that it aids in buying components intelligently. The buyer who understands what he's buying can strike a better bargain. "Let's face it," Kaplan says, "price is not a manufacturer's cost plus a reasonable fixed fee. Rather, it's what the market will bear. Helping a systems house to gauge his supplier's costs should more than pay for a microelectronics facility, even if this were the only benefit."

(Semiconductor manufacturers, incidentally, scoff at the notion that a line for fabrication of prototype IC's will give even a remote indication of production costs.)

Trust and prudence

Finally, there's the competitive advantage that design control provides. To stay in the running—to maintain their identify—in the competition for systems contracts, most manufacturers are convinced that they must originate some of the IC's they use. Westinghouse's List cites shift registers with correlation, which his company developed and will soon use in systems. Westinghouse, he says, has a three-year lead on the company that waits until such circuits are available as a catalog item. "The key is that it's very important for a successful systems maker to focus on what to put into the product to make it sell. You don't have to make 99% of the IC's that go into your systems to keep up. You can buy a certain number off the shelf, but you can't buy all of them because the competition could buy the same," List says.

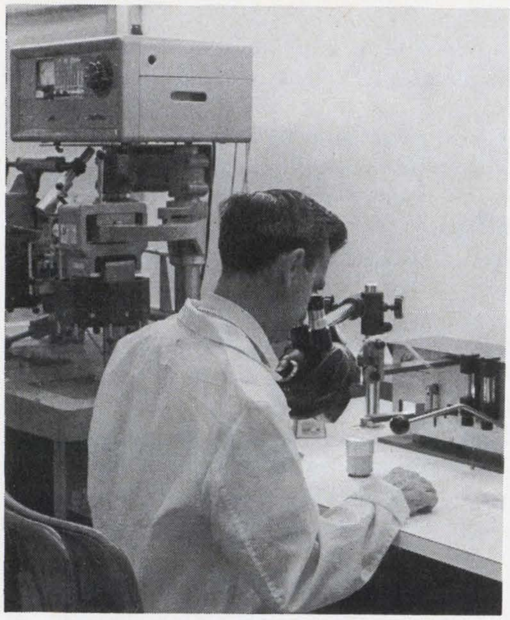
One of the reasons often given in the past to justify in-house microelectronics—protection of proprietary circuits or processes—appears to have little real significance. A Hewlett-Packard spokesman sums up the feeling of most systems houses: "In general we get along well with the IC manufacturers; we tell them a great deal about what we mean to do with their circuits, but not everything. There have been no cases where we feel an IC sales engineer has spilled our secrets." By and large, the systems houses don't see much benefit resulting from extreme attempts to preserve proprietary rights when they work with vendors; at best, they can only buy time. The prevailing attitude seems to be trust, with a dash of prudence, in dealings with vendors.

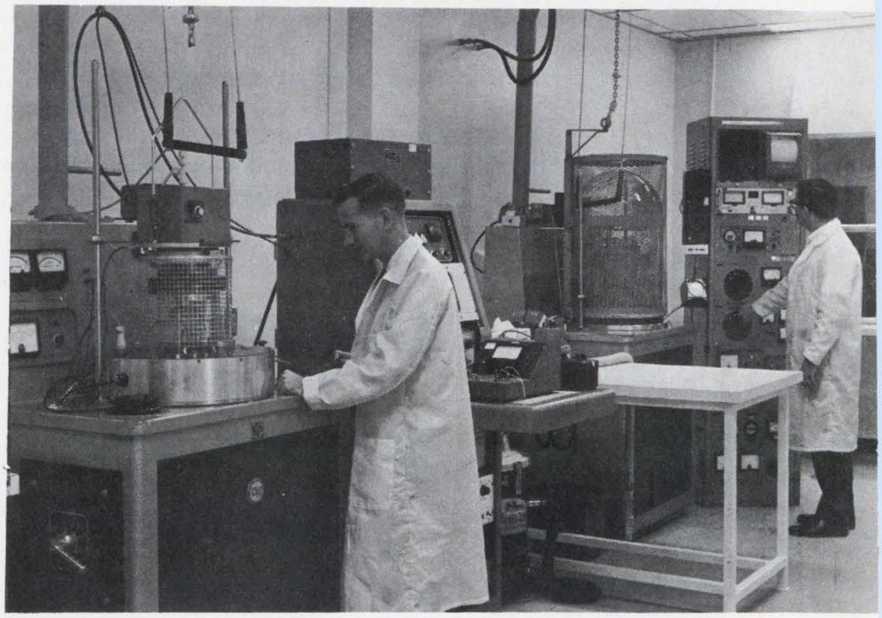
Vendors, on their part, are determined to merit their customers' trust. First, IC suppliers recognize that they have a position to protect; they can lose that position if they don't respect confidential information. And John A. Ekiss, manager of the circuit development department at Philco-Ford's Microelectronics division, points out that while the customer may indicate that information is proprietary, the semiconductor vendor often doesn't know why. The information might relate to a new system organization, for example, which the vendor would have no way of evaluating. "The semiconductor vendor does not want to capitalize on the fact that information is proprietary," Ekiss says. "What would he do with it?"

Thun, the Raytheon manager, concurs: "As far as systems information is concerned, component manufacturers are very ethical. I've never seen a leak."

TRW's position, however, is somewhat different. The company's policy is to share innovations if they are modifications of standard circuits. "But if a circuit gives you a competitive edge in a system, only a fool would let the design get out of the house," says Ben Duwaldt, manager of TRW's microelectronic center. "If you have a hot idea, you'll do everything possible to protect it, maybe even setting up a special in-house shop to develop it." (This shop would be in addition to the existing in-house semiconductor facility.) TRW hasn't been burned by semiconductor suppliers on proprietary designs because it hasn't let them get outside the house for production. "It's pretty rare that we have to go outside the TRW family for production quantities, so it's not difficult to protect a design" points out James Bowie, head of the microelectronic center's technology section.

The center designs, but doesn't make, its own masks. Bowie requires a guarantee from the mask maker that he'll keep the design confidential and return all masters. "But trust enters into it, too,"





Investment. Equipment for IC fabrication—such as the thermal compression pulse bonder (left) and thin-film deposition chambers (right) at Martin-Marietta—does not come cheap. One estimate puts the cost of a monolithic IC fabrication line at $1 million, of a thick-film line at $100,000, and a thin-film line somewhere in between—all for very limited prototype fabrication.

Bowie declares. On a highly proprietary design, the wafer would most likely be processed by the center.

Brash excursion?

Even when the IC vendor's parent company also maintains a systems division, proprietary considerations don't seem to be a serious problem. Kaplan of Lockheed Electronics puts it this way: "Whenever you deal with a components company that also has a systems division bidding for your own business, things can be sticky. We assume a certain amount of business ethics prevailing but we aren't foolish about it. Sure, fellows from the same company will talk to each other. But if we have more to gain than to lose, we go ahead and tell the components company what we're up to."

What do the traditional IC suppliers think of the emerging independence of their systems-oriented customers? Opinions range from complete acceptance (and willingness to work with the customer on his own terms) to strong disapproval of what's considered a brash excursion into the black art of IC technology. The middle ground, shared by the majority of IC producers, is approval of a small IC fabrication line—just enough to build prototype circuits, at the most. This, the IC houses say, would help the systems-house engineers gain a better understanding of IC design and technology, and would lead to more effective cooperation between vendor and user. The interface would still be a set of performance specifications for the IC, given by the customer to the vendor. The vendor would decide how the circuit should be designed and made.

William Dunn, who is in charge of custom LSI at Sylvania's Semiconductor division, sums up the middle-of-the-road policy: "The systems house will generally supply black-box specs, and we can tell from them if the design is practical." He continues, "A systems house can never duplicate the economic leverage of a true semiconductor vendor —thus, to my way of thinking, a systems house's capability should be limited to modeling, feasibility study, and so on."

Dunn cautions that "this doesn't mean that the systems house is going to be able to send his masks to a semiconductor producer and get back LSI, though. His approach might not interface at all with the production technology used at the IC maker's plant."

A sense of direction is needed, too, according to TI's Kilby. In-house capability is useful, Kilby says, when the systems house is big enough and when it needs components that aren't available outside.

Unfortunately, not many houses are using their capability in this way, Kilby adds. "Most are limited in size. Since they don't have enough money to keep up, they usually end up specializing in things available to them from outside. So, they don't perform an especially useful function." Often, systems houses will work on digital IC's; this, says Kilby, is a needless and wasteful duplication of activity in the semiconductor houses, which are far better equipped and more experienced. "We can produce these (digital circuits) cheaper than any systems house can. Unless they are prepared to put in enough dough to match our scale of operations, they will find that they are on a head-on collision course with our operations."

Raytheon's Thun is enthusiastic in his support of in-house capability: "Any firm doing about $150 million or more a year has no business being without some in-house development capability. Firms grossing $600 million a year and up should have manufacturing capabilities for captive needs." A big advantage, Thun feels, is that both vendor and customer feel that they cannot put anything over on the other. "This can make both sides run scared and that's good—makes 'em work and keeps 'em honest."

Another advantage is that in-house facilities are a source of technical innovation. "Many original ideas will come from systems houses," Thun says, "and eventually these should find their way into semiconductor lines." Engineers from the systems houses voice the same idea; they see the IC manufacturers as having a vested interest in existing technology.

On the other hand, Motorola's Callahan is still not convinced that the systems house should set up its own IC facility in the first place. The biggest problem is talent, Callahan says. "It's difficult for them to amass enough talent to take the next step forward" into production.

However, Callahan believes than an in-house facility may be justified for second sourcing, "to handle the small-volume jobs the large semiconductor manufacturers don't care to." He adds, "It's difficult for Motorola, TI, and Fairchild to second-source each other on complex functions, so the in-house capability at the systems house is justified as a second-source shop. The volume isn't great enough for the big manufacturers to second-source each other on these devices."

Costly proposition

However they feel about the advisability of a limited in-house capability, the IC manufacturers are predictably emphatic in discouraging systems houses from competing with them. "Unless it's a huge firm, it's a mistake to get into the business," warns Robert Sanborn, marketing manager for microelectronics at Hughes, because "there are so many suppliers available, the dollar investment is immense, and the technology is running too rapidly for such a company to set up its own facility." [For Sanborn's impression of the evolution of the interface, see p. 79.] Ekiss of Philco-Ford points to the highly competitive market for IC's. This should deter systems house from selling IC's outside, he says.

What about those giant corporations with both systems and IC manufacturing divisions? The advantages of such a combination may be more apparent than real. The IC division usually has to compete with outside suppliers for the systems division's business, and, by the same token, the systems division does not always have an inalienable right to the IC division's facilities and personnel. Only about 10% of Philco-Ford Microelectronics' business is in-house. "You need the conditioning of the external market," a Philco spokesman says. "That's the market that's going to keep you snappy, that's going to ensure that you're successful, that you obviously know how to do the business. Then you can be of benefit to the company. But if you don't have to stand the gaff of the open market, then maybe apathy can slip in."

Holding hands with a CAD

Even those companies that have major semiconductor divisions are still setting up in-house prototype capability for their systems divisions. Even though Raytheon, for example, has that large semiconductor operation in Sunnyvale, Calif., the company has established prototype monolithic IC capability at its Missile Systems division in Bedford, Mass.

General Electric, too, is augmenting its commercial semiconductor department with an Integrated Circuit Center (IC-squared to GE engineers). This custom facility will service the GE systems divisions with sophisticated IC's.

Hand-in-glove with the design interface are computer-aided design techniques. "There is literally no alternative to CAD, which under the proper circumstances can save five months' design time," says Dunn of Sylvania. Aside from speed, CAD means greater confidence in artwork and test procedures. But cooperative use of CAD by supplier and user is still very much in the formative stage.

CAD is pervasive in systems design—to describe functions, to partition them into circuits, to design the circuits, make masks for them, process them, and test them. But at some point, this chain has to be broken when the IC maker takes over. "What's needed to make this division of labor a smooth one, says Thun, "is a common form of documentation for use both by systems and semiconductor houses —and nobody has one."

Dunn agrees that there is a serious problem in transferring data from one company to another. "Differences in software and documentation just don't allow information to make the jump unscathed," he says. Dunn believes that vendors can help by describing in full their custom capabilities, wiring rules, spec guard bands, and so forth. "Then say also, 'This is our software interface; if you can adapt to it it will speed things up greatly.' This is another of these things which must be ironed out early in the user-vendor relationship."

Some companies have already made a start at cooperative CAD. Fairchild, for example, is making its Fairsim CAD program available on a limited basis. A proposed LSI design is coded into Fairsim language along with a test sequence. After simulation, the data becomes the basis for computer-aided cell placement, interconnection, and acceptance test programs.

More such schemes can be expected in the future, in view of the overwhelming importance of CAD in the design interface. As Kilby of TI points out, "CAD cannot be over-emphasized. It is the key. It makes all of this possible." ■

Circuit design

Designer's casebook

Improved Miller sweep uses an active load

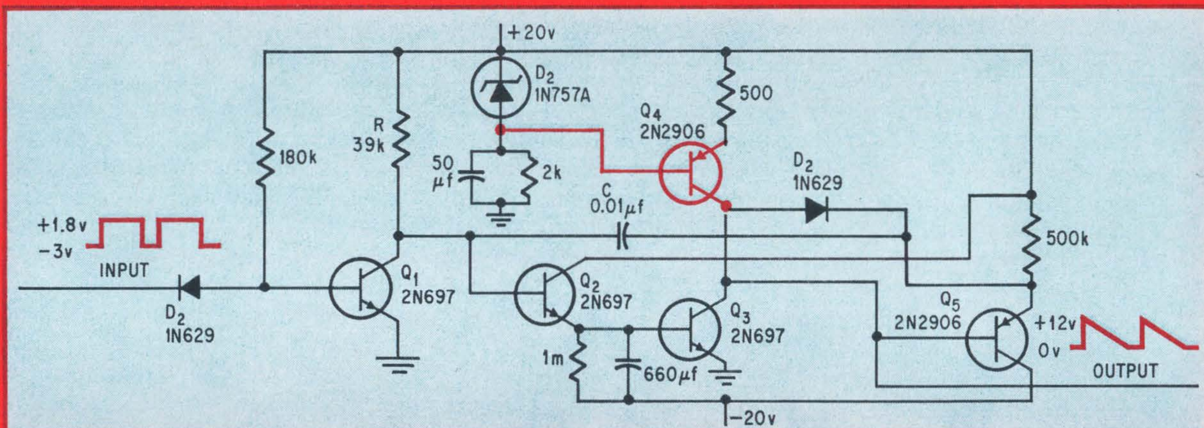
By Dipak K. Basu and Biswajit Nag

Jadavpur University, Calcutta

When a large load resistor is used in a Miller sweep circuit to obtain a high gain, the sweep's flyback time is increased and a high collector supply voltage is needed to ensure a good current gain from the amplifier's transistor. If the resistor is replaced by an active load in the form of a common-base transistor, the transistor will act as a current source, providing several megohms of dynamic impedance at a few milliamps of collector current. This reduces the flyback time and improves linearity.

A positive gating pulse turns Q_1 on, delivering a slightly negative voltage to Q_2's emitter and Q_3's base. Q_3 cuts off and C quickly charges from the current source, Q_4, through the diode D_2 and the switching transistor Q_1. Q_5 remains cut off because of the forward drop across D_2, but Q_5's emitter also contributes a small amount of charging current.

At the negative transition of the pulse, Q_1 turns off and its rising collector voltage is transmitted through Q_2 to Q_3's base, turning it on. C now starts to discharge through R, Q_5, and Q_3, starting the Miller rundown at Q_3's collector.



Linear. A positive gating pulse causes C to charge from the current source, Q_4, through diode D_2 and the switching transistor Q_1. On the negative transition of the pulse, Q_3 is turned on. C now discharges through R, Q_5, and Q_3, starting the Miller rundown at Q_3's collector.

Transistor "zener" has zero dynamic impedance

By Heinz Stadler

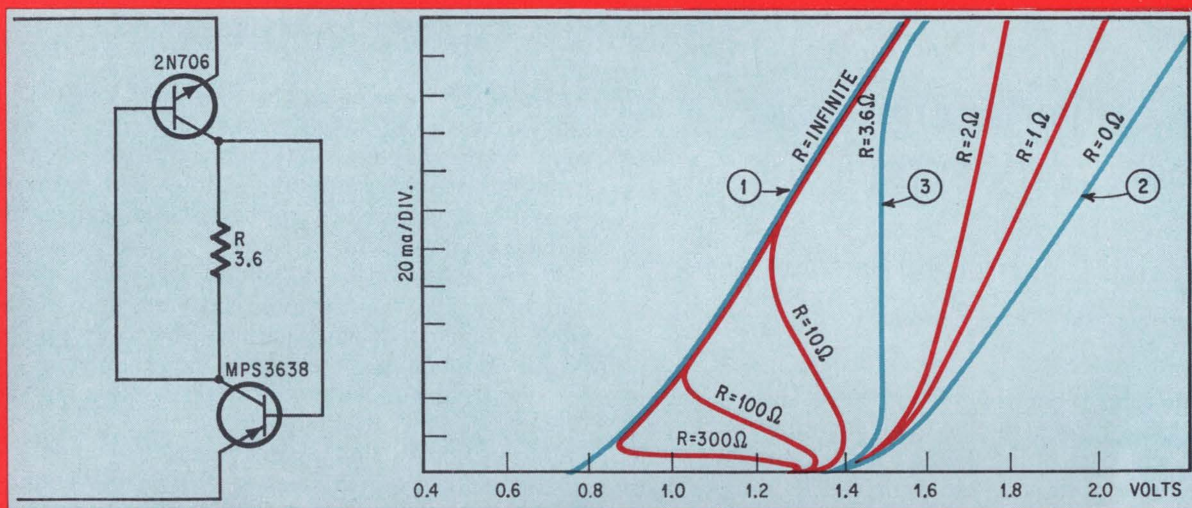
Georz Electro GmbH, Vienna

The best way to regulate voltages below the zener minimum of 2 volts is to use two transistors and a resistor. The advantage of this "zener" over the cascading of two or more silicon diodes is its zero dynamic impedance from 20 to 150 milliamperes.

If the applied voltage is greater than 1.4 volts, both transistors begin to conduct. When the resistor, R, is infinite, the circuit's characteristic is that of the first curve. The other extreme occurs when the resistor is zero (curve 2). Between these extremes exists a region where the dynamic impedance of the device can be made equal to zero (curve 3). If the base-emitter impedance, r_{be}, is linear and equal for both transistors, the resistor can be calculated:

$R = 2r_{be} (1 - h_{FE}/1 + h_{FE})$

The temperature response is –5 millivolts per degree Centigrade.



Simulation. The transistor circuit has a 1.5-volt zener diode characteristic. This "zener" has a zero dynamic impedance from 20 to 150 milliamps. If the applied voltage is greater than 1.4 volts, both transistors begin to conduct and the best curve is obtained with R at 3.6 ohms.

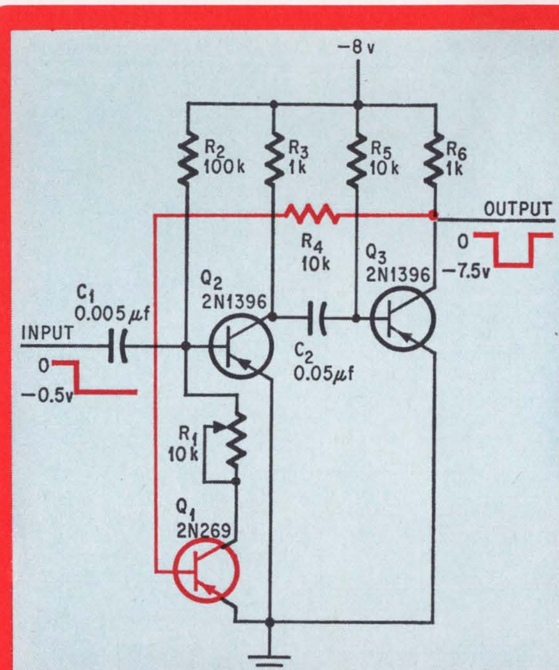
Pulse generator triggered by a step function

By Robert J. Hoss

Collins Radio Co., Dallas

Adding a single transistor to the feedback loop of a monostable multivibrator enables it to be triggered by a step function and generates a pulse of variable width. The circuit was used to produce trigger pulses for a digital system from the step function of a shaft encoder.

A negative going transition at the input to the circuit is differentiated and amplified by transistor Q_2, which then switches Q_3 off. Q_3 is ordinarily held off for a period determined by the constant, R_5C_2. But the negative-going voltage at the output is fed back to Q_1's base so that Q_1 is switched on as the output reaches its crest. The pulse's trailing edge is shunted to ground, switching Q_2 off. The charging current through C_2 reverses, switching Q_3 on and creating a fast falling edge on the output, which is taken off of Q_3's collector.



Step trigger. For the values shown, a 50-millivolt negative step at the input yields a 0.25-microsecond, 7.5-volt output pulse.

If R_1 is set at zero, Q_1 causes the output pulse to fall as soon as it crests, its width depends only on the delays in the transistors. R_2 determines the output pulse width.

By adjusting R_2, the amount of current which remains to keep Q_2 on after Q_1 has switched, can be regulated and consequently the width of the output pulse can be adjusted.

The input signal must be limited to a 0.5-volt level to prevent the circuit from breaking into damped oscillation.

The circuit values yield a 0.25-microsecond pulse.

D-a converter improves accuracy of thermal unit

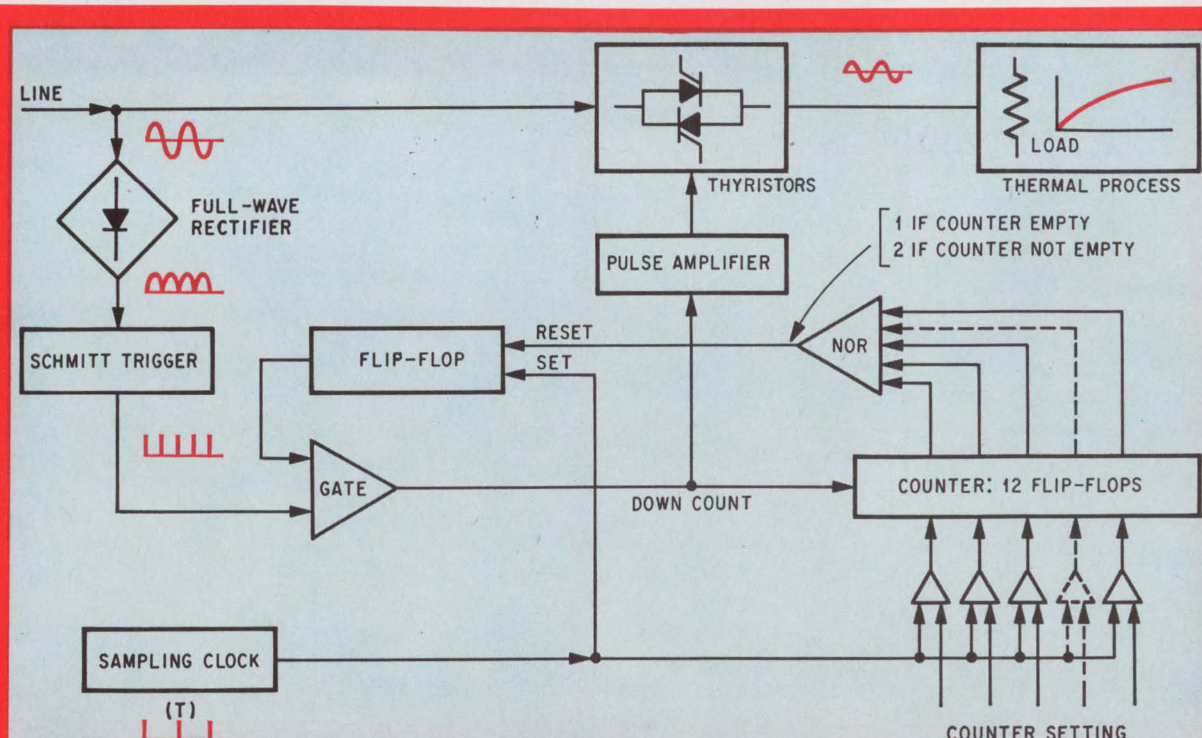
By Marcel Nougaret and Bertrand Lisee

University of Sherbrooke, Canada

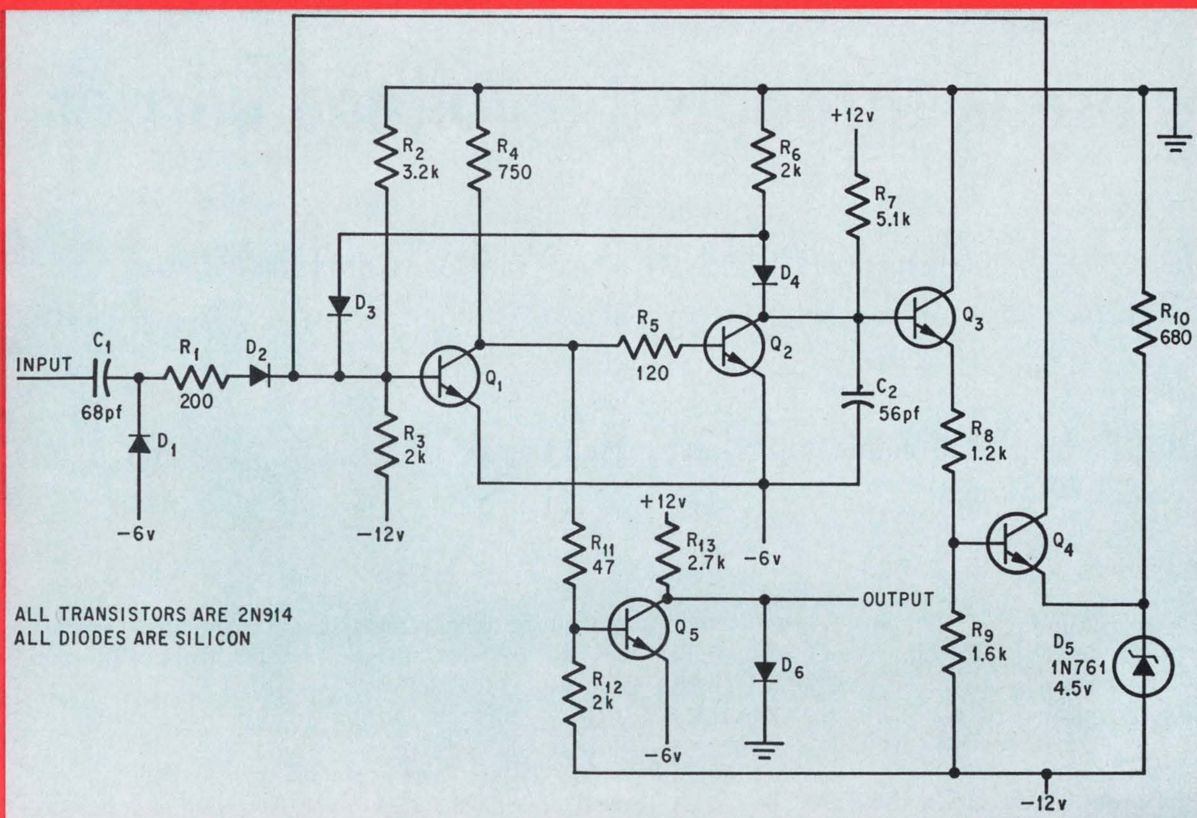
Temperature control systems that use a digital computer present a few special problems. If proportional control is required, as in programed temperature profiles, on-off control does not give accurate results. One can use a digital-to-analog converter followed by a memory device and a power amplifier to supply electrical heating to the load, but this is quite expensive.

One way to overcome these problems is to use a d-a converter in which pulses discharge a preset counter and charge an integrator until the counter is empty. At each sampling period, as many half-sinusoids as there were numbers in the register are delivered to the load.

At the beginning of the sampling period, T, the content of the accumulator is transferred to the flip-flop register through gating logic. The flip-flop is set and enables the pulses coming from the Schmitt trigger to enter the register. The register is wired as a down-counter, and as long as the counter is not 0 a signal gates thyristors—which are silicon controlled rectifiers—on. When the counter reaches 0, the flip-flop resets and the system waits for the next sampling period. It takes only a few microseconds to set the counter and the flip-flop, and the SCR's always fire at the 0 crossover point.



Legerdemain. A thermal process can be proportionally controlled even if one has only digital equipment available. The trick is to use a digital-to-analog converter whose pulses discharge a preset counter. This method is less costly than using a d-a converter with a memory device.



Quick discharge. The single shot achieves its extremely fast response through the use of a timing capacitor which discharges directly through the low impedance of a transistor, instead of through the customary resistor. The output pulse width is about 100 nanoseconds.

Full duty single shot recovers fast

By James H. Williams

International Business Machines Corp., Kingston, N.Y.

Many fast-recovery single-shot multivibrators permit false triggering, responding to an input pulse before the completion of the preceding output pulse. This single shot has a duty cycle of more than 95% and has little chance of triggering falsely. It has a faster recovery than most such circuits, and an output which is virtually independent of its input rise time, duration and amplitude.

To achieve its extremely fast response, the single shot uses a timing capacitor which discharges directly through the low impedance of a transistor, instead of through the customary resistor. The output pulse width is approximately 100 nanoseconds, large enough to make the duration of the output pulse independent of transistor variations.

In the quiescent state, Q_1 and Q_4 are off while Q_2 and Q_5 are on (Q_3 is an emitter follower, neither on nor off). A negative-going transition at the input turns Q_1 on, which turns Q_2 off. D_3 and D_4 provide isolation between C_2 and Q_1. Q_1 is held on by R_6 and D_3.

C_2, which was held at a low voltage by Q_2, now begins to charge through R_7. Q_3, R_8, R_9, and Q_4 compare the voltage on C_2 to a reference voltage generated by R_{10} and D_5.

After C_2 has built up a charge, its voltage is positive enough to turn Q_4 on, which then turns Q_1 off and completes the cycle. There is a rapid recovery because Q_2 turns on as Q_1 turns off, and very rapidly discharges C_2.

The output is translated into the required −6-volt level by R_{11}, R_{12}, and Q_5. R_{13} and D_6 help provide a rapid positive transition at the output. Since the time required to discharge C_2 is of the same magnitude as the fall time of the output, the circuit is ready to accept another input as soon as the output has fallen.

Once the timed interval has started, the circuit is insensitive to variations at the input, except for a very small period of time (10 nanoseconds).

IC's break through the voltage barrier

Operating levels of 300 volts are possible with a field plate for neutralizing surface charge and a directional etchant for dielectric isolation.

By Hans R. Camenzind, Bohumil Polata, and Joseph Kocsis
Signetics Corp., Sunnyvale, Calif.

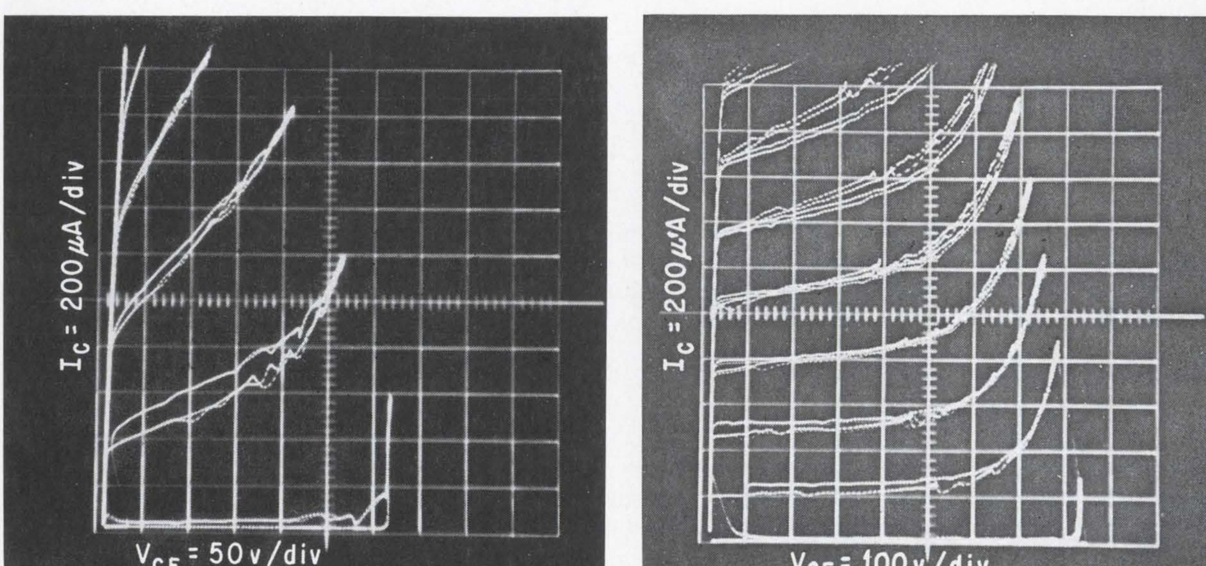
Constrained by the lack of integrated circuits that operate much beyond 50 volts, circuit designers often reluctantly go to discretes. One new type of IC, however, could not only cost less than discretes but also offer high breakdown voltages—up to 300 volts. Such devices can be made routinely; single laboratory circuits have attained 1,000 volts.

Up to now, most IC's have been low-voltage types because it's almost impossible to grow high-resistivity n epitaxial collectors on p substrates and because surface breakdown couldn't be controlled. But two recent developments make the routine fabrication technically and economically feasible.

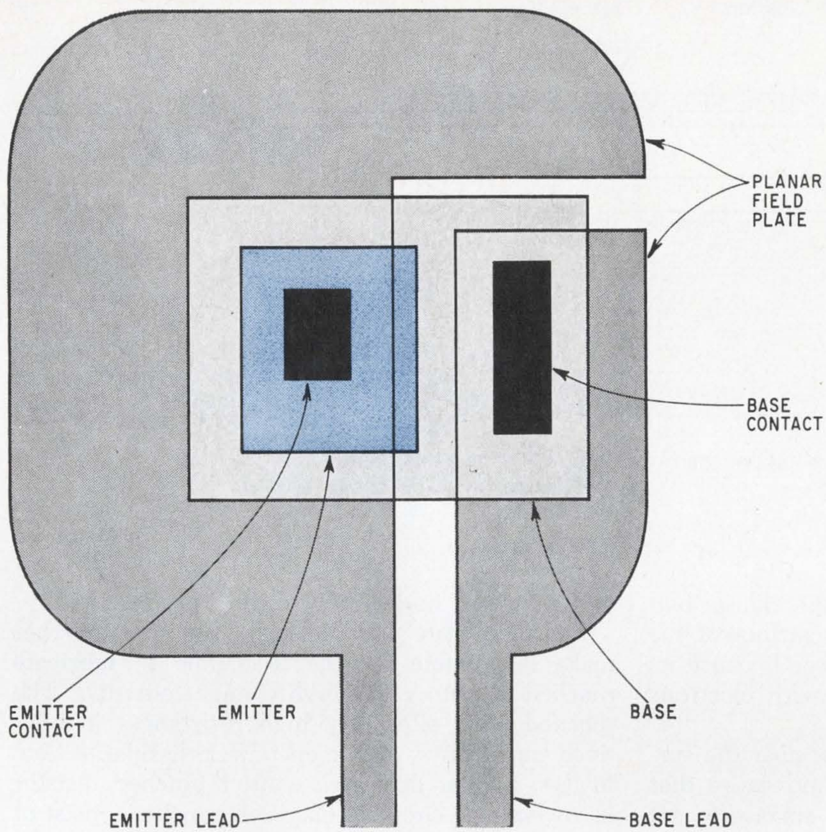
The first—a "field plate" that's merely an extension of the planar metal circuit contacts—neutralizes the positive surface charges responsible for premature breakdown.

The second—dielectric isolation with an anisotropic etchant—allows collectors to be formed on high-resistivity grown silicon rather than on epitaxial material. And it makes it possible for components in high-voltage circuits to be packed far more densely than they can be with p-n junction isolation techniques. This will be discussed in more detail in a future article.

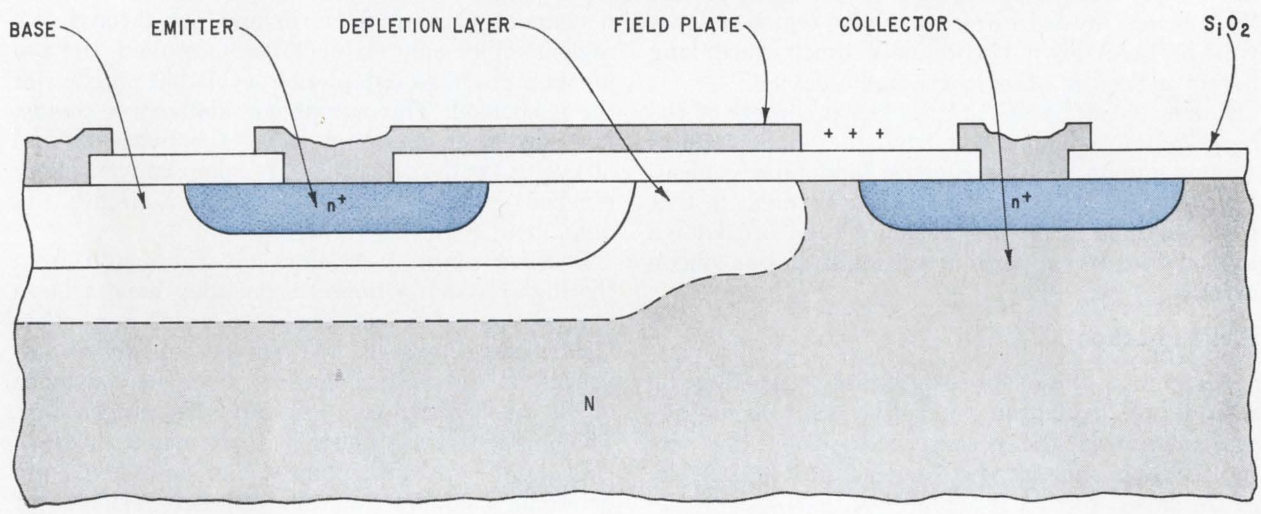
Positive charges gather at the surface of IC's for two reasons. For one thing, sodium and other impurities in either the passivating oxide layer or in

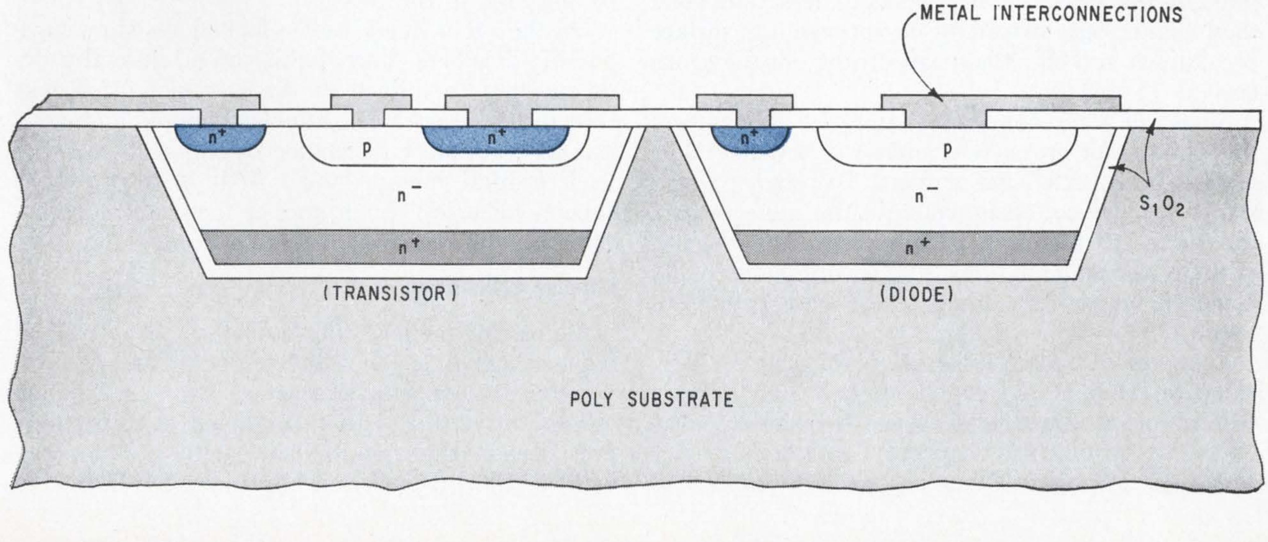


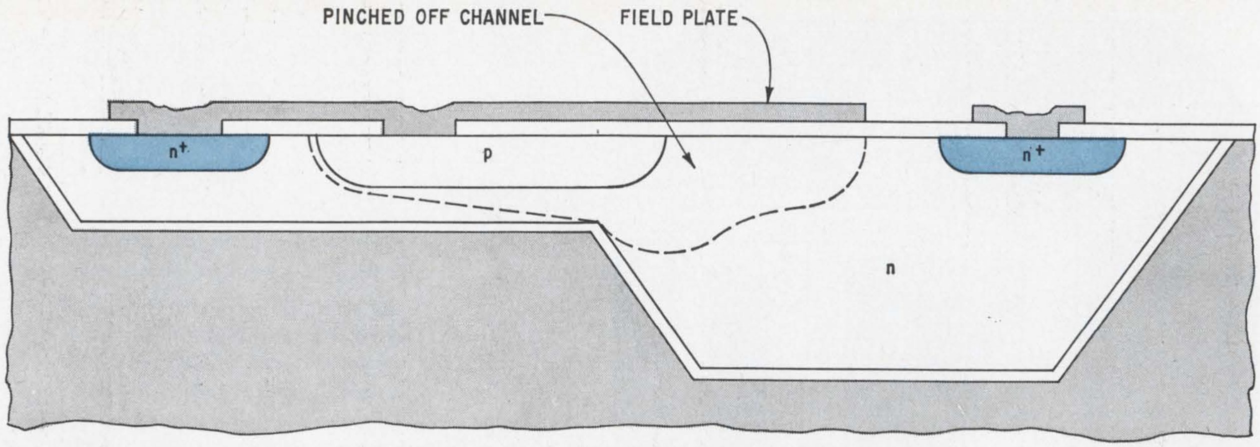
IC traces. Collector-emitter voltages of npn transistors fabricated in high-voltage IC's are plotted against collector current. Left, with base current equal to 5 microamps per step, breakdown voltage, BV_{ceo}, is 300 volts. Right, with I_B equal to 20 microamps per step, BV_{ceo} is 800 volts.



Plates and grooves. Keys to high-voltage IC's are field plate shown in top view and side view and dielectric isolation. Field plate spreads out depletion layer, preventing surface breakdown, and dielectric isolation allows collectors to be fabricated on a high-resistivity substrate.







In a pinch. Dielectric isolation makes possible pinched resistors such as this that deliver a constant low current and take up little space.

the metal interconnections disturb the charge balance. For another, the silicon at the surface of the single crystal has a net positive charge because its valence bonds end abruptly there, with electrons missing.

These charges add to the potential near the surface with an applied reverse bias and cause that part of the depletion layer near the surface to act like a low-resistivity area. As a result, the depletion layer bends inward toward the base region, so that voltage breakdown occurs near the surface long before it does in other parts of the device.

Other "weak" areas are the sharp corners of the base region, which result from the shallow diffusions common in IC's. Electric field lines concentrating at these corners in a manner similar to that in the corona effect can cause voltage breakdown long before it happens in the bulk of the silicon crystal.

Fielding action

Metallizing the oxide surface and connecting the resulting field plate to a negative point on the circuit neutralizes the positive charge near the surface. This is equivalent to increasing the resistivity of the layer, so that it actually exceeds that in the bulk of the crystal. The widened depletion layer then bends out instead of in, preventing surface breakdown and effectively smoothing out the sharp corners of the base.

Since all interconnections must be planar and the plate can't cross over emitter and base leads, it must be an extension of them. To prevent shorting of the device, designers split the plate in two, leaving a 10-micron gap between. The effect is virtually the same as that from a continuous plate, however, because the edges of the fields from both overlap.

Economical dielectric isolation was achieved by using an etchant developed by Bell Laboratories that attacks one crystal plane much faster than the other. The resulting V-shaped isolation area wastes very little silicon and can be precisely controlled vertically and horizontally during production.

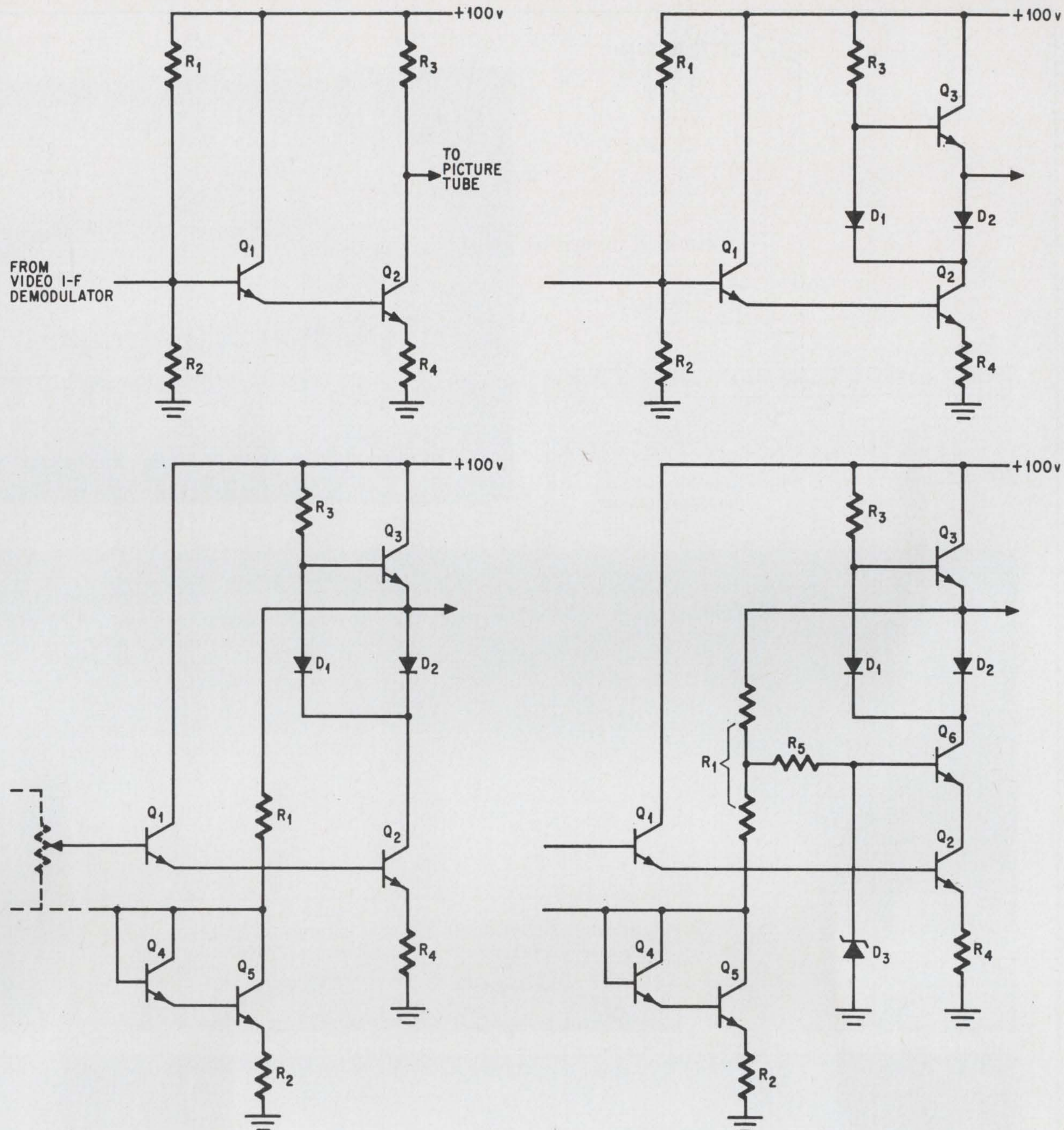
The field plate and dielectric isolation together make it possible for the first time to fabricate pinched resistors in high-voltage circuits. The pinched units offer very high resistances in relatively small areas and keep power dissipation low in IC's. Similar to a base-emitter pinched resistor in low-voltage circuits, these components consist of a p-type region that forms a junction with a narrow n channel. Current flows in and out through n^+ regions. With only about 20 volts applied, the p-n junction produces a depletion layer that pinches off the n channel. This component delivers a steady, low current at operating voltages between 20 and 300 volts. On the other hand, breakdown voltages of pinched resistors in junction-isolated circuits are only about 6 volts.

Because pinched resistors are fabricated from the high-resistivity bulk silicon, they have a large temperature coefficient—about 0.5 to 1% per degree Centigrade. However, this can be actually an advantage in high-voltage circuits, since the resistance of the pinched resistors goes up with temperature. This increase doesn't change performance, because gain and d-c operating point in high-voltage IC's are determined not by the value of each resistor but by the ratio of the resistors.

On the other hand, bulk pinched resistors have one disadvantage: they require an additional processing step to diffuse in the p region. For that reason they're not used in every type of high-voltage IC. The sheet resistance of the bulk material itself is high enough—about 5 to 10 kilohms per square—for many circuit applications and thus conventional diffused resistors are adequate.

Unique difficulties

Alternative methods don't do the job as well in high-voltage IC's. Thin-film resistors are too expensive because they add processing steps. (They are necessary in radiation hardened circuits, however, because diffused resistors exhibit high leakage when exposed to radiation.) And p type diffused re-

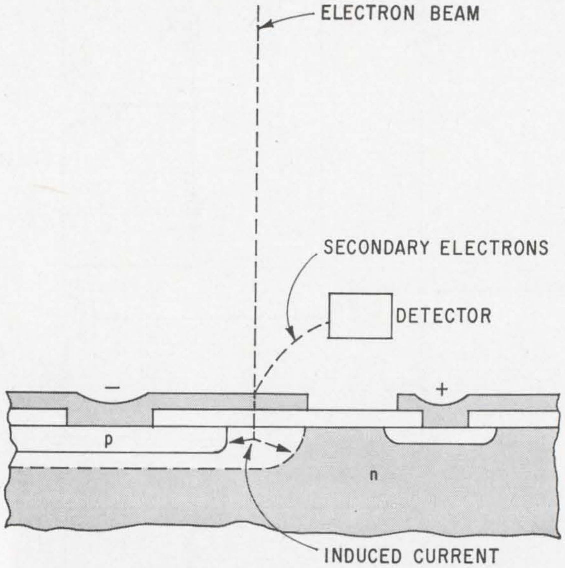


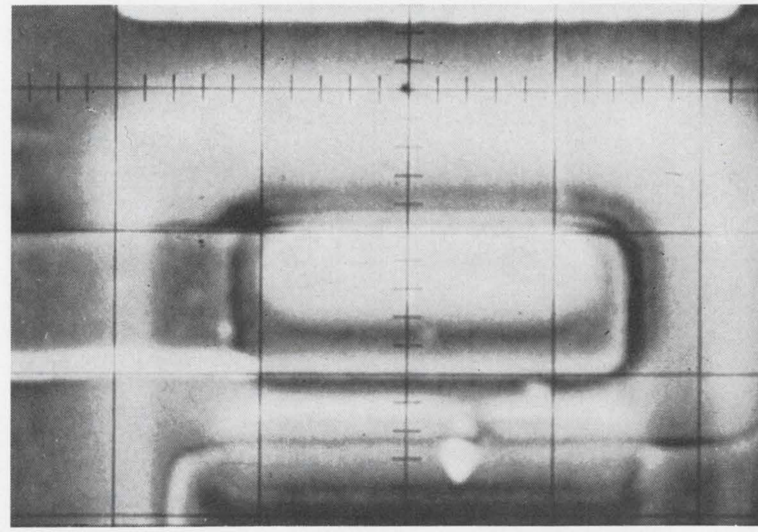
TV amp. Left to right, stages in development of high-voltage integrated video i-f amplifier are traced from discrete version, early IC version, intermediate version with poor frequency response, and final version, which includes additional active components.

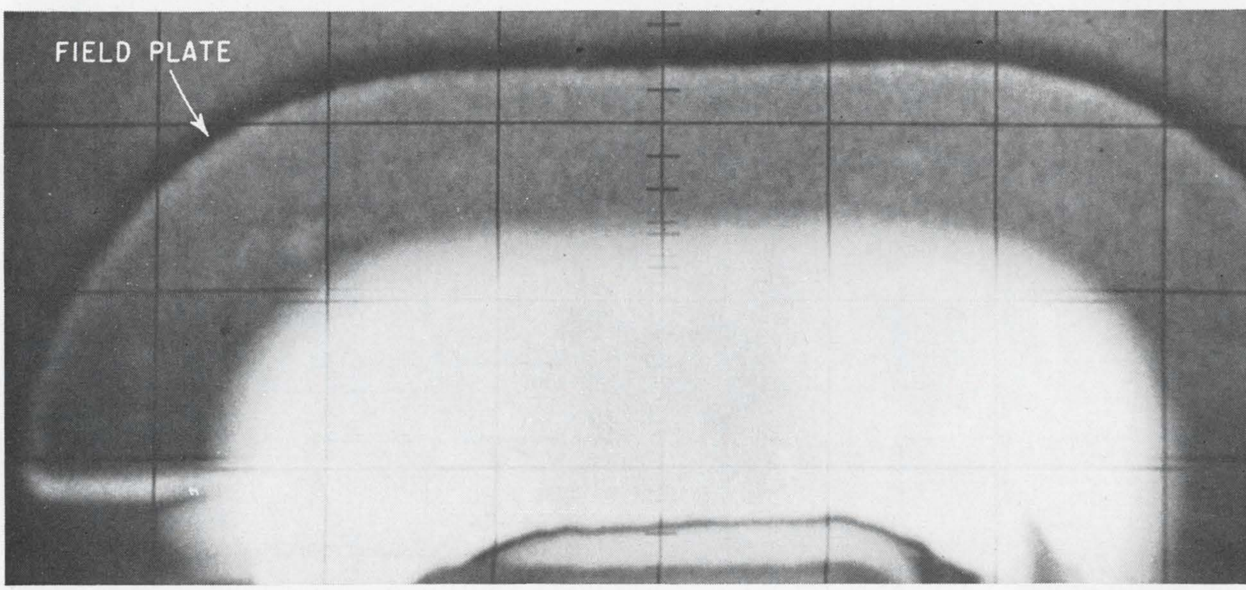
sistors are out for all high-voltage applications because their sheet resistivity is only about 135 ohms per square.

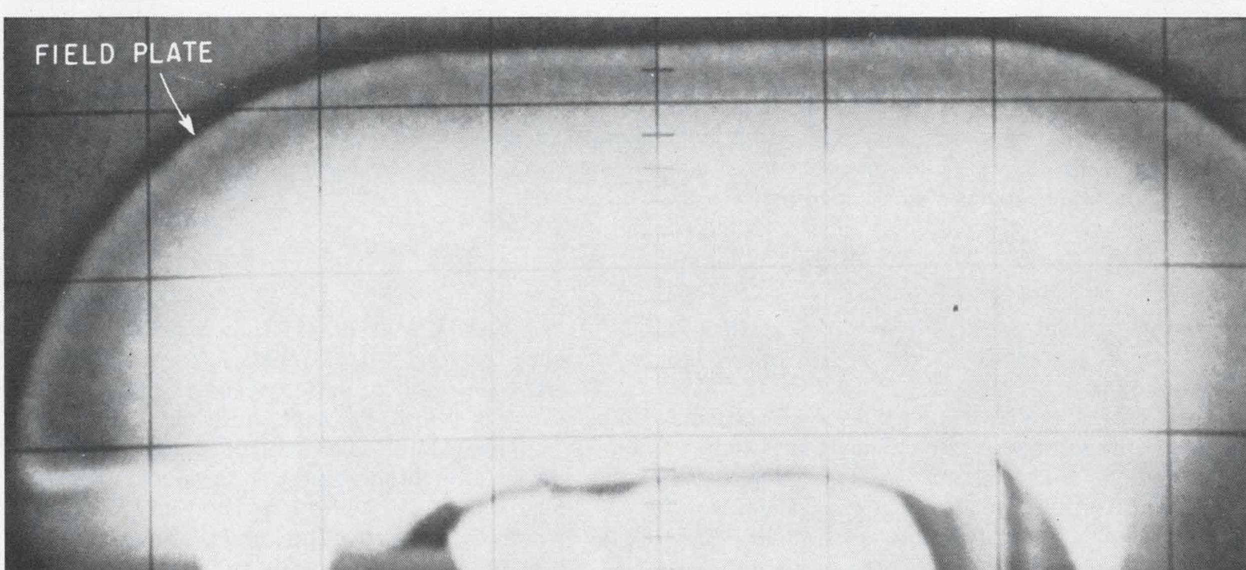
High-voltage IC design doesn't differ much from low-voltage design but does have some unique problems. For example, using high-resistivity silicon hurts transistor performance, requiring the addition of active devices to lower requirements for individual components. Also, more active devices are required than in low-voltage IC's to reduce power dissipation. High-voltage IC's must dissipate less than a watt unless they're large, and the big ones are expensive. Finally, circuits can't be designed around precision resistors because the bulk silicon's resistivity isn't uniform.

These factors were taken into account in the design of a high-voltage integrated video amplifier for a black-and-white television set. The amplifier, which drives either the cathode or grid of the picture tube, must provide a peak-to-peak voltage swing of up to 70 volts, a voltage gain of about 50, and a frequency response to at least 3.5 megahertz.


ELECTRON BEAM
SECONDARY ELECTRONS
DETECTOR
p
n
INDUCED CURRENT




FIELD PLATE


FIELD PLATE

Seeing is believing

A scanning electron-beam microscope can make visible the potentials near the surface of an IC making it possible to see how the shape of the depletion layer changes with variations in bias voltages and with the addition of a field plate.

As the beam is directed at the surface of the IC, secondary electrons bounce off and can be collected, amplified, and used to modulate the intensity of an oscilloscope. Metal, silicon, and silicon dioxide reflect electrons differently, so that an image of the IC's surface appears if the scope is scanned in synchronism with the electron beam. Deflecting the cathode-ray tube of the scope over a wider distance than the microscope beam gives a large magnification.

Pairing off. Some of the electrons from the beam aren't reflected but instead penetrate the IC and the field plate. In the silicon they create electron-hole pairs. If these pairs are within the depletion region, the electron is swept toward the positive voltage and the hole toward the negative one, causing a current to flow across the junction. This is the current that can be amplified. Hole-electron pairs created outside the depletion layer don't cause current flow because they recombine in a few microseconds.

Superimposing the reflected electrons and induced current causes a bright region to appear on the scope and shows how the depletion layer spreads out underneath the field plate as the bias voltage is increased. As this technique shows, when the IC doesn't have a field plate its depletion layer is much narrower and devices break down at a much lower voltage.

Bright spot. Combination of secondary electrons reflected from IC surface and induced current can be amplified and shown on scope to display transistor depletion layer. Top, without field plate, depletion layer (luminescent area) bends in near surface under application of 80 volts. With field plate, layer spreads out under 100 volts, middle and 300 volts. Thus, device doesn't break down prematurely at surface of IC.

It's instructive to follow the evolution of this circuit from the discrete stage. The picture tube represents a circuit load of about 10 picofarads and—along with the load resistor—forms a low-pass RC network that limits frequency response. The output resistor must have a low value, even when peaking coils are added, to provide the required frequency response. Thus, since the amplifier is class A, current through the output stage must be large and power dissipation about 1.5 to 2.5 watts—[see diagrams on page 93.]

More for less

Adding an output transistor and converting to class B operation lowers power dissipation and increases cost very little. In this circuit—designed in the early phases of the high-voltage IC work—a third transistor carries positive load current. As the negative part of the wave flows through the second transistor, a diode becomes forward-biased and the base-emitter voltage of Q_3 drops to zero. As a result, the two output transistors are never on together. On the other hand, the trouble with this circuit is that the two biasing resistors must have very large values to maximize input impedance and minimize power dissipation.

One solution to this problem was to design a circuit in which two transistors and a resistor provide a bias potential for the source. This combination, Q_4, Q_5, and R_2 is identical to that of Q_1, Q_2, and R_4, so that whatever current flows through the feedback resistor, R_1 also flows in the collector of Q_2—as long as there's no signal at the input. If R_1 and R_3 are made equal, the voltage drops across them must then be the same and the quiescent output voltage, therefore, stays at half the supply voltage. Because resistor ratios are predictable and insensitive to temperature changes in IC's, both the gain and quiescent d-c voltage are precise and stable.

However, this circuit has a frequency response of only about 1 Mhz because of the feedback capacitance (Miller capacitance) from the collector to the base of Q_2. In high-voltage circuits such as this one the feedback is essentially the collector-base capacitance multiplied by the voltage gain.

In the final version of the video amplifier circuit, the designers added a cascade stage to the output. This type doesn't contribute to gain but shields Q_2 from the large output voltage swing, thus eliminating the Miller capacitance. This circuit, fabricated on a 40-by-45-mil chip, has an operating voltage up to 250 volts, a gain of 50, a frequency response extending to 7 Mhz and a dissipation of 300 milliwatts.

Signetics has been selling a high-voltage IC driver for Nixie tubes. Other applications being considered by the company are comparators to drive high-voltage displays and sense an error signal, operational amplifiers with a ±100-volt swing for hybrid computers, audio amplifiers and voltage regulators for direct-line voltage operation, and line-voltage fault detectors. ■

Active filters: part 8
Positive results from negative feedback

By applying IC assembly techniques, engineers can now build highly stable filters with many active elements at a cost lower than they'd pay for discrete circuits employing positive feedback

By Gunnar Hurtig
Kinetic Technology Inc., Los Gatos, Calif.

Cost-consciousness largely explains the preference designers have shown for positive feedback in active filters. Although the positive-feedback circuits have a tendency to oscillate, they simply require fewer active elements than do more stable filters built with negative feedback.

This cost edge has been erased by integrated-circuit developments, however. The designer can now offset the need for more components by building a negative-feedback active filter in hybrid IC form. In doing so, he achieves the low Q sensitivity of this kind of circuit while paying out less than he would for a discrete device employing positive feedback.

The application of integrated-circuit techniques will also serve to make active filters more competitive. A typical passive filter now sells for about $5 per pole pair, against approximately $25 per pole pair for active filters made with conventional p-c or cordwood techniques. But the use of hybrid IC assembly methods can shave this 5:1 cost differential to about 2:1 in most cases.

Although sensitivity is of prime importance in active-filter technology, it wasn't until recently that general statements could be made regarding the behavior of active networks with active- or passive-element variations. It's now known that Q sensitivity to element variations in positive-feedback circuits is a function of Q. It can also be stated that negative-feedback structures exhibit smaller Q sensitivities—usually less than unity.

Another general statement can be added to this list: the use of monolithic active elements and hybrid IC techniques can result in high-performance active filters capable of operating from d-c to several megahertz. Such a filter has been built.

Two points must be kept in mind in selecting the circuit for an active filter. First, the network should generate the same complex poles and zeros produced by its passive counterparts. Hence, the designer wants a circuit that's as widely applicable as an LC network but is also capable of producing any stable second-order transfer function. Second, the cost of the filter should approximate that of a passive filter of equivalent performance.

The basic design chosen by KTI for its network is shown on next page, top. The denominator function, D(s), generated by the system is of second order:

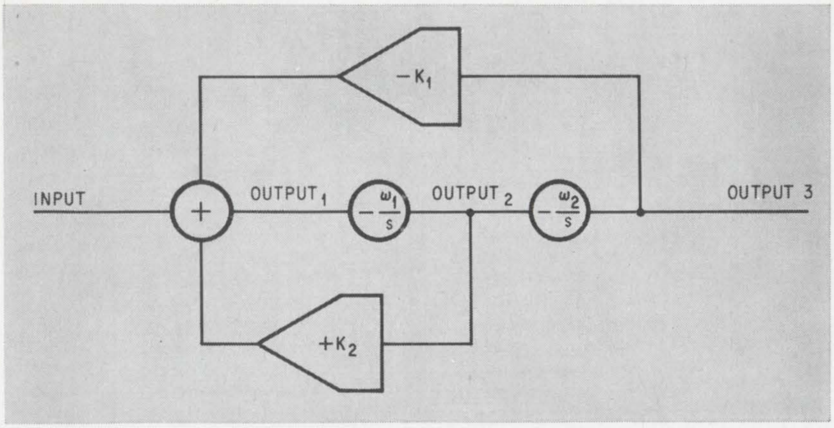
$$D(s) = s^2 + K_2\omega_1 s + K_1\omega_1\omega_2$$

Depending on where the output is taken, the overall transfer function takes one of three forms—low pass, high pass, and bandpass. Pole-zero diagrams for each of these simple second-order types are on the next page, along with an RLC circuit for achieving the values shown.

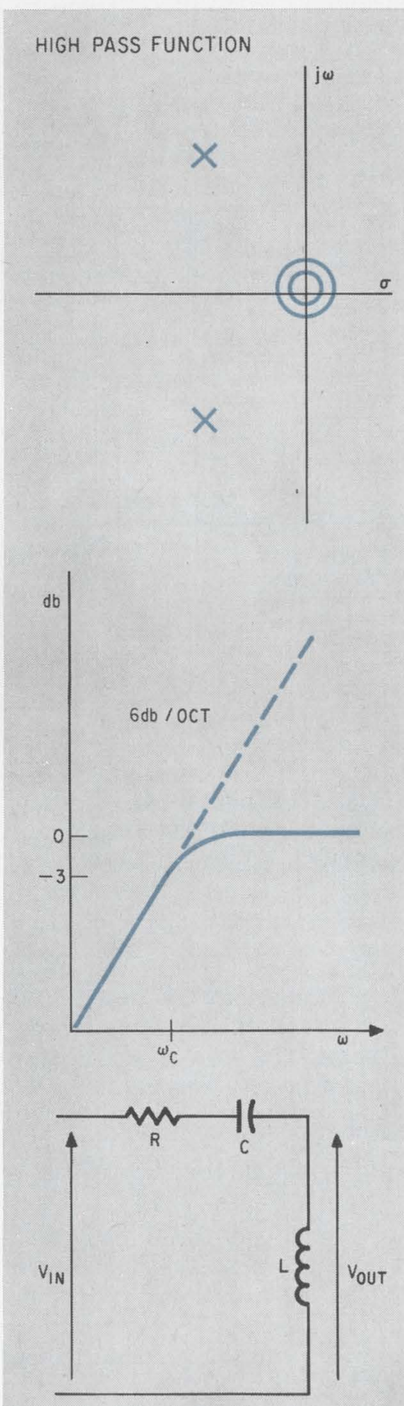
Those transfer functions that have zeros at other than zero or infinity are called complex second-order functions. In most active-filter networks capable of generating complex zeros, a change in a parameter's value causes an interaction between the zeros and poles. This isn't the case with the basic system described here, however.

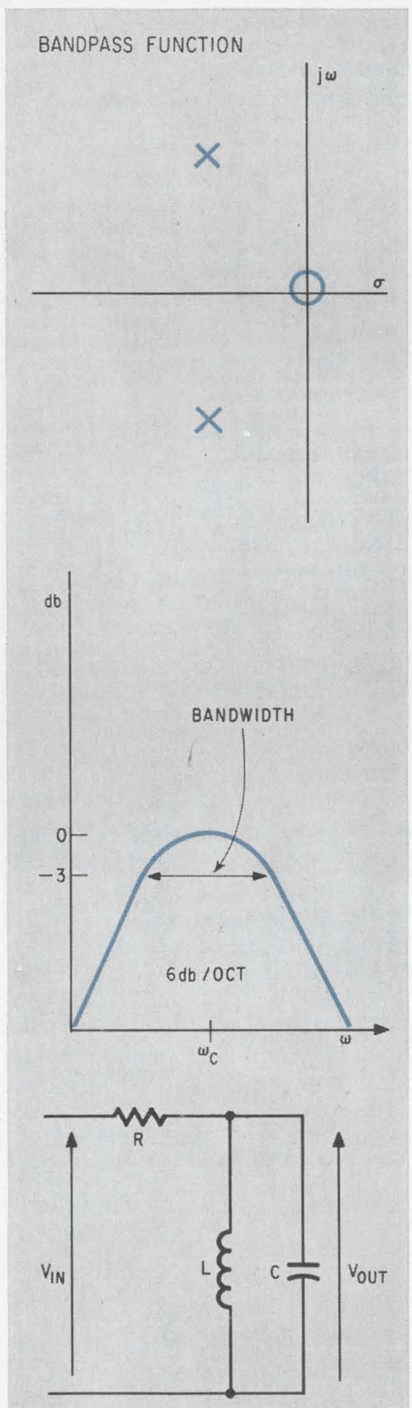
Any complex zero can be generated by summing the three outputs of the system in a simple differential amplifier. For example, any jω-axis zero can be obtained by simply combining the high-pass and low-pass outputs. The location of the jω-axis zero is the solution in s where the numerator, N(s), equals 0.

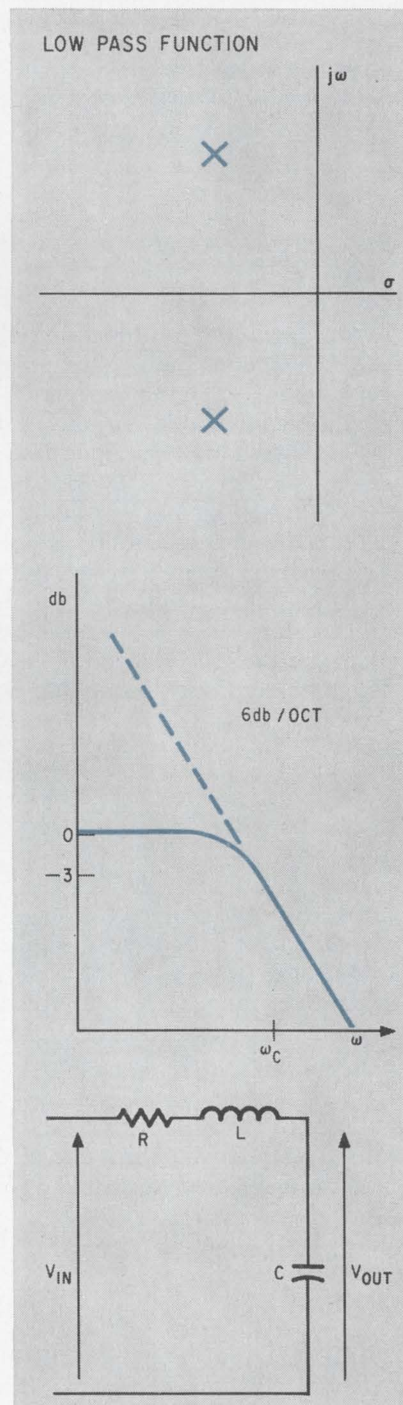
A root-locus plot helps the designer evaluate

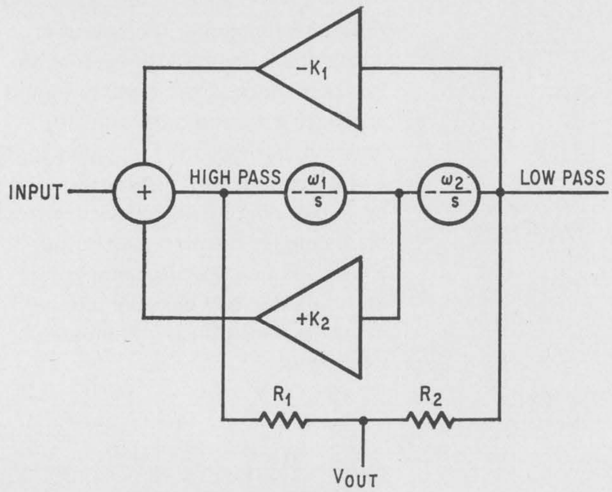


Feedback functions. The output of terminal 3 is fed back to the input in this case. Each of the three terminals produces a second-order transfer function, but only the feedbacks from 1 and 3 are negative. Output 1 produces a high-pass function, output 2 a bandpass function, and output 3 a low-pass function. Responses for each function and possible passive networks for producing them are also shown.

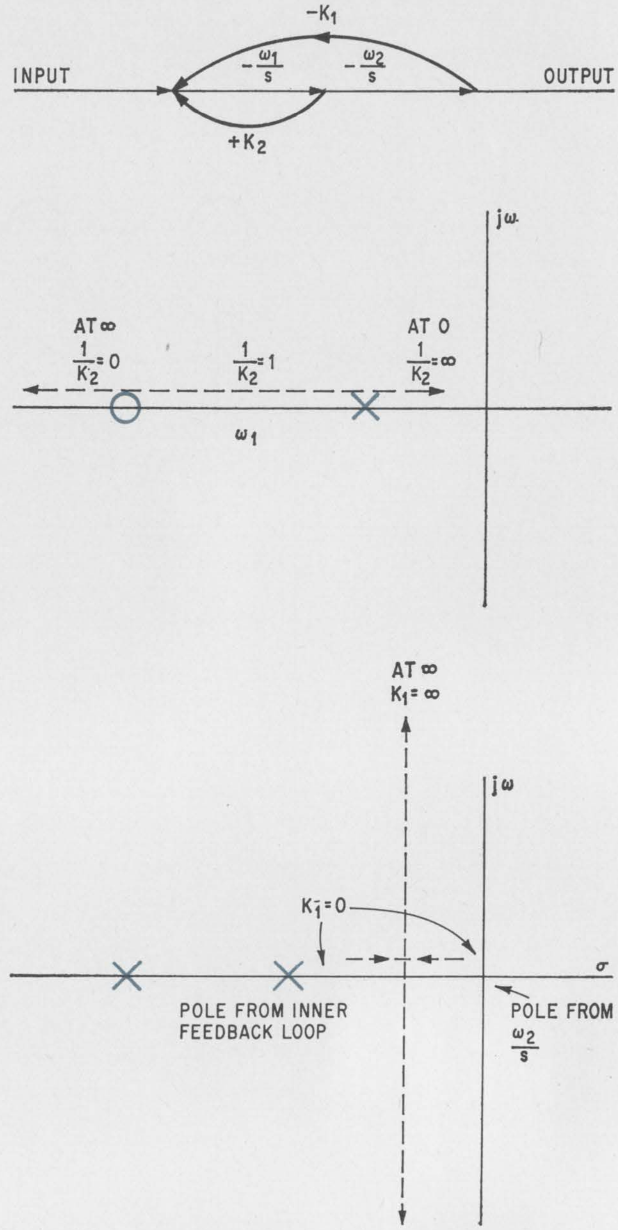








Producing naught. By combining the high-pass and low-pass outputs of the basic negative-feedback system, an engineer can get any zero on the jω axis.



Signal-flow graphs. In this representation of a negative-feedback system, root-locus plot for the inner loop is at bottom with a plot for the outer loop above it.

the system's sensitivity. Consider a simple flow graph of the system and the locus plot of the pole as a function of $1/K_2$. The designer determines from the root-locus analysis that if there are no poles on the negative-real axis due to stray capacitance or amplifier rolloff, the system is unconditionally stable for any value of K_1, K_2, ω_1, or ω_2. There's no oscillation because the root locus of this simple system doesn't cross the jω axis into the right-half plane. This behavior is expected in such a system—essentially a multiloop with negative feedback. Gyrators also fall into this class.

On the other hand, the possibility of oscillation in positive-feedback systems is indicated in the plot of a positive-gain amplifier on the next page. The transfer function in this flow diagram takes the form

$$T(s) = \frac{\dfrac{K_2\omega_1}{s + \omega_1}}{1 - \dfrac{K_1K_2s\omega_1}{(s + \omega_1)(s + \omega_2)}}$$

From the resulting root-locus diagram, plotted as a function of K_1K_2, the designer notes that for a sufficiently large value of K_1K_2 the poles of this system can move into the right-half plane.

For the positive-feedback system, the sensitivity of Q in relation to an element change is

$$[(\partial Q/Q)/(\partial E_i/E_i) \geqq Q]$$

The Q sensitivity of the negative-feedback system with an element change is

$$[(\partial Q/Q)/(\partial E_i/E_i) \leqq 1],$$

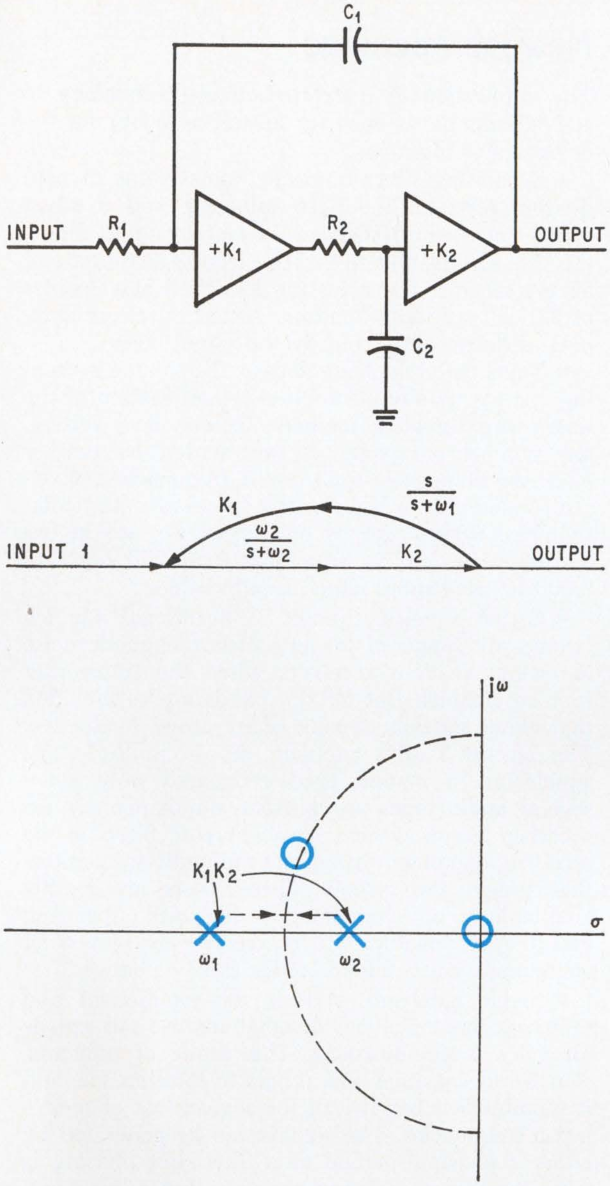
where

$$(\partial Q/Q)/(\partial E_i/E_i)$$

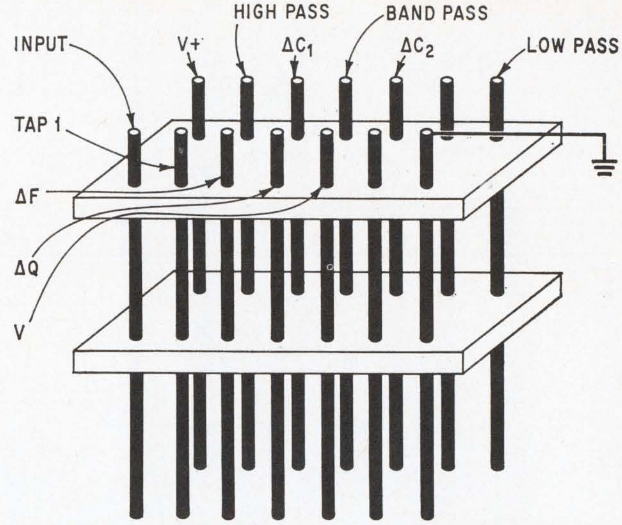
denotes the percentage change of Q with an equal percentage variation of an element, E_i. The conclusion is that multiloop, negative-feedback systems generate any stable form of second-order transfer function, aren't bothered by interaction among tuning elements, and have a sensitivity at least as good as that of passive networks.

Separating the elements

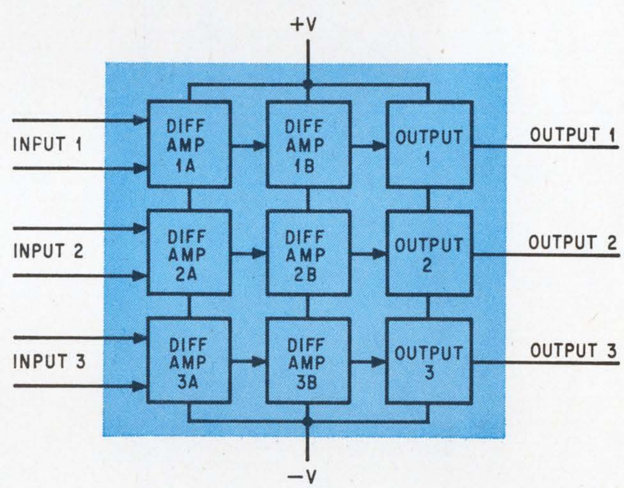
With these factors in mind, KTI built its hybrid active filter. To facilitate testing, the circuit is assembled on two ceramic substrates, each measuring 0.75 by 0.4 by 0.025 inch. The first contains all the resistors and capacitors necessary for setting Q and the center frequency. The resistors are hybrid thick-film devices with an absolute temperature coefficient of less than 200 ppm/°C and a capability for ratio tracking below 50 ppm/°C.

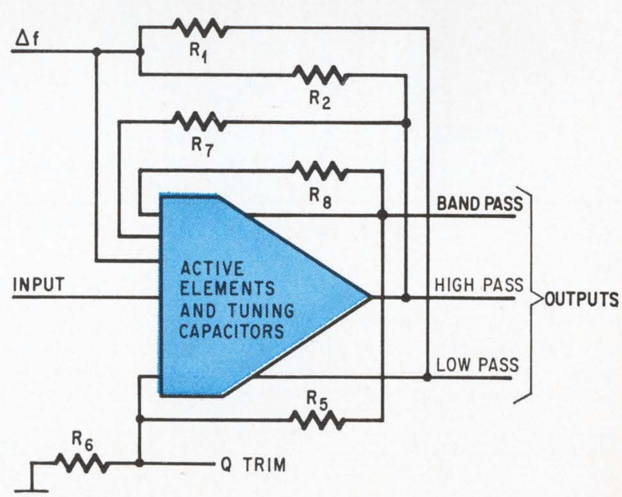


The plot develops. Signal-flow graph for this typical positive-feedback amplifier is used to plot the root locus. The larger K_1K_2 is, the greater is the chance of oscillation.



Two levels. In this active filter, the passive tuning elements are on the upper ceramic substrate and the active elements are combined with their compensations on the lower substrate.





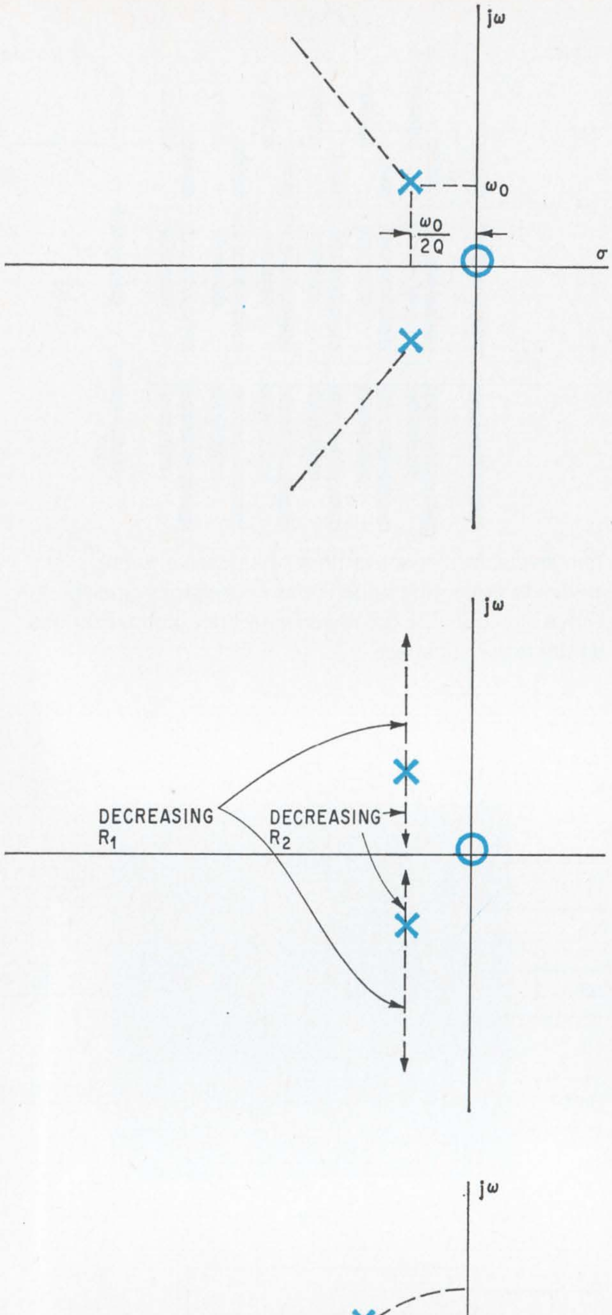
Hookup. In one version of KTI's negative-feedback filters, the MOS chip at top is connected to resistors that determine frequency and provide the output response.

The capacitors are ceramic and have absolute temperature coefficients of less than 25 ppm/°C.

The second substrate contains the active elements to which the external tuning elements are connected. Since the performance of the filter is essentially independent of the active elements, the choice of these elements is determined by the particular application.

Three verisons of the filter are currently in production. Two contain linear bipolar monolithic integrated circuits and are made with conventional chip-and-wire-bonding hybrid techniques. The third model uses a linear IC containing three completely compensated differential amplifiers. The substrate holding the passive tuning elements is

continued on page 102



Three routes. Graph at top shows path of the poles of D(s) as a function of decreasing R_7 and R_8 for a bandpass output. At center is the path as a function of R_1 and R_2, and at bottom is the path as a function of R_5 and R_6.

New job openings

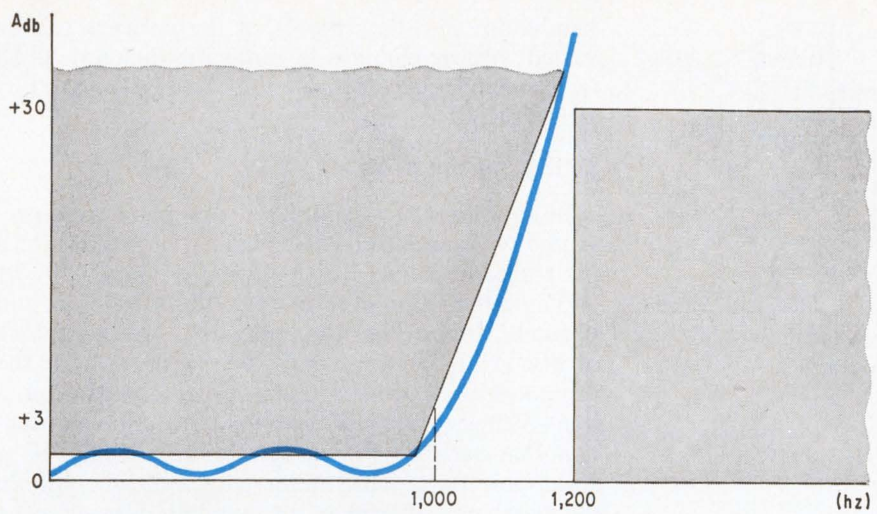
The application of integrated-circuit technology to active filters has opened up several new jobs for the devices. For instance:

- Separating silver from clad-metal coins. A clad quarter rings at about 16 kilohertz and a silver quarter at about 10.6 khz. By employing IC filters, the U.S. Mint is able to sort these coins at the rate of 50 per second. The coins are launched at velocities of 20 feet per second and are sorted by electromagnetic deflection triggered by the sound cues.
- Touchtone telephone dialing. Telephone switching systems usually incorporate a modification of the single-wire signaling method. In a typical system, any number or symbol is represented by two or more simultaneously transmitted frequencies, which are combined in a logic matrix to operate particular switches. Several groups of frequencies are in use at present, extending from less than 250 hertz to 2,000 hz. singlepole filters usually suffice.
- Coded squelch circuits. Conventional squelch circuits are supposed to mute electromagnetic noise in communications receivers when the transmitter isn't on channel. But today's bands are so crowded that these squelch circuits often prove ineffective. The answer to this problem lies in multiple-tone squelching, a system that's triggered only when several audio tones are present simultaneously for a certain length of time. Very sharp IC filters in the receiving equipment can select the audio frequencies that trigger the system. These filters are readily adaptable to any frequency in the audio spectrum and they're tunable; if the receiver is moved or new equipment is added, codes can be changed.
- Single sideband. Almost all commercial and military communications installations use ssb signals for voice communications. This mode of transmission is less sensitive than others to interference, and it requires less bandwidth for a given set of modulation frequencies. The signals can be generated by either a phasing method or a filter, but phasing is more expensive and requires frequent adjustment.

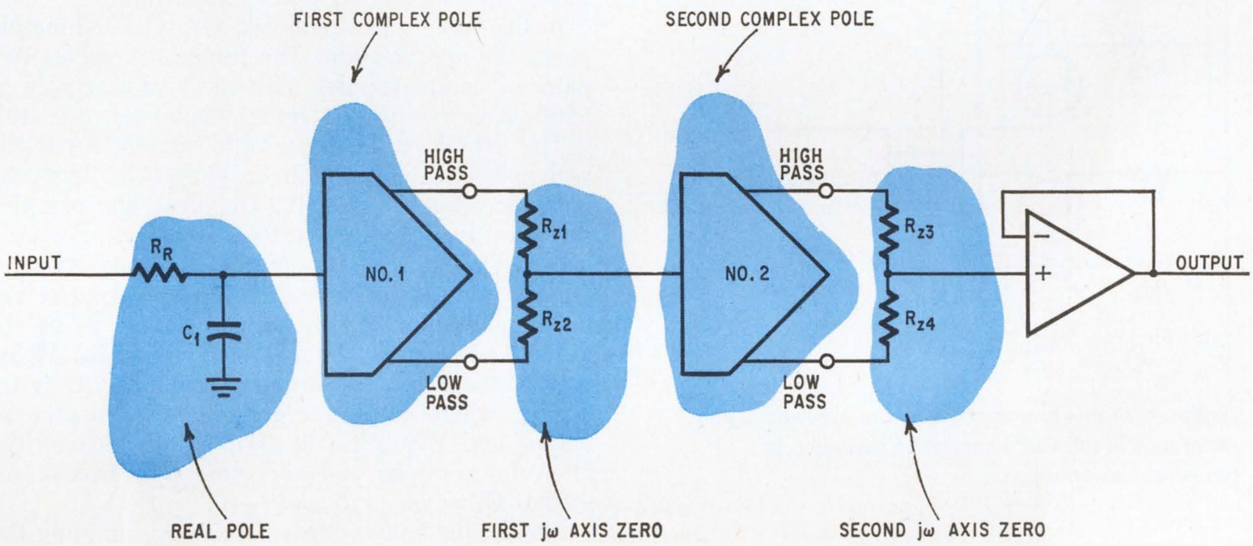
Until the advent of the active filter, crystal-lattice and mechanical filters were the only components with the bandpass characteristics necessary for ssb filtering. However, they were also costly, cumbersome, fragile, and nontunable.

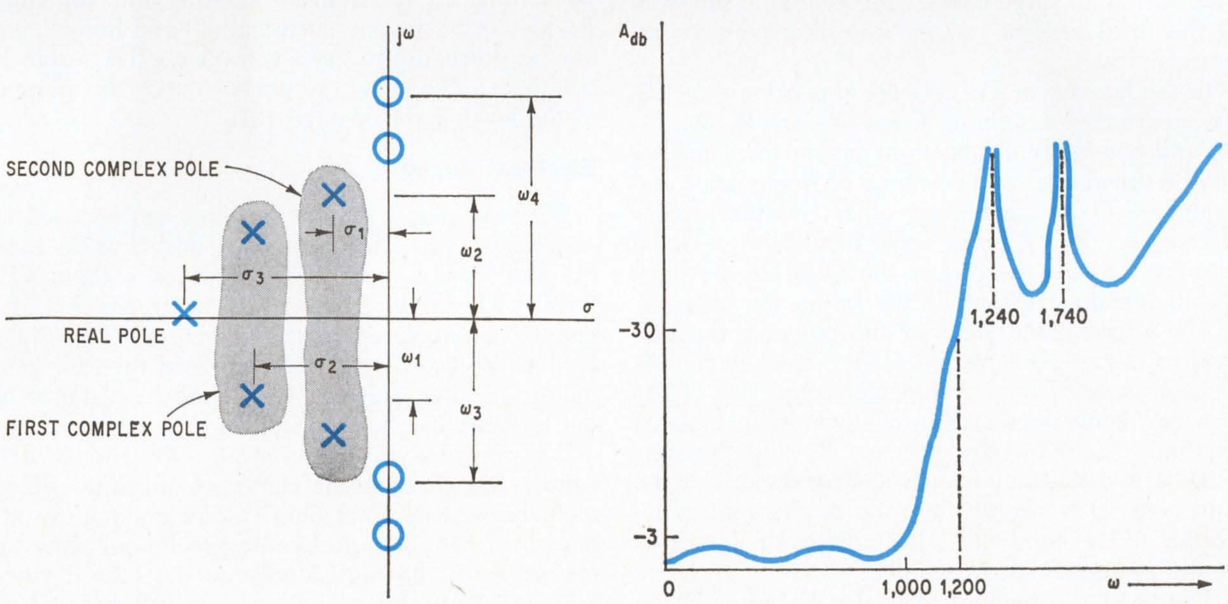
But now a single IC active filter can be tuned to the desired sideband while maintaining the bandpass characteristic required for the range of modulating frequencies in use. Its adjustable bandpass and center-frequency capabilities make the active filter applicable to voice or continuous-wave communications.

Another application of the active filter in equipment is speech processing. The task is usually handled by a speech amplifier with carefully designed interstage coupling and degeneration, a method involving circuit components and extra amplification stages. However, an elementary speech amplifier can be used if it's followed by an active filter adjusted to the bandpass and center frequency appropriate for the speech being filtered. This arrangement increases the efficiency of the ssb equipment, cuts its cost, and reduces the number of components needed.

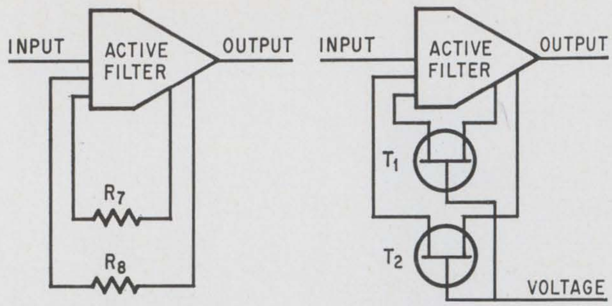


Specifications. This typical low-pass response curve calls for a flat response within 1 db between d-c and 1,000 hz.

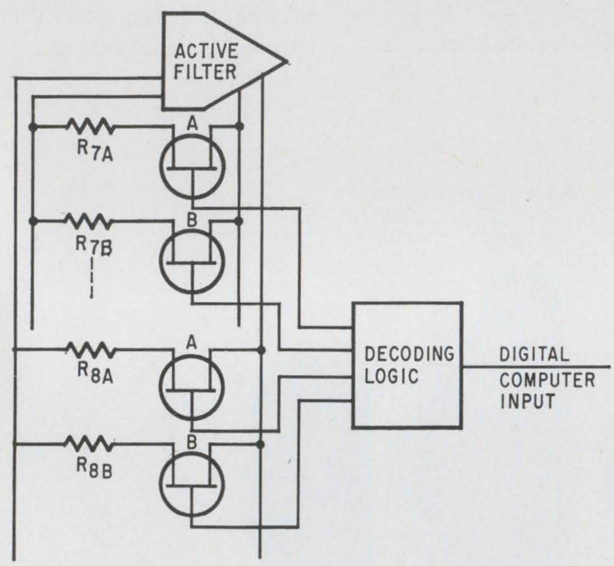




Cauer filter. The fifth order arrangement at top produces the low-pass response specified. At lower left is the filter's pole-zero location, and at lower right is its over-all response curve.



Analog. The filter can be electrically tuned if resistors R_7 and R_8 are replaced by MOS FET devices.



Digital. With this tuning scheme, the dynamic channel resistance of the FET's cannot be degraded by temperature variations.

identical in all three cases. The technique followed in the third version reduces the filter's power requirements.

In the hookup of the network shown on page 99, the elements determining frequency are R_7, R_8, R_1, R_2, and two internal capacitors not shown. The filter can be tuned over a wide range of frequencies and values of Q by paralleling other resistors across R_7 and R_8. If the poles were moved on a radial passing through the origin, the Q of the network would remain constant as the frequency changes.

The approximate locus of the poles of the network as R_1 or R_2 is varied is shown on page 100. Decreases in R_1 boost the center frequency of the network, while decreases in R_2 lower it. In contrast to tuning achieved by varying R_7 and R_8, this process is essentially a constant bandwidth mode. And since Q is simply the ratio of the center frequency to the bandwidth, it increases or decreases as the frequency rises or falls.

The Q of the network can also be adjusted by decreasing either R_5 or R_6. The locus of the poles in this case is also shown on page 100. The bandwidth, and thus the Q, of the network can be varied without changes in center frequencey. As R_5 is decreased, Q is decreased; as R_6 is decreased, Q is increased.

Setting up the poles

In building KTI's FS-20 filter, designers were presented with an amplitude specification calling for a flat response within 1 db between d-c and 1,000 hz and an attenuation of at least 30 db at 1,200 hz and beyond. Most active-filter networks aren't capable of generating complex or $j\omega$-axis zeros, so that the designers are restricted to an all-pole transfer function—Butterworth or Chebychev types. Such a function that satisfies the design criteria would be a seven-pole Butterworth filter with 1 db of ripple in the passband. However, by availing himself of a technique that permits the synthesis of complex zeros, the designer often finds that he's able to reduce the number of poles required.

In this case, a five-pole two-zero Cauer function meets the specification. The function involves two pairs of complex poles and one real-axis pole in addition to two $j\omega$-axis zeros, shown on page 101.

The actual synthesis is quite simple. First, the real pole is established by a simple RC low-pass network where $\sigma_3 = 1/R_{p1}\,C_1$. Next, the complex poles are tuned with two FS-20 sections. For pole one, $Q_1 = \frac{1}{2}\sigma_2$, $\omega_1 = \omega_1$, so that the center frequency is measured at the bandpass output of the filter and is adjusted by varying either R_7 or R_8.

The Q is then set by adjusting R_5 or R_6. Measured at the bandpass output of the filter, Q is f_c/BW_{3db}, where f_c is the frequency of maximum output and BW_{3db} is the 3-db bandwidth of the filter. In a similar manner, pole pair two is set so that $Q_2 = \frac{1}{2}\sigma_2$ and $\omega_{c2} = \omega_2$.

Finally, the $j\omega$-axis zeros are set by summing the high-pass and low-pass outputs in the proper ratio. By setting R_{z1} to equal 10 kilohms and adjusting R_{z2} so that a rejection occurs at ω_3—and following a similar procedure to get a zero at ω_4—the design is complete. The final response curve is plotted at the lower right of page 101.

Electrical tuning

Either analog or digital schemes can be used to vary R_7 and R_8 simultaneously, and thus to tune the filter over a range of frequencies without disturbing Q. In the analog scheme upper left, R_7 and R_8 are replaced by junction devices or MOS field effect transistors. By changing the d-c gate voltage on these devices, the channel resistance of the unit can be changed over a wide range.

It's desirable in many applications to switch among several different center frequencies. Since temperature can affect the dynamic channel resistance of a FET, a digital tuning technique may be preferred. In the digital scheme the FET devices are switched either full on or full off; when devices A are full on, resistors R_{7A} and R_{8A} are inserted in the circuit. ■

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Log diodes can be counted on

It has become easier to use these devices as computing elements; latest production methods assure uniform characteristics within batches, and thus eliminate the need for exhaustive testing by the purchaser

By Robert W. Hull and Karabet Simonyan

Computer Diode Corp., Fair Lawn, N.J.

Silicon technology has reached the point where logarithmic diodes with wide dynamic ranges can be consistently produced in fairly uniform batches. And this producibility increases the usefulness of these devices as computing elements. Log diodes have output voltages that are exponentially proportional to input current—a characteristic they employ to perform such arithmetic functions as multiplying, dividing, and raising to powers. The circuitry involved in these functions can be easily implemented.

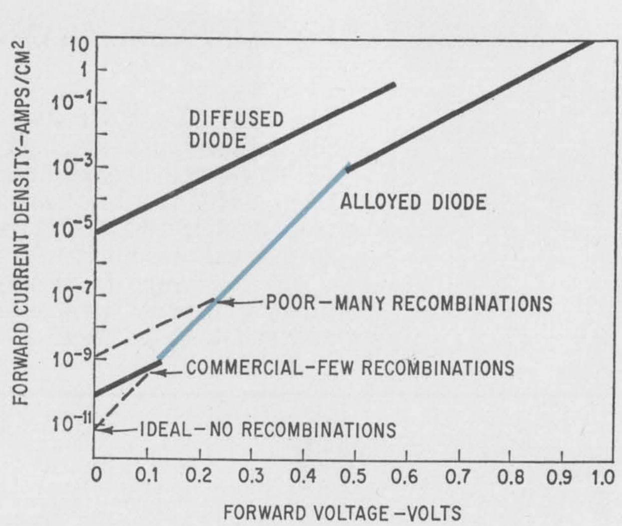
Though all silicon diodes exhibit an exponential relation between forward voltage drop and current, they're useless as computing elements unless their exponents stay constant over a wide range. However, with recent improvements in the technology, log diodes can now be designed and fabricated to assure this constancy both within themselves and in relation to other diodes in their batch.

This characteristic applies to both alloyed diodes having long carrier lifetimes and operating at low current densities, and diffused diodes with short carrier lifetimes and higher-current-density operations. But with a forward-voltage slope of 60 millivolts per decade over six to eight decades of current, the alloyed diode has a wider dynamic range than the diffused diode, with a slope of 120 mv per decade over four to six decades.

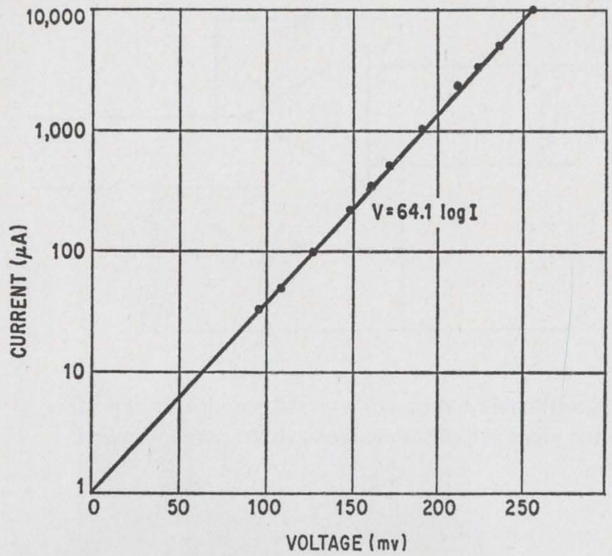
Exponents reflect many factors. The current transport across a p-n junction can be considered the sum of the currents stemming from carrier diffusion across the junction, carrier recombination in the junction region, surface recombination, channeling, and tunneling. It must also be kept in mind that the over-all current is reduced by ohmic losses in the electrode contacts and in the bulk semiconductor outside the active region. Each of the individual currents can be described by theoretical formulas, but exact computation is impossible. Many of the parameters can't be readily measured in the active regions; they can only be estimated.

As shown below, the logarithmic region increases as recombinations are suppressed as much as possible. This is done by using silicon free of deep trapping impurities and by forming the junction without generating dislocations that could serve as recombination centers. The series resistance of the contact electrodes should also be minimized. The curves shown are for an alloyed diode made with aluminum and n-type silicon doped to approximately 10^{16} donors per cubic centimeter, and with a junction area of 5×10^{-4} cm^2 and a base width of 5×10^{-3} cm.

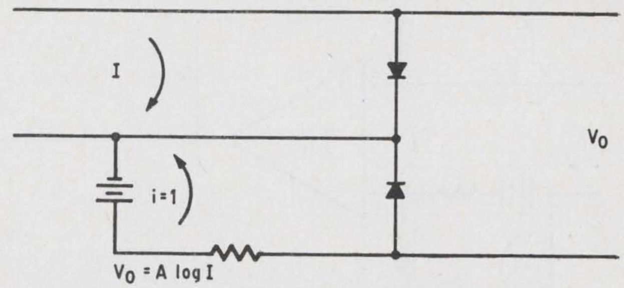
As indicated opposite, a quality diode's characteristics should follow the equation $V_o = A \log I$ —that is, the result should be a straight line on a



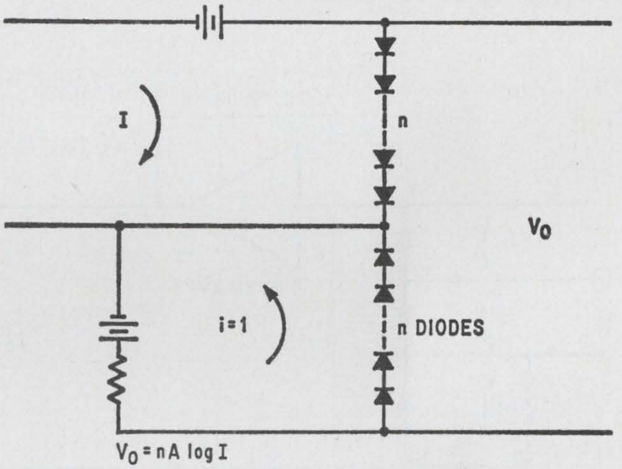
Log region. The widest logarithmic range is obtained by suppressing the recombination centers.



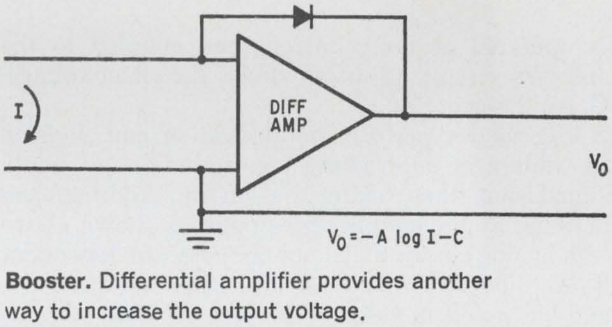
Straight up. An ideal log diode's characteristics should follow a straight line on a semilog plot.



Function. The log of the input is generated by one diode, while the other subtracts the constant C.



Chain reaction. With n diodes connected in series, the exponent of the output is increased by n.



Booster. Differential amplifier provides another way to increase the output voltage.

similog plot of I versus V_o. In this graph, the measured points deviate by less than 0.1%.

Log diodes are manufactured and classified according to the equation for forward conduction

$$V_o = A \log I + BI + C$$

where one constant, A, is a linear function of the absolute temperature, B is a series resistance, and the other constant, C, is a function of the built-in, temperature-dependent, barrier or offset voltage. In a properly designed log diode, B is negligible over the useful operating range and only A and C have to be considered in designing circuitry.

The improved production techniques permit the designer to choose a diode by type number rather than having to undertake the burdensome task of selecting and matching by exhaustive testing. Rather sophisticated equipment—and knowledge—are needed if one wants to test to millivolt accuracy over the required current and temperature ranges.

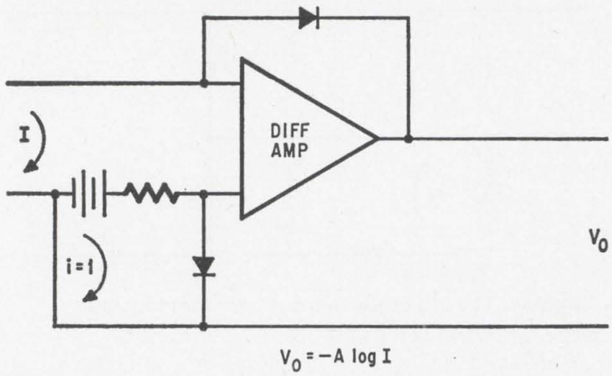
Least-square averaging of measured data and extraction of the equation for any specific diode can be done graphically, but the job is a very tedious one if a large number of diodes are to be checked. However, a recently developed computer program enables the vendor to quickly check and categorize many diodes and match them as sets.

As shown above right, a log function is generated by one diode, while a similar diode, operated at unity current, subtracts the constant C, eliminating offset voltage. Therefore, unity current represents the voltmeter zero on the log scale.

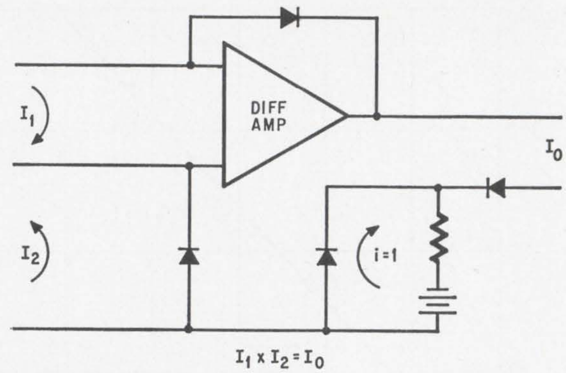
But since the constant A can't be removed in this manner, the output depends on temperature to the extent of a deviation of 0.3%/°C from 25°C. This temperature dependence can be minimized either by separate compensation networks or by maintaining the diodes at a constant temperature.

In the circuit above right, n diodes are connected in series to provide n times each diode's output voltage. This circuit is particularly useful in radiation detectors because of its high signal-to-noise ratio. There's a noise improvement for very small signals since the voltages add linearly while the noise adds by the square root. By feeding such circuits into an electrometer-type voltmeter, it's possible to measure input currents from 10^{-10} amps or less to 10^{-3} amps on a single logarithmic scale.

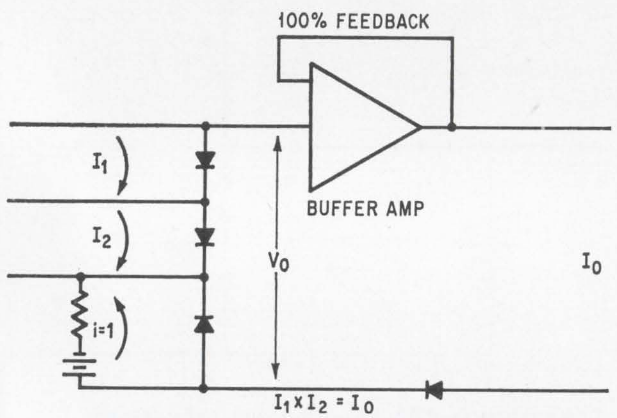
In another typical log function generator, shown above, a differential amplifier drives the output voltmeter. With only a single diode, neither the A nor C constants are removed. But if a second diode



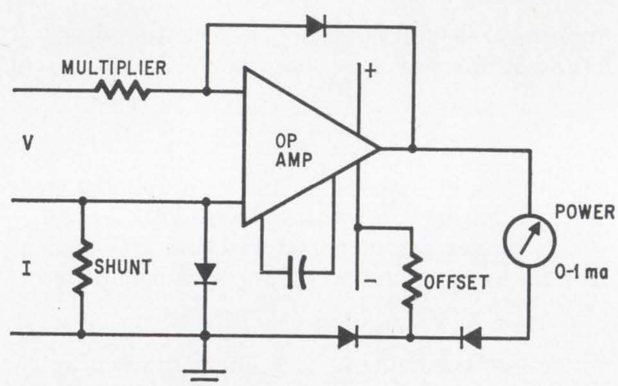
No offset. By adding another diode to the differential amplifier circuit, the constant C is eliminated.



Commonality. With a differential amplifier in the adder, the input and offset diodes have the same terminal.



Adder. A complete adding circuit employs an operational amplifier and an antilog diode.



Instrumental. Besides doing arithmetic, the log diodes can be used in such things as a wattmeter.

is operated at unity current and coupled to the amplifier circuit, as shown above, the offset voltage, C, can be canceled.

Log diodes perform multiplication and division by adding or subtracting logarithms of individual signals and then taking the antilog. Addition can be done by the simple series network shown above —an analog circuit that's not temperature dependent if all diodes are kept at the same temperature, and has no offset voltage. Because the buffer amplifier—an op amp with 100% feedback—has unity gain, the antilog diode (output) operates at the same current as the log diodes (input). All four diodes are identical, and it's mandatory that the same number of diodes face in each direction around the arithmetic loop if A and C are to be canceled.

With a differential-input operational amplifier as a buffer, the diodes can be used in the feedback paths so that the input currents and the unity offset current have a common terminal as shown above.

The input currents may, of course, be changed to input voltages by the use of series resistors. And parallel diodes of opposite polarity can be used for a-c inputs and outputs. Basic multiplication, division, raising to powers and root extraction can be combined in one circuit.

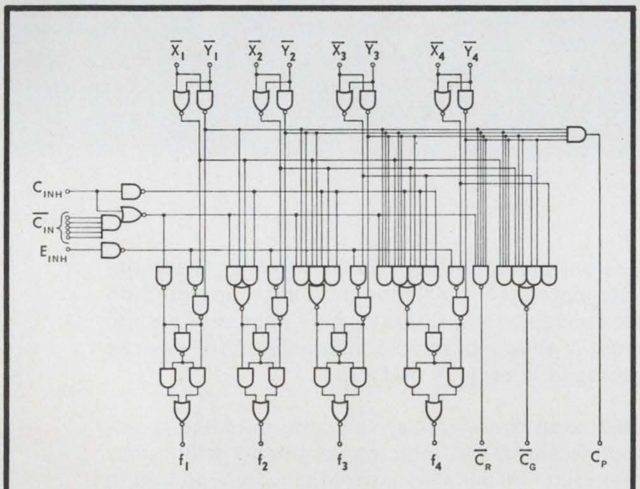
The circuit shown above functions as a wattmeter; voltage times current equals power. In this arrangement, temperature need not be constant but it must be precisely the same for all four diodes. The close mounting of the diodes in one epoxy module must therefore be considered. The precision with which the characteristics of the diodes track one another determines the precision of the computation. Accuracies of 0.1% to 1.0% are possible with currently available diodes.

A and C can be properly canceled only when the diodes are closely matched to the same characteristic curve. The op amp generates an error no larger than the inverse of its open-loop gain, and is, in this respect, superior to a single transistor; the transistor's base-emitter temperature coefficient and offset voltage make the cancellation of the constants extremely difficult.

Attempts have been made in the past to compensate for this problem by using diode-connected transistors. But such circuits were successful only where the devices were carefully selected. Emitter currents in diode-connected transistors fall under the same equation that applies to diodes, and the use of these transistors demands the same attention to the cancellation of constants. ■

Test your logic.

a) Suppose you designed the DCL MSI 8260, world's fastest adder, and its logic diagram looked like this:



b) And it gave a speed and package count, which beat any other IC family, like this:

No. of Bits	Package Count 8260	Package Count 8261	Package Count Quad 2-Input NAND Gates	Addition Time per Bit (ns)	Total Addition Time Input to Output (ns)
16	4	1	–	3.3	52
24	6	3	–	3.3	52
32	8	3	–	2.0	64
48	12	6	1	1.3	64
64	16	7	1	1.2	76

c) Next, suppose you came up with eleven new MSI elements—all perfect fits with the 8260, our other MSI elements, and the entire DCL family—like this:

8230	8-Input Digital Multiplexer
8232	8-Input Digital Multiplexer
8241	Quad Exclusive-OR
8242	4-Bit Comparator
8266	2-Input, 4-Bit Multiplexer
8267	2-Input, 4-Bit Multiplexer with Bare Collector
8268	Full Adder
8275	Quadruple Latch
8276	8-Bit Shift Register with Clock Inhibit
8284	4-Bit Binary Up/Down Counter
8285	BCD Up/Down Counter

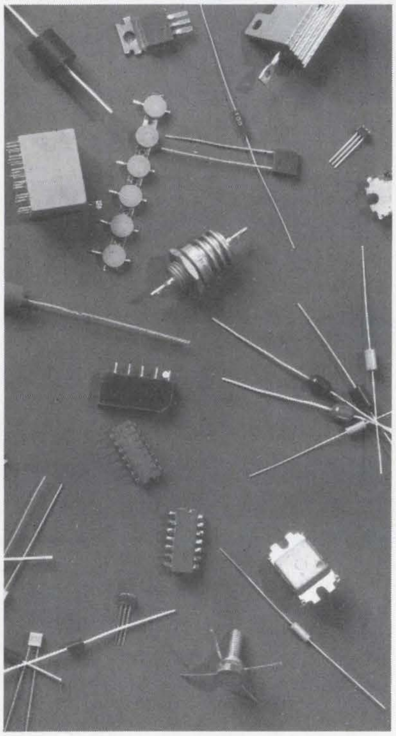
d) Now then: wouldn't you logically buy a full-page ad to tell the world in Electronics? And wouldn't you sign it like this:

Signetics DCL

Signetics Corporation/811 E. Arques Ave., Sunnyvale, Calif. 94086/A subsidiary of Corning Glass Works

Logical afterthought: For written proof that Signetics is right in the middle of MSI, send for our DCL handbook. It's 120 pages—and free!

When your IC bugs out, chances are the heat's on!



Devices packaged in Dow Corning® silicone molding compound are physically and electrically stable —even after long term exposure to both high heat and humidity. Derating, a practice common with organic packaging, is not necessary. In fact, you can design for high device and component density by using silicone molding compound. One manufacturer of glass package power diodes reduced the part to 1/30th of its former volume. Sizes from 1/5th to 1/3rd smaller can be obtained by using silicone molding compound in place of other plastics.

Little moisture absorption. Silicone molding compounds when exposed for 1000 hours to 93% RH at 70 C showed an average weight increase of 0.32% with the greatest increase being 0.5% and the least being 0.17%. Five organic plastics had average weight increases ranging from 1.0 to 2.1% —an average of nearly five times greater than silicone molding compounds under the same test conditions.

No cracking. Unlike other thermal setting plastics, Dow Corning silicone molding compounds are virtually unaffected by thermal shock. For example, a power resistor molded in Dow Corning® 307 compound was cycled repeatedly from —65 to 350 C without damaging the packaging material or the component.

Will not burn. Silicone molding compounds are inherently nonburning. Thus, components and devices packaged in silicone molding compound do not constitute a fire hazard. No flame snuffers are used—a source of ionic contamination for devices packaged in organic materials.

Corrosion free. These silicone molding compounds are free of ionic contaminants which may contribute to metallic corrosion when operating in high humidity and influenced by voltage bias.

Competitive price. Costing only a fraction of a cent per device, Dow Corning silicone molding compounds enjoy a substantial price advantage over metal cans . . . glass packages.

Manufacturing economies. Transfer molding enables manufacturers to package devices and components with a minimum of manual labor and supervision. Good mold release and minimum flash assure high production rates . . . reduced deflashing costs. These manufacturing advantages make silicone molding compounds totally competitive with organic plastics.

So why be bugged by device failures because of a cheap plastic package? Specify Dow Corning® brand silicone molding compound, and get the best package protection in your electronic equipment . . . lets you keep your cool. For technical data, write: Dept. A-8472, Dow Corning Corporation, Midland, Michigan 48640.

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 Circle 108 on reader service card

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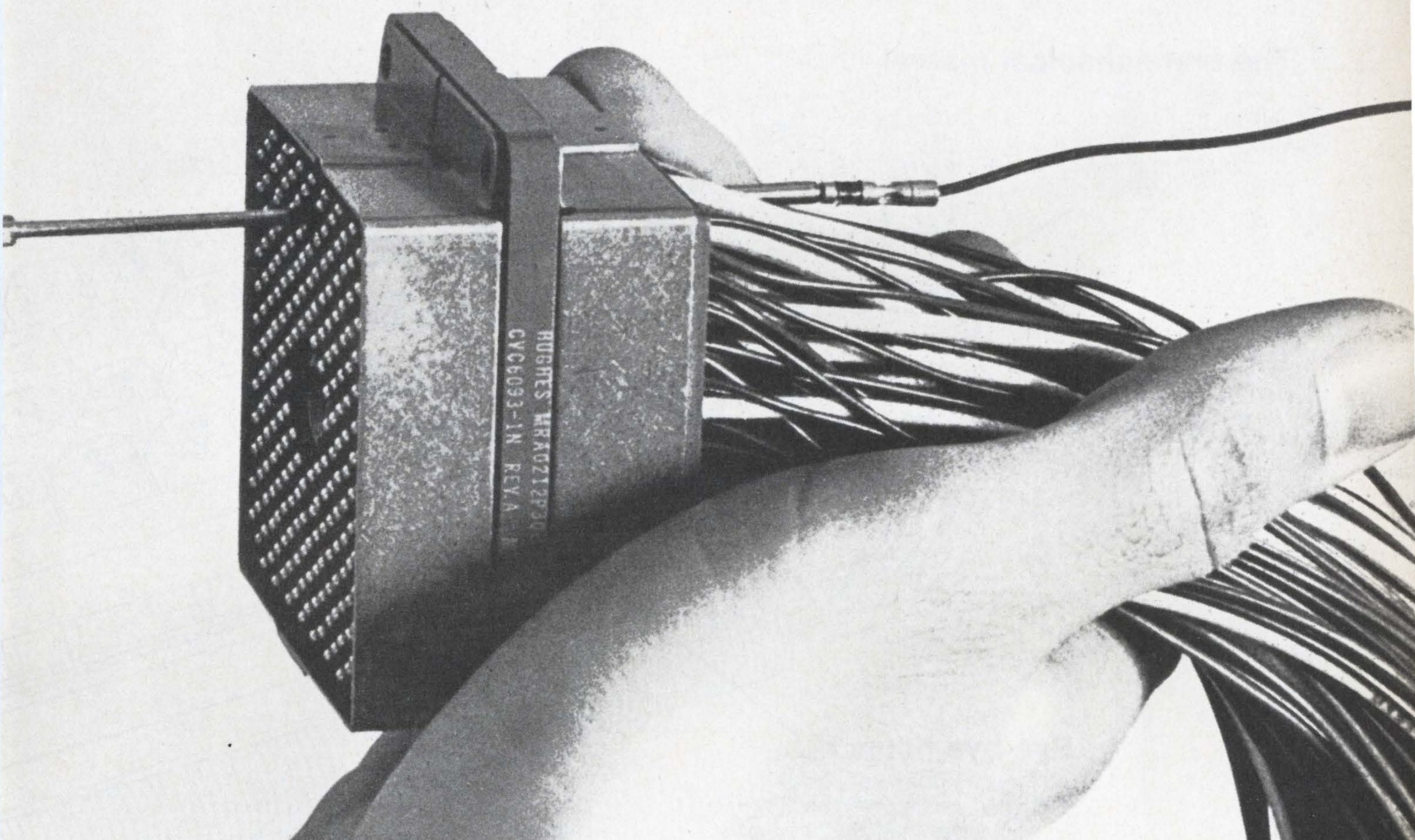

It's so obvious.

Instead of fighting your way through the back of a connector, you start from the front.

Our new Pull-Thru gun is the most obvious thing we've ever invented. And probably the longest overdue.

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You insert the Pull-Thru barrel into the contact cavity from the front and cock the trigger.

This activates a mechanism at the end of the barrel which grips the contact body.

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And it doesn't work only on our own connectors. You can use it on any brand that features a similar retention system.

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If it's happening in connectors, it probably started at Hughes.

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Circle 111 on reader service card

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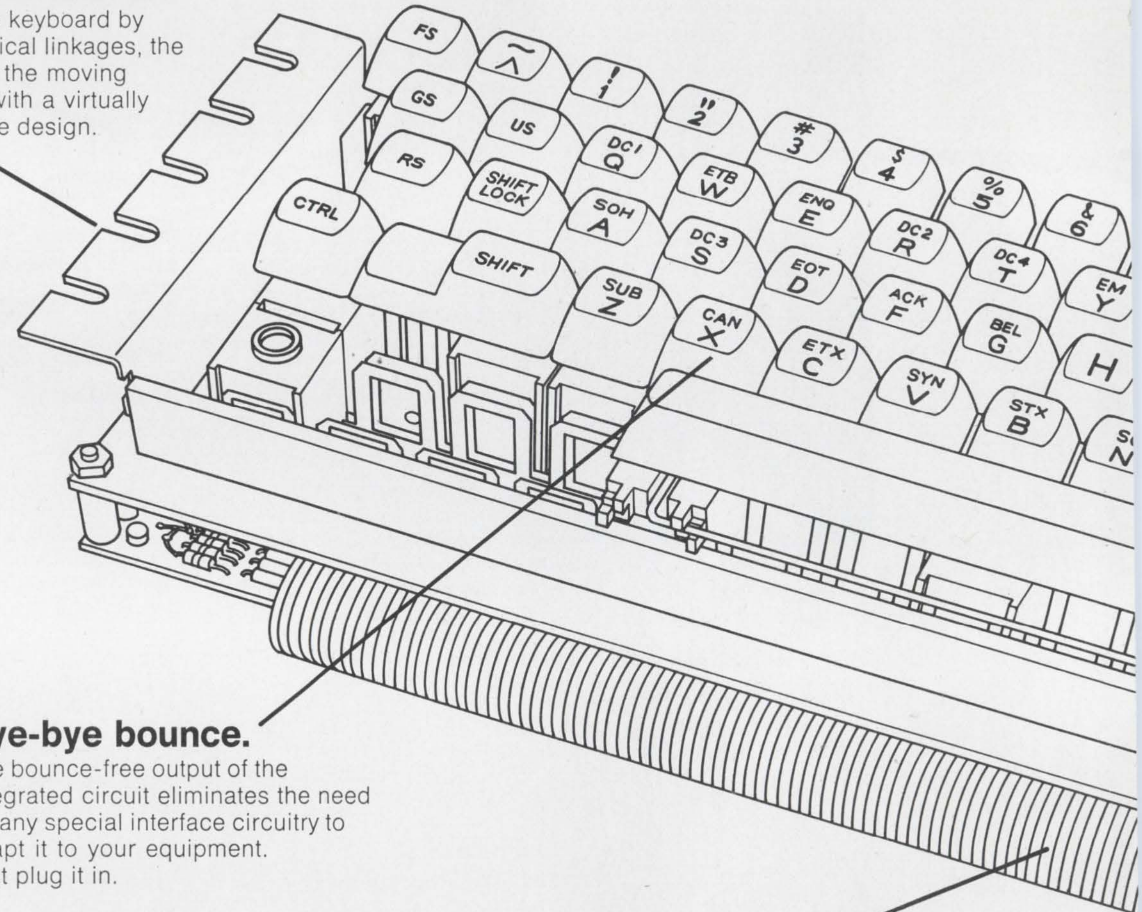

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We supply any 8-bit code (or less); hexadecimal; Baudot, BCD; USASCII mono-mode, dual-mode and tri-function; plus EBCDIC and custom codes.

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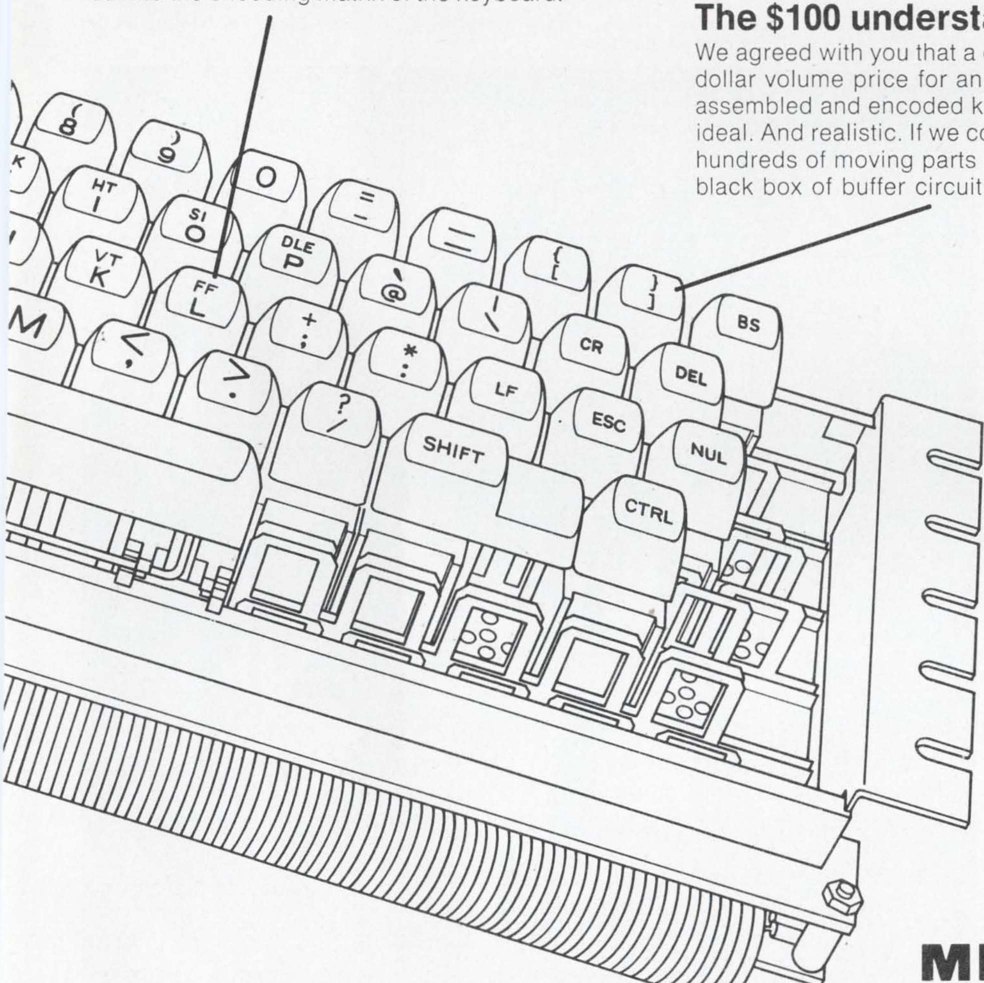

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Our handy "Condensed Keyboard Guide" briefly discusses keyboards and options to give you an idea of the broad offering that we already have available. MICRO SWITCH application engineers are ready to work with you in developing the most economical keyboard designs to meet your precise format and encoding needs.

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Circle 113 on reader service card

IBM Circuit Design and Packaging Topics

☐ Elevator control manufacturers reduce system size and cost with IBM relays

☐ IBM subjects reed switches to rigid tests before shipping

☐ Elevators: controller size and reliability critical

IBM wire contact relays help elevator control system manufacturers solve the major problem of reducing increasingly complex control systems without sacrificing reliability.

With many presently used large switching devices, for example, a typical controller unit for a 6-car installation fills a 10' x 10' room, floor to ceiling.

Larger and more complicated installations increase size even further, leading inevitably to controllers of unacceptable proportions. The answer is a smaller control system—which means smaller components. It is this trend that leads the elevator industry to growing recognition of the advantages offered by IBM relays.

☐ Elevators: relays allow dramatic reductions in size

One elevator manufacturer, Dover Corporation/Elevator Division, Memphis, Tennessee, chose IBM wire-contact relays after conducting extensive tests to determine which components offer the best combination of high reliability, small size, and low cost. Products were evaluated under worst-case conditions. Life tests showed that IBM wire-contact relays exceeded Dover's most stringent reliability requirements.

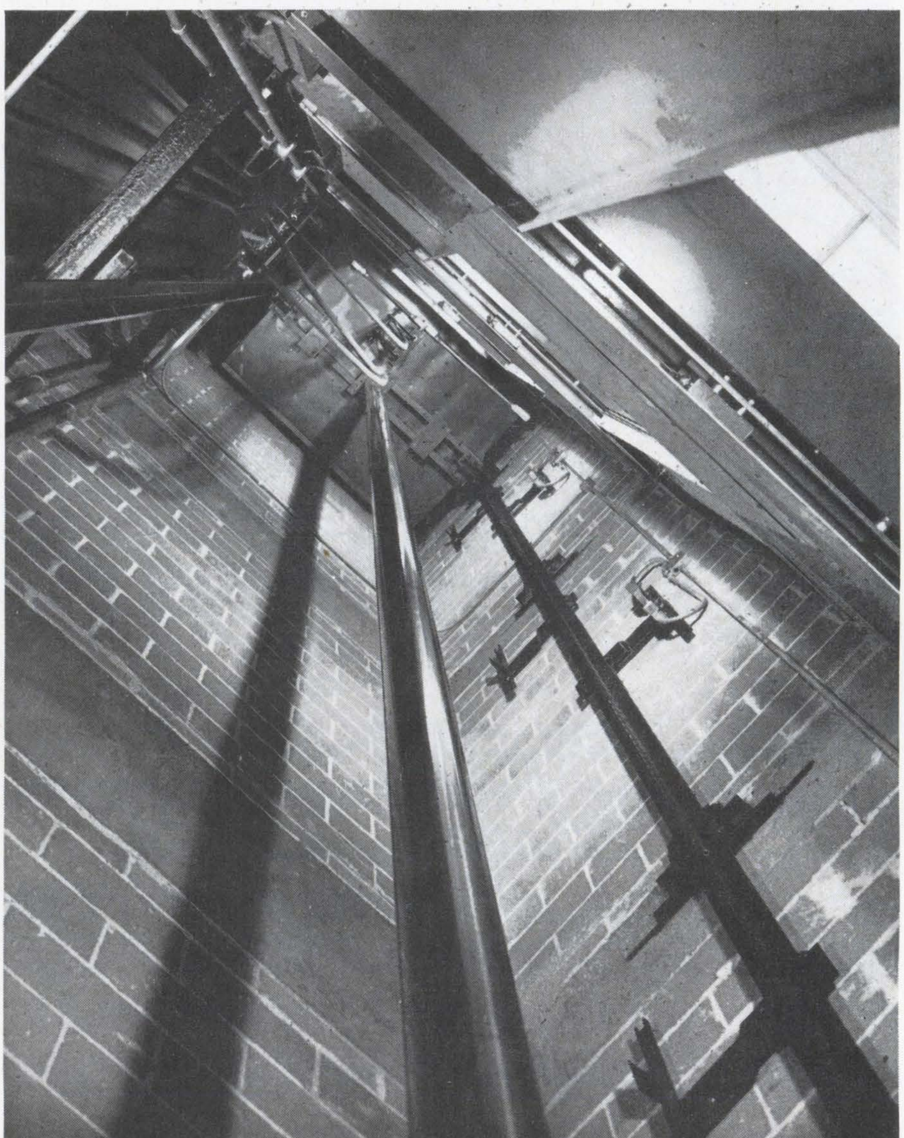
IBM wire-contact relays are smaller than most. The dense and compact packaging made possible by use of 4-, 6-, and 12-pole IBM relays slashes Dover's elevator controller size by over 75%. It also results in substantial manufacturing cost reductions plus savings in shipping and installation.

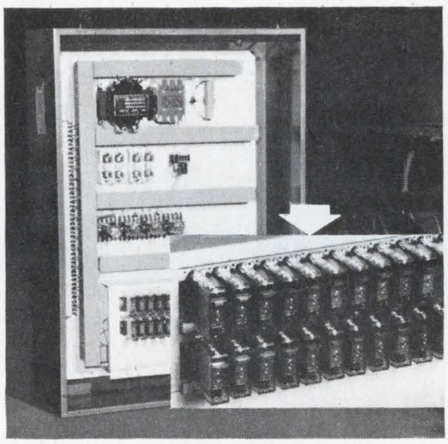
☐ Elevators: relays cut manufacturing costs

F. S. Payne Co., Cambridge, Massachusetts elevator manufacturer stresses that any new controller should use relay logic for serviceability and overall economy. IBM wire-contact relays were thoroughly tested in the lab, in Payne's test tower, and in field installations. They proved 100% reliable.

IBM relays cost less per contact than presently-used relays and their multipole configuration reduces the number of relays needed. Because the entire control system is smaller, it can be made in less time, with fewer parts, by fewer people.

Elevator passenger safety is the overriding design consideration which depends, in large part, on controller reliability. IBM relays greatly surpass reliability criteria for elevators while offering dramatic space savings in control unit size.





IBM relays can slash more than 75% off the size of elevator controller units without sacrificing reliability.

☐ Elevators: relays permit design flexibility

Another elevator manufacturer, United States Elevator Corp., Spring Valley, California, finds IBM wire-contact relays important for design flexibility.

Their controller is programmed to sense changing needs for elevator cars as traffic patterns vary, as opposed to timing cars to arrive during pre-determined peak traffic hours. This requires simultaneous switching of many circuits. When U.S. Elevator investigated various switching components, they found the IBM 12-PDT relay to be ideal since it offered up to twelve separate switching circuits within one small component.

Additional design flexibility is provided by plug-in insertion and taper-pin wiring of relay receptacles which allows for future controller expansion.

Long life and ease of maintenance are two important design considerations for all elevator controllers. The IBM relay, with mechanical life of 200 million-plus operations, and pluggable construction, fulfills both needs.

These are only three of many manufacturers benefiting from IBM wire-contact relays in their control systems. To find out how these relays can help you, contact IBM now.

☐ High-speed reed switches undergo rigid testing

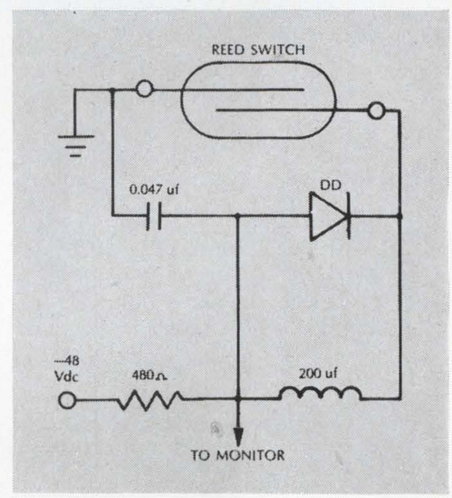
For applications requiring higher speed switching, IBM offers a line of reed relays built around the rhodium-over-gold IBM miniature dry reed switch.

These switches are designed for applications where fast, ultra-reliable operations are essential. They also serve ideally as an interface between solid state and relay logic.

To insure consistently superior performance with these switches, IBM uses advanced manufacturing equipment and rigid inspection techniques in every production phase.

For example, shipment populations of IBM reeds are sampled as a final process control measure to guarantee product uniformity. Switches are tested under four operating conditions for life vs. resistive load and one condition for life vs. inductive load (100 mA inductive load with diode suppression).

Full documentation on quality assurance and failure parameters concerning these reeds are available on request.



The diagram above shows just one of the circuits (48 VDC suppressed) used to test IBM miniature dry reed switches prior to shipment.

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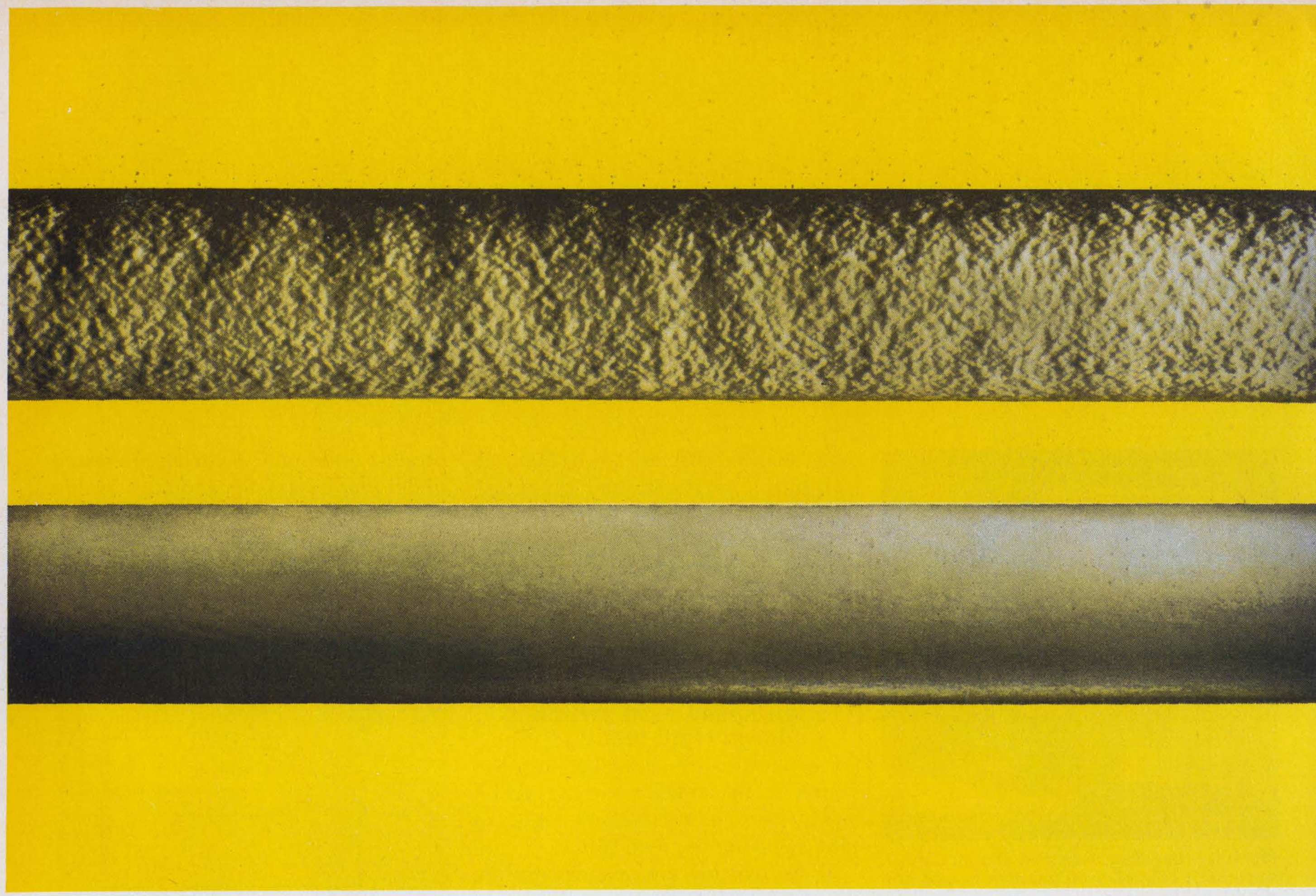


Nitride passivation links TTL, MOS

Several firms, notably TI and GI, believe they've hit on a process to make low-level metal oxide semiconductor devices

By Walter Barney

Associate editor

"In the real world," concedes Lee Seely of the General Instrument Corp., "there is TTL." Seely, general manager of the Microelectronics division of GI's Semiconductor group, has no real quarrel with the prevalence of transistor-transistor logic, but as a leading developer of metal oxide semiconductor technology, he would like to find some way to coexist with it. Historically, MOS has operated at higher voltages than bipolar circuits, meaning that level shifters and extra power supplies were necessary if the two were to work together. The incompatibility has undoubtedly delayed the development of MOS. In the past year, some companies—notably the National Semiconductor Corp. and American Micro-systems Inc.—have offered MOS circuits that worked at or near TTL voltage levels. And this month, both GI and Texas Instruments announced a new MOS process that they say overcomes some of the difficulties of making low-level MOS. Motorola and ITT Semiconductor are among the other contenders in nitride passivation.

The process turns out to be an old friend—silicon nitride passivation [*Electronics*, March 17, p. 35]. The bipolar world has taken to nitrides like a cat to catnip; Si_3N_4 has been hailed as the compound that makes possible the "hermetic chip." TI and GI do value the protective properties of nitride, since they think it will make plastic-packaged MOS feasible, but they cherish it too for its high dielectric constant (twice that of silicon oxide), which lowers the threshold voltage for metal oxide semiconductor devices.

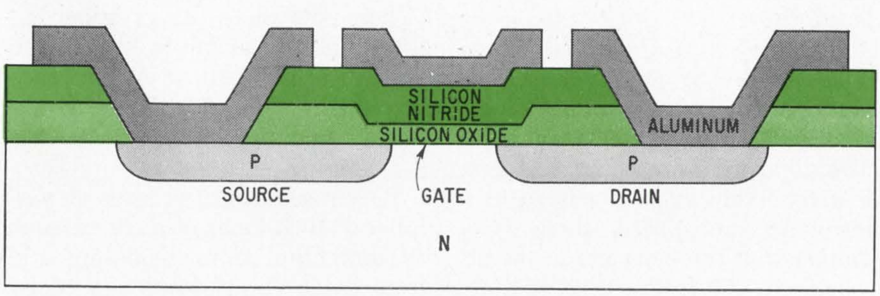
Geometric geography

An MOS transistor consists of two regions—source and drain—of a particular type dopant diffused into a substrate of the opposite type. (Normally they are p regions in an n substrate.) Current flows from source region to drain region when a voltage is applied to a contact over the area between them, temporarily creating mobile positive charges in the n substrate. The voltage required to invert this area, the gate, is directly proportional to the surface state charge (Q_{ss}) on the silicon and the thickness of the oxide over the gate, and inversely proportional to the dielectric constant of the insulator between the semiconductor material and the gate metal.

One can lower threshold voltage, then, by reducing surface state charge or oxide thickness, or by increasing the dielectric constant. Shaving the oxide, which may be only about 750 angstrom units thick to begin with, does not appeal to anyone. "The oxide is already as thin as it should be," says L.J. Sevin, who directs MOS activity at TI. Oxide defects can be murderous on yields. It is possible to reduce the surface state charge, however, by using silicon of a different crystal orientation, and this is what most companies have done.

National Semiconductor pioneered the switch from 111 silicon, which has a densely populated surface, to 100 silicon. The 111 plane has a lot of uncommitted bonds, which look like a charge on the silicon surface. Silicon cut on the 100 plane has fewer such bonds, and a significantly lower Q_{ss}. Devices made with 100 silicon have threshold voltages as low as 1.6 volts—compared with the 4 volts of passivated 111 SiO_2 devices—and consequently operate easily with a 5-volt TTL power supply. (The rule of thumb is that supply voltages should be about three times threshold voltages.)

GI is familiar with the 100 silicon route. "That sounds nice, and that's where we got led down the garden path," Seely says ruefully. A year ago, GI announced a device with a 1.6-volt threshold, but the



Two deep. The key to GI's low-level metal oxide semiconductor circuits is the low threshold voltage obtained with a layer of silicon nitride for passivation that's on top of a thin coating of silicon oxide. TI, Motorola, and ITT are also working in this area.

... two West Coast companies are trying to make memories with silicon nitride ...

firm was never able to deliver. The problem was unwanted field inversion. When contact metal on top of an integrated circuit passes over a diffused p region, the structure is topologically similar to the gate. This "phantom transistor" never turns on because the field oxide is so thick (typically 15,000 Å) that the threshold voltage is too high to be reached. But when 100 silicon is used, and Q_{ss} sharply reduced, the field threshold can drop dangerously, to 15 or 16 volts.

Secret solution. MOS systems need a second power supply for the devices that are used as a load resistor. The −12-volt supply available in many systems fills this role nicely, but the total voltage swing of 17 volts is frequently enough to invert the source or drain. GI's life testing showed that field thresholds of 20 to 24 volts tended to drift down, in time, to the danger level, and the company finally had to withdraw its low-level device.

Companies using the 100 silicon/oxide process are well aware of the field inversion problem. National Semiconductor claims to have solved it, but considers its solution top secret. Outside sources say that National uses an extra n+ barrier diffusion for isolation, as do Fairchild Semiconductor and the Motorola Semiconductor Products division. It is also possible to increase the field oxide thickness, but this method makes it difficult to use small device geometries.

The difficulties associated with 100 silicon led both GI and TI to look to the third factor in the threshold voltage equation—the dielectric constant—to obtain low-level operation with 111 crystal. Silicon nitride's dielectric constant is about twice that of silicon dioxide; when nitride is used as the insulator, the gate can be chemically thick—but electrically thin compared with SiO_2. What's more, the high dielectric constant improves the gain factor of the MOS transistor by 50%. This gain factor, K′, is the amount of current output relative to the voltage on the device; it is directly proportional to dielectric constant and inversely proportional to insulator thickness. "When you want to drive TTL, you have to drain current," Seely says, "and this current varies with the gain factor."

So, according to TI and GI, nitrides offer the same low-level operation afforded by oxides and 100 silicon, plus better reliability, higher gain, and adaptability to plastic packages and face-down bonding. (GI is working feverishly on beam-leaded devices for multichip packages. TI's Sevin says, "If you ever make unpackaged devices, beam lead with Si_3N_4 is the way to do it.") Why, then, is not silicon nitride all-pervasive?

A tricky process

Partly, it seems, because the nitride process is new and tricky. Both GI and TI reportedly had difficulty in getting a handle on it. Nitride-passivated devices tend to leak current. Silicon nitride does not interface well with silicon; the uncommitted bonds result in surface states that look like uncontrollable charges. Threshold voltages on devices made with a simple nitride insulator shift dramatically in one direction when the devices are biased negatively, and in the other when they are biased positively. (At least two West Coast companies are trying to exploit this effect to make memories using silicon nitride.) To prevent this shift, it is necessary to put a layer of oxide on top of the silicon, and a layer of nitride on top of the oxide. The process provides a bonus in that defects in one layer are unlikely to match with defects in the other. But it is not simple to learn.

"Nitride is a deposited film—much harder to control than thermally grown oxide," notes Charles L. Hutchins of TI's technical staff. The deposition process is complex; if one merely exposes silicon in a nitrogen atmosphere, there is a danger that trace oxygen in the atmosphere will form silicon dioxide, and that the nitride and oxide will be deposited in an amorphous mix whose chemical and electrical properties are unpredictable. Any trace contaminants, in fact, in the gases used to form the nitride can diffuse into the oxide, causing electrical characteristics to change under temperature stress. "The problem that we feel we have solved, on a limited basis at least, is the one of growing a compatible oxide layer," Hutchins says.

Other firms. Seely, who enjoys a friendly rivalry with Sevin, professes to be pleased by his competition's success. "If TI goes with nitrides, it will set a trend," he says. "I was disturbed when I heard that they were having trouble with the process; if they had abandoned it, they would have left us out in left field." Not that all has been smooth sailing at GI; Seely found that because nitride is almost impervious to chemicals, the device tolerances were much more critical. "It's a nice characteristic when you get done," he adds, "but it makes the process difficult to learn. You have to control the composition of the nitride very carefully." Seely and Hutchins agree that once the process is mastered, it is no more difficult than any other. GI, in fact, will sell its low-level devices at the same price as its regular line. Both companies say that circuit design was as big a headache as processing.

ITT's Semiconductor division has also introduced a nitride-passivated circuit, a dual 16-bit static shift register, although it has not advertised its process. And there are some indications that Motorola will follow suit. At present, Motorola uses 100 silicon and oxide passivation, and, because it is getting good results, is not ready to switch. "The advantages of nitride aren't so overwhelming as to make us change now," says Wally Raisanen, operations manager for IC memory and MOS products at Motorola. "There are some things about nitride that we haven't fully explored and we want to know all the ramifications of the process and be certain it's controllable before we use it."

Raisanen cites a number of peripheral advantages of nitrides, such as protection from pinholing and from device breakdown caused by transients that rupture gate oxide (nitride starts to leak current, dissipating the charge before it can harm the gate). But so far, Motor-

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ola, which has had considerable experience with nitrides because of its work with Bell Labs on the Sentinel program, and which introduced nitride passivation on discrete MOS devices last year [*Electronics*, May 27, 1968, p. 46], is holding back.

They'd rather switch

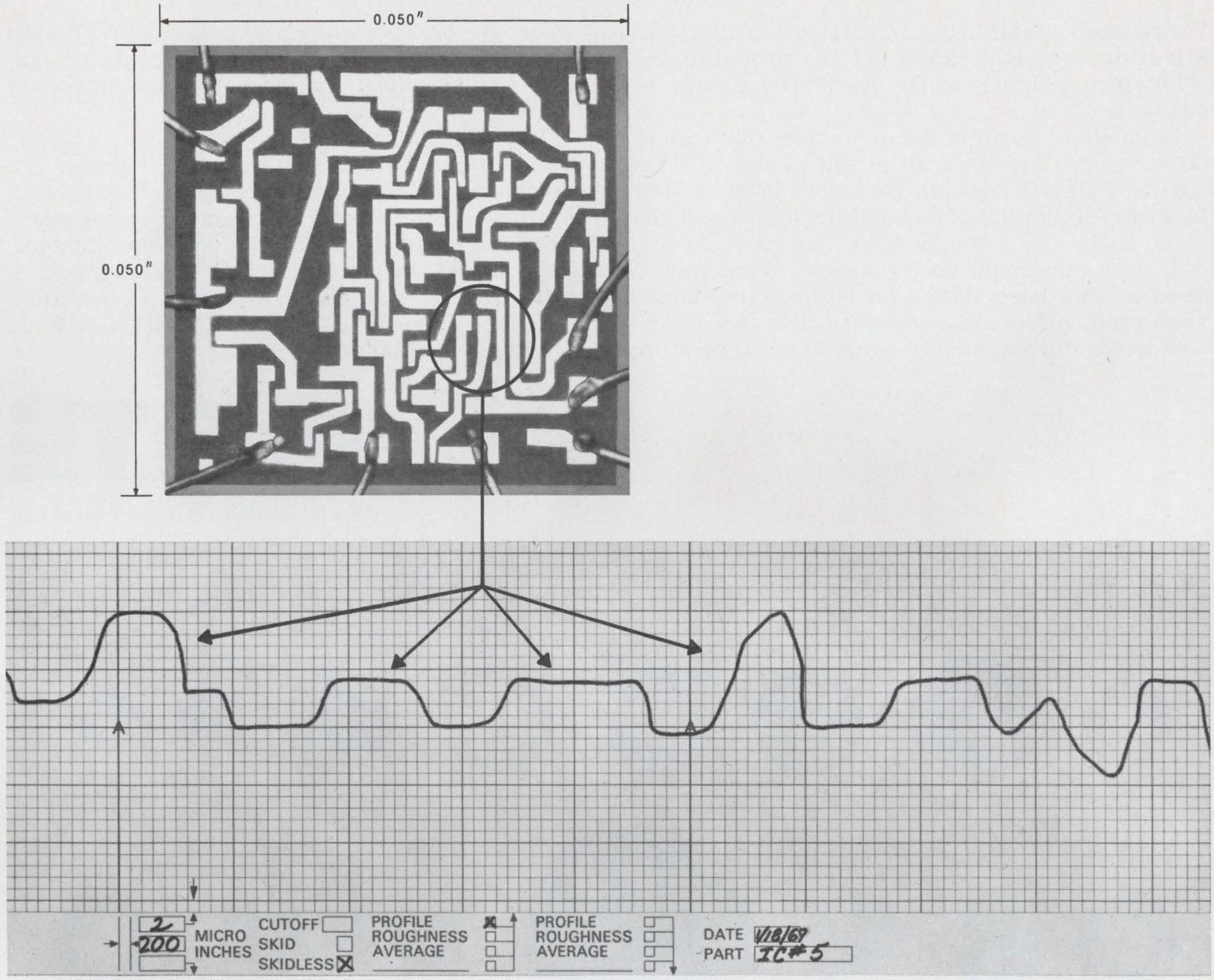
Even National, which is quite content with its oxide process, expects to switch to nitride for plastic packaging. "If oxide were satisfactory as a passivating layer, the question about nitride would never have come up," says Ken Moyle, National's MOS product manager.

GI is already running evaluation tests on plastic packaging at its Naples, Italy, plant, though it will not bring out the plastic package until the low-level line is well under way. Further downstream, Seely is looking at beam-leaded devices, and he says that GI is developing a method to put beams on other manufacturers' wafers—no mean trick. The first low-level device, a dual 16-bit static register, will be introduced in mid-May. The company will follow up with a 200-bit register, a 512-bit read-only memory, and a 16-channel multiplexer. TI's first products will be custom. (GI has been delivering military devices for nearly a year.)

Unlucky figure. The oxide and the nitride partisans may differ on methods of passivation, but no one challenges the desirability of operating at low voltages. Seely provides a dramatic example, admittedly worst-case: "We sell a serial-in, parallel-out shift register, the MEM 30-12 SP, for $6," he says. "There are 12 lines out and one line in—meaning that the user has to have 13 level shifters, at about a dollar a terminal. That's more than twice as much for buffers as he spends for the device. We still sell these parts, but we'd like to save those extra dollars."

Since the devices operate at lower voltages, they can operate with lower power dissipation; halving the supply voltage reduces power consumption fourfold. The devices can also operate faster, if they need drive only low-level TTL circuits. The low-voltage operation seems to have arrived; what's still to be decided is the best method of obtaining it.

Any chips off the new IC?



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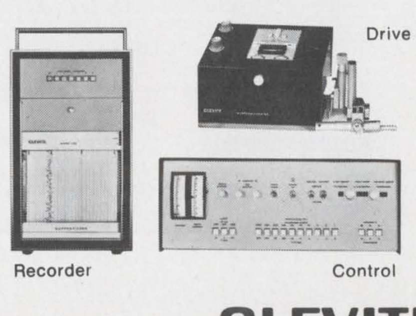

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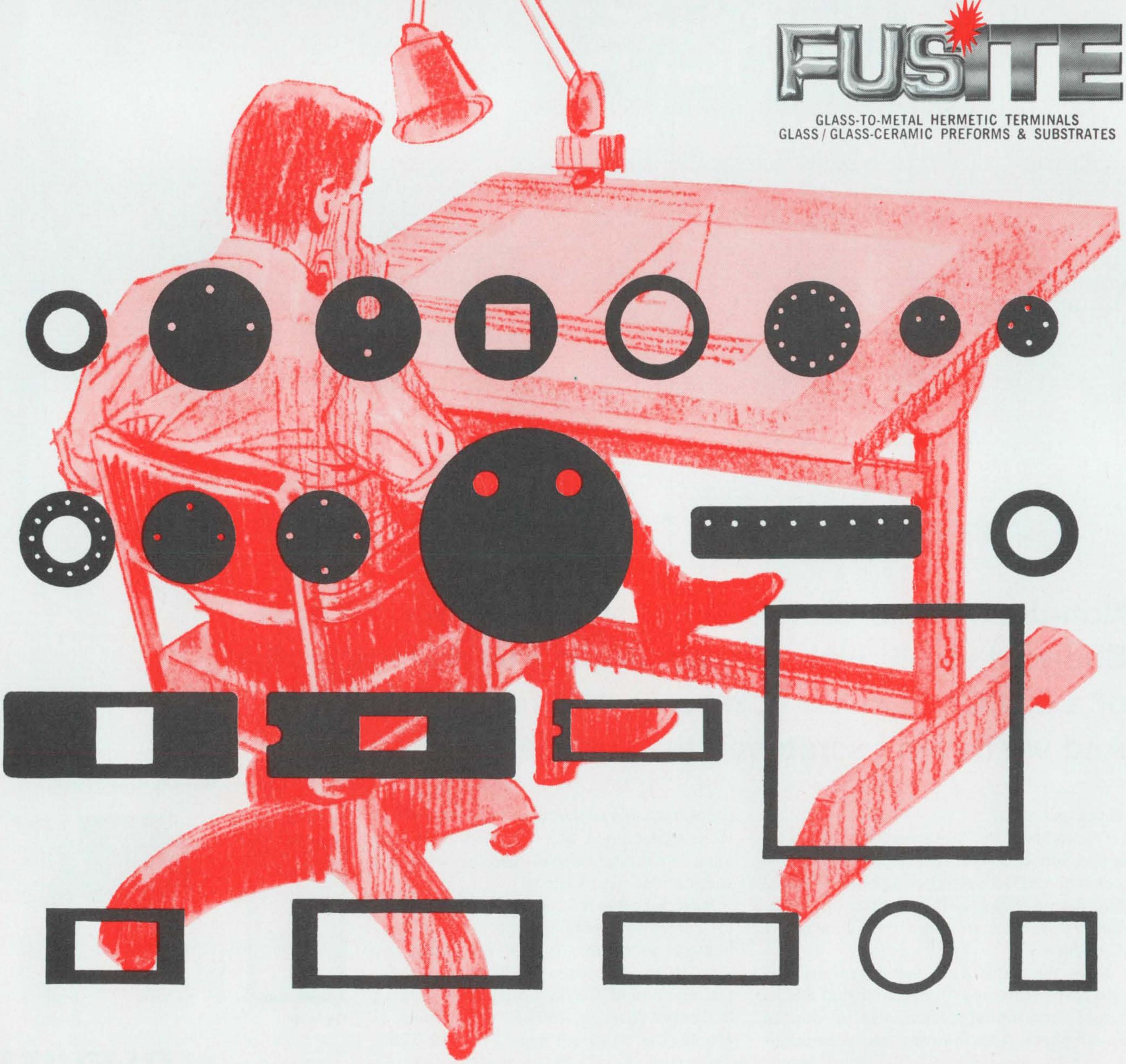


IUE tries to stem outflow of jobs

With one eye on big contract talks next fall, union is fighting relocations overseas, pushing for labeling of imports, and recruiting white-collar types

By Paul A. Dickson
Associate editor

The leaders of the International Union of Electrical, Radio, and Machine Workers (AFL-CIO) have more on their minds right now than the new three-year contracts they'll negotiate with Westinghouse and General Electric next fall. Not that these negotiations aren't a prime topic of conversation around the IUE's headquarters these days. In a year when not many large industrial contracts are up for renewal, the GE and Westinghouse deals loom as two of the most important in the nation. "Not only will they set the pace for the electronics and electrical industries," says a union spokesman, "but they'll be reflected in contracts in other industries." However, while the IUE girds for this traditional battle, it is also trying to come to grips with two recently emerging trends—the exodus of electronics jobs to other nations and the increasing willingness of engineers and other salaried workers to unionize.

Currently, the IUE has 340,000 members represented by about 600 locals at more than 1,200 companies. Membership in 1968 was about the same. But the union would like to keep growing—or at least to hold its ground. To do so, it must either stem the movement of blue-collar jobs to operations overseas or capitalize on the new inclination of white-collar workers to organize. The union would like to do both.

Entente cordiale. IUE president Paul Jennings and Shinryo Kiyoto, who heads Japan's metalworkers union, are pursuing common goals.

Kearny coup. Sanford V. Lenz, the head of the IUE's professional, technical, and salaried conference board, is an engineer who coordinates the union's recruiting in the white-collar area. Lenz can boast that the IUE has more than 15,000 white-collar workers on its rolls, most of them professional engineers. Last December, Lenz' group scored a major victory when more than 700 salaried workers at Western Electric's Kearny, N.J., plant voted to join the IUE. Most of these members are engineers, the rest being engineering assistants. It was the largest single catch of engineers to date by the IUE, and it came in the union's first attempt to enroll engineers at an industry giant.

Says Lenz, "I'm convinced that the action at Kearny was not a fluke but the emergence of a very real and important trend." He points out that the IUE is now involved in serious discussions with a large number of engineers at other

Western Electric facilities, with engineers at other companies, and with some small unaffiliated unions of engineers. Western Electric engineers at the Merrimac Valley plant will soon vote on IUE membership, and Lenz predicts that other large blocs of engineers will affiliate themselves with the union before the year is out.

According to Lenz, the trend reflects an increasing feeling of alienation among men with middle-level jobs. "These people see the production worker affecting decisions through his union, see the higher-echelon managers making company decisions, and see themselves excluded from the decision-making process," he explains. "As conglomerates continue to grow and companies become more and more diverse, this feeling of alienation becomes more acute. If we had to thank someone for helping us attract engineering and technical professionals, it would have to be the conglomerates."

Lenz and other IUE officials expect the white-collar segment of the union to show the highest percentage growth in the coming years.

Missing jobs

But while the union's white-collar membership is increasing, its blue-collar rolls are being steadily eroded by the relocation of production facilities overseas. Union locals have been regularly reporting the elimination of U.S. jobs as firms look to Asia and Latin America for labor and products.

The U.S. Department of Labor has recently released statistics that support the IUE's contention. The Government's figures show a decline of 50,000 jobs in the manufacture of radio and tv receiving sets and electronics components between 1966 and 1968. According to the report, U.S. employment in radio and tv production dropped from an average of 135,000 workers in 1966 to 110,000 in 1968, and from 287,000 to 262,000 in components production over the same period.

The IUE maintains that the situation is getting worse as more and more firms announce their intention to move manufacturing operations to the Far East or Mexico. Not only is the union concerned about further erosion in the consumer-products and components areas, but it sees a similar trend developing in the calculator and computer fields.

According to Abe Morganstern, IUE research director: "We've got a major problem with no easy answers. Electronics is a growth industry and we're not participating in the growth. Simply, we don't like layoffs and we're looking for ways to stop them without adopting a stance of protectionism."

Label lobby

The union's efforts to plug the leak with Federal legislation got results last month when Sen. Clifford P. Case (D., N.J.) proposed a "Truth in Import Labeling Act" for consumer electronics products. The bill, which was introduced at the request of the union, would require companies importing foreign-made appliances and equipment under their own trade names to clearly designate the origin of the products.

The bill calls for permanent and conspicuous labels made of metal, unless the Federal Trade Commission decides this to be inappropriate; the letters indicating the nation of origin would be at least half the height and width of the product's brand name, but no less than a quarter-inch high. The bill, which has been referred to the Senate Commerce Committee and is expected to come to the floor for a vote later this year, is described by Case as "a necessary and logical extension of the Truth in Labeling Act."

Ganging up. Besides lobbying for passage of the import labeling bill, the IUE is trying more direct means of keeping jobs in this country. For one, the union is working closely with unions in the countries where the electronics work is going.

IUE president Paul Jennings heads the International Metalworkers Federation's committee on multinational companies. In April, the committee will sponsor a meeting in Bogota, Colombia, of unions represented at GE facilities throughout the world, and similar meetings are planned for unions dealing with other large electrical and electronics firms. The aim of the Bogota conference is to press GE to equalize its wages and benefits on a worldwide basis and thus eliminate the conditions that cause it and other companies to globe-hop. Says a union official, "This type of action may be one of our best weapons."

Hands across the sea

In this same direction, the IUE itself is strengthening its ties with unions in other countries. For example, Denki Roren—the Japanese electrical workers union—and the IUE have agreed to reciprocal visits, exchange of information, and the like. In fact, several top IUE officials have just returned from a fact-finding mission to Asia. And Denki Roren will, in turn, send a delegation to the U.S. later this year. According to the IUE, Japanese unions are faced with a problem similar to its own: namely, work is being shifted from Japan to such low-wage areas as Taiwan, Hong Kong, Korea, and Singapore. While in Asia, the IUE officials visited Korea and Taiwan to get firsthand information on wages, unions, and the general labor situation.

The IUE also plans to make "runaway" jobs an issue at the bargaining table—demanding assurances from companies that they won't replace existing product lines with imports. And though it has had little luck so far, the union will continue to press for relief from the U.S. Tariff Commission under the adjustment assistance provisions of the Trade Expansion Act of 1962, which calls for the retraining and compensation of men who have lost their jobs because of imports. Morganstern says all applications so far have come back marked "rejected."

Field reports. But as the union wrestles with the problem in a general way, the situation is deteriorating in a very specific way. When the labeling bill was introduced, the union called some of its local presidents to Washington to discuss developments in their areas. The discussion was often grim.

- Local 491 president Ted Petty, representing salaried workers at the Westinghouse plant in Edison, N.J., said that membership in his unit had dropped from 225 to 84 in the past 18 months due to a shift of tv-set production to Asia.
- Local 401 president Ted

Aurillo, representing production workers at the same Westinghouse plant, reported a drop from 2,300 members in 1966 to 400 today as a result of imports.

▪ Local 101 president Joseph Burns of Philco-Ford in Philadelphia blamed foreign imports and runaway jobs for a drop in the work force there from 9,000 to 2,100 over the past decade.

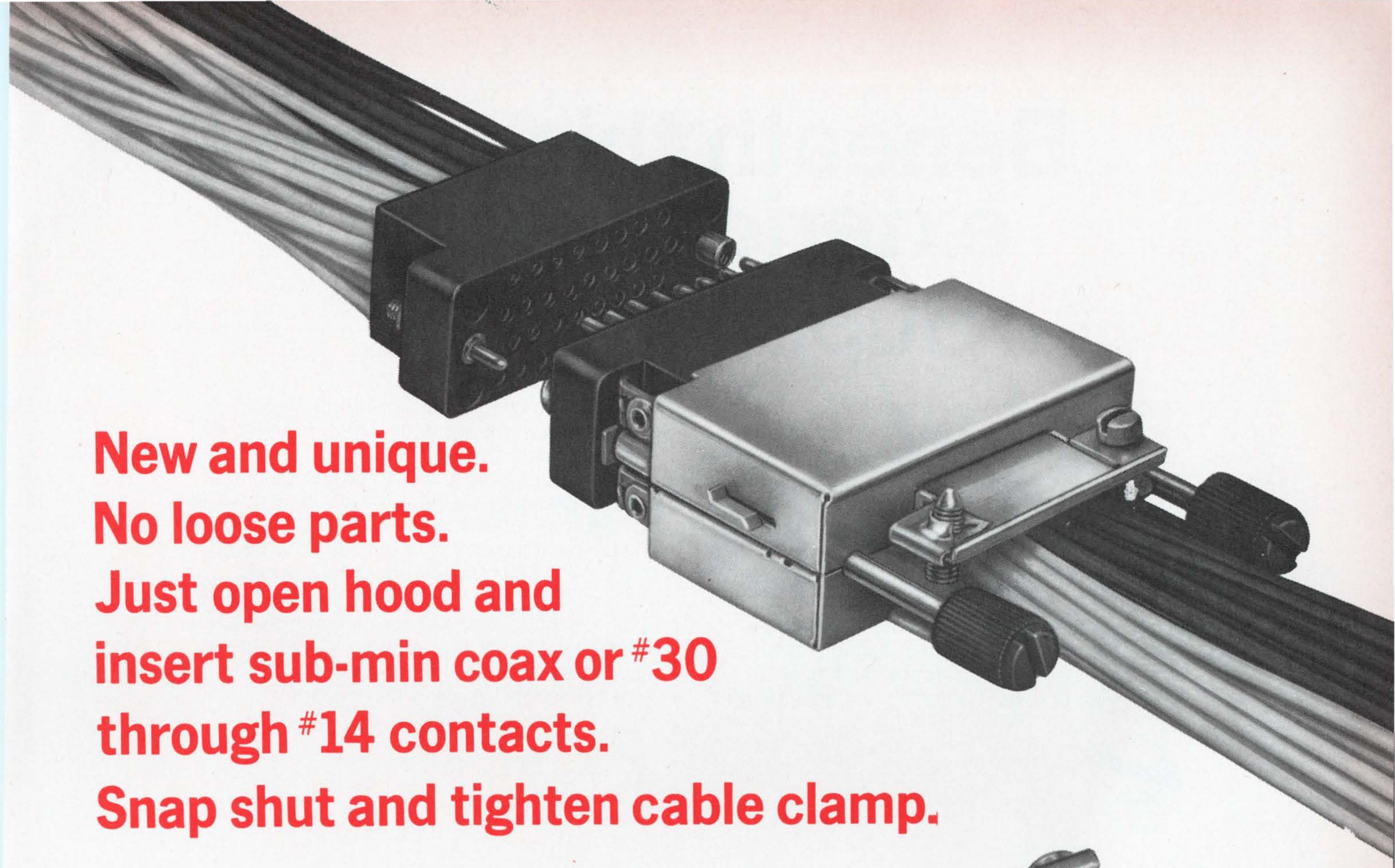
Basic training

Along with trying to protect its membership rolls, the union is moving itself into new areas. It has, for instance, embarked on an on-the-job training program in conjunction with the Labor Department and the firms at which the IUE is represented. In the first program set up with the Labor Department, 1,300 individuals were trained; under a second contract, another 1,200 are being trained. These programs have been aimed at members of minority groups, older people, the handicapped, and those with police records.

The IUE is proud of the work it's done in this area. It cites the case of one plant that employed no Negro production workers until the IUE program got going; at last count, there were 59 black workers at the plant, each making at least $2.75 an hour.

The union is also undertaking educational programs for members. Last year's IUE convention approved the establishment of high school equivalency programs, English literacy classes for Spanish-speaking members, courses in union activities vis-à-vis changing technologies, and a college degree program.

New lineups. But for all these new plans and programs, the IUE's big job is still at the bargaining table. And the negotiations later on this year will find the companies formally cooperating for the first time with the IUE's chief rival, the United Electrical Workers. In addition, the IUE will be involved in "coordinated bargaining" in alliance with 10 other unions. Current contract goals include a full cost-of-living escalator, a "substantial" wage rise, a "substantial" increase in pension benefits, broader insurance and hospitalization coverage, and a series of job-security provisions.



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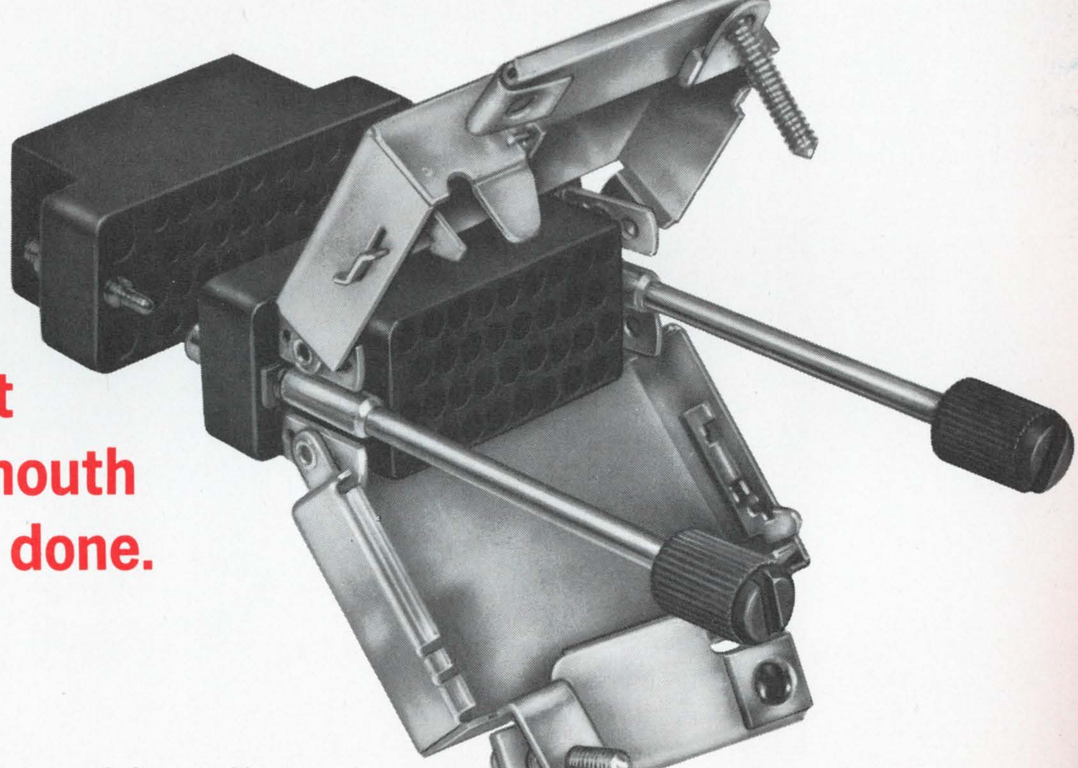

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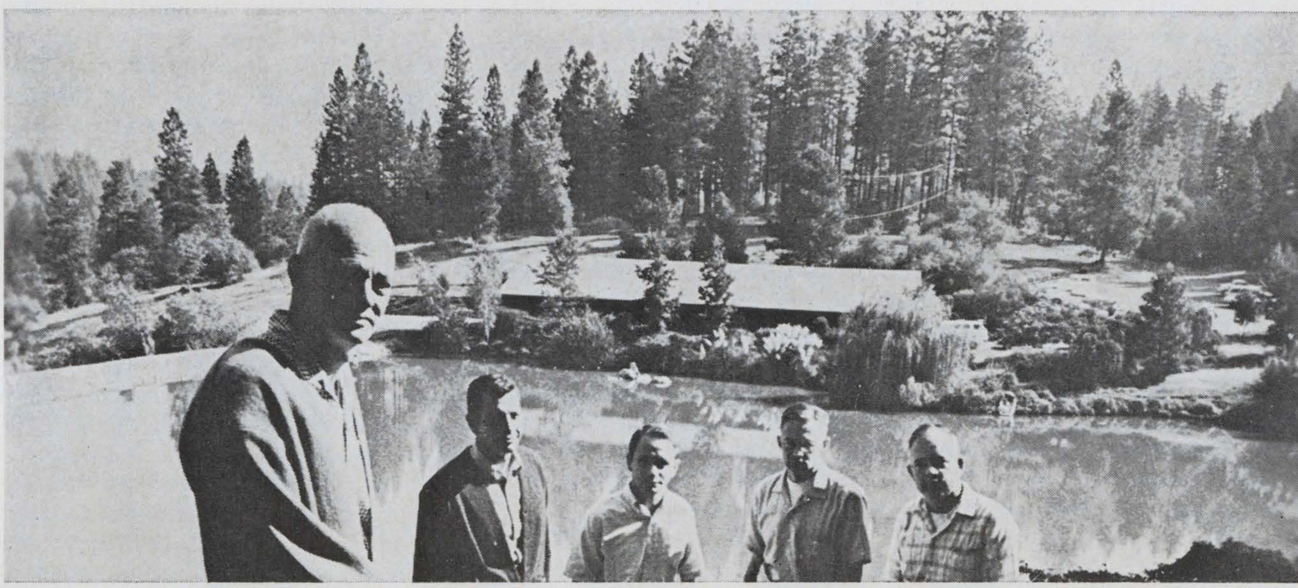
Bigtime profits in a rural setting

Tv-equipment maker takes to the woods, finds peace and quiet no bar to an earnings record that city slickers would envy

By Peter Vogel
Assistant editor



Anachronistic. Donald G.C. Hare, founder of GVG, and his executives find sylvan scene no drag on progress or profits.

Grass Valley, a small town in Nevada County, Calif., was nearly bypassed by the 20th Century. A relic of Gold Rush days, it is—as its name suggests—pleasant, quiet, rustic. Aging gas stations and supermarkets are its only external concession to modernity. Many residents won't drink from the public water supply, and some homes on the outskirts have no electricity. Yet sleepy Grass Valley is the home of an electronics company that has not only managed to stay in the forefront of television broadcast technology, but has compiled a phenomenal earnings record in the process.

The company, Grass Valley Group Inc., is the personal creation of physicist Donald G. C. Hare. He founded it 10 years ago, nursed it through some lean years as a one-product operation, and watched its revenue blossom from $200,000 to $2.2 million and its earnings from $27,858 to $482,845 over the past five years. Sales and profits began to soar a year after Hare moved GVG into the business of making solid state line and terminal equipment. The firm now has 85 employees (including 10 engineers, 6 technicians, and 18 sales and administrative personnel) and markets about 100 products that amplify, edit, process, and distribute video and timing signals for tv studio and transmission systems.

"The chances are excellent," Hare says, "that just about any television program in the country moves at some point through GVG equipment." About two-thirds of all of the nation's tv stations use GVG products, Hare adds, along with some 80 colleges and universities operating closed-circuit systems. The American Broadcasting Co., the General Electric Co., and the Ampex Corp. are heavy GVG customers.

Pastoral but productive

One small irony here is that GVG's employees have a hard time picking up the programs they make possible; reception in Grass Valley is pretty much limited to a couple of Sacramento channels. But Hare apparently chose shrewdly when he founded his company in the Sierra foothills. He has had no trouble establishing good labor relations with the local community, or in recruiting engineers who are fed up with metropolitan life. Grass Valley may be a one-industry town, but the company itself is unobtrusive; its elegant buildings are nearly in-

Hare and hounds. GVG's founder-president is a confirmed dog lover, and his dachshunds are given the run of the place, including the lab.

visible against the pine forest in the valley. The entrance is marked only by a small sign, behind which some of Hare's dachshunds may be seen sporting on the firm's putting greens. The dogs are just as likely to be curled up on Hare's workbench. Next to the office building is a man-made lake on which ducks and swans swim about.

The low-pressure atmosphere seems to work. It would be hard to find another company in the hotly competitive electronics industry that can match GVG's return on sales. Because it's a closely held company that hasn't paid a dividend since 1962, and because some outsiders are skeptical of Hare's ability to attract topflight management in the future, the company has been pretty much ignored by the financial community.

But GVG's backlog last month was at an alltime high of $690,000, of which $540,000 was in switching and special-effects equipment. Backlog a year earlier totaled only $110,000, and none of the orders was for such systems.

Hare started GVG in 1959 after leaving the Sangamo Electric Co. (Charles H. Lanphier, chairman of Sangamo, sits on the GVG board today.) For a year, Hare rode high on a $500,000 contract under which GVG made the five-channel sound equipment for Cinerama's 70 theaters. "Then," Hare says, "we starved for four years, waiting for another windfall." In 1963, the company actually had a loss of $21,000.

It was then that Hare decided to forget about sound systems and move into television. "Everyone advised me that it was too late to get into the tv-equipment business," he recalls. But Hare had one advantage over the competition: he could jump into the market with a line of completely solid state equipment, whereas his competition was still heavily committed to vacuum tubes. And GVG has under way a move toward even greater use of integrated circuits.

Even complete use of IC's won't solve the company's one basic problem: the commercial television equipment market is just about saturated, Hare concedes. So where, if the market is saturated, do you go with a fine organization and a history of excellent products and profits? Like many other presidents of successful corporations, Hare is considering diversification by acquisition.

Education moving

Hare ticks off figures about the increasing number of students and the decreasing number of teachers in the U.S., and then he considers the educational needs of the rest of the world. The big outlet of the future for a company like GVG, says Hare, is the educational television market—after the disputes about the merit, format, and content of instructional tv programs in schools are resolved.

"We have an educator on the payroll," says Hare, "and we're studying what the needs of instructional tv will be, both from the point of view of equipment and from the point of view of program content." The most successful company in the nascent educational tv market, he suggests, will be the company that offers a complete package—hardware and prerecorded educational videotapes. It's this area into which GVG may move.

The market for instructional tv equipment will be vast compared to the amount sold to the more than 1,200 commercial television stations. Now that color cameras and video recorders have gotten pricetags below $15,000, the run will start, Hare says. Further impetus will be added to the movement, Hare says, when the Government stops spending a "disproportionate" amount of the national income on defense preparations. In the long run, the real money will be in providing not just the line and terminal equipment, but in the production of tapes.

A major stumbling block to the expanded use of educational videotapes will be getting a consensus on how such tape should be prepared for school children. Many educators believe that the individual traditional approach to education is sacrosanct and will be impossible once the student is mated with a computer. To best overcome the objections of educators to videotape instruction the industry should introduce a method by which the student can ask questions and receive answers on the subject under consideration, Hare says.

Hare's experience with the Grass Valley community answers one of the questions frequently posed by the electronics industry. It is possible to establish a successful firm in an area not already inundated by skilled electronics personnel. Hare has recruited all his assembly personnel from the community and has trained them himself. Since electrical engineers deluge him with requests for employment anytime he advertises an opening, he can select among many applicants. Building costs and maintenance costs are low. Grass Valley offered a tranquil, rural setting yet didn't deny a continuing profit from the needs of metropolitan centers. Hare's company is a true participant in McLuhan's global village. ■

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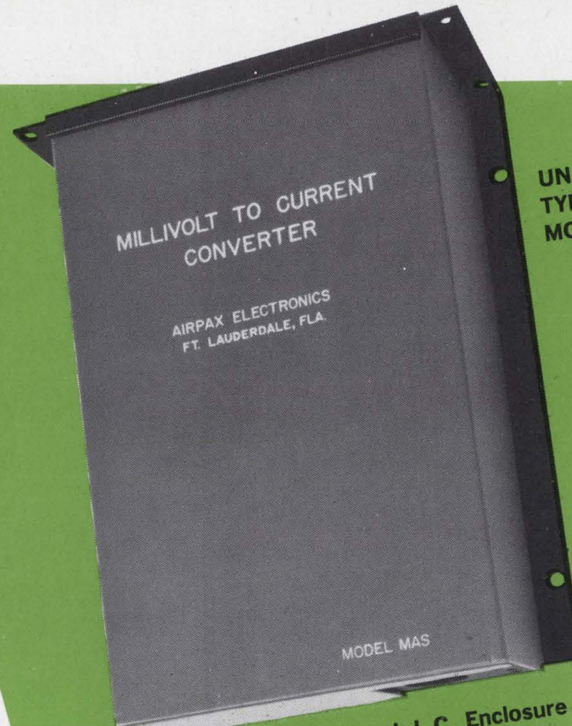

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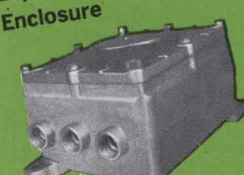

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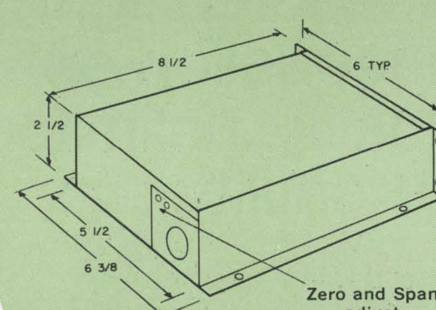

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Flat display has inherent memory

Plasma readout panel using two glass layers does not require refreshing and is driven directly from digital circuitry without need for a d-a conversion

The trip from lab to marketplace is proving a speedy one for plasma display panels. Only two years ago, D.L. Bitzer and H.G. Slottow of the University of Illinois described a prototype at the Fall Joint Computer Conference. But by last summer, a slew of electronics firms were vying to develop the first commercial panel of this type [*Electronics,* July 22, 1968, p. 39].

Owens-Illinois Inc. seems to be out in front right now. It's introducing what it calls the Digivue panel, a 6-by-6-inch transparent assembly only a half-inch thick and carrying a 4-inch-square array of about 18,000 tiny spots. The race is going right down to the wire, though. The Burroughs Corp. is close to announcing a plasma display panel of its own.

In the Owens-Illinois array, the spots can be lit up one at a time—or a whole line at a time—to display a wide variety of patterns. Once turned on, the spots continue to glow without refreshment until turned off by an erasing signal. The display is completely digital; it needs none of the digital-to-analog conversion required by conventional cathode-ray-tube displays.

Paned look

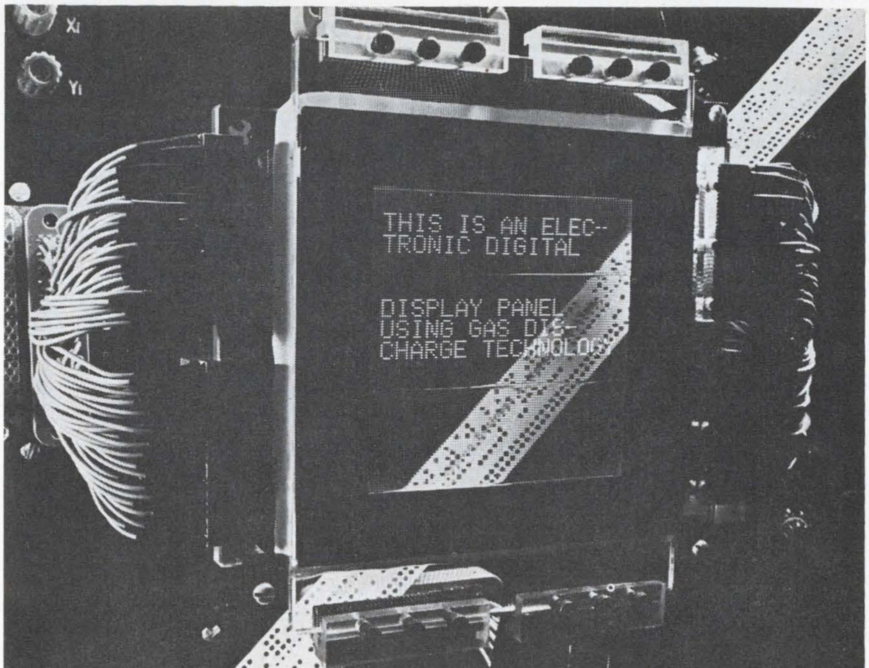
The new display consists of two quarter-inch-thick glass plates separated by a gas-filled gap about 10 mils wide. The gap is maintained by thin glass spacers. On the inner faces of the plates are two sets—horizontal and vertical—of transparent electrodes covered by a thin glass insulating layer. Each set is a series of parallel lines 30 mils apart and reaching all the way across the plate; the intersections of these lines establish the spots that form the displayed patterns.

When the display is operating, a sustaining voltage alternating at 50 kilohertz and 175 volts peak is applied between the two sets of conductors. To turn on a particular spot, a write pulse is applied to the corresponding pair of conductors just as the sustaining voltage crosses the zero level from negative to positive. The write pulse amplitude is about 200 volts—high enough to initiate a discharge in the gas that creates a bright glow, similar to that in a neon tube. This glow lasts only about a microsecond; it builds up charges in the insulating layers that oppose the writing and sustaining voltages and therefore quench the discharge.

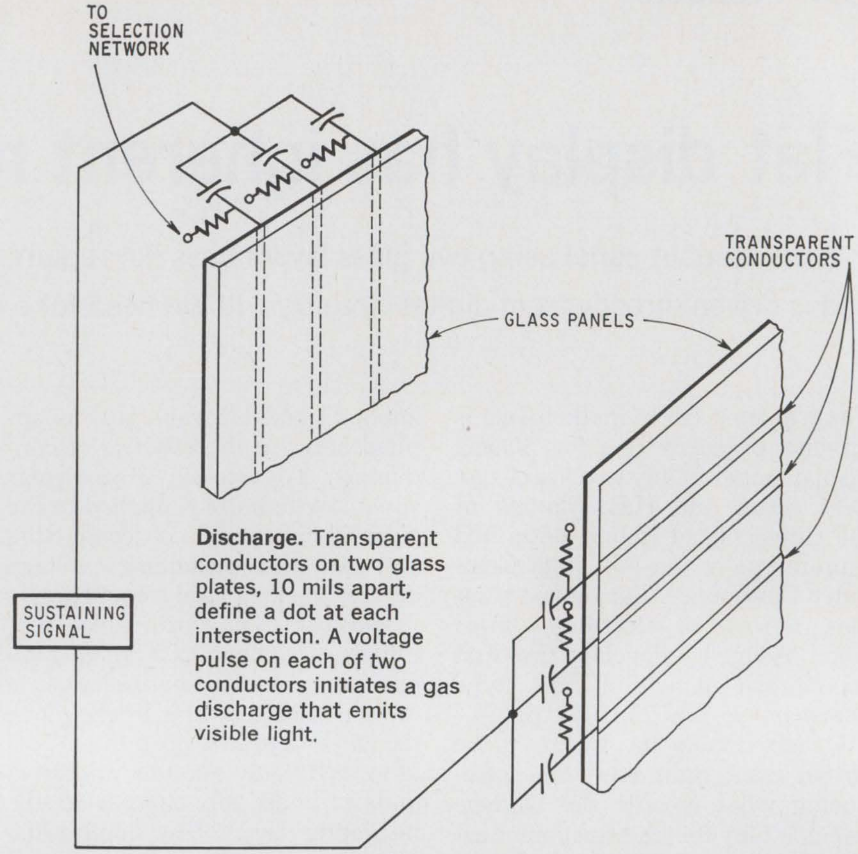
However, the charges remain in the insulation long enough to add to the sustaining voltage during the next half-cycle and thus initiate a new discharge, this time in the absence of a writing pulse. The flickering pulse thus continues at a 100-kilohertz rate until an erasing signal is applied, with the same timing as a writing pulse but with opposite polarity. This flickering is bright enough to make the display easily visible in ordinary room lighting even though its duty cycle is only 10%.

Three-decker. The Owens-Illinois design differs substantially from that of Bitzer and Slottow. They used a three-layer glass sandwich with holes in the middle layer through which the discharge occurred; the accumulated charges that kept the display going resided in the glass walls around each hole. The registration difficulties of this design are overcome in the two-layer arrangement, because the holes needn't be directly opposite the intersections of the two sets of conductors.

Writing and erasing voltages are



Dot by dot. A computer translates data from paper tape into coordinate information to build up flat-display pattern from arrays of dots.



Discharge. Transparent conductors on two glass plates, 10 mils apart, define a dot at each intersection. A voltage pulse on each of two conductors initiates a gas discharge that emits visible light.

usually applied to only one conductor in each set at a time, to turn a single spot on or off. They can also be applied to a single conductor in one set and several or all conductors in the other set to change the state of many spots in a single row or column at once.

Since a new writing pulse can occur in every cycle of the sustaining voltage, the entire display can be written in a little over 2.5 milliseconds—a new pulse every 20 microseconds on each of the 130-odd conductors in a set, with appropriate conductors in the other set selected. Erasing is just as fast, but sometimes it's easier just to shut off the sustaining voltage for a large fraction of a second, long enough to let the accumulated charges dissipate.

Owens-Illinois won't identify the gas used between the plates, other than to say it's different than what Bitzer and Slottow used. That's saying very little, however, because Bitzer and Slottow tried several different kinds.

Crowded track

The others in the race haven't given up by any means. IBM is said to be pursuing the technique avidly, although the company is still far from having a commercial product.

The Control Data Corp. says it considers the project still in the research and development stage, with a marketable product two to three years away. However, it's accepting orders from several customers for experimental models, expecting, for example, to deliver one to the National Aeronautics and Space Administration by the end of next month.

Robert H. Willson, who as a graduate student worked with Bitzer and Slottow at Illinois, is directing a plasma display project at the Westinghouse Electric Co. in Baltimore. His group has just completed a study for the Rome Air Development Center, concluding that plasma displays are feasible for wall-size panels. The Westinghouse researchers overcame a number of little problems, such as a tendency for large cells to be unstable and to have localized discharges that didn't fill up the whole cell. They've built small units with cells as large as 0.1 inch across and are working up from there.

Larger module. Willson expects the center to ask soon for bids on

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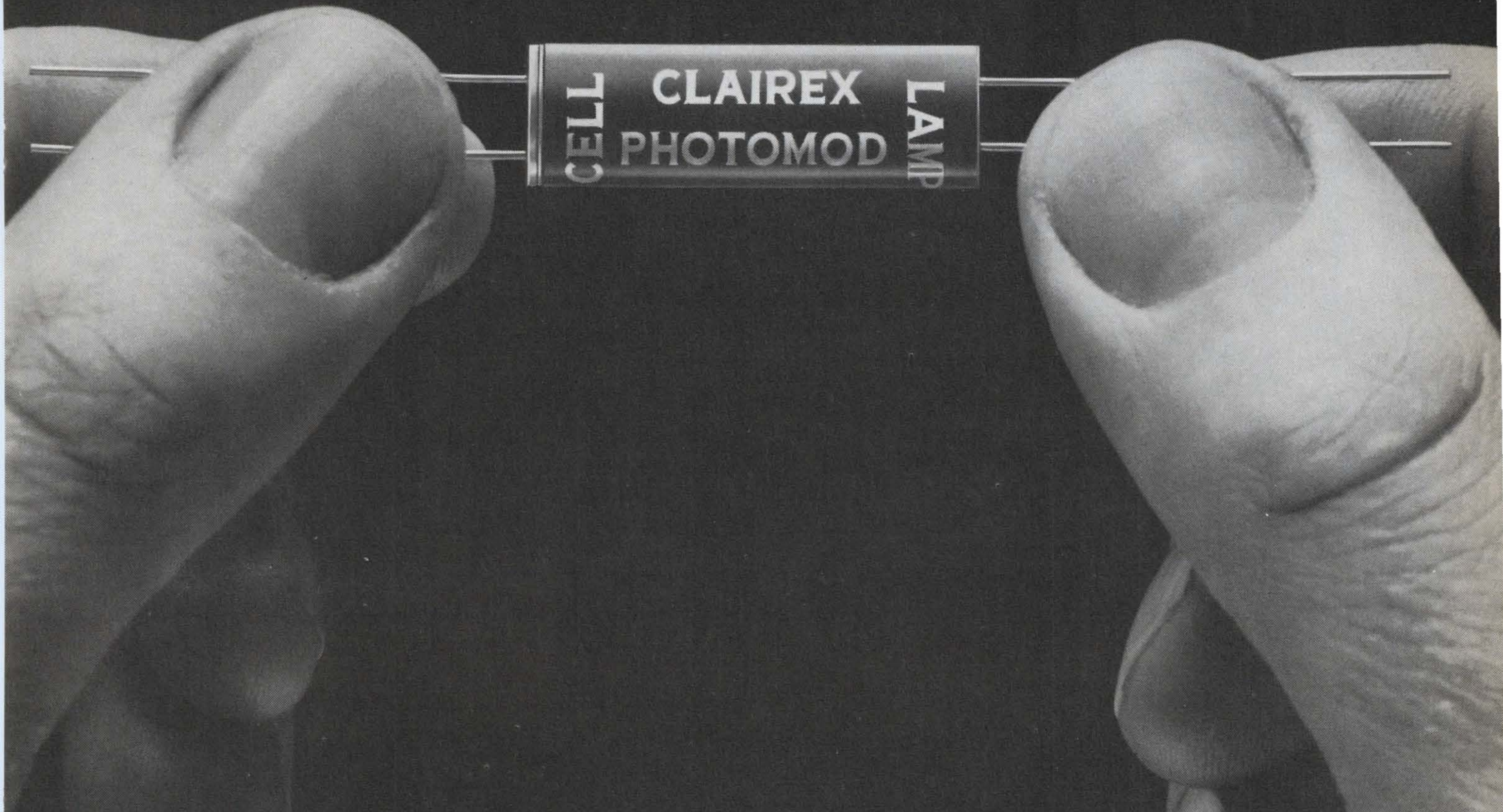

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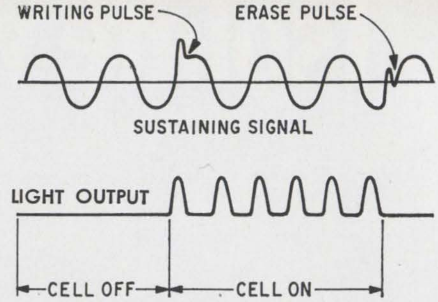


Timely. Writing pulse, plus sustaining voltage, begins discharge. Pulse of opposite polarity erases it.

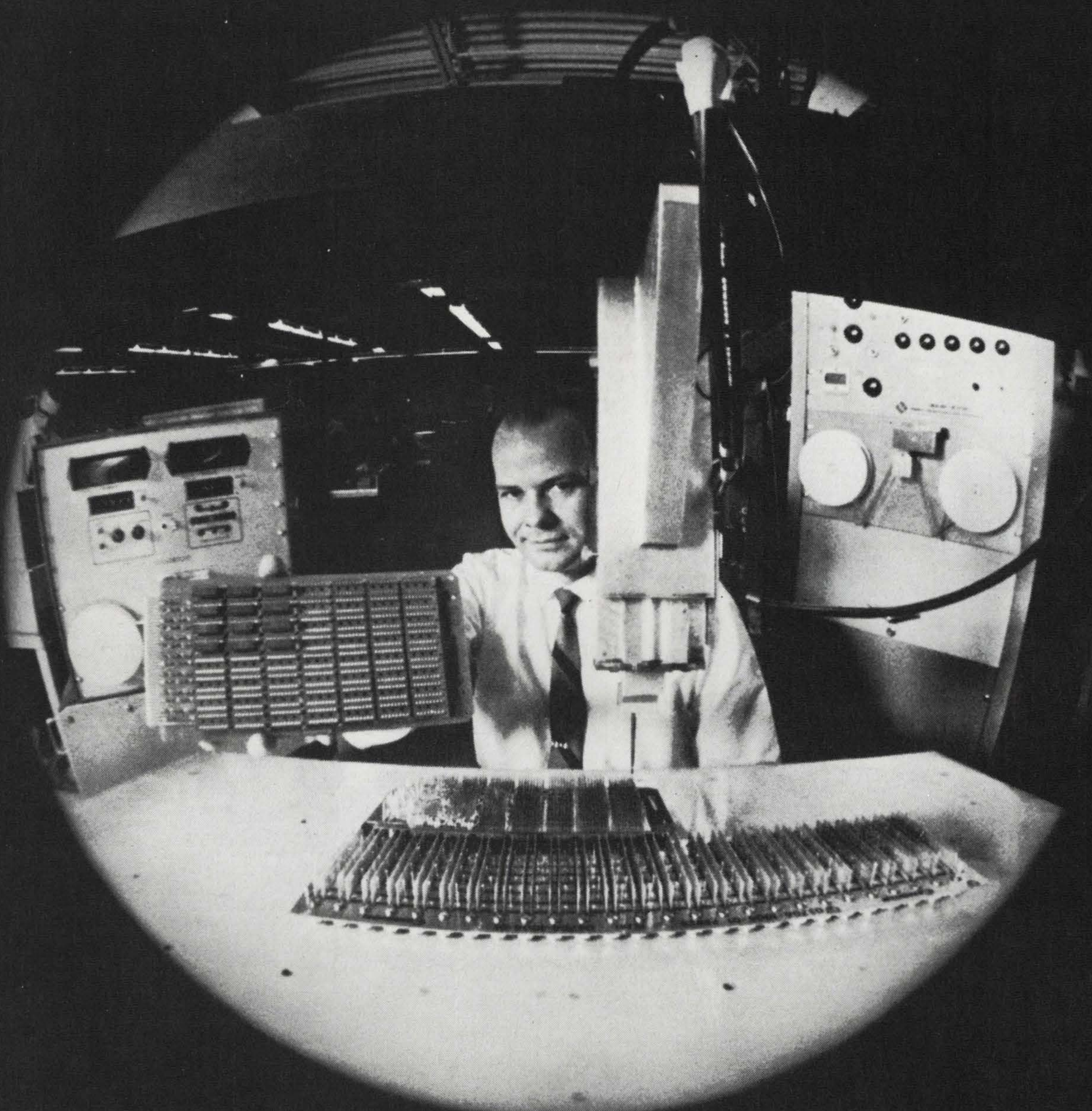
a prototype module several times as large using these big cells. Westinghouse, with its foot already in the door, stands a good chance of winning a contract for such a module. One problem that Willson foresees with such modules is how to interconnect them by dozens or hundreds so that a whole wall could be filled up with a display.

In its feasibility study, Westinghouse found that the display is capacitive, which throws some light on the difficulties others are having with the technology. Although a single cell showed only 0.1 picofarad, with thousands or even millions of cells in parallel, the capacitance would produce a reactive kick that would play hob with the switching circuits. Westinghouse solved this problem. But another company may have jumped with both feet into displays as large as conventional crt units—15, 20, or 25 inches across—while everybody else is still working with 4-by-4 units. In such a display, large voltage spikes would float around and punch through almost any ordinary insulation. Rumor has it that this is happening at IBM. It's a problem that would seriously delay any development project.

Zenith Radio was interested last summer in investigating the plasma idea as a possible approach to flat-screen television. There are obvious difficulties here, since the individual spots in the basic display are either on or off, without the gray scale that television technology requires.

A Zenith spokesman said the company still hasn't solved these or other problems but hasn't lost interest.

Owens-Illinois Inc., Toledo, Ohio 43601
[338]

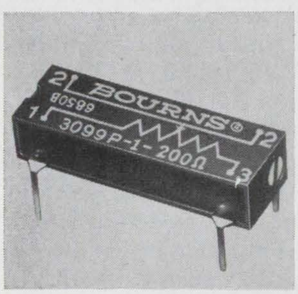


Slim magnetic modules keep company with IC's

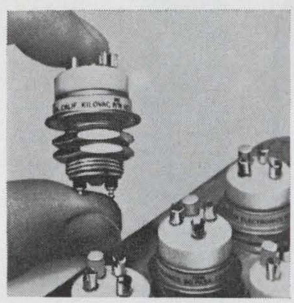
Flatpack modulators and demodulators permit p-c board stacking for applications in missile, satellite, and avionics circuits

Geometrically, magnetic components haven't been compatible with integrated-circuit packages. The trouble is that magnetic circuit elements depend on certain spatial relationships for their properties, and as a result, they tend to be bulky by semiconductor standards. When an equipment designer wants to stack circuit boards with rather close spacing—say 0.1 or 0.2 inch between the boards—there's no problem with the IC's. In flatpacks, they can easily fit between the boards. But magnetic modules are a different story, since up to now they've had to be packaged in cubes 0.75 or 1 inch on a side.

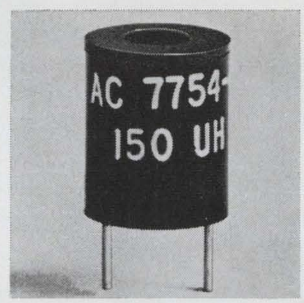
However, General Magnetics Inc. has changed all this by developing flatpack magnetic modules. The company is offering modulators and demodulators in a package that's only 0.1 inch thick, and can therefore be used on the same close-spaced circuit boards as IC's. Length and width range from 0.75 to 1 inch, depending on the module type. General Magnetics did it by "selecting a whole stream of new materials together with a different design approach and different geometry," according to Morris Tek-



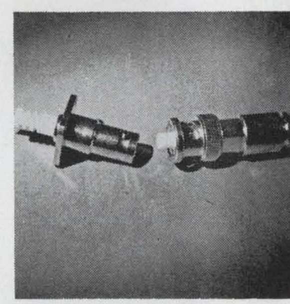
Dual in-line cermet potentiometer model 3099 measures 0.20 x 0.25 x 0.75 in. It has a standard resistance range of 10 ohms to 1 megohm, an operating temperature range of −55° to +125° C, and a power rating of 0.75 w at 25° C. Resistance tolerance is ±10%. It is sealed to meet or exceed immersion rquirements of MIL-R-22097. Bourns Inc., 1200 Columbia Ave., Riverside, Calif. [341]



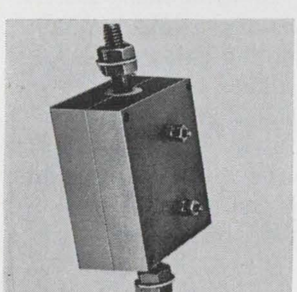
Ceramic vacuum relay model HC-1/S30 can hot-switch up to 2.5 kv d-c or 30 amps. It has a maximum operating time of 6 msec, standard coil resistance of 335 ohms. The relay will withstand vibraton of 10 g's from 5 to 2,000 hz and shock to 50 g's at 11 msec. It measures 0.9 x 1.25 in. and weighs less than 1 oz. High Vacuum Electronics Inc., 538 Mission St., S. Pasadena, Calif. [342]



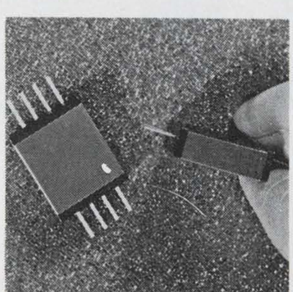
High Q miniature variable inductors AC7754 are offered in nominal inductances ranging from 0.1 μh to 4,700 μh. Designed for p-c application, the units measure 13/32 x ½ in. Two mounting terminals are spaced 9/32 in. on center for vertical mount. Tuning access is from either end. Approximate price is $1.50 in quantities. Automatic Coil Co., 76 E. 2nd St., Mineola, N.Y. [343]



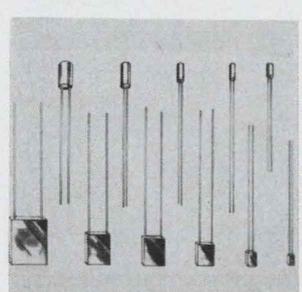
Miniature, h-v coaxial connectors have a center contact deeply recessed in Teflon with a dielectric withstanding rating of 7,500 v rms at 60 hz. A bayonet coupling device permits quick and efficient connect/disconnect operation while protection from high voltage during handling is provided by the polarized center contacts. Star-Tronics Inc., Moulton St., Georgetown, Mass. [344]



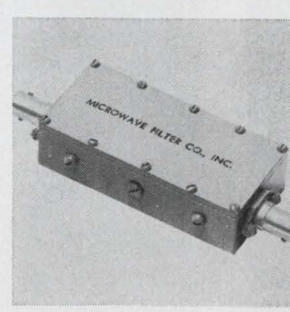
Power resistor SPR-390 has a range of from 0.001 ohm to 0.005 ohm with a temperature coefficient of ±50 ppm/° C from +25° to +125° C. Standard tolerance is 1%. Inductance properties are as low as 10 nh. The unit can dissipate 50 w when mounted on a 7 x 5 x 2 x 0.040 in. thick aluminum chassis. Size is 3.50 x 2.00 x 1.405 in. Dale Electronics Inc., Columbus, Neb. [345]



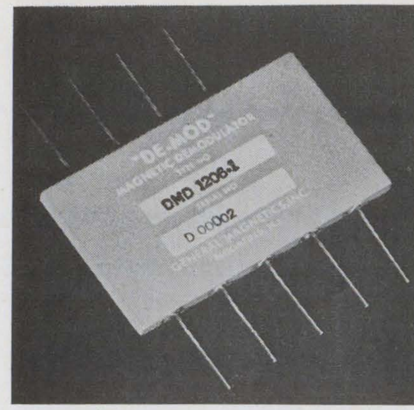
Packet relay series 14 incorporates contact assembly, bobbin, housing, and magnetic-shield/protective-cover into a single integrated sealed assembly. Units are offered with 3.6-, 6-, and 12-v coils of 300mw sensitivity and dpdt contacts. Operate time is 1 msec. Contact rating is 4 w with 200-milliohm resistance. Compac Engineering Inc., 845 Commercial St., San Jose, Calif. [346]



Solid tantalum capacitors in the Micron series are for applications requiring maximum packaging density. Capacitance-voltage range is 0.001-220 μf, 2-100 v d-c. Operating temperature range is −55° to +85° C at rated voltage and to 125° C with derating. Typical uses include by-pass, coupling, filtering and timing circuits. Union Carbide Corp., P.O. Box 5928, Greenville, S.C. [347]



Interdigital bandpass filters series 2600 are modified for in-line connectors and shorter length. Customer-specified bandwidth is 1 to 10% in the 500-1,500 Mhz range. Center conductors are of plated Invar steel to minimize tuning drift with temperature. Price is $178 to $232, depending on number of poles specified. Microwave Filter Co., W. Manlius St., E. Syracuse, N.Y. [348]



Flattened. Magnetic modulators and demodulators are as thin as IC's.

osky, company president.

Tekosky sees applications in missile, satellite, and aircraft where the new modules can be incorporated into control and guidance circuits, fire control and bombing computers, and other analog circuits.

A typical modulator, type IMM 1211-1, provides an amplitude-modulated a-c signal at 10 kilohertz in response to a d-c input. The differential gain is 1 volt rms a-c output per volt of d-c input. This response is linear within 0.25%. Input range is 0 to ±5 volts d-c, and output range is 0 to 5 volts rms. Input impedance for both the d-c signal and the a-c carrier is 10 kilohms.

The unit is operable over a temperature range of —55°C to 125°C. The zero-point variation over this range is no more than 25 millivolts.

Other versions are available with output frequencies from 400 hertz to 1 megahertz, and output voltages up to 10 volts rms. Current-sensitive versions are also available, with differential gains of 4 mv/-microampere and 16.5 mv/μa.

The flatpack demodulators, which incorporate switching transistors in addition to the magnetic elements, have similar characteristics.

In sample quantities, prices range from $175 to $220 for a modulator and $125 to $150 for a demodulator.

The company is developing other flatpack modules for d-c to a-c multiplication, raising to a power, taking a root, multiplication of an a-c by a d-c variable, and division of these quantities.

General Magnetics Inc., 135 Bloomfield Ave., Bloomfield, N.J. 07003 **[349]**

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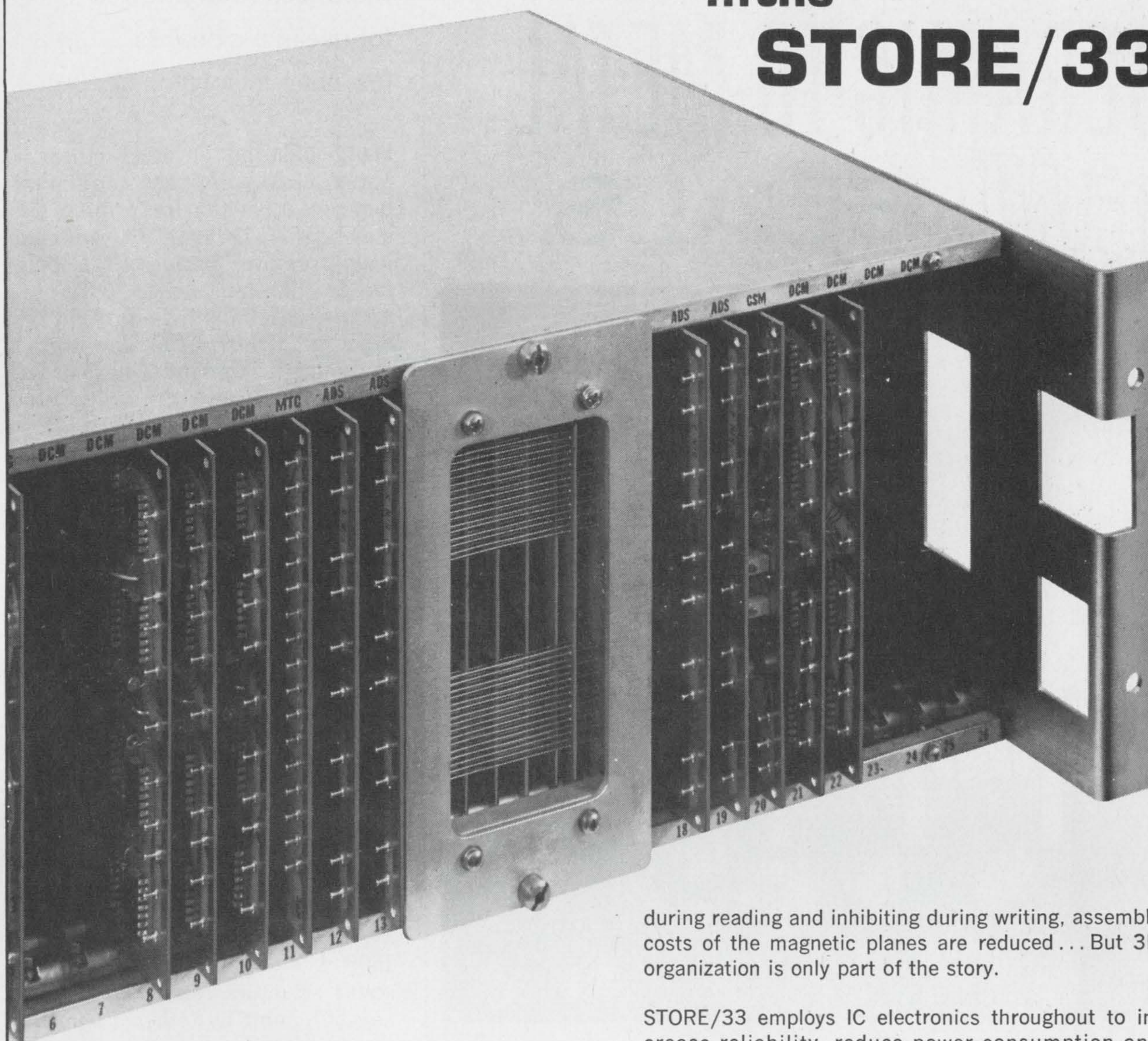

STORE/33 is in full production at Core Memories, Inc.* . . . now you can have 2½D speed at coincident-current prices! For example, the 4K x 16 version of STORE/33 uses 18 mil cores to give a full-cycle time of 650 nsec. The price? Under $4500** in production quantities.

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Plug-in switch is rugged

Multideck rotary device for use in p-c boards has snap-lock rotor

Hand-soldering or hand-wiring is not required with a new plug-in rotary wafer switch for printed circuit boards. To avoid the mechanical pressure problems encountered with rotary switches, the new unit is also built rugged, says the Standard Grigsby Co. The firm, a division of Standard Kollsman Industries Inc., says the ruggedness of its multideck rotary switch, called the SKPC, is due to its snap-lock rotor construction and its molded, glass alkyd wafer. The molded wafer has a one-piece metal stator contact path from the p-c termination to the switching point. Each wafer in the deck has eight rigid p-c terminals and, if needed by the customer, six auxiliary solder lugs. The molded glass alkyd serves as an insulator and acts as a natural barrier to prevent excess solder from flowing onto the various contact areas.

The key feature of the switch is its simplicity of design, says John A. Udisches, sales manager. From two to six contact selector arms are available within a maximum of a 180° rotating contact. This inner stator structure can be divided at any 30° point by either a shorting division having a single cut in the metal or a nonshorting division having a pair of cuts. To ensure positive detenting at each position, a starwheel and ball are used to achieve the 30° indexing. Both the stator contacts and p-c terminals are silver-plated brass. The detent spring's torque, says Udisches, can be easily varied to accommodate multiple wafer assemblies and specific requirements.

Tension helps. The stator insulator—the glass alkyd—also serves as the container for the snap-lock rotor, which is made up of the thermoset rotor itself and a thermoplastic retainer. Driven by a double-

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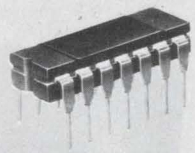

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Extended Temperature Range (−55°C to +125°C)	Dual 4-Input NAND/NOR Gate w/Expander	MIC930-1D	U6A993051X	N/A	SN15930N	PD993051	SW930-1P
	Dual 4-Input NAND/NOR Buffer w/Expander	MIC932-1D	U6A993251X	N/A	SN15932N	PD993251	SW932-1P
	Dual 4-Input AND Expander	MIC933-1D	U6A993351X	N/A	SN15933N	PD993351	SW933-1P
	Hex Inverter	MIC936-1D	U6A993651X	N/A	SN15936N	PD993651	SW936-1P
	Hex Inverter	MIC937-1D	U6A993751X	N/A	SN15937N	PD993751	SW937-1P
	Dual 4-Input NAND/NOR Power Gate w/Expander	MIC944-1D	U6A994451X	N/A	SN15944N	PD994451	SW944-1P
	RS/JK Clocked Flip-Flop	MIC945-1D	U6A994551X	N/A	SN15945N	PD994551	SW945-1P
	Quad 2-Input NAND/NOR Gate (6K)	MIC946-1D	U6A994651X	N/A	SN15946N	PD994651	SW946-1P
	RS/JK Clocked Flip-Flop	MIC948-1D	U6A994851X	N/A	SN15948N	PD994851	SW948-1P
	Quad 2-Input NAND/NOR Gate (2K)	MIC949-1D	U6A994951X	N/A	SN15949N	PD994951	SW949-1P
	Pulse Triggered Binary	MIC950-1D	U6A995051X	N/A	SN15950N	PD995051	SW950-1P
	Monostable Multivibrator	MIC951-1D	U6A995151X	N/A	SN15951N	PD995151	SW951-1P
	Dual 4-Input NAND/NOR Gate w/Expander (2K)	MIC961-1D	U6A996151X	N/A	SN15961N	PD996151	SW961-1P
	Triple 3-Input NAND/NOR Gate (2K)	MIC962-1D	U6A996251X	N/A	SN15962N	PD996251	SW962-1P
	Triple 3-Input NAND/NOR Gate (2K)	MIC963-1D	U6A996351X	N/A	SN15963N	PD996351	SW963-1P
	Dual J-K Flip-Flop	MIC9093-1D	U6A909351X	N/A	SN159093N	PD909351	SW705-1P
	Dual J-K Flip-Flop	MIC9094-1D	U6A909451X	N/A	SN159094N	PD909451	SW708-1P
	Dual J-K Flip-Flop	MIC9097-1D	U6A909751X	N/A	SN159097N	PD909751	SW709-1P
	Dual J-K Flip-Flop	MIC9099-1D	U6A909951X	N/A	SN159099N	PD909951	SW706-1P
Limited Temperature Range (0°C to +75°C)	Dual 4-Input NAND/NOR Gate w/Expander	MIC930-5D	U6A993059X	MC830P	SN15830N	PD993059	SW930-2P
	Dual 4-Input NAND/NOR Buffer w/Expander	MIC932-5D	U6A993259X	MC832P	SN15832N	PD993259	SW932-2P
	Dual 4-Input AND Expander	MIC933-5D	U6A993359X	MC833P	SN15833N	PD993359	SW933-2P
	Hex Inverter	MIC936-5D	U6A993659X	MC836P	SN15836N	PD993659	SW936-2P
	Hex Inverter	MIC937-5D	U6A993759X	MC837P	SN15837N	PD993759	SW937-2P
	Dual 4-Input NAND/NOR Power Gate w/Expander	MIC944-5D	U6A994459X	MC844P	SN15844N	PD994459	SW944-2P
	RS/JK Clocked Flip-Flop	MIC945-5D	U6A994559X	MC845P	SN15845N	PD994559	SW945-2P
	Quad 2-Input NAND/NOR Gate (6K)	MIC946-5D	U6A994659X	MC846P	SN15846N	PD994659	SW946-2P
	RS/JK Clocked Flip-Flop	MIC948-5D	U6A994859X	MC848P	SN15848N	PD994859	SW948-2P
	Quad 2-Input NAND/NOR Gate (2K)	MIC949-5D	U6A994959X	MC849P	SN15849N	PD994959	SW949-2P
	Pulse Triggered Binary	MIC950-5D	U6A995059X	MC850P	SN15850N	PD995059	SW950-2P
	Monostable Multivibrator	MIC951-5D	U6A995159X	MC851P	SN15851N	PD995159	SW951-2P
	Dual 4-Input NAND/NOR Gate w/Expander (2K)	MIC961-5D	U6A996159X	MC861P	SN15861N	PD996159	SW961-2P
	Triple 3-Input NAND/NOR Gate (2K)	MIC962-5D	U6A996259X	MC862P	SN15862N	PD996259	SW962-2P
	Triple 3-Input NAND/NOR Gate (2K)	MIC963-5D	U6A996359X	MC863P	SN15863N	PD996359	SW963-2P
	Dual J-K Flip-Flop	MIC9093-5D	U6A909359X	MC853P	SN158093N	PD909359	SW705-2P
	Dual J-K Flip-Flop	MIC9094-5D	U6A909459X	MC856P	SN158094N	PD909459	SW708-2P
	Dual J-K Flip-Flop	MIC9097-5D	U6A909759X	MC855P	SN158097N	PD909759	SW709-2P
	Dual J-K Flip-Flop	MIC9099-5D	U6A909959X	MC852P	SN158099N	PD909959	SW706-2P

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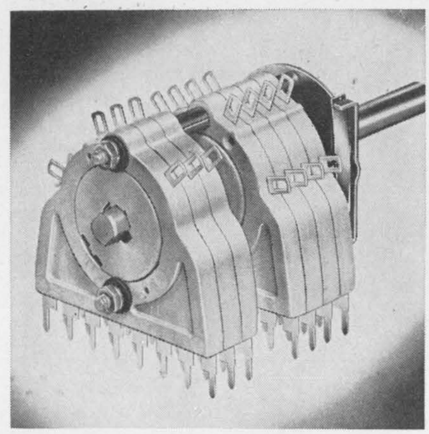
Circle 143 on reader servi[ce card]

flatted actuating shaft, the rotor holds the contacts in place and the retainer snap-locks them in. Thus, the rotor-stator relationship is established. According to the company, this tension minimizes end-play and backlash.

At 25,000 hertz and a contact resistance of 0.020 ohm, the SKPC's resistive load ratings are 3.5 amps at six volts d-c, 0.750 amp at 28 volts d-c, and 0.9 amp at 125 volts a-c. Maximum carrying current for a 20°C thermal rise is six amps; dielectric strength is given as 1,750 volts a-c to ground or between adjacent stator contacts.



Expandable. Each wafer in the deck has 8 rigid terminals to plug into a printed-circuit board.

Rated index life of the switch is 50,000 hertz minimum, and its temperature range is from −55°C to +85°C.

Standard Grigsby is also offering as optional assemblies single and dual a-c switches that can be mounted at the rear of the wafers, and either concentric shafts that can be used to drive separate detent mechanisms, or an inner shaft to drive a rear-mounted potentiometer.

Udisches says the device is being designed into new lines of hi-fi stereo sets and related equipment at Zenith, Magnavox and RCA as a function switch.

Price of the switch ranges from 40 cents to $3 each, depending on customer specifications and quantity of the order. Delivery time of production quantities is six to eight weeks.

Standard Grigsby Co., 920 Rathbone Ave., Aurora, Ill. 60507 **[350]**

BIG PRINT-OUT CAPACITIES COME IN SMALL MDS PACKAGES

22 or 32 print columns with speeds up to 40 lps...that's the story of the MDS Series 2200 and 3200 Digital Strip Printers.

These high-speed, parallel-entry printers offer a selection of several print drums, giving a variety of character choices. Both models provide numeric and alphanumeric printout.

The 3200 is supplied in a compact, easy-to-mount, two-chassis package with the printer in one chassis and the electronics in a matching chassis, for either local or remote operation.

Paper-loading on either model is easy because the printer mechanism slides forward on full-suspension, ball-bearing glide rails. Since the print drum is cantilever-mounted, paper can be easily slipped into position without being threaded. Either paper roll or fanfold stock is used in the 2200; only fanfold in the 3200.

The printer mechanism is built around a monolithic main body casting resulting in high mechanical stability and low maintenance. 120-day warranty. "Down-time" is the exception rather than the rule.

Ask for: Specifications and more information available in MDS folder-file on Series 2200/3200.

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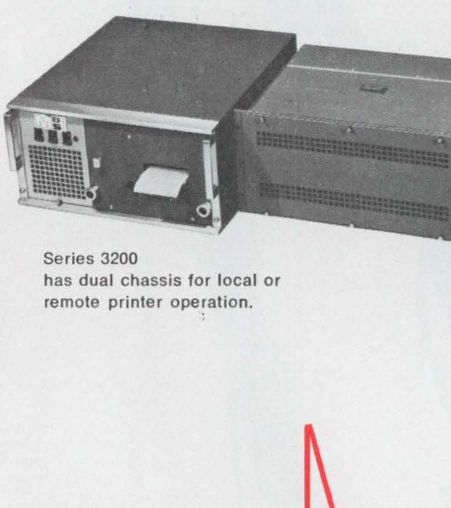

Series 3200
has dual chassis for local or remote printer operation.

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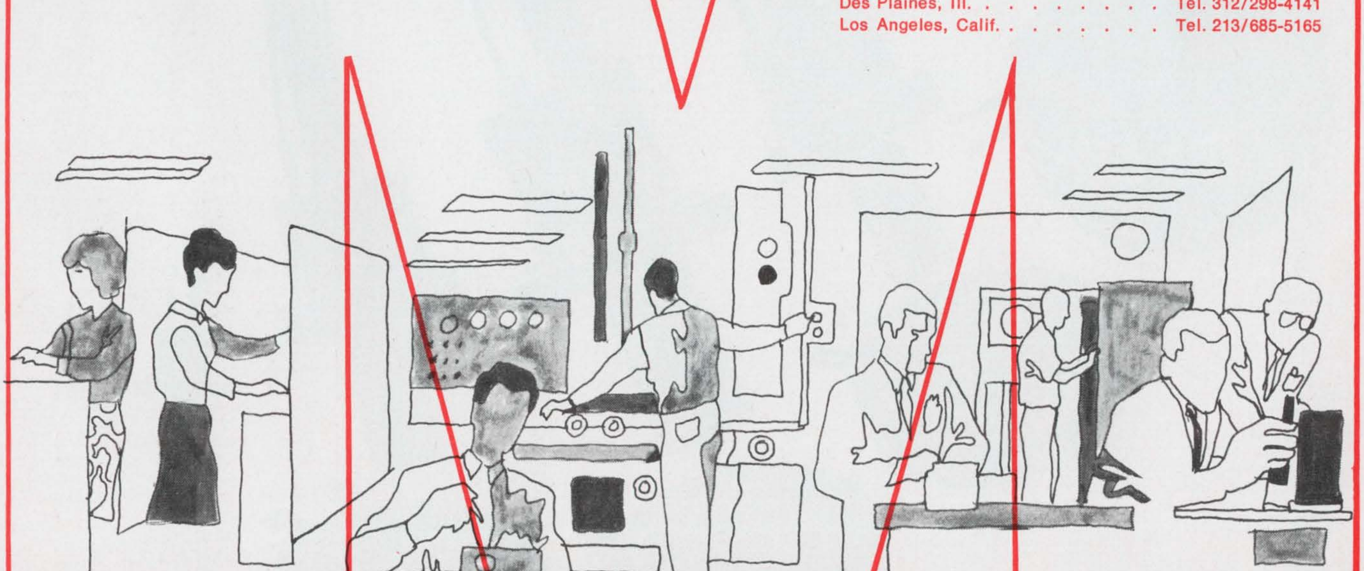


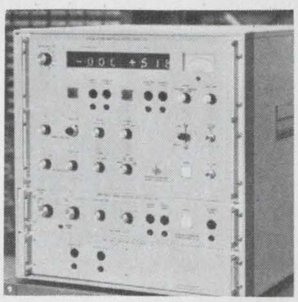
Single-sweep oscillator has multioctave range

Completely solid state generator covers 1.0 to 12.4 Ghz in either continuous-wave or sweep mode without plug-ins

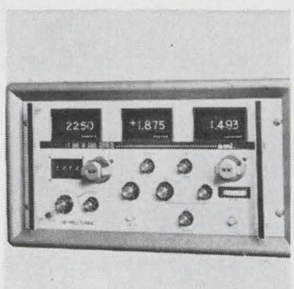
"Two heads are better than one" says the adage, but the Narda Microwave Corp. disagrees. The company has a completely solid state sweep oscillator that eliminates the need for several plug-in heads, each covering an octave. The model 9500, which sweeps from 1.0 to 12.4 gigahertz in one tuning head, should be welcomed by all those who would like to test broadband devices over multioctave bands without worrying about coverage between bands, or losing time to stop and change heads every time they go from one band to the next.

"We designed this sweeper to obsolete the term 'octave,'" says J.P. Schindler, Narda's vice president of marketing, "and we think it does just that. Our sweeper is completely solid state, uses integrated circuits in the logic circuitry, and a linear yig-tuned oscillator and filter combination developed for us by Watkins-Johnson."

The broadband sweeper can be programed and contains no backward-wave oscillators or other limited-life components; it can cover the complete 1- to 12.4-Ghz frequency band in one continuous sweep, or any percentage of that



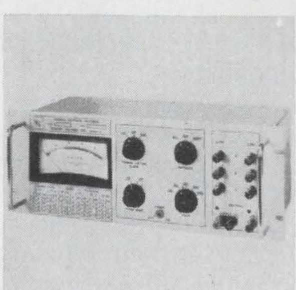
Pulse vector immittance meter series 1170 measures the driving point impedance or admittance of either a pulsed or c-w sine wave driven network. The meter supplies three simultaneous outputs: visual 3-decade decimal readout with polarity, 14-bit BCD data including sign, and analog d-c voltages. Scientific-Atlanta Inc., P.O. Box 13654, Atlanta, Ga. 30324. [361]



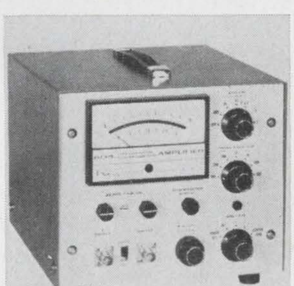
L- and S-band, f-m and p-m signal generator 3000 is for aerospace telemetry. It provides an output signal in the 1,435-1,540 Mhz and 2,150-2,310 Mhz bands. The carrier can be deviated up to ±5 Mhz. It uses digital panel meters and displays to indicate carrier frequency, peak deviation and modulation frequency. Advanced Measurement Instruments Inc., Somerville, Mass. [362]

Digital thermoelectric power meter D6685 is designed to provide an accurate readout of average power of c-w, pulse, a-m or f-m signals. It offers power ranges corresponding to 0.03 μw to 100 mw and −45 dbm to +25 dbm. Accuracy is provided by a solid state d-c amplifier that includes 100 db of feedback. PRD Electronics Inc., 1200 Prospect Ave., Westbury, N.Y. 11590. [363]

Memory voltmeter 5203, featuring a digital readout of d-c to 50 nsec pulses and amplitudes to ±1,000 v in 4 ranges, providing 100% over-ranges and BCD output, comes in a half-rack dual shielded cabinet. It will measure and hold the peak amplitude of one-shot or transient pulses, as well as repetitive pulses. Micro Instrument Co., 12901 Crenshaw Blvd., Hawthorne, Calif. [364]

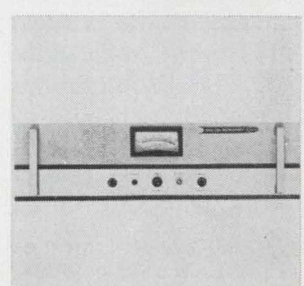


Wideband electronic wattmeter 1382A is for accurate measurement of the power consumed by small instrumentation motors, control circuits and the like. Features include full scale ranges as low as 1.25 w and as high as 160 w, 1% accuracy maintained at power factors near zero, and a frequency range of 60 hz to 1.2 khz. Scientific Columbus Inc., 1035 W. 3rd Ave., Columbus, Ohio. [365]

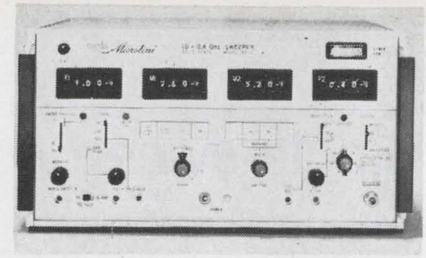


Differential electrometer amplifier model 604 features 10^{14} ohms input resistance and 75 khz bandwidth. Selectable gains are from 10 to 10^4. Stability is 4 mv/week. The instrument also features less than 20 μv noise and 90 db common mode rejection. It is useful as an amplifier, a millivoltmeter or a picoammeter. Keithley Instruments Inc., 28775 Aurora Road, Cleveland. [366]

Full accuracy of ±0.01% of reading ±0.01% full scale is held against virtually any noise found in normal operating environments by the model 4470/230 digital multimeter. Input impedance resistance is 10,000 megohms. Packaged in a 8½ in. wide unit, the instrument sells for less than $1,800. Delivery is 30-60 days. Dana Laboratories Inc., 2401 Campus Dr., Irvine, Calif. 92664. [367]



Variable frequency power conditioner V-2000 operates on the principle of the Varax variable inductor circuit that will accept any frequency from 45 to 75 hz and maintain a fixed voltage output that is both regulated to within 0.5% as well as filtered to 20 db. Prices start at $300. Availability is off-the-shelf. Wanlass Instruments, 1540 E. Edinger Ave., Santa Ana, Calif. [368]



Sweeping. Oscillator covers wide band without requiring additional heads.

band. The output power can be leveled to 1 milliwatt ±0.5 db across the entire band; the harmonically-related spurious signals are at least 20 db below the fundamental frequency, and other spurious signals are 30 db below the fundamental.

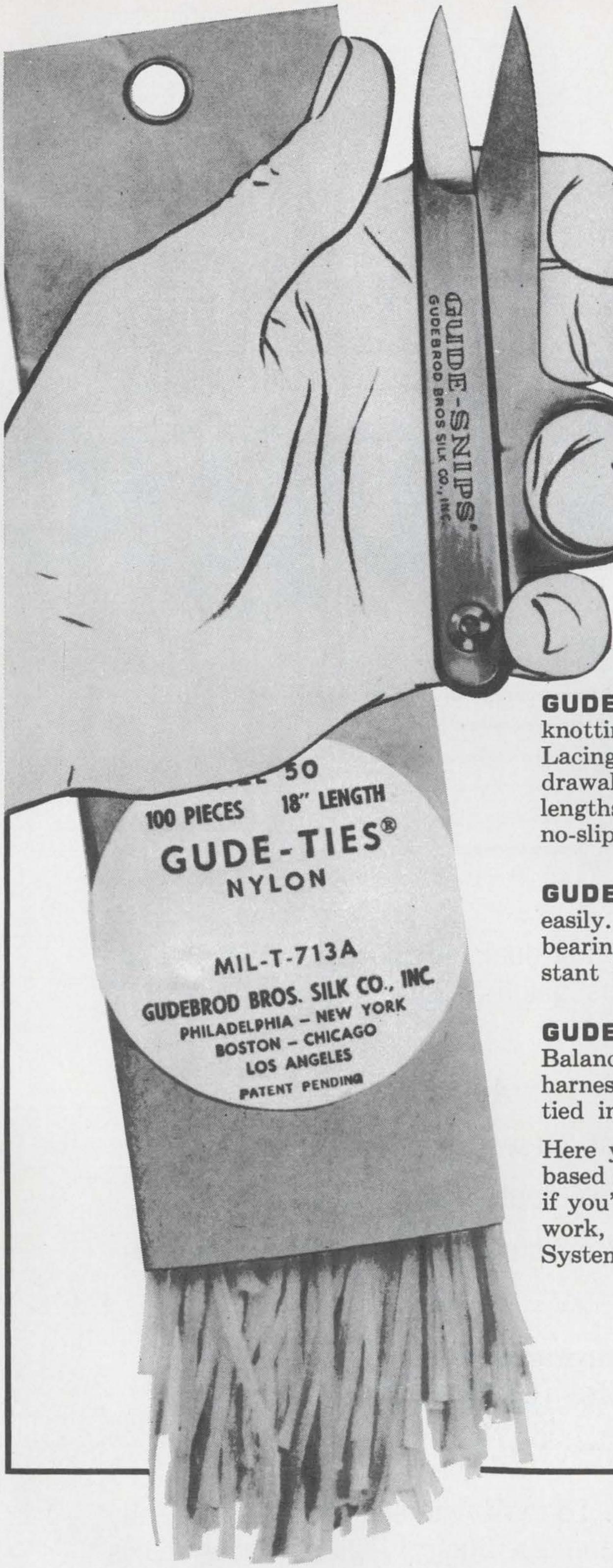
Both the frequency and the amplitude of the oscillator can be programed directly from an analog voltage source. To be programed, the frequency input requires a d-c level in volts that is just equal to the desired center frequency in Ghz. With this Ghz/volt sensitivity, one could program the entire frequency range from a simple low-voltage power supply without the need for any additional interface equipment. The amplitude of the r-f output signal is programed over a 30 db dynamic range by a 0-to-2 volt d-c control signal.

The front-panel frequency control and readout consists of four digital frequency programing wheels that allow the operator to set the oscillator to within 200 kilohertz of the desired frequency. This lets the user directly dial a continuous-wave frequency that is accurate to ±0.02% at 1 Ghz, and to ±0.0015% at the high end of the band, without the need of any interpolation of a slide-rule dial.

In the sweep mode, any combination of sweeps with or without markers can be selected by four independently controlled pushbuttons. In the c-w mode these pushbuttons allow up to four separate frequencies to be selected. Also, one of the pushbutton frequency controls has a fine control which allows the user to accurately set the frequency.

The dual-mode oscillator sells for $9,800, and the delivery time is three months.

Narda Microwave Corp., Engineers Hill, Plainview, N.Y. **[369]**



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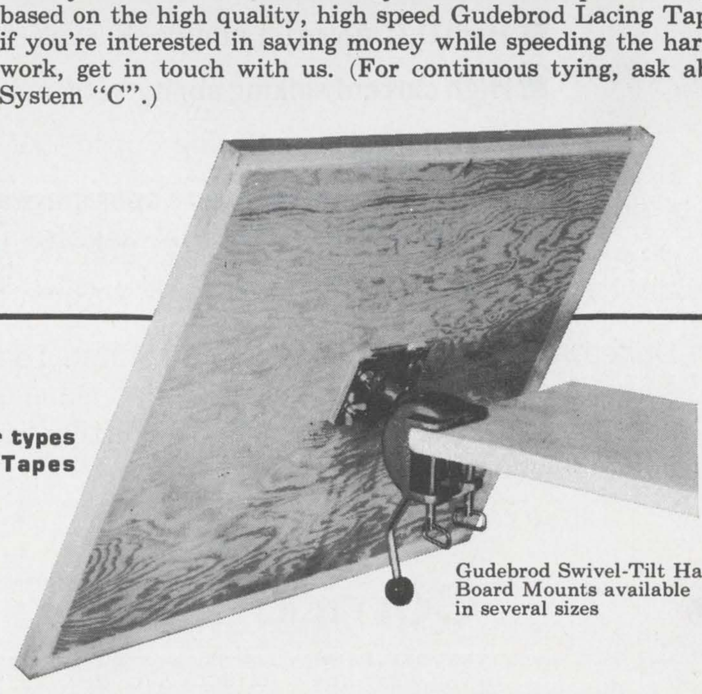

Gudebrod Swivel-Tilt Harness Board Mounts available in several sizes

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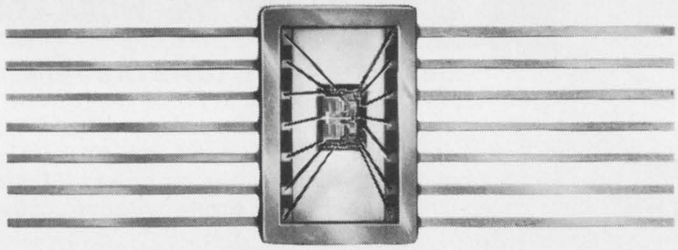

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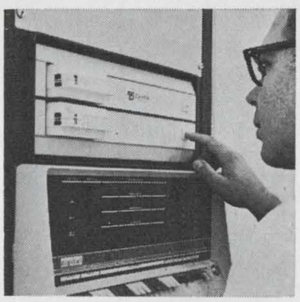
5-wire organization cuts core memory price

Two X and two Y lines plus a sense/inhibit line which is common permit simple, unidirectional circuits for applications where speed is not critical

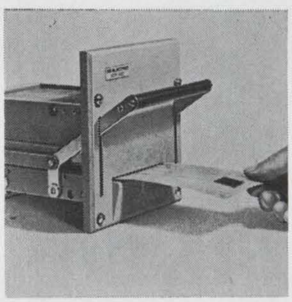
High speed isn't a big concern with users of buffer memories. As long as the cycle time is less than 10 microseconds, they'll consider the unit if it offers economy. Richard Bravo, product manager for core products at the Computer Products division of the Ampex Corp., says this is precisely the category the division's 3DM-3000 core memory is intended to fit.

He says the unit's introduction, which will come formally at the Spring Joint Computer Conference in Boston May 14-16, will complete the Ampex core memory line, which had lacked a buffer or display-refreshing memory. He also expects the unit to be used in data terminals that require a small memory.

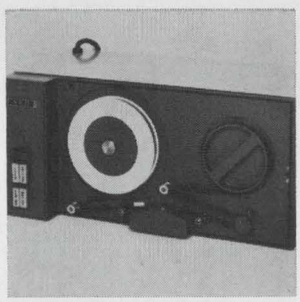
"The big market will be in applications where speed matching is a consideration," Bravo notes. "This is the situation in which you have a big burst of data coming in and sitting for 5 minutes before another burst comes in. Then the data is put out at a slower rate that tapes or a disk can handle." With a 3-nanosecond cycle time, the Ampex memory is slower than some comparable core memories for buffer applications, but it will sell for



Cartridge-loaded system called Cartri-File provides PDP-8 computers with 4 digital tape transports. The system can be used to sort, match, collate and merge data. The tapes also provide program loading, off-line storage for memory dumps, and buffering for uninterrupted data accumulation. Price is $5,700. Tri-Data, 800 Maude Ave., Mountain View, Calif. 94040. [401]

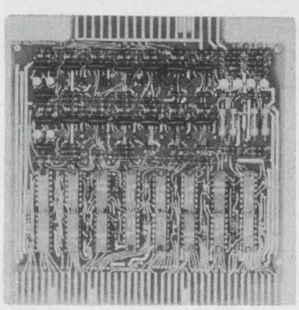


Sealectrocard 12x51 tab reader is suitable for use with microfilm IBM cards as shown. In this instance, the IBM card is used for microfilm reading as well as for word bit storage by means of punched slots. The instrument will read the card electrically, while a separate microfilm reader provides visual readout of data from the film strip. Sealectro Corp., Mamaroneck, N.Y. [402]

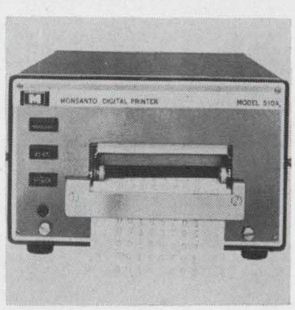


Digital magnetic tape transport model 7820 is for small digital computer and data communication terminal applications. It is an IBM compatible, 9 track, 12.5 ips, 800 bpi write/read tape transport, to provide data transfer rates of 10 khz. It occupies 7 in. of rack height. Price is approximately $2,750. Peripheral Equipment Corp., 9551 Irondale Ave., Chatsworth, Calif. 91311. [403]

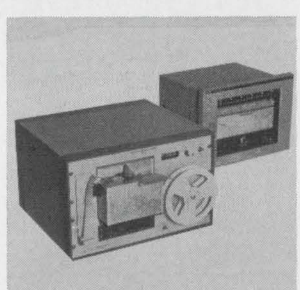
On-line digital correlator DC-100 is suited for filter functions with any data gathering or pulse recognition equipment, such as receiving systems or recorders used in radar, sonar, and other echo-sounding applications. Data storage is 3,072 8-bit words per channel, 12.28 sec at 4 msec rate. Price ranges from $20,000 to $22,000. Mandrel Industries Inc., Box 36306, Houston. [404]



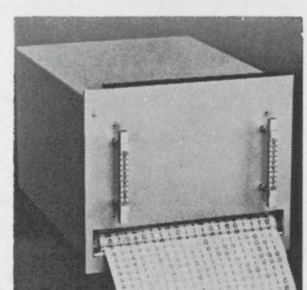
Analog I/O system ties into SPC-12 and -8 computers. It accepts up to 512 input channels of data from analytical instruments and sensors. After the computer has processed the data, it is outputted through up to 256 channels for driving displays, recorders, etc. System operates at 3.3 μsec per bit conversion rate. General Automation Inc., W. Ketella Ave., Orange, Calif. [405]



Digital printer 510A will accept either 1-2-4-8 or 1-2-2-4 BCD code, positive or negative true, as determined by internal connections. The half-rack unit prints up to 8 columns at speeds up to 4 lines/sec. Print cycle is initiated by a positive 0.9 to 10 v pulse having a minimum width of 1 μsec. Price is $995. Monsanto Co., 620 Passaic Ave., West Caldwell, N.J. [406]



Logger model 141 connects directly to multipoint recorders, digitizes and records the data for computer entry. It makes a 4-digit record of each data point on punched paper tape in 8-level ASCII or IBM code. Logging is synchronized to the recorder, permitting automatic, unattended operation. Price is $3,950. Control Equipment Corp., 32 Kearney Rd., Needham Heights, Mass. [407]



Digital events recorder model CH-183 is a panel mounted printer containing up to 17 columns of information against 24 hour time recorded by 10-minute intervals. Each column prints down time and operating time of any machine or process monitored. Down time is indicated by 0's, operate time by vertical lines. Practical Automation Inc., Shelton, Conn. 06484. [408]

Minimem. Core storage unit is suited for jobs in displays and terminals.

about 10% less than its competitors because of a novel organization.

A single module, consisting of two printed-circuit cards, will store data ranging from 128 words by four bits to 1,024 words by 12 bits; eight modules can be put together to give 8,192 words by 12 bits. One card holds the cores and the other carries the sense amplifiers, drivers, and timing circuitry. Most of the digital circuitry is transistor-transistor logic.

Simple flip-flops. The unit is essentially a three-dimensional, three-wire system in concept, but Ampex uses two extra wires. There are two independent lines in the X direction, two independent lines in the Y direction, and a common sense/inhibit line. The system doesn't reverse current after reading to write; instead, it uses separate X read and X write lines, and separate Y read and Y write lines. The fifth line, parallel to the two Y wires, acts as a sense line during reading and an inhibit line during writing.

Bravo says he knows of no other memories using this arrangement. Other units may have independent wires in both directions, he says, but they are six-wire systems because the sense/inhibit line can't be shared. It's the five-wire configuration that cuts costs. A memory that reverses the read current to write needs both read and write diodes and a tapped delay line for close timing accuracy. Because timing requirements can be relaxed in the nonreversing design, simple flip-flops can be used in place of the costlier delay line.

The module storing 128 words

by four bits is priced at $330 and the 1,024-word module at $950. The eight-module version will sell for approximately $6,840. These prices include a power supply, which is optional, but Bravo says the memory can derive its power from the 12-volt supply available in most systems using buffer memories.

Low-cost drivers. "You typically need two drive voltages—one for read and one for write—plus an additional voltage for the sense/inhibit line," he says. "Most systems require 25 to 30 volts, but most of our competitors can't derive all three voltages from that supply." The memory organization and use of low-drive cores reduce the voltage requirements of the Ampex drive. The cores are 30 mils in diameter.

The 3DM-3000 can derive all three voltages it requires from the 12-volt supply. Its slightly lower speed—requiring 500 millivolts full-drive against 800 mv for some faster units of comparable size—means lower-cost drivers can be used.

Two kinds of card cages are available as options: a unit 7.25 inches high to accommodate up to eight modules mounted vertically and one 5.25 inches high for the same number of horizontally mounted modules. The 3DM-3000 operates from 0°C to +55°C and has a storage temperature of −40°C to +85°C.

Ampex Computer Products Division, 9937 W. Jefferson Blvd., Culver City, Calif. 90230 **[409]**

Data handling

Computer directs in-out traffic

Machine takes on most of a processing system's communication problems

The first computer specifically designed to manage other computers —that's the way Lee Johnson, president of Comcet Inc., describes the company's Comcet 60 which proc-

esses data transmitted over communication lines to and from a computer. The machine reduces the communication load on the computer from 50% or 75% of its capacity to something like 5%.

"We're the first to address the communications problem from the systems point of view," says Leo O'Keefe, a marketing executive of Comcet, which was formed by a group of former employees of Univac. "Many firms are selling hardware or software for communications applications, but none tie their products directly into the customer's computer. So the customer has to do a tremendous amount of engineering to connect the equipment and get it going."

The Comcet 60 [*Electronics*, March 17, p. 62] takes over the tasks that usually have to be done in the system's central processor by software. The new machine will do some of these communications tasks with its own software, and others with special hardware. It will, for example, maintain queues of interrupt requests in hardware; by way of contrast, most communications-oriented computers rely on software for this important job.

A key feature of the 60 is its system activity monitor. The SAM repeatedly samples the 128 communication lines and 16 points within the Comcet processor to determine their status, accumulates the activity totals in its own local memory, and dumps the total in the Comcet 60's main memory once every five seconds. Further processing of these totals can be carried out by the 60's software for various statistical results, as determined by the programer. Any 32 of these activity levels can be manually selected and displayed as a percentage of maximum activity in the form of a bar chart on a cathode-ray tube screen.

Various experimental monitors have been built from time to time for measuring the activity of a communications-oriented or time-sharing computer, and a few small units are commercially available for certain limited applications, but the Comcet 60's SAM is the first commercially available monitor of such wide capability.

Comcet, Inc. 2 Research Court, Rte. 70-S and Shady Grove, Rockville, Md. **[410]**

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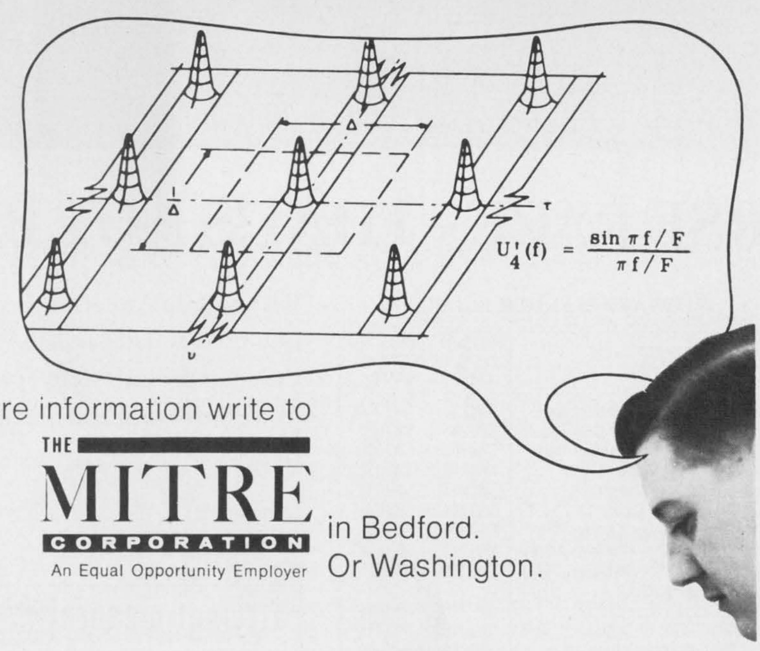

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■ Transportation Systems

MITRE's Washington Operations provides technical planning and system support to the Office of High Speed Ground Transportation, the Urban Mass Transportation Administration and the Federal Aviation Administration. Technical assistance is provided for transportation technology as well as the analysis of economic benefits and demands for transportation.

■ Communications Engineers

MITRE's responsibility in Bedford includes technical direction on such current communications systems as 490L Overseas Autovon, TACSATCOM, and Integrated Communication Navigation and Identification (CNI). There are also openings for communications engineers on 407L, Tactical Air Control System, and related tactical communications projects. Interest and background are desired in systems analysis; design, installation and checkout of communications networks; modulation and signal processing techniques; switching systems; voice and data transmission and satellite communications and associated airborne and ground terminal hardware.

■ National Military Command System

Scientists and engineers are needed in our Washington Operations for systems analysis and feasibility studies, communications system analysis, systems design, integration and design verification of the NMCS. This "capping system" contains all the facilities, equipment, doctrine, procedures, and communications needed by national command authorities to give them strategic direction of the armed forces. MITRE's main concern is with the technical design and integration aspects of the NMCS and the communications between NMCS and various other command systems, including the World-Wide Military Command and Control System — a group of systems operated by the unified and specified commands.

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CIRCUIT FUNCTION	MILITARY —55°C. to 125°C.	INDUSTRIAL 0°C. to 75°C.
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Dual 4-input Complementary Gate	SW1205	SW1005
Dual 4-input Complementary Gate	SW1206	SW1006
Quad 2-input NOR Gate	SW1210	SW1010
Quad 2-input NOR Gate	SW1211	SW1011
Quad 2-input NOR Gate	SW1212	SW1012
85-MHz AC-Coupled J-K Flip-Flop	SW1213	SW1013
Dual R-S Flip-Flop (Positive Clock)	SW1214	SW1014
Dual R-S Flip-Flop (Negative Clock)	SW1215	SW1015
Dual R-S Flip-Flop (Single Rail, Positive Clock)	SW1216	SW1016
Translator—ECL to Saturated Logic	SW1218	SW1018
Dual 2-input Expandable Gate	SW1224	SW1024
Dual 4-5 input Expander	SW1225	SW1025
Dual R-S Flip-Flop (Single Rail, Negative Clock	SW1233	SW1033

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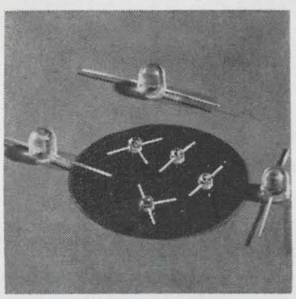
Ring-type barrier cuts power transistor leakage

Annular-structure devices, first in new line, dissipate 25 watts; deep-diffusion technology is principal key to development

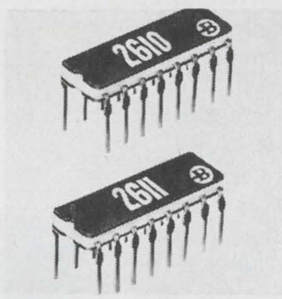
Mesa transistors usually have narrow-base regions, making them useful primarily for switching functions but not as true power devices. The narrow base doesn't provide enough area to handle high power. But if the base can be made wide, and the active regions can be isolated effectively to reduce both channeling and surface-induced leakage, true power performance with low leakage results.

Engineers at Motorola's Semiconductor Products division believe they've whipped the leakage and base geometry limitations of mesa devices by using an annular, or ring-shaped, structure they pioneered for small-signal silicon transistors. The fruits of their efforts are the first annular power transistors in the industry—the 2N3740A and the 2N3741A—versions of two popular homogeneous-base pnp silicon devices, the 2N3740 and 2N3741. The annular versions are directly interchangeable with their mesa counterparts. Furthermore, they offer a 1,000-to-one improvement in leakage over the mesa devices, says Leo Lehner, operations manager for silicon power devices.

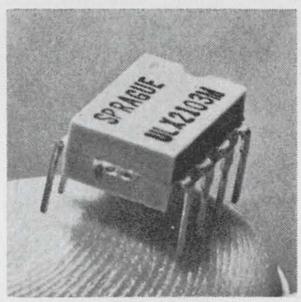
Diffusing the ring, which isolates



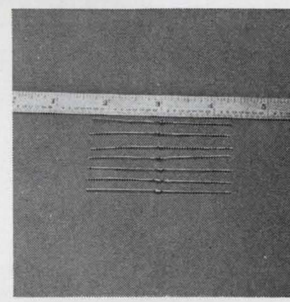
Molded-plastic phototransistors are designated MRD450 (in a two-leaded Mini-T package with an integral lens for highest sensitivity and definition), MRD100 and MRD150 (in subminiature Micro-T packages for high-density mounting use). Price of the MRD450 is $1.50 in lots of 100; the MRD-100, $1; and the MRD150, 80 cents. Motorola Semiconductor Products Inc., Phoenix. [436]



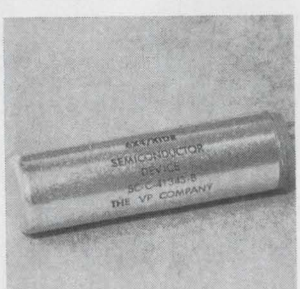
Monolithic integrated circuit decade counter type BIP-2610 is a dual in-line package designed to drive Nixie tubes directly. It is expected to find wide application in the industrial instrument and electronic controls market. With the 300 khz unit, one package now does what two packages did previously. Burroughs Corp., P.O. Box 1226, Plainfield, N.J. 07061. [437]



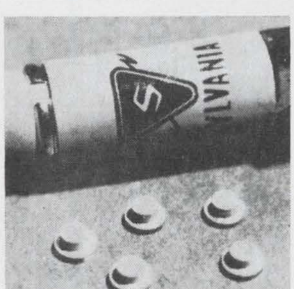
Integrated-circuit broadband amplifier ULNX-2103M having a 60 Mhz bandwidth with a 30 db typical voltage gain over the temperature range of 0° to +85°C comes in an 8-lead plastic dual in-line package. The IC provides a current gain of 10. The amplifier is suited for current amplification since input impedance is about 10 ohms. Sprague Electric Co., North Adams, Mass. [438]



Monolithic arc suppressor diodes for relay application are nonpolarized, performing the function of two back-to-back zeners. Standard electrical characteristics are available for 28 and 110 v relay suppression. Mechanical size is 0.065 x 0.100 in. with 0.020 in. leads. The 100 piece prices start at $1.68 each. MicroSemiconductor Corp., 11250 Playa Court, Culver City, Calif. [439]

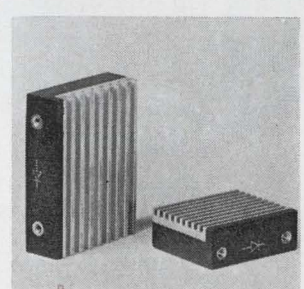


Full-wave rectifier module 6 X 4/X 1DR is a solid state replacement for electron tubes. It can be plugged into standard miniature tube sockets or adapted to p-c boards. The encapsulated device employs a matched pair of MIL type silicon diodes in a metallic envelope that protects against extreme temperatures and vibration. The VP Co., 330 S. Fair Oaks Ave., Pasadena, Calif. [440]



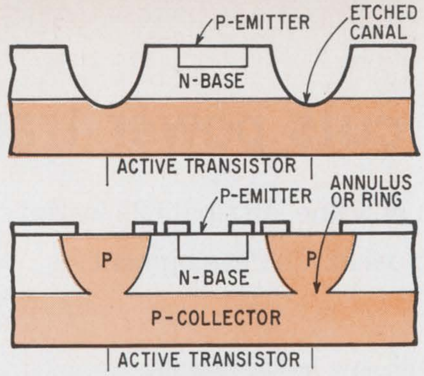
Planar germanium back diodes designed for use as video detectors come in a MicroPill (048) package for stripline applications. They consist of the D5610 (S-band), D5611 (C-band), and the D5621 (X-band). Values of tangential signal sensitivity range from –56 dbm at L-band to –50 dbm at X-band. Price (1-9) is $25 each. Sylvania Electric Products Inc., Woburn, Mass. [441]

MegaPack scr is being used in a-c and d-c motor speed controls, solid state contactors and electromechanical power supplies. When mounted in a 3-phase full wave bridge, it can control up to 1 Mw at 900 v d-c, without the cost or complexity of paralleling. It is available in ratings of 650, 850 and 950 amps rms. Power Semiconductors Inc., 90 Munson St., Devon, Conn. 06460. [442]



High voltage, medium power rectifier modules J531 and J532 dissipate 10 w and 20 w respectively in free air. Size of the 10-w module is 1⅝ x 2 x ¾ in.; the 20-w module, 2⅛ x 3 x ¾ in. Major uses are in general industry, particularly in heavy equipment and transmitting equipment, and in many r-f generating systems. Solitron Devices Inc., 256 Oak Tree Road, Tappan, N.Y. [443]

←Circle 158 on reader service card



Encircled. Ring-shaped barrier, bottom, is compared to mesa transistor.

the transistor's active region, presents no great problem in small-signal devices because the technique is essentially a surface treatment on these double-diffused devices, and only penetrates the active region to a depth of about 0.2 mil. But here's the rub: the ring must be diffused to a depth of three to four mils around the transistor—deep enough to contact the collector side of the collector-base junction in a homogeneous-base device. "That's simple enough to say but difficult to do," Lehner explains.

The two new devices lead off a series of annular products made possible by deep-diffusion technology. Motorola officials believe the 2N3740A and 2N3741A will simplify the design of such circuits as direct-current-coupled amplifiers using pnp devices, and find use as drivers, switches, and replacements for germanium power transistors.

The leakage story is best told by contrasting the leakage current I_{CBO} at 80 volts of a mesa device (100 microamperes) with that of the annular versions (0.1 microamp)—1,000 times less for the annular transistor. The annular units also feature low saturation voltage (0.6 volt at one amp collector current), a good second-breakdown safe area, 25-watt dissipation, gains of 30 to 100 at 250 milliamp collector current. Voltage ratings are 60 volts for the 2N3740A and 80 volts for the 2N3741A.

"If you don't have annular construction," Lehner says, "you can't make multiple-power designs; but because we have it, the technique will lead to monolithic power Darlington pairs.

Motorola Semiconductor Products Inc., Box 955, Phoenix, Ariz. 85001 **[444]**

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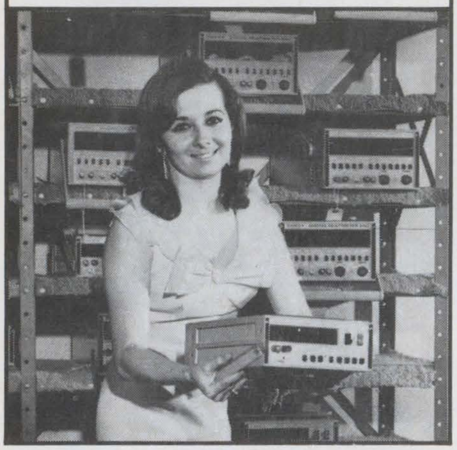

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DM 440 SPECIFICATIONS—4 DIGITS

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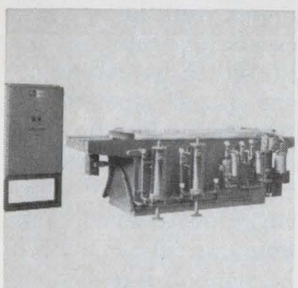
Flexible tester for digital IC's

With modular construction and multiple test stations, the system can be easily expanded to handle unusual or very complex devices

Special-purpose testers have to leave town when a new kind of semiconductor product blows in. They can't be adapted to handle it. Volume users and manufacturers of these products have tried using small general-purpose computers to control customized test equipment, but this approach becomes impractical when there's a great variety of items to be tested.

Well, the Industrial Products division of Texas Instruments, which has been building test systems for semiconductors for about 10 years, says it has solved the problem with its model 561 Digital Logic Tester. The secret to its solution is modular construction. The user, says TI, can start with a basic system that meets most test requirements, but then can easily expand it to handle unusual or especially complex devices and circuits.

The basic system consists of a data control unit, a functional-test unit, a test station with a test terminal, an operator terminal, and a station console. The control unit links all portions of the 561 to such peripherals as readouts and printers. Control and test programs are entered by a paper-tape reader,



Conveyorized circuit board stripper model CBS automatically removes silk screen and photo sensitive resists after etching. Special powered nylon brushes convey p-c boards through the machine at any speed from 2 to 14 ft a minute. At the same time, both sides of the boards are flooded with solvents. Baron-Blakeslee Inc., 1620 S. Laramie Ave., Chicago 60650. [421]

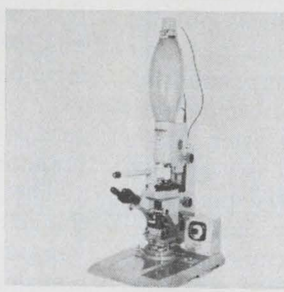
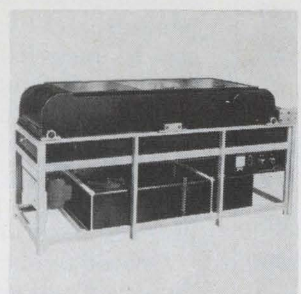
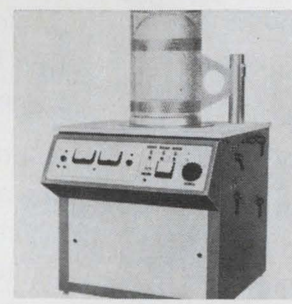


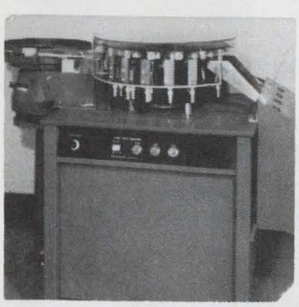
Photo-optical integrated circuit printer called Unimask 101 completely eliminates mask destruction problems associated with contact printing. It is comprised of 3 basic sections: a powerful (200,000X) radiation source, the optical image printing unit, and the multiple-eye alignment scope. Cost of basic system is $20,000. Radiarc Inc., 526 N. Garfield, Monterey Park, Calif. [422]



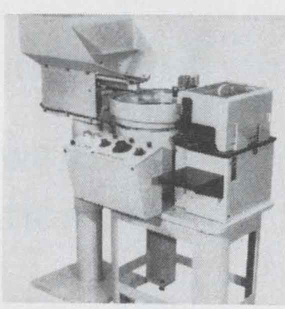
Spray etching machine model 440 is for etching and rinsing circuit boards. The 7-ft system features a 24-in. wide variable speed conveyor, which can accommodate large high-density boards or panels. Included are adjustable, two-sided spray manifolds, high pressure pumps and nozzles for increased operating speed. General Products Laboratory, 111 Lock St., Nashua, N.H. [423]



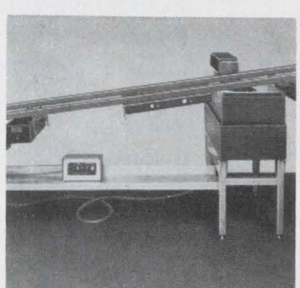
High-vacuum evaporator designated Econovap E-414 is a 1 x 10^{-7} Torr thin-film unit for relatively low-volume production requirements. Standard unit features a heavy-duty Pyrex bell jar, 14 in. in diameter by 24 in. high. It is supplied complete with an integral control panel. Weight is about 850 lbs crated. T-M Vacuum Products, 100 Rowland St., Riverton, N.J. 08077. [424]



Sorter type 1612, operating with suitable test equipment, automatically tests and sorts 3,600 leadless capacitors per hour. Capacitors placed in vibratory bowl are fed, probed, tested and classified into 8 bins. Special charge and probe stations have insulation resistance greater than 10^{12} at 500 v d-c. Daymarc Corp., 40 Bear Hill Road, Waltham, Mass. 02154. [425]



High-speed component printer model U-1185 utilizes rotary, offset printing techniques with variable speeds up to 16,000 per hour. It can print components such as plastic or metal transistors and integrated circuits in or out of the carrier. It is designed for in-line mounting to print vertically down, vertically up or horizontally. Markem Corp., 150 Congress St., Keene, N.H. [426]



Bench-mounted automatic soldering system series TDB handles p-c boards up to 14 in. wide in the solder wave that is 3/4 in. deep. Features include close control on the oil/solder intermix meter; large solder base capacity (450 lbs); 13 speed settings on the inclined conveyor from 12 in. per minute to 75 in. per minute. Hollis Engineering Inc., Nashua, N.H. 03060. [427]

Electrical connections to IC's can be tested for reliability with the Microbond Tester, which determines the gram-range rupture force required to break these bonded interconnects. The unit is furnished with an angular dynamometer and substrate positioning stage. Six gauges are available from 0.5-5 to 15-150 grams. Engineered Technical Products, Box 1465, Plainfield, N.J. [428]

and a teletypewriter provides error messages and data variables. The control unit can be expanded by the addition of a magnetic disk memory for bulk program storage and a magnetic tape unit for loading programs and transferring test results from the 561 to other data processing equipment.

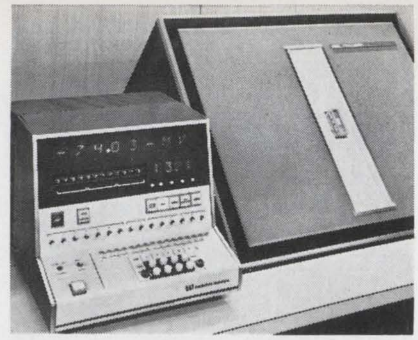
Four channels. According to R.K. Kressler, product manager at the Industrial Products division, a unique feature of the system's functional input-output interface is the availability of four differential-mode channels, a feature that allows a single control unit to supervise up to four test stations.

Functional tests are provided by an input-output signal assembler along with voltage-level converters and output comparators. There are also circuits for power monitoring, and power supplies for the test stations. Each station supply can furnish power for a maximum of 90 leads, and two of these supplies can be included in one test unit. Air flow, air temperature, and floating ground voltages are monitored by the test unit's master power controller. If any of these variables goes outside a specified range, the tester is automatically shut down.

One of the key factors affecting the speed and versatility of the 561 is the test terminal—one of the three parts of the test station. Circuitry at the terminal controls test conditions and the outputs from the device under test. Four printed-circuit cards in the terminal hold the necessary interface logic for programing and operation. This setup can take plug-in additions of up to 60 p-c cards, each containing the circuitry for three leads.

For straightforward testing of device functions, programing information stored in the controller is transferred as a 16-bit word into the signal assembler. Here the information is assembled into patterns of up to 180 bits, enabling the simultaneous testing of up to the maximum 180 leads. As one pattern is applied to the device, the next is being assembled.

Double-duty. Parametric d-c tests are patterned through function generators, a multiplexed analog-to-digital converter (in a separate cabinet), and a lead-switching matrix in the test station. According to Kressler, the 561 integrates functional and d-c parametric test capabilities to provide worst-case conditions prior to the parametric tests. A parallel feature is that the system can perform parametric measurements — either d-c or dynamic—with a functional setup.



Rotatable. Test terminal, right, is at angle suitable for sit-down operation.

The test-station console contains a monitoring remote power controller and provides a mounting for the test terminal. And the operator has switches and indicators at his terminal with which he can select magnetic tape, paper tape, or the teletypewriter for recording test data, or can reject the data entirely.

The system uses a symbolic language similar in format to common computer programs. The controller translates the symbols into system-language test tapes.

Delivery time for the system is five or six months and prices start at $100,000, depending on the number of leads and the type of testing specified.

Industrial Products Division, Texas Instruments, 12201 Southwest Freeway, Stafford, Texas [429]

Production equipment

Low-price tester sorts transistors

Instrument identifies leads, measures beta and breakdown voltage

If you buy transistors by the barrel and need to have them sorted by semi-skilled inspectors, a fast, versatile, and inexpensive tester made by Miracle-Hill Electronics may help with the problem.

The Model 800, which will sell for $495, identifies base, emitter, and collector leads; indicates whether the transistor under test is made of silicon or germanium, and whether it is an npn or pnp unit. The tester also gives a meter reading of beta. "Push two more buttons and you get breakdown voltage and leakage current," says the designer, Robert Youden.

No matter how the transistor is plugged in, the leads are scanned by circuitry until the instrument finds a combination of leads which will cause the device to function.

Voltage drop between the base and emitter terminals provides the basis for differentiating between silicon and germanium—about 0.7 volt for silicon, 0.3 volt for germanium; discrimination between npn and pnp depends on a determination of polarity derived from the current flow.

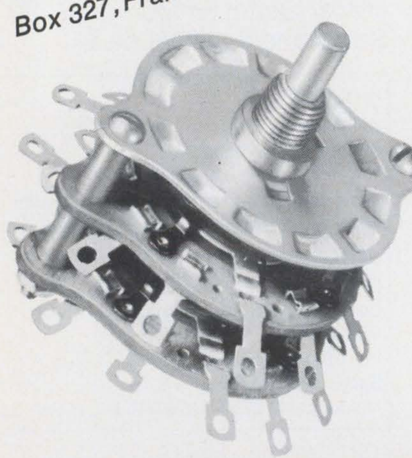
Autoranger. The leakage current is measured by again using the base-emitter drop to provide automatic change of range, or autoranging. For this reading, silicon requires a different scale than germanium.

The key components of the instrument are 16 inexpensive integrated circuits. Youden used the Signetics Utilogic II series.

Youden says the Model 800 may be used in hardware and electronics stores where amateur electronics technicians can test their transistors. More immediately, he expects that the instrument will be used for incoming inspection and quality control.

Delivery time is 30 days.

Miracle-Hill Electronics, 320-B Martin Ave., Santa Clara, Calif. 95050 **[430]**



New Books

Line drive

Transmission Lines for Digital and Communication Networks
Richard E. Matick
McGraw-Hill Book Co., 360 pp., $14.50

With a fairly academic, rigorous approach, the author, a member of the technical staff of the director of research at IBM in Yorktown Heights, N.Y., presents a good exposition of transmission-line theory as applied to pulse systems.

The book would be useful for a first course in transmission lines, for an engineer entering the pulse communications field, or even for an engineer who had the classical transmission-line course but now needs a brushup on pulse transmission. Throughout the book, the author attempts to supplement the mathematics with physical reasoning.

Of particular interest to digital designers will be the 57-page chapter discussing pulses on transmission lines. The chapter starts from the basic step-function response, is supplemented with a four-page table listing the output waveforms for various output terminations, and moves on to reflection from discontinuities in the line. The author then covers nonideal inputs with finite rise times and other adjustments to the ideal case. The payoff is in the section on pulse distortion on transmission lines, in which Matick explains how skin effect becomes the major contributor to distortion. The dielectric leakage conductance is usually small, and the dielectric constant is usually constant over the frequency spectrum of the pulse. The author then develops a set of normalized curves showing the responses to pulses with various rise times.

Other chapters discuss superconducting transmission lines, both in terms of power transmission and strip lines; coupled transmission lines, and practical transmission-line parameters. This last chapter covers coaxial, strip, and helical lines.

Recently published

Electronics Reference Databook, Norman H. Crowhurst, Tab Books, 232 pp., $7.95 hardbound, $4.95 paperbound

In 10 chapters this book explains how to make most of the common engineering calculations. Separate chapters deal with such topics as the *j* operator, filter design, semiconductors and tubes, and feedback. Included also are 45 tables.

Principles of High-Resolution Radar, August W. Rihaczek, McGraw-Hill Book Co., 498 pp., $19.50

After explaining how radar measurements are made on single targets, the book goes through the theory of resolution. Among the topics covered are target resolution and its relation to measurement ambiguities, the fundamental limits on resolution performance, and waveform design.

Introduction to Optimal Control, Ian McCausland, John Wiley & Sons Inc., 258 pp., $12.00

Intended as a primer on optimal control theory, this text reviews basic optimizing techniques, then discusses Weiner filtering and the Kalman filter theory. Later chapters introduce the calculus of variations, the maximum principle, and dynamic programing. Parseval's theorem and some relationships involving autocorrelation functions and spectral densities are included in the appendixes.

Principles of Quantum Electronics, William S.C. Chang, Addison-Wesley Publishing Co., 540 pp., $17.50

Strictly for graduate courses, the book first reviews quantum mechanics, then discusses the principles of quantum electrons, particularly as they relate to lasers.

Holography—State of the Art Review . . . 1969, Thomas Kallard, Optosonic Press, 182 pp., $12.00

This volume does the work of a very good librarian. Included in the text are a listing of books, articles, and Government R&D reports. Important patents are reprinted along with a list of manufacturers.

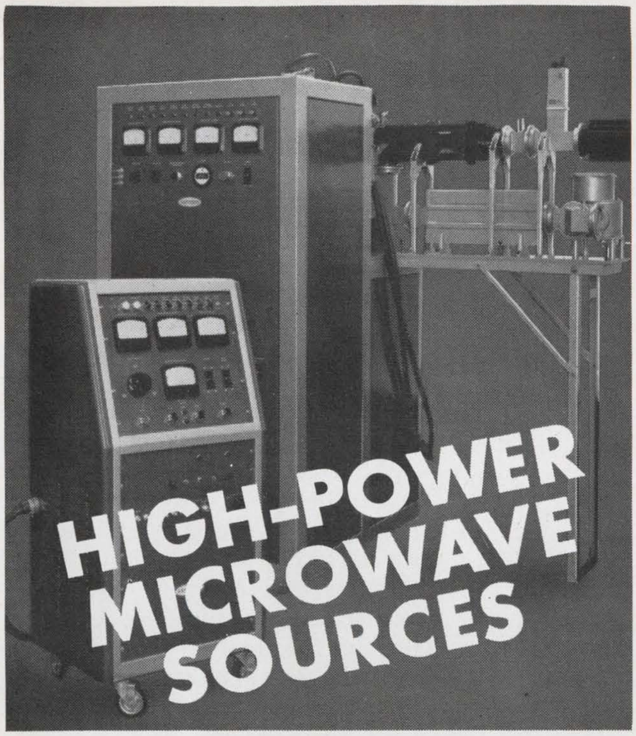
An Introduction to Statistical Communication Theory, John B. Thomas, John Wiley & Sons Inc., 670 pp., $15.95

This book, for graduate students, begins with a review of probability theory and then discusses random processes and spectral analysis. Following sections deal with such topics as linear and nonlinear systems with random inputs, modulation theory, and information theory. Nine appendixes explain mathematical concepts, such as the Dirac delta function and the calculus of variations.

X-ray Diffraction, B. E. Warren, Addison-Wesley Publishing Company Inc., 381 pp., $15.00
After a rigorous development of diffraction theory, the book discusses the application of this theory to problems in solid state physics and physical metallurgy. Some of the topics covered are temperature vibration effects, order-disorder, crystal imperfections, the structure of amorphous materials, and the diffraction of X-rays in perfect crystals.

Electrical Principles of Electronics, Angelo C. Gillie, McGraw-Hill Publishing Co., 732 pp., $11.50

This is the second edition of a 1961 book written for technician-school students. It's divided into three sections: d-c circuits, sinusoidal circuits and nonsinusoidal circuits. Among the topics covered are motors and generators, test instruments, and filters.



Now you can purchase highly reliable, completely mated RF sources—Raytheon-designed and -built—for precision-testing of high-power microwave components. You can also generate power efficiently for laboratory applications in UHF through Ku-Band.

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Raytheon Closed Flow Calorimetric Systems for use with RF sources include closed flow heat exchanger, calorimetric waterload, and thermopile-meter combination. Standard units cover UHF through Ku-Band.

For a complete line brochure, write or call: Raytheon Company, Accelerator and Equipment Operation, 190 Willow Street, Waltham, Massachusetts 02154. Tel: 617-899-8400.

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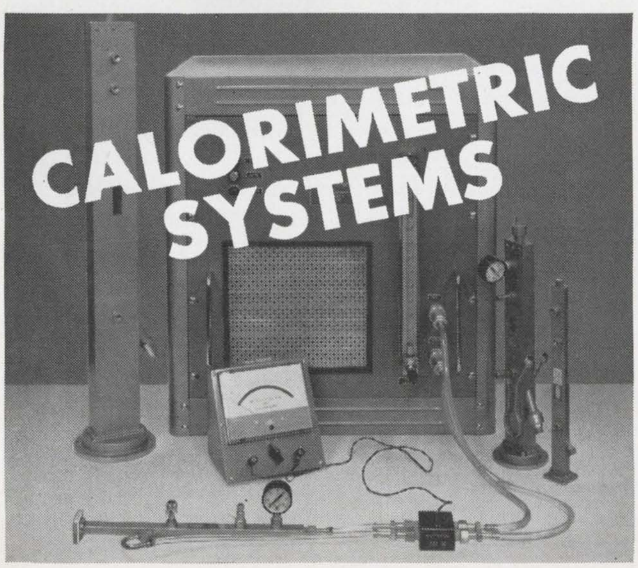

Circle 194 on reader service card

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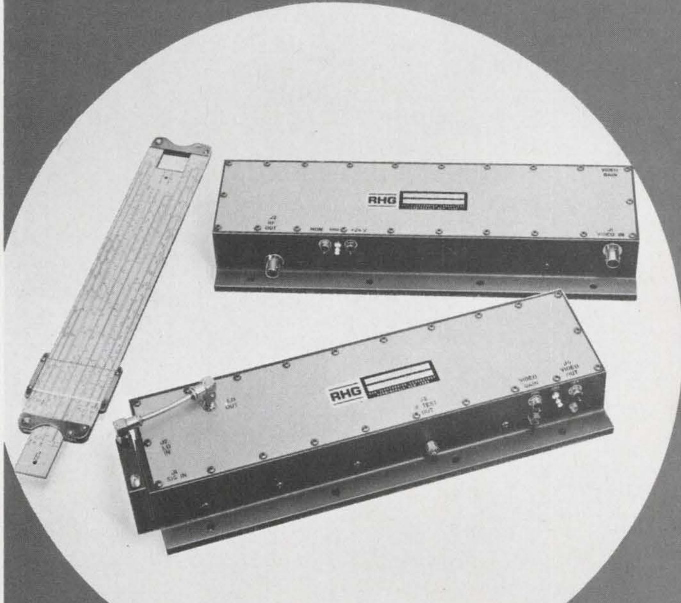

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Microwave Receivers, Transmitters and Components

Circle 167 on reader service card

Technical Abstracts

A model job

Computer analysis and simulation of MOS circuits
Albert Feller
RCA, Camden, N.J.

Transient and d-c analysis of p, n, and complementary metal oxide semiconductor circuits, once tedious and time consuming, has been greatly simplified by two new computer programs. Called CASMOS-1 and -2 (for computer analysis and simulation of MOS circuits), these programs apply, respectively, to linear passive devices and to nonlinear elements.

The inputs, on punched cards, are divided into two classifications—the circuit's topology and the parameter values for the built-in models of the active and passive devices. These values are the mask geometries, the threshold voltages with a zero source-to-substrate voltage, hole and electron surface mobility, oxide thickness, donor and acceptor densities, resistivity, and several additional constants.

Both programs consist of a main routine and 10 subroutines. One subroutine generates and evaluates a set of n first-order differential equations at time zero, describing the n-dependent voltage nodes as functions of time. Dynamic inputs can be supplied by two other subroutines, giving the user a Fortran option to define analytically one or several input driving functions.

The differential equations developed are then numerically integrated for succeeding intervals of time to produce new values for the dependent voltages. Integration is assisted by four subroutines based on a Runge-Kutta starting procedure and a predictor-corrector technique. The subroutines are controlled by predefined error criteria and change the integration interval automatically. At the user's option, a d-c solution can be printed out and used automatically as the initial conditions for the transient analysis. One of the subroutines inverts the matrix.

The mathematical models are defined through several equations—for the drain characteristics in the saturated and unsaturated regions, the threshold voltage as a function of source-to-substrate potential, the surface mobility with gate-to-source potential, and the nonlinear junction capacitance.

Parameters needed for the equations are found as follows:

- Threshold voltage—measured by connecting the devices as diodes and extrapolating the voltage where the drain current is zero.
- Surface mobility and diffusion depth—determined by first measuring the drain characteristics on the same chip of several saturated devices having different geometries and then using the drain equation for the saturated region to derive the values simultaneously. The gate-to-source voltage should be as low as possible.
- Doping level—determined by measuring the threshold voltage, but with the source biased with respect to the body or substrate. A large value of surface mobility will minimize any errors that result from assuming a value of, say, 0.75 volt for the surface potential.

Presented at the 1969 IEEE International Solid State Circuits Conference, Philadelphia, Feb. 19-21.

Matchmaker

A five-octave microwave thin-film amplifier
P.H.Y. Wang, Hewlett-Packard Co.
Palo Alto, Calif.

Microwave amplifiers have been built using a modular approach that lets the computer set up the proper module combinations needed to attain the desired over-all characteristics. When a sufficient number of two-stage amplifier blocks have been built and tested, the computer scans through the measured data accumulated and chooses a set containing three two-stage blocks and a power amplifier section that should optimize the amplifier's performance.

The final amplifier consists of several selected sections: three identical two-stage blocks that form a 36-decibel preamplifier, and a three-stage 12-db power amplifier that uses four transistors. Two of the four transistors are connected in parallel to deliver a power level +16 decibels above 1 milliwatt into a 50-ohm resistive load.

The microwave amplifier is housed in a 3- by 0.75- by 0.4-inch package. It has a gain of 48 db within 3 db from 50 megahertz to 2.1 gigahertz. The input and output voltage standing wave ratio is less than 2:1, and the harmonics are at least 30 db below the fundamental at an output level of +16 dbm.

All of the passive elements are made from films that are deposited on a single-crystal sapphire substrate. Because the thin-film construction techniques insure that the passive elements are uniform and reproducible within tight tolerances, it is possible to use any parasitics that do occur as part of the final design. The resistors, for example, are made of tantalum pentoxide and silicon dioxide dielectric. Microstrip transmission lines are used as high impedance lines and matching elements; these and the inductor patterns are gold plated. The transistors, which are made by Hewlett-Packard, are discrete npn silicon planar passive chips with a typical gain-bandwidth product, f_t, of 4 Ghz.

Because transistor parameters vary in value, the techniques used for the synthesis, calculation, and fabrication of the final circuits must be very accurate. If they aren't, the error accumulated over the many stages of amplification precludes any accurate computer matching. Also, the characterization of the circuitry and the devices is extremely important and is determined using scattering-parameter data.

The transistor chips are characterized in the common-emitter configuration as linear two-ports from 0.1 to 2 Ghz by varying both magnitude and phase of the feedback element in series with the emitter, and by mapping the resulting family of s-parameter curves on a Smith chart. From this a single-stage amplifier is synthesized using all the plotted s-parameter data for several frequencies. This particular technique gives a fairly good physical rather than a purely mathematical insight into the behavior of a single stage.

Presented at the 1969 IEEE International Solid State Circuits Conference, Philadelphia, Feb. 19-21.

New Literature

Microwave components. Raytheon Co., Micro State Electronics Operation, 152 Floral Ave., Murray Hill, N.J. 07974, offers a four-page pamphlet describing its line of microwave integrated switches and limiters.
Circle **446** on reader service card.

Operational amplifiers. Melcor Electronics Corp., 1750 New Highway, Farmingdale, N.Y. 11735. A 16-page catalog C1008 covers a complete line of d-c solid state operational amplifiers. **[447]**

Computer systems. Varian Data Systems, 611 Hansen Way, Palo Alto, Calif. 94303, has released a 20-page illustrated booklet on the Spectro System 100/200 family of laboratory data processing systems. **[448]**

Tubeaxial fans. IMC Magnetics Corp., 570 Main St., Westbury, N.Y. 11591. Illustrated four-page catalog ET10 presents detailed electrical and mechanical specifications, performance curves, dimensions, and wiring data for a full line of slim-profile tubeaxial fans. **[449]**

Semiconductor catalog. Siemens America Inc., 350 Fifth Ave., New York 10001, offers a comprehensive 32-page buyers' guide to the company's line of semiconductors. **[450]**

Chopper relays. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343. Models 33 and 33P field-effect chopper relays are illustrated and described in a two-page bulletin. **[451]**

Cable fault locating. Delcon Division, Hewlett-Packard Co., 333 Logue Ave., Mountain View, Calif. 94040. Three new brochures describe the applications and operation of cable fault locating instruments for power and communications. **[452]**

EMI miniature filters. Genisco Technology Corp., 18435 Susana Road, Compton, Calif. 90221. Lightweight EMI miniature filters, offering a wider range of current ratings and circuit configurations than previously attainable, are described in a new catalog. **[453]**

Small computers. Data General Corp., 275 Cox St., Hudson, Mass. 01749. A 16-page brochure features a discussion of new small computers and describes the hardware, input, output, facilities, instruction set, and software for the NOVA. **[454]**

Vibration test systems. Wyle Laboratories, 128 Maryland St., El Segundo, Calif. 90245, has available a six-page brochure on Hydrashaker high-force vibration test systems. **[455]**

Trigger program generator. Datapulse Division, Systron-Donner Corp., 10150 W. Jefferson Blvd., Culver City, Calif. 90230. Technical bulletin 206 describes a six-channel trigger program generator that offers bit repeats or bit pair repeats, 16 bits per channel, and clock rates to 2 Mhz. **[456]**

Oscilloscope calibrator. Edwin Industries Corp., 11933 Tech Road, Silver Spring, Md. 20904. A four-page brochure illustrates and describes the Bradley model 156 oscilloscope calibrator that permits time, voltage and risetime calibration, with automatic readout of percentage error. **[457]**

Engineering plastics. General Electric Co., Selkirk, N.Y., 12158, has published an eight-page bulletin describing Lexan polycarbonate resin. Noryl thermoplastic resins, Phenolic molding compounds, and Genal injection moldable thermoset compounds. **[458]**

Relay catalog. Magnecraft Electric Co., 5575 N. Lynch Ave., Chicago 60630. A list of 481 different relays is featured in stock catalog No. 270. **[459]**

Digital readout system. Infotronics Corp., 7800 Westglen Ave., Houston 77042, offers an eight-page brochure on its CRS-160 digital readout system for suited mass spectrometry applications. **[460]**

Portable oscillograph. Esterline Angus, Division of Esterline Corp., P.O. Box 24000, Indianapolis 46224. A portable 40-mm oscillograph priced at $725 and weighing 14 pounds is described in a two-color catalog sheet. **[461]**

Waveguide tubing. Washburn Division of A.T. Wall Co., 14725 Arminta St., Van Nuys, Calif. 91402, has issued a technical bulletin on its complete selection of laminated tubing for waveguides. **[462]**

Standard relays. Essex International Inc., Controls Division, 131 Godfrey St., Logansport, Ind. 46947, has published the SC-4RBM controls catalog describing over 450 different standard relays. **[463]**

DTL interchangeability guide. ITT Semiconductors, 3301 Electronics Way, West Palm Beach, Fla., 33407. A DTL interchangeability guide (one page two sides, with short flap) cross-references the company's hermetically sealed DTL part numbers with the part numbers of five other major manufacturers. **[464]**

Peak envelope power measurement. Bird Electronic Corp., 30303 Aurora Road, Cleveland 44139. A discussion of pitfalls in the accurate measurement of peak envelope power of video, pulse, a-m, and other envelope modifying modulations is the subject of a three-page application note. **[465]**

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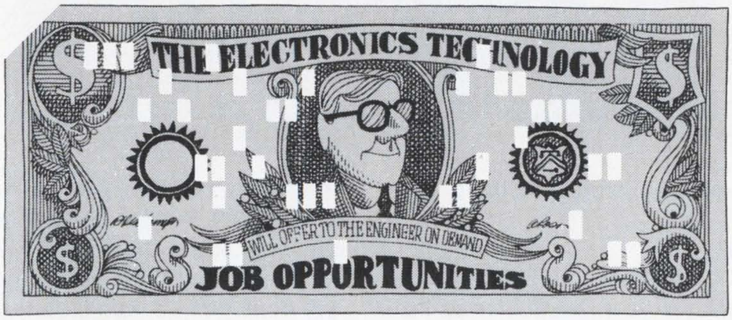

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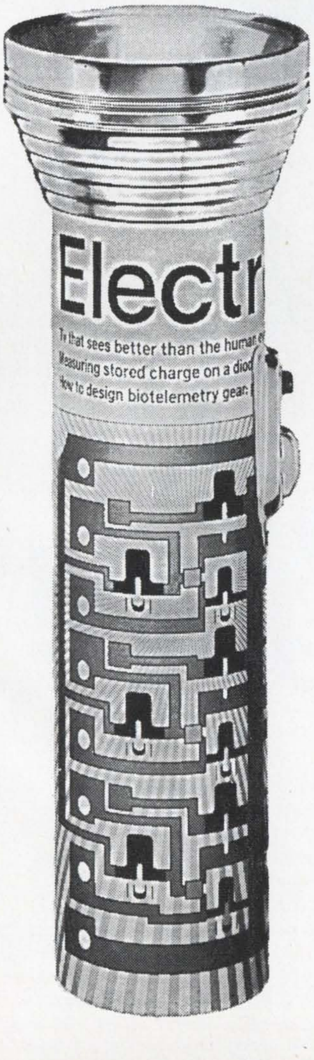

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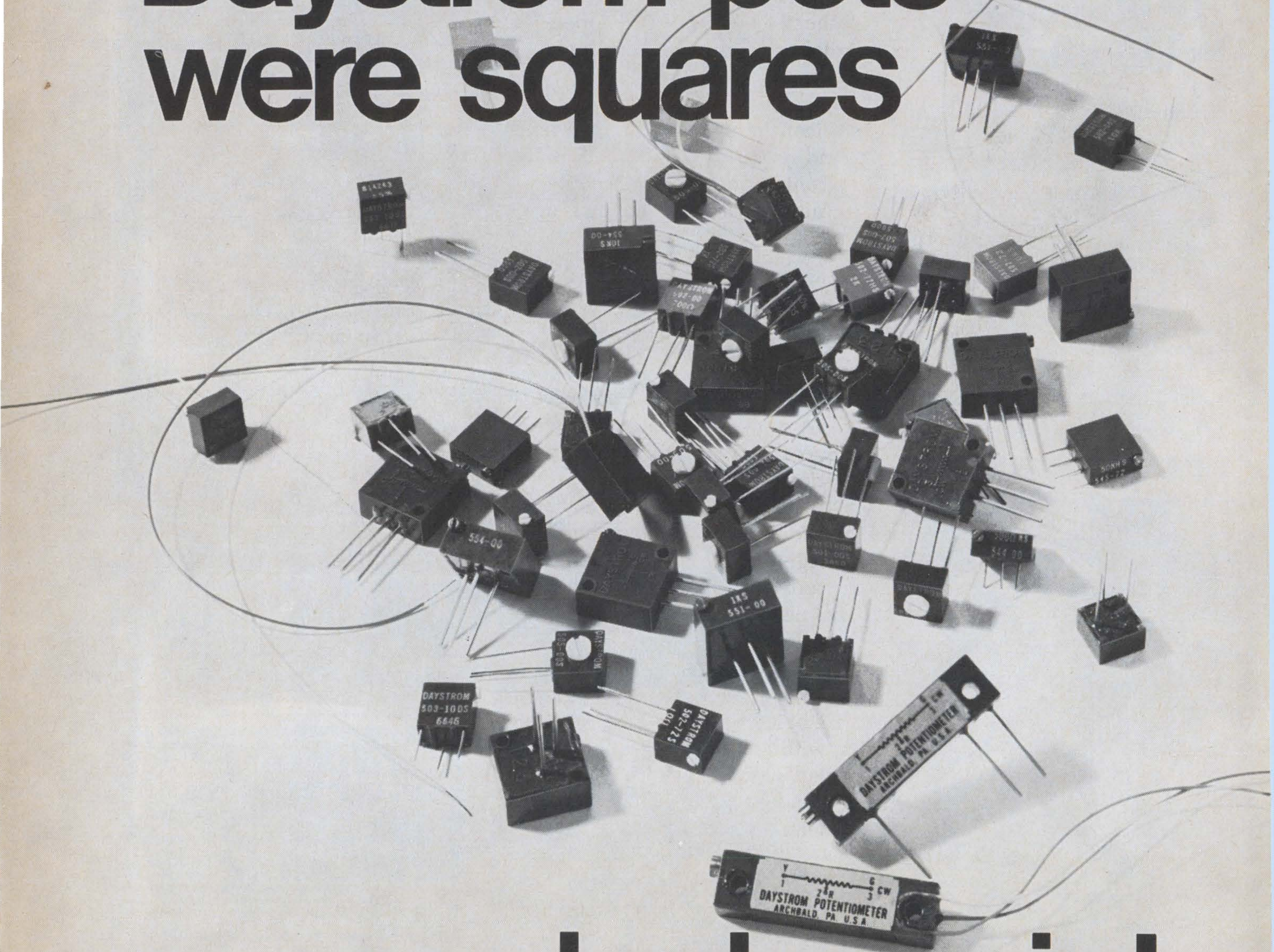

...look again!

Rectilinear components are still a necessary requirement in many circuit applications. That's why Weston has rounded out its high-performance potentiometer line with two new rectilinear models. RT-12 styles 534 and 535 are designed for both general-purpose and military applications. They feature the same ±5% tolerance, 10 ohm to 50K range, and slip clutch stop protection that are standard with Daystrom Squaretrim® units, plus 24-turn adjustability and humidity proofing. Also new this year ... models 553 half-inch and 543 three-eighth-inch Squaretrim potentiometers in military and commercial versions. Save board space as well as money with our field proven 501 Series multi-turn and 504 Series single-turn 5/16" Squaretrims offering values to 20K in a 0.02 cubic inch case. All Squaretrim Diallyl-Phthalate cased pots give you Weston's patented "wire in the groove" construction and your choice of flexible leads, pin and screw configurations. Whether your trimmer needs are military, industrial or commercial, you'll find the answer in this complete new low-cost line. Write today for data sheets and evaluation samples. DAYSTROM potentiometers are another product of WESTON COMPONENTS DIV., Archbald, Pennsylvania 18403, Weston Instruments, Inc., a Schlumberger company

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International Newsletter

March 31, 1969

Germanium diodes in X-band made by Matsushita

Prototype germanium microwave oscillator diodes, and X-band oscillators using them, have been developed by Matsushita Electronics. **The company claims they're the first such devices that are made in production quantities.**

Matsushita says the germanium devices run at least 10 decibels quieter than silicon impatt diodes, have less negative resistance and thus more gain, and require less than half as much supply voltage.

The company hasn't released details of the device's mechanism, so it's not certain whether breakdown is caused by tunneling or by the avalanche effect.

Mullard to sell matrix display by mid-1970

Mullard Ltd. expects to have a competitive glow-discharge matrix display in production by mid-1970. Samples of the displays, which have a five-by-seven array of dots, will probably be available by the end of this year.

In production quantities, the price for a display unit will run about $2 in Britain. A diode decoder to pair with the display itself will run $3 or $4 for numerals-only applications and from $15 to $20 for alphanumeric applications.

For desk calculators and similar equipment needing eight or more tubes driven sequentially by a numerals-only decoder, the flat displays will cost a little less than the tubes now used, Mullard believes. At the same time, there'll be a gain in brightness. Dot brightness in the prototypes Mullard now makes is 600 foot-lamberts for a current of 150 microamps at 120 volts.

Mullard builds the array around a flat lead frame containing 35 cathode pads. This assembly slips into a glass molding so that each cathode forms the base of a cavity. The tube is completed by adding an anode grid, then sealed with a glass faceplate. Sputtered cathode material, Mullard says, is trapped within the cavities and does not blacken the faceplate. Life tests so far exceed 15,000 hours without deterioration, say engineers on the project.

European airbus means a lift for avionics

A lift to avionics producers that could run as high as $50 million is in the offing from the A-300B European airbus. **France and Germany, eager to get work started on the 250-passenger plane, now say they'll go ahead with the project no matter what the potential third partner—Great Britain—decides to do.**

European avionics makers will get preference, but U.S. firms may wind up with a big chunk of the business. The reason: unlike the Anglo-French Concorde supersonic transport, the airbus is strictly for business and not for prestige. The project will have a fixed development budget of about $500 million financed by the two governments, and the **builders will be free to pick the best avionics offers even if they come from non-European companies.** For the Concorde, the guideline was "buy European"—even at a premium.

Unless Britain joins in, France's Sud-Aviation and Germany's Deutsche Airbus will build the plane. Deutsche Airbus groups five German aerospace firms interested in the project. **The sales target is 350 planes over 10 years, with the first planes in service by late 1973.**

International Newsletter

Toshiba twt has 300-watt output

A 300-watt traveling-wave tube for the 28 to 30 gigahertz range has been turned out by Toshiba's Central Research Laboratory. **Previous amplifier tubes in that frequency range put out only several watts, says Toshiba.**

The company was able to surmount a major obstacle for high output: as frequency increases, twt size decreases—and so does output power. **By improving component fabrication, and by putting the tubes together with greater precision, Toshiba managed to have almost 100% of the electron beam pass through the slow wave circuit.** It is loss in the slow wave circuit that limits output.

The tube is designed primarily for transmission of wideband multiplex pulse-code-modulation signals from ground stations to satellites.

Ferranti to try computer market in East Europe

A new twist may open up a market for Ferranti Ltd. Argus process-control computers in East Europe. The U.K. firm has lined up the Czech Institute for Industrial Management and Organization (INORGA) as its exclusive sales agent for Czechoslovakia.

Under the deal, Ferranti will supply hardware and standard software. **INORGA, though, will design systems, supply special software, install systems, and maintain them.** Other British computer makers operating in Eastern Europe tend to do the whole job themselves and keep teams of British engineers assigned to East European countries.

At the outset, INORGA has the right to sell in other East-bloc countries besides Czechoslovakia. **But if the Czech scheme works, Ferranti probably will look for native partners in other countries.** So far, Ferranti, acting as its own agent, has sold only three Argus installations in the bloc, all to Russia. Ferranti expects the Argus systems that INORGA sells will be worth between $150,000 and $250,000 each.

Messerschmitt wins apogee engine job for Symphonie

Messerschmitt-Boelkow GmbH, West Germany's leading aerospace firm, has cut itself in for more contracts on Symphonie, the Franco-German communications satellite, scheduled for launch in 1972. The company, which beat out French, Italian, and other German firms in the competition for Symphonie's apogee engine, **will develop and supply all of Symphonie's propulsion and orbit-correction systems.**

Messerschmitt-Boelkow's apogee engine is a liquid-fuel type that has a longer firing time (18 minutes) than the solid-fuel engines proposed by the other concerns. **Since the engine also requires less fuel, Symphonie's payload can be increased by about 55 pounds—to 220 pounds—allowing more electronic equipment and related gear to be installed.** The liquid-fuel engine also will cut the total project cost by several million dollars (to $50 million) because it can be reused after each test firing.

Murata to make IC's for Oak tv tuners

Japan's Murata Manufacturing Co., which already has a joint venture with Oak Electro/Netics making vacuum tube tuners, will furnish Oak with thick-film hybrid integrated circuits for vhf television tuners. **Each tuner will use four transistors and three diodes, one of which is a variable capacitance type for automatic frequency control.**

The joint venture, which is owned 51% by Murata and has about 200 employees, will switch to the manufacture of IC tuners next year and is expected to turn out about 150,000 a month. **Also, a new plant, eventually employing 500, will be built in Kanazawa because the original facility 150 miles away, near Tokyo, can't expand its labor force.**

Low-cost British instrument plots impurity profiles of semiconductors

Special-purpose machine eliminates need for tedious series of voltage-capacitance measurements; it will be sold starting this summer for about $1,700 in the home market

Specialists in semiconductors who visited the mid-March Physics Exhibition in London found what many of them had long been waiting for—the prototype of a reasonably priced instrument that plots the impurity profiles of semiconductors.

The instrument, developed by Peter Baxandall of Britain's Royal Radar Establishment, gives an on-the-spot plot of impurity concentration versus depth for semiconductors having from 10^{13} to 10^{17} impurity atoms per cubic centimeter. The profiles are crucial to semiconductor producers, particularly when they're making gallium arsenide wafers destined to become Gunn oscillators. A reading on the impurity concentration at different depths through the wafer tells if its doping is uniform enough to make it usable.

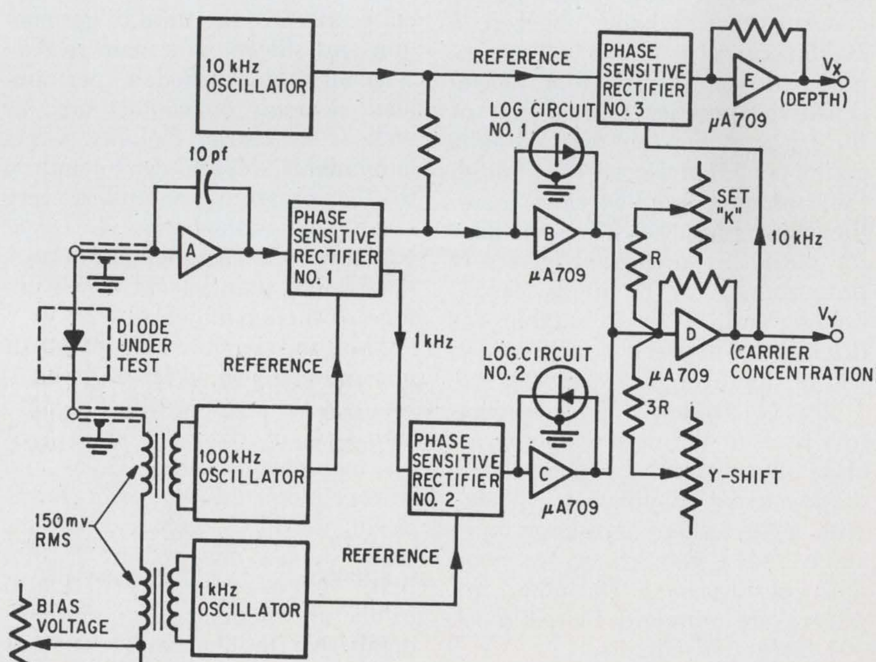
J.A.C. Electronics Ltd. will market the impurity-profile plotter. The company expects to sell the instrument in its home market for around $1,700. This price compares with as much as $50,000 for conventional units.

Tedium. The usual way of taking the profile is to evaporate metal dots onto the wafer surface and thus turn it temporarily into a batch of Schottky-barrier diodes. After that comes an exhaustive series of voltage-capacitance measurements taken with a capacitance bridge. The data then goes to a computer, which plots the profile.

The technique is possible because the capacitance of a semiconductor diode depends essentially on the depth of its depletion layer. The capacitance is also a function of the impurity concentration in the depletion layer. As the layer is driven deeper into the semiconductor by increasing the d-c bias on the diode, the change of capacitance stays linear if the impurity concentration is uniform.

Actually, the Royal Radar Establishment was not the first to find a way to get around tedious capacitance-bridge-and-computer methods to ferret out impurity profiles. At the International Electron Device Meeting in Washington last October, John A. Copeland of Bell Telephone Laboratories told about the "Profilometer" he had invented. Bell Labs and the Western Electric Co., the Bell System's manufacturing arm, have since put a dozen Profilometers in trial operation. No one so far plans to market the instrument, but Copeland figures the hardware to build one would cost about $3,000.

Ready for market. Meanwhile, J.A.C. Electronics expects to have its first batch of a dozen profile plotters ready in about three months. The instrument is essentially a small special-purpose analog computer that manipulates the capacitance-change input from the wafer



In on the plot. Phase-sensitive rectifiers and logarithmic amplifiers measure changes in semiconductor diode capacitance that reflect the carrier concentrations at different depths in a wafer.

diode that is undergoing the test.

D-c bias is set manually and applied in series with 100-kilohertz and 1-khz signal voltages at 150 millivolts rms. The 100-khz signal produces an a-c current flow through the diode; this current is amplified and fed to the first phase-sensitive rectifier. The rectifier's output current, proportional to the diode capacitance, becomes an input to a logarithmic amplifier.

The 1-khz voltage applied to the diode modulates slightly the 100-khz component, so there's a second output from the first phase-sensitive rectifier, a 1-khz component whose amplitude is a measure of the capacitance change for the change in a-c voltage across the diode. This small a-c voltage goes to the second phase-sensitive rectifier. The rectifier's output current, proportional to the change in capacitance, goes to the second log amplifier. The outputs of the two log amplifiers are summed to get a d-c signal to drive the Y axis of the plotter, which shows the log of the carrier concentration.

Special amp. To get the other output, a voltage proportional to the depth at which the carrier concentration is being checked, a 10-khz current is fed to the log amplifier driven by the first phase-sensitive amplifier. The output of the log amplifier thus has a 10-khz component that is carried through the summing amplifier and on to the third phase-sensitive rectifier. Its output is a current inversely proportional to the diode capacitance, and is thus suitable for driving the plotter's X axis, which shows depth of measurement.

The 1-, 10-, and 100-khz oscillators used in the plotter operate as class D current switchers. The diode-current amplifier is special, with a field effect transistor input stage and a gate choke for good noise performance. The other amplifiers are standard Fairchild μA 709 integrated circuits.

In absolute terms, the plotter's performance isn't much—an accuracy of only ±50%. But the variation in carrier concentration with depth—the key to the semiconductor's uniformity—is measured to within ±3%.

Mixing it up

In a laboratory laser setup, a supercooled semiconductor is a workable way to get a detector with fast response. However, in the cruel but insufficiently cold everyday world, helium-cooling equipment becomes a nuisance, so there's a search on for good room-temperature laser detectors.

The most likely candidate at the moment is the point-contact semiconductor diode, according to Colin Payne and Brian Prewer of EMI Electronics Ltd. Last week, at a conference on lasers and optoelectronics held at Southampton University, they told why.

Payne and Prewer have been working on detectors and mixers for submilimeter wavelengths. They've been using a cyanide gas laser that develops an output of from 1 to 5 milliwatts at a wavelength of 0.3337 mm. And they think their detectors will be suitable for much shorter wavelengths.

Softie. At first glance, n-type gallium arsenide would seem the best semiconductor material for a submillimeter diode detector. But GaAs, despite its superior electrical properties, ran third to germanium and silicon. The main reason: a point-contact diode's performance depends on contact area as well as on carrier mobility. GaAs is relatively soft and can't stand up to the pressures around a very small point-contact area. The larger contact area required for GaAs, then, more than offsets its advantage of higher mobility.

The best combination the EMI men have found so far is germanium with a tungsten whisker. With this kind of diode in an experimental detector setup, Payne and Prewer detected—at power levels down to 10^{-6} watt—cyanide-gas laser signals chopped at 2 kilohertz. In a mixer setup with a local oscillator frequency of about 890 gigahertz, the performance was vastly better: 10^{-12} watt. The improvement comes, Payne and Prewer say, from the high i-f, only 1 Mhz below the signal frequency. The i-f cuts down inverse frequency noise and gives the germanium-tungsten diode a noise equivalent power (threshold for useful signals) of 2.4×10^{-12} watt in a mixer that has a local oscillator input of 3 mw.

Runner-up. After germanium and tungsten, the next best combination was silicon and tungsten. Here the noise equivalent power was 3.8×10^{-6} watt in straight detection and 3.8×10^{-11} watt in mixing. Actually, the silicon diode's contact area was smaller than that of the germanium diode, but not enough to offset the lower mobility of the p-type silicon.

With GaAs, the noise equivalent power turned out to be 3.8×10^{-5} watt in straight detection and 1.2×10^{-10} watt in mixing. All kinds of whisker materials—phosphor bronze, platinum, platinum-iridium, and gold-copper—were tried to improve the diodes, but none could skirt the basic difficulty: the softness of GaAs. Another drawback of GaAs is its need of forward biasing, which adds to the noise.

Payne and Prewer believe they'll eventually get noise equivalent power of 10^{-8} watt in straight detection and 10^{-15} watt in mixing with germanium diodes.

Long lived

Battery life can be a matter of life and death for a cardiac patient who's wearing a pacemaker. Occasionally, the pacemaker itself stops working; but more often the mercury cells that power it fail. That means surgery for the patient, or else.

Medical electronics people on both sides of the Atlantic have been working on long-lived pacemaker batteries for some time. The goal is a power pack that will last a decade or longer instead of the two years or so that's usual for mercury batteries.

Nearest to that goal seems to be the United Kingdom Atomic Energy Authority. This month, the agency let out that it has had a nuclear-battery powered experimental pacemaker in operation since last June. What's more, UKAEA says it expects to be ready for clinical trials in 15 to 18 months. The U.S. Atomic Energy Commission's timetable for pacemaker batteries calls for implants in animals by the end of 1969 and first clinical tests in 1975.

The British battery has an output of 540 microwatts and comprises a plutonium 238 heat source and a bismuth telluride thermocouple in a stainless steel can about 1 centimeter in diameter and 5 cm long. Paired with the battery is a three-stage dc-dc converter that boosts the 1.5-volt battery potential to the 4.5 volts needed for the pacemaker circuits.

As for the pacemaker itself, UKAEA won't say much except that it generates 4.5 volt pulses with a duration of about 1 millisecond at a rate of 72 per minute. Some outsiders are convinced the agency has developed a new kind of pacemaker circuit but intends to keep mum about it until it's patented.

Japan

All wound up

A new twist—literally—on an old idea may one day make most of us consumers of prerecorded video tapes.

The twist is a bifilar winding around a tape reel, and the old idea is to duplicate video tapes by "contact printing." Do both, reports a Matsushita Electric Industrial Co. research team headed by Hiroshi Sugaya, and you can copy a 2,400-foot reel of tape in just 2 minutes. With conventional copying, it takes an hour to duplicate the same tape.

Matsushita's method is elegantly simple. Both the master tape and the duplicate-to-be are wound together on a takeup reel after passing under a pressure roll that squeezes out any air trapped between the tapes. When the reel is full, a 50- or 60-hertz transfer field is applied for a few seconds. The leakage flux from the master tape then acts as a signal field and the transfer field as a bias field, so there's magnetic recording on the slave tape. After the transfer, the tapes are rewound on their respective reels.

Limitations. Simple as it is, the method eliminates the major drawbacks of conventional copying, where master and slave tapes pass together in running contact through a transfer field. With the full windup before transfer, there's no slippage, as there can be with running contact. And there's no chance of trapped air keeping the tapes slightly apart, which makes for fuzzy contact printing. As a result, Matsushita's method can handle wavelengths down to about 2 microns, compared to a 10-micron lower limit for conventional copying.

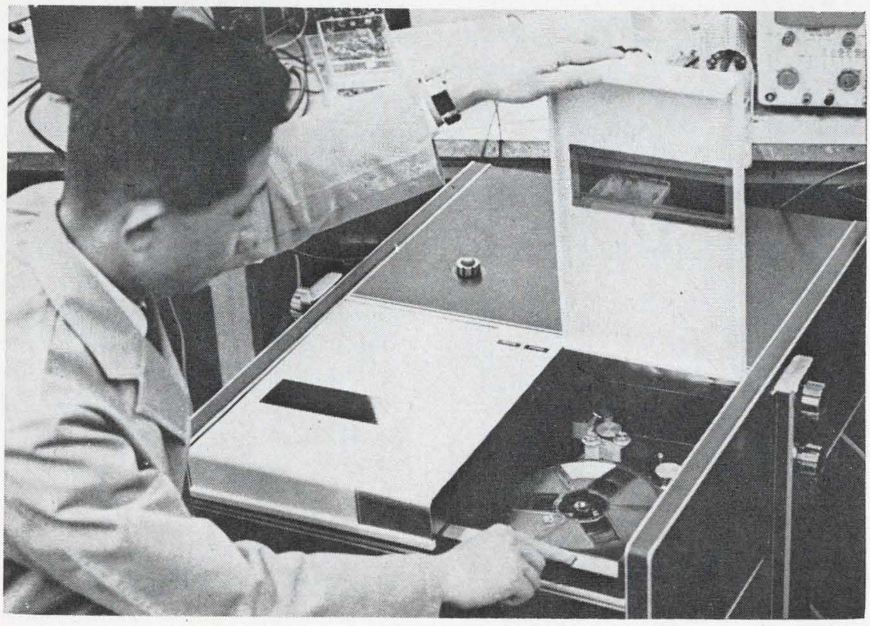
There are some limitations—none serious—to the Matsushita technique. If there's an audio track on the master tape it must be wiped off before the video contact printing and put on both slave and master during the rewind. This is because the longer wavelengths of the audio signals tend to print through more than one layer.

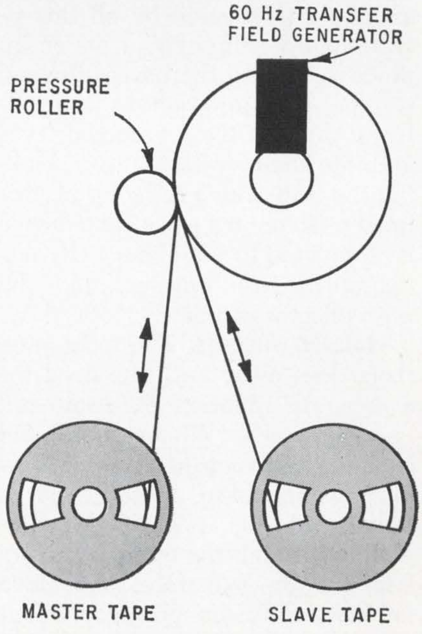
And the master, of course, has to be recorded on tape that has a coercive force about 2½ times higher than the slave tape's. What's more, the master tape has to be a mirror image of the recording to be printed. So a special recorder is necessary, one with a reversed tape run around the recording drum.

Close quarters

The way to pack scads of bipolar transistors onto an integrated-circuit chip is to cut down the elbow room each transistor needs around it to isolate it from its chipmates. And one way to shave isolation areas is to build a "collector wall" around each element [*Electronics*, Oct. 28, 1968, p. 204].

An even better way, say Kiyoshi





Fast whirl. Matsushita video tape copying equipment can duplicate a 2,400-foot reel of master tape in just two minutes. Bifilar winding of master and slave tapes on the same reel is what makes machine a speedster.

Demizu and Katsuhiko Yukawa of the Mitsubishi Electric Corp., is to adopt double epitaxial isolation. The technique not only makes for smaller isolation diffusion regions, they add, but it saves some steps in the production cycle. More development work is needed, but Demizu and Yukawa are sure the technique has exceptional promise.

Extra growth. Double expitaxial isolation starts with diffusion of an n+ layer into a p substrate in those regions that will hold the finished transistors. So far, nothing new. But next, a p-type epitaxial layer 2 to 3 microns thick is grown on the same areas, followed by an n-type epitaxial layer about 2 microns thick. Both layers are grown in one continuous process; the switch from p to n is achieved by changing gases at the appropriate time.

During the heating cycles of the epitaxial processing, there is an auto-diffusion from the n+ buried layer into the p epitaxial layer. As a result, the p epitaxial layer above the buried layer becomes a high-resistivity n-type material and the collector of the finished transistor. The p diffused base extends completely through the n epitaxial layer, and the actual base-collector junction is in the inverted epitaxial layer.

Those regions of the p epitaxial layer not over the diffused n+ areas are unaffected by all this p-type material throughout the entire process. During the base diffusion, p type isolation regions are diffused through the n epitaxial layer and into the p epitaxial layer, making the transistor's collector an isolated n island in a p sea. The device is completed by simultaneously diffusing the n+ emitters and the n+ collector contacts.

Isolated success. The technique, then, does away with the need for a separate isolation diffusion and isolation mask. What's more, the isolation diffusion need be only as deep as the base; in the conventional process, it must go completely through the epitaxial layers and into the substrate. And since impurity diffusion proceeds about the same distance laterally as vertically, the shallower isolation diffusion yields narrower isolation regions. Thus, each transistor takes up less space.

There's still another advantage. With other isolation techniques, the thickness of the epitaxial layer must be precisely controlled. But this factor is much less important during the double epitaxial process because effective thickness can be adjusted by subsequent heat treatment.

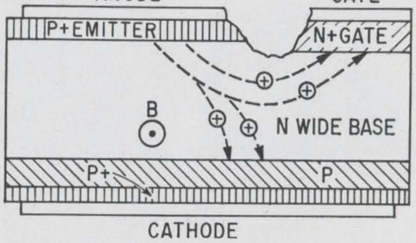
Czechoslovakia

Good timing

Many's the time pulse-circuit designers have wished for an easy way to control the switch-on delay in a power semiconductor. And now a research team at the Czech Institute for High-Current Technology thinks it's found the answer: a thyristor-like device that operates in a magnet's air gap.

The Czechs call their development a "timistor," and at a meeting last week in Munich on semiconductor device research they said its switch-on time could be varied from a few microseconds to several milliseconds. In addition to power pulse circuits, the timistor should be useful for d-c motor control and for some logic circuits, says the institute's Jan Bydzovsky.

Four layers. Basically, the timistor is a 300-micron, four-layer silicon structure with three contacts. Under the anode contact there's a 10-micron p+ emitter layer. A shorter but thicker 15-micron n+ layer underlies the gate contact. Then there's an n "wide" base about 230 microns thick, a p "narrow" base, a second p+ emitter, and the cathode contact.



Variable. Magnetic field oriented as shown deflects carriers into wide base to cut down turn-on time.

The silicon slab is soldered to a copper heat sink and encapsulated in plastic. After that, the device is about 1.5 by 7 by 0.5 millimeters, small enough to slip into the air gap of a small magnet.

Deflection. Excitation of the element is through the wide base, and the basic turn-on time depends on the current fed to the gate. A typical range of basic delays is 5 to 100 μsec. In a magnetic field, the carrier flow between the emitter and the gate changes. The basic delay is stretched out if the field shunts more carriers toward the gate. A magnetic field in the opposite direction sends more carriers into the wide base, and the basic delay is shortened. The effect of the magnetic field is enhanced if the control voltage has a sawtooth waveform.

Typical timistors developed at the institute have cutoff voltages between 100 and 500 volts and carry maximum currents of about 300 milliamps. Control voltages run between 5 and 15 volts and control currents between 2 and 15 milliamps.

West Germany

Taking a rain check

German weathermen will be taking to the hills when it rains. A team has been assigned to work in Bavaria over the next four years to perfect techniques for measuring rainfall.

From a weather-forecasting observatory perched on the 3,000-foot Hohenpeissberg, these meteorologists will take radar readings of rainfall over an area about 60 miles in diameter. The results will be modified by data on raindrop size and later compared to information gathered by conventional rain gages and electronic integrators.

The radar the team is using is a Plessey 43X model operating in the 3-centimeter band and delivering 0.5- and 2.0-microsecond pulses with a maximum power of 75 kilowatts.

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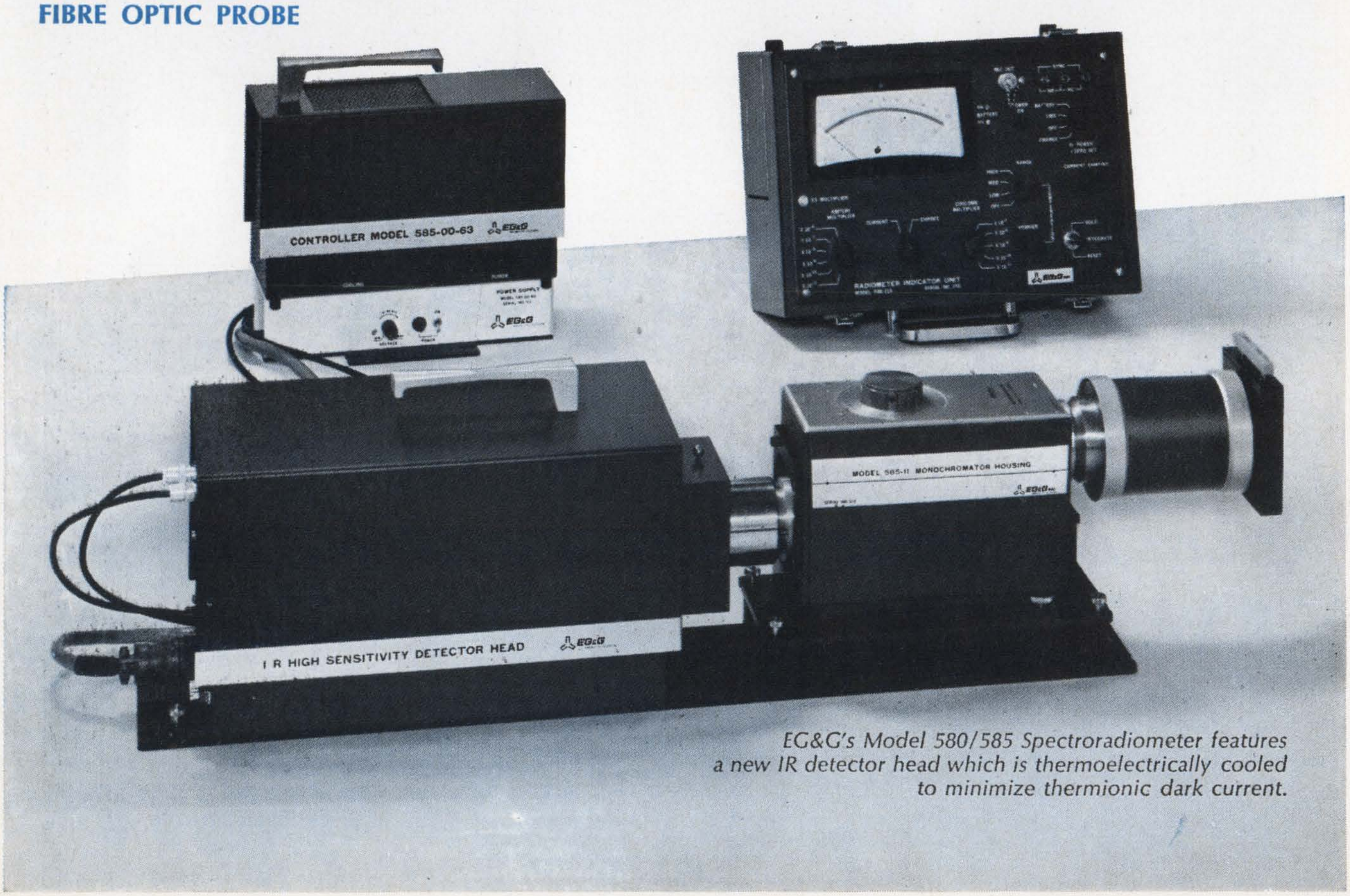

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