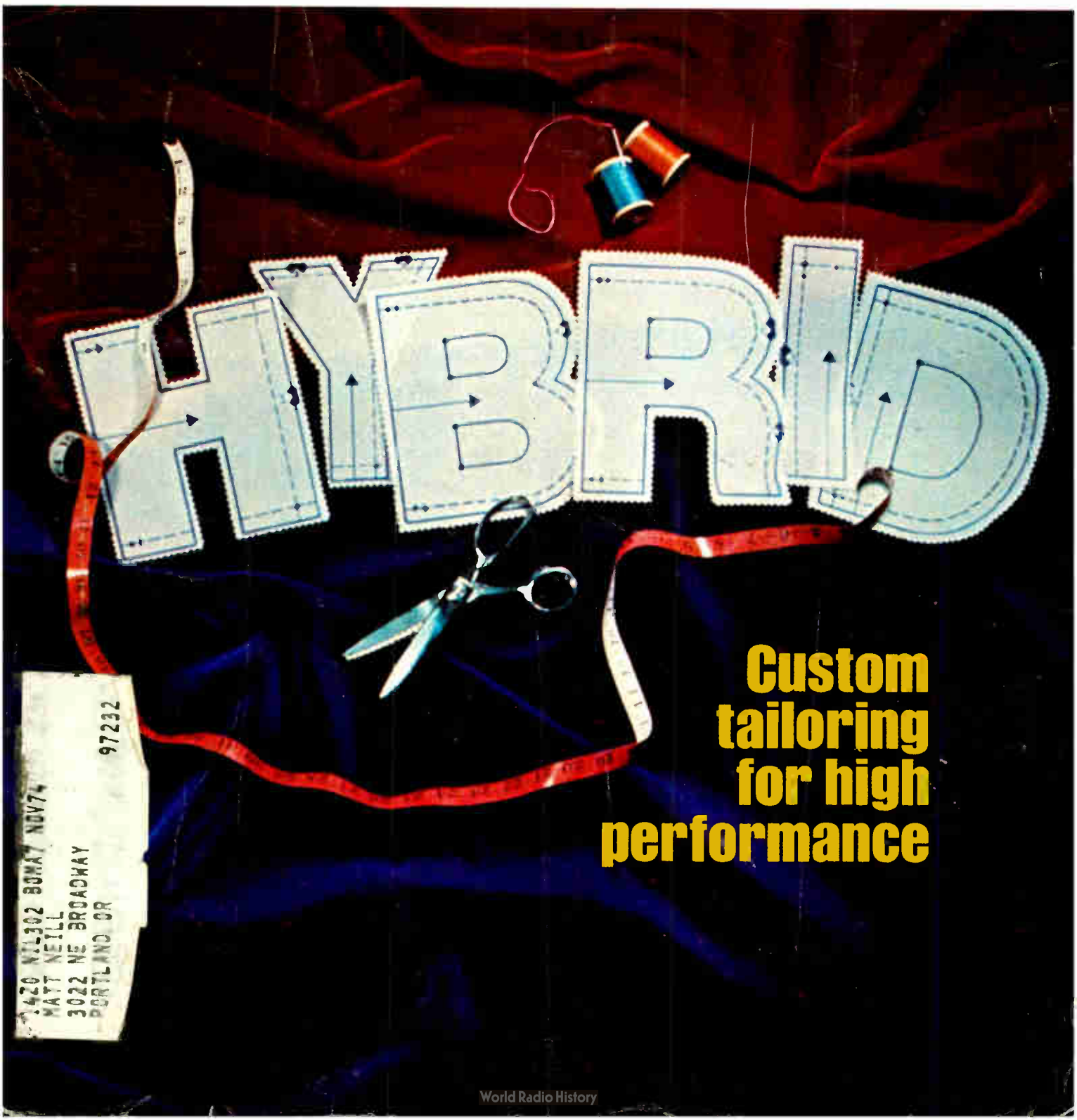


- 69 A mixed prognosis for computer-output microfilm
- 109 Sixteen-bit minicomputer breaks \$1,000 barrier
- 117 Standard C/MOS ICs: versatile grist for designer's mill

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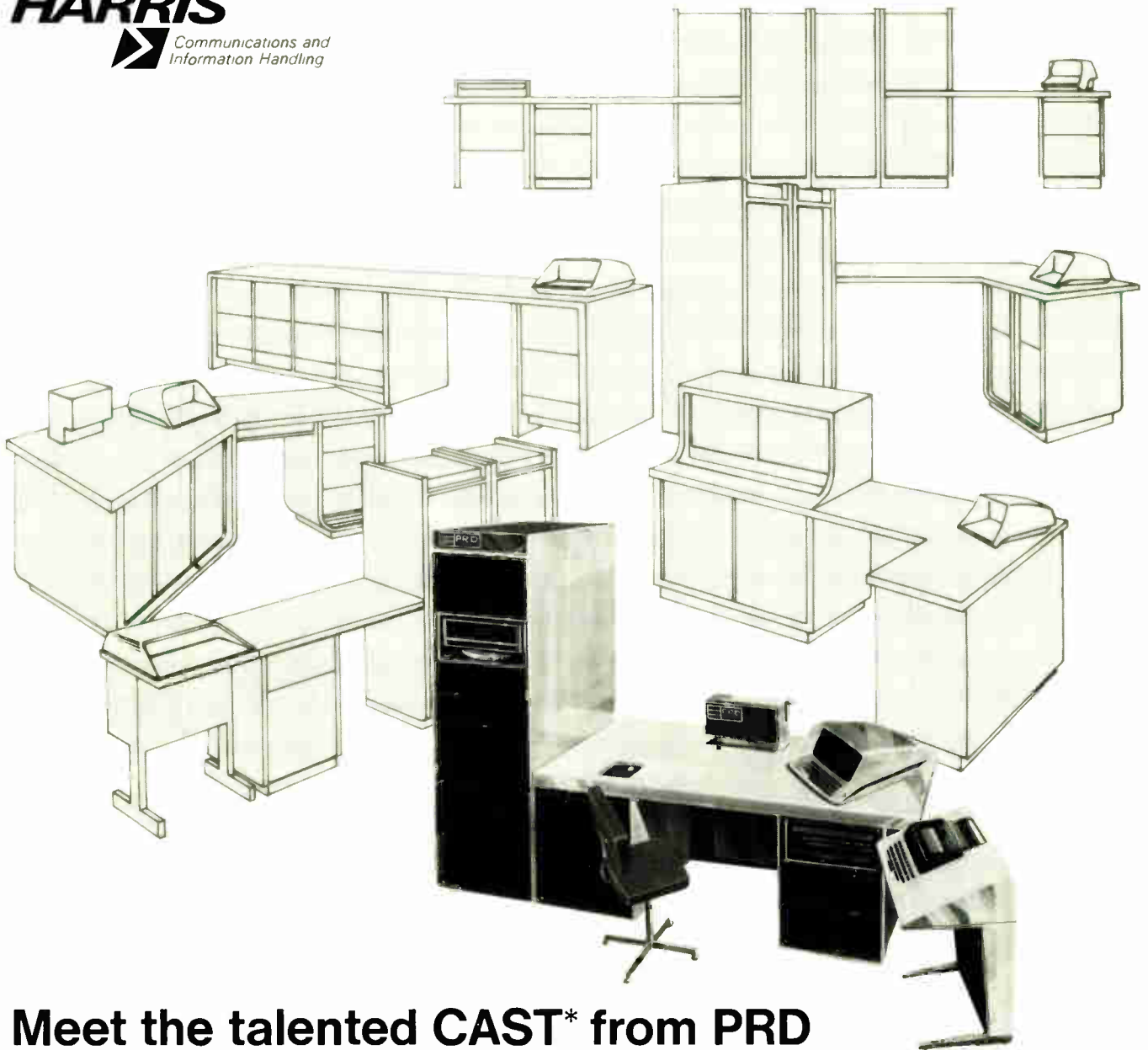
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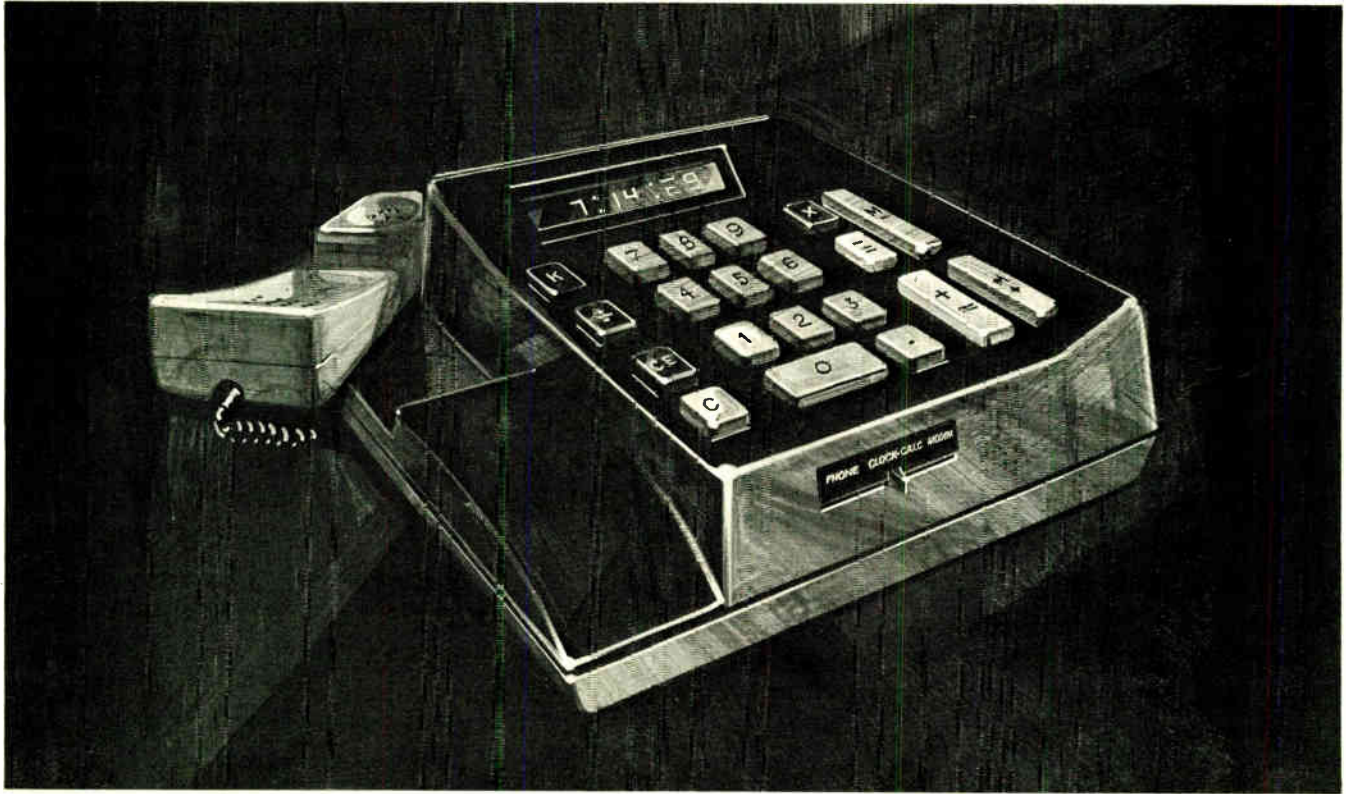


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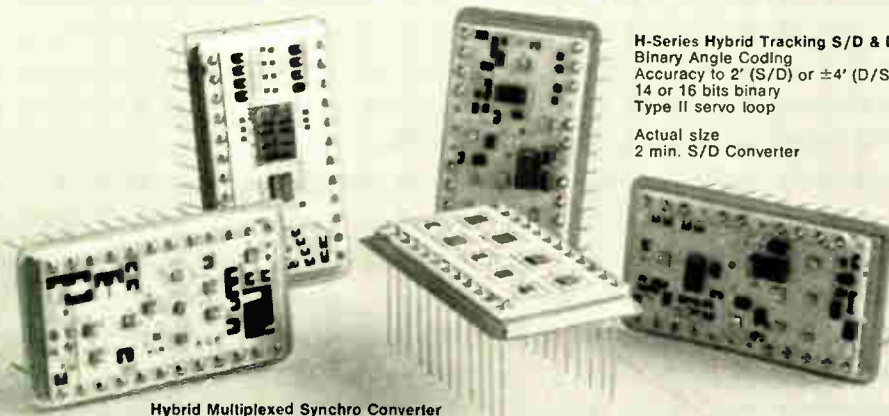
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## Electronics review

COMPUTERS: Toshiba microcomputer challenges U. S. machines, 39  
Copiers mated with computer, 40  
SPACE ELECTRONICS: Comsat technique ups station capacity, 40  
INSTRUMENTS: Fast scan converter can be time-shared, 41  
Pocket slide rules get price push, 42  
PRODUCTION: DuPont mixes gold pastes for hybrids, 42  
AVIONICS: High-angle approach means new avionics, 44  
DISPLAYS: Sony's SSD scheme makes cheaper GaP, 46  
CONSUMER ELECTRONICS: Uhf alternatives proposed by FCC, 46  
TRADE: Curbs on Nixon trade bill sought by industry, 48  
NEWS BRIEFS: 51

## 62 Electronics International

JAPAN: Gas plasma cleans and etches IC wafers, 62  
FRANCE: Portable radar brings in the helicopters, 62  
JAPAN: A new low calculator price: \$38, 63

## 69 Probing the News

PERIPHERALS: Computer microfilm pushes forward, 69  
COMPANIES: C-MOS goes to sea—from Switzerland, 72  
COMMERCIAL ELECTRONICS: European TV automating fast, 74  
COMPANIES: The kit isn't what it used to be, 80

## 89 Technical Articles

SPECIAL REPORT: Hybrid technology solves tough design problems, 89  
DESIGNER'S CASEBOOK: Ice warning indicator for cars, 106  
Single-supply reference source uses self-regulated zener, 107  
Eliminating offset error in sense amplifiers, 108  
COMPUTERS: Low-cost mini opens up new system opportunities, 109  
ENGINEER'S NOTEBOOK: C-MOS minimizes the size of oscillators, 117  
C-MOS holds down parts count for digital clocks, 118  
Generating pulses with C-MOS flip-flops, 119

## 123 New Products

IN THE SPOTLIGHT: Chopper-stabilized op amp fits in DIP, 123  
PACKAGING & PRODUCTION: IR scanner spots failure modes, 124  
SEMICONDUCTORS: IC company enters module market, 128  
DATA HANDLING: Laser provides 20-mile data link, 137  
COMPONENTS: 3-ampere relay has low profile, 145  
MATERIALS: 148

## Departments

Publisher's letter, 4  
Readers comment, 6  
40 years ago, 8  
People, 14  
Meetings, 30  
Electronics newsletter, 35  
Washington newsletter, 53  
Washington commentary, 54  
International newsletter, 65  
Engineer's newsletter, 121  
New literature, 150  
Personal Business, 155

## Highlights

### The cover: The tailor-made circuit, 89

Stimulus from the military, as well as the specialized requirements of the communications, computer and instrumentation industries, have pushed custom hybrid circuits to new technological heights. Contributing to their increased versatility and performance are the recent advances in thick and thin films and in monolithic ICs.

### The coming of COM, 69

Computer output on microfilm is catching on slowly for off-line terminals. But it is having some difficulty in living down its early, overblown image as the ultimate answer to the paper problem.

### Stripped-down mini scales up demand, 109

"An elastic market" is the economist's term for the way in which minicomputers more than double their sales every time they halve in price. Latest example of this trend is a low-cost, 16-bit minicomputer on a single pc board, which executes most instructions in 4.8 to 9.6 microseconds and performs well enough to satisfy most applications.

### Chips in a DIP for a chopper-stabilized op amp, 123

Till now either a bulky module or an array of discrete devices, the chopper-stabilized operational amplifier has at last been packed into a standard 14-lead dual in-line package. The circuitry is divided between two chips, one bipolar and one MOS. Coming soon is a single-chip version.

### And in the next issue . . .

Automotive electronics . . . digital storage for a better low-frequency spectrum analyzer . . . the ins and outs of laser trimming.

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While computers on a chip, 4,096-bit semiconductor-memory chips, and other high-density integrated circuits are grabbing the spotlight, a lot of work is still being done using that old stand-by approach, the hybrid IC.

In fact, as Larry Altman, our Solid State Editor, points out in the special report starting on page 89, hybrid ICs make sense when high performance with short production runs is the goal. What's more, the cost advantages of thick-film techniques, the close tolerances possible with thin films, and today's improved materials and more sophisticated active and passive circuit elements all add up to a workbench full of design tools that are hard to beat with monolithic IC methods.

And, just as is the case with many other segments of electronics where developments in one discipline have fostered progress in another, the rapid growth of monolithic techniques helped spur advances in hybrid technology. So now, far from being shunted aside by the more glamorous monolithic circuits, the oldest IC fabrication method is really coming into its own.

When is dividing by two equal to multiplying by ten? When you are designing minicomputers, according to the authors of the article on how one company cut the cost of a 16-bit minicomputer to less than \$1,000. The story on how they did it, using MOS technology and large-scale integration, appears on page 109.

But back to the slightly tortured mathematics—which has relevance all across the electronics scene. The authors, Ken Gorman and Phil

Kaufman of Computer Automation Inc., point out that halving the price of a minicomputer does much more than double the sales. They say: "Indeed, history has shown that an order-of-magnitude increase in demand is a realistic expectation." And that's not just true in minicomputers but just about every growth area in electronics.

Perhaps even more significant is the time frame involved in this price drop. The company's previous model, the one on which the new machine is based, is only two years old. Even for the electronics field, that's fast turnaround.

Not only is electronics a pervasive technology, it is a worldwide one as well. Just take a look at the variety of international stories in this issue. Leading off the main news section, *Electronics Review*, is a microcomputer story (see p. 39) by our correspondent in Japan, Charlie Cohen, the only full-time electronics reporter stationed in Tokyo for an American magazine. Then, two out of the four stories in the Probing the News section came from Europe. One tells about the plans of a marine electronics maker in, of all places, land-locked Switzerland (see p. 72). The other chronicles the fast pace of European broadcast-station automation (see p. 74). Both, by the way, came from our Paris-based Managing Editor, *International*, Art Erikson. Finally our regular *Electronics International* section has more stories from overseas.



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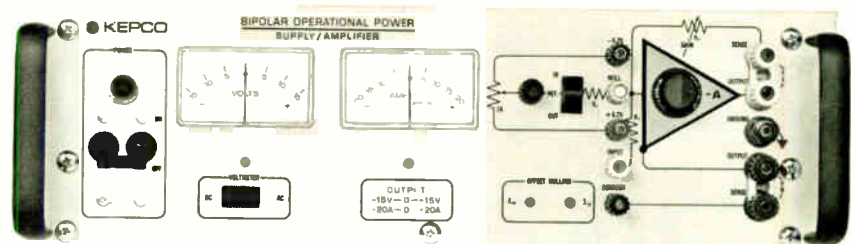
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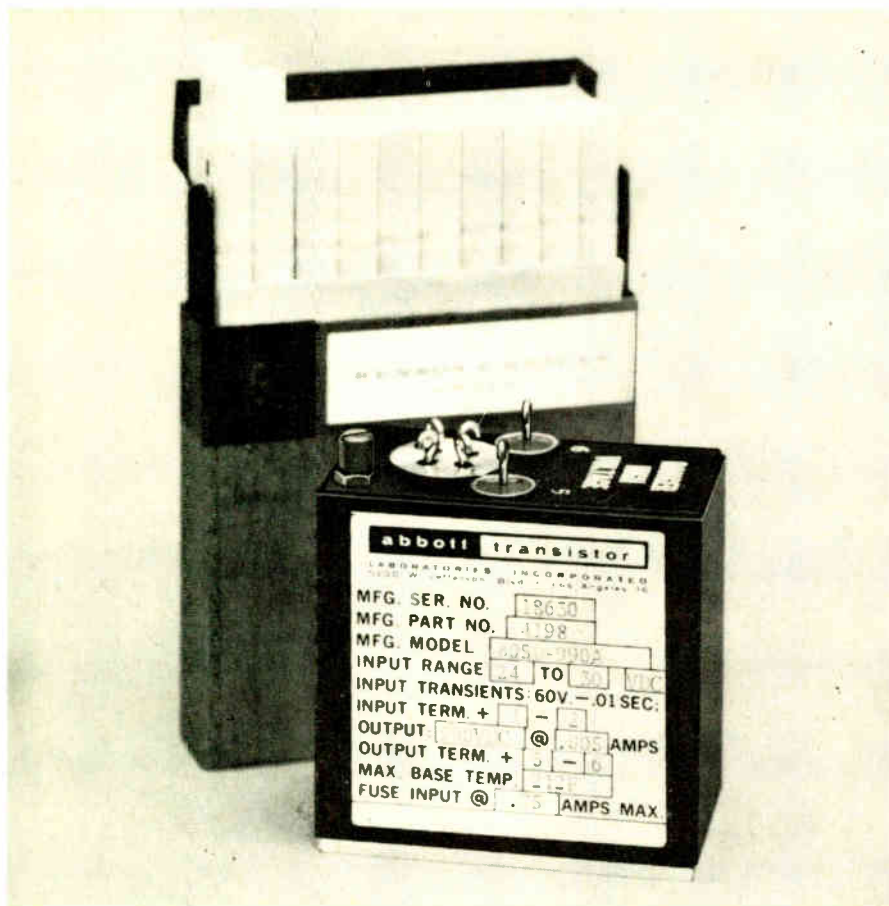
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## Readers comment

### Boella effect

**To the Editor:** The article "Matching oscilloscope and probe for better measurements" by Vic Bunze (March 1, p.88) makes a common mistake in an otherwise clear and concise treatment of loading errors. The author states: "Purely resistive loading effects, of course, are independent of frequency." This is true, but not as useful as one might hope, since "pure resistances" are hard to come by. What has been overlooked is the "Boella effect," first described by M. Boella in 1934, and later extended by C.W.O. Howe, Pavlasek and Howes, and others.

Essentially this effect, which is attributable to the distributed capacitance of a resistor, causes the effective parallel resistance to decrease as the frequency is increased. Although the original work was on carbon composition resistors, the same effect applies to film-type resistors such as those used in the probes under discussion. A typical 1 megohm film resistor will have an actual rf resistance of about 700 kilohm at 10 megahertz, falling to about 250 kilohm at 100 MHz.

This change in resistance with frequency must be considered when discussing high-frequency loading effects, particularly when measurements are made on high-impedance circuits. One obvious example would be a parallel-tuned circuit, where the Q easily could be degraded by the lower-than-expected loading resistance.

Wallace F. White  
Applications Engineering Manager  
Boonton Electronics Corp.  
Parsippany, N.J.

■ *The author replies: The observation regarding the Boella effect is quite correct. The degraded input resistance could detune a high-Q circuit at high frequency. However, long before this occurs the normal shunt capacitance of a typical divider probe would create loading orders of magnitude greater than that caused by the Boella effect. Hence, while it is true that divider probes do not have a purely resistive component at high frequencies, this is rather academic because of the ruinous effects of the shunt-capacitance of the probe.*



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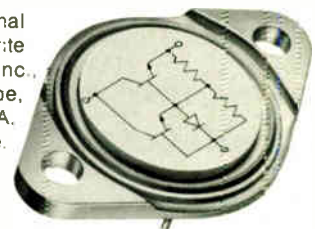
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With events at Washington moving in the direction of industry control and government partnership in industry, it is likely that the radio manufacturers will shortly be called upon to set up a Code of Fair Competition under the expected new law. For this the instrumentality will undoubtedly be the Radio Manufacturers Association, which now has imposed upon it new responsibilities and opportunities such as never before. With the radio industry's Code of Fair Competition approved by the President, or by his delegated Radio Administrator (or "radio dictator"), the burden of price competition will then be lifted off the radio industry, and manufacturers and engineers can turn once more to their prime job of improving service and quality.

This will leave the radio engineers free to develop better technical equipment,—instead of engaging in price-whittling and quality-degradation which has been the sole theme in most engineering offices for twelve months past. It is to be hoped that the Institute of Radio Engineers will seize this opportunity to exert leadership in co-ordinating the work of radio engineers to produce a better complete radio system, all the way from microphone, through transmitting station, to the listener's set and speaker. This task of designing and engineering the whole chain, as well as its individual links, can become a timely theme at the Chicago Convention this month.

Encouraging signs are in the air—despite the long continued efforts of the radio industry to ruin itself on the rocks of squeak boxes made of tin. Not only is automobile radio on the up and up; not only are there signs of a revival of interest in high quality reception; but there is evidence that such reception will soon be possible in spite of the smallness of the sets now merchandised to virtual exclusion of consoles. And looming largely is the heretofore unheard-of vision of Government fostering, demanding, insisting on the radio industry cooperating within itself.



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For product or sales information, call the AMD sales representative nearest you. In Sunnyvale, Shel Schumaker at (800) 538-7904 (toll free from outside California) or (408) 732-2400; in the eastern United States, Steve Marks or Bill Seifert at (516) 676-4500; in Washington/Baltimore, Ken Smyth at (301) 744-8233; in Mid-America, Chuck Keough at (312) 297-4115; in the Los Angeles area, Steve Zelencik or Russ Almand at (213) 360-2102 or Larry Strong at (213) 870-9191; in the United Kingdom, Des Candy at Herne Bay (Kent) 61611; and in Germany, Hermann Lichotka at (0811) 594-680.  
Advanced Micro Devices is distributed nationally by Cramer and Hamilton/Avnet Electronics.

# tant attempt to get all business we can:

## Low power RAM

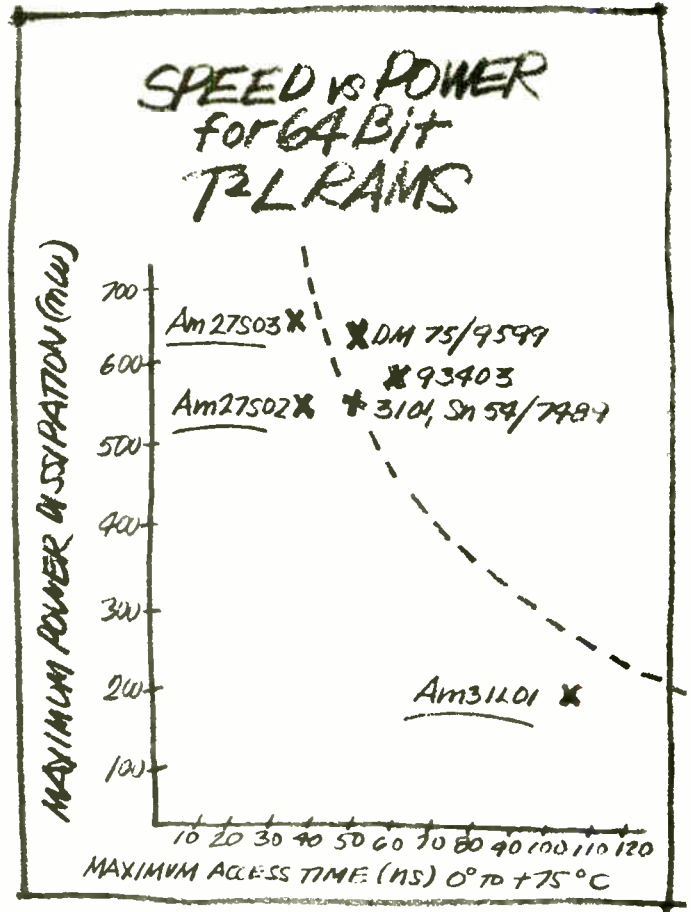
We've got a great low power 64-bit RAM, too.

Our very own Am31L01.

It offers all the advantages of low power (185 milliwatts, maximum) while maintaining a respectable 105 nanosecond maximum access time.

The Am31L01 comes in both military and commercial temperature versions with open collector outputs and is available in any kind of package you can name.

And while it goes without saying that the Am31L01 is built to MIL-STD-883 and that we guarantee its specs over the full temperature range, we'll say it anyway.



# Advanced Micro Devices, Inc.

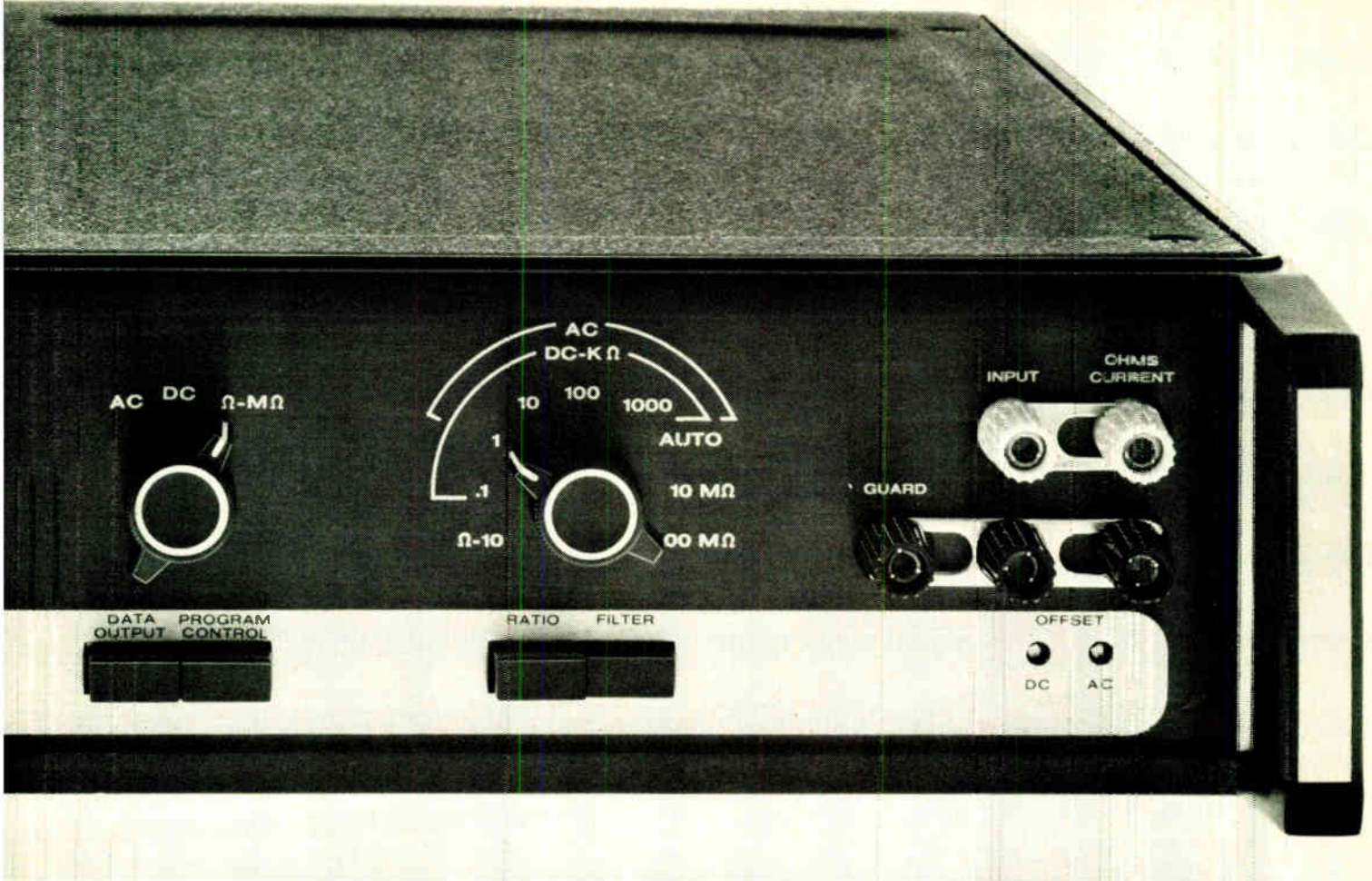
(If you need anything else, ask us.)



THE INCREDIBLY FAST 5900+. 100 READINGS PER SECOND IN THE 4½ DIGIT MODE.

**You can either make it better.  
Or you can make it cheaper.**

**Now, do both.**



*The challenge infuriates an engineer. Excellence cannot traditionally be compromised by economics. But if you can't afford it, you won't buy it. So sometimes we have to do both.*

*Above you see one of the "plus" machines from Dana. "Plus" because it is truly a better machine. And "plus" because it is priced to give you a new level of quality for the money.*

### **The 5900+. A new standard.**

This new unit may well be the world's most accurate and stable 5-digit multimeter.

It delivers 0.001% total accuracy.

It has 350 volts RMS protection on all ohms measurements.

It provides true systems capability. It has 5 DC ranges, 60% overrange, and full ratio capability. Its basic price is \$1795. Nothing at that price is comparable in accuracy and quality.

### **The 5000+ DVM. The price is lower. The standards aren't.**

This new DVM is the lowest priced 5-digit multimeter we've ever produced. Yet because it was engineered and built by men who have been dealing with units costing ten times as much, the 5000+ reflects their standards.

It is absolutely reliable. (Silicon solid state circuitry plus LED display.)

It has 5 DC ranges capable of measuring from 1  $\mu$ V through 1000V.

It offers autoranging in all functions and 100% overranging on all ranges.

It's available as a complete multimeter. Its basic price is \$995. Nothing with its features and its quality is available for the price.

Examine these products and study their incredible performance/price. Contact Cliff Hamilton at Dana Laboratories, Inc., 2401 Campus Drive, Irvine, California 92664. Or call collect at (714) 833-1234. Ask him about these plus machines.

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## People

### McGurk's other CIA takes on giant IBM

Dan L. McGurk, who describes himself as an old war horse that "has fought IBM a long time," is president of the Computer Industry Association, a relatively new group that "wants to bring the light of day to what's happening in litigations" involving IBM.

The CIA—and McGurk makes no apology for those initials—is headquartered in Encino, Calif. Its members to date are peripherals makers, software and leasing companies, and at least one minicomputer manufacturer. McGurk, one-time president of Xerox Data Systems, spends a good deal of time traveling from the Los Angeles area to New York City and Washington, D.C. The association maintains volumes of information in New York and California on the Justice Department's anti-monopoly suit against IBM, as well as on the Telex Corp. suit that has brought top IBM officials into the news recently for their testimony.

**Attack.** McGurk's testimony before the Senate subcommittee on antitrust and monopoly last month was another association effort to focus attention on the problem of the dominance of IBM in the computer industry.

McGurk went on record as believing that when a few companies dominate an industry, new technology may be curbed, U.S. exports could be hurt, and imports invited. He said the computer industry has some of these problems now, and was especially vocal about the threat of foreign competition.

"My own experience and observation," he told the subcommittee, "have led me to believe that the very large corporations that are characteristic of concentrated industries normally have serious inefficiencies in production, development, administration and distribution. These inefficiencies invite foreign industries to compete effectively both in the United States and throughout the world."

McGurk's background, including



**Foe.** Dan McGurk says restructuring IBM would be good for the computer industry.

his more than five years at the former XDS, lends clout to a young organization. The CIA was formed in June, 1972, by a group of peripherals companies with sales between \$50 million and \$100 million.

**CIA informs.** McGurk regards competition and industry structure as the first major problem facing the association, hence CIA's desire to make available as much information as possible on the various litigations involving IBM—through the New York and Encino files, a newsletter called "On Line" that digests computer industry news, and a campaign that includes his testimony that IBM could be "reorganized with a facility that might amaze some."

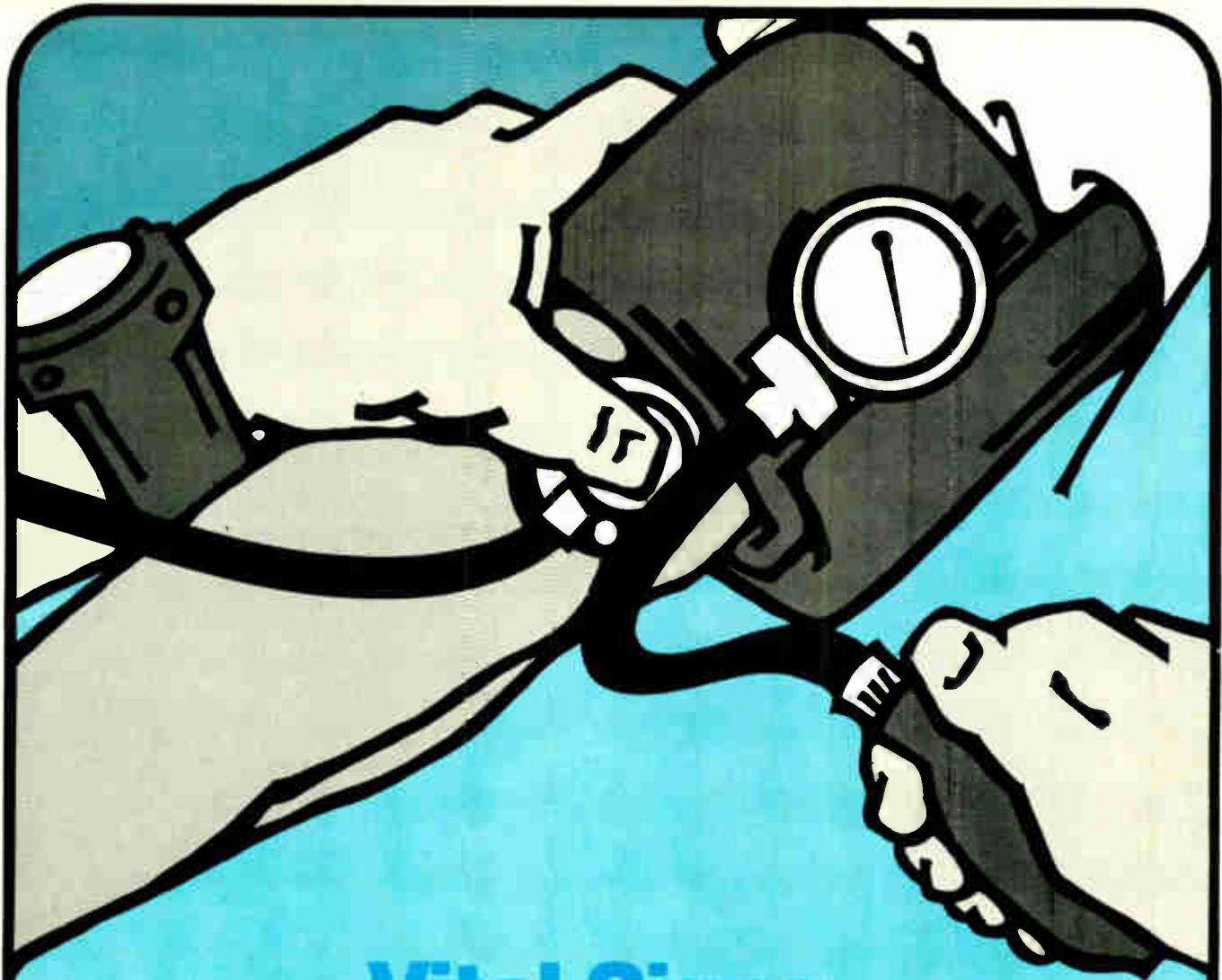
McGurk believes a restructuring of IBM into seven full-range computer companies would be good for the economy. He thinks, though, that now that the Computer Industry Association is a going thing, he'd rather not be the standard-bearer too much longer. "I hope to get back to tennis and investments," says the well-tanned 46-year-old resident of the Los Angeles area.

### Poppa is new head of peripherals firm

Pertec Corp. has found a chief to replace founder Harold Kurth, who left last fall after a revolt of the palace guard. The company's new president, Ryal R. Poppa (PAH-pay), has an impressive background. Formerly executive vice president of Mohawk Data Sciences Corp., Poppa takes over Pertec just as it returns to the decentralized organization that Kurth had abandoned in a move that precipitated his eventual departure.

Pertec is best known for its pe-





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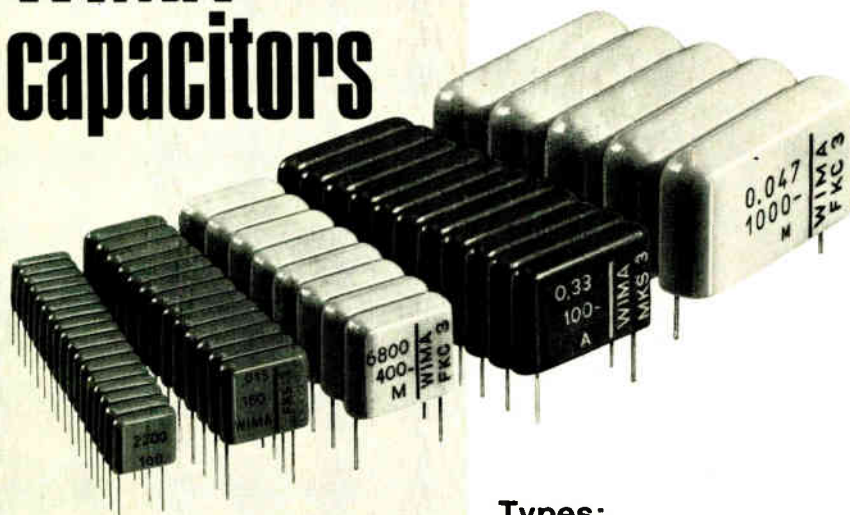
EMR Systems are used with confidence wherever important real-time decisions are being made . . . decisions which require critical evaluation of "vital signs."

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a. c. characteristics.  
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**WIMA MKS 3** Metallized polyester capacitors for 100 and 250 V d. c. 0.022  $\mu$ F... 0.47  $\mu$ F.

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**WIMA FKS 3** Polycarbonate film and metal foil capacitors suitable for frequency divider circuits. Close tolerances available. 160, 400, 630 and 1000 V d. c. 100 pF... 0.1  $\mu$ F.

**WIMA FKS 2 min.** Polyester film and metal foil capacitors, subminiature, suitable for very small equipment. 100 V d. c. from 100 pF... 0.047  $\mu$ F.

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## **People**

ipherals (the source of the name). First came tape drives, then disks, and, most recently, printers. Its expanding non-peripheral lines include key-to-tape and computer-output microfilm equipment. Unlike many troubled companies in the computer industry, Pertec has shied away from direct competition with IBM and instead has concentrated on OEM and "semi-OEM" business—supplying key-to-disk systems that the Singer Co. markets with its extensive sales staff.

Poppa says that he came to Pertec because it is involved in the data processing industry and "has the long-term prospects of becoming a \$500 million company." But that's a long way from the present \$25-30 million annual rate.

Poppa has been involved in the data processing industry for 22 years. That is pretty surprising since he's only 39, but "I started by running tab gear in college [Claremont College in California]," he says. While there, he was also studying the industry, and that led to his joining IBM where he worked for 11 years in the southern California area. He also served as president of Greyhound Computer Corp. and in a similar position at DPF Inc., a \$45-million-a-year computer leasing firm.

Poppa doesn't have as much time as he'd like for such leisure time pursuits as skiing, golf, tennis, and motorcycling or a quieter pastime: woodworking. He has built everything from lamps and cabinets to whole rooms and also enjoys sculpting: "I find it very satisfying and relaxing to work with wood."

**New Pertec president.** Ryal R. Poppa believes the peripherals firm can become a \$500-million-a-year company.



JUNE, 1973

## in this issue

Statistics right at  
your fingertips

Real-time software  
for large or small systems

Three scopes in one

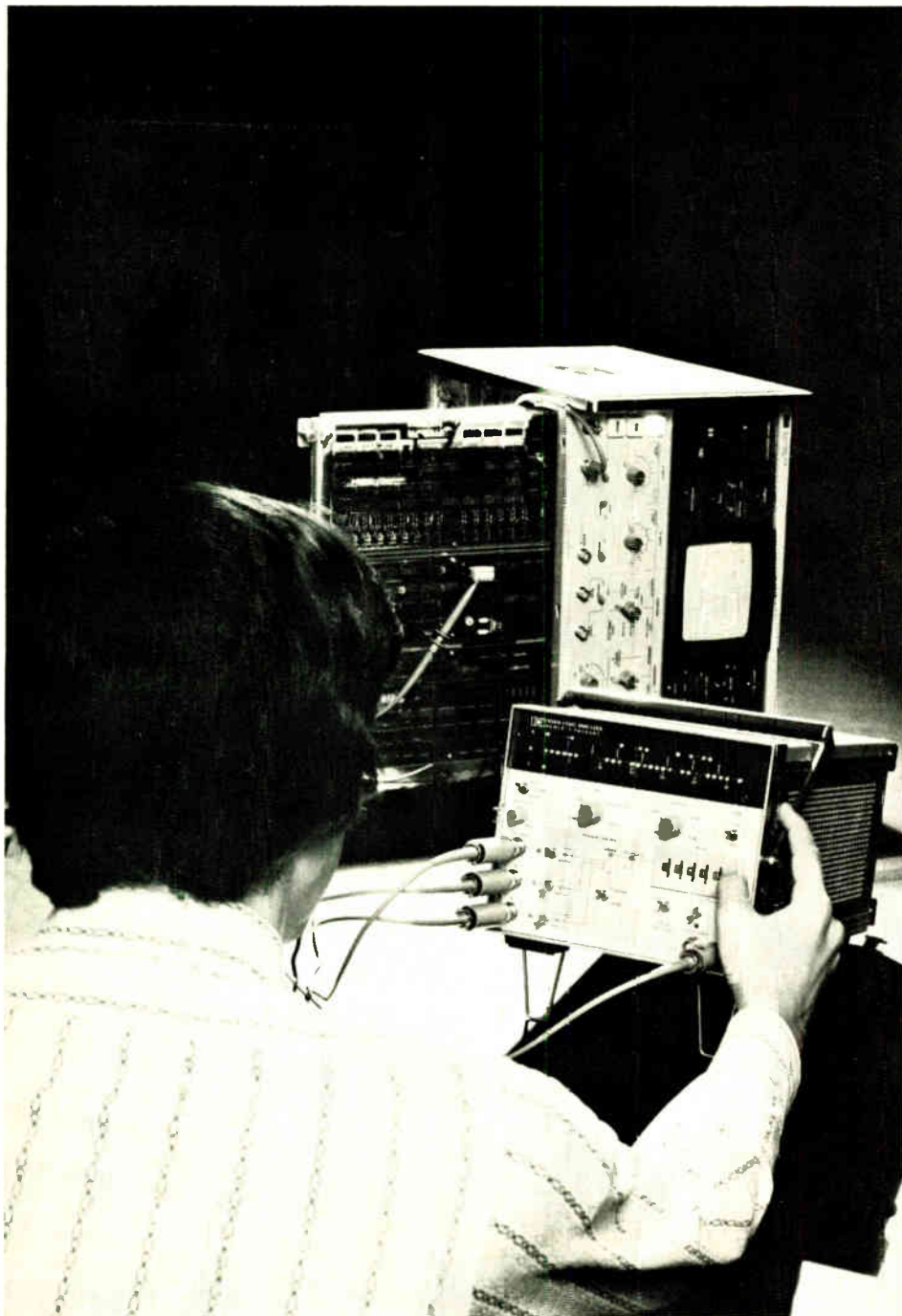
## New HP logic analyzer solves digital problems

The new 5000A logic analyzer checks  
digital signals from a correlator

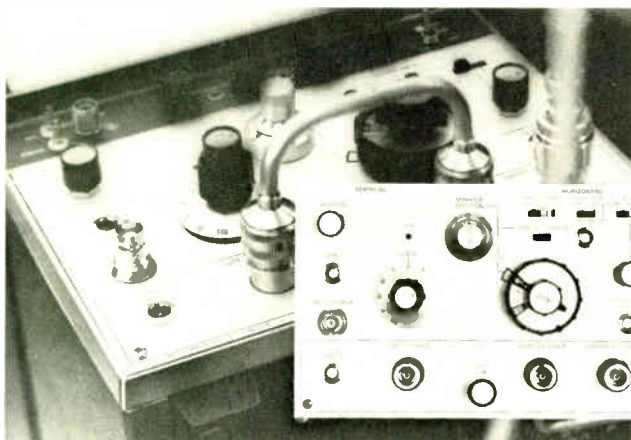
Until now, bit watchers have attempted to extend their analog oscilloscopes to their digital problems. HP's new 5000A logic analyzer brings a new dimension to the study of logic states vs. time. Now, single-shot bit streams are captured automatically and stored indefinitely. Long digital sequences can be analyzed precisely because the 5000A delay is digital, locked to the clock of the system under test. And a catastrophic event may be used as a trigger source; the analyzer can even display information that preceded this trigger event.

The 5000A logic analyzer displays 32 clock cycles for each of two data channels (or 64 clock cycles for a single channel). The display is by bit—i.e., the analyzer's 32 LEDs per

*(Continued on page 4)*



# Detect cable faults less than 1 inch apart



The 1818A time domain reflectometer is easy to use and extremely practical for field measurements

Time domain reflectometry is used to check transmission systems, components and terminations. Now, HP makes it easy for you; merely insert a low-cost, 170-ps TDR plug-in into any 180 series oscilloscope main-frame. You get quick, accurate displays on cable lengths up to 1000 ft (300 m).

A time domain reflectometer displays reflected voltages caused by discontinuities in a transmission line. The display shows the location, magnitude and nature of each impedance discontinuity. HP's 1818A

plug-in resolves discontinuities less than an inch (2.54 cm) apart, so you can pinpoint problems in a long cable without having to physically examine the entire cable length. Because it is so compact, this lightweight wideband TDR system is especially useful for checking shipboard, airborne or remote communications equipment.

*For details and specifications, check B on the HP Reply Card.*

# System monitors spectrum automatically



Spectrum surveillance and monitoring using a van-mounted 8580B is thorough and accurate.

The HP 8580B automatic spectrum analyzer, a fundamental measurement tool for a broad range of applications, can be augmented with optional equipment to optimize spectrum surveillance and monitor-

ing. The 8580B collects and analyzes large amounts of data and can operate unattended.

Performance is further enhanced by a new set of optional preselector/preamplifier units covering 0.1 to 18 GHz in three bands. They increase system sensitivity by 15 to 30 dB, eliminate unwanted responses, and reduce intermodulation distortion caused by strong out-of-band signals. These features also permit the automatic spectrum analyzer to make rapid and accurate EMI/RFI measurements.

*For full information, check K on the HP Reply Card.*

# New multimeter, display for modular instrument

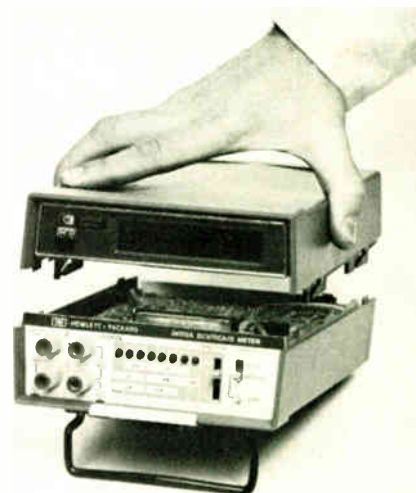
Two new "snap-on" accessories—a high-sensitivity multifunction unit and a 5½ digit display—enhance HP's 3470 measurement system. The 3470 system consists of five compact instruments that fit together in various combinations to form a digital voltmeter, a multimeter, a battery-operated field instrument, or a digitizer with BCD output.

The new 34703A dc/dca/ohms meter features six dc voltage ranges from 10 mV to 1000 V full scale, six dc current ranges from 1  $\mu$  A to 100 mA full scale, and eight resistance ranges from 1  $\Omega$  to 10 M  $\Omega$  full scale. Basic sensitivity is 1  $\mu$  V in dc voltage. Overranging is 100% on all functions and ranges, except 20% on the 1000 V range. Besides overranging, the multimeter features fast autoranging (< 250 ms) and a new self-test feature that performs 16 different tests on the internal circuitry.

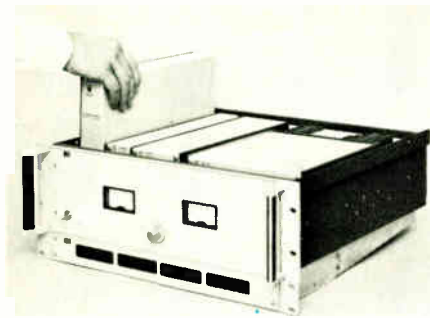
Snap the new 34750A display module on top, and your answers appear on a 5-1/2 digit display.

*For more information, check E on the HP Reply Card.*

With these two modules, the 3470 measurement system now has seven different instrument combinations.



## New flexible dc power supplies for OEM



OEM supplies come in  $\frac{1}{8}$ ,  $\frac{1}{4}$  and  $\frac{1}{2}$  rack widths; you can choose any combination up to a full rack width.

Need a multiple output dc power system that you can plug in and forget? HP's new family of modular power supplies and rack accessories lets you choose from over 50 different standard models (both 62000 series linear and 62600 series transistor-switching types) with ratings from 3V to 48V. That includes the most popular ratings, such as: 5V at 2, 4, 8, 16 and 40A; 12V at 1.5, 3.6, 12 and 23A; and 15V at 1.25, 2.5, 5, 10 and 20A. To supplement these standard ratings, HP uses an interactive computer-aided design system to produce a quantity of supplies with special output ratings.

To complete your power system, just add a 19-in. (48 cm) rack mounting tray, front and rear panels, and slides. The rack tray accommodates any combination of modules totaling a full rack or less. There's plenty of room behind the front and rear panels to add wiring for meters, switches, controls, terminal blocks and fuse holders. You can choose one of several standard panels, modify low-cost blank panels on your own, or let us build the complete system to your specifications. If you need extra cooling, a compatible cooling unit mounts directly below the rack tray and blows room-temperature air up into the power supplies.

OEM and quantity discounts are available. For more information, check P on the HP Reply Card.

## New systems minicomputer is microprogrammable

For greater microprogramming convenience, add the 12908B writeable control store option to the 2100S. Two WCS cards, each containing 256 24-bit words of storage, can be plugged directly into the computer.



Now, HP offers a minicomputer with built-in "extras" including microprogramming. Extended arithmetic instructions, floating point hardware, dual-channel direct memory access, power fail interrupt, memory parity check, and memory protect—they're all built into the new 2100S computer. A programmable time base generator, communications control channel, and 16K words of 16-bit memory are also standard.

You can run programs in assembly language, FORTRAN, BASIC or ALGOL. A full range of software systems are available for batch processing, real-time, time-sharing,

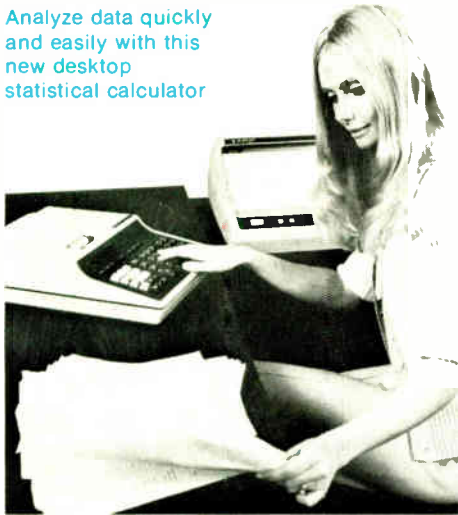
data acquisition, and automatic testing.

Because the 2100S contains an efficient microprocessor (a computer within the computer), you can write and store microprograms to suit your application and save valuable memory space. With this 196-ns microprocessor, critical sub-routines are executed 5 to 10 times faster than if you use conventional software.

For more on our new "mini," check D on the HP Reply Card.

# Powerful new calculator makes statistics easier

Analyze data quickly and easily with this new desktop statistical calculator



Should you need to analyze research data, HP offers a new dedicated statistics calculator that solves many basic statistical problems with a single keystroke. The new 9805A desktop calculator has a solid-state memory similar to those used in computers. The built-in printer uses standard adding machine paper tape; it prints ten digits plus

the sign, and up to six places to the right of the decimal point.

With the 9805A, you can:

- Calculate and plot a complete histogram with normal curve overlay.
- Fit curves using linear, parabolic, power, exponential, and logarithmic regressions. The plotting option lets you plot these curves with labelled axes.
- Calculate mean and standard deviation.
- Calculate  $t$  for both paired and unpaired data.
- Calculate one way analysis of variance for any number of data groups.

Other built-in functions include percentage,  $1/x$ ,  $x/12$ ,  $1n x$ , logarithms, exponentiation, and grand total accumulation. Options include 10-digit display, plotter compatibility, and additional statistical calculations.

For more information, check O on the HP Reply Card.

## RF signal generator has synthesizer precision

Fully-calibrated AM, FM and CW signals with synthesizer accuracy, stability and spectral purity are under your fingertip control with the HP 8660B synthesized RF signal generator. Keyboard entry of frequency settings (with LED readout) plus swept and manual tuning provide operating flexibility that's truly unique in signal generators. RF plug-ins are available with these frequency ranges: 10 kHz to 110 MHz, 10 kHz to 160 MHz, and 1 MHz to 1300 MHz. All offer 1 Hz resolution.

Some key performance characteristics are:  $3 \times 10^{-8}$ /day frequency stability, -80 dB spurious (at most frequencies), < 1.5 Hz residual FM, and calibrated output levels from +10 to -146 dBm. All functions—frequency, output level, even modulation—can be remotely programmed, which makes the 8660 a natural choice for automatic test system applications.

For details and specifications, check L on the HP Reply Card.

If your requirements call for precision generation of signals in the frequency range between audio and UHF, there's an 8660 configuration that will fill your needs.

(Continued from page 1)

channel represent 32 successive clock cycles of the system under test. The LEDs turn on for a logic "high," and turn off for a logic "low".

To view data beyond the first 32 bits after the trigger, use digital delay to bring it into the analyzer's display. (Up to 999,999 bits of delay can be used.) If the data of interest is before the trigger, up to 32 bits of negative delay allows you to look ahead of the trigger event to see what has happened.

You can select any unique system event to trigger the 5000A: either

data channel; an external trigger input; or high and low combinations of the three inputs ANDed together for parallel triggering. The 5000A is compatible with all logic families—TTL, ECL, MOS, RTL, HTL and CMOS.

With this new logic analyzer, you can design, test or service digital equipment faster and more efficiently.

For more information, check G on the HP Reply Card.



## New card reader accepts any type card



The new 7260A card reader simplifies record keeping, is quiet enough for the office.

A new optical mark card reader accepts all types of punched or marked tab cards and reads them up to 300/min. You can use tab cards without clock marks or any card length from 7-3/8 in. (18.7 cm) to 11 in. (27.9 cm). It's easy, compact and quiet enough for office use, yet can run unattended under computer control. (An optional stacker is available for computerized operation.)

Data transmission rate ranges from 110 to 2400 baud. The card data is stored in buffers to optimize the feed rate for high transmission efficiency.

Besides saving computer input time, the 7260A is well suited to many applications. In hospitals, patients' lab test results can be recorded on cards then later added to medical records; the costs of the lab tests can be marked on other cards for the billing department. Schools use card data entry for student records, grades, test results, and course registration. The new card reader can also process the results of laboratory and field research.

For more information, check J on the HP Reply Card.

## New couplers for wide range swept testing

Two new broadband directional couplers add economy and convenience to swept reflection and transmission coaxial measurements. With their wide frequency coverage (2 to 18 GHz), these couplers can replace several conventional couplers, thereby reducing setup, calibration and measurement time.

Both the 11692D (dual) and 11691D (single) have at least 30 dB directivity from 2 to 8 GHz, 26 dB from 8 to 18 GHz. Coupling variation with frequency is less than  $\pm 1$  dB, and auxiliary arms typically track within  $\pm 0.7$  dB.

Precision performance and wide bandwidth make these couplers ideal companions for the HP 8755 frequency response test set, a 0.1 to 18 GHz detection and display system. You can make simultaneous swept measurements of insertion loss and

return loss with this versatile microwave measuring system.

For more information, check C on the HP Reply Card.

Make accurate reflection measurements over several octaves (2 to 18 GHz) with the 11692D dual directional coupler.



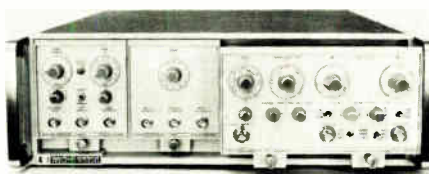
## New pulse generators test fast logic circuits

Two new pulse generators—a plug-in and an independent instrument—test modern high-speed logic circuitry such as TTL-S, ECL-I, ECL-II and MECL 10000. Each has rep rates up to 100 MHz, 5V

amplitude, variable transition times, variable offset and several output formats. A constant 50  $\Omega$  source impedance ensures minimum pulse distortions.

The new stand-alone generator, 8007B, is well suited for measuring propagation delay and testing wideband linear amplifiers. Pulse transition time can be 2 ns to 250  $\mu$ s; independent control of transition times permits ratios up to 50:1. Slope nonlinearity is below 3% above 20 ns.

Model 1916A plugs into a 1900A or 1901A pulse generator mainframe. Slope nonlinearity is under 5% above 5 ns. Like the 8007B, the 1916A output format may be positive or negative, and complementary or symmetric. In addition, the 1916A features dual output.



Both the plug-in (top) and stand-alone (bottom) pulse generators can be externally triggered and their pulse widths, externally controlled.

For details, check S on the HP Reply Card.

## New low-cost core-based real-time system

# Distributed systems: one plus one is greater than two



Now a core-based real-time system from HP

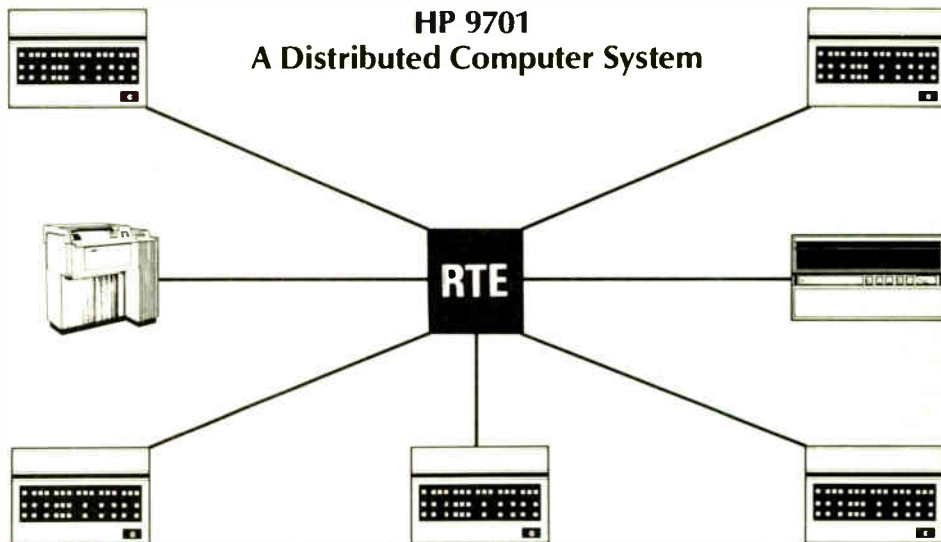
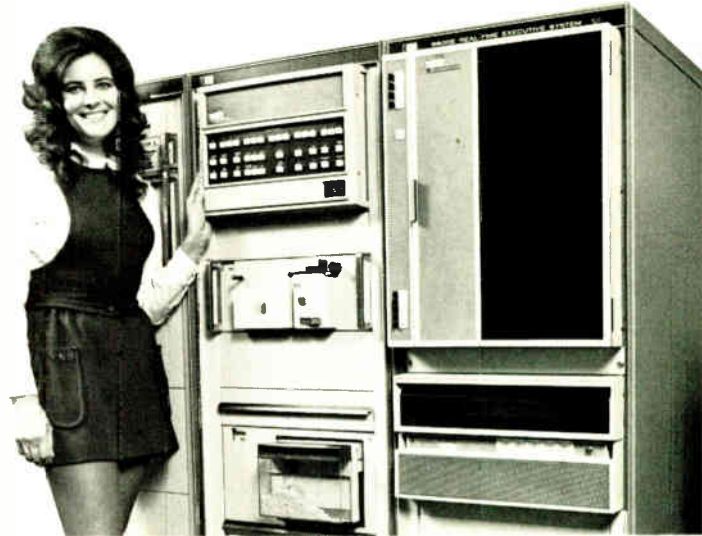
HP introduces a new real-time computer data acquisition and control system for small, dedicated applications in industry and in research and development laboratories.

Many small laboratory or testing situations require scheduling, multiprogramming and priority interrupt; but they don't need foreground and background programs or a large data base. The answer: RTE-C, a smaller low-cost version of HP's real-time executive, that provides concurrent program operations with on-line control by the operator.

System languages are HP FORTRAN and assembly language. Memory capacity is 8K to 32K words; the number of I/O channels vary from 1 to 42. And as your application grows, you can move up to a disc-based system without costly modifications to existing software.

For details, check M on the HP Reply Card.

HP's 9700 series distributed system



The 9700 distributed system concept involves satellite computers that interface with a central multiprogramming real-time information system. Remote computers can be added in modular fashion.

HP distributed systems solve many of the problems confronting multi-computer system users. In large systems, it is often advantageous to distributed computer processing over a number of independent minicomputers. The HP 9701 distributed system interface kit allocates functional capabilities to multiple remote computers that communicate with a central real-time executive by common carrier telephone lines or by cable (up to 2 miles).

Data collection, sensor-based data acquisition, automatic testing, laboratory automation, and process

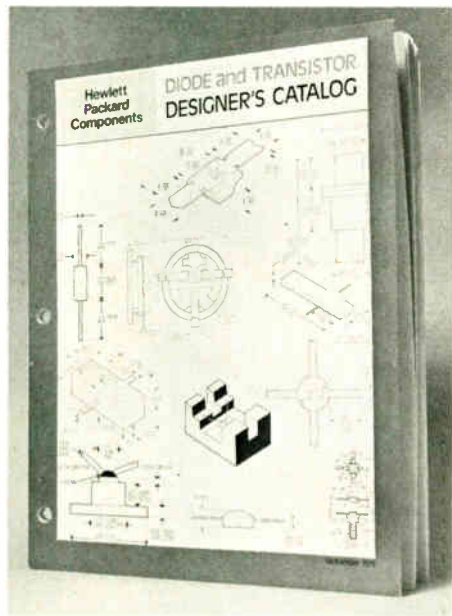
monitoring and control can be dedicated to the remote computers, while program development and storage, data management, additional data analysis, and report generation occur at the RTE information center. You can program in ALGOL, FORTRAN, or assembly language. And as your application needs increase, additional remote computers can be interfaced.

To find out how distributed systems can fit your particular application, check N on the HP Reply Card.



## HP components: new catalog tells all

Send for this complimentary catalog for component users.

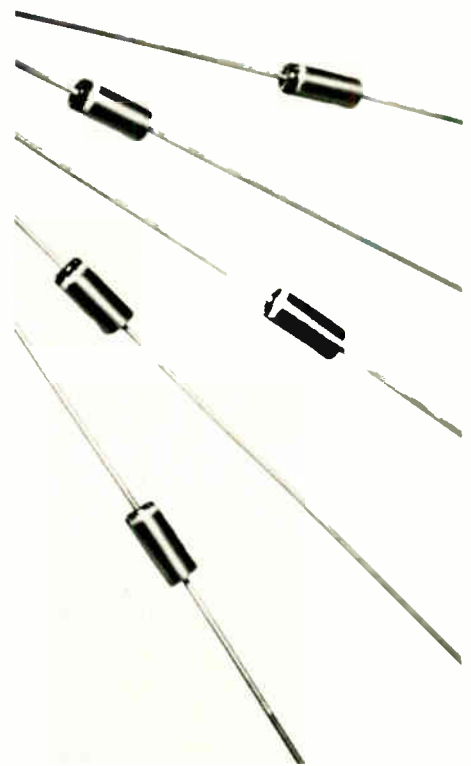


If you are a circuit designer, development engineer or instrument manufacturer, the 1973 HP components catalog should be on your desk. This 160-page "Designer's Catalog" contains complete descriptions and specifications for HP diodes and transistors, including:

- General purpose Schottky diodes
- Microwave Schottky diodes
- PIN diodes
- Step recovery diodes
- IMPATT diodes
- Microwave transistors
- Devices for hybrid integrated circuits.

For a free copy, check Q on the HP Reply Card.

## New band switching PIN diodes



The 5082-3168/3188 planar passivated silicon diodes come in an axial lead, hermetically sealed glass package.

Two new low-cost PIN diodes are available for VHF/UHF switching and general-purpose switching applications that require high performance and mechanical ruggedness. Capacitance is less than 1.0 pF at -20V, and the residual series resistance is typically .35 ohms at 10 mA.

For specifications and details, check I on the HP Reply Card.

## PIN diodes for UHF/VHF switches, attenuators

A new low-capacitance device, the 5082-3077 PIN diode is designed for RF switching, modulating and automatic gain control applications. You can use it in RF duplexers, antenna switching matrices, digital phase shifters, analog phase shifters, electronically-tuned filters, and variable RF attenuators.

Effective minority carrier lifetime is > 100 ns, resulting in low harmonic distortion in the 100 to

1000 MHz frequency range. Dynamic range is 1  $\Omega$  to 10 k $\Omega$ ; reverse bias capacitance is less than 0.3 pF. CW power switching capability is 2.5 W.

Delivery is from stock.

For more information, check H on the HP Reply Card.

# Use HP battery-powered storage scopes in the field and in the lab



Here, a 1703A storage scope is used to check the audio circuits in a videotape machine

The 1702A/1703A scopes offer laboratory performance in a rugged portable package, and they're the first storage oscilloscopes that operate on ac, dc or batteries. Both have 35-MHz bandwidths, dual-channel 10 mV/div deflection factors, and 10 ns/div sweep speeds. (The only difference is that model 1702A has a standard time base while the

1703A has a calibrated delayed sweep.) You can use either as a conventional scope, a variable persistence scope, or a storage scope.

The 1702A/1703A scopes have a bright, crisp trace. CRT linearity, bandwidth and deflection factors are specified over the entire  $6 \times 10$  division (0.85 cm/div) display, from dc to 35 MHz. The burn-resistant tube

requires no more operating care than a conventional CRT.

Need variable persistence? You can retain a trace for over an hour. Variable persistence provides extra brightness for dim traces—such as rep rate pulses—and eliminates flicker, common to slow sweep speeds.

With storage, you can capture single-shot events (e.g., noise-related transients) or infrequently-occurring events (e.g., random-bit dropout). Just push STORE, and your waveform is preserved for up to one hour. Either storage scope replaces a conventional scope and a camera (with all the associated inconvenience).

Applications for these scopes include such areas as acoustics, biology, chemistry, oceanography, pneumatic, fluid, electrical, mechanical and civil engineering. Battery operation enables you to use them for field service applications, as well as in the laboratory.

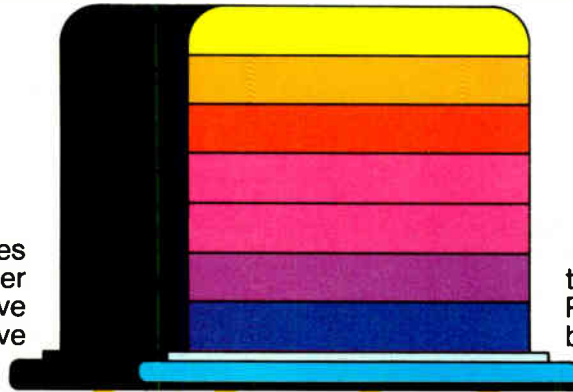
*For more information, check A on the HP Reply Card.*

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# UHF demanded 1 GHz FETs. Signetics D-MOS does it.

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Two single-gate D-MOS FETs. SD-200, unprotected by design. SD-201 with diode protection against transients. Both offer exceptionally low gate leakage. Plus unbeatable high-gain, low-noise figures.

And two dual-gate diode-protected FETs, that show excellent linearity in cross- and inter-modulation. SD-300 with AGC capacity, and ultra low noise SD-301.

Superb cross modulation characteristics at 1 GHz. Remarkably low input and feedback capacitance. Extremely high transconductance. The lowest noise figures

of any existing FETs. And simpler bias schemes.

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Record-breaking low cost too. Our D-MOS FETs obviously outperform standard bipolars, hands down — for less than one-fifth the cost. Under four bucks in 100-piece quantities, instead of the \$20 or \$30 you'd expect.

Available now through your distributor in TO-46 hermetic cans, with four leads. Call for immediate delivery. Or tune in for the news behind the news, by sending for complete data sheets, technical and editorial back-up information, and of course, our application notes.



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FREE to play around with.

N-Channel D-MOS FETs			
CHARACTERISTIC	SD-200/201	SD-300	SD-301
Gain at 1 GHz	10dB	13dB	14dB
Noise at 1 GHz	4.5dB	8dB	6dB
Fwd. Transconductance ( $\mu$ MHO)	15,000	10,000	10,000
Input Capacitance	2.0pF	2.0pF	2.0pF
Output Capacitance	1.0pF	1.0pF	0.6pF
Feedback Capacitance	0.13pF	0.02pF	0.02pF
Drain-to-Source Voltage	+30V	+30V	+30V

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## signetics



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**Research and development.** Siemens spends over one million dollars every day on R & D, much of it in the component field. It's no wonder, then, that 90% of the components we offer today were unknown 10 years ago.

**Wide product spectrum.** Last year Siemens produced over 700 million components in more than 50,000 different shapes and sizes. These included capacitors, ferrites, transistors, diodes and microwave tubes. Plus a large variety of relays and surge voltage protectors.

Siemens Corporation, 186 Wood Avenue South, Iselin, New Jersey 08830. (201) 494-1000.



Relays



Capacitors



Surge voltage protectors

Circle 29 on reader service card

Dear Gabby: \_\_\_\_\_

**"Why is parallel vs serial automatic IC testing like comparing a Ferrari to a Model T Ford?"**



**Datatron's Girl Gabby**

**DEAR GABBY:** My neighbor who works for a large IC user says that comparing Datatron's parallel automatic IC tester to serial testers is like comparing a Ferrari to a Model T Ford. Can this be true?  
CAR BUFF

**DEAR BUFF:** A good analogy indeed! Serial testers apply a stimulus to an IC input and sequentially monitor all outputs. A very slow process. Datatron is a parallel tester with individual electronic cards (PECs) for each pin of the IC under test, making it possible to force and monitor all inputs and outputs simultaneously.



High slew rate  
PECs are located  
inches from  
D.U.T. on 10MHz tester

**DEAR DESPERATE:** Slip him a data sheet on Datatron's Model 4500 test system which will exercise his memory at 10MHz and perform access time measurements in parallel as well! Program generation uses simple English language too. He's sure to come home happy!  
GABBY



Model 4400 has separate PECs for each pin which contain force/monitor circuits

This drastically reduces test time, simulates actual IC operation, and makes it easy to expand or update the system.  
GABBY

**DEAR GABBY:** My husband is in charge of testing at Integrated Circuits Inc. Lately, he's been grumpy with me and the kids because he can't exercise his memory

★ ★ ★  
Confidential to Weight Lifter from Muscle Beach: Thanks for the snapshot showing your "pecs". However, since the "PECs" we refer to are our exclusive Pin Electronic Cards, I'm afraid we can't use your services.  
GABBY

★ ★ ★  
Send your questions — either straight or humorous — to Gabby. We'll mail a Flair pen for all received and pay \$100 if we use question in future ad.

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## Meetings

**International Conference on Communications:** IEEE, Washington Plaza, Seattle, Wash., June 11-13.

**Frequency Control Symposium:** ECOM, Howard Johnson's Motor Lodge, Atlantic City, N.J., June 12-14.

**National Cable TV Association Annual Convention:** NCTA, Convention Center, Anaheim, Calif., June 17-20.

**Microwave 73:** IERE, Metropole Convention Centre, Brighton, England, June 19-21.

**International Symposium on Electromagnetic Compatibility:** IEEE, New York Hilton, New York, June 20-22.

**International Symposium on Fault-Tolerant Computing:** IEEE, Palo Alto, Calif., June 20-22.

**Joint Automatic Control Conference:** IEEE, AIAA, et al., Ohio State University, Columbus, June 20-22.

**Canadian Computer Conference:** CIPS, Edmonton, Alta., June 20-22.

**Design Automation Workshop:** ACM, IEEE, Sheraton, Portland, Ore., June 25-27.

**International Symposium on Information Theory:** IEEE, Ashkelon, Israel, June 25-29.

**International IEEE G/AP Symposium and USNC/URSI Meeting:** IEEE, U. of Colorado, Boulder, Aug. 21-24.

**17th Annual Meeting and Equipment Display:** SPIE, Town and Country, San Diego, Calif., Aug. 27-29.

**European Microwave Conference:** IEEE, IEE, Brussels University, Belgium, Sept. 4-7.

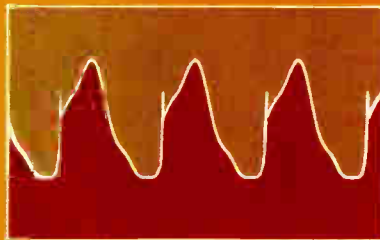
**Third European Solid-State Device Research Conference:** IEEE et al., Munich Technical University, West Germany, Sept. 18-21.

Fluke problem solvers

# Plug in true rms... at the lowest price available!



These new Fluke plug-in options let you add true rms capability to Fluke 8200A and 8400A DVMs. Take the measure of non-sinusoidal waveforms in 500 ms. Get accurate readings from 1 mv to 1000V rms.



Now you can put true rms to work in your Fluke 8200A for just \$595, and for only \$750 in the 8400A. These are the lowest prices offered for true rms in 4½ and 5½ digit DVMs. But pride is only part of our story. Even at an unexcelled low price, we offer performance the others don't even begin to match... for instance, ac or ac plus dc coupled measurement capability.

Now look at low level accuracy. We measure low levels that competitive units can't touch. Why? because we use an exclusive converter technique which doesn't have square law response limitations of thermal rms converters.

This same technique allows us to measure waveforms that quasi-rms or distortion insensitive converters can't handle. And, we can do it up to five times faster than thermal converters. Mid-band accuracy (50 Hz to 10 kHz) is 0.1%.

For details call your local Fluke sales engineer. In the continental U.S., dial our toll free number, 800-426-0361 for his name and address. Abroad and in Canada, call or write the office nearest you listed below. John Fluke Mfg. Co., Inc., P.O. Box 7428, Seattle, Washington 98133. Phone (206) 774-2211. TWX: 910-449-2850. In Europe address Fluke Nederland (B.V.), P.O. Box 5053, Tilburg, Holland. Phone 13-673973. Telex: 844-52237. In the U.K. address Fluke International Corp., Garnett Close, Watford, WD2 4TT. Phone, Watford, 33066. Telex: 934583. In Canada, address ACA, Ltd., 6427 Northam Drive, Mississauga, Ontario. Phone 416-678-1500. TWX: 610-492-2119

A crest factor of seven takes care of waveforms with a duty cycle as low as 2%. Common mode rejection from DC to 60 Hz is greater than 120 dB.

These options are field installable. All other features and specs are those of the respective instrument. The Model 8200A is a high-speed 0.01% 4½ digit voltmeter with 60% overranging, auto polarity, and

auto ranging on all functions. It features switched input filter, full 1000 volt guarding. Full multimeter and systems options are available. Base price is \$995.

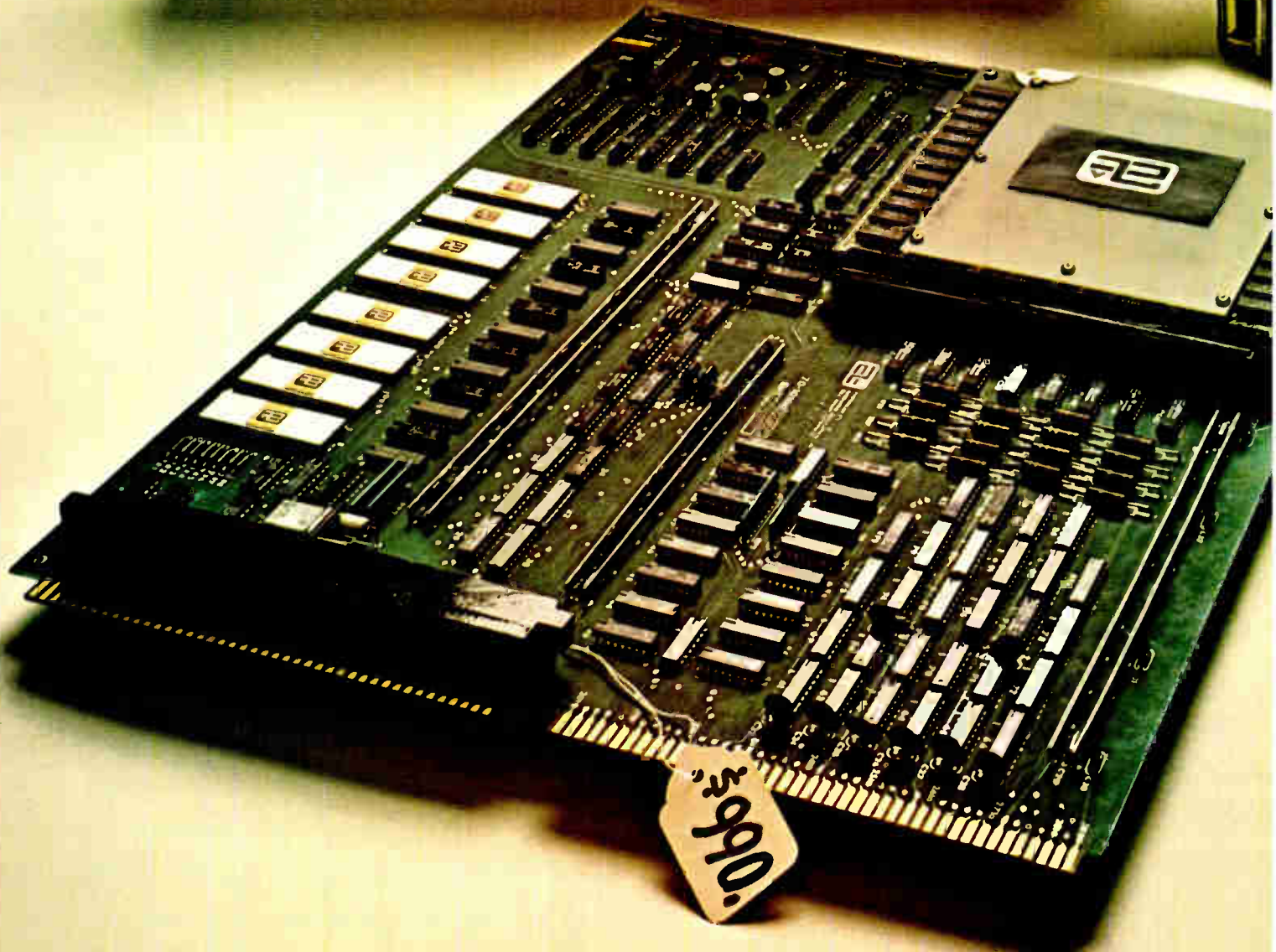
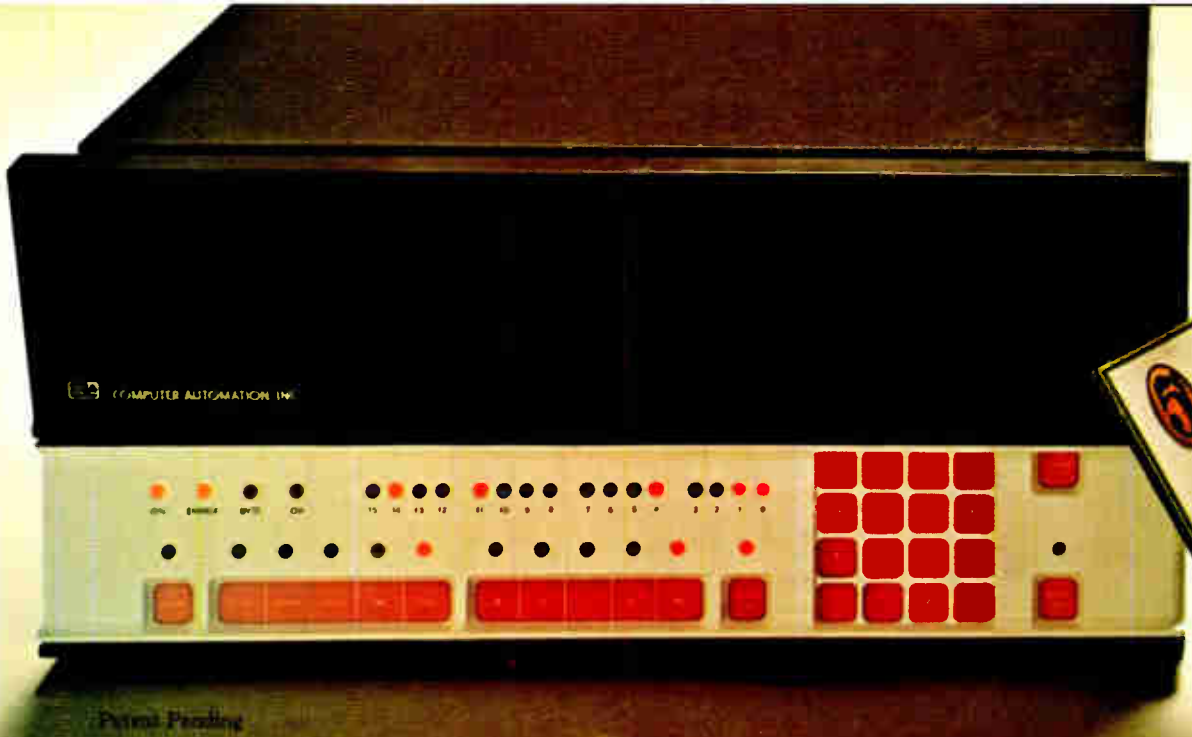
Fluke's Model 8400A is the ultimate bench and systems DVM. It features an accuracy of 0.002%, 1 microvolt resolution, resistance measurements down to 100 micro ohms, auto polarity and auto ranging. For \$2450 you get five ranges of DC from 0.1V full scale to 1000 volts with 20% overrange. The switched filter provides better than 65 dB noise rejection for DC, AC, resistance and ratio.

Both DVMs feature 1500V peak overload protection and the ability to meet tough environmental specs.

For full details, call your nearby Fluke sales engineer or contact us directly.



Circle 31 on reader service card



# The NAKED MINI/LSI™



# What this country needs is a good \$1,000 full-scale computer.



Introducing the computer for everybody. NAKED MINI/LSI.<sup>™</sup>

It's the computer for people who never thought they could afford a computer for their product.

It's also for people who have always been able to afford more, but have always gotten less computer than this.

NAKED MINI/LSI is the first OEM computer designed for widespread, multi-level use. The first computer able to do more jobs than any computer could ever do before.

Jobs that computers were too expensive to do. Jobs that were, consequently, always left to old-fashioned hardwired circuitry. Which meant that products weren't as flexible or immune to obsolescence as they could have been.

Or jobs that were done by more expensive computers. Which meant that products cost more and were less competitive than they should have been.

To make a computer capable of handling this kind of range, we had to give it an unheard of combination: extensive 16-bit computing power and a small price tag. Specifically, NAKED

MINI/LSI is the first computer powered to satisfy 90% of all potential minicomputer applications — and yet be priced as low as \$990 in OEM quantities of 200.

Imagine it. For a price less than most hardwired circuitry, your product can benefit from a computer having arithmetic capabilities, full byte and 16-bit word processing, and extremely flexible input/output. Without going into all the jazzy widget features, let's just say that the NAKED MINI/LSI gives your product all the intelligence it needs to monitor, sequence, and control effectively.

At this point, you may be wondering why a computer with all this clout was ever named the NAKED MINI/LSI. Actually, the name is very appropriate.

The NAKED MINI means that we designed it without all the over-design found on other minicomputers. All the extra, redundant features that make other minis too unwieldy and costly for OEM use have been purposely left off. (But everything you need has been deliberately built in.)

The LSI stands for large-scale integration, the latest technological advance in electronics. It enabled us to build a complete computer that fits on a single 1" x 15" x 17" card, weighs only 4 lbs., and uses 89% fewer components for unequalled reliability.

For full details on the NAKED MINI/LSI (or its stand-alone counterpart, ALPHA/LSI<sup>™</sup>), write Computer Automation Inc., 18651 Von Karman, Irvine, California 92664. Or call: (714) 833-8830. TWX 910-595-1767.

## from Computer Automation.

Circle 33 on reader service card



You don't have  
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carbon composition  
performance to  
save space.

If you're really  
serious about cost,  
be serious about quality.

Are you cramped for board space but not in power handling capabilities? Is reliable performance vital? Then use Allen-Bradley 1/8 watt carbon composition resistors. Get the pulse handling and overload capabilities that are superior to resistors manufactured by other technologies. Exclusive hot molded construction for a

dense resistance element which reduces noise, and results in a consistent performance. Most importantly, our 1/8 watt resistors have all of the quality and reliability common to our larger sizes. Quality that really can cut your fixed resistor costs. If you think resistors are identical, write for "7 Ways to Tell the Difference in

Fixed Resistors Available from your Allen-Bradley Electronic Distributor, or: Allen-Bradley Electronics Division, 1201 South Second Street, Milwaukee, Wisconsin 53204. Export: Bloomfield, N.J. 07003. Canada: Allen-Bradley Canada Limited, Cambridge, Ontario. United Kingdom: Jarrow, Co. Durham NE32 3EN.

Actual size



Circle 34 on reader service card



**Allen-Bradley**

Milwaukee, Wisconsin 53204

## Triple diffusion rises again for bipolar logic

Triple diffusion went into disuse in the 1960s when bipolar IC makers began using epitaxial techniques to speed up logic, but TRW Systems is resurrecting the technology to make huge bipolar logic circuits with yields in the 15% range—usually high for bipolar LSI. James L. Buie, senior scientist at TRW's micro-electronics center in Redondo Beach, Calif., says that **triple-diffused circuits containing 5,000 to 25,000 elements can be produced with today's precision masking techniques.**

The TRW circuits are made of vertical npn and pnp transistors. Three diffusions, which achieve much the same effect as isolation, are made in a homogeneous p-type substrate that serves as the collector contact. Then base and emitter contacts are added at the top of the wafer. **The circuits are not fast—they operate at 10 to 30 megahertz—and they cannot be operated at high voltages, Buie said, but they are suitable for many digital functions.**

## Electron beams brightens TI's processing outlook

Electron-beam technology is beginning to pay off for Texas Instruments. **The firm is delivering two types of bipolar microwave transistors, fabricated in its EBM-1 electron-beam pattern generator, to the U. S. Army Electronics Command.**

The transistors—the ML-220 and the L-216—are 6-gigahertz devices fabricated on the same silicon wafer from a lanthanum boride source working through a PPMA photoresist. Gain achieved with the ML-220 has reached 9 decibels, and the noise figure is 4.5 dB. **With its emitter opening down to 0.5 micrometer and 0.2-micrometer alignment accuracies, the transistor could not have been fabricated using conventional photolithographic techniques, says TI.**

## Pinhead laser has long life

Bell Telephone Laboratories seems about to crack one of the major barriers to laser communication on fiber-optic light pipes. **The Murray Hill, N.J., research arm of the Bell System has developed a tiny heterojunction laser that has been operating continuously for three months, and Bell Labs engineers estimate it will last for 10,000 hours. Previous semiconductor lasers had lifetimes of about 30 hours. This was considered to be a major drawback to optical communications systems.**

The new gallium-arsenide laser is the size of a pinhead; it is the same heterojunction design developed by Bell Labs in 1970 [*Electronics*, Aug. 31, 1970, p. 37]. But Bell has reduced the bonding strain in the manufacture of the material and refined its clean-room techniques during processing. **Bell Labs says the device may be an "economical source of light for future optical communications systems."**

## CO<sub>2</sub> 3-in. laser has 1.4-W output

Scientists at Hughes Research Laboratories, Malibu, Calif., have developed a CO<sub>2</sub> laser only 3 inches long that has an output of 1.4 watts. The laser, which could be used for space communications, operates at significantly higher pressure (150 torr) than conventional CO<sub>2</sub> lasers, providing wider bandwidth and increased frequency tuning capability, typically 1.5 gigahertz.

Preliminary tests also indicate it has a **far longer operating life than conventional low-pressure lasers.** The laser operates in a 7.5-cm-by-1.5-

mm<sup>2</sup> channel machined in an alumina block, with the cavity mirrors bonded to the ends of the waveguide. Efficiency is 7%.

## **Varactor tuner is light-sensitive**

Standard Components, Chicago, has developed a light-sensitive varactor uhf-vhf television tuner that costs \$15 in large quantities—several dollars cheaper than conventional varactor tuners. **The new device uses light-sensitive potentiometers rather than the usual carbon-composition resistors.** Channels 2 through 83 can be tuned in continuous sequence to within 150 kHz, and only 164 photoresistors are needed, which is about half the number used in other types of varactor tuners. Moreover, the units have a memory system.

## **Monolithic FET op amps undercut discrete-FET types**

The cost of monolithic FET-input operational amplifiers will soon be less per channel than amplifiers assembled with field-effect-transistor pairs and conventional monolithic bipolar amplifiers, says Jack F. Gifford, director of analog products at Intersil Inc., Cupertino, Calif.

**Within a month, Intersil will start selling a dual monolithic FET amplifier for \$6.50 in 100-up quantities and about \$5 in lots over 1,000.** The target price in high volume is \$4—only \$2 per channel—Gifford says. At that price, he adds, the cost per channel will be under the cost of assembling even low-cost discrete components for “mundane” transducer amplifier and integrator designs.

**The new 8043 is a dual version of the single-channel 8007, which lists at \$5.** Both are classed as high-performance amplifiers, since their input currents run as low as 1 picoampere and typical slew rate is 6 volts per microsecond. The 8043 operates as two internally compensated, independently nullable channels with a common power supply. At 100 decibels, the isolation between channels is comparable to the 747's.

## **Plastic packages with integral connectors studied**

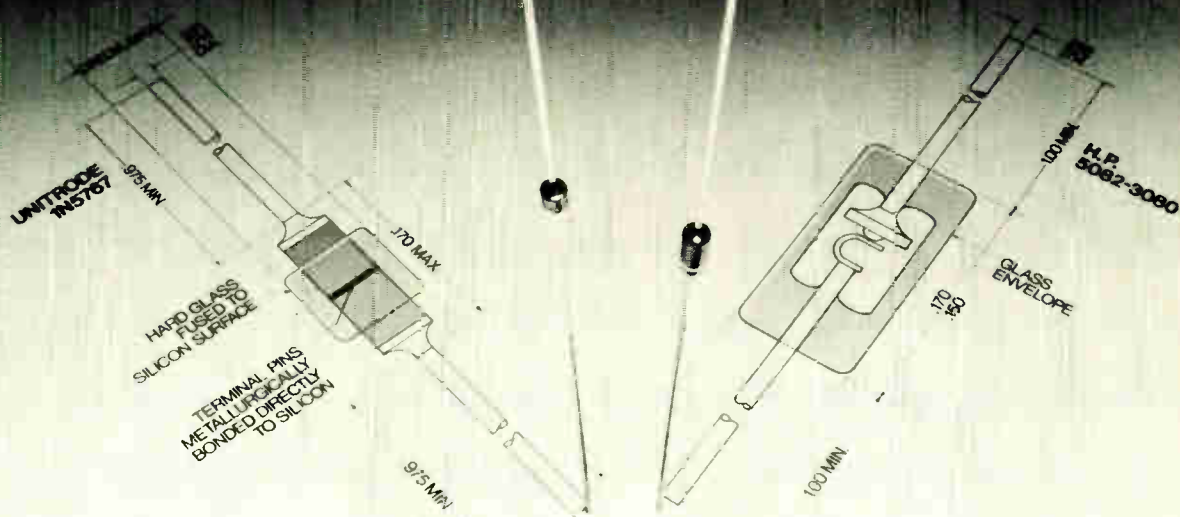
Hermetically sealed plastic packages with molded-in connectors, rather than conventional pins or leads, are under development at the components division of Bendix Corp., Sidney, N.Y. **The goal is a rugged cavity package with a leak rate of  $1 \times 10^{-6}$  cc—too low for military applications but high enough for automobile electronics and other commercial circuits that must work in adverse environments. If all goes well, packages for hybrid ICs and large-scale ICs will go into production in six to eight months.**

## **Fairchild ECL RAM has 8-week delivery**

At a time when semiconductor makers are regularly quoting 20 weeks or more for delivery of some products, 8-week delivery will be welcomed by customers, especially when the product is an extremely fast random-access ECL memory. **Fairchild Semiconductor says it can ship several thousand units per month per customer of the 128-bit ECL Isoplanar RAM, which has a typical access time of 12 nanoseconds and a typical chip-select access time of 3 ns.** Maximum read-write access time is guaranteed at 15 ns over a  $\pm 5\%$  variation in power-supply voltage and a 0° to 75° C temperature range.

The voltage-compensated F10405 is compatible with Fairchild's F10K ECL logic family and is usable with other devices in the 10,000 series and the 95K series. It is aimed at computer central processors and priced at \$48 in quantities of 100–999.

# C-LINE PIN DIODES



## Compare Unitrode's 1N5767 with H.P.'s 5082-3080

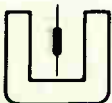
The 1N5767 is HP's EIA Registration of the 5082-3080. Both Unitrode and HP meet the same specs. Both are competitively priced. The difference is in how they're made. Unitrode's fused-in-glass process results in a monolithic structure with the lowest possible thermal and series resistance available. The silicon chip is metallurgically bonded directly to the terminal pins and a hard glass sleeve is then fused to the pins. The result is unmatched peak and average power dissipation. And the normal parasitic inductance and capacitance is far less than in conventional diodes with straps, springs, whiskers, or ceramic packages. Unitrode's 1N5767 can withstand thermal cycling from

-195°C to +300°C and it exceeds all military environmental specs for shock, vibration, acceleration, moisture resistance and solderability. They're ideal for use in general purpose PIN diode applications such as CATV attenuators and switches and simple series switches for transceivers, radar, etc. As to HP's diode construction, we think it only fair that they should tell you about it. For samples, call Howard Kaepplein at (617) 926-0404 collect, Unitrode Corporation, Dept. No. 7 Y, 580 Pleasant St., Watertown, Mass. 02172. For the name of your local Unitrode distributor or representative, dial (800) 645-9200 toll free, or in New York State (516) 294-0990 collect.

### ELECTRICAL SPECIFICATIONS (25°C)

Unitrode Series	$C_T$ Total Capacitance 50V, 1MHz pF	RF Resistance @ 10 $\mu$ A, 100MHz $\Omega$	RF Resistance @ 20mA, 100MHz $\Omega$	RF Resistance @ 100mA, 100MHz $\Omega$
1N5767	0.4 max.	1000 min. 3000 typ.	8 max. 4 typ.	2.5 max. 1.5 typ.

See EEM Section 4800 and EBG Semiconductors Section for more complete product listing.



**UNITRODE** quality takes the worry out of paying less.

Circle 37 on reader service card

# GE boosted profits for an OEM by helping design a better product

Technical Labs, Inc., Chamblee, Georgia was about to start production of electronic power controllers. There were some problems, however, but their local components distributor saw that some good SCR application assistance might solve them.

He called on General Electric. Our Electronic Components Sales Department salesman visited Technical Labs. They familiarized him with the controller and the problems. Then he called Ralph Locher, a GE SCR application engineer in Auburn, N. Y.

It was discovered that under the original design the controller would be overstressed. Its life would be short, possibly resulting in expensive recalls and replacements. So our engineers came up with a new design for them. One that increased the product's life considerably.

Technical Labs used the new design. They got a long-lasting controller — and a successful, profitable product for the marketplace.

GE has found that going this far to help a customer makes the soundest business sense. It's the way we get good customers. And the way we're keeping them.

**GE won't leave you alone.**



**GENERAL**  **ELECTRIC**

## Japanese microcomputer ready to compete with U. S. machines in world market

by Charles Cohen, Tokyo bureau manager

With its domestic market set to double for the next few years, Toshiba claims superiority over U. S. units

**It had to happen.** With the flurry of activity to get microcomputer chip sets to the market in the U.S. [*Electronics*, March 1, p. 63], it is little wonder that a Japanese company, aware of its own healthy domestic needs, would develop a one-chip microprocessor to tap that market and become a major competitor in a world market.

The company is Tokyo Shibaura Electric Co. Ltd. (Toshiba). It estimates the domestic Japanese market alone at \$11 million to \$12 million, with the market size doubling each year for the next few years. Moreover, Toshiba claims that its microprocessor surpasses those now available in the U.S. (see p. 40). Toshiba estimates the price of a semiconductor kit, including peripheral logic and control circuits and all required memory, would add up to approximately \$580.

In addition to the central processor, the smallest possible configuration of the microcomputer also requires at least three other devices in the series. These are the 128-word-by-4-bit static random-access memory, the 512-word-by-4-bit erasable and electrically programmable avalanche MOS read-only memory, and the memory interface unit. Other devices in the series include a 512-word-by-4-bit read-only memory, an input output device controller, a 12-bit-bidirectional bus buffer, a universal input-output reg-

ister, and an 8-bit interrupt latch.

Toshiba expects that initially it will be selling about 1,000 central-processor LSI chips a month. (This would require processing only about twenty of the company's 3-inch wafers if the yield is perfect.)

The single-chip microcomputer processor contains approximately 11,000 p-MOS transistors on a 5.6-by-5.9-millimeter chip in a 42-pin dual in-line ceramic package. The chip includes a 12-bit parallel processor, 4,000 bits of microprogram, 8 words of 12 bits each of internal memory, six registers, an internal clock, and control circuits for peripheral circuits. The system is designed for operation over the  $-40^{\circ}$  to  $+125^{\circ}$  C range.

Add and subtract execution times are 10 microseconds, while multiply and divide execution times fall between 30 and 60 microseconds.

**Large and wide.** Both the large size of the chip and its wide tolerance to temperature range are intimately related to the semiconductor technology used. Silicon gates were used to build p-MOS devices with a channel length of 6 micrometers. Enhancement type p-MOS driver transistors and depletion-type p-MOS load transistors make it possible to operate circuits from  $\pm 5$ -volt power supplies rather than the higher-voltage power supplies required when load transistors also are enhancement type. Thus, chip power consumption is only 0.8 watt

**Mini vs micro.** Toshiba's microcomputer breadboard compared with its minicomputer.



## East challenges West

The available data from U. S. microcomputer manufacturers does not precisely match that released by Toshiba. But if Toshiba is to compete in a world market with its microcomputer, it will likely be challenged by these U. S. chip sets:

- American Micro-systems Inc.'s AMI 7200 in final development. An 8-bit, byte-oriented, expandable machine with 32 stack and file registers and 12 general registers. Can be used as 16-bit computer. Is microprogramable and has 65-kilobyte memory capacity. Speed is described as one half to one third that of a minicomputer.
- Intel's MCS-4. Microprogramable 4-bit chip set. Adds two eight-digit numbers in 850 microseconds. Contains seven 8-bit registers, plus eight in address stack, up to 4,096 8-bit words in ROM, 5,120 bits in RAM.
- Fairchild's PPS-25. Microprogramable 4-bit chip set. Adds two eight-digit numbers in 240 microseconds. Contains seven 25-character registers. Takes up to 6,656 12-bit words in ROM and 1,280 data words in RAM. Also adds two data words, in BCD digits, in 62.5 microseconds.
- National's GPC/P 4-bit chip set. Microprogramable, expandable in 4-bit increments to 32 bits. (IMP 16 is 16-bit version.) Has seven general registers and a 16-word stack regardless of word length. Up to 65 kilowords in RAMs or ROMs. Typical macroinstruction time is 7 microseconds. An add takes five microinstructions of 1.4 microseconds each, plus two main-memory read cycles with 0.25-microsecond delay, which works out to 7.5 microseconds.

with dissipation margin for operation at high temperatures.

Toshiba claims that its processor is easier to use than previous types developed in the U.S. because many auxiliary circuits, including clock drive, are included on the single processor chip, making it complete in itself. The 12-bit parallel processing mode is said to be ideal for control computers. □

## Computers

### Copier is mated with computer

The marriage of technology by two divisions of the Xerox Corp., New York, has resulted in a new nonimpact printer called the model 1200, which combines the company's xerographic copying techniques with computer control. In essence, a computer or magnetic tape unit is used to drive a copying machine.

The project, developed by the Business Products Group in Rochester, N.Y. and the Information Services Group in El Segundo, Calif., has been three years in the making.

But it had a predecessor based on the company's LDX system developed in Rochester several years ago [*Electronics*, Sept. 18, 1967, p. 50], which connected a xerographic printer to a computer over long-distance telephone lines. That system, however, was never debugged and was abandoned.

Since then, Xerox Corp. bought Scientific Data Systems, Inc., and has presumably benefited from the experience of the people at SDS (which became Xerox Data Systems, and then the Information Services Group), and from their work with peripherals for the Sigma line of computers. And in the 1200 system ASCII characters are generated from either a Sigma mainframe and channel adaptor or a magnetic-tape unit, then are passed through a controller and an optical-character generator and finally are optically cast on the selenium drum of the xerographic printer. An output stacker is also included in the unit.

**Versions.** The 1200 is available in two versions: an off-line version that is compatible with any 800- or 1,600-bit-per-inch nine-track magnetic tape that is usable on IBM, Xerox, and most other computers, and an on-line version that is com-

patible only with Xerox Corp.'s Sigma 6, 7, and 9 computers.

The print rate is 4,000 lines per minute or about one page a second. Unsensitized 8½-by-11-inch paper is used, formatted to 66 lines of 132 columns each. The unit can print its own forms as it goes, or can use pre-printed paper stock; and it can print an unlimited number of copies—where impact printers are limited to six copies—which come out already decollated. But there's a tradeoff: an impact printer's six copies are made all at once with carbon paper, whereas the unlimited number of copies from the 1200 are made one at a time.

The magnetic-tape version will be available for lease in the last quarter of 1973, and the on-line unit will be available in the first quarter of 1974. Price for the off-line version will be \$2,600 per month minimum and for the on-line model, \$2,100 per month minimum. Both prices include \$1,100 in copy charges and 100,000 copies. □

## Space electronics

### Comsat technique ups station capacity

In tune with the communications industry's drive toward an all-digital world, Communications Satellite Corp. has come up with a new digital television transmission system called DITEC-1, which the company contends will produce "substantially reduced costs" by doubling earth-station capacity.

Developed by Comsat Laboratories at Clarksburg, Md., DITEC-1 makes use of frequency-interleaved sampling and of differential pulse-code modulation (or DPCM) with edge coding as its two key signal-processing techniques. Comsat's efforts produced a patent for the DPCM segment of the system last December, as well as a patent application covering the entire DITEC system, according to Leonard S. Golding, image processing department manager at Comsat Labs.



An alternative to DITEC's 50% saving in rf bandwidth—compared to frequency-modulated transmission systems now in use—is a saving of up to 10 decibels in satellite power. Trading capacity for more power, DITEC can be used to deliver monochrome- or color-broadcast quality signals into a small, inexpensive earth station with a 15-ft antenna instead of one requiring a 32-ft dish. This could reduce the estimated \$150,000 cost of a small earth station by approximately a third, says Burton I. Edelson, a Comsat assistant vice president and acting director of the laboratories.

Though the ground-station savings effectively would be a one-time economy, not counting lower personnel and related operating costs, Comsat expects to capitalize on it in its domestic-satellite communications venture through the CML Satellite Corp., the new name assigned to the company it owns jointly with MCI Corp. and Lockheed, and which Comsat staffers have dubbed "Camel."

While DITEC-1 has been designed to handle any 525-line, 60-field-per-second TV signal, it is not limited to satellite applications, says Comsat. By better controlling transmission distortion problems such as differential phase and gain, the digital system's greater efficiency "makes it attractive for increasing capacity over terrestrial microwave relays," in Comsat's view.

**Flexibility.** DITEC-1 can double the capacity of a 20-megahertz radio relay link to handle two TV signals, for example, just as it does for an earth station. Moreover, Comsat says its system can also be used "with existing or future terrestrial microwave links for improved service and the use of a greater number of repeater 'hops' without degradation of the signal by repeater action." It has the additional ability to be operated with some band-limited cables. Such claims suggest a potential market for the system in the developing special-service common-carrier market.

For a recent demonstration of DITEC-1, Comsat used a 15-ft Radi-

ation Systems Inc. antenna, which can be set up without a crane or guy wires and without a foundation. The antenna received signals transmitted from Comsat's Andover, Me., earth station to the Intelsat 4 satellite over the Atlantic Ocean. □

## Instruments

### Fast scan converter can be time-shared

By combining an electrostatic deflection system with an external magnetic focusing coil, engineers at Tektronix Inc., Beaverton, Ore., have come up with what is probably the world's fastest practical video scan-converter tube. The new tube is limited in speed only by its plate capacitance—about 175 picofarads per plate—and achieves a full-screen sweep rate of 1 megahertz at a drive current of only 25 milliamperes.

By contrast, conventional scan-converter tubes, which use magnetic focusing and deflection, are typically limited to full-screen sweep rates of about 200 kilohertz, according to project engineer Bill DeVey. Above that frequency, DeVey explains, power consumption in the deflection circuitry grows to impractically high levels, and yoke resonances cause nonlinearities in the sweep.

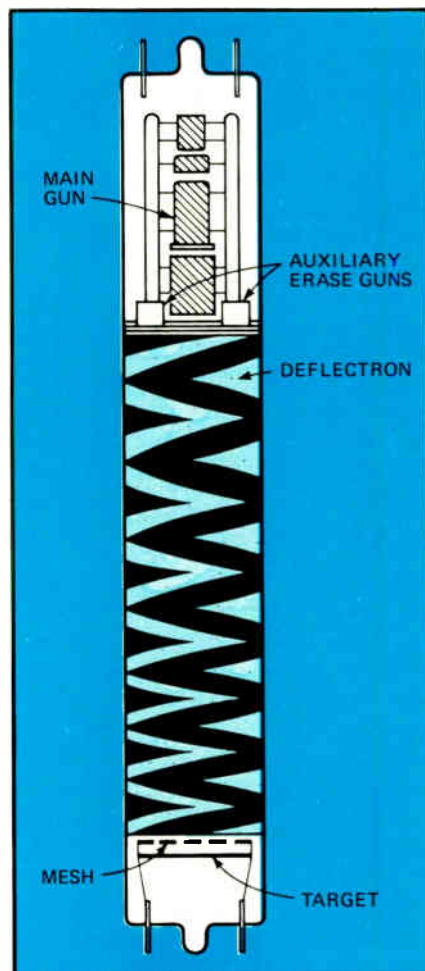
A key element in the tube design is a deflectron deflection structure. Unlike conventional deflection plates, the deflectron has its electrodes deposited on the inside wall of the tube as two pairs of interdigitated zigzag stripes.

**Time-shared.** The new tube is fast enough to be used in a "time-shared" mode—that is, it can, in effect, read and write at the same time. For instance, when a computer output is to be viewed on a standard TV monitor, the tube can run its electron beam along one line of the TV raster, picking up anything written on that portion of the target, then be switched into its write mode and for 8 microseconds record whatever input the computer has to give

it. This makes it unnecessary for the computer to accommodate the slow scanning rate of the TV monitor.

After one raster scanning cycle in the time-shared mode, the tube produces a dotted-line image of the input waveform. If the waveform is repetitive, the blank spaces will fill in during succeeding cycles. If the waveform varies, the converter can show it in a variable-persistence mode. That is, separations between dots decrease so that the trace appears to build up in intensity as the waveform sweeps across the screen. The effect makes it easy to see the history of electrocardiograms or other complex waveforms like a decaying trace on an oscilloscope.

A scan converter built around the tube can resolve more than 1,000 TV



**Deflectron.** Distributed deflection plates in Tektronix' new scan converter tube are deposited on the inside of the envelope in a zigzag pattern. Auxiliary electron guns provide rapid erase.

lines per picture height at 50% modulation at the center of the screen, dropping to 850 lines at the corners. (A modulation level of 50% is comparable to half-signal amplitude; at zero modulation, noise would swamp the signal.) To obtain this high resolution in the time-shared mode, the Z-axis control amplifiers, which govern beam intensity, have the high bandwidth of 30 MHz.

Despite its improved performance, the new scan converter will cost less than most magnetically deflected types. According to Jerry Ramey, the converter's marketing program manager at Tektronix' Information Display Products division, a low-resolution magnetically deflected converter currently made by Tektronix lists at \$3,175. The new one will cost \$2,950 in a 500-line resolution version, and \$3,450 with 1,000-line resolution. □

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**Instruments**

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## Pocket slide rules get price push

Engineers waiting in line for an HP-35 shirt-pocket calculator got a break last week. Hewlett-Packard cut the price to \$295 and it offered an updated model at the old figure of \$395. The new HP-45 performs 47 operations—25 more than the HP-35—and it can also do register arithmetic with nine addressable registers.

The moves were not surprising. Even though the HP-35 has been one of Hewlett-Packard's most successful products [*Electronics*, Feb. 1, p. 102], and over 75,000 have already been sold, the company can't help but be alert to competitive pressures as others aim for a share of an established market.

Company spokesmen explained the marketing strategy. At \$395, the HP-35 commanded the middle of the calculator market because of its popularity among engineers and scientists as a personal "electronic slide rule." At \$295, a price made possible by rising production rates, it

should win much of the huge potential market among college students. Meanwhile, the new model is being aimed at professionals who have been buying higher-priced desk calculators with more automatic functions than the HP-35. Some of the HP-45's extra functions, like its ability to do trigonometric calculations in degrees, radians, and grads (a European measure of angles) are also expected to entice surveyors, navigators, and the like into the Hewlett-Packard fold.

Peter Dickenson, HP-45 project manager, considers it the equal in versatility of some programmable calculators costing around \$2,500. It cannot be set up to run complex equations automatically, but the register arithmetic capability gives it almost the flexibility of a computer in the hands of a skilled operator, he explains. Other miniature calculators, including the HP-35, have only one addressable register.

**Desktop with printout.** Hewlett-Packard is also offering an inexpensive, desktop printing calculator built around the HP-45 chip set. Designed for people who like records kept as they wend their way through a problem, it prints out the functions performed, generates error codes when illegal entries are made, lists register contents, and shows negative results in red ink. This version, the HP-46, costs \$695 plus \$95 for an optional display.

The extra functions of both machines are the result of a four-fold increase in memory size and a shift key that turns most of the original 35 keys into dual-function controls. In the HP-35, programs and constants were stored in three 2,560-bit MOS read-only memory chips. Those chips are replaced by two quad ROMs storing a total of 20,480 bits, plus a 10-register chip. The five central-processor and display chips are unchanged.

Among specific uses of the nine addressable registers are accumulating two-dimensional vector values and statistical data. By pressing keys, the operator can immediately see mean and standard deviations of the accumulated values. The 10th memory register implements a "last



**Packs a wallop.** This is a 47-operation machine with nine addressable registers.

"X" function that allows the operator to recall the previous argument and recover from an error in a new entry. □

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**Production**

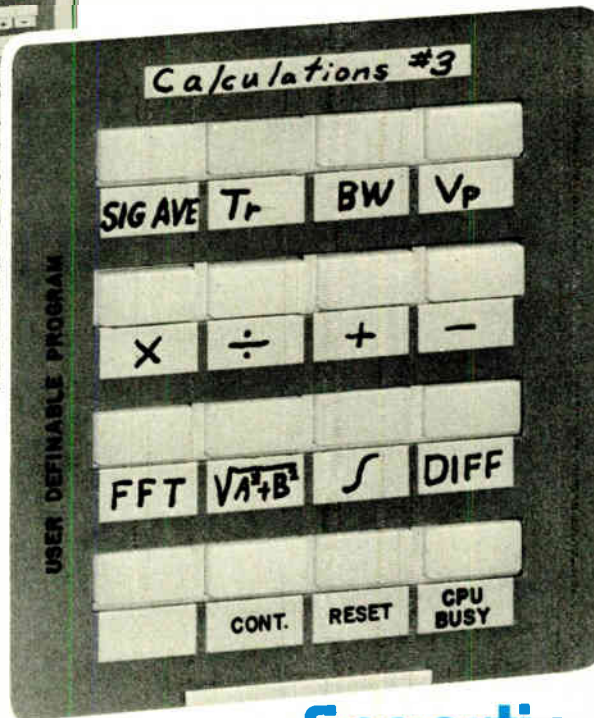
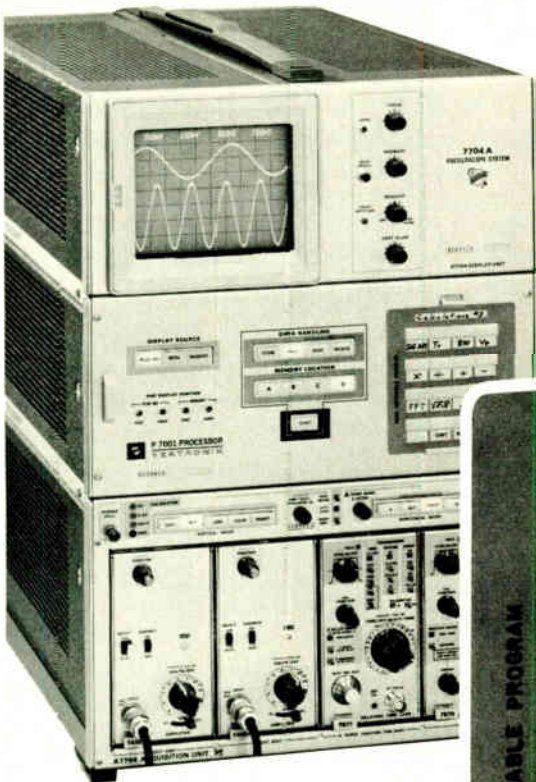
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## Du Pont mixes gold pastes for hybrids

Last year, the Du Pont company tantalized hybrid IC producers by showing—but not selling—a "thin-thick-film" gold paste. Exposed to ultraviolet light, the film polymerizes like photoresist. It can be developed on a ceramic substrate and then fired like screen-printed paste, allowing conductor patterns almost as fine as those made by thin-film processing to be formed without vacuum-deposition systems.

Last month at the Semicon III conference in San Mateo, Calif., Du Pont disclosed an equally interesting material—a photoetchable di-

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However, the Digital Processing Oscilloscope isn't a specialized one-capability unit. It combines the general-purpose 7704A Laboratory Oscilloscope and powerful PDP-11 Minicomputer. These units are linked by the P7001 Processor which provides complete In/Out interfacing. Capabilities include A/D and D/A conversions, waveform storage, recall, and display of those waveforms. The total package is an easy-to-use and significant state-of-the-art product.

This significance is increased by the scope's signal acquisition capabilities, which include more than 25 plug-ins from the TEKTRONIX 7000-Series Family . . . and by the developed software packages APD BASIC I and APD BASIC II (for PDP-11's with 8-k and 16-k core memories respectively) . . . and of course CRT READOUT on the large display screen.

If you would like to learn more about the many uses of the user Definable Program overlay (shown above), and of the Acquisition-Processing-Displaying capabilities of this oscilloscope — please write for your copies of The Digital Processing Oscilloscope Brochure, the magazine feature article reprint "Scope with Brain Power" and the 7000-Series Oscilloscope Catalog. Write: Tektronix, Inc., P. O. Box 500A, Beaverton, Oregon 97005 or check the reader service box.



For a demonstration circle 42 on reader service card

Circle 43 on reader service card 43

electric paste. With the two materials—called Fodel by Du Pont—high-density, multilayer interconnection patterns can be developed and fired. To form such patterns with thin-film layers has required complex selective deposition or etching technologies.

In one sample, shown by Eric Jolle of Du Pont's materials research staff, small rectangles etched from a dielectric film served as crossover insulations between conductors. In another, X-Y wiring levels were interconnected at vias etched through a dielectric interlayer. The gold stripes were 3 mils wide and spaced 3 mils apart, and the vias were 5 mils square. In a third exhibit, a microphotograph, the conductor ends were shown narrowed to an array of 1-mil-wide fingers, ready to receive a beam-leaded monolithic chip [*Electronics*, April 26, p. 76].

Jack Barrington, sales manager, expects a line of Fodel to be ready in the fall. While most thin-film manufacturers have photoetching equipment, many thick-film manufacturers do not, and "our concept has been to offer this capability to thick-film houses," Barrington explained.

Fodel films must be handled under yellow "safe" lights until they are developed, and the patterns must be exposed to ultraviolet light in vacuum-printing frames to produce narrow-line patterns. After exposure, the patterns are developed by removing the unexposed film with a solvent. Then the circuits are washed, dried and fired in air in a

furnace at temperatures from 750° to 1,000°C. A typical firing temperature of 850°C gives the gold lines a resistivity of less than 15 milliohms.

In small quantities, the gold paste will cost around \$350 an ounce, and the dielectric paste \$200. The dielectric costs more than conventional glass frits, but the gold is about the same per unit area as conventional gold pastes. The gold is applied only about a third as thickly as conventional screen-printing pastes, so it covers more area. It can be screen-printed for rough patterning and photoetched to conserve paste. □

## Avionics

### High-angle approach means new avionics

Although adopting quieter jet engines is one method the airlines use to reduce annoying jetliner noise around airports, a \$3.6 million Government-industry-airline program seeks a complementary and faster way: instead of an incoming jetliner making the usual long and shallow-angle approach to the runway, a two-segment approach is proposed by NASA. This brings the plane in at a steeper—and thus higher—angle part of the way before it changes to a normal glide slope. If the two-segment approach promises to be quieter, a market for new avionics may well be in the offing.

Preliminary signs are that the idea works well on a Boeing 727

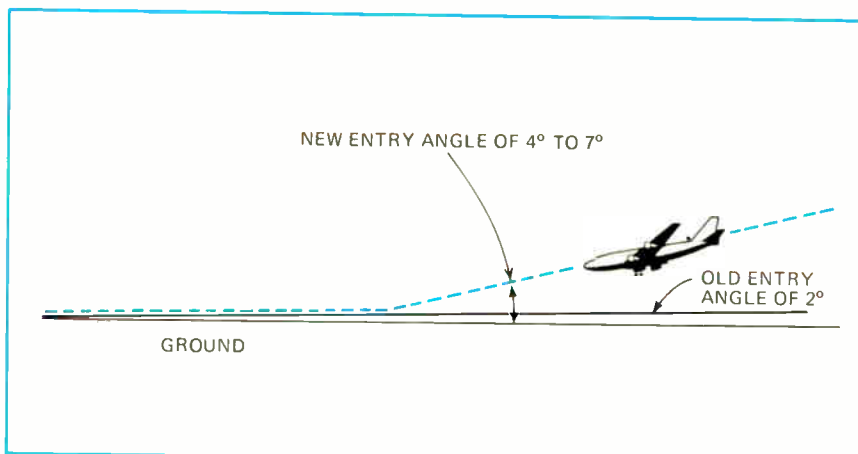
that United Air Lines recently put into scheduled West Coast service, says Dallas G. Denery, project manager for the two-segment approach at NASA's Ames Research Center, Sunnyvale, Calif. Another program using a UAL DC-8 will begin later this year, he adds. Each two-segment project cost \$1.5 million for UAL's participation and about \$250,000 to avionics supplier Collins Radio Co. Also watching are the FAA, other airlines, airline pilots, and equipment makers.

Recent FAA regulations and public pressure spurred new interest in the concept, which has been kicking around NASA and the FAA for some time. A plane enters the upper segment between 4,000 and 6,000 feet and follows a steeper descent of between 4° and 7° to an altitude between 400 to 1,000 feet, where it changes to a normal glide slope, usually 2° to 3°.

**Updated avionics.** Modern avionics make it possible. To implement the two-segment system for the 727 program, Collins added a small analog computer to direct the necessary inputs to the plane's normal autopilot, autothrottle and flight director avionics. The special-purpose glide-slope computer uses inputs from an altimeter corrected for barometric pressure. These inputs are combined with data from ground-based distance-measuring equipment for the upper segment and instrument-landing-system glide-slope data for the lower segment, Denery says.

The system avoids "overshoot" on the upper segment and "undershoot" on the lower segment, and it doesn't add to the pilot's chores during landing. For the DC-8 program, Collins will modify its Mark Two digitally-computerized area navigation system to accommodate the two-segment approach.

Although the concept cuts down noise, airlines will have to measure its cost effectiveness. A redundant analog system for the 727 would



**Sound-saving approach.** By bringing an aircraft in at a steeper angle, NASA believes it can reduce jetliner noise around airports. It can also boost avionics sales.

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### Electronics review

cost about \$30,000 while an area navigation system costs several times that, Denery estimates. Besides the different landing characteristics of the two jetliners, the program also will assess these two alternatives to the two-segment approach. □

### Displays

## Sony's SSD scheme makes cheaper GaP

Green light-emitting diodes are scarce and costly because gallium-phosphide crystals are difficult to grow by conventional zone-refining and Czochralski methods. But that difficulty has been overcome by a new growth process—called synthesis, solute diffusion (SSD)—reported last month at the Semicon III conference in San Mateo, Calif., by the Sony Corp.

Sony believes an uncut SSD crystal would not cost much more than the raw materials plus factory overhead. The reason: the equipment is very simple.

Uniform crystals about 2 inches in diameter and 3 to 4 inches long are being grown in small reactors at Sony's research center in Yokohama, Japan. The reactors require hardly any attention—unlike the complex Czochralski pullers—and can be scaled up in size to produce crystals with diameters of 3, 4 and maybe 5 or 6 inches, according to Akikaza Shibata, of Sony's research staff. The lab-grown crystals are larger than those now made by conventional production machines.

Sony's SSD reactor is a vessel containing a quartz crucible shaped like a test tube. A gallium-phosphide seed crystal is placed in the crucible, which is then filled with gallium. A charge of red phosphorus is placed in the outer vessel. Heating coils hold the bottom of the crucible at a crystallization temperature of 420°C and the top at a melting temperature of 1,200°C. The warm phosphorus vaporizes, enters the melted gallium, and combines with the gal-

lium which supersaturates and crystalizes on the seed crystal.

**Low but slow.** The crystal conforms to the shape of the crucible, emerging as a rod of uniform-diameter. Unlike crystal pulling, the process is not hazardous because the pressure in the vessel is low, about 1 atmosphere, but it is slower, taking several days. Growth by the Czochralski process ranges from 1/10 in. per hour to 1 in. per hour, depending on crystal quality and size.

A major advantage of Sony's SSD process is that the reactor can be left unattended. Only a failure of the heating-coil would stop the crystal from growing properly.

The rods are not perfect single crystals, being composed of single-crystal grains up to about 1 cubic centimeter in size. However, diode chips containing parts of two crystals do work. The emission variations of about 20% to 30% in intensity across the diodes is not apparent to the eye.

Hardly any point defects are found on the GaP wafers. Conventionally grown GaP crystals have 100,000 to a million defects per square centimeter, according to Sony. Such defects degrade diode performance and are generally covered over with an extra epitaxial layer. Sony merely applies one layer by a liquid-epitaxy method. In the lab, the layer is formed by pouring molten GaP over wafers heated in a tube containing inert gas.

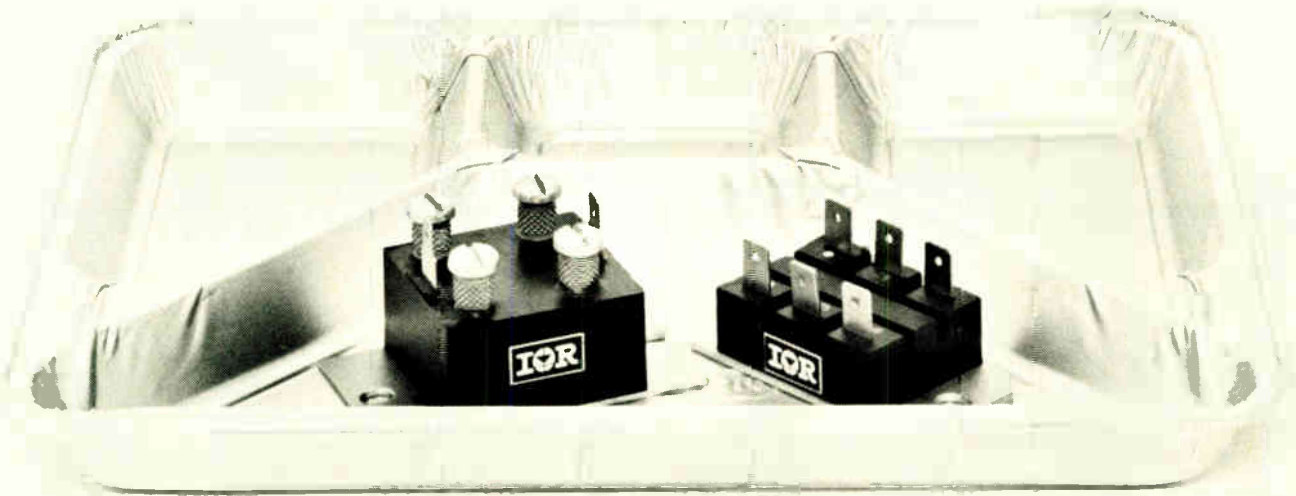
The diodes, once doped to emit green light, have a quantum efficiency of 0.15%. Red diodes have efficiencies to 7.4%. □

### Consumer electronics

## Uhf alternatives proposed by FCC

The FCC is hoping to ease the troubled uhf-vhf television tuner parity issue by proposing two alternative methods of making uhf tuning as easy as vhf tuning when a 70-position detent tuner is used in a receiver. The commission is making

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this move because manufacturers have not been able to meet the original requirements of the FCC, which is ruminating on comments from tuner makers filed June 1.

The proposals are: the elimination of routine fine tuning on monochrome and color sets—where routine means the need for adjustment on a day-to-day basis—and for monochrome receivers only, a channel-selection mechanism capable of positioning the tuner within  $\pm 1$  megahertz of the correct frequency with equal uhf and vhf fine-tuning speed. This mechanism would be a replacement for the automatic frequency control circuitry in monochrome receivers. On one hand, removal of the afc requirement is a boon to makers, but the more stringent  $\pm 1$ -MHz requirement is not.

The FCC initially mandated uhf-tuner parity for monochrome and color sets in November 1971 and set a schedule that would complete total parity by July, 1974 [*Electronics*, Feb. 28, 1972, p.95]. But TV tuner makers could not meet the requirement that the tuner had to be accurate to within  $\pm 3$  MHz of the pull-in range of afc. As a result, waivers of different duration were granted to a number of tuner makers and set manufacturers beginning a year ago [*Electronics*, May 8, 1972, p.31 and July 3, 1972, p.43] and finally the FCC extended the schedule to July 1, 1975.

The FCC has based the latter proposal on a tuner prototyped by General Instrument Corp.'s Sickles tuner division. The new tuner is a 70-position uhf detent tuner accurate to  $\pm 1$  MHz, with a tuning speed of 22 kilohertz per degree of rotation. Further, William Firestone, group vice president of Sickles, says there have been no problems in meeting the demand for  $\pm 3$ -MHz detents.

Sarkes Tarzian Inc., GI's main competitor in the field, also claims no hardship in meeting the same demands of the industry although set maker RCA, for example, has said it has felt the brunt of a shortage from both GI and Sarkes Tarzian. And says its president, Sarkes Tarzian, of GI's new tuner, "It's premature. It is

impossible to meet that requirement on a mass-production basis without going to great expense."

Tarzian's reply to the FCC is a plea not to legislate progress. "When manufacturers can produce this kind of product in mass production, then requirements should be set," proposes Tarzian. "Then we'd avoid waivers and this kind of situation."

The Electronic Industries Association has also filed a comment, supporting the commission's proposal to change the requirements. However, the EIA has voiced doubt as to whether  $\pm 1$ -MHz accuracy can be achieved in all cases. It has noted that there are no available uhf tuners that do not have tune-in errors when the worst case is included. The EIA recognizes that the proposed rules are an improvement. But it suggests maintaining the current rules for another year to give tuner manufacturers enough time to develop an accurate tuner.

Meanwhile the varactor tuner, which does meet accuracy requirements, has not come down in price, and is still used for top-of-the-line sets. And most industry insiders agree it will take several years of evolution before the varactor unit becomes inexpensive enough for use across the board. Manufacturers of varactor tuners not only include Sarkes Tarzian and GI, but RCA, Motorola, ITT Semiconductor and Oak Industries Inc. Selectronics division. GI claims to be working on an alternative to detent and varactor tuning, and ITT is also working on a new type of varactor. □

**Trade**

**Industry, labor seek curbs on Nixon bill**

Electronics manufacturers and organized labor are in apparent agreement that President Nixon's Trade Reform Act of 1973 should be amended to require ongoing participation by industry, labor, and other affected parties in any new inter-

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# SCIENCE/SCOPE

Canada's Anik 2 communications satellite, launched in April, will provide additional capacity to meet the demand for Telesat Canada's commercial services. Like Anik 1, world's first domestic synchronous satellite, it has a capacity for more than 5,000 telephone circuits or 12 high quality color television channels. Hughes is building a similar series of satellites for two American companies that plan U.S. domestic systems to start in 1974 and 1975.

Several new composite materials developed for NASA space projects hold great promise for civilian use in such fields as biomedicine, agriculture, and furniture manufacturing, according to Hughes scientists who have just completed a technology utilization study for NASA. Medical applications include bio-compatible prosthetic devices of carbon fibers in an epoxy-resin matrix and braces of graphite-fiber-reinforced plastic (equal in strength to steel at one-eighth the weight).

Filament-wound graphite-glass fiber composites reduce the cost of grain silos and water tanks. Air-inflated barns and other structures made from fiber-reinforced plastics have a life expectancy of at least 20 years. Foams with fire-suppressant and self-extinguishing properties have been developed for furniture -- both hard foams for casting replicas of carved wood and soft foams for upholstering.

An Australian domestic communications satellite system is the subject of an extensive study by the Australian Post Office (APO). The system would distribute telephone, telegraph, television, and educational services throughout Australia's vast territory. Hughes was the successful competitor in a worldwide competition to provide consultant services to the APO for this study, which will initially determine the operation, benefits, and economic feasibility of the system.

Jacques Cousteau's oceanographic research vessel, Calypso, safely navigated the hazardous Drake Passage at the southern tip of South America with the help of an earth-orbiting sensor and a satellite built by Hughes. The multispectral scanner aboard NASA's Earth Resources Technology Satellite 1 photographed weather and ice-berg formations along the route. The pictures were processed by Goddard Space Flight Center and relayed to the U.S. Navy's Fleet Weather Facility, which relayed the information to the Calypso via Applications Technology Satellite 3.

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1500 watts of electricity from solar energy are being produced by the FRUSA (Flexible Rolled-Up Solar Array) system aboard a U.S. Air Force Agena satellite. Its two 16-foot panels, each with 17,250 solar cells, were rolled into a cylinder at launch, then unfurled in space. Now Hughes is developing an advanced multi-mission version with an analog/digital voltage regulator. Welded aluminum construction will enable it to tolerate much higher temperatures during near-sun missions.

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Circle 50 on reader service card

World Radio History

## Electronics review

national trade negotiations before they are concluded by the President. But that, plus a call for rapid and mandatory enforcement of anti-dumping and countervailing duty laws, was about all the two sides could agree on in testimony at the end of May before the House Ways and Means Committee.

Congressional sources question whether Committee Chairman Wilbur Mills (D., Ark.) can meet his August deadline for reporting out H.R. 6767, which would give the White House sweeping new powers to negotiate trade agreements. Part of the problem facing Mills is the

need to accommodate the divergent views of industry and labor. Labor continues to support the Burke-Hartke bill, which industry and most Federal officials regard as overly protectionist and threatening to offshore operations.

Largely similar positions were presented on May 30 by the Electronic Industries Association and WEMA. Both strongly opposed the Nixon plan to eliminate Items 806.30 and 807 of the U.S. Tariff Schedules, under which unfinished parts exported for assembly are reimported in a finished product with duty only on value added. □

## News briefs

### Fairchild raises SSI prices

Fairchild Camera & Instrument Corp. is raising distributor prices on TTL and DTL small-scale integration products by about 15% across SSI product lines. Robert M. Skinner, director of distribution for Fairchild Semiconductor Components, says that although competitive pressures had driven SSI pricing down over the past few years, demand for TTL and DTL SSI products has recently soared.

"This has caused lead times for SSI products to stretch out intolerably, while MSI products are relatively available," states Skinner. Skinner says the company is convinced that the cost adjustment will improve Fairchild's ability to supply TTL products in the mix demanded by the industry.

### National to set up shop in Thailand

National Semiconductor Corp., Santa Clara, Calif., has received approval from the Board of Industry of Thailand to manufacture integrated circuits and transistors in that country. According to Charles E. Sporck, president of National, the company plans to establish a manufacturing facility in Samrong this September. The company has additional plants in Connecticut, Singapore, Malaysia, Hong Kong, Scotland, and West Germany.

### Japan not dumping microwave ovens, U.S. says

The U.S. Treasury has determined that "microwave ovens from Japan are not being, nor are likely to be, sold at less than fair value" within the meaning of the Antidumping Act of 1921. The mid-May ruling followed a tentative determination in favor of the Japanese in early April that allowed interested parties to present written or oral objections to the agency; the principal U.S. complainant was Litton Industries Inc.

### Fairchild, TRW launch satellite plans

Joining forces to pursue the growing commercial communications satellite market, TRW Systems Group, Redondo Beach, Calif., and Fairchild Industries, Germantown, Md., have teamed to bid on the projected \$85 million satellite system being assembled by RCA Global Communications Inc. and RCA Alaska Communications Inc. The system is scheduled to be launched in late 1975. Under the terms of the agreement, Fairchild will construct the satellites, and TRW will supply the communications transponders and altitude, command, and control systems.

### RCA expands power-devices facility

A booming electronics industry has triggered a host of recent facilities-expansion projects such as those of Fairchild and Motorola [*Electronics*, May 10, p. 38]. Now RCA, joining the trend, is expanding its power-devices facility at Mountain Top, Pa., by leasing a 44,000-square-foot building.

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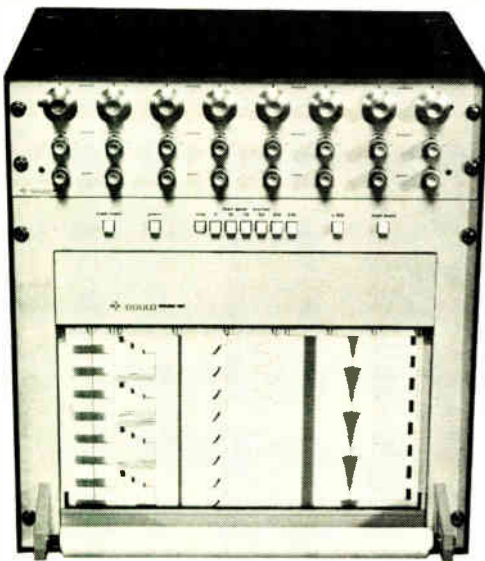
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BRUSH INSTRUMENTS

 **GOULD**

Electronics/June 7, 1973

## **Packard opposes Nixon trade tax plan. . .**

Former Nixon cabinet member David Packard, on WEMA's behalf testifying before Congress on the President's Trade Reform Act of 1973, has advanced a counter-proposal that could wipe out an Administration plan to boost U. S. treasury tax revenues. The plan opposed by Packard **would assess U. S. taxes on overseas operations in nations offering extended "tax holidays."** Hewlett-Packard Co.'s chairman says that, if these taxes are enacted, **"the proper action for Hewlett-Packard Co. would be to pay a fair share of local taxes** rather than asking the governments of Singapore and Malaysia to continue our 'tax holiday' status." Packard's reason: "We believe American business has a responsibility to make sure their foreign operations are good citizens of the nations where they operate. Part of this is paying a proper share of taxes in the host country."

## **. . . defends foreign plants as export sales booster**

Packard defended H-P's foreign operations by noting that the company's **exports to Germany, Britain, and Japan have soared since the establishment of plants in those countries.** Being accepted as a "local supplier" has given H-P an entree for export sales that otherwise "we would not have secured," he explained, citing a 46% increase in international orders to nearly \$140 million in the first half of H-P's fiscal 1973 compared with the same period in 1972. In that year, 40% of the company's business, or \$200 million, came from foreign orders, and 74% of these were filled with U.S. exports.

## **FAA's cutback posture worries some firms**

Although there are some indications that the spending hold-down at the Federal Aviation Administration may be loosening, companies eyeing new business are increasingly worried by the continuing drought of new contracts. One apparent victim of the agency's cutback posture, mandated by the Office of Management and Budget, is **Lockheed Electronics' development of the Automated Radar Terminal System 2 (ARTS 2),** now undergoing prototype testing (see p. 66). Although the agency originally wanted to buy 90 of the 145-unit order in the first three years, it now is talking about only 70 and possibly rebidding for production units.

**Another victim of FAA hesitation is the estimated \$30 million first phase of the ARTS 3 enhancement program.** Sperry-Univac has developed the prototype package of ARTS 3, but agency infighting reportedly is delaying decisions on how to implement the program and whether it should be a sole-source procurement to Univac.

## **Arinc to build own Chicago net but lease one in L.A.**

Aeronautical Radio Inc., which thought last year that **it might be cheaper to buy service from other companies for its planned microwave communications networks** in the Chicago and Los Angeles areas [*Electronics*, Dec. 18, 1972, p. 49], changed its mind at a special board meeting on May 25 and **decided to split its bets.** It will ask the FCC for licenses to build its own system in the Chicago area and dicker with microwave companies for service in the Los Angeles area. However, if negotiations with companies in the Los Angeles area don't work out, Arinc could wind up building its own system there, too.

## Wrapping DOD's black boxes

Q. What is it that you carefully package after manufacture and then unpackage to put into another equally sturdy package that costs up to 400% more?

A. Semiconductors and most other electronics products sold to the Department of Defense.

Why? Because, despite the judgment of most electronics contractors that their commercial packaging is adequate for most military shipping and storage needs, many military commands still operate by a book filled with packaging guidelines that are sometimes ill-conceived, often outdated, frequently duplicative, and always expensive. These are the conclusions of congressional auditors in the General Accounting Office, who have been looking at defense packaging requirements for a couple of years now. And, for a change, the GAO's assessment of the problem has delighted Federal suppliers, some of whom have been known to grumble at some of the agency's other efforts to turn up examples of military program mismanagement.

Military packaging and its peculiar range of problems do not seem destined to become front-page material, particularly in a city still transfixed by Watergate and its political fallout. Nevertheless, the GAO and the contractors it surveyed are convinced there is something wrong with a system in which as much as 10% of an annual outlay of \$13.4 billion goes for bags, boxes, containers, crates, and plastic wrap.

### Solid gold boxes?

The problem is not that DOD "must be buying solid gold containers," as one congressional recipient of the study mused. But it is buying individually packaged semiconductors, machine screws and even metal washers that are usually distributed to the military in quantities of at least 10 and sometimes in the hundreds.

"The only difference in packaging and packing between commercial and military semiconductors is that of labeling and its cost," says one contractor. "However, the electronics industry has recently been directed by the Defense Electronics Supply Center to package all semiconductors that they buy in a barrier material per MIL-B-81705A." The minimum cost increase to meet that specification, he figures, "will exceed 400% of the cost for commercial items."

Then there are contracts that contain such literary gems as: "LEVEL C PACKAGING SHALL BE METHOD IC-2 FOR LEVEL A IN STEPS 1, 2 AND 4 AND ENCLOSING THE ITEM(S) IN A SNUG FIT-

TING HEAT SEALED BAG OR WRAP FABRICATED FROM BARRIER MATERIAL CONFORMING TO L-P-378 OR TYPE B-2 OR B-3, CLASS 1, GRADE A, B OR C OF MIL-B-13239 OR TYPE II OR III OF MIL-F-33191." To locate and run through the variety of brochures and manuals defining these codes and then see that they are coordinated and implemented, contractors protest that they must maintain special staffs of legal, accounting, operating, transportation and lots of clerical personnel. "That is where most of your costs are," explains one former electronics plant manager now assigned to Washington to "wrangle over just such stupidity as this."

Worse than that, sometimes the codes for similar parts are different. "We pack a lot of modules for DOD," observes another manufacturer's man, who cites just one part that it is possible to label either 3G11000BGxD3YYAYYYY—or else, with no less a degree of confusion, 2M1100DABBBXXY10AAQAD. "I guess it is up to the person that codes the part," he sighs.

### Going commercial

Whatever the reason—and rest assured that DOD will always argue that it has a good one—no one in industry disputes the contractor who concludes that "Government packaging specifications are definitely not clear and easy to follow; and only someone with a complete updated file of all Government booklets and pamphlets . . . can hope to even begin to cope with lengthy sets of code numbers and letters that call out Defense Department packaging. It is my considered opinion, based on eight years of Government contracts administration, that the Government could realize a very considerable cost savings each year by converting to standard commercial packaging."

Where the Defense Supply Agency and the Army have achieved limited economies by turning to commercial packaging for some products used in the U. S., the GAO contends the Air Force and the Navy still specify "very high levels of packaging," particularly for electronics products. Though GAO wants congressional consideration of the problem, little is likely to happen without some strong and well-organized industry complaints. Packaging has never been high on the list of congressional priorities. "For one thing, it's dull, dull, dull," says one candid congressional staff man. "If contractors want action, why don't they try the Pentagon? They have a new Secretary of Defense over there, and new secretaries for most of the services. This is really their job."—Ray Connolly

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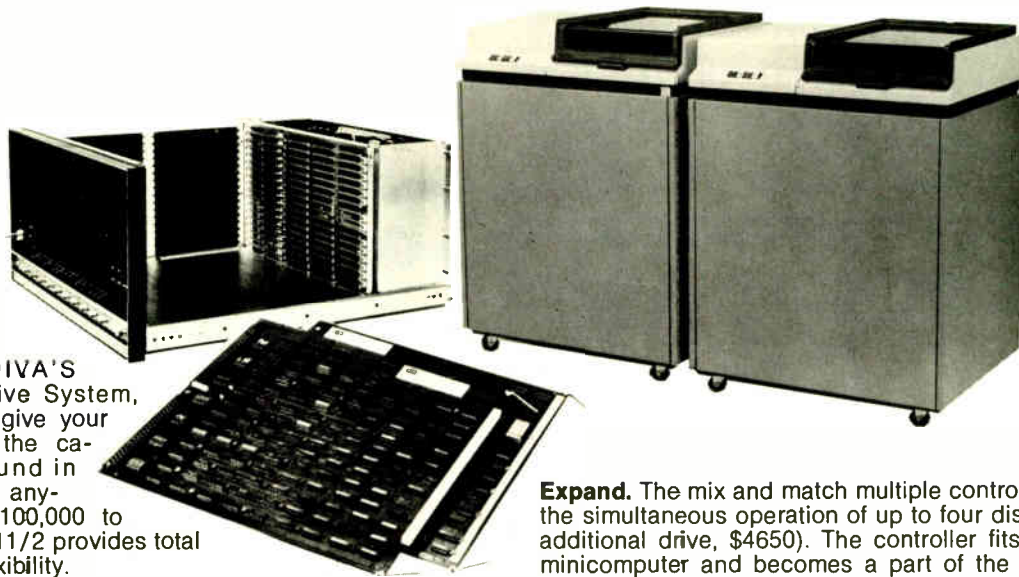
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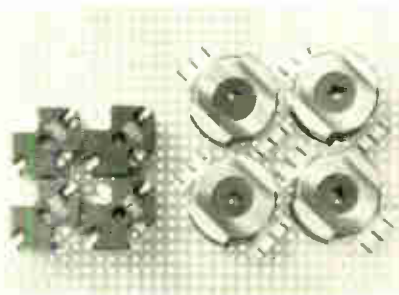
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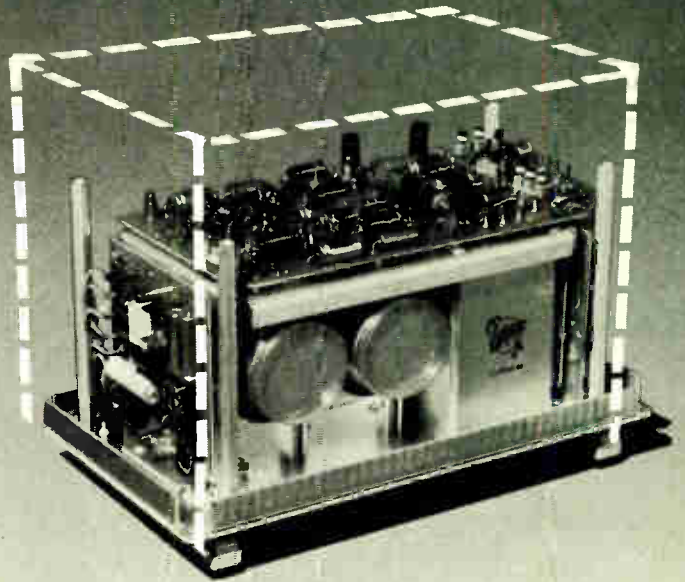


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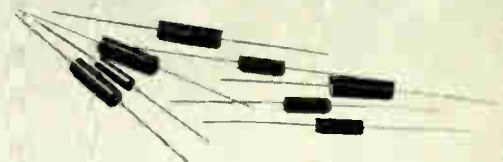
## **Ceramag 24**



Toroids of Ceramag 24 were used by Tektronix, Inc. for transformer cores. Again, this is a proven material, widely used by the computer industry for pulse transformer cores. It has a tightly controlled initial permeability, and tooling for a variety of sizes is also available.

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Gas plasmas dissolve resists on integrated-circuit wafers—and etch circuit patterns—in a process developed by Mitsubishi Electric Corp. [*Electronics*, May 24, p. 59]. Among the approach's advantages are high yield, fine line widths, and a cut in processing steps and time. What's more, the plasmas react to form harmless gases and water, which are easy to dispose of—unlike used acids and solvents.

**On line.** The company already has six plasma reactors on its production lines and expects to double the number soon. Large-scale-integration chips for computers, silicon-gate LSI memories, and linear bipolar circuits are being produced in the reactors.

The etching process is equally applicable to other devices—including high-speed logic circuits—requiring a masked etching of a silicon nitride or polycrystalline silicon layer overlying a silicon dioxide layer. An oxide layer is required because the process selectively etches silicon nitride and silicon about 10 times as fast as it etches silicon dioxide. Thus, without the silicon dioxide layer there is the danger that the process could not be controlled closely enough to prevent it from eating into the silicon substrate. The photoresist removal process is applicable to almost any device.

The usual chemical process for etching nitride layers is complex because photoresist films cannot mask the process. It is necessary to grow an oxide film over the nitride film, and then apply the photoresist over the oxide film. A photoresist mask is used for masked etching of the overlying oxide layer, after which the photoresist is removed and the resulting oxide mask defines the etching of the nitride layer. Then the oxide layer is removed.

Not only does this process require growth, etching, and removal of an

extra silicon dioxide layer, but even those operations common to it and to the plasma approach are more complex in the chemical process. For example, chemical removal of photoresist requires a dissolving operation followed by two washes and a drying.

In plasma photoresist removal, the worker loads a fused quartz boat with wafers, inserts it into the plasma reactor, and pushes a start button. Oxygen is automatically fed into the reactor and ionized by a high-frequency coil surrounding the reactor tube. Oxygen ions in the plasma convert the resist film into water and carbon dioxide vapors, which are released to the atmosphere.

**Etching.** Plasma etching of nitride films is quite similar to photoresist removal. Fluorine ions in a freon-gas plasma react with the silicon nitride layer to form silicon fluoride and nitrogen, both harmless gases

that are released to the atmosphere. Undercutting is in general smaller than for a chemical process and the angle of cut can be selected by adjusting operation conditions.

There may be some damage to the silicon substrate during plasma-etching. But this operation is normally followed by a high-temperature process, so that any damage is annealed with no additional manufacturing operations.

Engineers say that the switch from chemical to plasma processing eliminates five separate steps. Saving in wafer processing time is 210 minutes. Drop in labor time, which is counted for only that portion of the operation that requires worker intervention, is 100 minutes per lot, a savings that enables processing to be performed with eight fewer people. In addition, the new process makes it possible to successfully manufacture LSI chips with line accuracies within  $\pm 0.5$  micrometers. □

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### France

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## Mobile radar system brings in the helicopters

French air force chiefs are in a hurry to get their hands on a new highly-mobile surface-radar system designed specifically for helicopter control by Thomson-CSF, France's largest electronics company. Thomson-CSF designed the system for all-weather operation and says it's the first truly mobile unit to combine both ground-approach surveillance and landing control for choppers.

The equipment, known in its French military version as Spartiate, went on sale to foreign customers at the Paris Air Show at Le Bourget this month under the name of Perceval. Even without foreign custom-

ers, Thomson-CSF's helicopter hardware has good prospects. Already 15 complete systems have been ordered by the French armed forces. Only two prototypes exist today.

**Impetus.** The chief motivation behind the domestic order is the need to put helicopter bases, complete with the radar facilities normally only available at permanent bases, into operation as fast as possible. Spartiate's functions cover navigation control, collision avoidance, identification, and landing. Says the project's commercial chief Jean Mothes: "The Indochina war taught us the need to move as many men

from one place to another as fast as possible—and this means helicopters rather than surface transport.”

It also means that radar facilities have to be established quickly. The Spartiate system can be moved to a freshly cleared landing site loaded aboard two trucks and can be operating within two hours after arrival.

For ground-approach surveillance, the system displays primary radar data and friend-foe identification signals up to a range of 40 miles. It can also record identification signals up to about 120 miles without interfering with the primary radar function. These signals are picked up by the continuously rotating azimuth antenna. For landing control, both azimuth and elevation antennas come into play, with horizontal and vertical signals displayed alternately at 2-second intervals. When both modes are combined, the elevation antenna is fed about every 3 seconds in alternation with the azimuth antenna, which covers a sector of about 15° on either side of the landing axis.

**Combination.** Thomson-CSF engineers are particularly enthusiastic over the incorporation of a moving-target indicator system to counteract ground clutter, which is likely to be severe with low-flying helicopters. The system is of the digital phase-threshold-inhibition type and features a very high fixed-echo rejection ratio, a staggered pulse-repetition frequency to reject blind speeds beyond normal approach speeds, and mechanisms to cancel blind phases and to control false alarms.

A major problem in Perceval design, say the engineers, was to overcome the danger of interference between so many different radar and radio functions squeezed together into two small packages. The difficulties were eventually overcome through use of filters and, in particular, by two ferrite attenuators to increase decoupling between the azimuth and elevation channels.

Thomson-CSF will not have much time to put things right if their two prototypes do not perform as planned. The French air force wants to put the system in service so badly that work has already started on



**Low cost.** Although Sharp's new calculator has only three-digit display, its circuitry handles a 12-digit number and gives serial display.

building the 15 units it has ordered. After initial tests this summer, full operational tests on the first prototype are scheduled to begin in January. Thomson-CSF hopes that foreign customers could get delivery of Perceval during 1975. □

## Japan

### New low calculator price: \$38

The price of electronic calculators in Japan has hit a new low of yen 9,980, or about \$38, with a new model just announced by the Sharp Corp. That price punches a hole in what appeared to be the floor of yen 12,800 set last August by Casio Computer Co. and since followed by three more companies—Busicom Corp., Omron Tateisi Electronics Co., and Citizen Watch Co.

**Prospects.** Sharp says that it will soon have production up to 70,000 units a month, and by yearend expects to be producing 150,000 units a month. Tadashi Sasaki, executive director for the Industrial Instruments Group, says that he expects the calculator to go over very big in the European market.

Casio cut the price and power drain in its low-price unit by going to a six-digit fluorescent display, rather than the eight digits every-

body else was using in their low-price calculators. Sharp went Casio one better by going to a three-digit fluorescent display. But Sharp didn't cut corners as much on its calculator LSI circuit and so it still offers a full 12-digit machine—actually nine digits before and three after the fixed decimal point. Sharp also claims that it is one of the two suppliers for the calculator chips—until now all its calculator chips had been purchased from outside suppliers.

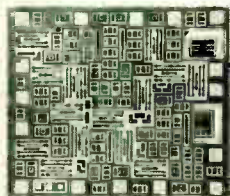
To facilitate readout, Sharp has added a new partial digit to the right of the least significant digit. This digit position gives two new symbols—one or two commas in the middle of the digit. Translated into engineering notation, the two commas read  $10^6$  and the single comma reads  $10^3$ . Thus, the user can read a 12-digit answer unambiguously in up to four readings of the 3-digit display. The user can choose two modes of operation. One requires manual shifting of digit groups; in the other the calculator automatically steps through the groups of three digits.

Sharp has also added a counter button that enables the calculator to be used to count events. Calculations can be performed on the counted number, if desired.

The calculator operates from three penlite cells. Battery drain is 0.6 watts, which gives battery life of five hours with low-priced cells and 15 hours with alkaline cells. □

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## **British makers set to go with 110° models**

British TV-set makers at last seem to be ready to launch 110°-tube color sets onto the home market, **several years behind most other countries with an established color service and set-making industry.** Thorn Consumer Electronics Ltd., Philips Electrical Ltd., Rank Bush Murphy Ltd., and Pye Ltd. plan to have 26-inch-screen models available by year-end, and 22-inch sets probably next year. Thorn, Philips, and RBM will offer finger-tip-touch tuning on luxury models, and the first two companies will offer ultrasonic remote control of some operations as well, **partly to increase the difference between the new sets and established 90°-tube sets—and so justify noticeably higher prices.** The new sets also have more integrated circuits than present models, seven or eight being the new norm. Where touch tuning isn't used, push-button varicap tuning is standard, the selector unit based on a thick-film module. Look for steady penetration of thick-film construction into TV sets where power is too great for monolithic construction; several makers are making experiments, for instance for deflection circuitry and the varicap diode module of the tuner.

## **Failure of French rocket casts gloom on whole program**

French efforts to muster foreign support for their L3S satellite launcher now face even more formidable odds than before. **Hopes of persuading the West German government, and possibly the Dutch and Belgians too, to chip in a combined total of 40% of the cost** took a dive when the Diamant-B rocket plunged into the Indian Ocean along with the Castor and Pollux satellites it should have put into orbit.

The failure has also thrown a shadow over the whole future of the Kourou launch base in French Guinea, where the two previous blast-offs also misfired. When Europa-2 exploded after its launch from the French-built site in December 1971 it became clear that its failure would bring the ELDO concept down with it [*Electronics*, May 10, p. 55]. **Two successive failures of Diamant-B rockets may now sound the same warning for the Kourou site itself and even for the French launcher program.** Right now yet another French launcher is waiting in the wings. The Diamant BP4 uses the same first and third stages as its predecessor but has a larger second stage. It could take over another attempt to launch two other Castor and Pollux satellites presently under construction. But if the fault for last week's failure is pinned eventually on the third stage, this project too could be in trouble.

## **AEG-Telefunken, Sony patch up PAL dispute**

AEG-Telefunken and the Sony Corp., which have been fighting a court battle over alleged violations of PAL television patents by the Japanese firm [*Electronics*, Aug. 14, 1972 p. 65], have finally settled their dispute. Settlement was reached by a licensing pact under which **Sony has acquired the rights to build a certain number of PAL receivers in Japan for distribution in all countries using the AEG-Telefunken-developed color-TV transmission standard.** According to the agreement, the maximum screen size of the sets Sony may build is limited to 18 inches. The licensing arrangement, which also allows Sony to use certain AEG-Telefunken patents in black-and-white receivers and fm-radio sets, is similar to the ones made with other Japanese firms and needs only Japanese government approval. **Sony also has obtained from EMI a license to sell color-TV sets in the UK under AEG-Telefunken patents.**

## Helical-scan recorders for broadcasters bow at symposium . . .

Quadraplex video tape recorders, pioneered by Ampex Corp. and long the mainstay for TV broadcasters, face a serious challenge in PAL and Secam territories. Two international teams of VTR producers launched helical-scan, broadcast-quality color machines at the late-May television symposium in Montreux and both maintain their machines will obsolete their quadraplex predecessors.

One far-flung team has California's International Video Corp., France's Thomson-CSF, and Britain's Rank Precision Industries as members. With IVC as team leader, **they've developed a VTR that records with a pair of ferrite heads on 2-inch tape.** IVC claims that the helical-scan machine costs about one third less than similar quad machines and slashes operational costs as well. Tape consumption, for example, drops by half, and head life stretches to 1,500 hours. Initially, IVC will produce the hardware for its European partners.

Philips Gloeilampenfabrieken of the Netherlands and Robert Bosch Fersehanlagen GmbH of West Germany joined forces to produce the second helical-scan contender. It works with a single ferrite head and 1-inch tape. **The Dutch-German team claims that its broadcast color recorder halves the initial hardware cost, compared to like quad machines, and cuts tape consumption by some 60%.**

## . . . where Philips unveils new low-light camera

Philips Gloeilampenfabrieken is taking a hard look at a new pickup-tube concept that could lead to a new generation of color-TV cameras for on-location work. **The tube pairs an image intensifier and a 1-inch Plumbicon tube, coupled with fiber optics.** They are packaged, with a deflection unit and a field-effect transistor input stage for the camera's preamplifier, in a housing that's almost identical in size to a standard-Plumbicon/deflection-unit assembly. In the package, Philips uses a low-gain light intensifier rather than a high-gain see-in-the-dark type. The combination keeps the tube's performance well within broadcast-quality standards, **all the while upping the camera's sensitivity by at least two full lens stops.**

## First ARTS 2 for Europe sold to Italy

Italy's Ministry of Defense has bought the first European ARTS 2 automated air-traffic-control system from Lockheed Electronics Co.. **The system, using a 12,000-word minicomputer to simultaneously handle data from 256 aircraft, will be delivered late this summer.** Installation site is still to be determined. Lockheed initially developed the prototype system under a \$1.5 million award from the Federal Aviation Administration. Lockheed declined to specify the price of the Italian production system, but the FAA has estimated its ultimate costs for 98 systems will work out to about \$350,000 each.

## Disk head floats, but never crashes

Many manufacturers are working on floating head assemblies to achieve the maintenance-free magnetic disks needed in future consumer electronic products. Head assemblies float on a thin layer of air but crash into the disk when it slows down. Japan's NHK Technical Laboratories has developed a new **leaf-spring mounting, which actually holds the assembly away from disk until the Bernoulli effect, which reduces air pressure between head and disk when the disk is in motion, overcomes spring tension.** But when the spacing becomes very small the layer of air between the head and disk maintains correct spacing.

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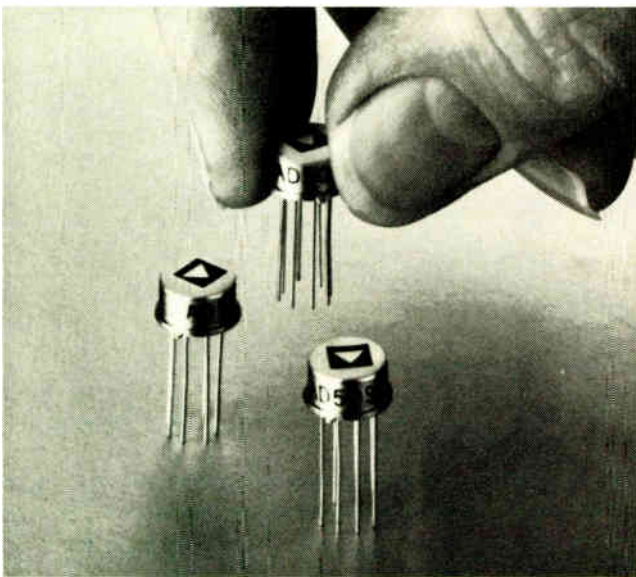
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# Probing the news

Analysis of technology and business developments

## Computer microfilm pushes forward

Makers battle to change old image of medium as something to be used for dead storage as they push concept of off-line terminal

by Paul Franson, Los Angeles bureau manager

**Surviving** the incomprehension of would-be users and the over-enthusiasm of early promoters, computer output on microfilm is now a steadily growing business and is also moving into new territory as an active communication medium. However, companies in the field have found profits elusive. Competition, high development costs, the cost of re-educating prospective users, and the practice of leasing equipment have made COM profits either nonexistent or marginal for most makers.

Growth is about 20% per year, starting from the present level of \$22 million to \$28 million in sales and revenues for computer-output-on-microfilm recorders. Total COM-related revenue—including auxiliary equipment—is in the \$60 million to \$80 million range.

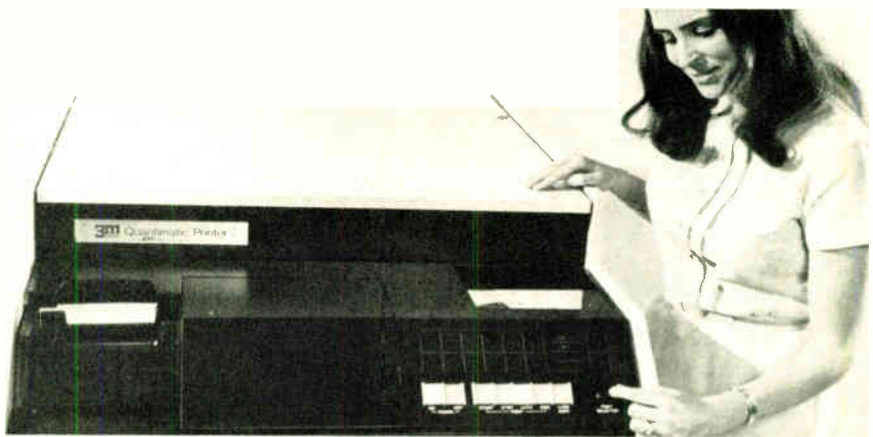
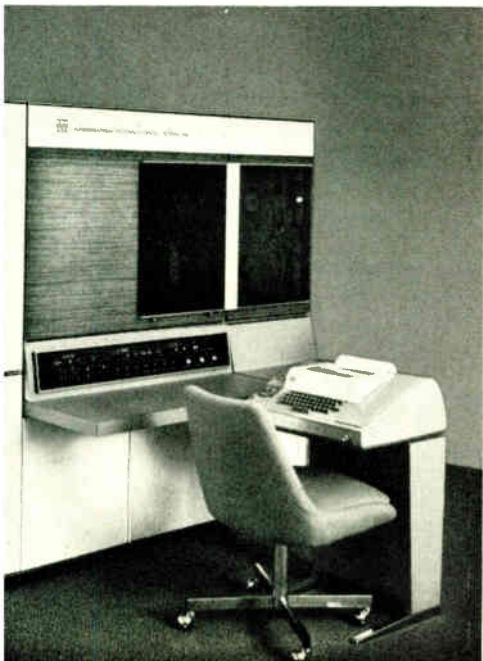
**Copy cats.** Computer output on microfilm products come from information international (below), 3M (top right), and California Computer Products (bottom right). Industry reports sales climbing.

Estimates of total worldwide installations range from 750 to more than 1,000. And those machines range from \$30,000 replacements for line printers to \$350,000 high-speed, high-resolution graphic/alphanumeric systems. Sources in the industry expect the total to double by 1975. As John O. Ferris, COM sales manager at Pertec business systems, Santa Ana, Calif., puts it, "We'll meet the 1970 projections by 1975."

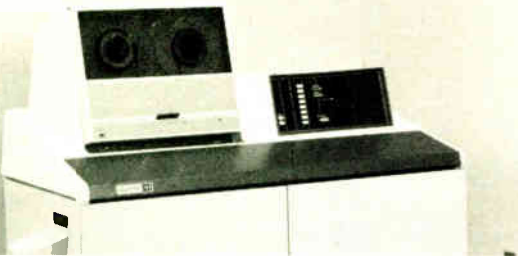
Ferris refers to what the industry now views as disastrous over-enthusiasm in its early days—the middle to late 1960s. Then, prophets saw microfilm solving the computer paper glut and caused many firms to rush into a market that could stand neither the hyperbole nor competition. Because chemicals had to be handled and existing equipment

was simpler to use "COM was not that readily accepted," admits Edward T. Keating, vice president and general manager of Stromberg DatagraphiX of San Diego, the industry's pioneer and still by far the largest supplier. The ensuing debacle combined with generally bleak economic conditions to cause severe price erosion, then attrition and mergers.

The survivors include DatagraphiX, with half the worldwide total, Eastman Kodak, Pertec, Quantor, Memorex, Calcomp, Seaco, 3M, Gould, Singer's Micrographic Systems, and Information International. Not all compete with each other, though. DatagraphiX serves the widest segment and also offers a wide range of the required auxiliary equipment—developers, duplicators, and viewers among others. At the



## Probing the news



**Ready to go.** Quantor's 105 COM processor, left, develops film in same unit. Big selling point of 3M's 600 reader-printer is easy-load-unload feature—it uses 16-mm microfilm cartridge.

low end of the market, Calcomp—California Computer Products, Anaheim—has an alphanumeric unit that plugs in as an IBM 1403 printer replacement at a competitive price, as does financially troubled Memorex Corp., Santa Clara, Calif., which pioneered in this area.

The most popular type of COM recorder takes digital input from a computer or magnetic tape and forms characters on a CRT screen at up to 120,000 characters per second. The images are reduced optically and expose high-contrast microfilm. The film is then developed in the same unit, in a separate stand-alone developer, or even in a conventional darkroom. The result, in either roll or fiche format, can be viewed or copied.

Off-line systems are most popular. Pertec's entry, priced at \$80,000, though most COM equipment is leased, features wide versatility. But the hottest entry at present is undoubtedly a \$65,000 unit from Quantor Corp., Mountain View,

Calif., that combines a COM recorder with integral film processor—the user doesn't even have to touch chemicals, for in the U.S. they're replaced once a week by an NCR serviceman as part of a deal with NCR.

With more capability—and at a higher price—than the alphanumeric units most popular in business, are the graphic recorders or plotters for scientific and engineering use. They are offered by a number of firms including Calcomp, best known for its flatbed and drum plotters. Calcomp, in fact, finds the alphanumeric area “disappointing” and is emphasizing graphic units. Gould Data Systems division in Boston offers two Beta-com graphic models, and at the top of the line is Information International Inc., Los Angeles, with its COM-80 that typically sells for \$300,000 to \$350,000 and, needless to say, offers high performance. The company has about 30 in the field.

Also active in both alphanumeric

and graphics is Seaco Computer Display of Garland, Texas. Its equipment is handled by Remington Rand, but Seaco has been through a bankruptcy reorganization within the last year. Singer Micrographic is most active in high-end graphic recorders, while 3M appears to be retrenching at present. Kodak's Business Systems division in Rochester, N.Y., sells the KOM-80 and KOM-90, alphanumeric machines assembled for it by Cubic Corp., San Diego, Calif.

A major concern of makers of COM equipment at present is trying to change the image of microfilm—for most people, the rolls of back issues of *The New York Times* in college libraries. One company, Quantor, is promoting microfilm as a fast-access substitute for computer display terminals that access batch-processed data. Jack Ferris of Pertec concurs: “This viewer is really a \$150 off-line terminal.” Traditional microfilm, of course, is used largely for archives, and the microfilm industry, though claiming COM, doesn't really seem to know what it's for.

One user that apparently does is Lockheed California in Burbank. The savings over paper have been substantial, says Donald Stanley of the Scientific Systems group. He notes the COM is used to plot wind-tunnel test results. “They would have tied up our Calcomp plotters forever,” he says.

However, he adds that there's a real need for a good method of generating hard copy.

With their varying opinions, one thing all manufacturers seem to agree on is the reluctance of data processing managers to get involved with photographic systems. Taugner of Information International suggests that it's time for the data manager to give up the decision on form of presentation. “Perhaps the publication department should handle it. The EDP man is too attuned to the limitations of his computers.” However, whether or not the EDP man loses the output, few manufacturers see COM taking over from paper as once projected. Charles Askansas, president of Quantor, says, “COM will not, as some predicted, replace 50% of the computer printers. It is a complementary alternative.” □

### The pro of COM

Computer output on microfilm seems to have compelling advantages over printing on paper with line printers, but that hasn't been enough yet to overcome tradition and inertia. “The economics have always been there,” says Terry Taugner of Information International Inc. So suppliers continue to hammer on the door while emphasizing the newer concept of an “off-line terminal” for information that doesn't really require instant updating. The argument for the off-line terminal is also economic—compare a \$150 viewer, plus the few cents it costs to make and mail a microfiche, with the cost of a cathode ray terminal and communications lines.

The more traditional emphasis has been on the low cost of film versus paper, especially for multiple copies. A fiche costing a nickel can hold the information in a manual of more than 200 pages, and eliminates the need for forms, decollating, bursting, binding, postage costs, and storage. The microfilm can be prepared 10 times faster than paper, and retrieval is much easier, especially with properly organized microfiche. On top of that, many users eventually make microfilm for their archives. “Why not do it right to start off?” asks Taugner.

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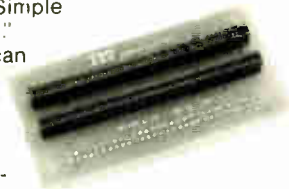
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Companies

## Going to sea—from Switzerland

Small Geneva company is making C-MOS instruments for deepwater yachts as part of plan to spin off 'mini-enterprises'

by Arthur Erikson, Managing Editor, International

In early September, a fleet of big yachts will stand out of Portsmouth, England, and head south on the first leg of a round-the-world race. The course—around the Cape of Good Hope, the Southwest Cape of Tasmania, and Cape Horn—figures to be a grueling run for the crews. And aboard the 56-foot yawl Tauranga, it will be a tough test as well for some extraordinary electronic navigation gear made in Switzerland.

Tauranga has been fitted out for the race with the entire line of instruments offered by Oxy Nautical, a tiny Geneva company that's getting C-MOS out to sea. That deep-water hardware should come out of land-locked Switzerland seems somewhat unnatural. Equally unexpected is Oxy Nautical's genesis. It was spawned by a diversification program set up by a company whose main business is metal-plating equipment and chemicals—Oxy Metal Finishing International (OMFI).

**New direction.** OMFI's effort to expand its outlook from plating baths to the high seas started some four years ago. At that time, the metal-finishing business was on a plateau, and the company has a nucleus of electronics expertise acquired from its development of automation systems for electroplating machinery. OMFI president René Rochat figured he might use that expertise as a springboard into new businesses. "To keep the diversification under control," he explains, "we decided to go into 'mini-enterprises,' the smallest viable units possible to give people with ideas a chance to try them out."

OMFI's rolling five-year plan for 1970 thus called for two mini-enter-

prises by 1973—and the company had two in action by the end of 1972, Oxy Nautical and Oxy Micro Computer Applications (OMCA). And they are just the beginning. The sales targets for the two this year add up to less than a quarter of a million dollars; OMFI's consolidated sales figure will run well over \$100 million. But in another five years, Rochat figures, sales generated from mini-enterprise business could soar to between 40% and 45% of the total. OMCA, particularly, may have a real winner in a gasoline-pump calculator it has readied for the market.

In a sense, OMFI began its venture into unknown seas back in 1965, when a young electronics engineer named Antoine Savary joined the company, then Swiss-owned and called Sel-Rex. "I was amazed to find," Savary recalls, "that somewhere between 80% and 90% of big

plating lines were still controlled electromechanically. And the main problem was to sell people in the plating field—mainly chemists—on electronic controls." Savary, now 34 years old and a vice president at OMFI, lobbied for electronics with the company brass for four years. By the beginning of 1969 Sel-Rex had a two-man electronics division, himself and George Zarb, an Egyptian-born Englishman trained at the University of Dijon and London University, who's now research and development manager for OMFI (Sel-Rex was taken into the "Oxy" group headed by the Occidental Petroleum Corp. in 1969).

**Ideas from sea.** Meanwhile, Jean-Claude Protta, one of Savary's classmates from the Ecole Supérieure Technique, in Geneva, was getting close to a long-planned fling with adventure—a trek to the West Indies in a sloop he'd been building in his

**See the sea.** Jean-Claude Protta, Oxy Nautical head, before poster of Oxy instruments.





spare time almost since he pocketed his degree in electronics in 1961. Protta set sail in May 1970, and when he got back to Geneva 16 months later went to see Savary about a job. Savary at the time was sifting ideas for mini-enterprises that would get OMFI into the "leisure market." It didn't take him long to find out that Protta had come back from his voyage with a flock of ideas for better yacht instruments based on electronics. OMFI had its first mini-enterprise, headed by Protta.

Protta's first instrument, the Modu-log, was ready in time for the 1972 boat shows in Paris and London. Instead of the usual propeller found on conventional small-boat logs, Protta's uses strain gages mounted in a small, retractable probe just forward of the keel. The strain gage outputs are amplified and processed with C-MOS circuits to get readouts of speed, distance covered, speed variation, and drift angle. The drift-angle readout, picked off the athwartship pressure on the probe, makes the instrument unique.

All this sophistication also makes the instrument much too expensive for most sailors. A complete Modu-

log with all four readouts and cockpit repeaters for speed, speed variation, and drift angle sells for roughly \$950. The basic module with speed and distance readout can be had alone, but Oxy Nautical's real bid for the "low" end of the market is with its Microlog. It goes for roughly \$220.

Here, a propeller mounted through the hull generates pulses that are counted down and converted to speed/distance readouts by C-MOS circuitry. The power consumption is so low that Protta didn't even put in an on-off switch. With average 2-knot speed, battery life is theoretically two months.

**Wind and time.** Oxy Nautical's line also includes an electronic wind indicator, called a Windicator, and quartz/electronic chronometers. A sextant accessory that's called an Astro-Quartz should be ready this summer. This is a special handle with an electronic chronometer built into it. When a navigator takes a sight with the sextant, he presses a button. This stops the chronometer for 90 seconds, long enough for him to note the precise time he took the fix. Ordinarily, a navigator calls out a "mark" to another crew member who notes the time at the ship's chronometer. During the 90 seconds, the pulses that normally drive the chronometer's stepping motor are stored in a shift register. Then the motor runs at four times its normal speed until the register is emptied.

The chronometer can be stopped ahead of time, too; there's simply a lesser count for the shift register to feed back in. For the Astro-Quartz, Protta hopes to find a market

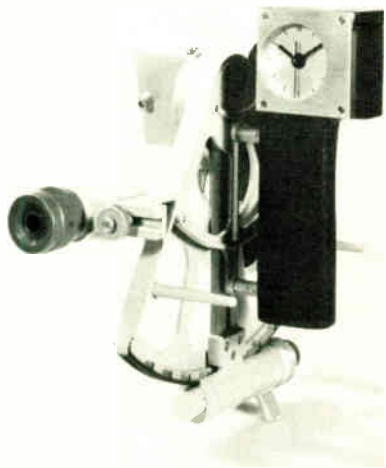
among merchant marine officers as well as yachtsmen. The price will be around \$480.

And there will be more new products coming. By the end of the year or in early 1974 Protta hopes to add an electronic compass to his line. With this module, Oxy Nautical will have available the three basic inputs—wind direction, speed, and ship's heading—for still another module, an on-board navigation computer. It will compute the true distance run on each leg of a course; in addition, the computer will continuously compare the boat's speed with the wind speed and signal if the headway isn't fast enough.

Protta also hopes to develop an autopilot with consumption low enough to meet the rules for single-handed sailing competitions, which permit hardware run by nonrechargeable batteries. There's also a digital version of the Astro-Quartz on the work list. With all this, Protta has no day-to-day production problems, since all the fabrication is done by contractors.

So far, the business sailing has been swift for Oxy Nautical. During its first year, the mini-enterprise logged \$55,000 in sales and showed a gross profit of about \$6,500. Sales this year figure to soar to \$160,000 with profits at least 10% of sales. This is good news for Protta, since as manager of Oxy Nautical he gets a 20% cut of the profits.

Oxy Nautical's initial success has been regional, with sales limited to France, Switzerland, and Britain. By the end of the year, Protta will have distributors all over Europe. Eventually he expects to tackle the U.S. market. □



**From the Alps.** Oxy's sextant clock is at left. Below it is René Rochat, president of Oxy Metal Finishing International. And below right is the Oxy electronics brain trust—left to right, Jacques Lederrey, division manager; George Zarb, R&D manager; Antoine Savary, vice president; Georges Matile, lab chief; and Hans Nissen, automation engineer of the company.



Commercial electronics

## European TV is automating fast

Electronic systems are turning the jobs of programing and monitoring into push-button operations across the continent

**It will be years, if ever, before the men at the consoles of Europe's television stations go the way of lamp-lighters, town criers, and like victims of technological progress. All the same, automation of station operations in Europe is coming on fast.**

No one has yet gone quite all the way—using computers for administration, program planning, production, and broadcasting. But from Britain to Yugoslavia, automated program-switching systems have gone into service in recent months, or will do so later this year. Electronic video-tape editing systems abound throughout Europe, too,

and there's a trend to automatic monitoring of picture quality. Much of the new hardware was in evidence at the late May Montreux television symposium, the biannual technology festival for European broadcasters and the manufacturers who supply them.

In West Germany, Robert Bosch Fernsehlagern GmbH dominates in video studio automation. Last month it finished installing a computer-controlled programing system for Nord Deutscher Rundfunk in Hamburg, which expects to have the system operating next month at the latest.

The installation uses a pair of Digital Equipment Corp. PDP-11 computers to control sequencing of "events"—snippets of video-tape recorder images fed to a master recorder from up to seven slave VTRs. Bosch's system can work both on line for program control and off line for editing, so there's also a trio of VTRs for producing work copies with time codes on them.

Besides Hamburg, Bosch automated program controls are operating at Sender Freies Berlin and at

**Putting it together.** Computer-controlled presentation system is by Thomson-CSF.





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## Probing the news

the Sarajevo station of the Yugoslavian TV network. Horst Harmuth, manager for video development engineering at Bosch, says he's on the verge of signing up another customer for an automated program control.

Thomson-CSF ranks in France as Bosch ranks in West Germany, and the French company had presentation automation achievements to re-

port at Montreux. At home, the Office de Radio-Télévision Française in mid-May put into service a presentation-switching system for its all-color third network. Aided and abetted by a CII 10020 mini-computer with 20,000 words of memory, this system can store up to 80 sequences each for two different programs at a time, getting its inputs from VTRs, film islands, announcer mikes, and the like. As with nearly all automated systems, the computer rather than the operator

worries about things like run-up times and synchronization. It also produces a log of what went out to the transmitter when the operator can override the stored program, so the log can't simply be a printout of the program fed into the memory.

**For Belgium.** Thomson-CSF has put similar, but more elaborate, equipment into the new radio-TV center of the Belgian radio-television broadcast agency on the outskirts of Brussels. The agency expects to have it operating by year end. Here there will be two programs—one French, one Flemish—each with up to 100 sequences. Program automation systems are essentially tailor-made, but Thomson-CSF kept its hardware as modular as possible, particularly in the interface between the computer and the studio equipment. Control signals from the computer go out through standardized addressable memories; the computer gets status reports back from equipment switching on or off through standard multiplexers.

Program automation is being carried out with hard-wired hardware, too. The Austrian broadcast agency Osterreichischer Rundfunk (ORF) put its second automated program on the air in February, only three months after its first went into service. Each program handles up to 100 events and is stored in core memories.

**Times change.** RCA designed and built the hardware, a task that took about four years. "If we were designing it today, we would surely have used a minicomputer. But when we started, what we needed wasn't there," says Jukka Hamalainen, one of RCA's men in Vienna. The ORF program control doesn't log events, but otherwise comes off well enough in a comparison with computer-based systems. There are 16 channels for program sources including VTRs, film islands, announcer cameras, insert cameras, outside lines, and a "black" input.

In Britain, too, there's a new hard-wired program control at work at Ulster TV. UTV has been on the air with it for two months. GEC-Marconi Electronics' Marconi Communications Systems did the job, and the company's development manager for TV systems, Henrik Mirwinski, stoutly maintains it's the first automatic switcher that has

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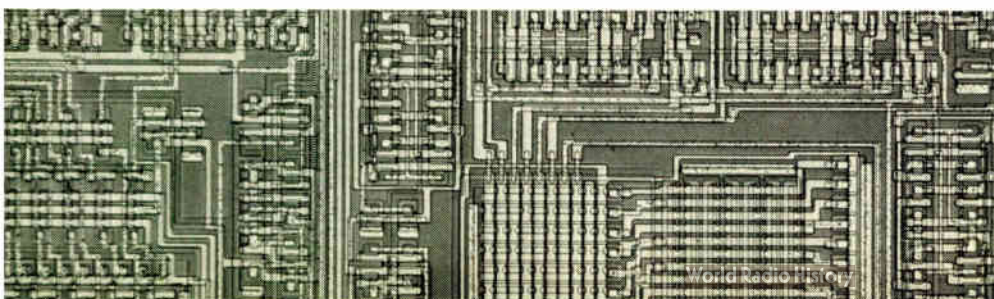
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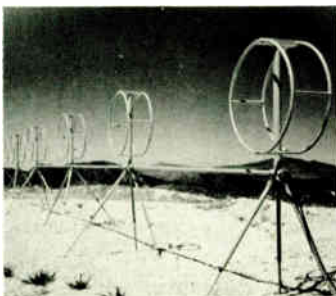
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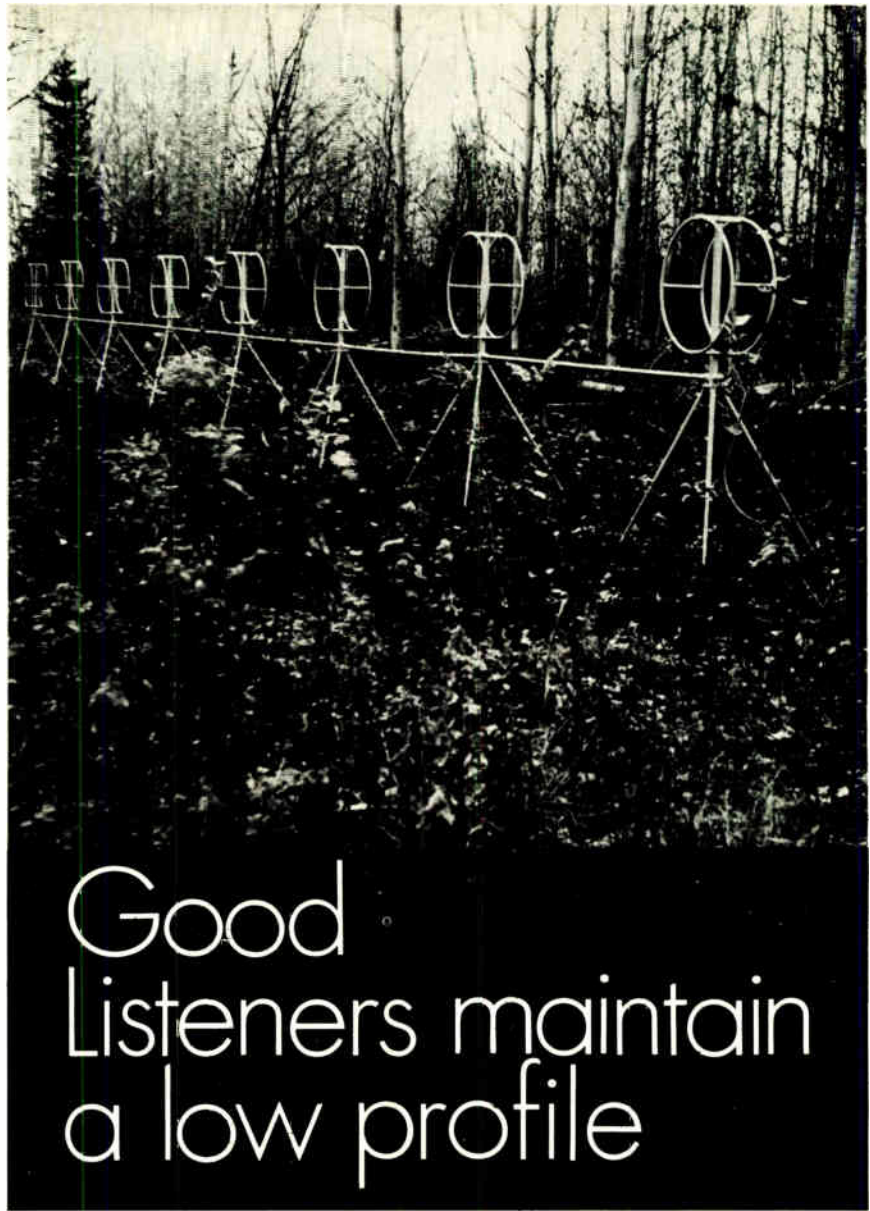
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## Probing the news

fully succeeded for color broadcasts in Britain. In Mirwinski's view, station operators are wary of computer controls and their teletypewriter inputs, and that's why some of the earlier installations still aren't fully on the air.

**Computer-like.** Actually, Marconi has what comes close to a special-purpose mini in its program control. It can switch inputs from up to 16 sources, store 15 events in its memory, and includes a character generator. To avoid interface problems, Marconi designed its own hardware, rather than build around a general-purpose computer. A capacity of 15 events looks low at first glance, but Mirwinski says it's not a drawback for the station operators, since they can load the memory as it empties by punching buttons on a conventional-looking control panel. There's also the possibility of stocking the memory through paper tape, magnetic tape, or a computer.

For its automatic picture-quality monitor, Marconi Instruments Ltd., a sister GEC-Marconi company, also eschewed computers. The Marconi hardware analyzes test signals in-

serted between fields during transmission. When a test-signal parameter is out of limits, the monitor checks that it's not transient, runs a trouble-shooting sequence, and automatically switches transmitters or video inputs as necessary.

Marconi already has an order for this gear from the Independent Broadcasting Authority in the UK and from the South African Broadcasting Corp. that puts Marconi out in front—in sales anyway—of Philips Gloeilampenfabrieken. Like Marconi, Philips turned up at Montreux with interfield test signals analysis equipment, but unlike Marconi, designed its analyzer to work with a small minicomputer, its own P-850.

**Soft and hard.** This system can check up to 21 kinds of distortion and provides for both "soft" alarm when a parameter strays from its nominal limits, but not seriously, and "hard" alarm for transmitter breakdown. Philips feels the computer gives its hardware the edge because of the flexibility inherent in software-programed systems. With a slightly larger computer, for example, trend analysis on key parameters could give advance warning when major transmitter components are on the verge of failing. □

## Back in the New World

In the United States, a number of automatic programming systems have been installed and have started operating within the last year or so. Westinghouse Broadcasting's KYW-TV in Philadelphia and Cox Broadcasting's WHIO in Dayton, Ohio, and WIC in Pittsburgh are three stations with mini-computer-controlled gear that switches between program segments from a variety of machines.

However, such automation has not been 100% successful, largely because it's so difficult to predict what has to happen in the course of a broadcast day, points out Ernest L. Adams, vice president of engineering for Cox in Atlanta. Union rules also work against it, he says, and he believes there is "a real reluctance on the part of station managers to accept it." The approach to automation now usually followed is to make each job as easy for a man to do as possible, not to eliminate the man entirely, he says.

Neil Vander Dussen, division vice president of RCA Broadcast Systems, Camden, N.J., agrees. Station managers are interested in an "evolutionary" approach to automation, he says, with automated systems being worked in with present operations. Eventually, these islands of automation could be placed under control of a central computer, but this is not the immediate goal. Such automation is exemplified by such products as RCA's two-year-old TCR-100 cartridge tape recorder, which can play pieces of tape from as many as 22 cartridges, and the TCP-1624, which does the same for 16-millimeter film. Other examples are some of the features included in RCA's TK-45 color camera. Automation on the business side—with such things as time availability, logging of commitments, acknowledgement of commercials shown, and billing stored for immediate access in a computer system—is proceeding smoothly.

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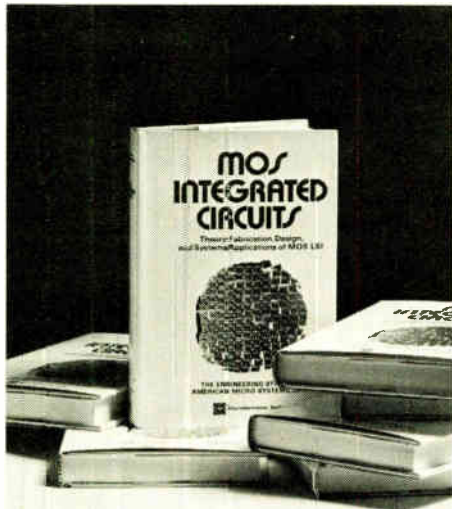
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Companies

## Putting it together at Heath

Kit company prospers by keeping quality high, and finds that most expensive product in each of its lines sells best

by Larry Armstrong, Midwest bureau manager

The Heath Co. has come a long way since its first kit—a \$199 airplane with an 18-foot wingspan (less engine, F.O.B. Chicago). Forty years later, the Benton Harbor, Mich., subsidiary of Schlumberger Ltd. is still flying, but its only airborne products now are radio control servos for model airplane buffs.

Sales at Heath have tripled to \$66 million in the last 10 years, and the firm has broadened its initial electronic-kit business by adding a full line of assembled scientific instruments, from strip chart recorders to spectrophotometers, as well as a few new mechanical kits, such as trash mashers and motorbikes.

Heath got into the electronics business in 1947 with a \$39.50 oscilloscope kit and made its name supplying kit-form electronic equipment at half the cost of the assembled versions. It still advertises “savings up to 50%,” but Heath is now known as a high-quality,

high-price, top-of-the-line home entertainment and instrument manufacturer.

“The approach in the early days,” says Eugene C. Fiebich, engineering vice-president, “was that the availability of war surplus materials determined the product—resulting in considerable cost savings to our customers.”

**Savings there.** Do-it-yourselfers can still realize that kind of savings on many kits—amateur radio gear and some test instruments, for example, and in general those that don’t compete with high-volume, mass-produced consumer items.

So what keeps the hobbyists buying? Partly, it’s the “eureka complex,” the point where he turns it on and, by golly, it works. But it’s also quality. “We know that price isn’t the reason that people buy the kit,” says William E. Johnson, marketing vice-president. “In almost every product line, the most expensive product is the best seller. We’ve got to hang on the features that people want; if we don’t they’re not interested.”

Adds product planning manager William H. Hannah: “We know we can’t compete with the high-volume, low-cost suppliers, so we take another tack. We compete in quality in the high end of the line. If it takes a buck or two extra in components, we design it in and let the price fall where it may.” Heath buys quality parts for other reasons, too. “Our kit builder examines, handles, and fondles every part with loving inter-

est,” Fiebich says. Quips Johnson: “We can’t slip this guy any paper capacitors.”

“Generally we have to operate at a much higher quality-control level than our competition,” Fiebich explains. “They can line trouble-shoot, and we can’t.” And since Heath products are designed to be adjusted without factory instrumentation, the circuits in them cannot be as critical.

“Besides building quality in,” Hannah observes, “there’s another ingredient. We tell the guy how to get in and tweak his set to peak operating condition. He understands where the parts are and what they do.” Heathkit manuals now include instructions on alignment with and without extra instruments, “and in many cases, the gap is surprisingly small,” Fiebich adds.

In some cases where adjustment is critical, such as the i-f assembly on TV receivers, Heath designers pro-



**Kits are their bag.** Eugene Fiebich, left, engineering vice president, and William H. Hannah, product planning manager, help keep the Heath Co.’s lines moving.



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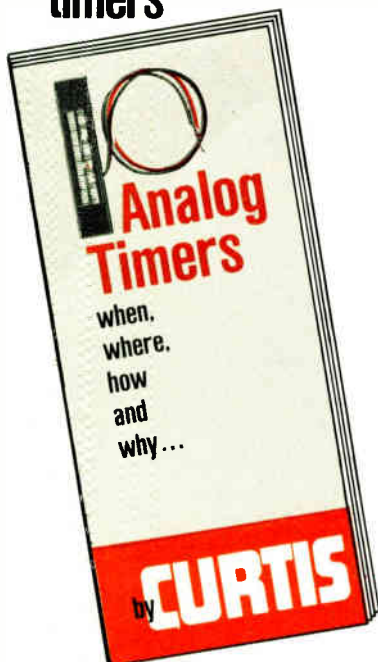
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## Probing the news

vide drop-in modules. In others, meters serve dual functions, as on stereo receivers where signal-strength meters double as ohmmeters. In color TVs, a dot generator is built in for convergence checks. And in TV products, which account for a whopping 25% of the firm's sales, Heath provides a small multimeter with the kit for resistance and voltage checks on the boards and set—not only during the initial construction, but the multimeter also comes in handy after the set has been in service several years.

**Give more.** As for that cost differential, Heath says it's still there. "We still give him more bang for his buck," says Johnson. "We try to save him 30% on the price of a comparable product, or give him at least 30% more in demonstrable features."

Heath's basic philosophy is to copy in kit form. "We don't want to pioneer," Hannah says. "We violate that in TV to a small extent, and in audio to a large extent. But in instruments, we stick pretty much to tried and true techniques and practices in the industry." Recent attempts to broaden Heath's electronic kit base demonstrate this: the firm collaborated with Whirlpool Corp. on a kit for a trash compactor, and with Litton Industries on its microwave-oven kit. But last year's AF-1510 stereo receiver wowed the audio industry—it's completely digital, the only receiver on the market without a knob on it, and in the process uses more than 50 transistor-transistor and emitter-coupled logic integrated circuits.

Solid state made its debut at Heath in 1963 in the audio line, and the company is generally recognized as the first successful solid-state audio manufacturer. "We were led into it because of the kit concept," says Heath president David. W. Nurse. "We were looking for a better way to do it, and we just weren't going to have our customers build a tube receiver."

"Solid state opens up new market areas for us like nothing else has done since the pc board," he says. "It makes complex products feasible, such as stereo, and now clocks

and calculators." But with these complex, dense, sophisticated products comes the chance that the novice kit-builder would be even more intimidated—particularly since the thing that keeps most people from buying and trying Heathkits is fear of failure. So Heath has initiated a drive to add introduction-to-the-fraternity products, including small radios, light dimmers, photoelectric switches, and telephone amplifiers—all under-\$20 kits. The result is that in taking steps to insure its customers' success, Heath:

- Breaks up the tedium of big kits by supplying small packages containing a single printed-circuit board and its components; the customer builds and tests each mini-kit separately.

- Is going to greater pains to identify each part, by putting it into a coin envelope, or by illustrating it with photographs or life-size drawings.

- Maintains a staff of a dozen technical correspondents in Benton Harbor to field mail or phone inquiries.

- Keeps 125 technicians in the field and has recently added "jiffy service benches" in its stores—"we'll teach a beginner how to solder, we'll visually inspect works in progress, or we'll point out a builder's problems and let him fix them himself," Nurse says. And all that help is all free.

- Runs a 48-hour turnaround mail-in repair service for pc boards, with a \$5 maximum charge for parts and labor, or with no charge at all in warranty.

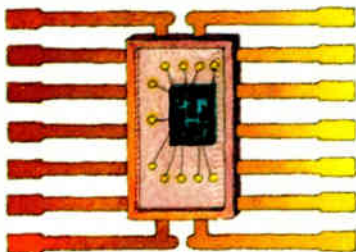
- Socks 50 cents of each R&D dollar into the manual, which now includes an "in case of difficulty" section to ease after-purchase service, and a "theory" section "so you can build a color TV and learn to solder, or you can build a color TV and learn everything about color TV," as Nurse puts it. (Heath TV kits are used at several technical schools to teach TV service.)

Will Heath ever do away with the tedium of wiring all those little bugs together? It will never happen, Hannah counters.

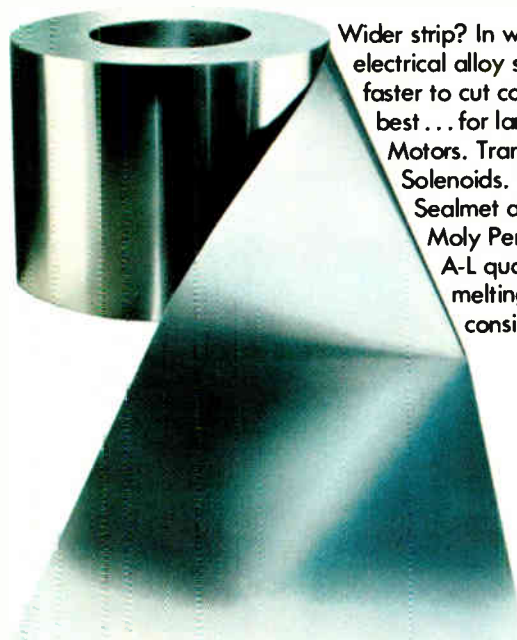
"We're doing things to accelerate the building process, but we don't want to carry it too far," he says. "You have to remember why our customers buy our kits." □

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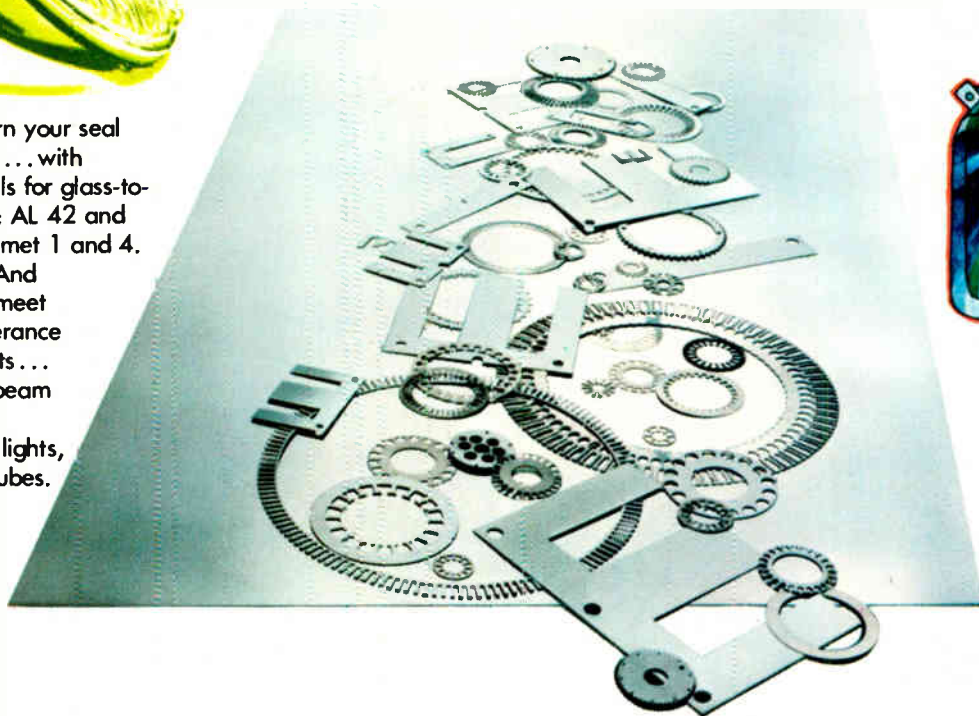


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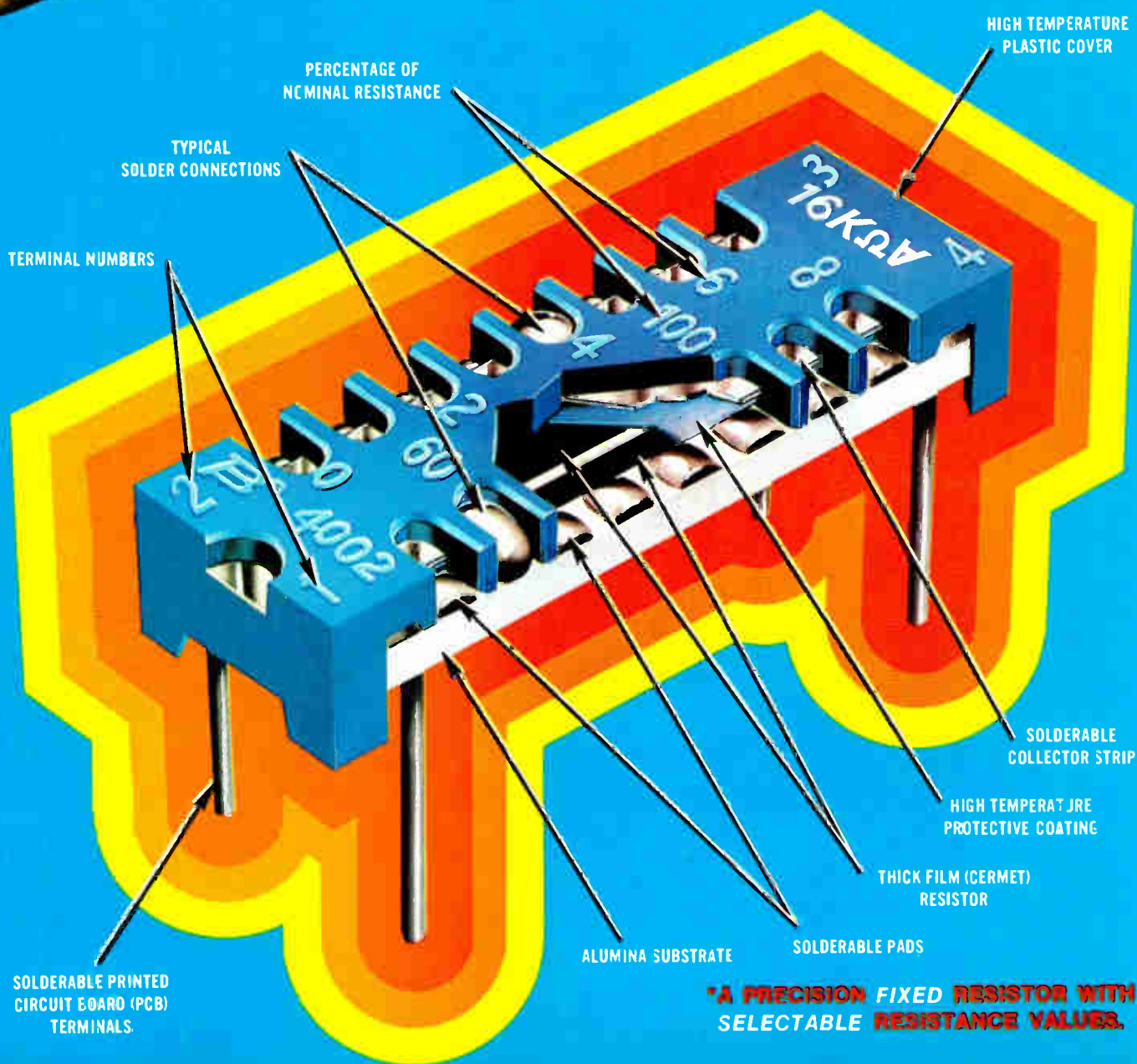
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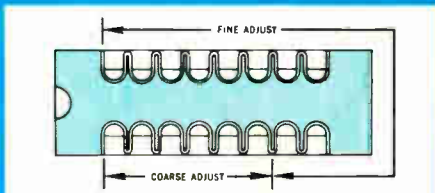


Figure 1



Figure 2



Figure 3

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SN54S/74S86 Quad Exclusive-OR  
SN54S/74S135 Quad Exclusive-OR/NOR  
SN54S/74S181 4-bit ALU and function generator  
SN54S/74S182 Carry look-ahead for SN54S/74S181  
\*SN54S/74S280 9-bit odd/even parity generator/checker

SN54S/74S151 8 to 1-line multiplexer  
SN54S/74S251 8 to 1-line multiplexer, 3-state output  
SN54S/74S157 Quad 2 to 1-line multiplexer  
SN54S/74S257 Quad 2 to 1-line multiplexer, 3-state output  
SN54S/74S158 Quad 2 to 1-line multiplexer  
SN54S/74S258 Quad 2 to 1-line multiplexer, 3-state output  
SN54S/74S153 Dual 4 to 1-line multiplexer

SN54S/74S138 3-8-line decoder/demultiplexer  
SN54S/74S139 Dual 2 to 4-line decoder/demultiplexer  
\*SN54S/74S124 Voltage controlled oscillator (VCO)

#### Series 54S/74S Schottky SSI Circuits

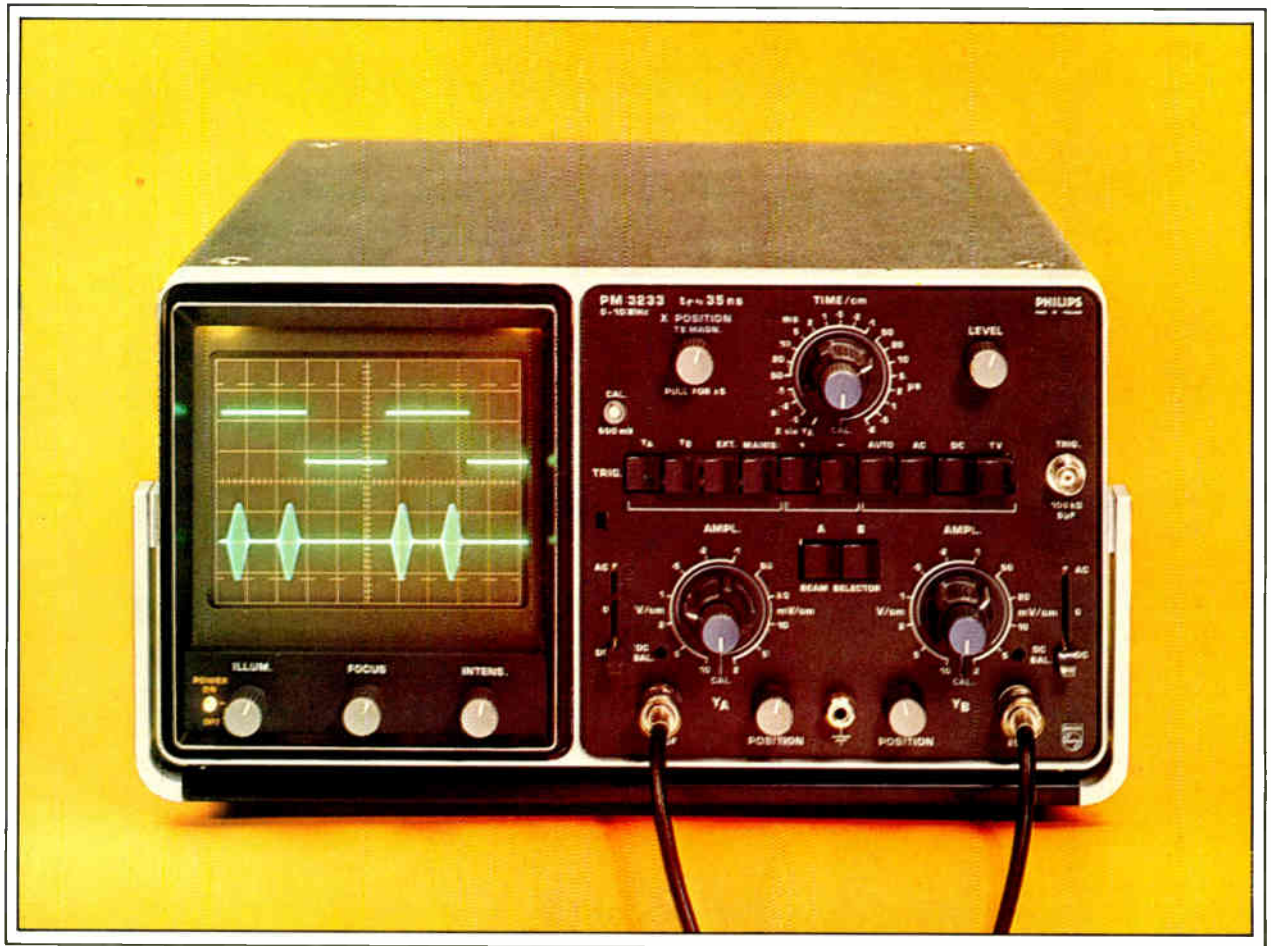
SN54S/74S00 Quad 2-input NAND gate  
\*SN54S/74S02 Quad 2-input NOR gate  
SN54S/74S03 Quad 2-input NAND gate, o.c. output  
SN54S/74S04 Hex inverter  
SN54S/74S05 Hex inverter, o.c. output  
SN54S/74S10 Triple 3-input NAND gate  
SN54S/74S11 Triple 3-input AND gate  
SN54S/74S15 Triple 3-input AND gate, o.c. output  
SN54S/74S20 Dual 4-input NAND gate  
SN54S/74S22 Dual 4-input NAND gate, o.c. output  
\*SN54S/74S30 8-input NAND gate  
SN54S/74S40 Dual 4-input NAND buffer  
\*SN54S/74S51 Dual 2-wide, 2-input AND-OR-INVERT gate  
SN54S/74S64 4-2-3-2-input AND-OR-INVERT gate  
SN54S/74S65 4-2-3-2-input AND-OR-INVERT gate, o.c. output  
SN54S/74S74 Dual D-type flip-flop (110MHz), preset, clear  
SN54S/74S112 Dual J-K flip-flop (125 MHz), preset, clear  
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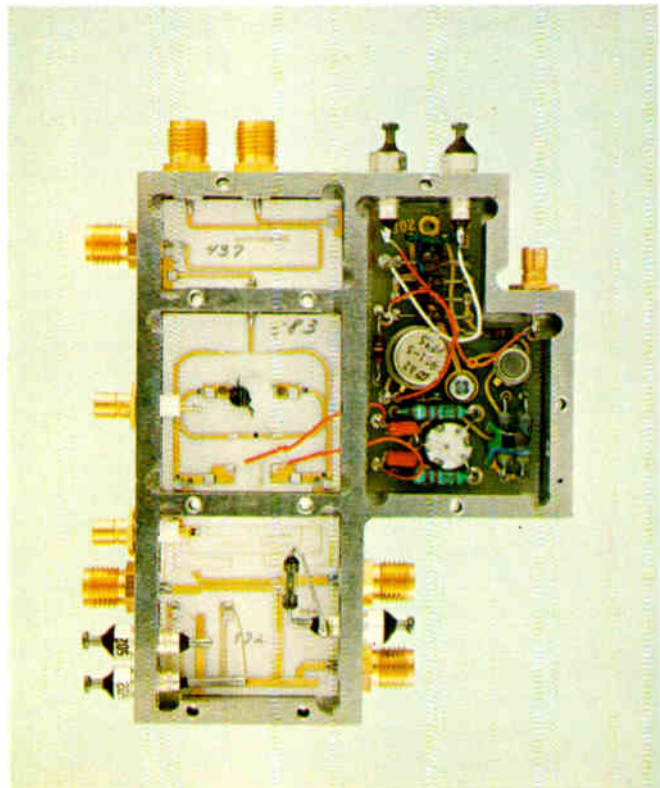
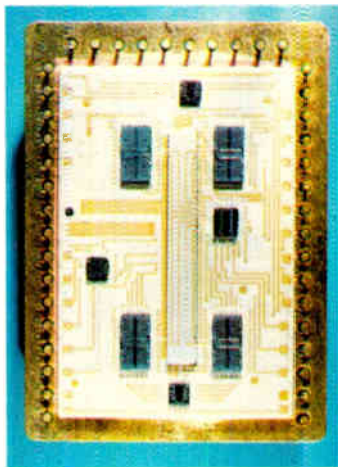
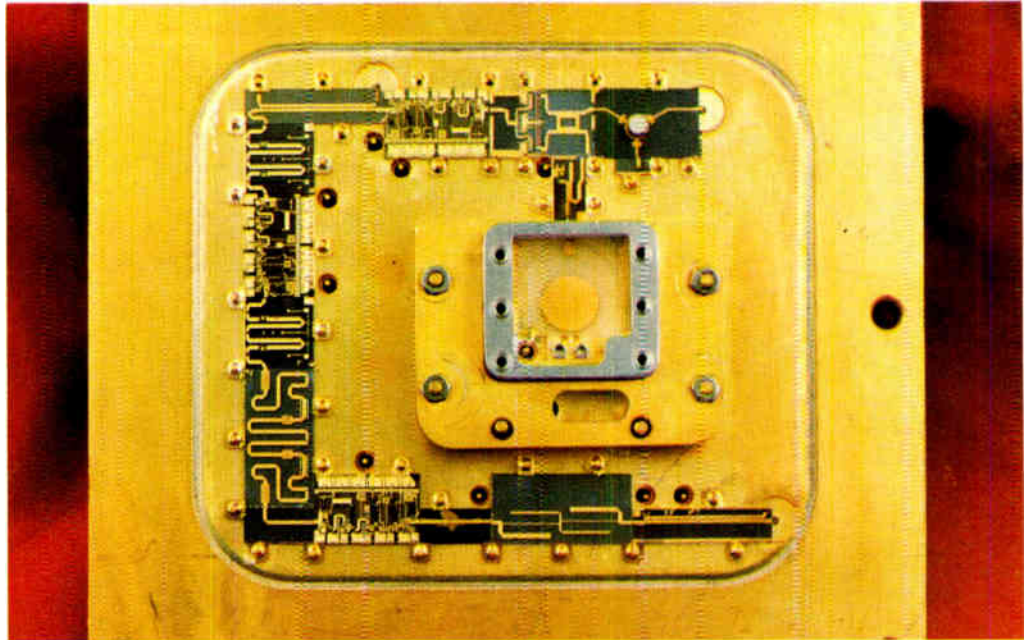
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# Hybrid technology solves tough design problems

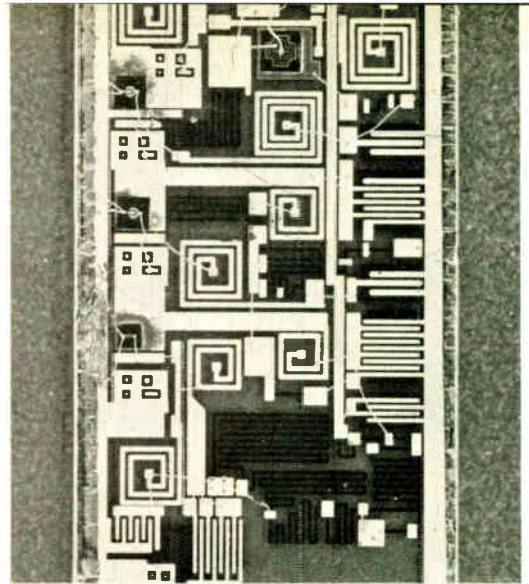
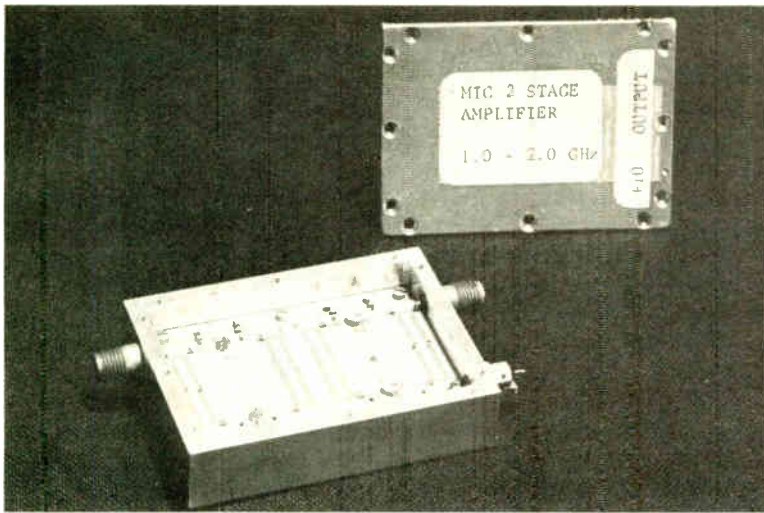


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Thanks to new thick- and thin-film techniques, materials, and circuit elements, the original approach to IC making is more useful than ever

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by Laurence Altman, *Solid State Editor*



**Thin-film power.** The development of thin-film hybrid technology has pushed the frontiers of amplifier integrated circuit design into the highest reaches of the rf and microwave spectrum. Built by Sylvania on a 1-by-2-by-0.25-inch alumina substrate using chrome, copper, and gold metalization, the two-stage amplifier (left) operates in the 1-2-GHz band and provides 21-dB gain with maximum noise figure of 3 dB at 2 GHz (room temperature). The Hewlett-Packard 2-GHz communications amplifier (right) is capable of providing better than 20-dB gain.

□ Although it is the oldest of the integrated-circuit techniques, hybrid microelectronic technology is only now attaining its full potential. The methods of placing integral devices onto a common substrate have come to full flower in the last few years with the development of new materials and more sophisticated active and passive elements. A host of refined and automated thick- and thin-film techniques—many borrowed from monolithic technology—are giving designers of hybrid circuits a range of tools unmatched by other methods.

In the monolithic market, standard products are pushing the frontiers of the technology. But the hybrid industry has been brought to new levels of performance by its custom work. The stimulation from military requirements, plus the in-house demands of the communications industry and instrument and computer makers, have made the custom segment of hybrid technology both the source of new techniques for system designers and the focus of interest where higher performance is needed. These developments have enabled hybrids to penetrate equipment production to an amazing degree.

Thick-film circuits now dominate in rf and mobile communications. Industrial control and converter systems rely on hybrid digital-to-analog and analog-to-digital circuits, resistor-ladder networks, thick-film operational amplifiers, comparators, sample-and-hold circuits, and the like. Airborne computers are built with beam-lead hybrid memories, while video-camera systems are now using thick- and thin-film logic and control circuitry. Telephone and telecommunications equipment, from audio through microwave, has reached its highest performance levels only when amplifiers, analog switches, multiplexers, transceivers, isola-

**A sampling from the many builders of hybrids.** Tektronix built a thin-film spectrum analyzer (preceeding page, bottom right) for a line of instruments, and Boeing's hybrid group made a thick-film, 4,096-bit RAM (bottom left). A thin-film communications circuit by Hewlett-Packard (top) uses a Gunn diode as a local oscillator.

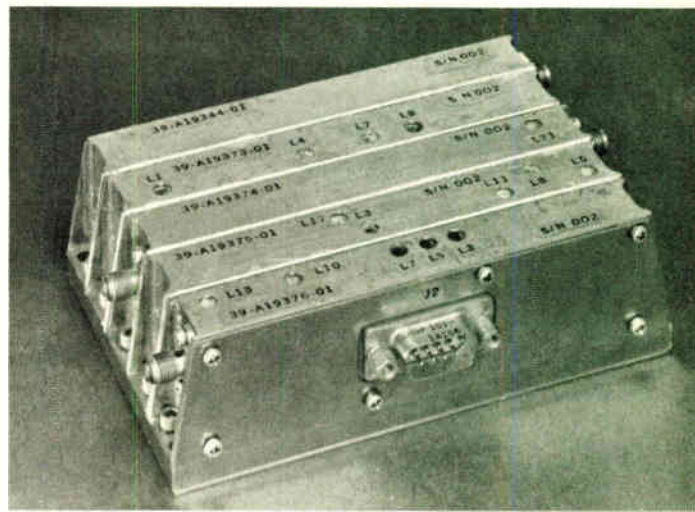
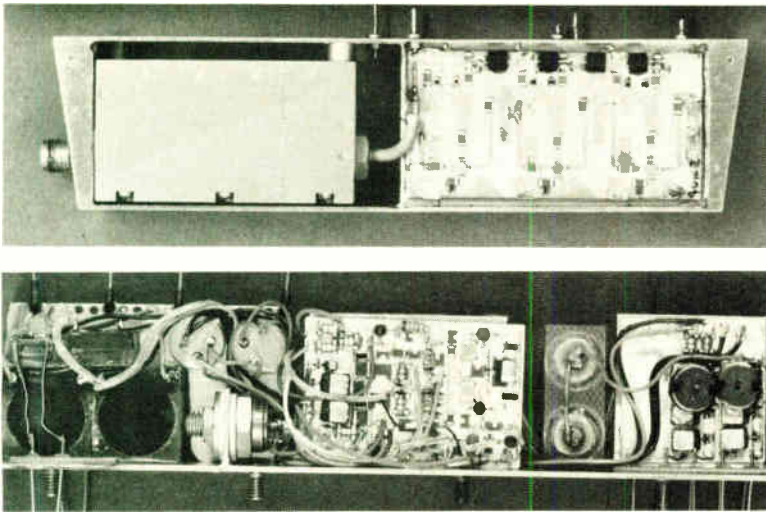
tors, and couplers are built with hybrid circuits. Designers of instruments, from complex oscilloscopes to sensitive quantitative measurement gear, are now turning more than ever to hybrid techniques to satisfy their toughest design goals. The military and the aerospace industry have been able to attain enormous ruggedness, sophistication, and miniaturization in an extremely diversified mix of microelectronic equipment through the use of the latest hybrid techniques.

This diversity of product areas and design techniques has led to vigorous market activity. But because so much of hybrid activity is directed toward in-house system goals, the true measure of market activity is difficult to gauge. It's estimated that standard products represent only one third to one half of the published total hybrid sales. U.S. sales of these products are expected to total \$125 million in 1973, so the estimate for the total U.S. hybrid market would be \$350 million—surprisingly large compared with the total monolithic IC market of about \$600 million. In Europe, the hybrid market is booming as well, with European factory sales expected to exceed \$30 million this year.

### Thick or thin?

The first question in starting a hybrid facility is whether to use thick- or thin-film techniques. In many cases the choice is clear, but the area between high rf and low microwave frequencies—from 900 megahertz to 2 gigahertz—is a gray area where either thick or thin could be used. This question has become even tougher lately because new methods of applying thick films have increased that technology's utility in building low-microwave circuits previously possible only with the more expensive thin-film techniques.

Thick-film techniques are generally used to build circuits operating below 1 GHz that do not require the tolerances and line precision obtainable with thin-film techniques, circuits with large-value resistors and inductors, and circuits requiring high levels of power in systems where big packages can be tolerated. Thin-film



**Thick film communicates.** The thick-film technology used in this S-band transponder built by Philco-Ford shows how that technology can meet the tough demands of high-frequency space equipment. Shown are a 2.1-GHz input filter and rf preamp section (top left), a dc-dc converter (bottom left), and the completed unit (right). All circuits were built with thick-film resistors on a lumina substrate with attached capacitors and package chips. The substrates, power semiconductors, and magnetic components are mounted to an aluminum frame.

fabrication, on the other hand, is ideal for high-frequency microwave applications, and those requiring highly-precise line widths and circuit elements.

The thin-film technique has become the dominant technology in the microwave industry—up to 30 GHz—because it can achieve the fine-line geometry required at high frequencies. Thin-film circuits also are beginning to dominate the high-performance military market, which requires small, rugged devices. Indeed, it is the thin-film circuit technology that has been responsible for stimulating the development of new chip-bonding techniques, such as those using beam leads, flip chips, and the like.

But the high performance of thin films means that the production facilities cost more than those for thick films. It has been estimated that a start-up thick-film facility can be established for less than \$10,000—requiring pastes, inks, simple die presses, and masking facilities. Active devices in standard packages or on naked dice can be wired directly to the thick-film conductors. In many cases, packaged resistors and capacitors on chips can be used for the passive elements, eliminating the need for building these elements on the substrate.

Because of this, makers of low-cost consumer and industrial equipment have found that thick-film technology is the way to go. In addition to the simple methods of fabrication, thick-film circuits can be made with rougher and cheaper substrates than can thin-film circuits, and screening and firing is cheaper than the photo masking and etching required in thin-film fabrication.

Besides large-volume applications, thick-film technology is also cost-effective for pilot-line production because the investment is far smaller than in equivalent thin-film setups. It has been estimated that a thick-film operation with an output of about 200,000 circuits per year can be established for less than \$75,000, excluding trimming equipment. A similar thin-film facility, requiring clean rooms and expensive vacuum and photoengraving equipment, will cost more than \$750,000. Experienced managers of hybrid facilities put the cost of

developing a circuit from breadboard to finished hardware of a moderate quantity of circuits—say, 100 to 500—for typical aerospace applications at almost 100% higher for thin films than for thick films.

However, for complex and high-performance circuits, such as phased arrays for microwave radar, high-power microwave amplifiers, and high-frequency spectrum analyzers, thin-film techniques will pay off because the developmental manufacturing costs are often a smaller fraction of the total cost, which includes assembly, packaging, and tests. In the high-performance product areas—computers, test equipment and instruments, and military electronics—thin-film hybrid circuits have achieved a dominant position.

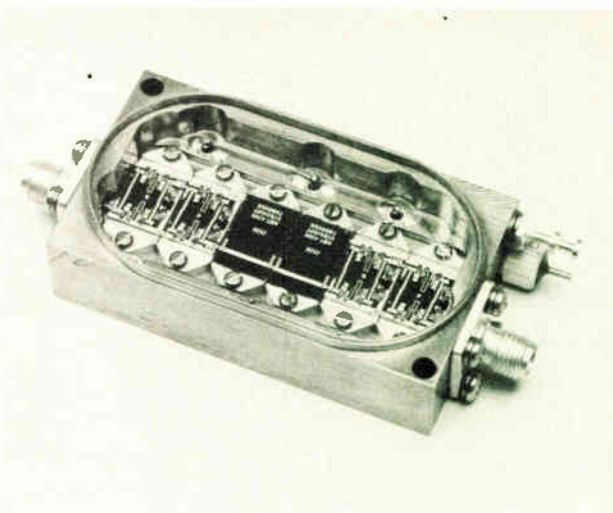
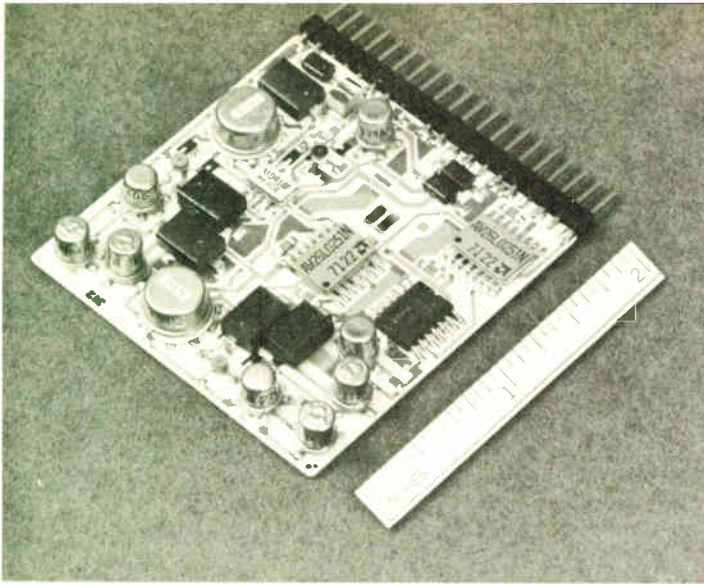
### Thick-film techniques

Thick-film hybrid circuits are as old as integrated-circuit technology itself. But thick-film techniques have remained essentially the same; only the materials and active devices have improved, and with them the performance of the circuits.

Thick-film structures are prepared by screening and firing or by pyrolytic deposition. They generally contain only conductors, resistors, and capacitors, with the other components added as discrete entities. All are put down on a substrate, which generally is composed of some form of alumina or, for high-power applications, a compound of beryllia.

A thick film is defined as a conductive, resistive, or insulating film thicker than 0.01 inch that is produced by firing a thixotropic paste deposited on the substrate. (A thixotropic fluid changes viscosity as a function of the rate at which it is sheared.) The paste is composed of powdered inorganic solids, such as metals and metal oxides, mixed with a powdered glass binder and suspended in an organic vehicle.

These pastes are deposited on the substrate by the stencil screen process, an outgrowth of the silk screen method of printing. The silk has been replaced by a woven mesh of fine stainless steel wires, which is used to



**The thick and thin of it.** Whether to use thick- or thin-film technology to achieve a circuit goal is often a trade-off in performance, cost and circuit complexity. The phase detector portion of a frequency synthesizer (left) built by Sylvania uses thick-film circuits, so that hermetically sealed active components as well as large tantalum capacitors can be accommodated. On the other hand, thin-film techniques are ideal for Avantek's 3.7–4.2-GHz, four-stage communication amplifier (right). Built in modular form, this device is capable of 20-dB gain at 5-dB noise.

hold the pattern for the components to be deposited. The pattern is produced photographically, and the holes in the mesh are blocked by an emulsion wherever the inks are not to be deposited.

A different screening composition must be used for each type of component—resistor, conductor, or crossover. The ink, which can be obtained commercially from dozens of suppliers, contains the polycrystalline solids needed to produce the right electrical characteristics: metals for conductors, glasses with high dielectric constants for capacitors, and oxides and metals of various resistivity values for resistors. A major ingredient in these inks is the glass frit that bonds the metals and oxides and provides adherence to the substrate when fired at temperatures of 750°C to 950°C. These inks are applied to the substrate through the stencil mask. A typical screener consists of a frame with a sledge that presses ink through the screen. After the pattern has been screened onto a ceramic substrate and dried, it is fired in a furnace, where the organic binder is burned off and the glass frit reflowed.

Although thick-film processing is simple, converting a schematic to a thick-film circuit requires careful material selection and sequencing. Conductor materials that fire around 900°C cannot be applied to a substrate after the application of resistors that fire at 750°C. Each successive firing cycle should have a peak temperature at least 50°C below that of the preceding one.

The design team makes a schematic of the circuit, calculates resistor sizes and printed capacitors, and makes a layout on conventional grid paper. Each screening requires a master pattern. Patterns are needed for conductors, crossovers, capacitor dielectrics, resistors, and resistor protective-glass encapsulants. These masters are photographically reduced and a positive of normal size is made for each.

Masks are made from these screens by either of two methods. In the first, the photo-sensitive emulsion is painted onto the bare screen and allowed to dry. The screen is then photographically exposed in contact with

the master pattern and developed. The open area through which the screen is to be squeezed is washed out to remove any unexposed emulsion material.

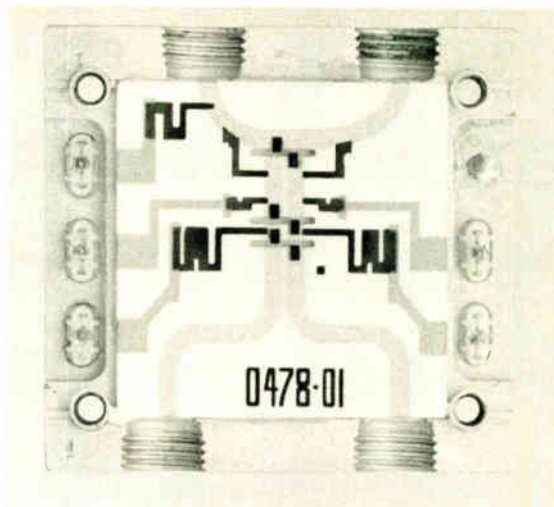
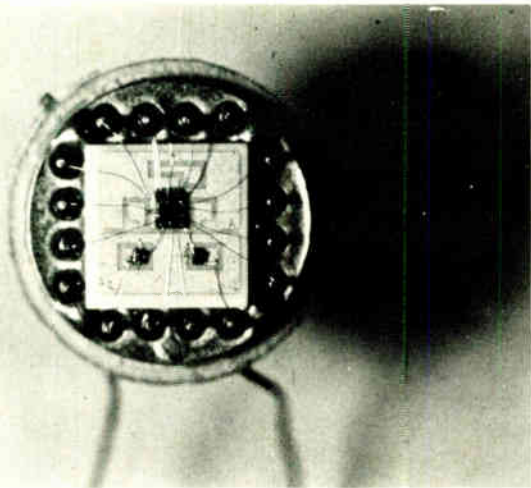
The second technique uses an indirect, or transfer, emulsion of light-sensitive gelatinous film, backed by a polyester sheet. The photographic exposure, development, and washing out are done on this film. When the developing processes are complete, the wet film is transferred to a clear, raw screen to which gelatin adheres. After drying, the polyester backing is stripped off, and the screen is ready for use. This technique can produce finer lines and irregular patterns with better definition than the first technique. The life of this screen type is approximately 10% that of the direct-emulsion type, so the screen must be used soon after it is made and cannot accommodate a long-run production schedule.

### Thin-film techniques

Where thick-film processing is a paste-and-trim approach, thin-film production is as complex as any modern IC technology. But this very difference makes the critical thin-film processes more reproducible and more amenable to analysis and control.

Thin films are deposited by evaporating the source material in a high vacuum (Fig. 1) or by cathode sputtering in the presence of a low-pressure discharge (Fig. 2). The latter has become the more useful technique. Unlike evaporation, which rarely transfers alloys or compounds with their chemical properties intact, sputtering transfers almost perfectly the bulk parameters of the material to the film. Since the inception of sputtering numerous more powerful methods have been developed, including radio-frequency sputtering, which permits the tailoring of process parameters to suit a particularly material.

Many dollars have been spent to develop techniques for evaporating or sputtering through stencil masks, similar to the thick-film method, but the attempt has been largely abandoned because of the insurmountable problems of mask stress and particle contamination.



**Made to measure.** Among the biggest builders of hybrid circuits are instrument makers, who consider high performance in small spaces a paramount design goal. Shown at right is a CRT driver built by Tektronix for a new instrument line. Using thin films on a BeO substrate and packaged in a TO-8 can with integral heat sink, this 350-MHz bandwidth device accepts differential signals from a buffer amplifier and provides the gain required to drive a CRT. The thin-film sampling head (right) is also used in Tektronix equipment.

The problem got worse as the complexity of the circuits, and with it the complexity and delicacy of the masks, increased. To eliminate the need for stencil masks, a thin-film technique was developed in which the films were set down in continuous sheets covering the entire substrate area, and the patterns subsequently etched by standard photolithographic methods.

In this filming method the substrates, after being coated with photoresist and baked, are exposed, with the thin-film side up, to photo masks in special mask aligners. Next, the photoresist that forms the etch mask is developed and selectively removed to form the desired pattern. Finally, the thin film itself is etched. Of course, when circuit substrates containing various conductor, resistor, and dielectric layers are processed, the need for selective etchants creates a rather complex process. Complicating matters even further is the sensitivity of thin films to changes in such deposition parameters as source temperature, deposition rate, residual atmosphere, substrate temperature, surface condition, and composition of the film material.

### Hybrid design tradeoffs

Although thick-film technology is usually less costly than thin-film, it requires a larger substrate to accommodate the same circuit complexity. Generally speaking, a thick-film hybrid circuit will be limited in resistor tolerances to no better than  $\pm 1\%$ , resistances to less than 5 megohms, frequency of operation to less than 3 megahertz, and capacitors to no larger than 1 microfarad.

Package size is another design constraint, and may be the most serious limitation on the proliferation of complex thick-film circuits. Since thick-film circuits often contain active and passive devices in standard packages, the actual size of the components must be known before a decision can be made on the ability of thick-film techniques to satisfy particular circuit goals. For example, a typical thick-film resistor should not exceed 60 by 60 mils in area, which limits the resistive value to about 1 megohm. A typical capacitor—say, up to 10 to 20 pi-

cofarads—will require 80 by 80 mils of substrate area. A typical diode chip consumes 20 by 20 mils, while a transistor chip needs 30 by 30 mils. Most linear ICs are available on 60-by-60-mil chips, resistor-transistor-logic and diode-transistor-logic chips come with dimensions of about 40 by 40 mils. TTL chips range from about 50 by 50 mils up to 100 mils on a side for the more complex medium-scale-integration varieties. LSI MOS chips can be as large as 200 mils on a side for the high-density read-only and random-access memories.

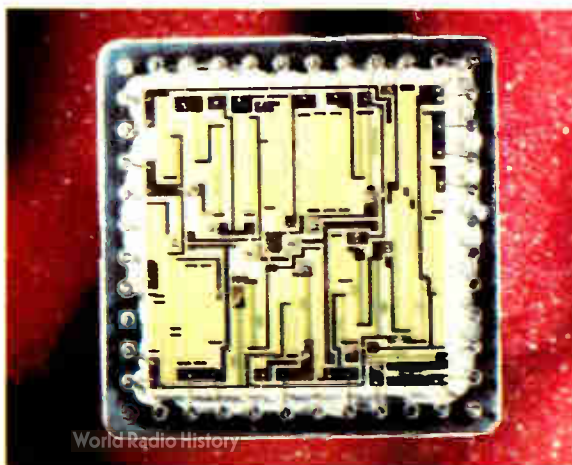
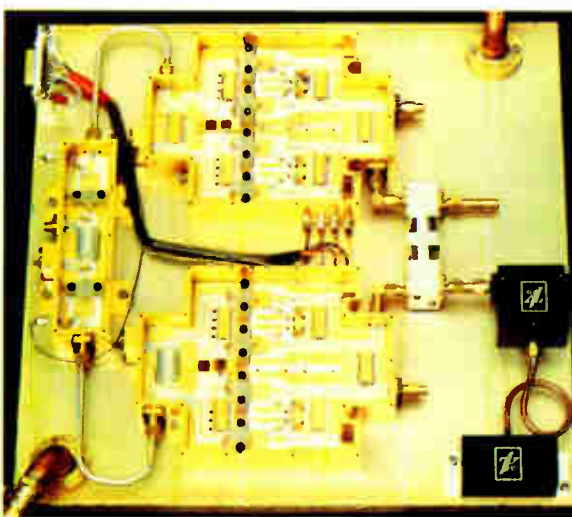
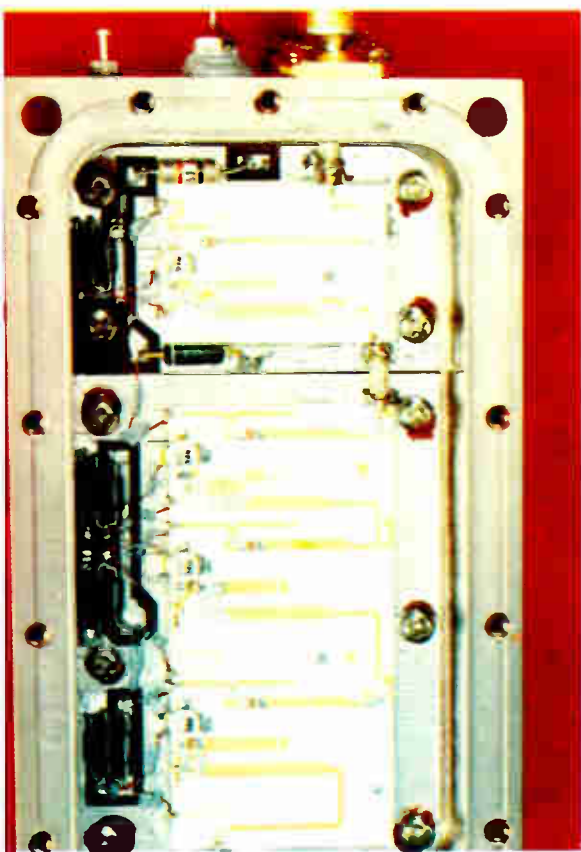
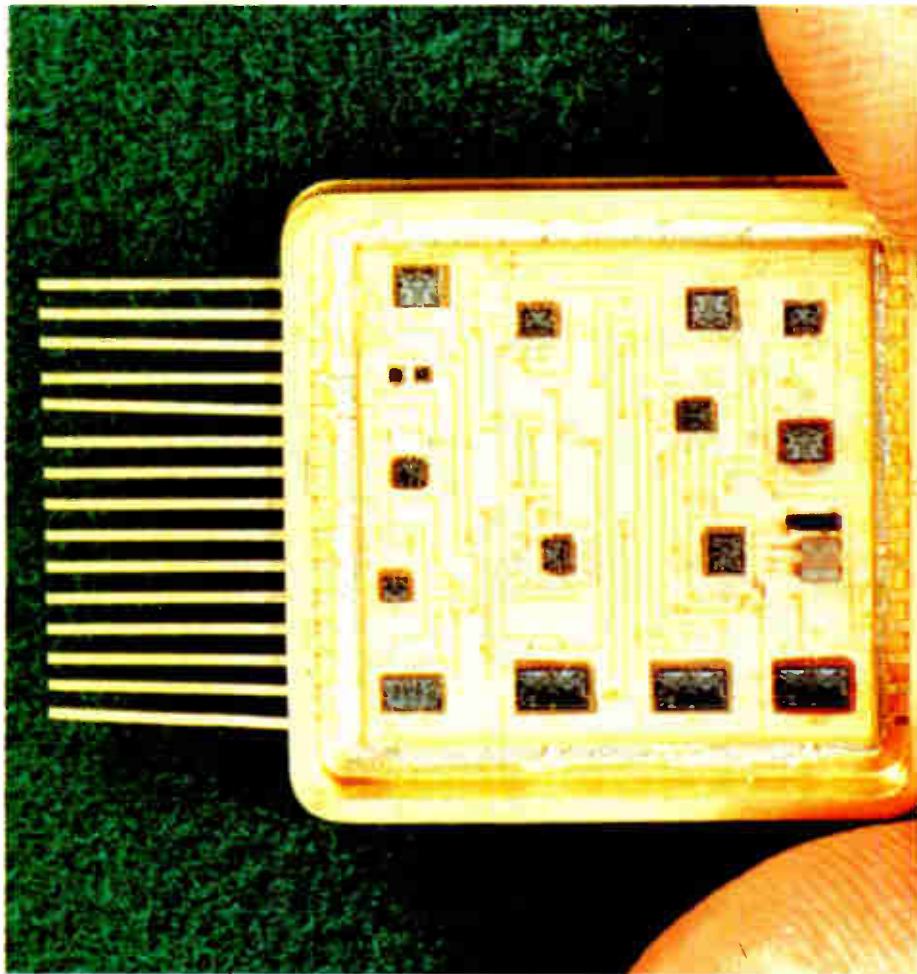
When figuring the total substrate area required for a given thick-film-circuit configuration, one must also account for the conductors, bonding pads, and spaces between elements, all of which consume 80% percent of the substrate, leaving only 20% of the area for the active and passive circuit elements.

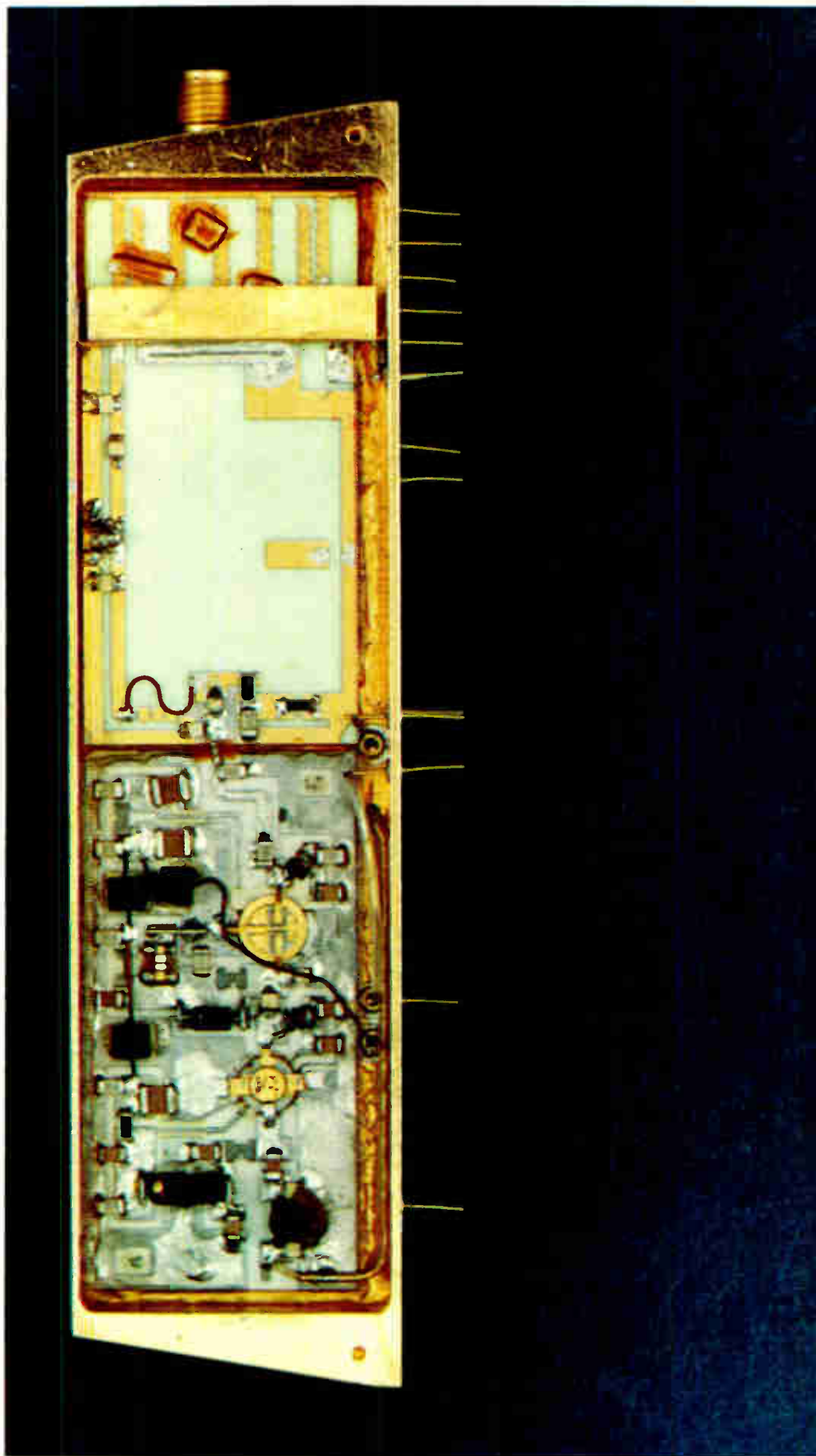
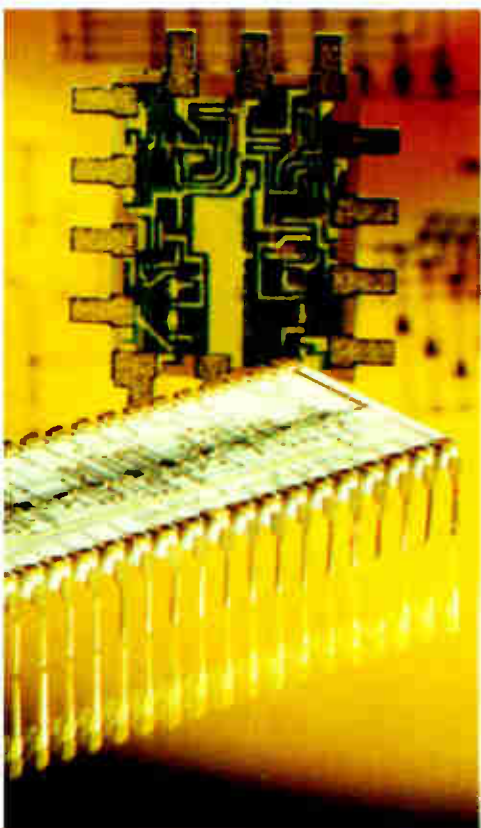
High density in small spaces can be achieved with thin film primarily because of the fine geometries—down to a couple of micrometers—available with this technology. The metalization of thick-film circuits occupies 80% of the substrate, but thin-film metalized lines occupy far less, leaving the rest for active devices. What's more, the very thin metallic films of resistive, conductive, or dielectric materials can be deposited quickly and precisely, an ideal capability for mass-produced batch-processed circuits.

Power handling capacity is another constraint. Here thick-film technology has proven to be the best approach. There is general agreement that, when alumina is used as the substrate, a thick-film configuration can handle as much as 10 watts per square inch. Even higher powers are available with thick films if substrates with high heat capacities, such as beryllia, are used. With a thermal conductivity about four times that for 96% alumina, thick-film BeO circuits can handle about 50 w/in. if properly heat-sunk. Indeed, power packs capable of supplying several kilowatts at low frequencies have been built by such companies as the International Rectifier Corp. using BeO substrates.

Thermal ratings for all devices commonly used in

**The various faces of hybrids.** This assortment of diverse hybrid circuits shows the many jobs that thin- and thick-film hybrids are being called upon to do. Taken clockwise, a Martin-Marietta control circuit for miniature TV-camera systems (top), a Philco-Ford frequency multiplier used in phase-modulator gear for the Viking programs, a Texas Instruments beam-lead custom assembly, a Philco-Ford 1.55-GHz, 110-W power amplifier (top), a Boeing thin-film amplifier meeting Mil Spec 38.510 (bottom), and a Sylvania L-band 4-stage thin-film amplifier.





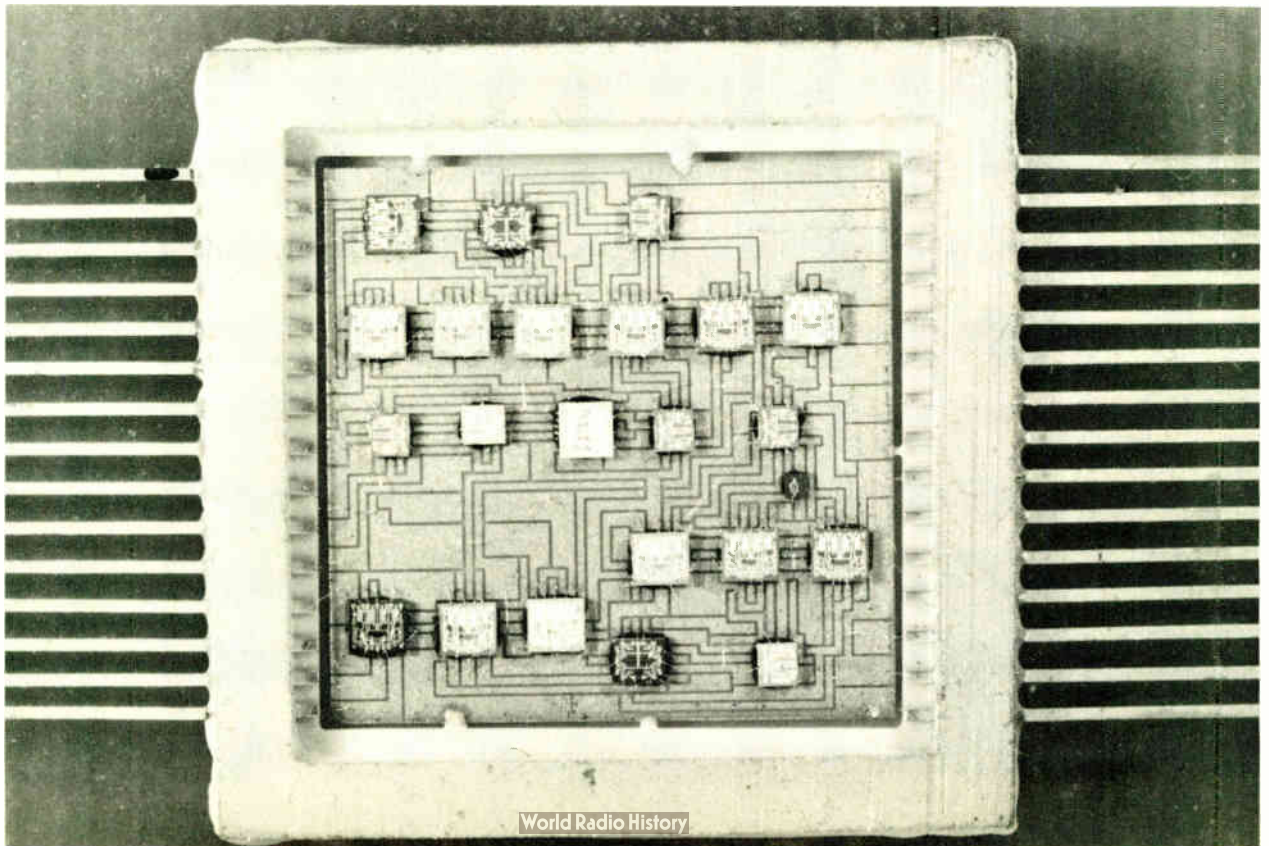
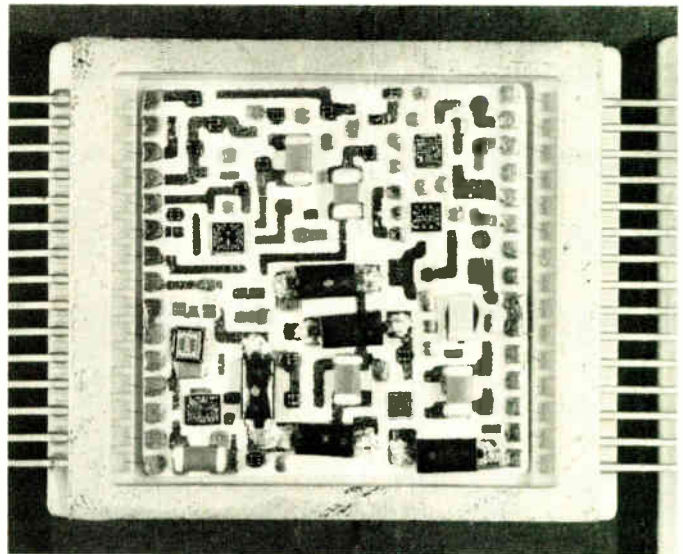
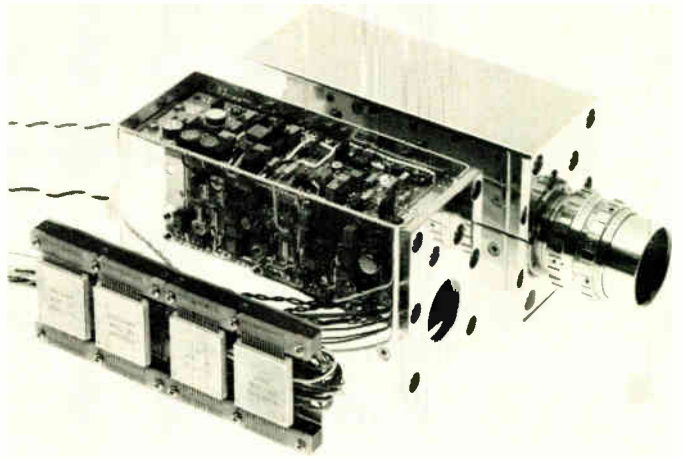
## Hybrid circuits get on TV

One of the greatest strengths of hybrid technology is its ability to tailor a circuit design to an over-all system goal. A subminiature TV camera built with hybrid techniques by the Westinghouse Electric Corp.'s Defense and Electric Systems Center in Baltimore is an excellent example of how hybrids can be used in commercial applications, such as TV cameras, as well as in their more familiar role in military systems.

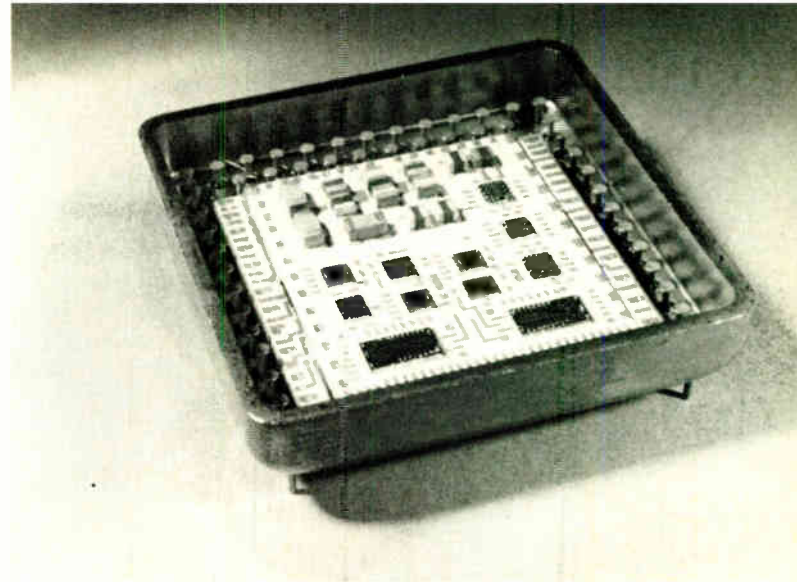
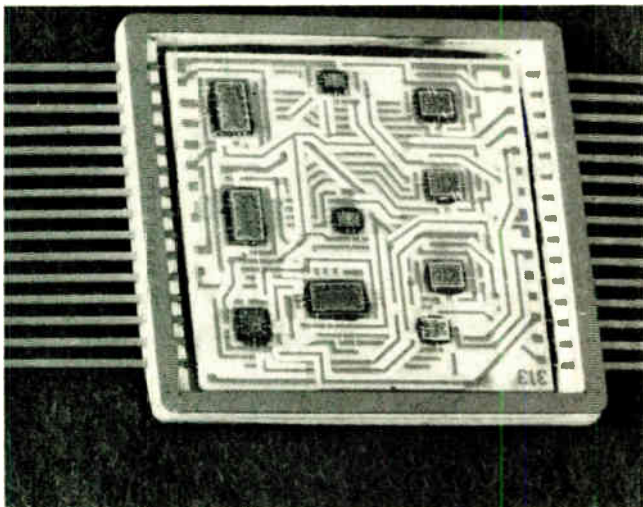
In the Westinghouse camera system, multichip thick-film hybrids are teamed up with advanced video-sensor designs to produce a full-capability camera in a package nearly an order of magnitude smaller than conventional cameras. One key to achieving this compactness, as well as ruggedness and reliability, is the use of three hybrid circuits: a sync generator, a sweep circuit, and an aperture-corrector package. The sync generator (middle photograph) has 22 memory and logic chips to provide full EIA sync, blank, and horizontal- and vertical-drive outputs. This circuit, the one used in the Apollo color-TV camera, is more reliable and rugged than conventional TV-camera circuitry.

With the sync-generator circuit, a multichip package has been assembled that can operate in the 525-line U.S. image format, or, with one jumper, in the 625-line European standard. This assembly, contained in only 1 square inch, is a direct replacement for commercially available units that are typically a hundred times its size.

Another hybrid provides the sweep circuitry (bottom photograph). A five-layer thick-film circuit, it uses a Miller run-up feedback configuration to generate the vertical-current sawtooth, while the horizontal-deflection sawtooth is generated by an inductive-flyback approach. Included in the sweep package are the master oscillator, high-voltage drive, horizontal- and vertical-sweep fail protection, which blanks the sensor cathode during failure, and cathode-blank driver circuits. The entire camera assembly with all circuits and image sensor (top photograph) measures only 1.5 by 1.5 by 5 inches and weighs 9 ounces.







**High density in thick-film circuits.** This portion of a thick-film divide-by-n circuit (left) built by Sylvania for a synthesizer achieves MSI densities through a multi-level hybrid assembly. Bare chips are bonded onto a substrate that is suitable for hermetically sealed packaging. Boeing's hybrid 16-channel multiplex thick-film circuit (right) is packaged in an unusual dual substrate form to increase component density. The bottom substrate, containing 50 resistors, has three conductive layers, while top substrate has five conductive layers.

thick-film hybrid circuits have been tabulated by the device suppliers. For example, an eight-lead TO-99 package is rated at about  $40^{\circ}\text{C}/\text{w}$ , and a  $\frac{3}{8}$ -by- $\frac{3}{8}$ -in. flat pack with 14 leads containing a die 245 mils square is rated at about  $50^{\circ}\text{C}/\text{w}$  in junction-to-case thermal resistance, or  $125^{\circ}\text{C}/\text{w}$  for the junction-to-free-air thermal resistance. A 30-lead 1-by-1-in. flat pack with a  $\frac{3}{4}$ -in. substrate is rated at  $20^{\circ}\text{C}/\text{w}$  junction-to-case and  $60^{\circ}\text{C}/\text{w}$  junction-to-ambient. A typical power thick-film hybrid can have up to 10 active devices per substrate, if a normally size substrate, 15 or 25 mils thick, is used.

#### Thin films for microwave ICs

Nowhere is the power of thin-film technology better illustrated than in the microwave area. Since using discrete components in strip-line configurations is costly and not suitable for complex circuits, thin films are really the only method open to the microwave integrated-circuit designer for frequencies above 3 GHz. Developed in the early 1960s, thin-film microwave ICs have become increasingly more sophisticated, until a whole range of microwave equipment, from 20-w X-band (5,200 to 10,900 MHz) amplifiers to heterodyne detectors and low-noise isolators and circulators, are now available for any number of microwave systems.

Although the microwave configuration developed over a decade ago is still the most popular microwave circuit technique, several other configurations have been developed and are gaining in popularity. These include the suspended strip-line, slot-line, and lumped-constant configurations. (A great deal of development work is under way in monolithic microwave ICs, but no practical circuitry has emerged.)

In the microstrip configuration illustrated in Fig. 3a, supplied by the Bendix Microelectronics division, the conductor pattern is fabricated on one side of the substrate, so that with a ground plane on one side only, the geometry is nonsymmetrical, and part of the electromagnetic energy is contained in the air above the conductor. This air gap presents a waveguide limitation on

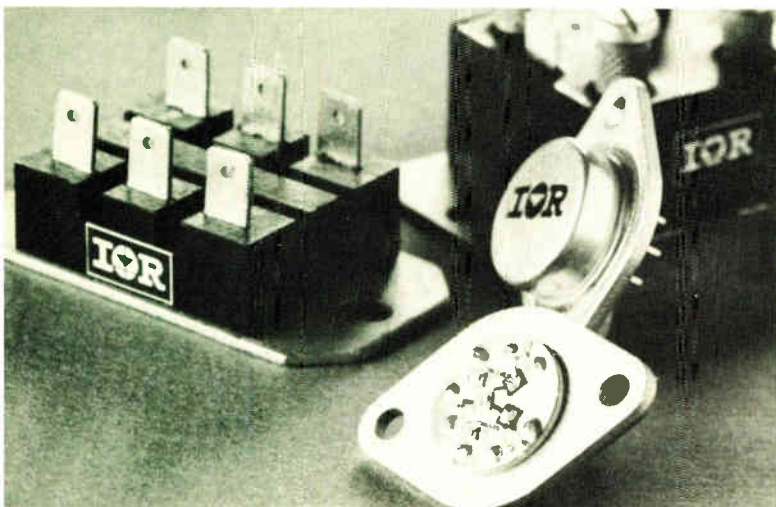
the frequency and power capability of a particular circuit because of the difficulty of matching the impedance of the air with that of the strip line.

However, this restriction is largely overcome in the suspended strip-line configuration illustrated in Fig. 3b, where a conducting pattern on a substrate is suspended between two ground plates, with equal air space on either side of the substrate. Here, because the geometry is symmetrical and the air dielectric is partly loaded by the substrate, microwave power as high as 100 w can be obtained at frequencies up to 20 GHz.

The slot-line configuration shown in Fig. 3c has recently been developed to provide even higher performance. It consists of a narrow slot in a conductive plane, with the opposite side of the substrate exposed to the air. Since the width of the slot can be correlated to the resonant frequency of the electromagnetic wave, this method is the most efficient for propagating signals.

The choice of transmission-line configuration also determines the size of the circuit elements and therefore the ultimate complexity that can be handled by a substrate. In the suspended strip-line configurations, for example, the space between the conductor and the top ground plane is occupied by air, while the space below the conductor is occupied in part by the dielectric substrate but for the most part by air. Since the air greatly reduces the dielectric loading, the degree of integration is low, the effective dielectric constant being approximately 1.5, compared with 1 for air. Since the degree of integration in the material depends on the size of the effective dielectric constant compared with that of air, the suspended strip-line configuration does not appreciably reduce circuit size. Thus complex circuits requiring many active elements will often be too large for the system, although the wide track of the configuration does reduce the tolerance and loss problem.

In the slot-line configuration, with conductors on only one side of the substrate, devices can be shunt-mounted with no holes drilled through the substrate. Here, since half of the electric field is in air, the effective dielectric



**The high and the mighty.** High power and high frequency are areas illustrating how thick-film technology can be tailored to design goals. The 10-A device (left), by International Rectifier, on a BeO substrate comes in a standard TO-3 package. Replacing two SCRs and three diodes, this small unit can be compared to IR's older 25-A and 42.5-A hybrids also shown. Thick-film hybrids are also pushing up the performance of uhf and vhf modules. These standard modules (right), with active devices on separate substrates, are by Motorola.

constant is half the sum of the substrate dielectric constant and the dielectric constant of air. For an alumina substrate, the effective dielectric constant is 5.5, a value that permits three times as much circuit reduction as the suspended strip-line configuration.

This slot-line, lumped-element configuration has been extended over the last few years to frequencies as high as 10 GHz. The inductors and capacitors used in this design must have dimensions of less than 1/16 of a wavelength, if distributed effects are not to interfere with circuit operation. As an example of the size reduction possible with this design approach, an S-band (1,550 to 5,200 MHz) amplifier has been fabricated by the Bendix Corp. on a 0.2-by-0.15-in. substrate. The microstrip equivalent of this would require a 1-by-1-in. substrate. Again, large-quantity fabricating costs for such small circuits can be very low, inasmuch as batch processing is possible.

### Microwave IC materials

In selecting conductor materials, prime consideration should be given to rf resistance, substrate adhesion, and thermal expansion. Table 1, compiled by Bendix, lists these characteristics for some of the more common conductor metals.

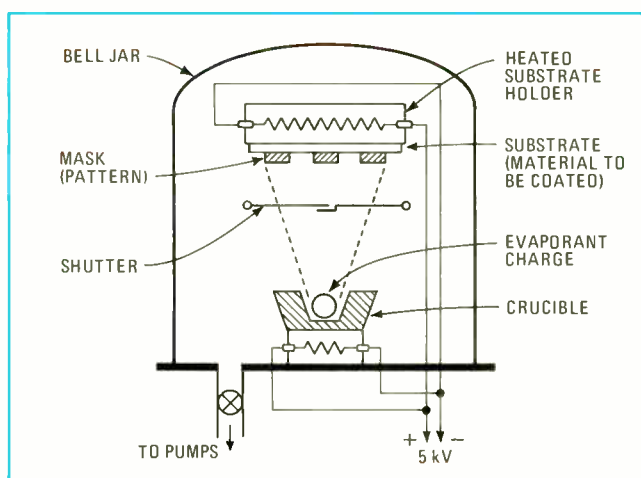
It can be seen that these metals, unfortunately, fall basically into two categories: those with good conductivity and poor adhesion, and those with poor conductivity and good adhesion. Alumina represents something of a middle ground, demonstrating fair conductivity and fair adhesion. At present the most commonly used conductor combines a chromium layer, approximately 100 angstroms thick, with a gold layer thicker than 0.1 mil.

Also, many alloy combinations have been tried to improve the conductivity-adhesion tradeoff. Common among these is the use of a thin chromium layer, which provides for a good adhesion and has little effect on the rf loss of the stripline. Layers of chrome greater than 500 angstroms thick, however, combined with layers of

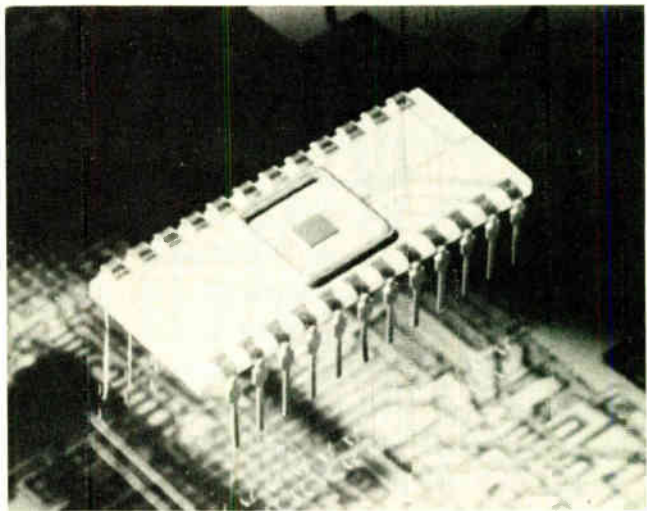
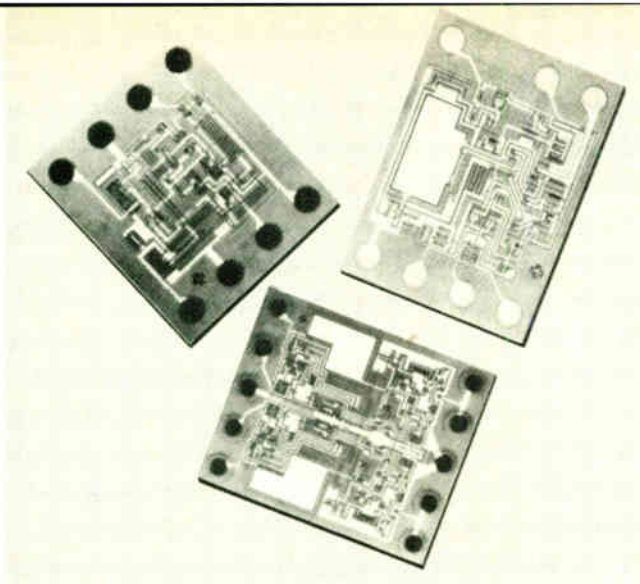
gold less than 0.1 mil thick, have poor temperature characteristics and suffer from chrome diffusing into the gold to create a high-resistance conductor.

A chrome-copper combination, on the other hand, does not exhibit this increased resistance but instead suffers from a copper oxide build-up that becomes lossy. The use of titanium or tantalum as adhesion layers is currently being evaluated, although they would have to be separated from the conductive layer by an additional barrier layer to prevent migration.

With microwave circuits, as with lower-frequency thin-film circuits, metalization is generally accomplished by vacuum deposition or sputtering. At microwave frequencies, however, sputtering creates a mechanical bond between conductor and substrate, requiring a rough surface finish on the substrate that tends to degrade rf loss, particularly at frequencies above 5 GHz. Vacuum deposition creates a chemical



**1. Hot filament.** One method of evaporating thin films onto a substrate employs a hot filament to raise the temperature of the metal. The substrate to be coated with metal is placed in a carrier and positioned over the evaporation source.



**Attachments.** Flip chips, which reduce costs by eliminating the die-attach step and wires, have been in short supply, but relief is coming. On the left, linear flip chips by Motorola (type-741 dual op amp) can be attached with a single reflow-solder operation. Attach bumps are 90/10 solder on a chrome-copper-gold base. Beam-lead assemblies (on the right, from TI), another method of lowering fabrication costs and raising reliability, require fewer bonds. Supplies of beamed chips—from Raytheon, Motorola, and TI—are on the increase.

bond and must be used for surface finishes of less than 6 microinches. Here best results are obtained if multiple conductor layers are deposited in the same vacuum run and phased together at the crossover point.

Conductor depositions suitable for microwave ICs may also be accomplished by a thick-film process that involves screening through a mask. Gold or silver is printed and screened in a glass frit, which is then applied to the substrate and fired at temperatures above 750°C. The resulting metalization—typically 0.5 mil thick—is impure. But it is combined with the glass frit, a situation that increases the resistivity and therefore results in a greater rf loss. The thick-film pattern definition is also much inferior to that obtained with etched thin films, and in general this technique is limited to circuits operating below 2 GHz.

Microwave performance also puts a premium on the quality and composition of substrates. The best sub-

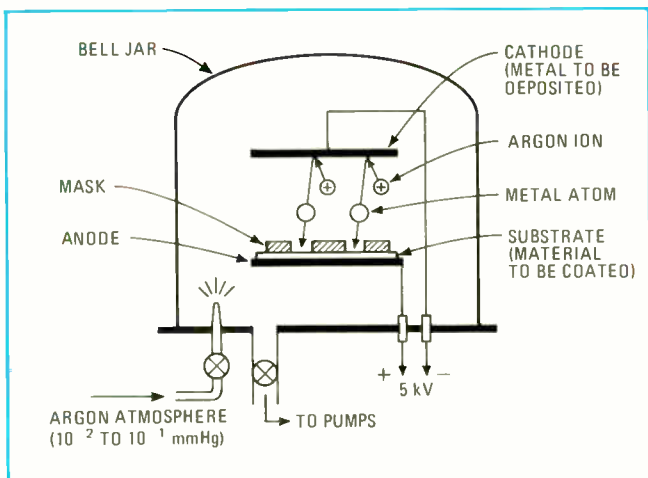
strate materials are characterized by low dielectric loss, smooth finish, a temperature-independent dielectric constant, good thermal conductivity for high-power dissipation devices, and a uniform dielectric constant from batch to batch.

The properties of the more commonly used substrates are listed in Table 2. Alumina, the material of the greatest utility, has good over-all characteristics and is inexpensive—if no precise surface finishing is required. Sapphire is used where an ultrasmooth surface is required, particularly at the higher frequencies. Although beryllia has excellent thermal conductivity, it is difficult to work with because it is toxic; it is used primarily as a carrier for high-power active devices. Rutile is used largely for slot-line configurations, and ferrite and garnet for non-reciprocal magnetic components.

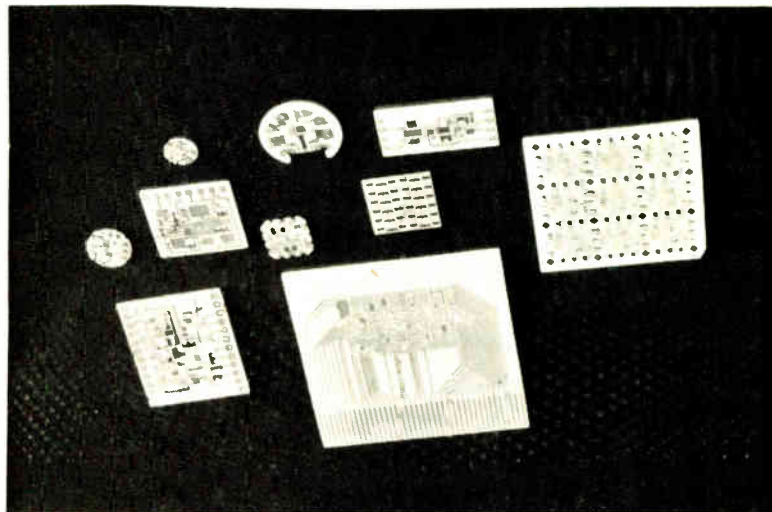
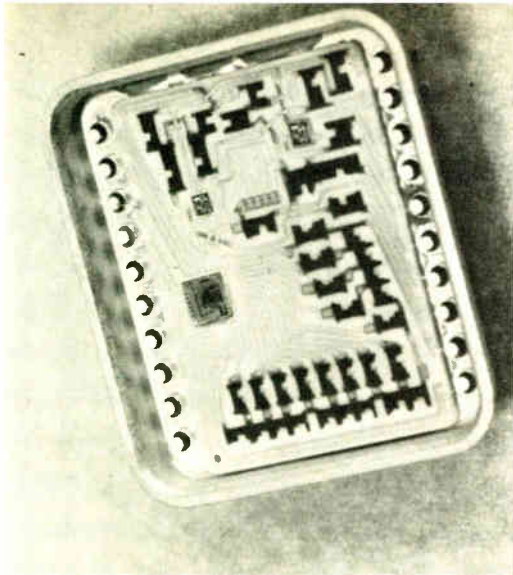
### Some circuit examples

Designers of microwave systems have used these materials and thin-film techniques to build a variety of operational circuits for a host of applications—ranging from telecommunications to airborne radar and communications systems and high-performance instrumentation equipment. A single-pole double-throw switch built by Bendix operates over a frequency band of 800 to 1,400 MHz with a minimum isolation of 25 decibels and a switching speed of less than 600 nanoseconds. Insertion loss is less than 0.5 decibel, the maximum input power being 1.5 kilowatts peak and 15 w average. The switch uses two p-i-n-diode chips, shunt-mounted a quarter-wavelength from the common junction, and six chip capacitors for direct-current blocking and rf bypassing. Over-all package dimensions, excluding connectors, are 1.25 by 1.25 by 0.37 in.; an equivalent strip-line package would be 3.25 by 3.25 by 0.5 in.

An S-band 10× multiplier also developed by Bendix incorporates both microstrip and lumped-element design. This multiplier, fabricated on an alumina substrate measuring 1 by 0.5 by 0.025 in., uses thin-film inductors and chip capacitors for the 225-MHz input-matching.



**2. Cathode sputtering.** Thin films can also be deposited by applying a large (5-kilovolt) voltage across the electrodes in a low-pressure argon environment. The ions accelerate toward the cathode material at a force great enough to adhere to the nearby substrate.



**Hybrids for industry.** Builders of industrial control equipment are finding that thick-film technology is a good way to get high performance with devices that are small, reliable, and cost-effective. The four-quadrant, general-purpose digital-to-analog converter (left) built by Beckman Instruments will accept a 13-bit binary code, and on command convert and hold the number as an output voltage. Thick-film circuits from National (right) range from digital-to-analog converters and power amplifiers to custom multiplex and communications equipment.

bias, and diode-drive circuits. It also contains a shunt-mounted, step-recovery diode chip and a high-Q microstrip resonator to resonate the tenth harmonic. With a 15-W input, the output power is greater than 1 W over the range 2.2–2.3 GHz. This design is superior to conventional coaxial or strip-line approaches because it permits parasitics, stray radiation, and circuit-element values to be precisely controlled and reduces the circuit area by a factor of four. It also significantly reduces circuit-assembly time, since the great majority of the circuit elements are formed during the etching process.

Another circuit having high performance is an L-band (390 to 1,550 MHz) transistor oscillator, in which microstrip techniques have been incorporated on an alumina substrate measuring 0.7 by 0.6 by 0.05 in. The oscillator generates 250 milliwatts at 1.7 GHz, using a 2-W, 2-GHz transistor chip. A 6-dB isolation in the output provides a frequency stability of better than  $\pm 0.5$  MHz over the temperature range from  $-55^\circ$  to  $+75^\circ\text{C}$ . with a load-voltage standing-wave ratio of 5:1 at any phase angle.

A unique combination of semilumped-element and microstrip techniques has been incorporated in a low-pass filter and directional coupler. The filter, a semi-

lumped-element version of a low-pass design, uses low-impedance lines for the shunt capacitive elements and high-impedance lines for the series inductive elements; a narrow gap between the shunt capacitors provides the series capacitive element. The lumped-element configuration reduces circuit size to half that of a distributed inductance/capacitance microstrip design and also increases rolloff skirt selectivity. With a cutoff frequency of 1.2 GHz there is a 30-dB rejection at 1.5 GHz and a 60-dB rejection at 1.9 GHz; the insertion loss is less than 0.8 dB between 1.02 and 1.1 GHz.

The meandering coupling gap used in the 17-dB directional coupler to equalize the even- and odd-mode phase velocities provides superior directivity (more than 20 dB) to that obtainable with a straight coupling gap (less than 15 dB). The differential phase velocities result from the greater percentage of the electric field that propagates through air in the odd mode because of the field between adjacent conductors; in the even mode, there is no such field.

A good example of the many functions that can be integrated in a microwave, IC, and of the number of interconnections that are thus eliminated, is a design using an alumina substrate that measures only 3 by 2 by 0.05 in., but can support a 30-dB monitor probe, a single-pole double-throw switch, two low-pass filters, two transmit/receive diplexers, four directional couplers, two fixed attenuators, and two reflected-power monitor detectors.

The unit has an insertion loss of less than 1.8 dB with a 1-kw input at 1.09 GHz. Its switching speed is less than 600 nanoseconds, and its receive loss is less than 1.2 dB at 1.03 GHz. Combining all these functions on a single substrate eliminates 14 coaxial interconnections, considerably reducing the size and cost of the circuit.

### Hybrids in Europe

Like their U.S. counterparts, European system designers are turning more frequently to hybrids when they need high performance. A good example of this ac-

TABLE 1  
CHARACTERISTICS OF METALS USED FOR CONDUCTORS

Metal	Properties			
	Direct-current resistivity (relative to gold)	Coefficient of expansion ( $^\circ\text{C} \times 10^6$ )	Skin depth at 2 GHz [mils (micrometers)]	Substrate adhesion
Silver	0.73	19.1	0.056 (1.42)	poor
Copper	0.76	17.0	0.060 (1.52)	very poor
Gold	1.00	14.1	0.064 (1.63)	very poor
Aluminum	1.21	23.5	0.076 (1.93)	good
Chromium	5.89	6.6	0.160 (4.06)	good
Tantalum	6.16	6.5	0.176 (4.47)	very good
Titanium	25.0	8.9	0.402 (10.21)	very good



**Trimming them up.** Laser trimming systems have become standard tools for tailoring resistance values to specified tolerances. These systems—at Garrett Manufacturing Ltd., Rexdale, Ont. (left) and Beckman's facility in Fullerton, Calif (right)—are completely computer controlled for automatic trimming of thick- and thin-film circuits in both substrate and packaged form. Most systems in use include an automatic probing unit that determines whether the individual resistors printed in the substrate require laser trimming.

tivity is the development underway for the Franco-German wide-body Airbus, where some 80% of the autopilot analog circuitry will be hybrid modules. "There will be anywhere from 800 to 1,000 packages on each airbus, depending on the configuration," says Alain Gayet, commercial director of Sintra Microelectronique, supplier of the hybrid packages.

Sintra is producing four different packages for the autopilot—a dual comparator, two kinds of analog gate, and a resistance network. The comparator package has three op amp chips—two National Semiconductor LM101As and Fairchild  $\mu$ A740—plus two diodes and 15 resistors (14 of them laser trimmed to an accuracy of one part in one thousand.) The substrate is glass and the resistor patterns are nichrome overlaid with gold, and 25-micrometer gold wires link the chips to the wiring pattern on the substrate, which is packaged in a Mil Standard 12-pin, hermetically sealed TO-8 can.

In another package, Sintra has put three thin-film substrates in a metal can measuring 18.5 by 25.5 by 4.5 millimeters. On one level is a stabilized 27-v power supply and an active passband filter. Above these lies a voltage-controlled oscillator that converts the input to a frequency output.

Thick-film custom hybrid circuits are also on the increase. Switzerland's LN Industries, for example, has built thick-film circuits that control a solenoid valve directly off 220-v line supplies. The key circuit element is a thyristor rated for 1.6 A at 400 V. The chip also carries two other thyristors used as diodes and one transistor. These chips are die bonded on a ceramic substrate after the passive elements have been screen-printed on.

The substrate measures roughly 25 by 13 millimeters. It's molded in plastic and housed right inside the valve, which is made by the Lucifer Valve division of Sperry Rand Corp. in Geneva. The same circuitry with discrete components required a package that measured 2 by 8 by 15 centimeters and had to be mounted outside the valve and connected to it by cable.

In Belgium, the Electromag division of Sprague

World Trade Corp. is supplying an instrument maker with a ac-dc converter. The thick-film resistors in the package are linear to 0.1%. Along with the eight resistors, there are three tantalum capacitors and three plastic-packaged transistors.

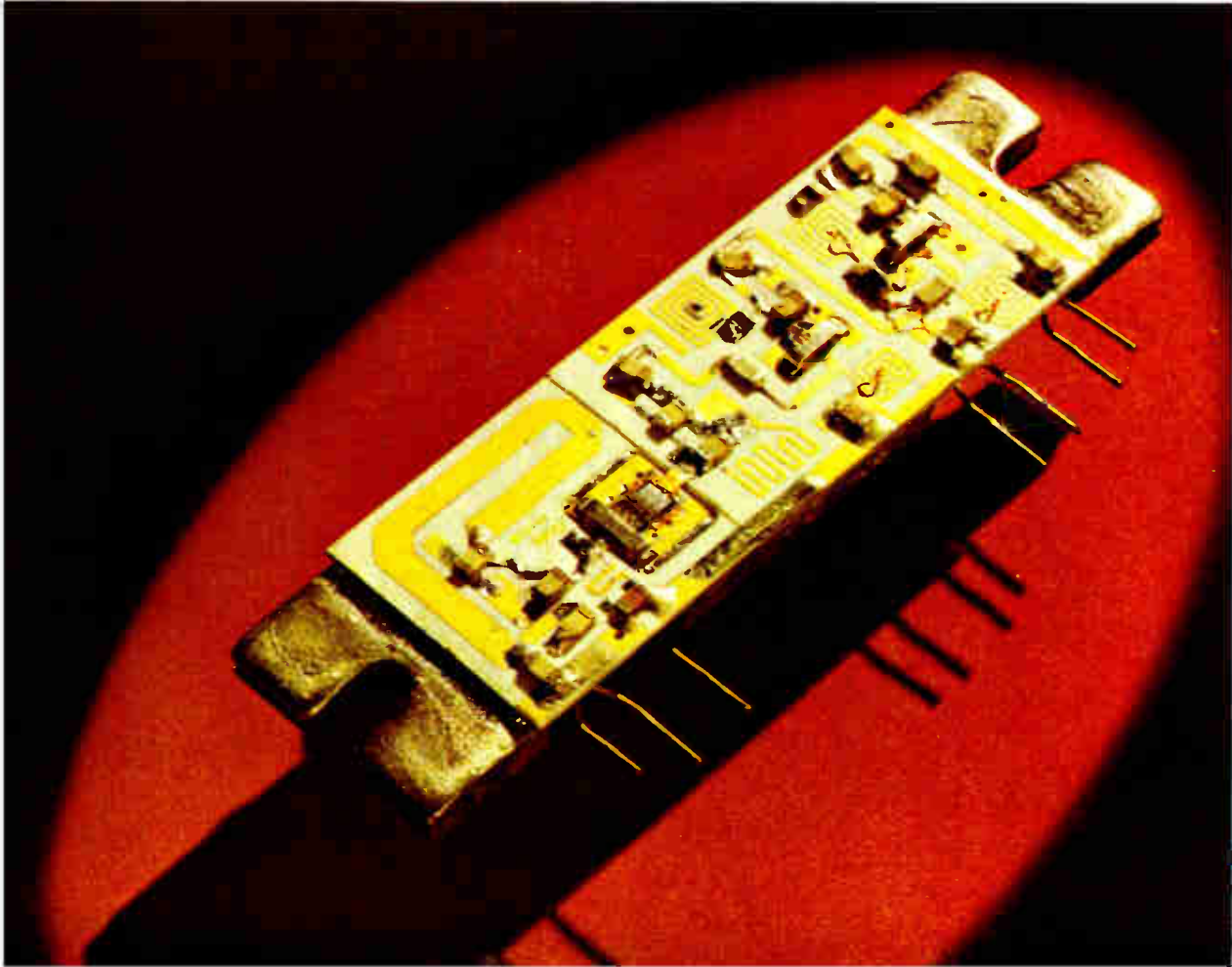
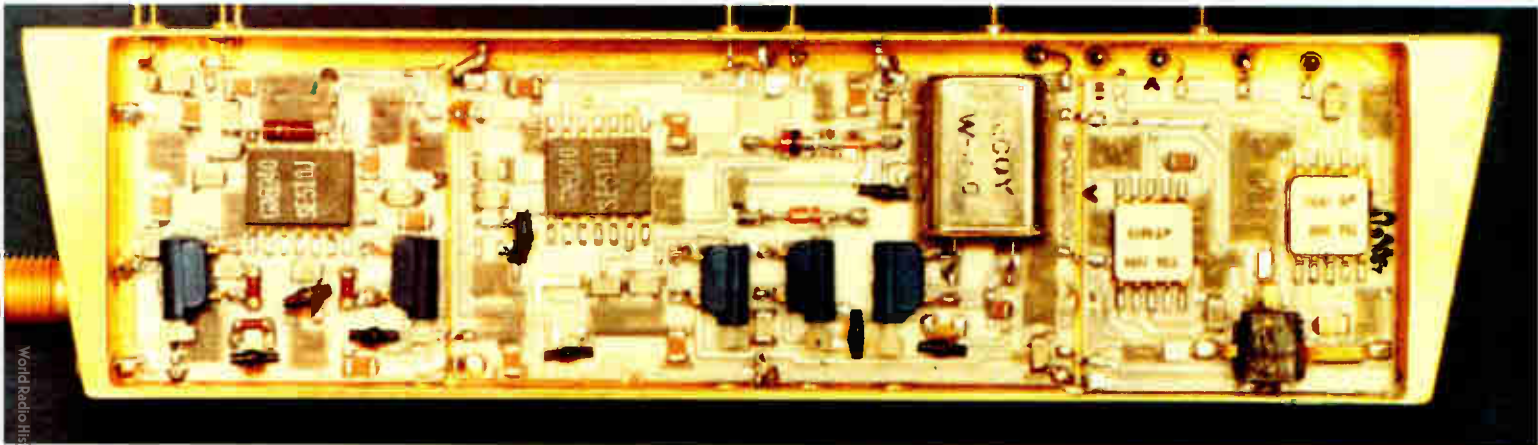
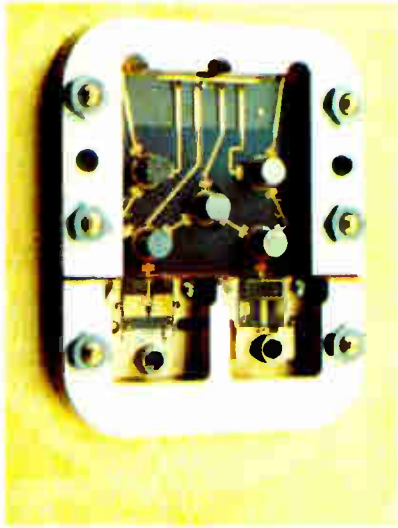
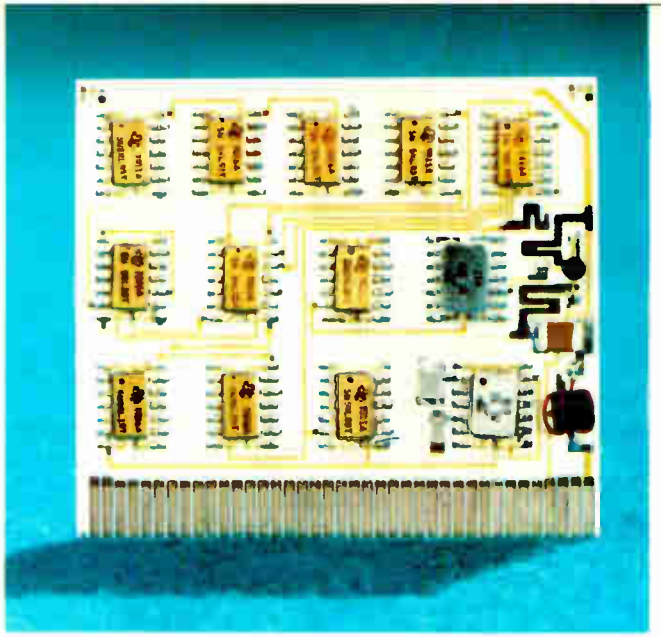
In England, hybrids are being used in Ford trucks. These thick-film modules are supplied by M.C.P. Electronic Ltd. to Ultra Electronics Ltd., which uses them in an electronic control box for the trucks. M.C.P. makes three different modules—two frequency-to-voltage converters used for engine-speed control and a power supply. The controller is mounted close to or sometimes on the engine, and since many of these trucks are used in Alaska, the controller has to work properly on an engine started from cold at  $-40^{\circ}\text{C}$  and rising to normal running temperature of around  $100^{\circ}\text{C}$ .

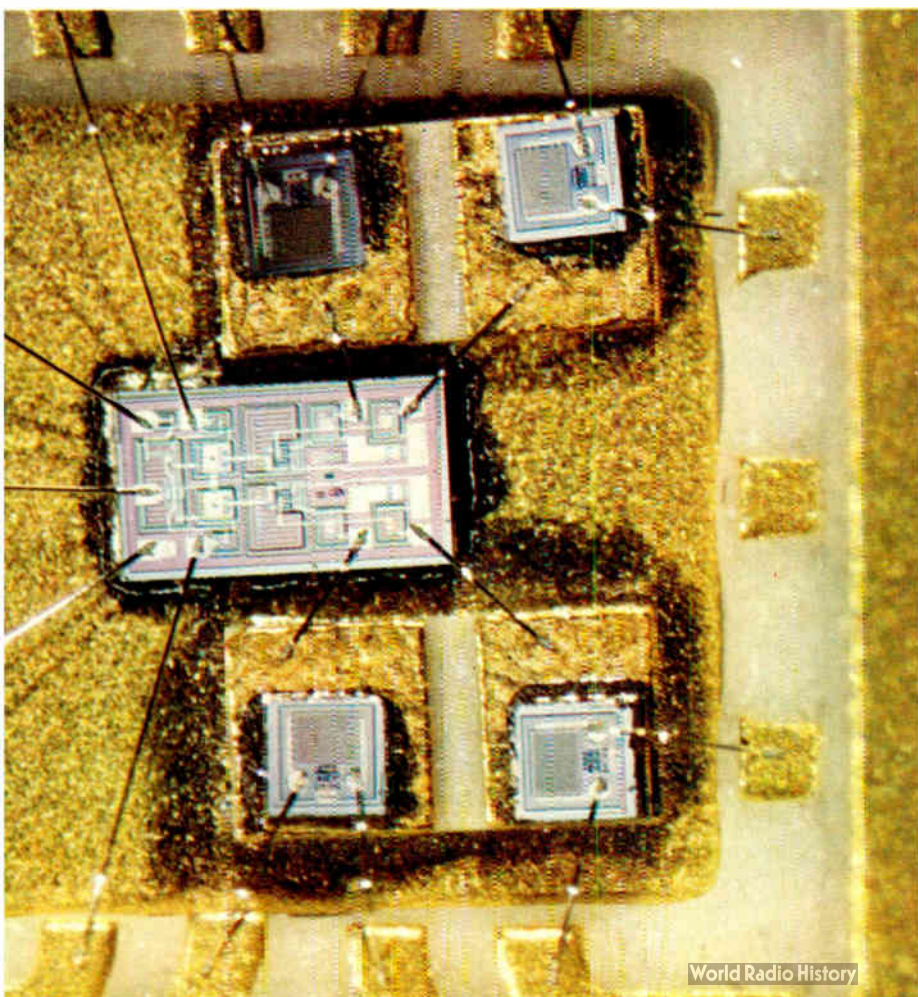
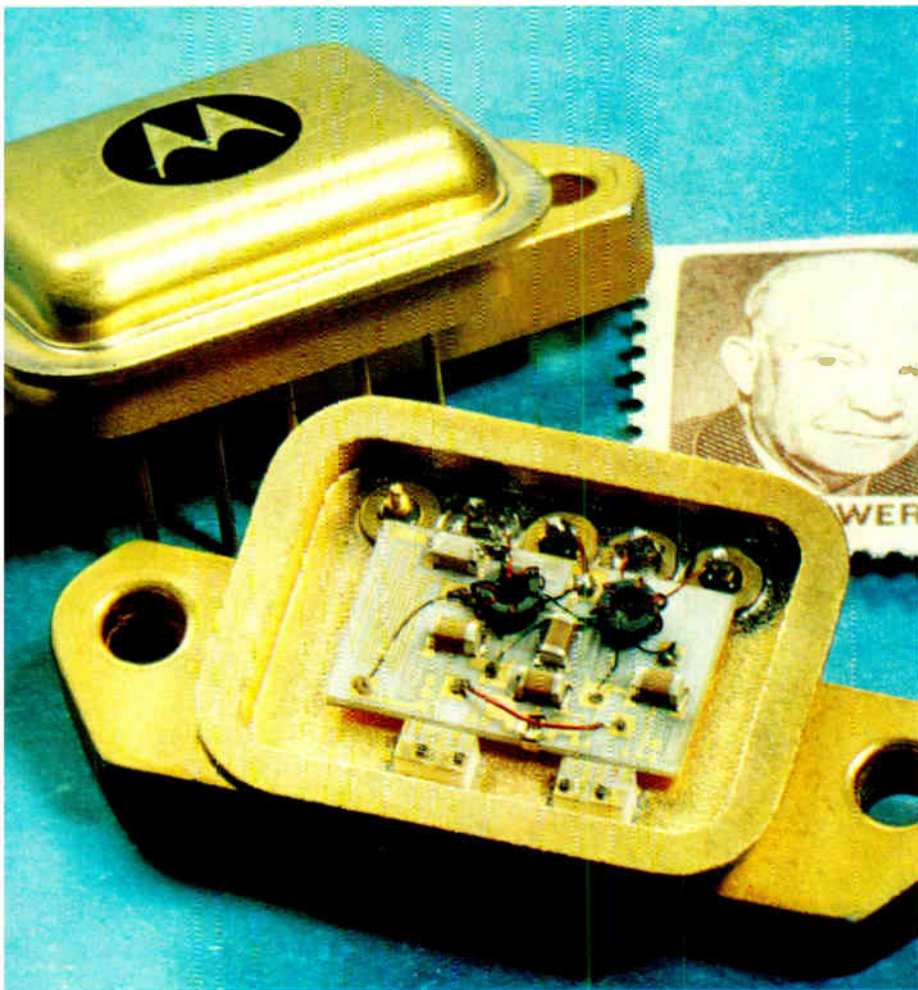
Because the controller's bare chips are bonded directly onto the substrate, complex three-layer encapsulation is required to prevent cracking from thermal cycling stress. Epoxy resin is first put over the active devices to protect the wire bonds. This layer is followed by a silicone-rubber coating, after which all of the circuit is covered by epoxy resin.

The reliability of thick-film devices is exemplified by

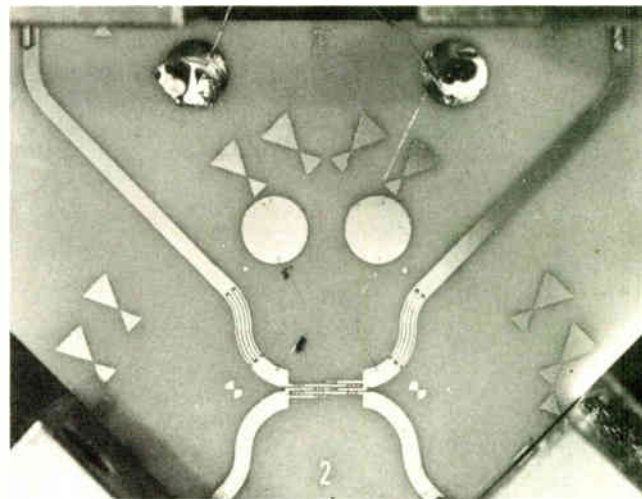
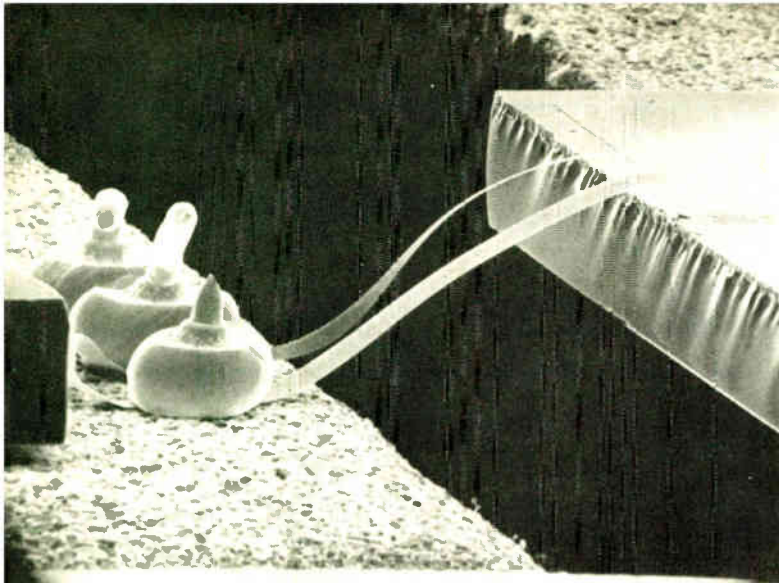
TABLE 2: SUBSTRATE MATERIALS

Substrate	Properties			
	Dielectric constant at 10 GHz	Loss tangent at 10 GHz	Surface roughness [microinches (micrometers)]	Thermal conductivity (watts/cm <sup>2</sup> °C)
Alumina, 99.5%	10	0.0001	4 (0.10)	0.30
Alumina, 96%	9	0.0006	24 (0.61)	0.28
Beryllia	6.5	0.0001	24 (0.61)	2.5
Sapphire	10.5	0.0001	1 (0.025)	0.40
Quartz	3.8	0.0001	1 (0.025)	0.01
Glass	5	0.0020	1 (0.025)	0.01
Rutile	100	0.0004	24 (0.61)	0.02
Ferrite/garnet	15	0.0002	12 (0.305)	0.03

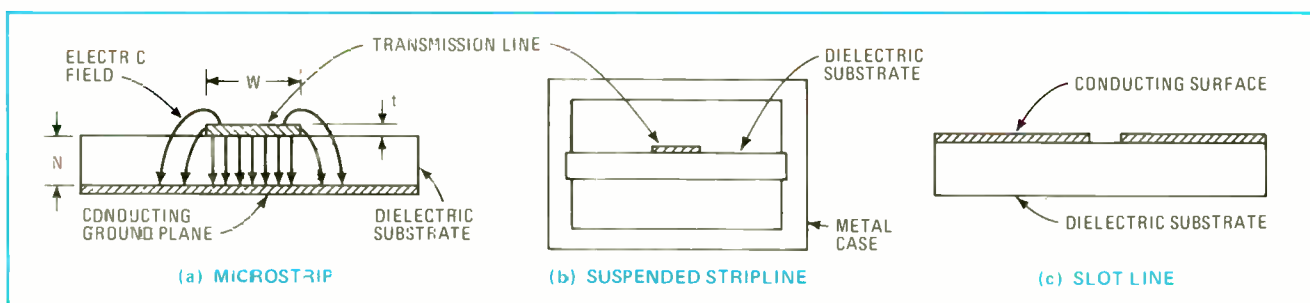




**Standards and customs.** Hybrid technology can boost the performance of both custom and standard products, supplying off-the-shelf and special in-house requirements. Shown clockwise, starting at far top left, is a Hewlett-Packard standard-product 1-W, 30-dB-gain, X-band amplifier, a custom logic circuit by Sylvania, a standard broadband linear-amplifier module for the CATV industry by Motorola, a Siliconix standard-product driver gate, a TRW communication module offered as a standard product, and a custom voltage-controlled oscillator and signal conditioner built by Philco-Ford for an in-house project.



**Hybrid techniques take many forms.** Tektronix method makes low-capacitance bonds on high-frequency devices (left), such as scope signal-sampling circuits. Here a thin gold tab is deposited onto the silicon, folded back, and connected to the substrate or header on which the device rests. This tear-tab process can handle tabs as narrow as 0.00035 in. Key component in a 3.4-W Kp-band (12.2 GHz) hybrid amplifier, built by Phi'co-Ford, is this 90° interdigitated coupler using thin-film chrome-copper-gold metalization on 0.025-in.-thick alumina.



**3. Configurations.** In microstrip configuration (a), conductor pattern is on one side of substrate. In the stripline (b), conductor is suspended between ground plates. Slot line (c) has narrow slot in conductive planes.

a successive-approximation analog-to-digital converter that has been working in a British space vehicle for 19 months. It's part of the pulse-code-modulated data collection and transmission system. Because of the circuit's success, the next satellite, to be launched in February 1974, will use 16 similar thick-film modules.

Hybrids are going into medical equipment as well. ITT Components Group Europe makes thick- and thin-film modules containing the circuitry for heart pacemakers built by Implants Ltd. of Welwyn Garden City. Hybrid construction was chosen because its reliability allows a pacemaker to remain unattended in the body for about three years.

The pacemaker circuitry—three thick-film modules and one thin-film passive timing circuit—all fit in a hermetically sealed can, which measures about 1.5 by 0.5 in. The unit, implanted in the body, with a wire (called a catheter) leading to the heart, applies 5 v, 1-millisecond-wide pulses at a preset rate, often about 70 pulses per minute, to the heart.

In Germany, Lewicki Microelectronic has produced 42 different types of hybrids, which are found in almost half of the scientific measuring equipment on board the German-American Helios sun probe spacecraft. Included are thick-film high-voltage cascades and resistors networks in the megohm-gigohm range with high stability for generating and distributing voltages from 1 to

6 kilovolts, ceramic substrates for imaging devices, miniature secondary-electron multipliers, and space-pack modules incorporating ferrite-core transducers and diodes for driving three Helios core memories. The design concept can accommodate as many as 80 components in a package measuring only 1 by 0.5 by 0.1 in.

Another thick-film circuit from Lewicki is a programmable matrix element designed as a customized data-input device. To replace bulky electro-mechanical crossbar distributors, it can also be used as a semiconductor read-only memory or program generator.

The matrix consists of two levels of conductors sandwiched between ceramic insulating layers. The conducting paths in one level are at right angles to those in the other level. The device constitutes an array of ohmic crosspoints. To program this matrix, a current is sent through a crosspoint so that the connection between the upper and the corresponding lower path is severed.

Unlike a conventional bipolar diode matrix, the hybrid matrix has linear current-voltage characteristics, making it suitable for handling currents and voltages from dc to rf. Also, because of high dielectric isolation between inputs and outputs, the current at open crosspoints has a zero value even when handling levels of several hundred volts

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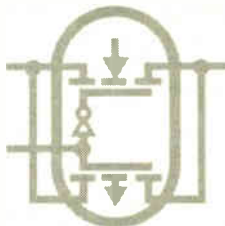




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J FET



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CMOS  
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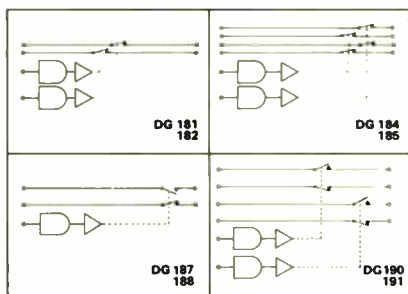
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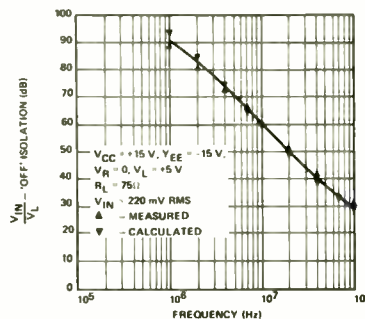
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DG181-DG191 Functional Diagrams

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Switch OFF Isolation vs Frequency — DG181

to ground is only 200 $\Omega$ , providing good a-c by-pass on the FET switch gate. Contrast this with other driver circuits with impedances as high as 26 M $\Omega$ , which adversely affect isolation characteristics.

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## Ice warning indicator monitors road conditions

by Steven E. Summer  
Hauppauge, N.Y.

For more than 10 years, Rover automobiles have had a built-in indicator that warns their drivers of possibly icy roads. With the availability of the versatile and economical integrated quad op amp, this same safety feature can now be installed quite easily in any make of automobile.

The ice warning indicator shown monitors ambient air temperature to alert the driver to the conditions under which ice will start forming on the roads—that is, when air temperature is between 32°F and 36°F in wet weather. The device is rugged and provides good noise rejection.

The circuit produces a variable duty cycle to control the flash rate of a light-emitting diode. At 36°F, low-duty-cycle light flashes are generated, and as the temperature drops towards 32°F, the LED indicator remains on continuously. The flashes occur about once a second.

A thermistor with a nominal resistance of 15 kilohms at 25°C acts as the temperature-sensing probe. It is

mounted in a baffled enclosure that is exposed to ambient air. The baffle prevents erroneous readings due to air movement.

The circuit's three amplifiers are part of the same chip as the quad op amp. Since circuit action depends on current ratios, circuit operation is insensitive to variations in battery voltage, making zener regulation unnecessary.

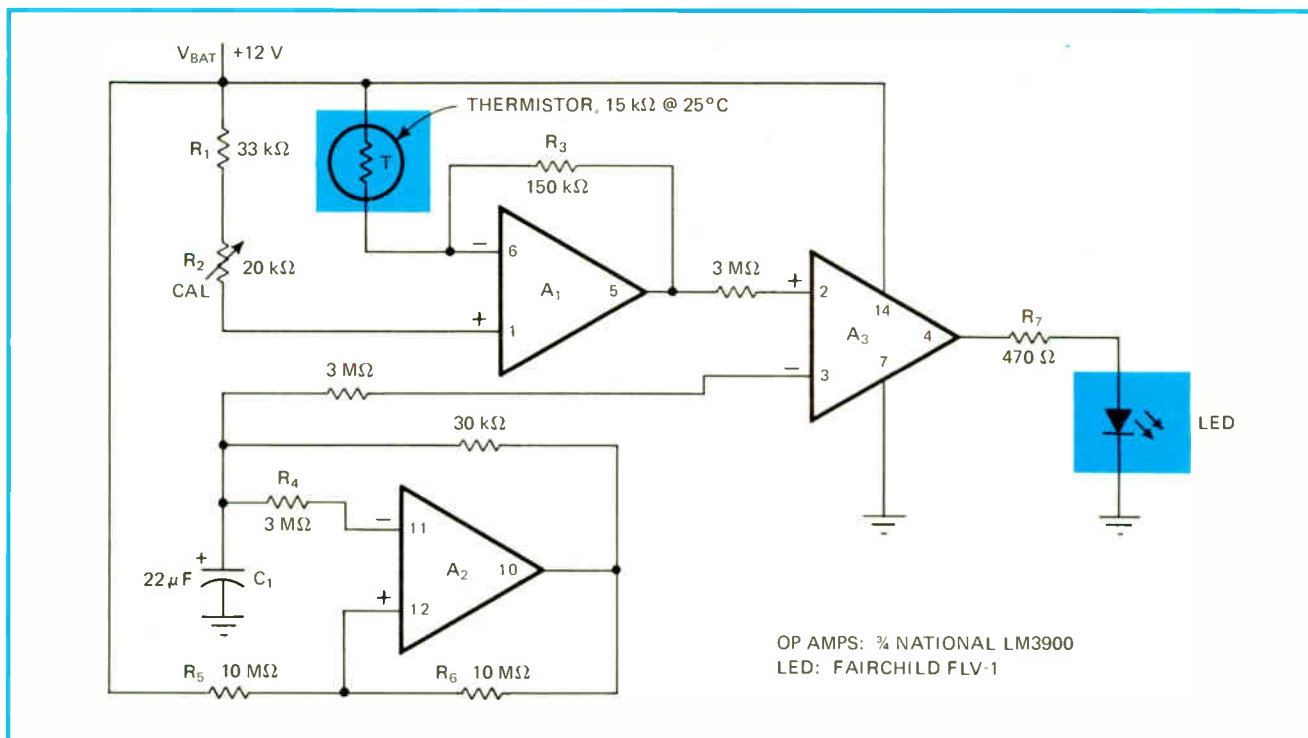
Amplifier  $A_1$  compares the resistance of the thermistor to the series combination of resistors  $R_1$  and  $R_2$ . Feedback resistor  $R_3$  sets the correct slope of  $A_1$ 's output-voltage response to temperature. At 32°F,  $A_1$ 's output is  $0.6V_{BAT}$ ; at 36°F, it's  $0.3V_{BAT}$ .

Amplifier  $A_2$  is connected as a free-running multivibrator having a repetition rate of approximately one pulse per second. Three resistors— $R_4$ ,  $R_5$ , and  $R_6$ —set the upper and lower voltage limits for capacitor  $C_1$  at  $0.6V_{BAT}$  and  $0.3V_{BAT}$ , respectively.

The outputs of amplifiers  $A_1$  and  $A_2$  are compared by amplifier  $A_3$ . When the multivibrator ( $A_2$ ) output is lower than  $A_1$ 's output,  $A_3$ 's output goes positive, lighting the LED. Resistor  $R_7$  limits LED current to around 25 milliamperes.

Resistor  $R_2$ , which calibrates the circuit, is adjusted by placing the thermistor probe in an ice slurry and setting  $R_2$  so that the LED is always on. Other operating points can be obtained by changing the values of resistors  $R_1$ ,  $R_2$ , and  $R_3$ . □

**Driving aid.** Ice warning indicator, which puts the flexibility and economy of the quad op amp to work, uses a thermistor probe to sense air temperature. At 36°F, the LED indicator flashes once per second. This flash rate increases as temperature approaches 32°F until the LED remains on continuously. A varying-duty-cycle output determines the flash rate. Amplifier  $A_2$  is wired as a free-running multivibrator.



# Single-supply reference source uses self-regulated zener

by William Goldfarb  
Cornell University, Ithaca, N. Y.

Temperature-compensated zener diodes provide a reference voltage that remains stable despite changes in time and temperature. But they exhibit a rather large dynamic impedance, from 100 to 400 ohms, and current supplied to them must be regulated precisely.

By using voltage comparison, one of these reference zeners can be made to control its own current, eliminating the need for a separately regulated temperature-compensated current source. A precision voltage reference source can then be realized with only a single unregulated power supply. And the cost of the circuit will be dominated by the cost of the zener, keeping parts cost to somewhere around \$6.

The voltage reference source in the diagram provides a nominal output voltage of 10 volts that is stable to within  $\pm 7$  millivolts. It can operate over a supply voltage range of 12 to 18 v. With the output voltage at  $V_{REF}$ , the current through the zener is:

$$I_Z = V_{REF} - V_Z / R_1$$

The current-booster transistor actively keeps the voltage at the inverting input of the operational amplifier at:

$$V_1 = V_{REF} R_2 / (R_2 + R_3) = I_Z R_1$$

Zener current  $I_Z$  can then be expressed as:

$$I_Z = V_{REF} R_2 / R_1 (R_2 + R_3)$$

And reference voltage  $V_{REF}$  is held to:

$$V_{REF} = V_Z (R_2 + R_3) / R_3$$

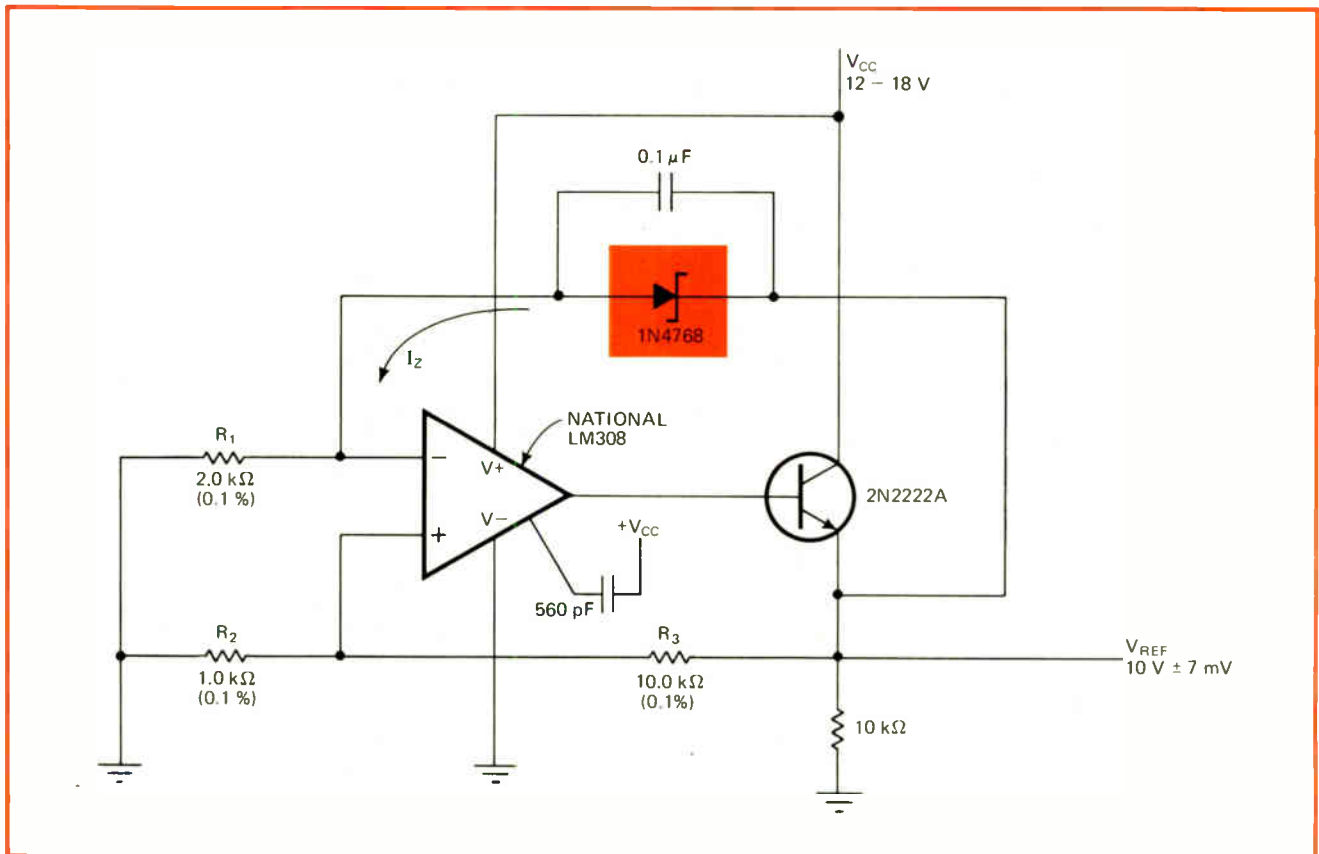
A pitfall in any dc bootstrap scheme like this is the possible existence of stable states other than the desired one. For this circuit, such a state exists when the output voltage is zero. Connecting a capacitor between the power supply and the op amp's compensation input prevents the circuit from being locked into the zero-output-voltage state when it is first turned on. The capacitor causes the turn-on transient to put the circuit into the desired condition, with the output voltage at  $V_{REF}$ .

For the components shown, the output is stable to within  $\pm 7$  mV over a temperature range of  $0^\circ\text{C}$  to  $75^\circ\text{C}$ , even with a supply variation of  $\pm 10\%$ . The output current is 30 milliamperes maximum. The capacitor across the zener serves to attenuate noise that may be generated by the zener at high operating frequencies.

A negative output voltage can be obtained by reversing the diode, using a pnp instead of an npn transistor, and grounding the op amp's positive supply input. □

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**Making do with one supply.** Voltage reference source, which operates from a single power supply, maintains its output at 10 volts  $\pm 7$  millivolts over a  $75^\circ\text{C}$  temperature range and with  $\pm 10\%$  supply variations. Through voltage comparison, the zener reference regulates its own current, thereby eliminating the usual zener constant-current source. The circuit's maximum output current is 30 milliamperes.



# Eliminating offset error in sense amplifiers

by Dan Chin  
Cambridge Memories, Newton, Mass.

A sense amplifier for a memory must detect a pulse signal during a gated time interval. But a significant error occurs at the amplifier's output when its input offset voltage is large in comparison with the voltage amplitude of the pulse signal.

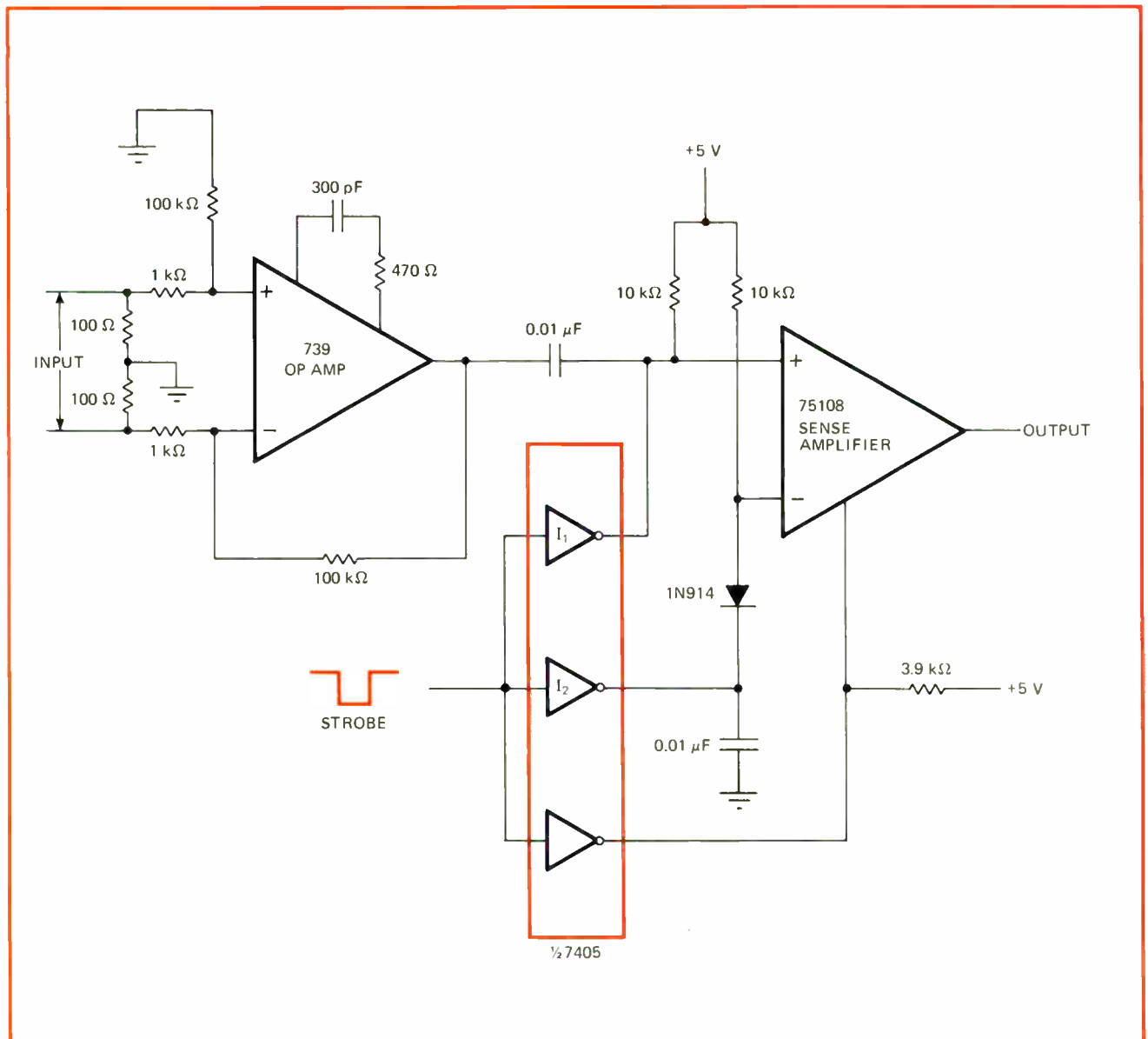
If the offset voltage is removed by ac coupling, however, the pulse's baseline could shift when the readout data pattern changes. But if, in addition to being ac-

coupled, the pulse is held to ground except during the time interval of interest, a reference voltage can be developed and the pulse compared to it.

The dc-restored sense amplifier in the figure makes use of this technique. The input operational amplifier performs as a basic linear amplifier, providing a signal gain of 100. The amplifier's output is ac-coupled to the sense amplifier for detection.

Dc restoration is accomplished by the open-collector inverters connected to the inputs of the sense amplifier. Two of the inverters,  $I_1$  and  $I_2$ , assure that any offset voltage is applied equally to both inputs of the detector, permitting offset error to be eliminated by the detector's common-mode rejection. The diode in series with the detector's negative input sets the threshold level halfway between the pulse baseline and the minimum expected peak voltage. □

**Sensing pulses, barring offset errors.** Data is ac-coupled from the operational amplifier to the sense amplifier to get rid of offset-voltage error. The dc signal level is then restored by open-collector inverter gates. Any additional offset error is eliminated by the sense amplifier's common-mode rejection because inverters  $I_1$  and  $I_2$ , at each of the sense amplifier's inputs, introduce equal offsets.



# Low-cost minicomputer opens up many new system opportunities

Revised version of an established minicomputer packs a 16-bit processor on one pc board; economical design exploits MOS LSI technology as well as a flexible form of read-only memory called a programmable logic array

by Ken Gorman and Phil Kaufman, *Computer Automation Inc., Irvine, Calif.*

□ Minicomputers, as they get cheaper, not only take over existing jobs but create unexpected new applications for themselves, as in point-of-sale systems. Such developments are reflected in the fact that, when the price of a given minicomputer design drops by a certain percentage, the number of units sold usually increases by a much larger percentage.

To halve the price of a machine of given capabilities more than doubles the demand for it. Indeed, history has shown that an order-of-magnitude increase in demand is a realistic expectation. To achieve the goal of halving the price of the two-year-old Naked Mini 16 minicomputer, metal-oxide-semiconductor technology was exploited. The MOS approach was enhanced by the use of a programmable logic array, a special form of read-only memory offering flexibility not available in normal ROM structures.

Under the Naked Mini concept, the OEM customer is supplied with a processor, a memory, and one or more input-output interfaces appropriately packaged and ready for use. He must supply his own chassis, power supply, and manual controls, which, however, are usually available as part of the equipment in which the minicomputer is a component. Consequently, even the Naked Mini 16 costs very little, and now even this cost has been cut in half with the new Naked Mini LSI.

The Naked Mini LSI, packaged on a single printed-circuit board and with a 4,096-word semiconductor memory, sells in quantities of 200 for \$990—the first full-fledged 16-bit computer to sell for less than \$1,000. The machine is also available in other memory capacities, and is the heart of the stand-alone Alpha LSI computer (Fig. 1), which adds chassis, power supply and console to the basic pc board. The two machines are both software-compatible and input/output-compatible with the older models, although they are also rather slower.

## Instruction power

Several other goals, of nearly equal importance, gathered around the designers' primary goal:

- The new computer was to retain a level of performance high enough to satisfy all but the most demanding applications.
- As a corollary of this performance goal, a powerful instruction set and input-output architecture would be required.

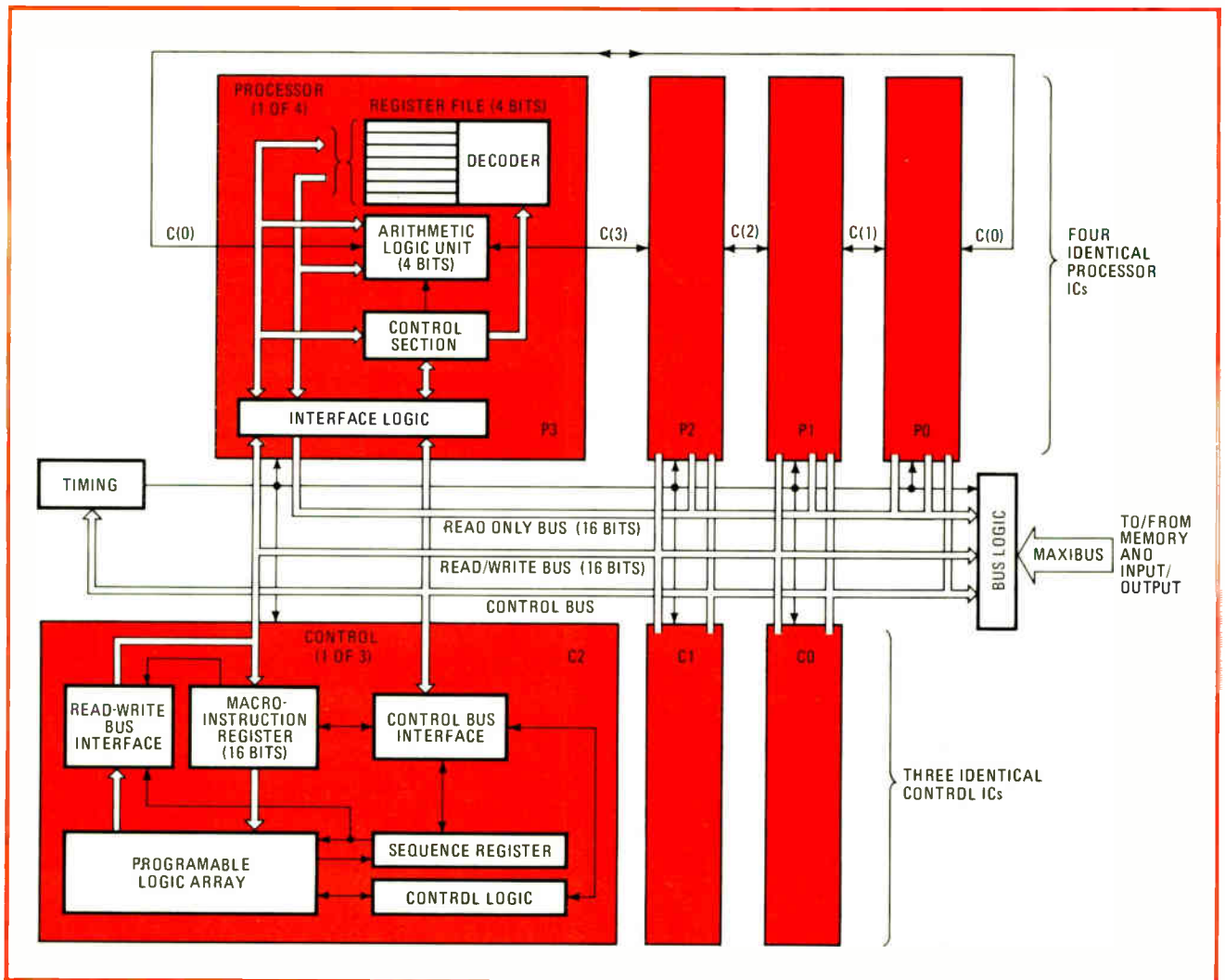
■ As a corollary of the primary goal of low cost, the entire computer would have to fit on a single printed-circuit board.

To maintain the performance level of previously available minicomputers, the full 16-bit word length was required. Furthermore, a substantial memory capacity, a real-time clock, an interface to a teleprinter or a cathode-ray tube terminal, direct access from peripherals to the memory, and power-failure detection with automatic restart were necessary.

To maintain these features while halving the cost required reductions in the chassis and motherboard, into which the necessary components are plugged in conventional designs. The key step was to dispense altogether with the chassis and motherboard. Since ordinarily this hardware holds the rest of the components together, its elimination implied that the entire computer would have to fit on a single printed-circuit board, 15 by 17 inches. To get a whole computer on one board, including up to 8,192 words of memory, only one technology

**1. Naked and Alpha.** One-board computer (top) is first on the market for less than \$1,000, yet has the same capability as its twice as expensive predecessor. Same computer plus chassis, power supply and console produces the Alpha version (bottom). Eight white ICs at left are the central processor, its controls, and one dummy.





2. Seven-chip processor. Each processor chip is a four-bit slice of the computer; the four chips process 16-bit words in parallel. The three control chips are also identical except for the contents of the programmable logic array, which is like a read-only memory but more compact.

would work: large-scale integration of metal-oxide-semiconductor circuits.

The desired performance of the system required an extensive set of powerful instructions. Such instruction sets are not available in the various "microcomputers" that have been appearing recently; for, although some of them can perform tasks as complex as those performed by, say, the Alpha 16, they must limp through the tasks with a limited set of instructions that require more execution cycles and more space in memory. Moreover, offering a computer with half the instruction power of a competitive machine, even at half the base cost, would be useless if the reduced instruction set required twice as much memory to perform a given task, because the cost of the additional memory would be prohibitive.

For this reason, an instruction set at least as powerful as that of the older Alpha 16 was desirable. Making the new machine software-compatible fulfilled this objective, since it meant that the new machine would be capable of both byte and word processing, hardware multiplication and division, conditional and unconditional input-output operations, 128 kinds of conditional jumps, shift instructions involving both single and

double registers, automatic interrupts, and so on.

Software compatibility also meant that all Alpha 16 input-output equipment had to work with the new machine. That equipment, for example, generates up to five levels of interrupts, four of which trigger routines beginning at fixed locations in memory, and one of which requires the processor to inquire of the input-output controller at what address the interrupt routine begins. (This address is hardwired in the controller when the system is installed.) Both approaches eliminate the need for interrupt polling to determine the interrupt source.

Furthermore, controllers require parallel access to data, address, and function lines, presenting at least the threat of pin limitations in packaging. There are also some input-output instructions whose execution depends on the status of the controller, and a class of automatic input-output in which a single instruction executes a whole subroutine, controlled by interrupts.

### Processor implementation

Thus, starting from the need for software compatibility and the capabilities implied by this requirement, the designers tackled the actual building of the processor.

The fact that MOS LSI circuits on a single pc board were the only feasible approach to this project doesn't have to imply that all the circuits should go on a single chip. On the contrary, physical limitations on chip size, circuit density, and associated cost required the processor logic to be partitioned among several chips—and partitioning brings up the problem of interconnection.

Packages with more than 40 pins are not cost-effective at any level of production. But a partitioning plan limited to fewer than 40 pins per package tends to yield too many packages and too many interconnections, indicating difficulties in getting everything onto one board and problems in assembly and reliability.

## The programmable logic array

Like a conventional read-only memory, the programmable logic array is a matrix of crosspoints. At each crosspoint a connection is either made or not made by a mask superimposed on the array during its manufacture. In the model shown, each connection is a diode, permitting energy to flow in only one direction and eliminating spurious "sneak paths" through the array.

The matrix in the array is in two parts, as shown at the right. In the upper part, connections are made to vertical product-term lines from the  $n$  horizontal input lines and their complements. This part corresponds to the decoder in a conventional read-only memory. (The read-only memory is actually only a programmable logic array containing product terms for all possible input combinations and corresponding output data for each product term.) The diodes in this part, plus the inverters between the upper and lower parts of the matrix, make up a logic NAND gate. The output of any particular inverter is logically true (low) only if all the inputs, including complements, that are connected to its product-term line are logically true (high). When neither an input nor its complement is connected to a product-term line, the quantity or signal represented by that input is a "don't-care" condition for that particular product term.

In the lower portion of the diagram, more diodes connecting the inverted product-term lines to output lines, plus the inverters on the output lines, make up a logic NOR gate. (The configuration is identical with the NAND gates in the upper part of the matrix, but since the signals have been inverted, the function in this case is NOR. This is an example of the logic-design rule,  $\overline{A \cdot B} = \overline{A} + \overline{B}$ .) The output of the second set of inverters is logically true (high) if any one or more of the product-term lines is logically true (low).

In a MOS programmable logic array, the actual cross points are transistors, not diodes. And because of the signal inversion through the transistor, the inverters between the two matrices are not required.

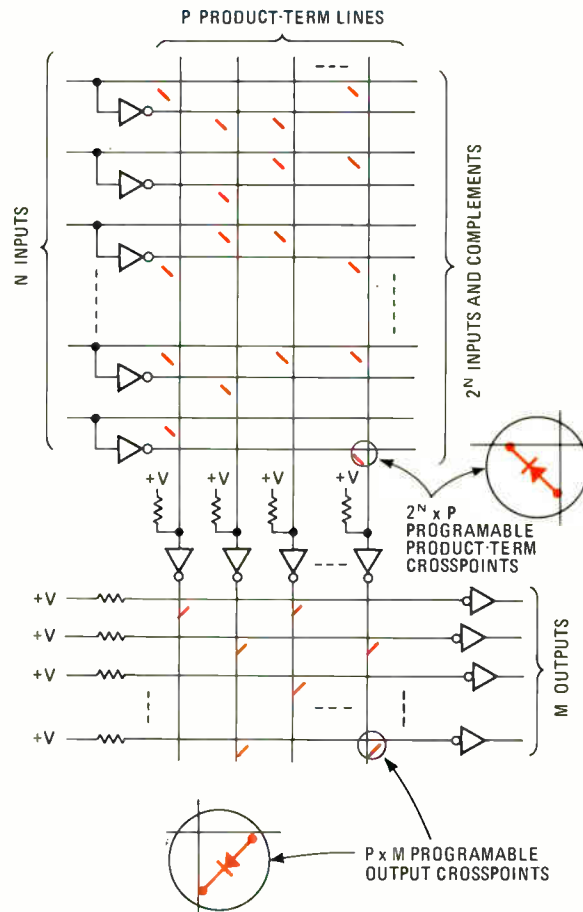
With this organization, outputs can be programmed for any combination of input states. For any given output, the inputs are described in the form of a logical sum-of-products expression, such as

$$ABC + \overline{D}E + \overline{F}GH$$

Each logical product is formed on a separate vertical line in the upper part of the matrix, and the sum formed in the lower part. One product term can be used in two or more outputs if necessary. Only enough product terms are required to implement the total number of terms for all the outputs together.

This dilemma was solved with a processor architecture that time-shared the package pins for multiple functions. For example, the processor's internal data bus is used both for data transmission to and from the memory and input-output subsystems and also for microinstruction transmission between the processor's control and arithmetic sections.

Through use of this time-shared architecture, the entire processor was partitioned into two chip types, four identical P chips making up the arithmetic unit, and three essentially identical C chips containing the control logic. Otherwise, had these seven chips all been different, development and production costs would still have



In the programmable logic array, these outputs are the equivalent of microinstructions. A set of 40 microinstructions types initiate input-output data transfers and control instructions and data access from the main memory, the various functions of the arithmetic logic unit, and execution of the microinstructions themselves as defined by status flags. The short microinstruction word length of only 20 bits is a result of pin limitations on the package—but even in this short length individual microinstructions can perform both word and byte processing directly address the next microinstruction to be executed. Since the jump command and address are inherent parts of every microinstruction, they take up no additional execution time, as do jumps in conventional read-only memories.

been too high to meet the primary cost goal.

The design of the P chip is straightforward and relatively simple. It is organized as a four-bit slice of registers and arithmetic/logic unit, so that four chips working in parallel process 16-bit words.

Each C chip contains, among other things, a control memory whose contents are determined by a masking step at the time of manufacture. Except for this masked content, the three C chips are identical. Details of the chips and the processor partitioning are shown in Fig. 2.

### ROMs are not feasible

The control memory in each C chip is a programmable logic array. It is used in the same way as a conventional read-only memory in microprogrammed computers, but is more compact.

A control memory approach is necessary in an LSI computer with many complex instructions to eliminate the otherwise enormous amount of random control logic and thereby hold down the physical size of the LSI chips. The control memory is microprogrammed to execute the computer's actual instruction set, called macroinstructions, in a number of relatively simple microinstruction steps.

The prime disadvantage to the use of read-only memories as a control memory is attributable to the exhaustive decoding of the address input lines. That is, for  $n$  input lines,  $2^n$  ROM locations are provided (see Fig. 3). In a computer with macroinstructions using all 16 bits of instruction as operating code information, the number of address lines,  $n$ , must be at least 16. A control memory, implemented from ROMs would require at least  $2^{16}$  or 65,536 locations.

A two-stage control memory, with one stage doing partial decoding and the other doing the actual control, would get around the need for a large array by effectively reducing  $n$  for each stage. But because of the slow access of MOS ROMs, additional ROM accesses would be needed before beginning actual processing of instructions, and this would compromise system throughput to an unacceptable level.

Furthermore, in a ROM implementation if several instructions share parts of common code segments in the microprogram, either those segments must be repeated or microprogrammed jumps to common segments must be provided. Because such jumps require the insertion in the microprogram of a specific "jump" microinstruction, which takes up space in the read-only memory and requires an extra machine cycle to execute, they degrade system throughput badly.

Thus the only feasible approach was to use a programmable-logic array—essentially a read-only memory, except that its address decoder is not exhaustive and can be programmed to accept only the desired addresses. The array may even decode only some of the address lines, so that instructions that have common processing steps can be made to share a single microinstruction routine in the array if its decoder is programmed to respond only to the common instruction bits and to disregard the dissimilar bits ("don't care" bits). Branching to micro-routines can thus be avoided.

By eliminating the exhaustive address decoder, the number of address lines,  $n$ , can be large without result-

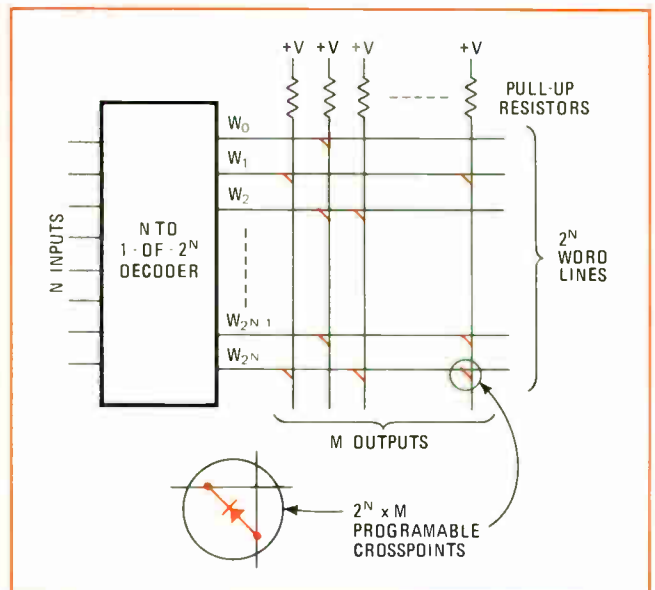
ing in  $2^n$  locations. In the Naked Mini LSI,  $n = 24$ , but only 300 locations are required to implement the 162 macroinstructions, as opposed to 16,777,216 locations that would result from a ROM organization with 24 address lines. The implication is that a large number of bits can be examined to derive a microinstruction without suffering the penalty of excessive control storage.

With the power of the Naked Mini's normal set of macroinstructions, little need is expected for specially programmed logic arrays. However, for large-volume applications such special programs can be prepared; and, in fact, the architecture provides for a fourth C chip, which increases the array capacity by a third. Of course, any instruction set change in any computer is likely to play havoc with all existing software for that computer and should be planned carefully.

### Microprogramming?

In the Naked Mini LSI, the programmable logic array is a matrix of transistors where interconnections are made or not made, as determined by a single mask in the semiconductor manufacturing process. These interconnections, which make up the control memory, define its step-by-step operation in the course of executing the various macroinstructions. Accordingly, changing the interconnections changes the macroinstruction set.

Since this is essentially the definition of a microprogram, the Naked Mini might seem to be a microprogrammed minicomputer—and so it is, but in a new way. Classical microprogramming controls a processor that can execute several simple processing steps during a single cycle of the main memory—in machines where the main memory is much slower than the processing circuitry. In MOS computers, this speed disparity does not exist. In fact, a high-performance memory can easily run faster than the central processing unit's basic cycle time. Because the central processor and main memory have similar basic speeds, it is desirable for the



3. The conventional situation. Read-only memory for microprogram exhaustively decodes every input address, without exceptions, and is not capable of ignoring any input combination. Content is  $2^n$  words, for  $n$  inputs.



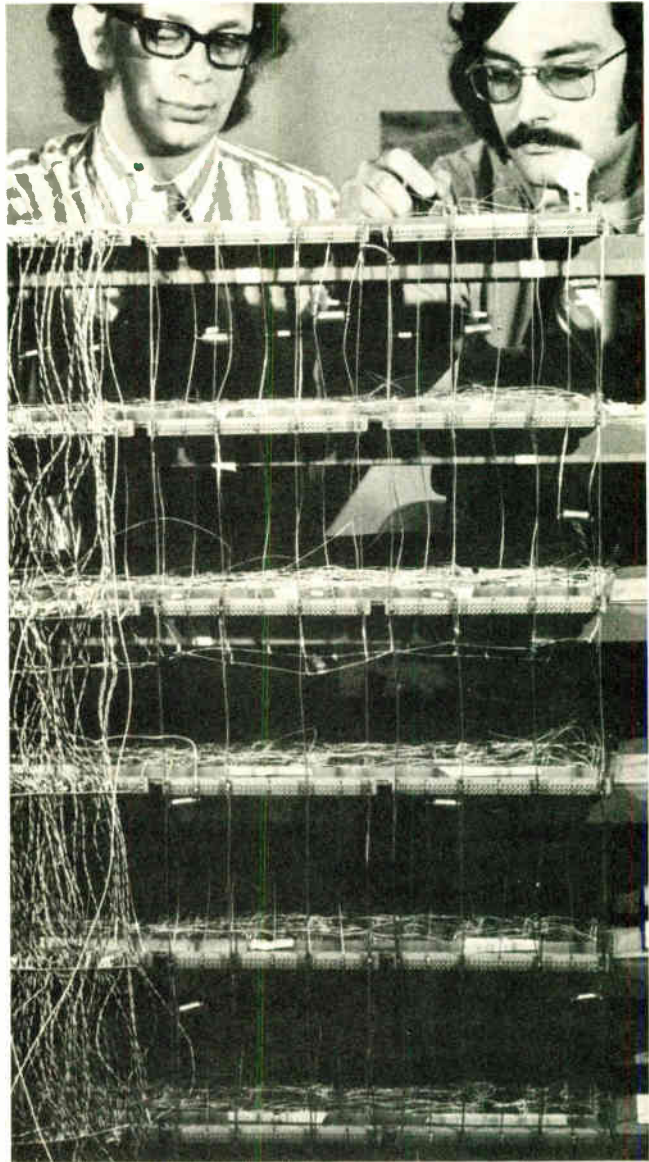
## On the breadboard

Large-scale integration, because it is unforgiving of design errors, calls for a perfectionist approach to system development. Since no jumper wires can be added nor etched conductors cut, even small changes require a wait of several weeks while new masks are made and corrected ICs produced.

Therefore, to ensure that its design was as nearly perfect as possible before any chips were laid out, the complete Naked Mini was built in breadboard form—rather than being simulated in a computer—so that test software could actually be run and real input-output devices connected and tested. Conventional small-scale TTL gates and latches were used, and the entire computer built up from this level as the eventual LSI circuits were built up—bypassing even medium-scale ICs. Four-phase clocking was used in the breadboard model, just as in the finished versions. The speed of the TTL circuits compensated for delays in the long wires used in the breadboard, and D-type flip-flops were inserted where necessary to simulate the capacitive storage that occurs at the gates of MOS circuits.

What eventually became a single MOS chip was constructed on the breadboard as over 225 TTL devices on a separate card 16 by 22½ inches. (Contrast that size with the size of the single pc board in the final version.) Seven of these cards were mounted as separate “shelves” in a rack six feet high, with interconnections through cables running vertically up and down the rear of the rack. The programmable logic arrays were simulated on three special diode boards holding up to 7,000 diodes each. Various auxiliary chassis for memories and optional equipment completed the breadboard model, as shown in the photo at the right.

All diagnostic programs prepared for the older Alpha 16 were run on this breadboard, along with all Alpha 16 peripherals and all system software, including assemblers, operating systems, and Fortran and Basic compilers. Then to eliminate timing and loading problems, the MOS logic was subjected to a computer dynamic analysis—from which the areas of the MOS transistors were optimized for speed and fanout at minimum area.



processor to perform many operations in parallel and avoid the sequential decoding and processing of normal ROM microprogramming to achieve reasonable processing speeds. The programmable logic array is ideal for this application since it allows many inputs to be examined simultaneously and multiple branch decisions to be made without time-consuming microprogram jumps.

### Technology selection is complex

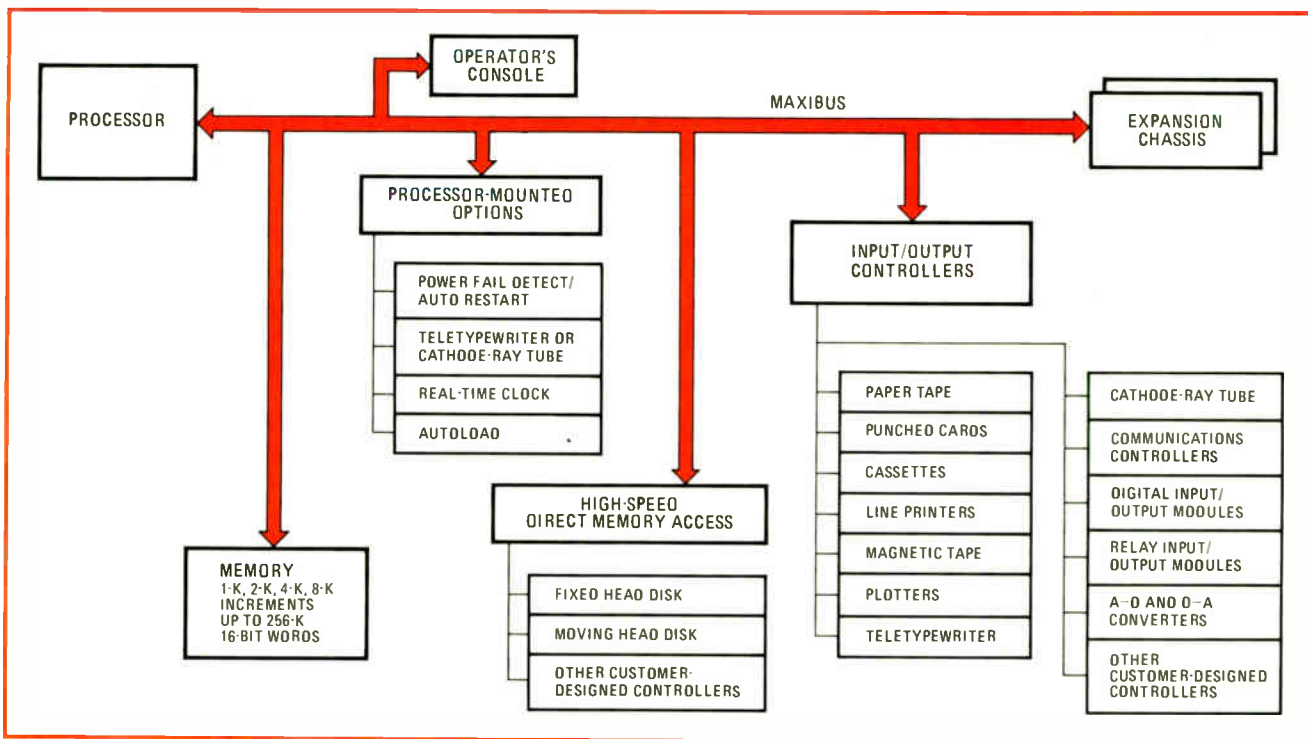
Designers of the Naked Mini LSI anticipated that the circuitry for the P and C chips would be rather more complex than in off-the-shelf MOS LSI products like shift registers, random-access memories, and clocks. They also recognized that as chip size grows linearly, chip cost grows exponentially. Therefore the MOS process that could put all the circuits in the smallest chip was at a big advantage.

The designers ruled out n-channel MOS, despite its su-

perior performance, because they felt that the technology was unproven and lacked a suitable yield history. Standard metal-gate p-channel MOS offers the lowest theoretical cost, but suffers a rather slow circuit speed. Adding an ion-implantation step to a p-channel device would enhance its performance but do little to hold down the size of the chip.

For the random logic on the P chip, which is characteristically interconnection-limited, the silicon-gate p-channel MOS technology seemed to be the best choice, because it provides an extra interconnection level on the chip. It also has a low gate capacitance, providing a definitely better performance than the metal-gate approach.

At first, metal-gate p-channel MOS, perhaps with an ion-implantation step, seemed best for the C chip, because of the large logic array—a non-random logic configuration. But during system design, it proved imprac-



4. **Maxibus.** Processor is connected to input-output devices and memory via this single bus. Bus can handle both addresses and data in parallel. Direct-memory access channel can keep two memory modules going at once, both via single Maxibus.

tical to reconcile the performance disparity between the metal-gate and silicon-gate technologies, so that the C chip was changed to the silicon-gate design.

More or less by accident, therefore, the Naked Mini LSI is faster than was intended. More than 80% of the instructions in it can be executed in from 4.8 to 9.6 microseconds. This is about a third the speed of the original Naked Mini, but for most of the expected new applications it will be more than fast enough.

### The Maxibus

The Naked Mini LSI processor consists of the four P chips, the three C chips, timing logic, and a set of buffers that isolate the processor's MOS circuits from external circuits. These processor components are interconnected with a set of three buses shown in the block diagram (Fig. 1).

Outside the processor, connecting it with input-output and memory devices and the system console, is another bus, called the Maxibus (Fig. 4). It contains four major signal groups: address, data, memory control, and input-output control. Input-output controllers and memory modules share the address and data lines but use separate timing signals.

Transfers of data to and from memory are asynchronous, allowing memory modules of any speed to be used with the Naked Mini LSI, including intermixed modules of different speeds. All memories include both address and data registers and use the Maxibus for only a small proportion of their cycle times. This design allows the processor to operate in parallel with the memory and permits the processor and the direct memory access channel to keep two memory modules running simultaneously. Multiple memory modules can also incorporate odd/even interleaving (all odd ad-

resses in one module, all even addresses in another) to reduce the apparent access time when successive accesses are made to sequential addresses.

The processor and the memories drive the bus with three-state transistor-transistor-logic circuits. This type of logic provides both active pull-down and active pull-up, with a third "off" state that permits many modules or devices to be connected to a common bus driven by one and only one of them at a time [*Electronics*, Sept. 14, 1970, p. 78]. This connection enhances high speed without needing terminating networks on the bus or pull-up resistors on the circuits.

The Naked Mini LSI input-output connections are electrically and physically compatible with previous Computer Automation controllers. They use open-collector drivers rather than the three-state circuits, to achieve this compatibility and to make interface design simpler for the users who design their own special input-output equipment and interfaces. (Among original-equipment manufacturers, the market served by Computer Automation, this is far more common than in the end-user market, where standard general-purpose equipment is usually satisfactory.) Apart from other advantages, the use of open-collector circuits avoids the strict timing requirement needed by three-state logic, in which no two drivers connected to a single bus can be turned on even for a moment without risking destruction.

Electrically, the use of both open-collector and three-state drivers on the same lines on the Maxibus calls for a relatively high-valued pull-up resistor at the processor end of all lines driven by input-output controllers. Passive pull-up on the bus during I/O operations restricts the speed of these lines, yet memory operations on the same bus lines can operate at higher speeds because of

the active pull-up that is provided by the tri-state drivers.

Under direct memory access, any controller on the Maxibus can request the processor to relinquish the bus. When the request has been acknowledged, the controller has access to any memory module on the bus and to other controllers, so that communication between devices is possible. A priority structure is included in direct memory access, permitting any number of controllers to compete for the bus.

### Memory choices

The only logical companion for an MOS processor is an MOS random-access memory—or is it? MOS memories are volatile and at present rather expensive. Volatility (loss of stored data when power turns off) isn't a serious problem in large-scale computers, because the operating system can be reloaded from a magnetic disk or other bulk storage unit when power is restored. But OEM users of low-cost minicomputers usually don't have this bulk storage available and need a battery backup at additional cost. In terms of cost, MOS memory is competitive with ferrite-core memory only in small sizes or high speeds.

Thus, because it is "logical," MOS memory is available on the Naked Mini LSI. But because of these drawbacks, core memory is also available. The former comes in modules of 1,024, 2,048 or 4,096 words and the latter in either 4,096-word or 8,192 word capacities.

All five memory sizes and types are available on the Naked Mini LSI's pc board. The storage medium (core stack or MOS circuits) is contained on a 6½-by-7½-inch pc board that plugs into a connector on the main board carrying the processor and related processor and memory circuits. Additional modules of either core or MOS are available on separate boards.

Another piggy-back connector similar to the one holding the memory is available for an option board that carries teleprinter or CRT display controllers, autoloader logic, or real-time clock, or any combination of these. The real-time clock interrupts the processor at intervals of 100 microseconds, 1 or 10 milliseconds, or twice the ac line frequency, as defined by a jumper on the connector. It can also be driven by an external source as an event counter.

The teleprinter controller operates over a full-duplex line, including a remote motor on-off control, and it can be equipped with the Electronic Industries Association RS-232 standard voltage interface for use with a CRT display.

The autoloader contains a program in a read-only memory for loading a user's program from a teleprinter, a paper-tape reader, a standard nine-track magnetic tape or cassette, or a moving-head disk. It is a complete loading program, capable of working with any of the five sources without modification, loading into any part of the computer's memory as specified from the console, with full error checking—as contrasted with the autoloaders used in most other computers, which first pull in a bare minimum bootstrap loader from the source and then load the user's program into a fixed location without error checking.

The Naked Mini LSI, complete on one card, might be

used, say, in an intelligent terminal—perhaps even within a teleprinter, an application that heretofore has been only a gleam in the eyes of semiconductor prophets. It also has many other applications that it can perform without further expansion.

On the other hand, some applications will require more than the 8,192-word maximum memory capacity of the Naked Mini, or more input-output controllers. Some users may want stand-alone capability, not possible with the Naked Mini. For these applications, the Alpha LSI is available.

In keeping with the basic design goals—low cost and high performance—of the Naked Mini LSI, the Alpha LSI consists of a steel chassis with an integral power supply and five horizontal double-card sockets interconnected via a double-sided pc motherboard, plus system console. The Naked Mini fits into one of these double sockets; the other four can handle additional memory modules, input-output controllers, or other equipment on single or double cards (up to four doubles or eight singles). A wide variety of these options is available.

### The Alpha's console

The Alpha LSI computer includes a console that stays within cost goals consistent with the LSI processor, yet is fully functional and reliable. For example, the switches are flat membrane sandwiches designed as part of the whole minicomputer project, not simply purchased off the shelf. One contact of each switch is plated on the pc card that holds the console logic and displays; an insulating sheet with holes punched at the switch position is placed over these contacts; and a grounded conductive sheet is laid over the insulation. Finally a thin legend sheet is laid over the conductive sheet to label the various switches.

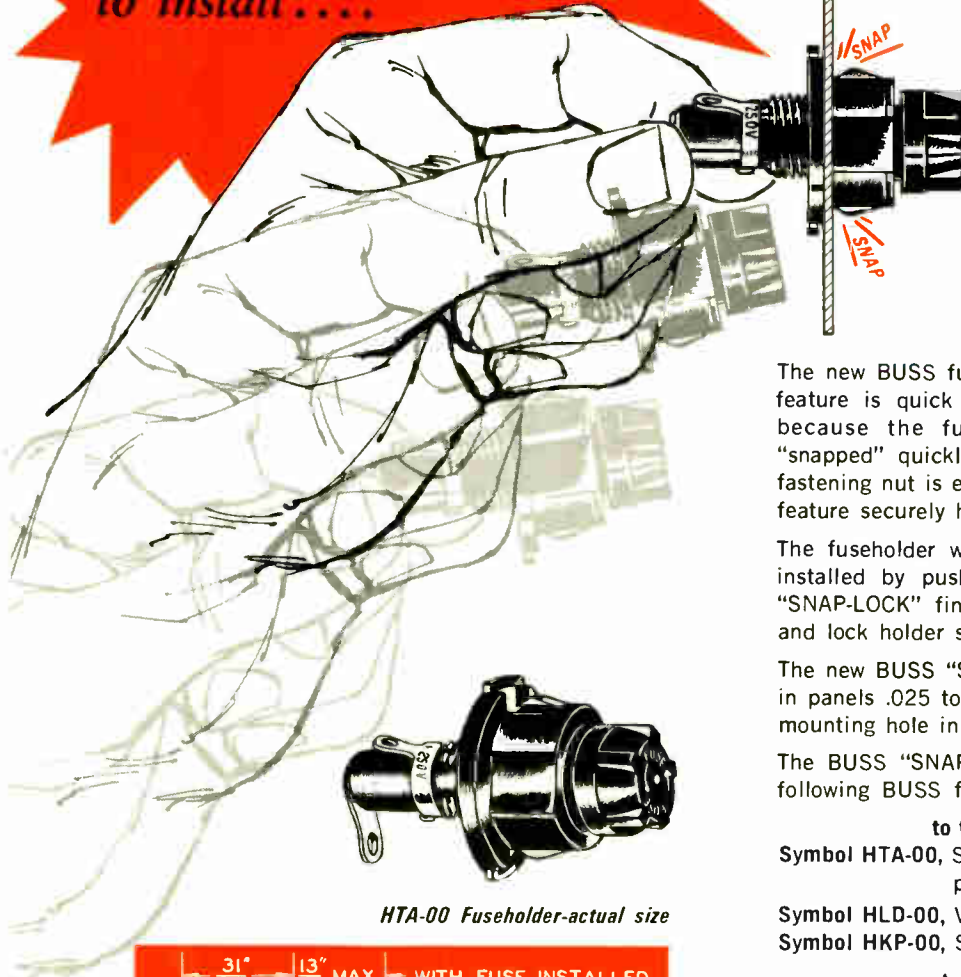
This switch array has no moving parts, is very reliable, and is easy to manufacture. Similar switches are available on the market from various vendors, but none of them could supply a custom configuration at a suitable price in line with the cost goals of the rest of the project. Switch vendors priced switches on a per-contact basis, whereas a per-square-inch price is more appropriate for the membrane approach.

For entering and displaying data, the console has 16 switches and 16 light-emitting diodes, each arranged in four groups of four. The diodes show the contents of a particular word, bit for bit, permitting the programmer to observe individual bits, but the switches enter data in hexadecimal code (base 16 instead of base 10), in accordance with most programmers' preference.

Actuating any one switch enters the corresponding combination of four bits into the four right-most positions of the word, shifting the entire word to the left four places. The entry is into a register associated with the console; when 16 bits have been entered (four hexadecimal digits), the console register contents are transferred either to the computer memory or to internal registers. For this operation the console acts as an input-output device, interrupting the processor and triggering a console service routine in the microprogram of one of the C chips. Data is output to the console in the same way. □

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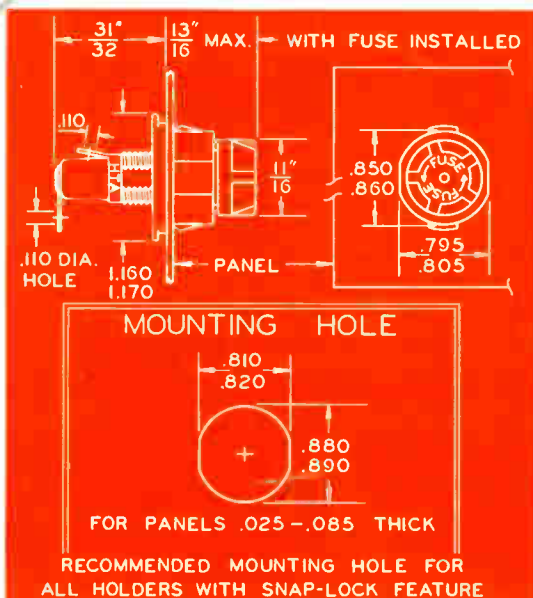
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Among the now familiar features of complementary-MOS ICs are low power consumption, wide power-supply voltage range, temperature stability, and high noise immunity. Another not so obvious advantage of the C-MOS circuit, particularly the basic C-MOS inverter, is

its ability to function with very few external components. This is especially evident when the C-MOS inverter is used as the prime active element in a clock generator. Here are some design ideas that demonstrate the versatility of the C-MOS circuit.

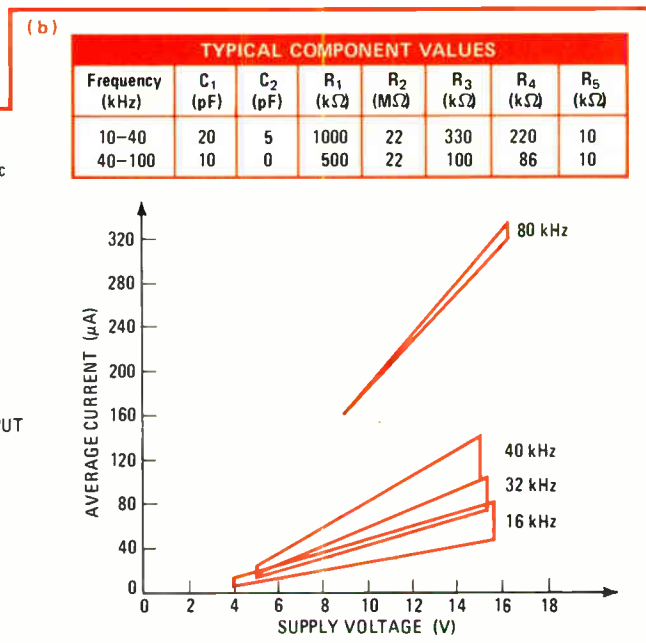
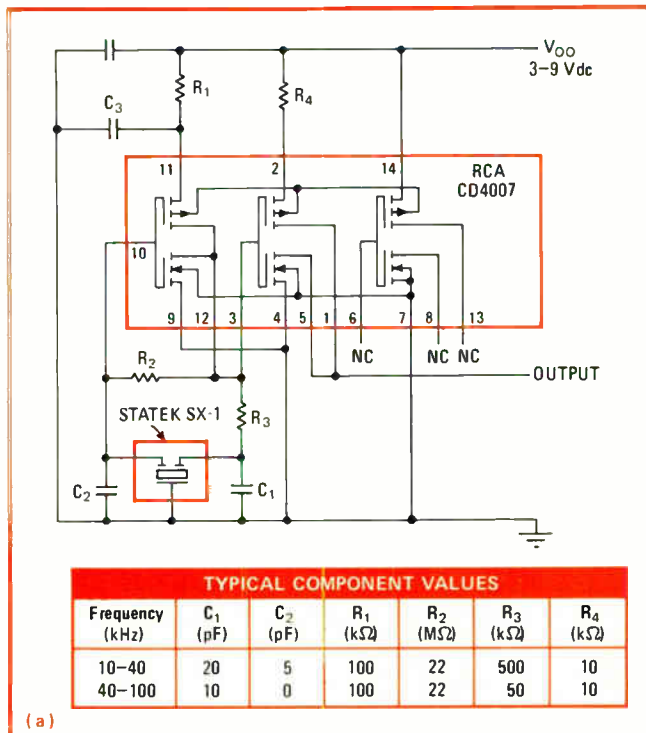
## C-MOS minimizes the size of crystal oscillators

by S.S. Chuang  
Statek Corp., Orange, Calif.

The improved manufacturing technology and dropping costs of crystals, coupled with the advantages of complementary-MOS, are making the crystal-controlled oscillator a better design choice than the less accurate and less stable RC and LC oscillators.

Ultraminiature quartz crystals can now be produced with photolithographic techniques, such as those used for making integrated circuits. This means that these crystals can be manufactured in volume by batch processes at very low cost. They are rugged devices that are shaped like tuning forks, typically measuring 150 to 250 mils long, 25 to 40 mils wide, and 1 mil thick. These crystals are available with operating frequencies as low as 10 kilohertz and are excellent for fabricating hybrid-circuit constructions.

For only a few dollars, a C-MOS crystal oscillator (a), which can be powered from a supply voltage between 3 and 9 volts, can be built. And with the proper component selection, this oscillator will draw as little as 10 microamperes from a 5-v supply. Another low-power os-



**Perfect circuit mates.** Crystals that are manufactured like ICs make ideal companion components for the conventional C-MOS inverter. Resulting low-power crystal oscillator is both small and inexpensive. Supply voltage can be 3 to 9 volts, as in (a), or 9 to 15 V, as in (b).

cillator design (b) can also be built to run from a higher supply voltage, from 9 to 15 v.

In both circuits, a standard C-MOS inverter package is used to make up the oscillator and buffer amplifier sections. Supply voltage  $V_{DD}$  must be sufficiently greater than the sum of the threshold voltages of the n- and p-channel MOSFETs to provide a bias current for the amplifier. This current allows the circuit to develop enough gain to start and maintain oscillation. For either circuit, the driving voltage for the crystal must not exceed 2 v peak to peak. The tables list typical component values for two ranges of operating frequencies.

In oscillator (b), an n-channel MOSFET is used in the oscillator stage as well as the first stage of the buffer amplifier. Complementary MOSFETs form the output stage of the buffer amplifier. The crystal-drive voltage is limited to between 0.6 and 1.4 v. Supply voltage  $V_{DD}$  can be 5 to 15 v for frequencies of 10–60 kHz, and 9 to 15 v for frequencies over 60 kHz. The graph is a plot of the average current drawn by this oscillator for various supply voltages and operating frequencies.

The components in each of the oscillators perform the same functions. Resistor  $R_1$  sets the gain of the amplifier in the oscillator stage, thereby determining the circuit's output voltage and the crystal-drive level. This re-

sistor also reduces the current drain of the over-all circuit. Its value depends on operating frequency and supply voltage.

Resistor  $R_2$  is a biasing resistor, and it must be large enough to avoid affecting the phase of the circuit's feedback network. Resistor  $R_3$  limits the crystal-drive level, while providing a voltage that is large enough to drive the first stage of the buffer amplifier. This resistor also supplies the appropriate phase shift when the crystal "tank" circuit is operated slightly below anti-resonance.

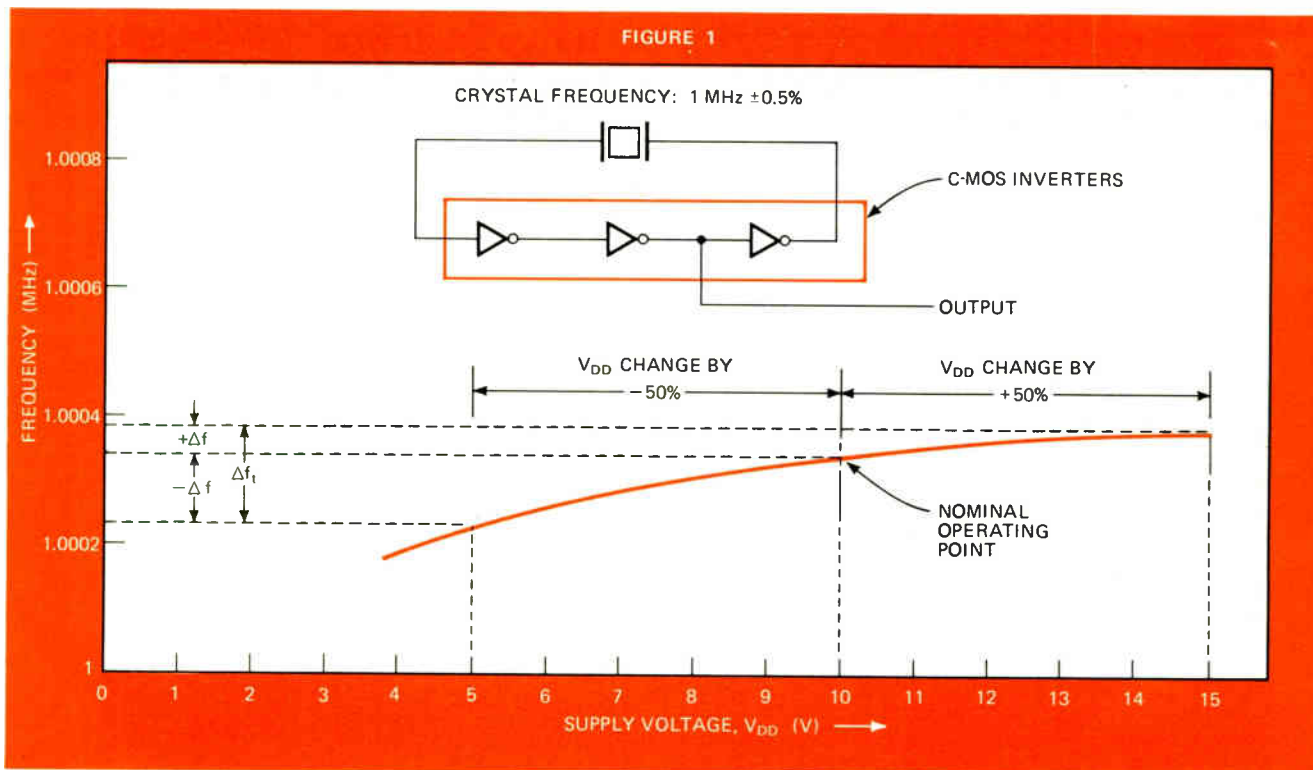
Resistor  $R_4$ , as well as resistor  $R_5$  for oscillator (b), determines the output voltages of the first and second stages of the buffer amplifier, in addition to limiting the current in the buffer amplifier. It must be large enough to allow the amplifier to saturate, yet small enough to give the amplifier sufficient drive capability.

Capacitor  $C_1$  sets the level of the crystal-drive voltage; it also provides the appropriate phase shift in the feedback network. Capacitor  $C_2$  governs the input voltage of the oscillator stage; its value is optimized by trading off frequency stability against gain. The decoupling capacitor,  $C_3$ , is selected, along with resistor  $R_1$ , to give an RC time constant that isolates the circuit from low-frequency noise. In the n-channel design, capacitor  $C_3$  can even be eliminated. □

## C-MOS holds down parts count for digital clocks

by Sukhendu Das  
Bell-Northern Research, Ottawa, Canada

Quartz-crystal clock generators are usually employed only when high frequency stability is required, because the crystal and other close-tolerance components necessary for the circuit are expensive. However, for most digital systems, a clock generator having an over-all frequency accuracy of just 0.1% provides sufficient immunity against changes in supply voltage and temperature.



A two-component crystal oscillator that is ideal for digital systems can be made with an inexpensive crystal—one having a tolerance of 0.1%—and a standard complementary-MOS inverter package. The operating frequency of this simple clock generator can range from 500 kilohertz to 10 megahertz over a supply-voltage range of 5 to 15 volts.

For a nominal supply voltage of 10 v, the oscillator exhibits a frequency change of less than 0.02% for supply variations as high as  $\pm 50\%$ . For a  $\pm 10\%$  change in the supply, the frequency varies less than 0.0015%. The temperature range is  $-50^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ .

The oscillator can easily be constructed as a hybrid circuit by mounting the crystal in the same package as the C-MOS inverter IC. An even better approach is to use the crystal as the substrate for a C-MOS inverter chip.

As shown in Fig. 1, the circuit consists of a crystal, which determines the frequency of oscillation, and three C-MOS inverters. To prevent the formation of an unwanted stable dc state, any resistance between 100 kilohms and 40 megohms may be inserted in the feedback loop. Since each inverter has an inherent delay, its phase shift is not quite  $180^{\circ}$ . This delay, together with that of the crystal's phase-shifting characteristic, can be exploited to realize a stable oscillator that does not need any external capacitor or resistor.

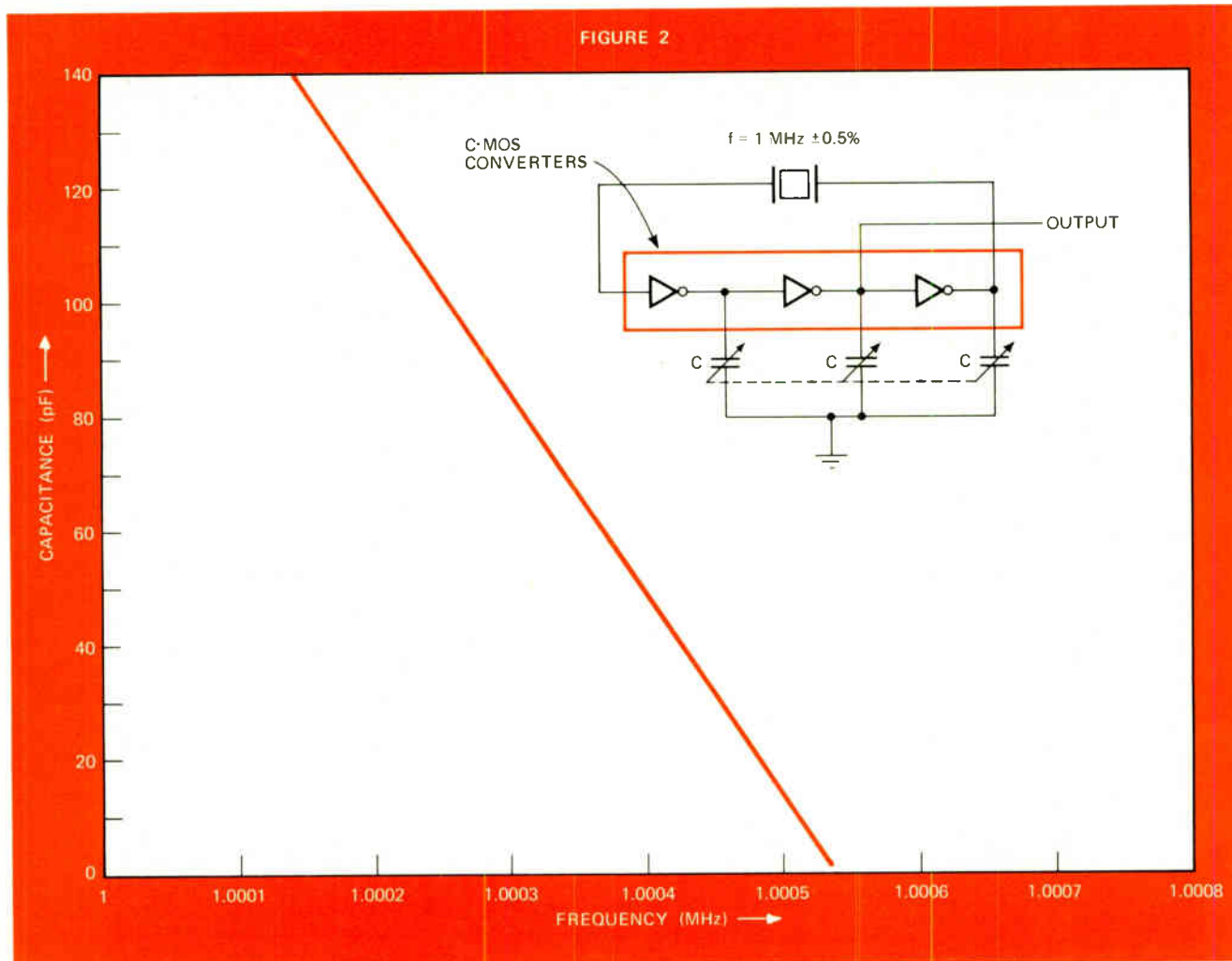
Figure 1 shows how output frequency changes with

supply voltage. If an RCA 4007AE inverter IC is used, the highest stability is obtained when the circuit is operated from a nominal voltage of 10 v for frequencies between 600 kHz and 5 MHz. The nominal voltage should be increased to 13.5 v for frequencies from 5 to 10 MHz. If an RCA TA5987 inverter IC is used instead, the nominal supply voltage can be kept at 10 v.

Figure 2 illustrates how frequency varies when capacitors of equal value are introduced at each of the inverter outputs. This increases the total time delay through each inverter and changes the phase angle for which the crystal has to compensate. The capacitance introduced in this way also acts as a load on each inverter output. (Load capacitance due to worst-case stray capacitance is actually less than 20 pF.)

This two-component oscillator can produce square clock pulses well within an over-all frequency tolerance of 0.05%. Pulse rise and fall times are within 35 nanoseconds, and average power dissipation is 10 milliwatts when the frequency is 1 MHz and the supply is 10 v.

The circuit will function properly as long as the appropriate crystal frequency is selected, along with C-MOS inverters or gates that have the correct propagation delay and sufficient drive capability. The crystal chosen must be damped against overtone and spurious oscillations. If a precise mark-space ratio is needed, the output may be buffered through a simple trigger flip-flop. □



# Generating pulses with C-MOS flip-flops

by F.J. Marlowe and J.P. Hasili  
RCA Laboratories, Princeton, N.J.

A complementary-MOS D-type flip-flop and just a single external resistor and capacitor form a handy edge-triggered one-shot. What's more, two of these one-shots will form a simple gated oscillator when they are cross-coupled and a NOR gate is inserted in the feedback path.

The C-MOS flip-flop uses little power and can operate from a wide range of power-supply voltages (3 to 15 volts). In addition, because of its high MOS input impedance, the flip-flop allows very large resistance and capacitance values to be used. For instance, a gated oscillator circuit containing 1-megohm resistors and 500-picofarad capacitors will have an output period of 20 minutes.

In the one-shot circuit of (a), a positive transition on the clock input switches the Q output from low to high, which in turn charges capacitor C through resistor R. When capacitor voltage,  $V_C$ , reaches the flip-flop threshold for direct reset, the Q output returns to the low state independently of the clock level, and capacitor C discharges through resistor R.

The circuit works well for a wide range of resistance

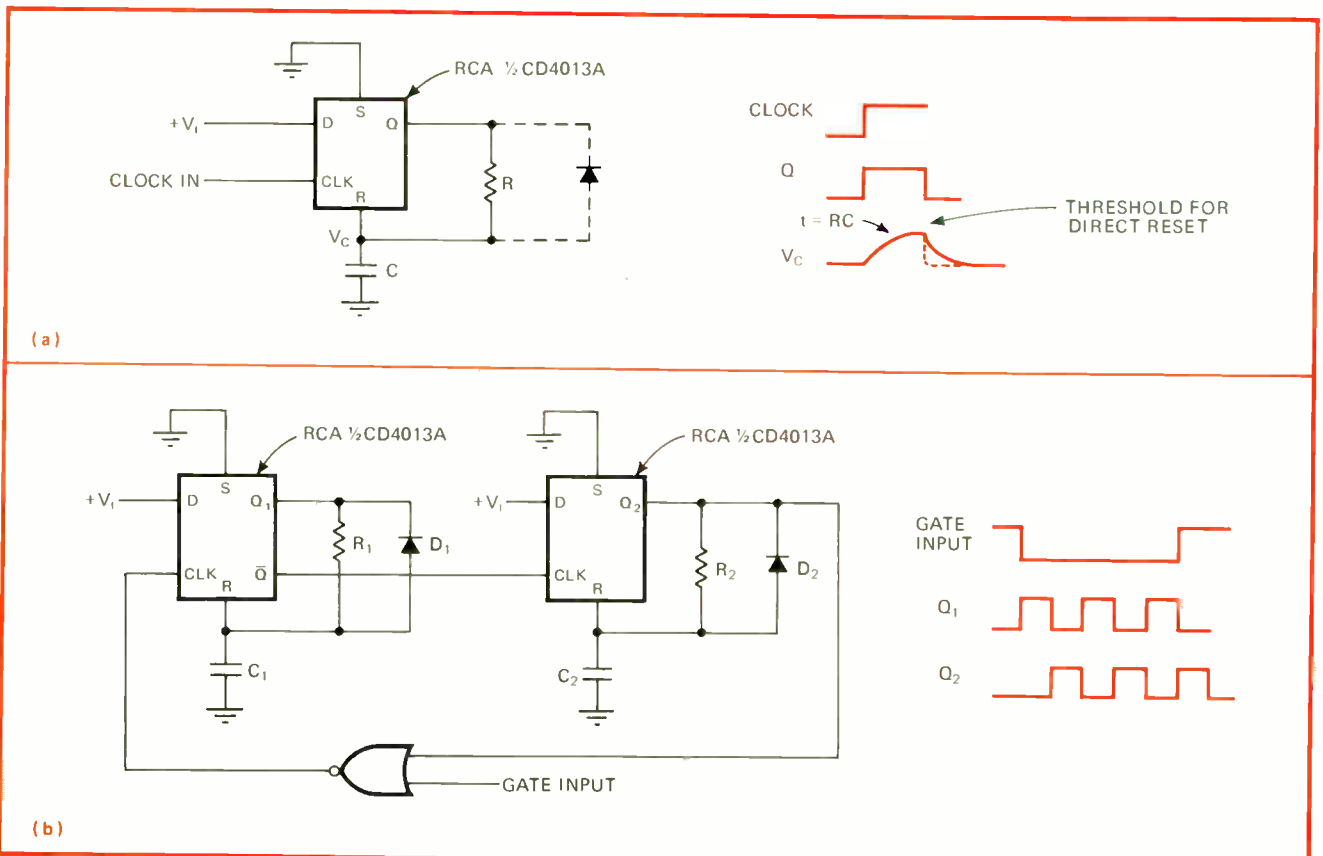
and capacitance values, but if resistor R is less than 4 kilohms, the Q output amplitude and rise time may be badly degraded by the flip-flop's output impedance, which is about 400 ohms. As a refinement, a diode can be placed across resistor R to speed up the recovery time of the capacitor discharge (the dashed line in the plot of capacitor voltage  $V_C$ ). This speed up in recovery time is important—if a positive clock transition occurs before the capacitor is fully discharged, the next one-shot pulse interval will be shorter than it should be.

By cross-coupling two of these one-shots, a convenient two-phase oscillator with complementary outputs can be made with only a single dual flip-flop package. The oscillator's output duty cycle can be varied by using different RC time constants for each one-shot.

Furthermore, placing a NOR gate in the feedback path, as shown in (b), permits the oscillator to be gated. When the gate input goes low, the oscillator is started with the same phase each time. When the gate input returns to its high state, the oscillator completes the cycle and then stops. Additional gating can also be provided through the data (D) inputs or the direct set (S) inputs. Diodes  $D_1$  and  $D_2$  fully discharge capacitors  $C_1$  and  $C_2$  after each half cycle, so that the oscillator's first few cycles will last no longer than its steady-state cycles.

Since the charging rate of the capacitors in these circuits depends on the voltage of the power supply, timing stability and accuracy are functions of power-supply regulation. □

Engineer's Notebook is a regular feature in Electronics. We invite readers to submit original design applications and measurement ideas. We'll pay \$50 for each item published.



**Pulse generators.** Lone C-MOS D-type flip-flop (a) requires only two external parts to produce single pulses. Cross-coupled flip-flops and NOR gate (b) make gated oscillator having adjustable duty cycle. Time constants can be long because of flip-flop's high input impedance.



# Engineer's newsletter

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## Glass-silicon diodes have class

Builders of tuning circuits might check out a new class of semiconductors made from glassy materials that Innotech Corp. of Norwalk, Conn. is developing. It has already built **variable-capacitance diodes with heterojunctions in glass-silicon semiconductor**. Unlike all-silicon-junction diodes, these devices can easily achieve capacitances in excess of 3,000 picofarads. Their tuning ranges are better than 15:1 at operating frequencies as high as 100 megahertz, so that **one diode could tune through the whole a-m audio range**.

Besides responding to changes in voltage, such a diode can also be made sensitive to light. When used with a light source, it forms a photozener that is free of leakage current and exhibits an extremely sharp switching characteristic.

## Linear circuits can make use of MOS

Many of the new IC designs for chopper-stabilized op amps make use of MOS linear gain blocks instead of the more conventional bipolar amplifiers in portions of their circuits. That's **an idea that could catch on for more general linear-circuit design**. The input structure of an MOS device needs almost no input bias current so that the gain comes practically for free. True, MOS amplifiers offer small gains compared to bipolar devices, and they are too noisy to cascade. Combining MOS on the input with bipolar on the output would be the perfect answer, but that means making the two processes compatible on the same chip, an exercise that's under intense investigation at many semiconductor laboratories today.

## The noise DVMs cannot suppress

One advantage of integrating-type digital voltmeters, such as the dual-slope units, is their ability to suppress power-line noise. But since perfect suppression is obtained only at one frequency and power-line frequencies are not completely stable, the question arises: how much short-term fluctuation is on a power line, and what is its effect on the normal-mode rejection? The answer, according to Hewlett-Packard's Application Note 158, "Selecting the right DVM," is that **short-term fluctuations of up to  $\pm 0.15\%$  can be expected from a nominal 60-hertz line in North America, causing a normal-mode rejection of 56 decibels**.

## Finding a filter's center frequency

**To find the center frequency of a low-Q filter, it's better to measure the circuit's phase shift** than its amplitude response. Phase angle changes rapidly with frequency in the vicinity of resonance, but amplitude changes may well prove unmeasurable for small frequency deviations. For  $Q = 2$ , for example, a 5% change in frequency causes an amplitude change of less than 0.01 decibel, while the phase shift is almost  $3^\circ$ .

## A vital new connection

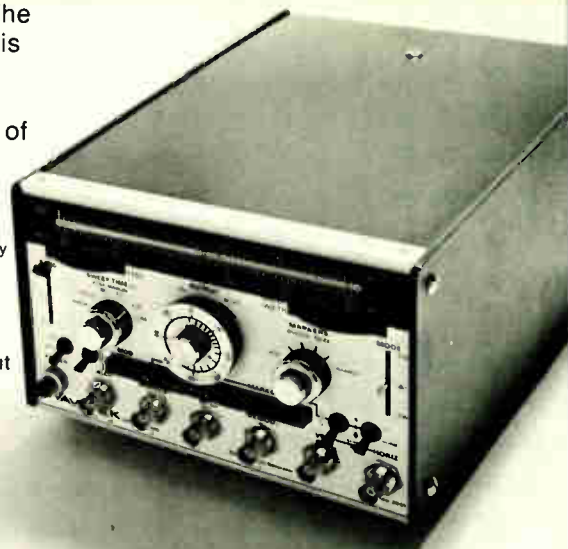
If you need a matched-impedance connector for equipment that operates at frequencies up to 6 gigahertz and can't afford a BNC or SMB type, you'll be interested in the ALC-5 series of subminiature coaxial connectors from Amphenol's RF division in Danbury, Conn. A push-on version is now available, and snap-on types will be announced soon.

The boxes may seem quite similar. The specifications can appear identical. But when it comes to performance, as seen on a screen, the picture suddenly changes.\* Because that's where the Wavetek 2001 shows its class. The width of its crystal-controlled markers is adjustable for wide- or narrow-band operation and the

amplitude is always the same. The equal spacing between markers is an indication of the RF output linearity. The kind of output you need for precise work. The kind of output most people will gladly pay \$1,695 to get.

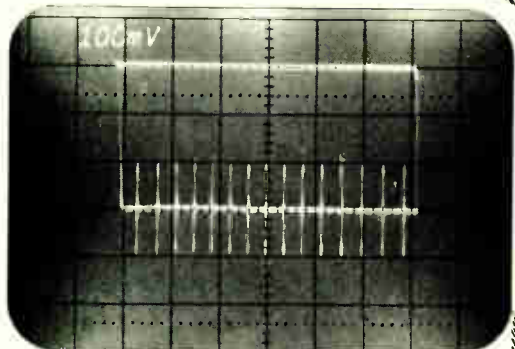
\*Measurement conditions for both units were the same: 10 MHz harmonic markers measured directly at the RF output connector using an HP Model 423A detector.

1 MHz to 1.4 GHz freq. range  
+10dBm to -80 dBm calibrated output  
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Plug-in markers accurate to .005%

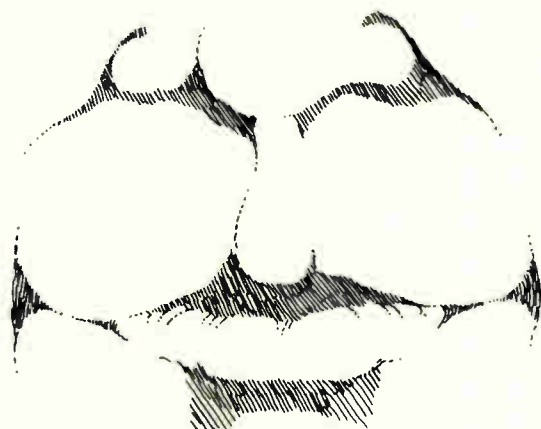
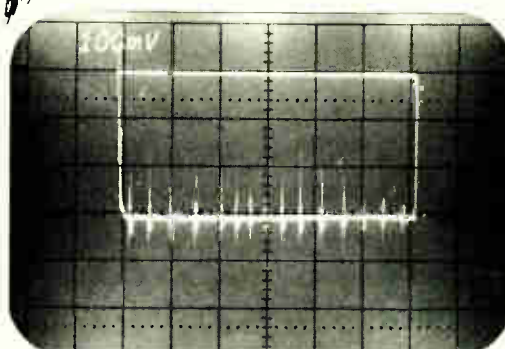


## Anyone who thinks sweep generators look alike must not be an oscilloscope.

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## Chopper-stabilized op amp fits in DIP

Two chips—one MOS and one bipolar—are built into single package; device provides 130-dB gain, 25-V/ $\mu$ s slew rate; holds drift to 0.6  $\mu$ V/ $^{\circ}$ C

by Laurence Altman, Solid State Editor

Makers of integrated-circuit operational amplifiers have for years been trying to build a device that will give both low input characteristics (for accuracy) and high electrical output values (for good performance). That has led either to chopper-stabilized units built in bulky modules or to arrays of discrete devices that are expensive for the user of the equipment to assemble.

But Texas Instruments Incorporated has now optimized input and output parameters in a single chopper-stabilized device that is housed in a standard 14-pin dual in-line package. The SN62/72088 consists of two monolithic circuits mounted in a single package—a bipolar chip measuring 75 by 90 mils, and a p-channel MOS chip that is 73 by 108 mils. (Harris Semiconductor is in the final stages of developing a single-chip chopper-stabilized op amp [*Electronics*, Oct. 9, 1972, p. 35].

The performance of TI's new 088 makes it one of the best general-purpose IC op amps on the market today. "With its high slew rate of 25 volts per microsecond and low input current of 5 nanoamperes, the 088 is competitive in performance with the best junction-FET-input IC units available," says Mike Callahan, a design specialist in TI's linear devices group.

**For high accuracy.** Where the 088 pulls away from the JFET devices is in its extremely low input offset voltage. This value—0.075 millivolt—makes the new device at least two orders of magnitude better than the JFET units for such applications as analog-to-digital converters, sample-and-hold circuits, transducer

amplifiers, bridge amplifiers, and wherever else high accuracy is required.

A comparison of the 088 device with other types of op amp that are popular is shown below. For general-purpose applications, the relevant parameters of slew rate, input current, and input offset voltage comprise a figure of merit, defined as slew rate divided by input current times offset voltage. Using this formula, the 088 achieves a figure of merit of 66.7, almost 50 times higher than its closest competitor on the market.

**Complex circuit.** Because of the chopper-stabilized feature of the 088, its circuit is more complex than is normally encountered in op amps, but the offset voltage drift is a very low 0.6  $\mu$ V/ $^{\circ}$ C.

Of its two chips, one contains all of the circuit's bipolar devices: the JFET input stages, and two amplifiers. One of the amplifiers has three gain stages, the first of which has very low gain so as to reflect a minimum Miller-effect capacitance to the input, and the second and third

of which have high gain so that the over-all gain is about 100 dB at dc. The second amplifier, which has one high-gain stage, is used as a low-pass integrator as well as to control a differential current source that knows the offset voltage of the first amplifier. Thus, the second amplifier is responsible for the 088's impressive offset voltage characteristics.

**Five analog switches.** The second chip contains the MOS logic and linear amplifiers. Included are a clock generator, flip-flop dividers, decoding and analog-switch drivers, and five analog switches for the chopper, demodulation, and sample-and-hold circuits.

The SN62088 is specified for operation from  $-25^{\circ}$  to  $85^{\circ}$  C, and the second version, the 72088, for 0 to  $70^{\circ}$  C. Delivery time for evaluation quantities is eight weeks. Prices in quantities of 25 to 99 are \$120.75 each for the SN62 type, and \$69.80 for the 72088.

Texas Instruments Incorporated, Inquiry Answering Service, P.O. Box 5012, M/S 308, Dallas, Texas [338]

COMPARISON OF OP AMPS

Device	Unity-gain slew rate (V/ $\mu$ s, typical)	Input current (nA, max)	Input offset voltage (mV, max)	Figure of merit (nA x ns)
741	0.5	500	5	0.0002
101A	0.5	75	2	0.00333
108A	0.1	2	0.5	0.1
725A	0.005	75	0.5	0.000133
770	2.5	15	4	0.04166
531	30	500	5	0.012
740	6	0.2	20	1.5
8007	6	0.2	20	1.5
118	70	250	4	0.07
088	25	5	0.075	66.7

All specifications at  $25^{\circ}$ C.



Packaging & production

## Scanner spots failure modes

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Infrared thermal imaging system has high resolution for screening pc boards

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With a thermal resolution of  $0.05^{\circ}\text{C}$ , an infrared imaging system developed by Dynarad Inc., Norwood, Mass., is said to provide exceptional precision for searching-out "hot spots" and failure modes in a variety of applications including the screening of circuit boards.

The system, called the model 810, includes a digital readout and variable fields of view and display modes.

Eugene L. Zuch, marketing engineer at Dynarad, says the thermal resolution is due to a combination of state-of-the-art electronics and use of a mercury-cadmium-telluride photodetector that is cooled to liquid-nitrogen temperature to give the proper spectral response and sensitivity. To assure stable operation and correct, linearized output, the signal is referenced to a black-body source once during each scan line.

Field of view is variable in  $5^{\circ}$  steps from  $10^{\circ}$  by  $10^{\circ}$  to  $25^{\circ}$  by  $25^{\circ}$ , controlled by a switch. "With the 810, you can be up close and still get a wide-angle view," says Zuch. The camera head can rotate from  $0^{\circ}$  to  $90^{\circ}$ , and the focus is motorized.

For high thermal resolution, the scan rate in the new model is 60 lines per second. Frame time is selectable from 1 to 16 seconds per frame, resulting in thermal pictures of 50 to 800 lines. Instantaneous field of view is 1.7 milliradians.

The 810 can cover a range of  $-50^{\circ}$  to  $450^{\circ}\text{C}$ , or  $0^{\circ}$  to  $500^{\circ}\text{C}$ , and the difference-temperature range is from  $1^{\circ}$  to  $200^{\circ}\text{C}$ . A calibrated gray scale and a temperature-range indicator are to the left of the 3-by-3-inch display.

The system has three basic display modes and five video display

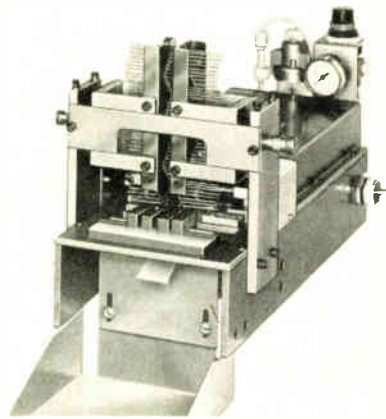
functions. Display modes include normal (unprocessed analog signal), contours (bright constant-temperature lines), and line scan, which displays temperature vs position. The thermal image can be video-recorded and played back over the system, since—like the standard TV recorder—the unit has a 60-cycle scan rate. Price of the 810 is \$24,800, and delivery time is 60 days.

Dynarad Inc., 1416-20 Providence Highway, Norwood, Mass. 02062 [391]

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## Preformer processes axial-lead components

With adjustable speeds of up to 1,500 components per hour, an automatic preforming machine processes axial-lead components of any size. The model ZZ3 unit offers an adjustable chute and adjustable



dies, and forms and cuts the component into its final configuration, making it ready for wave-soldering. The machine is air-operated.

Manix Manufacturing, Box 65, 925 Pennsylvania Blvd., Feasterville, Pa. 19047 [395]

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## Laser scriber permits speeds to 6 inches a second

Designed for line scribing of ceramic substrates, a laser scriber designated the 340 operates at speeds from 4 to 6 inches per second. The system uses a pulsed  $\text{CO}_2$  laser and can cut or drill a wide variety of dielectric materials. Scribing can be up to 40 mils thick, and laser pulses

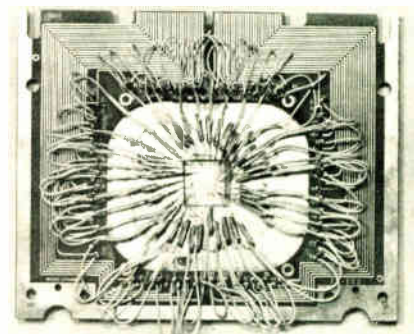
are synchronized with the table movement so that the scoring mechanism is independent of the work table's speed. Price is \$27,900.

Apollo Lasers Inc., 6357 Arizona Circle, Los Angeles, Calif. 90045 [394]

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## Kelvin blade probes hybrid circuits

A true Kelvin blade is designed to probe thin- and thick-film and hybrid circuits. The photo shows a probe card using two 3-mil-thick,



hardened, heat-treated, gold-plated blades separated by 0.5 mil of dielectric. Kelvin blades are desirable when testing low-resistance circuits, 100 ohms or less. Use of the probe eliminates the need for two separate probes and two separate alignment operations, and it is useful in laser-trimming of resistors. Price is based on number of probes and circuit type.

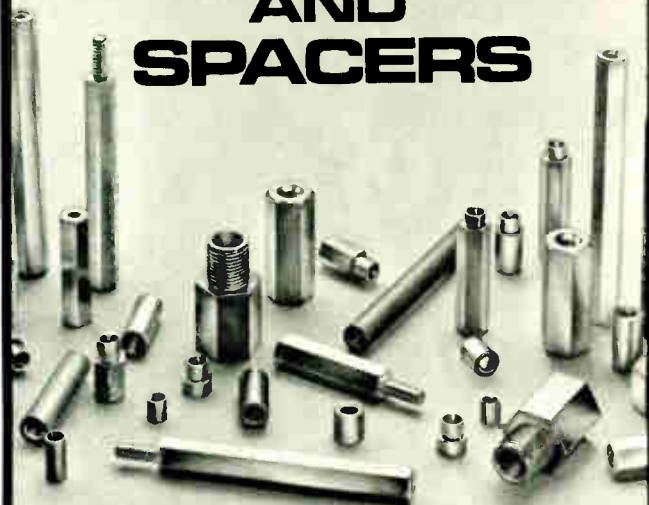
Microdynamics, 9855 Dupree, S. El Monte, Calif. 91733 [397]

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## Machine places 500 chips per hour on substrates

A production machine designed to place microelectronic chips on substrates previously screened with epoxies or gold pastes is called the model CP222. Suitable for use with LSI, MOS, diodes, transistors, LEDs, chip capacitors or resistors, and for multiple-chip placement in hybrids, the machine mounts 400 to 500 chips per hour. Features include micrometer adjustments on X and Y axes, magnetic stop and lock on the slide table, adjustable die column,

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Total Error (Max) With Trim	—	2%	—	0.1%
Without Trim	1%	—	1%	0.2%
Slew Rate	25V/ $\mu$ sec	25V/ $\mu$ sec	25V/ $\mu$ sec	0.3V/ $\mu$ sec
Bandwidth	1 MHz	1 MHz	1 MHz	7 KHz
Package	TO-100	TO-100	module	module
Price, 1-24	\$39.00	\$22.50	\$45.00	\$129.00

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$\pm 15\text{VDC}$ DUAL SUPPLIES	RATED OUTPUT Current (min.)	REGULATION No load to full load (max.)	PRICE (1-9)
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551	$\pm 50\text{mA}$	$\pm 0.05\%$	\$37.00
552	$\pm 100\text{mA}$	$\pm 0.05\%$	\$49.00
553	$\pm 200\text{mA}$	$\pm 0.05\%$	\$69.00

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560	250mA	$\pm 0.1\%$	\$39.00
561	500mA	$\pm 0.1\%$	\$47.00
562	1.00A	$\pm 0.1\%$	\$67.00

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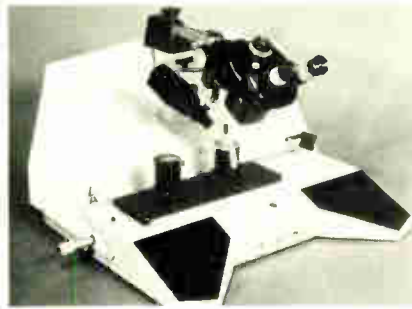


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## New products



and adjustable pick-up arm. Price is \$1,700 plus \$440 for optics and illuminator.

Laurier Associates Inc., 550 Newtown Rd., Littleton, Mass. 01460 [393]

Modular terminals are for control, command circuits

A line of modular terminals for high-density wiring applications are particularly aimed at uses in control



and command circuits. The units are rated at 300 volts and 27 amperes. Each terminal can be snapped on and off a prepunched rail individually, without disturbing its neighbors. Density is 50 units per foot rail. The terminals require no connections, and all live parts are protected.

Hathaway Industries Inc., Box 45381, Southeast Sta., Tulsa, Oklahoma 74145 [396]

Thermocouple connector meets 1,000°F ambients

Applications with ambient temperatures to a continuous level of 850 F and an intermittent level of 1,000 F are met by a thermocouple connector made of silicone reinforced with glass fiber. The connector will not crack when dropped, and its combination of impact strength and temperature resistance makes it suitable for use in demanding applications



in power plants, engine test stands, and so forth. The units may be stacked.

Thermo Electric, Saddle Brook, N.J. 07662 [398]

DIP sockets offer easy insertion

A line of 14- and 16-pin dual in-line sockets incorporates a tapered entry way for simplified automatic or manual insertion. The wide, chamfered entry accommodates slightly bent or misaligned component pins and guides them to strong gold-plated beryllium-copper contacts. The sockets accommodate either 0.010-by-0.020-inch rectangular leads or round leads up to 0.024 in. in diameter. The sockets are 0.150 in. high. Price in lots of 1,000 is 34 cents each for the 14-pin version and 37 cents for the 16-pin type.

Vector Electronics Co., 12460 Gladstone Ave., Sylmar, Calif. 91342 [399]

Test points, jacks built for high-density circuits

A line of test jacks and test points is for use in high-density electronics assemblies where test readings are desirable or necessary at selected circuit spots. Many of the miniature



points can be used with flexible circuitry, and they can also be used as receptacles for jack-in connections between components or chassis.

Sealectro Corp., Circuits Hardware Div., Maroneck, N.Y. 10543 [400]

Semiconductors

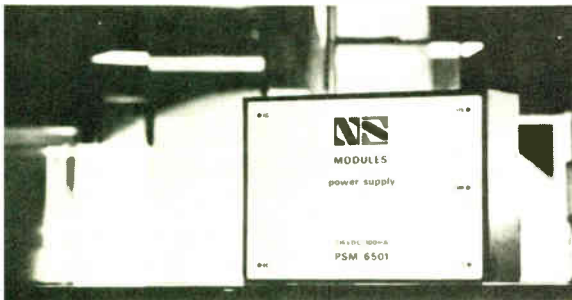
## IC firm enters module market

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National's first is a 100-milliampere supply for operational amplifiers

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While integrated circuits have cut deeply into such analog module markets as FET-input amplifiers and high-speed buffers, modular power supplies contain transformers and have remained the province of mod-



ule makers. But that too will change soon when National Semiconductor Corp., Santa Clara, Calif., goes into the modules business, using its own semiconductor products to undercut the established price structure by about 25%.

National's first module is a dual-output, 100-milliampere power supply for operational amplifiers. According to Dean L. Coleman, National's hybrid IC marketing manager, this module will likely be followed by a 1-ampere bipolar-logic supply, an MOS supply with a 300-mA output at 5 volts and a 100-mA output at -12 v, and a MOS supply that converts +5 v dc to -12 v at 100 mA.

Coleman has pegged the op-amp supply's price at \$35 in small quantities, and at \$29.95 in lots of 100 to 999 units. Presently, 100-mA supplies sell for about \$49.

The price cut is primarily due to the use of monolithic voltage regulators, with output levels fixed by circuitry on the chip rather than by discrete components. Two of them—

one with a 15-v output at a minimum of 100 mA dc, and the other a -15-v, 100-mA type (LM 320 and LM 340)—comprise most of the op-amp supply. They are assembled with a small ac transformer, a diode rectifier, and filter capacitors on a printed circuit that goes into a standard module package measuring 2.5 by 3.5 by 1.25 inches.

Ironically, when the fixed-output regulators went into production last winter, National tried first to get the major module manufacturers to buy them. "We argued they would cut costs and improve reliability," Coleman recalled, "but the module companies said the ICs were not as cheap as cordwood designs." Cordwood refers to a type of assembly, made primarily with axial-lead components, that resembles a miniature stack of firelogs.

Like most recently developed monolithic regulators, the National devices have protective features not usually found in assembled regulators. Chip elements monitor operating temperature and output voltage and current, preventing thermal runaway and keeping the supply in a safe operating area. The outputs are also protected against system shorts, like conventional regulators.

In other respects, National's op-amp supply is a plug-in replacement for Analog Devices' 902 supply and nine similar modules manufactured by other companies. It is called the PSM6501.

Says Coleman, "We can make a profit at \$35 because we don't have to mark up the diodes and regulators—we make them."

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051

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Tuning diodes are for uhf, vhf applications

A series of five silicon voltage-variable-capacitance tuning diodes are designated the TIV21, 22 and 23 for uhf applications and the TIV24 and 25 for vhf applications. Total capacitance at 25 volts is 2.5 picofarads for the 21, 2.8 pF for the 22 and 23, 7.5 pF for the 24, and 6.5 pF for

the 25. Reverse voltage and reverse current for each device are 30 volts and 100 nanoamperes, respectively. Price ranges from \$1.20 to \$1.55 in quantities of 100 to 999.

Texas Instruments Incorporated, Box 5012, M/S 308, Dallas, Texas 75222 [351]

---

Power transistor delivers 60 watts of rf power

A broadband linear power transistor delivers 60 watts of radio frequency power from a 28-volt supply. The model C2M60-28 can be operated class A, AB, B, or C. The unit covers the range of 225 to 400 megahertz and can be used for military applications. Guaranteed to withstand infinite VSWR at all phase angles when operated at 400 MHz and 60 W, the unit offers single-chip construction in a ceramic stripline package. Price is \$103 in quantities of 100 to 499 and \$125 for 1 to 99.

Communications Transistor Corp., 301 Industrial Way, San Carlos, Calif. 94070 [413]

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Op-amp flip-chips eliminate wire, beam-lead bonds

The MCCF series of linear flip-chip operational amplifiers offers single-step mechanical and electrical attachment but does not require use of bonding equipment since the design does without wire bonds and beam-lead bonders. The chips can instead be simultaneously attached by a reflow-solder operation. This feature also eliminates the need to subject an entire hybrid assembly to possible damage by die-bonding temperatures. Price for 100- to 900-lots ranges from \$1.25 to \$4.

Motorola Semiconductor Products Inc., Box 20912, Phoenix, Ariz. 85036 [414]

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Amplifier puts out 6 watts at 14.4 volts

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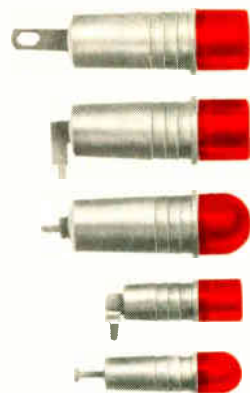
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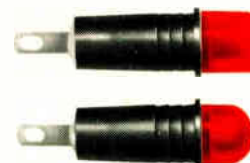
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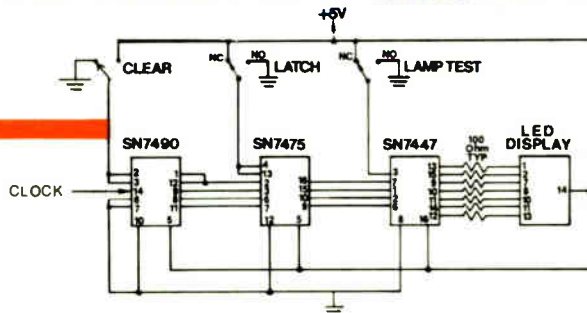
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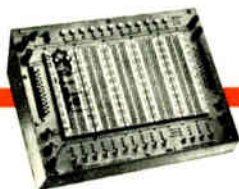


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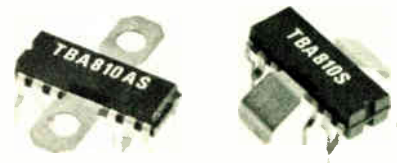
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## New products

which voltage there is protection against short circuit and accidental overload. Typical applications of the device, which operates with supply voltages from 4 to 20 v, are in car radios with 3.2- or 4-ohm speakers; ship-to-shore radios; and any other application where high power



output, low operating voltage and low idle current are required. The TBA810S is supplied in a 12-lead quad in-line plastic package with external cooling tabs to fit printed-circuit boards. Price is \$4.50 in quantities of 1 to 99.

SGS-Ates Semiconductor Corp., 435 Newtonville Ave., Newtonville, Mass. 02160 [415]

## Decoder-driver designed for LED displays

A monolithic TTL medium-scale integrated circuit is specifically designed to decode and drive LED seven-segment displays directly without external components. The device is designated the 9368 and is for use with the company's FND-79 1/4-inch displays and is also compatible with other common-cathode LED digits. The unit includes a high-speed 4-bit latch for storing input data, a 1-of-16 decoder, a seven-segment encoder, and output components that source 19 mA of current at 1.6 V. Price in lots of 100 to 999 is \$2.90.

Fairchild Camera and Instrument Corp., Semiconductor Components Group, 464 Ellis St., Mountain View, Calif. 94040 [419]

## Microminiature zeners conserve pc-board space

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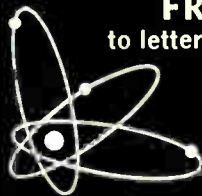
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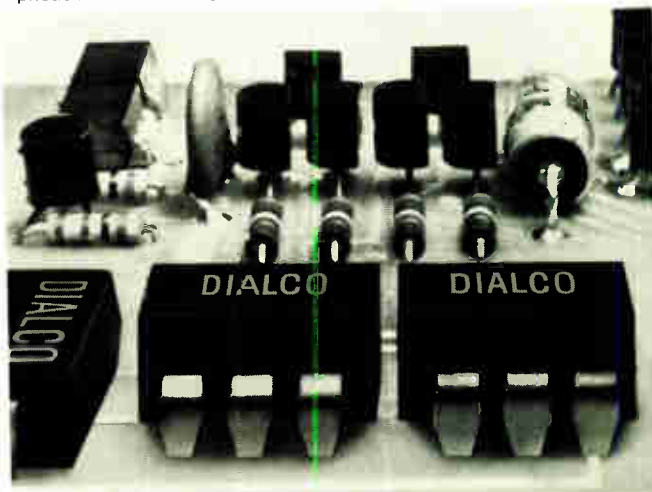
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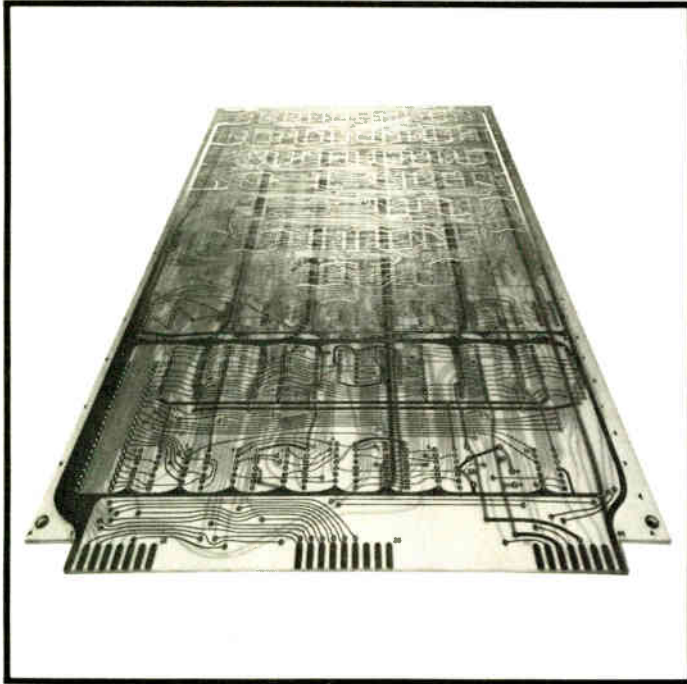


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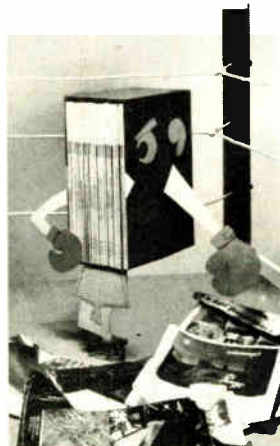
Please send me:  boxes @ \$4.25 each;  
 3 boxes @ \$12.00;  6 boxes @ \$22.00

My check or money order is enclosed.

Name \_\_\_\_\_

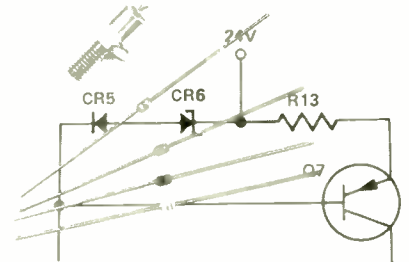
Address \_\_\_\_\_

City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_



## New products

a package smaller than most ¼-w devices. The units measure 0.155 in. long and 0.085 in. in diameter and use a triple-passivated voidless construction. Reverse-current limits can be specified as low as 25 nA at 70% of zener voltage. Price of the zeners



ranges from 70 cents each to \$1.40 in quantities of 100. Delivery is from stock.

Microsemiconductor Corp., 2830 S. Fairview St., Santa Ana, Calif. 92704 [416]

## Bus-line driver/receiver

is for party-line operations

A combination bus-line driver and receiver is designed for high-speed party-line operations. The Am26S12 and Am26S12A transceivers, built with Schottky-clamped transistors, offer driver current-sinking capability of 100 milliamperes at a maximum of 0.8 volt. The current sink capability of the drivers, coupled with high input impedance of the receivers, allows as many as 200 devices to be connected to a 100-ohm double-terminated bus line. Price ranges from \$1.95 to \$6.40 in 100-quantities, depending on temperature range and packaging.

Advanced Micro Devices Inc., 901 Thompson Pl, Sunnyvale, Calif. 94086 [418]

## Monolithic multiplier-divider

needs no external trimming

A monolithic multiplier-divider provides a guaranteed maximum multiplying error of 1% and a ±10-v output swing without the need for external trimming resistors or an output operational amplifier. Designated the AD532, the device, whose

- Q.1 Who just slashed RTV adhesive/sealant prices?  
 Q.2 Is there an easy way to improve TV reception?  
 Q.3 How can I cut prototype mold costs by 25%?  
 Q.4 What's a practical way to protect delicate parts from shock?

**A1** GE did. By as much as 12%. Which means you can now use one-part RTV silicone engineering grade adhesive/sealants without paying a premium. So why compromise? Specify GE RTV-102 (white), 103 (black), 108 (clear) or 109 (metallic). And you'll meet industry, government, UL and food-grade requirements. Circle Reader Service No. 91.



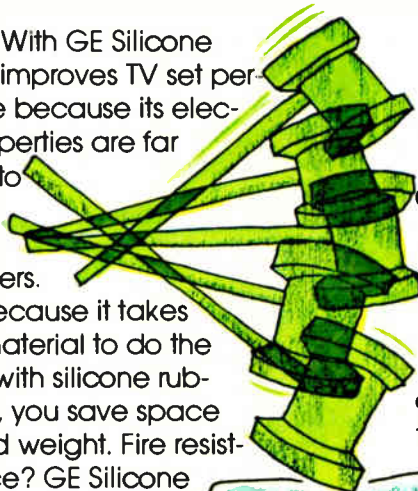
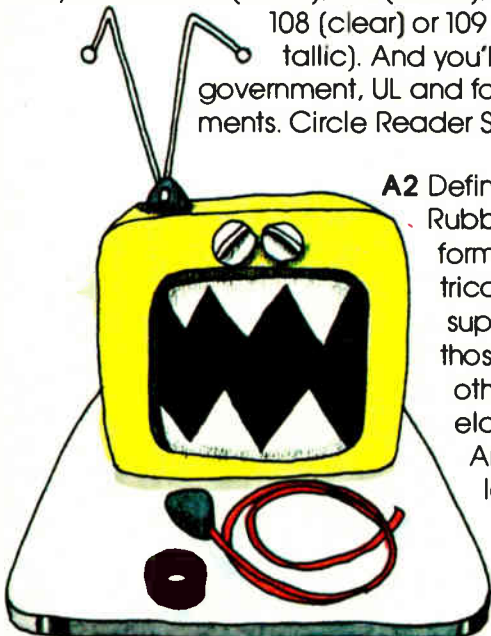
**A3** Use GE RTV-700, the strong, two-part silicone mold-making compound that needs no postbake, cures in 24 hours and has the high tear strength and elongation to reproduce precision parts quickly and accurately. Circle Reader Service No. 92.



**A2** Definitely. With GE Silicone Rubber. It improves TV set performance because its electrical properties are far superior to those of other elastomers.

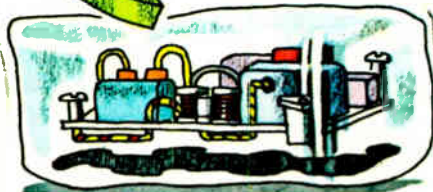
And because it takes less material to do the job with silicone rubber, you save space and weight. Fire resistance? GE Silicone

Rubber meets all the latest TV industry safety requirements. It's perfect for wire insulation, corona rings and anode caps. Circle Reader Service No. 93.



**A4** With GE RTV-619 Silicone Gel. It cures at room temperature into a clear, resilient, dielectric gel cushion for circuitry and for protecting electronic assemblies. RTV-619 cures without exotherm and can withstand temperatures from  $-65^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ .

Circle Reader Service No. 94.



For all the details, write: Section AY6383  
 Silicone Products Dept., General Electric Co., Waterford, N.Y. 12188.

GENERAL  ELECTRIC

**GE silicones.**  
**The answer.**

# NEW Super Small, 12-Bit D/A Converter



## DAC371I-12

- $\pm 0.025\%$  Linearity
- Complete and Ready-to-Use
- Binary or BCD Coding
- All Hermetic Components
- TTL/DTL Compatible

**\$35.** in singles

The current output DAC371I-12 — the smallest 12 bit D/A converter on the market — has been especially designed for the size and price-conscious engineer. The unit is so small (1.1" x 1.7" x 0.4") that it only takes up the size of two standard 16 pin IC sockets. And, it's priced right too, selling for \$35.00 in singles.

The DAC uses some significant new proprietary breakthroughs in component technology to achieve this size and cost. Nonetheless, the unit is complete with precision resistor ladder, switches, and a high accuracy internal reference, and just requires  $\pm 15V$  power for operation. Contact us for full details.



## HYBRID SYSTEMS CORPORATION

87 Second Avenue, Northwest Industrial Park, Burlington, Mass. 01803  
Telephone: 617-272-1522 TWX: 710-332-7584

Write for our new data conversion products catalog.

Circle 134 on reader service card

# KNOCKOUT PUNCH.



Our 9640 Printing Punch is really a "knockout"; it's fast, versatile and fully buffered too. Not only can the 9640 punch and/or print 96 column cards at 120-240 cpm, but it can also be equipped with an optional 1000 cpm pre-punch read feature!

And the 9640 can be combined with any of our eight other 96 column punched card peripherals to provide full I/O flexibility and growth for progressive OEM's. If you want to build systems that'll K.O. your competition, contact Decision Data -- the world's largest independent supplier of 96 column card equipment.

**THE 9640: Another SuperMachine from Decision Data.**

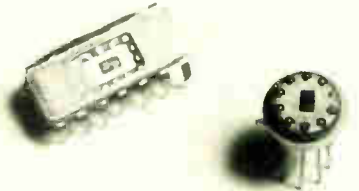


**DECISION DATA®**  
COMPUTER CORPORATION

100 WITMER ROAD, HORSHAM, PENNA 19044  
(215)674-3300 □ TELEX 83-1471

## New products

deposited thin-film resistors are laser-trimmed directly on the circuit chip, multiplies in four quadrants with a transfer function of  $XY/10$ ; divides in two quadrants with a  $10Z/X$  transfer function; and square-roots in one quadrant with a transfer function of  $\pm$  the square



root of  $10Z$ . Price for 1 to 24 units ranges from \$26 to \$60, depending on multiplying error and temperature range.

Analog Devices Inc., Rte. 1, Industrial Park, Box 280, Norwood, Mass. 02062 [417]

SCR turns off  
in 12 microseconds

A 25-ampere-rms inverter SCR, called the model CS 4.9, features a turn-off time of 12 microseconds, permitting the use of small, inexpensive commutating components in circuits for motor control and battery charge applications, for example. The device is available to 600 v, and 220-v units are priced at \$3.49 in lots of 100.

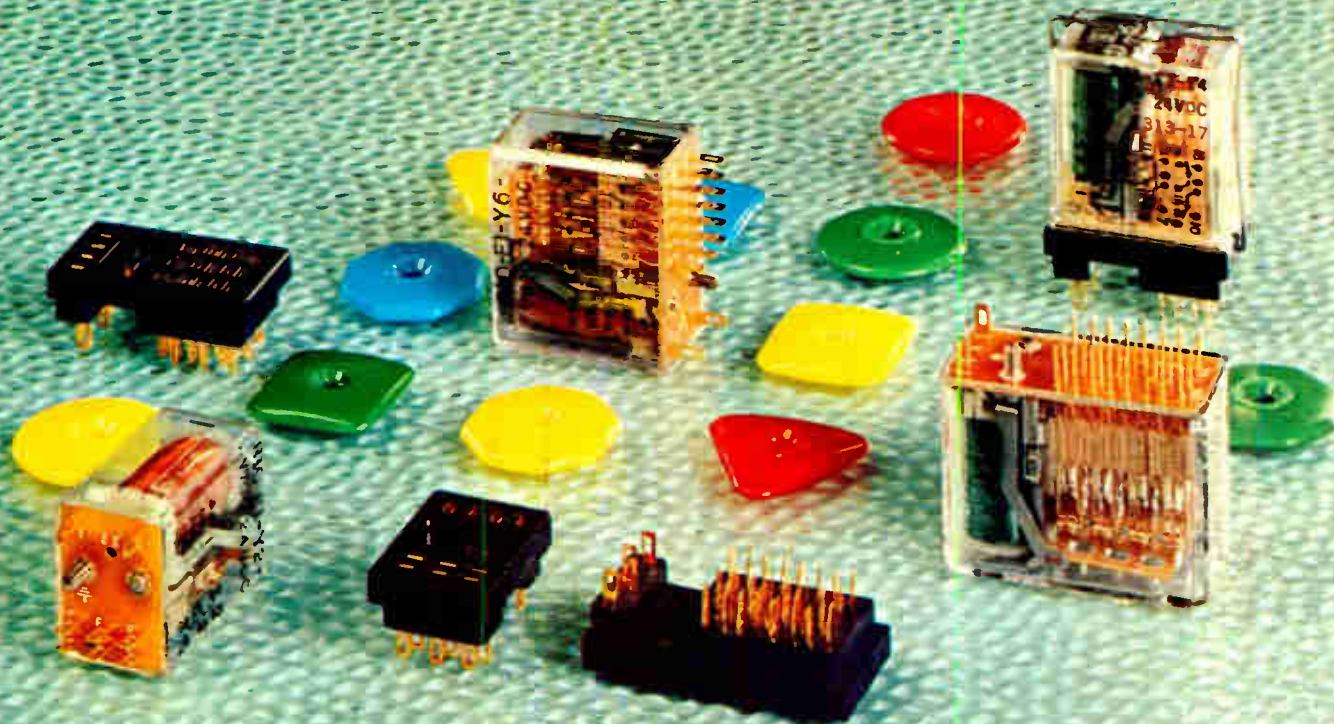
Brown Boveri Corp., 1460 Livingston Ave., N. Brunswick, N.J. 08902 [420]



134 Circle 168 on reader service card

Electronics/June 7, 1973

# P&B's compact R10 relays help you solve more application problems than with any other relay.



Relays shown actual size.

Our R10 relay series offers designers a whole family of AC and DC industrial relays that combine extraordinary versatility of application, the reliability of telephone-type relays, plus small size (less than a cubic inch). They are widely used in copiers, computer peripherals, business machines, and precision instruments.

These relays have so many options that each model may literally be designed by you to meet your particular needs. This single family of relays, with many common mechanical dimensions and mounting techniques, cover the whole range of switching loads from dry circuit to 10 amperes, 28 VDC, 120 VAC. There are terminal styles for octal plug,

solder, or pc board mounting. And, sockets multiply design options even more.

R10 relays can be ordered with Form A, B, C and D contacts and up to 8 Form C. Recognized by Underwriters Laboratories under file 42810. R10 relays have a continuous power dissipation of 2.2 watts maximum. Standard sensitivity is 125 milliwatts per pole (more sensitive units available on special order). Electrical life ranges from 100,000 to 100 million operations.

For complete information on R10 industrial relays, call your local P&B Representative. Or, call or write Potter & Brumfield Division AMF Incorporated, Princeton, Indiana 47670. Telephone 812 385 5251.



### FREE PUZZLE\*

Arrange the pieces so that no color or shape is duplicated in any row, column, or either diagonal. As an engineer, you should solve this puzzle in 27 minutes.

Like to try your hand at solving the puzzle shown above? Ask your P&B representative for one.

\*"Bali-Buttons". © Behavioral Sciences, Inc.

Solving switching problems is what we're all about.

**AMF**  
**Potter & Brumfield**

Circle 135 on reader service card

# You supply the transducers and the computer...



## System 620 takes care of the rest

### A WORD FROM OUR AMPLIFIER-PER-CHANNEL

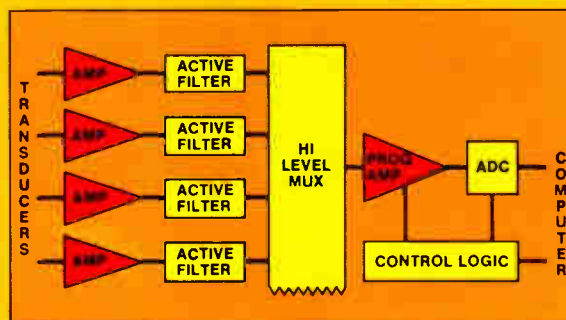
There's one of us for each channel. We isolate transducer signals right at the source. This means lower noise, less crosstalk, higher CMR, high input impedance, and continuous analog outputs for each channel. If one of us gets zapped by a tidal wave input, the rest don't feel a thing. You can set our gain from 0.1 to 1,000 in the field with our plug-in gain modules.

### OUR HIGH LEVEL MUX CHIMES IN

I'm FET & fast. I'm addressed sequentially or at random. Then I zip data to our programmable gain amplifier. It's your turn, amp.

### OUR ADC SPEAKS HIS MIND

I'm responsible for the 50KHz throughput with 12 bit digital output while my slower brother can output 14 bits at 20KHz. And my sample & hold amplifier insures accuracy with dynamic signals.



### OUR CONTROL LOGIC DEMANDS EQUAL TIME

Using DTL/TTL logic, I'm the one that makes it so easy to interface your computer with System 620.

### OUR ACTIVE FILTER SPEAKS UP

Anyone in the know will tell you that the place to filter is *after* amplifying the signal. No wonder I'm so active. I limit the signal bandwidth, which reduces noise and eliminates signal components which produce aliasing errors. It's easy to set my bandwidth from 1Hz to 1KHz in the field with my little plug-in module. System 620 puts the cart (that's me) after the horse, where it belongs.

### LET'S HEAR FROM OUR PROGRAMMABLE AMP

I'm fast too. And my gain is also under computer control. I can increase the input sensitivity of System 620 by 1, 2, 4, 10, 20 or 40. This allows our input amplifiers to accommodate maximum signal levels, while your computer programs me for best signal to noise ratio.

### IN UNISON !!!

Imagine, 64 amps & filters, a MUX, a programmable amp, an ADC & control logic in a 7-inch rack cabinet for less than \$150/channel. And expandable to 256 or 2048 channels. No wonder we're multiplying like rabbits in installations everywhere.

**NEFF**  
INSTRUMENT CORPORATION

1088 E. Hamilton Rd., Duarte, Calif. 91010  
Tel. (213) 357-2281 TWX 910-585-1833

Circle 136 on reader service card



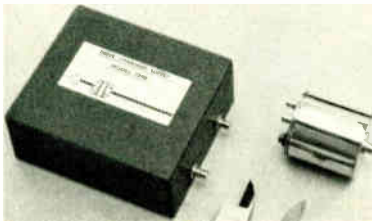
**Data handling****Laser provides  
20-mile link**

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One-way system includes gallium-arsenide transmitter, avalanche photodetector

---

A simple solution to relatively short-range, line-of-sight data communications problems is offered by two small modules. One is a gallium-arsenide laser and drive, and the other an avalanche photodetector with



amplifier. Together, they provide a one-way data link with a range up to 20 miles. The transmitter handles 10,000 pulses per second, while the receiver has a wider, 15-megahertz bandwidth and can be used at higher data rates with cooled diode lasers or other sources.

Price for each is about \$300, a fifth that of other modules on the market, says Duncan Campbell, president of American Laser Systems.

The modules are 1.125 inches in diameter and about 1.2 in. long. They are designed to slide back and forth for focusing in a tubular mount. To simplify this operation, both the laser and detector are mounted for maximum response in the center axis perpendicular to the face of the module. Relatively simple external lenses are suitable.

Campbell says that range for the units is naturally dependent on atmospheric conditions as well as optics. Rain and snow aren't much of a problem, but fog and smog can limit range. The equipment seems most attractive for distances of a few miles—between plants or buildings in large facilities, for example,

where cable-laying can be difficult.

The model 729A laser module (shown at left) has a peak output of about 12 watts at 10 kilopulses per second when used with a 9-mil-diameter close-confinement laser. Current drain is 300 microamperes maximum quiescent at 12 volts dc, plus 15 microamperes per pulse per second. The unit is compensated for temperatures in the 0° to 150°F range. An internal wideband current probe is included. The model 7298 drive-charging supply is separate, and it measures 3 by 2.63 by 1.25 in.

The model 728A photodetector and preamplifier module contains a 10-mil-diameter silicon avalanche photodetector (larger detectors are available). The 728A provides a 100-to-1 improvement in signal-to-noise ratio over a p-i-n detector in systems with a narrow field-of-view and large bandwidth, according to the company. A 15-MHz bandwidth is standard and provides reception of 30-nanosecond pulses. Signal-to-noise ratio is 1 with a 0.58-nanowatt optical signal. Bandwidths to 50 MHz are optional, though with lower sensitivity. The model 728B power supply is external, and measures 2.95 by 1.4 by 1.2 in. It requires 7 milliamperes at 12 volts.

All units are fully shielded for low noise.

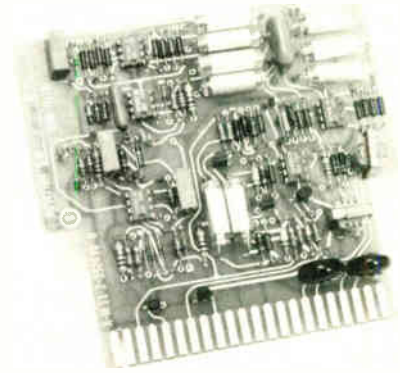
Price is \$350 for the complete transmitter, \$295 for the receiver.

American Laser Systems Inc., 106 James Fowler Rd., Santa Barbara Airport, Goleta, Calif. 93017 [361]

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**Modem card  
sells for \$50**

A modem card is designed to sell in the \$50 range and is compatible with Bell series 103F. The device is intended for use in multipoint polled data nets, as well as in applications such as credit-card, security, point-of-sale, and credit verification systems. Features include answer-or originate-mode frequencies, carrier detection and request-to-send. The unit operates on four-wire private lines and requires a minimum of fil-



tering.

Novation Inc., 18664 Oxnard St., Tarzana, Calif. 91356 [363]

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**Teleprinter operates to  
30 characters a second**

The model 9030 teleprinter uses a matrix impact printhead and offers operating speeds of 10, 15 or 30 characters per second. Other features include a 132-column print capacity, full ASCII code; half- and full-duplex local operation; odd, even or no-parity error detection;



and an RS232C interface. Price is from \$2,895 for a single unit to \$1,955 for quantity orders.

Di/An Controls Inc., 944 Dorchester Ave., Boston, Mass. 02125 [364]

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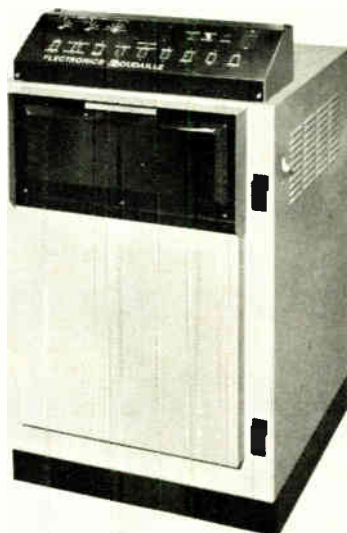
**Analog input system  
converts data for computer**

A low-level analog input system with good noise immunity converts analog signals to digital computer input. For use with Varian's 620 and V73 computer series, the model 620-855 is a self-contained unit that includes an analog-to-digital conver-

# Houdaille's versatile new n/c systems offer pluggable circuits, countless options -- and unbelievably low cost!

2- or 3-axis systems. Options include computer-assisted tape preparation, sophisticated contouring capability. The low cost is standard. So is Houdaille's nationwide factory service. Request information, and learn how to custom-automate economically with Houdaille. Electronics Division, Houdaille Industries Inc. 9023 Wehrle Drive / Clarence, N.Y. 14031 / 716-632-8412.

**ELECTRONICS**  **HOUDAILLE**



Circle 138 on reader service card

## It isn't just what it does. It's what it costs for what it does.

You might find this hard to believe, but you can now purchase a pulse and data generator for \$695.

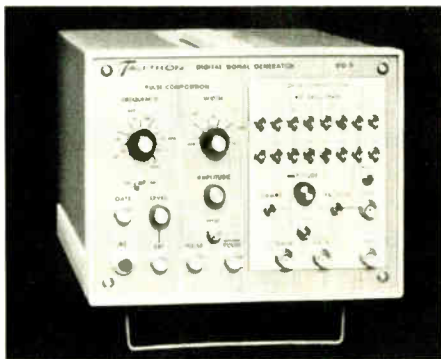
**\$695.**

For a pulse and data generator.

And not just any pulse and data

generator. A self-sufficient unit, one that provides rep rates to 35 MHz and 16 bit words in either RZ or NRZ. You get frequency control, plus amplitude, offset and width variability, and a lot more.

For R&D, for engineering development, for production QC or digital system testing, where can you get more capability for less cash than our DG-7?



**The Troubleshooters, from  
Tau-Tron, Inc.**

685 Lawrence Street Lowell, Massachusetts 01852

138 Circle 169 on reader service card

### New products

ter, low-level multiplexer, sample-and-hold amplifier, and programmable timer. Applications are in a wide range of data acquisition systems: industrial, research and development, and scientific. Price for a 16-channel system is \$6,000.

Varian Data Machines, 2722 Michelson Dr., Irvine, Calif. 92664 [365]

### Computer display terminal provides forms capability

With a forms capability—the arrangement of displayed data to resemble the source document—the model 4023 computer display terminal also offers on-screen editing, and full upper- and lower-case alphanumeric. Forms information can be retrieved rapidly, updated, edited, and entered. It can also be ruled with an optical package that draws solid horizontal and vertical lines. The unit has a capacity of 1,920 characters.

Tektronix Inc., Box 500, Beaverton, Ore. 97005 [366]

### Parallel card reader links directly to computer

Functional data entry cards are also source documents for an optical card reader designated the model 7261A. The parallel reader is designed for use directly with a computer or smart terminal. It saves data-preparation time and reduces errors since the need to keypunch already gathered data is eliminated. Ordinary pencil marks are read directly, as well as prepunched and preprinted data. Maximum feed



Electronics/June 7, 1973

## New products

rate is 300 cards per minute. Price is \$2,575; rental and lease terms are available.

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [367]

## PDP-11 peripherals perform Fourier transforms

Two PDP-11 computer peripherals for hardware Fourier transforms and related operations are said to enable PDP-11 users to perform such computation ten times as fast as with a software version. For a 1,024-point fast Fourier transform, the model F2 does the processing in 146 ms, and the model F4 in 100 ms. The processors interface directly to



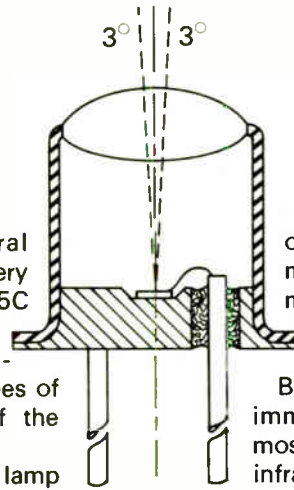
the computer's Unibus, and both are microprogramed, using the computer's core memory. Price of the F2 is \$5,750; the F4, \$6,450.

Time/Data Co., 1050 East Meadow Circle, Palo Alto, Calif. 94303 [368]

## Display technique presents data in 4 dimensions

A display technique, developed to present organized digital data in a combined digital-analog form for rapid visual inspection, extracts the macro-information content of large fields of interrelated numerical data. Known as Direct Digital Graphics, the technique employs a group of 16 optically weighted numerical characters called the Opti-Font. A fourth dimension of information display is provided by a range of four levels of printing intensity—

# You gain fundamental design advantages with General Electric infrared SSL's (LED's).



For example, General Electric guarantees\* every SSL-55B and SSL-55C infrared lamp for:

Precision beam alignment, to within 3 degrees of the mechanical axis of the lamp.

Power output of each lamp will be within the less than 2 to 1 range, as published; the SSL-55B

output ranges from 3.5 mW minimum to 6.0 mW maximum; the SSL-55C from 4.8 mW minimum to 7.5 mW maximum.

Both types are available for immediate delivery, as are most other General Electric infrared SSL's. For prices and complete SSL infrared data write or call today.

## Green Glow Lamp for flexibility.



Actual Size

This GE broad spectrum bright green glow lamp gives you greater design flexibility than ever before. It also emits blue, with suitable color filter.

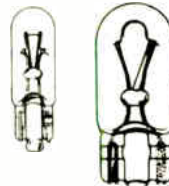
Called the G2B, it is directly interchangeable electrically and physically with GE's high-brightness C2A red/orange/yellow glow lamp. You can use the G2B alone for 120 volt green indicator service. Or together

with the C2A to emphasize multiple functions with colors. For example: for safe/unsafe functions, for dual state indications and to show multiple operations in up to 5 colors.

They should be operated in series with an appropriate current limiting resistor. Both the G2B and C2A save money because of low cost, small size and rugged construction.

## Now Wedge Base Lamps in two sizes.

If space for indicator lights is your problem, the GE T-1 $\frac{3}{4}$  size all-glass wedge-base lamp is your solution. It measures only .240" max. diam. The wedge-base construction virtually ends corrosion problems; it won't freeze in the socket. Like



its big brother — the T-3 $\frac{1}{4}$  wedge base lamp with a .405" max. diam., the filament is always positioned in the same relation to the base. And it makes possible simplified socket design.

For free technical information on any or all of these lamps, just write: General Electric Company, Miniature Lamp Products Department, #4454-M, Nela Park, Cleveland, Ohio 44112.

\*Lamps not meeting published specifications will be replaced or money refunded.

**GENERAL**  **ELECTRIC**

# DIP REED RELAYS

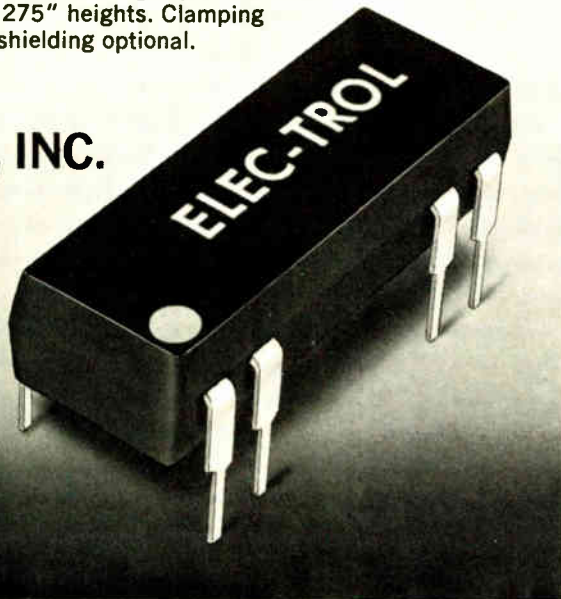
Available in all standard configurations  
From distributor stock

Elec-Trol's totally encapsulated DIP REED RELAYS can be driven directly by TTL logic. Available in 1 and 2 Pole Form A, 1 Form B, 1 Form C with 5 through 24 VDC standard coil voltages. Contact ratings up to 10 watts. Available in .225" and .275" heights. Clamping diode and electrostatic shielding optional.

Phone, wire or write.

## ELEC-TROL, INC.

26477 N. Golden Valley Road  
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(213) 788-7292  
TWX 910-336-1556



1973-74  
**eem**  
VOL. TWO

Circle 170 on reader service card



## NEW! LIGHT TOUCH. 7 MORE KEYS.

It's the High Density "Super Mini"

Introducing a new generation of calculator keyboard switch assemblies. They have 25 keys and fit where 18 used to. So now you can add more functions (memory/square root/logarithms/etc.) with the new more powerful chip sets in your same housing.

Features are • Reduced key size (1/2-inch centers) • Redundant bifurcated scissor spring contacts • Light 2-ounce touch like quality big machines • 0.100" stroke (including 0.050" overtravel) • Superior life (over 10 million cycles) • bounce 1 millisecond or less • Contact resistance less than 1 ohm • 2-shot keys in all colors • Available less housing • Competitively priced with conventional 18 key assemblies.

To see how one fits, write or call for data. Or, send us your bare case and we'll send you a sample. You'll get 7 more keys with the "right" touch.



Controls Research Corporation

an affiliate of MIBTEX

2100 S. Fairview, Santa Ana, Calif. 92704  
Phone: (714) 557-7161 • TWX-910-595-1106

## New products

from light grey to full black.  
Digicom Inc., Paramount Bldg., North  
Chelmsford, Mass. 01863 [396]

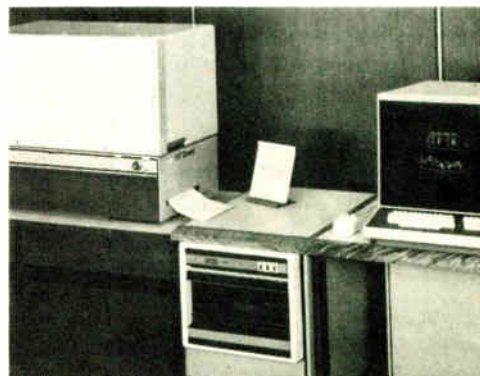
Line printer can run  
at 200 lines per minute

The series 2000 line printer consists of two models: the model 2100, which prints at 125 lines per minute; and the model 2200, which prints at 200 lines per minute. Both offer 132 columns, 64 ASCII characters, and a crosspoint printing technique. The model 2100 has a six-lines-per-inch spacing and a 7-by-8 dot matrix, while the 2200 has a selectable line spacing of six or eight lines per inch and a 5-by-7 dot matrix.

Tally Corp., 8301 S. 180th St., Kent, Wash.  
98031 [370]

Graphics display system  
shows 3,000 characters

An interactive graphics display system consisting of a full line of peripherals can display more than 3,000 characters refreshed at 40 frames per second on a 17-inch CRT. Other specifications include 2,000 inches of vector at 40 frames per second with 1,024-by-1,024 resolution, a memory cycle and an instruction execution of less than 1 microsecond, display subrouting hardware up to eight levels, and optional floating point computation. Also offered as options with the PDS-4 is two-dimensional rotation hardware including zooming and



140 Circle 140 on reader service card

Electronics/June 7, 1973

It's our new RT-02.  
Whereas our RT-01 has  
been a big hit because people  
know they can count on it.

It's numeric.  
Our new RT-02 is  
alphanumeric.

32 alphanumeric characters  
on a single-line gas-discharge  
type readout panel to be exact.

It has its own self-contained  
power supply and weighs so

little, it's really portable.

It's ASCII compatible so  
you can interface it, input and  
output, to any computer that's  
got a Teletype port.

And it doesn't cost much  
more, really, than our RT-01  
that's sold so well.

And it's simple as saying  
your A,B,C's to use.

We're the Logic Products  
Group, Digital Equipment

Corporation, Maynard, Massa-  
chusetts 01754/(617) 897-5111  
in the U.S.

81 route de l'Aire, 1211  
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And we'll be happy to show  
it to you, no matter how remote  
you are.

**digital**

## Introducing a remote data entry terminal that you can read as easy as A,B,C. Anywhere you want to read it.



Circle 1 on reader service card



## OTHER RESISTORS DO A **SLOW BURN** UNDER SPRAGUE'S TORCH TEST!

CERON® CERAMIC-INSULATED FLAME-PROOF WIREWOUND RESISTORS are a *new* development to meet the need for a *truly* non-flammable resistor in electronic equipment. Unlike some other so-called "flame-proof" resistors, which open-circuit before burning when subjected to high overloads, new and exclusive Sprague Ceron® Resistors are absolutely inert in the presence of heat or flame. They will not ignite under any degree of overload. *Actually, they will not burn even when placed directly into the open flame of an oxyacetylene torch!* This is clearly indicated in the photo, which dramatizes the protective qualities of the flame-proof Ceron® coating as compared with that of a

conventional silicone-coated resistor.

The special coating is completely resistant to standard industrial cleaning solvents. Totally inorganic, it is also immune to attack by fungus. It provides excellent protection against thermal shock, humidity, and vibration. Dielectric strength, measured in a "V" block, is 500 volts a-c.

Series 380E (standard) and Series 400E (non-inductive) Ceron® Resistors meet moisture requirements of Specification MIL-R-26. Resistance values range from 1 to 60,000 ohms, in wattage ratings from 1 to 10 watts. Resistance tolerances as close as  $\pm 1\%$  are available. Sizes range from  $\frac{1}{8}$ " D. x  $\frac{3}{8}$ " L. for the 1-watt resistor to  $\frac{5}{16}$ " D. x  $1\frac{3}{4}$ " L. for the 10-watt unit.

**For complete technical data, write for Engineering Bulletin 7250 to: Technical Literature Service, Sprague Electric Co., 509 Marshall St., North Adams, Mass. 01247.**

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### New products

windowing. Price is less than \$14,000.

Imlac Corp., 150 A St., Needham, Mass. 02194 [371]

### 50-MHz half-tone storage CRT aimed at OEM market

A variable-persistence storage CRT, the L14-110GH/55, is built for use in scopes and other monitoring de-



vices with bandwidths up to 50 MHz. It permits displays of 72 by 90 mm and has an internal graticule of 8 by 10 divisions (9 mm/div.). OEM price, in 100-lots, is \$700.

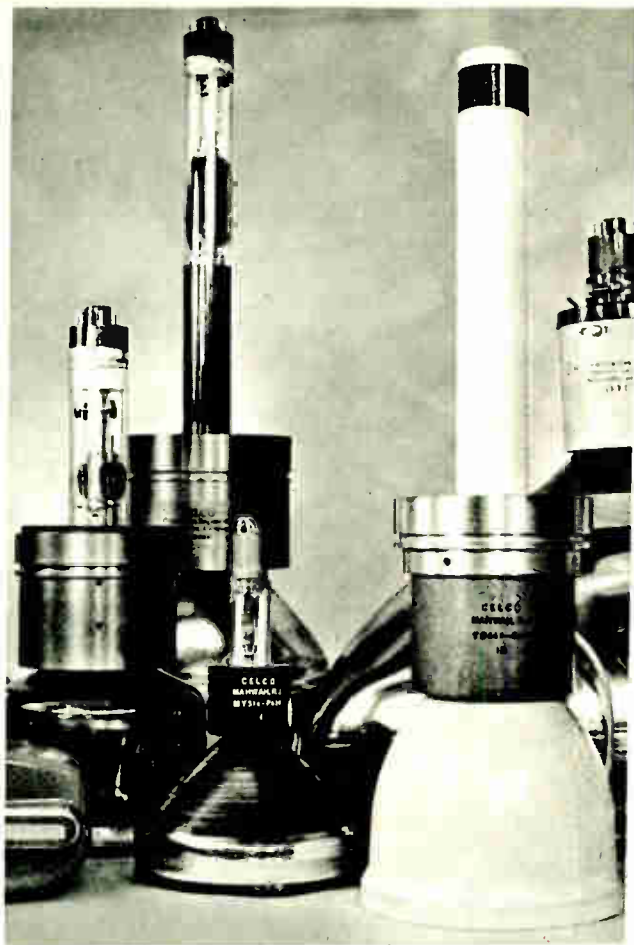
Amperex Electronic Corp., Slatersville, R.I. 02876 [339]

### Tape recorder/reproducer includes electronic editing

A tape recorder for broadcast applications allows the operator to move the tape across the recording heads so precisely that he may "split" musical notes and phrases. With this "electronic editing," either reel may be moved manually, in minute increments, without a creeping effect. Price is \$1,695.

Tape-Athon Corp., 502 S. Isis, Inglewood, Calif. 90301 [340]





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And unlike DAP, it provides greater impact resistance and higher dielectric strength at lower finished-part cost.

VALOX resin has the rigidity and dimensional stability to prevent warpage, changing tolerances and loss of critical contacts. Plus heat resistance to over 400°F, built-in

lubricity and unsurpassed chemical resistance. And it usually molds easier and injection cycles faster than any other engineering plastic.

For full details on VALOX thermoplastic polyester, The Connector Material, write Section 176, Plastics Dept., General Electric Co., One Plastics Ave., Pittsfield, Mass. 01201

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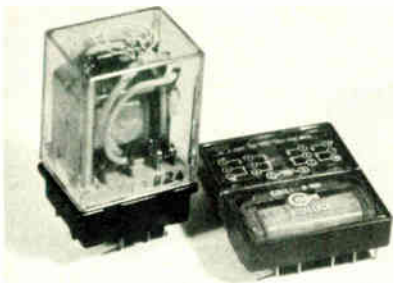


Components

## 3-A relay has low profile

Flat motor assembly is a key to package only 0.35 inch high for circuit board jobs

After four years of second-sourcing standard general-purpose relays, C. P. Clare and Co. unveiled at the National Computer Conference the first of a line of general-purpose relays of its own design.



**Redesign.** Low-profile relay (right) performs same function as earlier, bulkier unit.

The "me-too" strategy was planned in 1968. "We felt if we were to get into the general-purpose market long range," says Charles J. Montante, product marketing manager for the Chicago-based, General Instrument Corp. subsidiary, "it would be valuable to have relays in the market to get experience and to establish our credentials."

Its new series 311 relay is a low-profile version of Clare's first general-purpose relay, the GP1, and is capable of switching up to 3 amperes at 120 volts ac or 28 v dc. To achieve contact forces capable of switching that load, nominally 9 grams on the 311, Clare engineers developed a flat motor assembly that delivers the total force for the four Form C contacts.

The relay package stands only 0.35 inch high so that it can be used on printed-circuit boards spaced on half-inch centers, and it also reflects Clare development work. "Others

have made relays for pc boards, but the base is molded first and then the pins are pressed in," Montante comments, "yielding a very good capillary path that will wick the solder up into the relay." However, to prevent the relay or its contacts from being contaminated during wave-soldering and subsequent partial-immersion cleaning operations, Clare loads the terminal pins into a mold, then molds a five-sided box of diallylphthalate around the pins, and builds the relay in the box.

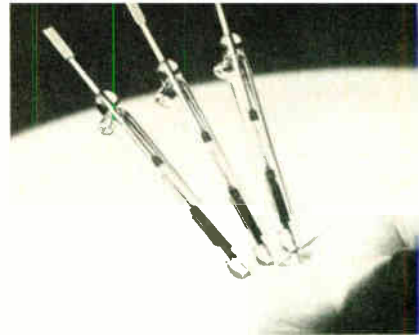
The series 311 relay, designed to meet UL Bulletin 508 requirements, is available off the shelf in seven models with coil voltages from 6 to 110 v dc. Contact resistance is 100 milliohms maximum initially, insulation resistance is 50,000 megohms minimum, and life expectancy exceeds 100,000 operations at rated load. Operating time is 15 milliseconds maximum including bounce. List prices are comparable to the GP1: between \$4 and \$5.

Clare also introduced two new solid-state relays at the conference. The 202 series is a zero-cross, 10-A power-switching relay capable of handling down to a 0.35 power factor. It will switch a ¼-horsepower motor with a 100-A peak, one-cycle surge rating, and is also suitable for high in-rush loads such as heating elements and incandescent lamps. The second relay, the 203 series, has similar capabilities and will also track down to a 0.35 power factor, but is rated at ¼ ampere, 120 v ac. Both are DTL/TTL-compatible, and will list at less than \$20.

C. P. Clare and Co., 3101 W. Pratt Ave., Chicago, Ill. 60645 [341]

Switch stays closed until opened by magnetic field

A Form B reed switch is part of Hamlin's DRVT series. Called DRVT-15 B, the unit is designed to remain closed until opened by a magnetic field. Capacities are up to 30 kv. Other specifications include a voltage breakdown of 15,000 v dc minimum, a switching voltage of 12,500 v dc maximum, and a life ex-



pectancy of  $10^6$  closings at maximum load. Evaluation samples are available on telephone or letterhead inquiries.

Hamlin Inc., Lake Mills, Wis. [343]

Lamp can be driven by TTL buffer gates

An incandescent subminiature lamp offers a current of 40 mA at 5 v and can be directly driven by many types of TTL buffer gates. The H 540



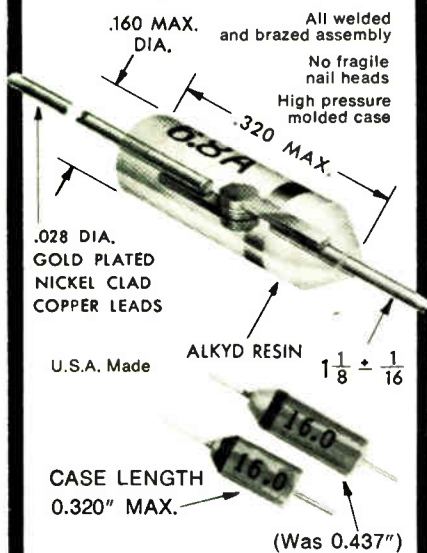
lamp has an average life of 25,000 hours and a brilliance of 0.03 mean-square candlepower. The unit has a T 1¼ submidget flange base and is available in all socket-base styles. Applications include the OEM telecommunications market. Price in 1,000-lots is 0.252 cent each.

Industrial Electronic Engineers Inc., 7720 Lemona Ave., Van Nuys, Calif. 91405 [346]

Switch's supply voltage ranges from 6 to 16 volts

The model 5SS solid-state switch line offers a flexible supply voltage range extending from 6 to 16 v dc. The miniature, magnetically operated Hall-effect devices incorporate

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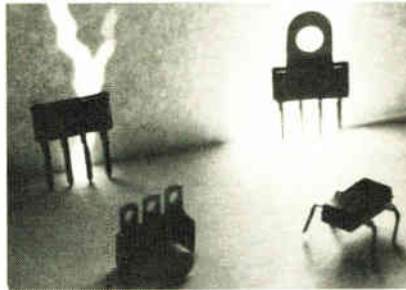
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## New products

an integrated voltage regulator that permits switches to accept voltages from unregulated power supplies over a range of  $-40^{\circ}$  to  $+125^{\circ}$  C.

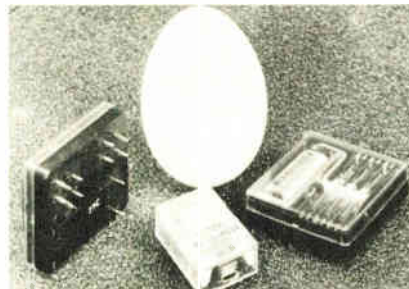


Rise and fall times are both 1.0 microsecond and rate of operation is 100 kHz. Price is \$4.25.

Micro Switch Division, Honeywell Inc., 11 W. Spring St., Freeport, Ill. 61032 [345]

Circuit-board relays are only 0.4 inch

A line of printed-circuit-board relays with a height of 0.4 inch permits rack-mounting of boards on 0.5 inch centers. The units feature two-



four- and six-pole, double-throw bifurcated configurations and are rated at 1 ampere. The bases are sealed to prevent flux or solder from entering the unit, and this permits automated soldering techniques to be used. Price is below \$3 in 500-quantity.

Siemens Corp., 186 Wood Ave. South, Iselin, N.J. 08830 [348]

Transformers trigger SCRs and triacs

Designed for SCR and triac triggering applications, the 7330 series transformers perform four primary

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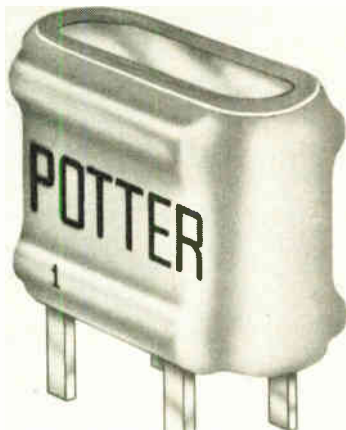
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## New products

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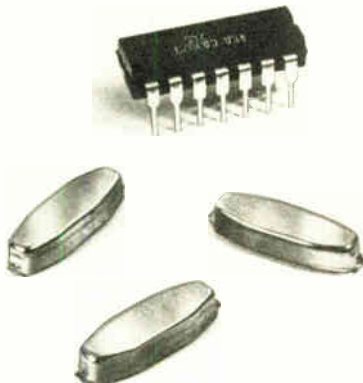
tion to providing isolation between circuits and 180° phase reversal in full-wave circuits, their leakage inductance capability minimizes potentially damaging switching spikes. Cost is \$2 each in prototype quantities.

The Potter Co., a Division of Pemcor Inc.,  
10441 Roselle Ave., San Diego, Calif. 92121  
[347]

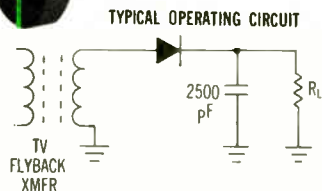
## Quartz crystals require 100 nW of drive power

An ultraminiature quartz crystal rated at 32,678 hertz is designed to provide a high Q factor and high resistance to shock. Used in micro-power circuits, the crystal requires typically about 100 nanowatts of drive power. The units measure 15 mm long by 5 mm wide by 3 mm high. Price is \$9.75 in 100-lots.

Frequency and Time Systems Inc., 182 Conant St., Danvers, Mass. 01923 [349]



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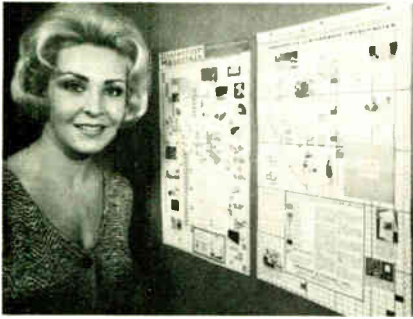
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Force Chemicals Division, American Solder & Flux Co. Inc., 63 Industrial Blvd., Paoli, Pa. 19301 [476]

A range of aerosols includes switch and contact cleaners, an antistatic spray, a magnetic-tape-head cleaner, and insulating varnishes. Also included is Electrical 88, which deposits a hydrophobic film, displacing and repelling moisture. The film will not emulsify, harden, or flake and is nonstaining. It is effective from -50° to +400°F.

PBRA Ltd., 33 Holmethorpe Ave., Redhill, Surrey, England [477]

A family of preplate products for metalizing printed-circuit boards is designated the oxytron preplate system. The products include substrate preparation, activator, accelerator, and electroless copper. They were developed to be compatible with the company's processes including solders, nickels, coppers and precious metals, and to avoid problems that can occur in sensitizing pc boards after drilling.

The Sel-Rex Co., 75 River Rd., Nutley, N.J. 07110 [478]

A ceramic adhesive, for use at temperatures above 600°F and suitable to 2,500°F, can attach high-temperature thermocouple leads to metals. Called Ceramcoat 512, the material is available as a premixed paste, which is brush-coated over both the leads and the metal surface and dries in air. It offers a dielectric strength of 40 v per mil at 400°F. Price is \$34 for a quart container and \$122 for a gallon.

Aremco Products Inc., Box 145, Briarcliff Manor, N.Y. 10510 [479]

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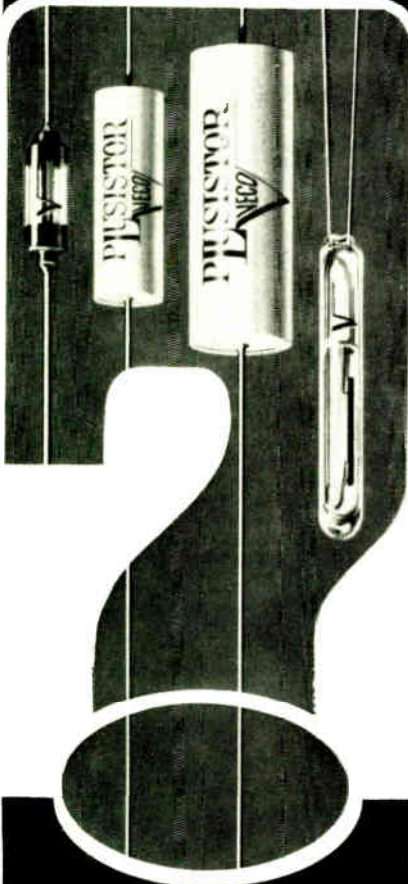
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## New literature

**Bobbin winder.** A two-page technical bulletin from George Stevens Mfg. Co. Inc., 6001 N. Keystone Ave., Chicago, Ill., contains information on the model 615-PM bobbin winder that has applications in solenoids, resistors, and repeater coils. Circle 421 on reader service card.

**Packaging system.** Modpak, 31A Green St., Waltham, Mass. 02154. An electronics packaging system is described in a 16-page catalog, which includes ordering information. [422]

**Micrologic cards.** A designer's handbook and applications manual includes information on DTL and TTL micrologic cards and is available from Control Logic Inc., 9 Tech Circle, Natick, Mass. 01760 [423]

**Cylindrical connectors.** Stanford Applied Engineering Inc., 2165 S. Grand Ave., Santa Ana, Calif. 92705. A 40-page brochure describes the MIL-C-5015F cylindrical connector and includes examples of military-connector alternative designs, ordering information, mounting dimensions, finish and material variations, standards and thermocouple contacts, insert configurations, and specifications. [424]

**Fiber optics.** American Optical Corp., Fiber Optics Division, Southbridge, Mass. 01550. A fiber optics catalog covers the company's standard line of products as well as custom-design capabilities. Featured in the new catalog are flexible Fiberscopes that are used to view inaccessible areas, light guides, image conduit, clad rod, faceplates, and components. [425]

**Switches.** Cherry Electrical Products Corp., Box 718, Waukegan, Ill. 60085, has published a switch catalog that provides information on selecting the appropriate switch for any application. Also included are specifications, drawings, and operating characteristics. [426]

**Panel meter.** Panel meters with plastic-dial light-diffusing illumination

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## New literature

are among several discussed in a 36-page catalog issued by Modutec Inc., 18 Marshall St., Norwalk, Conn. 06854 [427]

**Parametric amplifiers.** A four-page brochure from Aertech Industries, 825 Stewart Dr., Sunnyvale, Calif. 94086, describes the company's line of parametric amplifiers. [428]

**Capabilities brochure.** Masterlite Industries, Master-Flex Products Division, 2841 Lomita Blvd., Torrance, Calif., has issued a four-page brochure describing the capabilities of the company and of the line of flexible jumpers used for distributing groups of signals between circuit boards. [429]

**Photosensitive devices.** Hamamatsu Corp., 120 Wood Ave., Middlesex, N.J. 08846. A catalog of photosensitive products lists specifications on devices such as photomultipliers, phototubes, light sources, and infrared vidicons. [430]

**Data communications.** Syntech Corp., 11810 Parklawn Dr., Rockville, Md. 20852, has published a data-communications shortform catalog. Products described include high-speed spectrum shift modems, time-division multiplexers and error-rate test sets. [431]

**Broadband amplifiers.** A battery-operated instrumentation preamplifier is described in data bulletin FM-ACC-3, available from Singer Instrumentation, 3211 S. La Cienega Blvd., Los Angeles, Calif. 90016 [432]

**Test accessories.** Pomona Electronics Co. Inc., 1500 East Ninth St., Pomona, Calif. 91766. A general catalog contains a listing of more than 500 products in the company's line of test accessories. These include test cables, test-socket adaptors, and patch cords. [433]

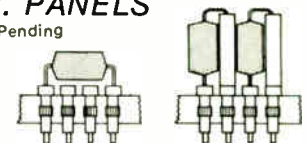
**Pattern generator.** A four-page data sheet from Gyrex Corp., 400 East Gutierrez St., Santa Barbara, Calif. 93101, describes the model 1001-4 pattern generator. [434]

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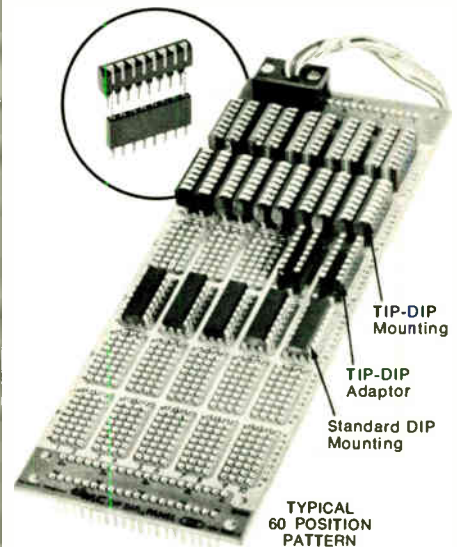
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<b>* Adret Electronique</b>	21E	<b>* GAF Corporation</b> Michel-Cather, Inc.	46	<b>Rochester Gas &amp; Electric—</b> <b>Advertising Group</b> Hutchins Advertising Company, Inc.	146
<b>Advanced Memory Systems</b> Writing Unlimited	9	<b>General Business Services, Inc.</b> Kal, Merrick & Salan, Inc.	168	<b>* Rohde &amp; Schwarz</b>	1E
<b>Advanced Micro Devices</b> Keye/Donna/Pearlstein	10-11	<b>‡ General Electric Electronic Components</b> Robert S. Cragin, Inc.	38	<b>Schauer Manufacturing Corp.</b> Nolan, Keeler & Stiles	146
<b>* Advanced Micro Devices</b> Keye/Donna/Pearlstein	20E	<b>* General Electric Co.,</b> <b>Miniature Lamp Div.</b> Carr Liggett Advertising, Inc.	139	<b>* Schneider R. T.</b> Intermedia	11E
<b>Allegheny Ludlum Steel Corporation</b> VanSant Dugdale and Company, Inc.	83	<b>* General Electric Company (Plastics Dept.)</b> <b>-Silicone Products Dept.</b> Ross Roy of New York, Inc.	133	<b>* Schoeller</b> Sigma Studio 1	28E
<b>Allen-Bradley Company</b> Hoffman, York, Baker & Johnson, Inc.	34	<b>* General Electric Company, Plastics Dept.</b> Ross Roy of New York, Inc.	144	<b>* Sescosem</b> Perez Publicite	12E
<b>American Microsystems, Inc.</b> Wilton, Coombs & Colnett, Inc. Advertising	78-79	<b>* General Instrument Europe S. P. A.</b> Studio Hedy	26E	<b>Sheaffer World-Wide, A Tentron Company</b> Sperry Boom, Inc.	168
<b>AMF/Potter &amp; Brumfield Division</b> Fuller & Smith & Ross, Inc.	135	<b>* General Radio</b> Grad Associates	5E	<b>‡ Siemens</b> Ries Cappiello Colwell, Inc.	28-29
<b>* Amphenol-Tuchel Electronics</b> M & A Markenwerbung & Absatzforderung GmbH	27E	<b>* Gould, Inc./Instrument Systems Div.</b> Carr Liggett Adv., Inc.	52	<b>Signetics Corp., Sub. of</b> <b>Corning Glass Works</b> Hall Butler Blatherwick, Inc.	27
<b>* Analog Devices, Inc.</b> Schneider Parker Guy, Inc.	68	<b>* Grayhill, Incorporated</b> Carr Liggett Advertising, Inc.	143	<b>* Silec Electronique</b> France M-1	84
<b>Atlantic Richfield Co. (ARCO)</b> Needham, Harper & Steers, Inc.	156	<b>Grinnell Fire Protection Systems Co., Inc.</b> Hutchins/Darcy, Inc.	164	<b>Siliconix</b> Robertson West, Inc.	105
<b>‡ Bourns, Inc.</b> Malborough Assoc., Inc.	84-85	<b>Hermes Electronics Ltd.</b> Public & Industrial Relations Limited	77	<b>SINGER INSTRUMENTATION—ALFRED DIV.</b> N. W. Ayer/Jorgensen/MacDonald, Inc.	75
<b>Burr-Brown Research Corp.</b> N. A. Winter Advertising Agency	126-127	<b>* Hewlett-Packard, Electronics Products Group</b> Corporate Marketing Communications	17-26	<b>* Sodeco</b> PF Service	2E
<b>* Busmann Mfg. Division</b> <b>of McGraw-Edison Co.</b> Henderson Advertising Company	116	<b>Houdaille Inds., Inc., Electronics Div.</b> John E. Hayes Co., Inc.	138	<b>* Sodern</b> Realisations Publicitaires Industrielles	9E
<b>Cal-Tex</b> CTS Advertising	1	<b>Hughes Aircraft Company</b> Foote, Cone & Belding	50-51	<b>* Sprague Electric Company</b> Harry P. Bridge Company	8, 142
<b>CELCO</b> Stano Advertising	143	<b>Hutson Industries</b> Warren-Guild	154	<b>Stackpole Carbon Company,</b> <b>Electronic Components Division</b> Ira Thomas Associates, Inc.	61
<b>Chessco Industries, Inc.</b> Robert A. Paul Advertising Agency, Inc.	151	<b>* Hybrid Systems Corp.</b> Susan E. Schur	134	<b>Stran Steel Corp.</b> Rives, Dyke & Co., Inc.	155
<b>* Chicago Dynamic Industries, Inc.</b> Burton Browne Advertising	125	<b>* ILC Data Device Corporation</b> Marchin Weitman Advertising, Inc.	2	<b>* Systron Donner Concord Instruments</b> Bonfield Associates	45
<b>* CIT Alcatel</b> Promotion Industrielle	19E	<b>‡ Interdesign, Inc.</b> Hornisher & Associates	64	<b>Taiyo Denki Co., Ltd.</b> Daiyusha, Inc.	154
<b>* Clairrex Corporation</b> Black-Russell-Morris	4th cover	<b>‡ International Rectifier Corp.,</b> <b>Semiconductor Division</b> William E. Wilson Company	47	<b>Tau-Tron</b> Clark Bernard Husband	138
<b>* Colorado Video, Inc.</b> O'Connell-Colburn Inc. Creative Business Communications	153	<b>ITEK Business Products</b> Baker, Watson & Giurlando, Inc.	167	<b>Tektronix, Inc.</b> Dawson, Inc.	43
<b>Computer Automation</b> Cochrane Chase & Company, Inc.	32-33	<b>* ITT Cannon</b> D'Arcy-MacManus & Masius, Inc.	71	<b>* Teledyne Relays</b> S. Michelson Advertising	6E
<b>* Computer Components, Inc.</b>	28E	<b>Japan Electric Measuring Instruments</b> <b>Manufacturing Assoc.</b> Kohkoku-Sha Co., Ltd.	153	<b>Test &amp; Measuring Instruments, Inc.</b> Sam Groden, Incorporated	88
<b>Constantine Engineering Laboratory Co.</b> Stano Advertising	143	<b>* Kepco Incorporated</b> Weiss Advertising	5	<b>Texas Instruments Incorporated,</b> <b>Semiconductor Group</b> Tracy-Locke Advertising, Inc.	86-87
<b>Controls Research Corp.</b> Ron Jenner & Company	140	<b>* Keystone Electronics</b> Lawrence Nelson Advertising	125	<b>Thermalloy</b> Warren-Guild	148
<b>* Curtis Instruments, Inc.</b> Marc Dorian, Inc.	82	<b>* Lambda Electronics Corporation</b> Michel Cather, Inc.	3rd cover	<b>* Thomson CSF</b> Bazaine Publicite	62
<b>Dana Laboratories</b> Dailey & Associates	12-13	<b>Lika Corporation</b> Moorhead Marketing	132	<b>* Topaz Electronics</b> Mesa Copy	130
<b>Datatron, Inc.</b> Larry Courtney Company	30	<b>Linear Digital Systems Corporation</b> Technical Publications Corporation	151	<b>* TRW Electronics, Semiconductor Division</b> The Bowes Company	7
<b>Decision Data Computer Corporation</b> Jordan Frederick & Company	134	<b>* LTT</b> Publibel	22E	<b>* Uniltron Corporation</b> Impact Advertising	37
<b>* Dialight Corporation</b> Michel-Cather, Inc.	131	<b>Lyon Metal Products, Inc.</b> Reincke, Meyer, & Finn, Inc.	165	<b>* VARO SEMICONDUCTOR, INC.</b> Warren-Guild	147
<b>Digital Equipment Corporation</b> Schneider Parker Guy, Inc.	141	<b>* Magneti Marelli S. p. A.</b> Pubbicor	85	<b>* Victory Engineering Corporation</b> A. D. Adams Advertising, Inc.	150
<b>* The Digilran Company</b> Jansson Advertising, Inc.	29E	<b>Magnetics, Inc.</b> Lando, Inc.	58	<b>* Wavetek Indiana</b> Chapman Michetti Advertising	122
<b>Divi, Inc.</b> Halloff & Caine	60	<b>Marco-Oak</b> Jansen Associates, Inc.	129	<b>Westinghouse Corporation</b> Ketchum, MacLeod & Grove, Inc.	162-163
<b>* Ducati Elettrotecnica Microfarad</b> Studio Busoli Gastone	24E	<b>Master Appliance</b> Klau-Van Pietersom-Dunlap, Inc.	129	<b>W. H. Brady Company</b> Klau-Van Pietersom-Dunlap, Inc.	166
<b>* Dynascan Corporation</b> <b>(Industrial Products Division)</b> Albert Jay Rosenthal & Company Advertising	143	<b>Micro Power Systems</b> Associated Adventures	76	<b>Wima, Westernerm</b>	16
<b>Eastern Air Devices</b> Weston Associates, Inc.	125	<b>Microsystems International Ltd.</b> Media Advertising Ltd	48-49	<b>Winnebago Industries, Inc.</b> Bozell & Jacobs, Inc.	161
<b>Eaton Truck Components/ATA Foundation</b> Meldrum and Fewsmitth, Inc.	170	<b>* Microtecnica</b> Lea Advertising	27E	<b>* Yokogawa Electric Works Ltd.</b> General Advertising Agency, Inc.	47
<b>Elec-Trol, Inc.</b> S. Michelson Advertising	140	<b>National Electronics</b> Lea Advertising	131	<b>Xerox Corp.</b> Needham, Harper & Steers, Inc.	159
<b>Electronic Applications Co.</b> Art Wroobel & Associates	131	<b>* National Semiconductor Corp.</b> Chiat/Day, Inc. Advertising	55-57		
<b>* Electronic Associates, Inc.</b> Gerald Clarke, Inc.	147	<b>Neff Instruments Corp.</b> Larry Courtney Company	136		
<b>* Electronic Molding Corp.</b> The Williams Company	151	<b>* Newport Labs</b> Hall Butler Blatherwick, Inc.	81		
<b>* Electronic Navigation Industries</b> Hart Conway Co., Inc.	67	<b>* Oscilloquartz SA, Neuchatel</b> M. R. Hofer Werbeagentur BSR/EAAA Bern	13E		
<b>* EL Instruments, Inc.</b> Langeler-Stevens, Incorporated	130	<b>* Philips Elcoma</b> Tag Intermarco	14E		
<b>Emerson &amp; Cuming, Inc.</b> Edwin F. Hall	148	<b>* Philips N. V. Pht/T &amp; M Division</b> Marsteller International S. A.	64		
<b>Emr-Telemetry</b> Carol Marketing Associates	15	<b>* Plessey Inc. Materials Div.</b> TCI Advertising	23E		
<b>* English Electric Valve Co. Ltd.</b> The London Advertising Partnership	16E 17E	<b>* Plessey Capacitors</b> Roles and Parker Ltd.	8E, 10E		
<b>* Excellon Industries</b> Eigin Davis, Inc.	28-29	<b>PRD Electronics, Inc.</b> Caroe Marketing, Inc.	2nd Cover		
<b>Executone, Inc.</b> Nadler & Larimer, Inc.	169	<b>* Procond S.p.A.</b> Quadrangolo	32E		
<b>* Fairchild GmbH</b> Evan Steadman Services Ltd.	30E	<b>RCA (Mobile Communications Systems)</b> J. Walter Thompson Company	168		
<b>Ferroxcube</b> Black-Russell-Morris	59				

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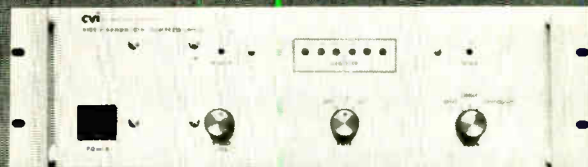
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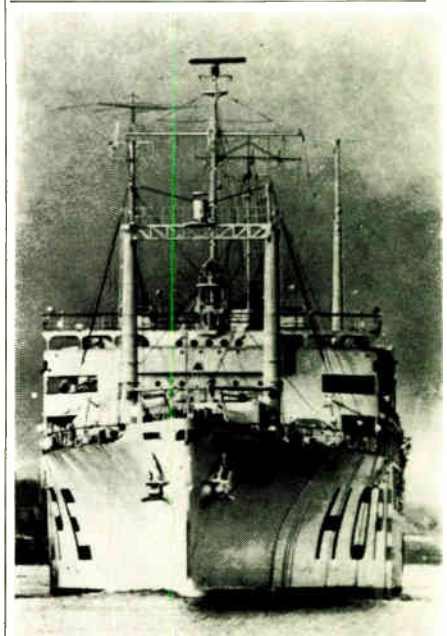
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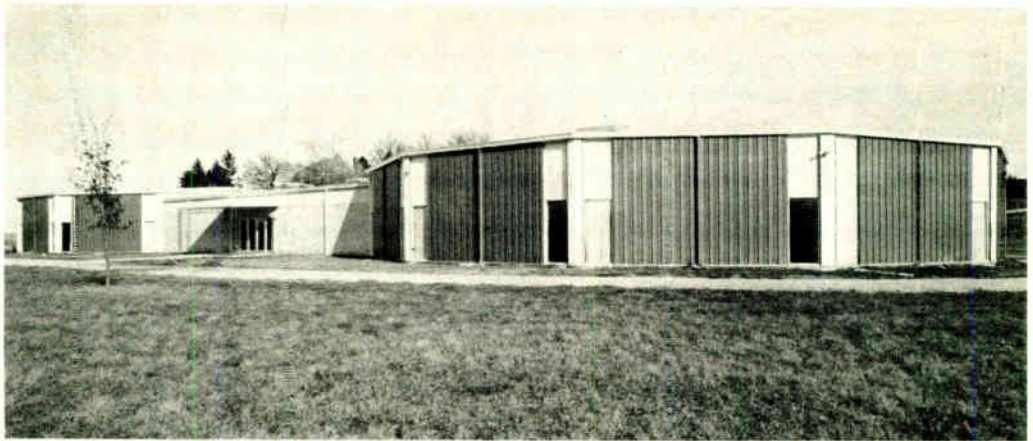
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# Petroleum and You (A History of the Former)

## Chapter Two: The Early Years

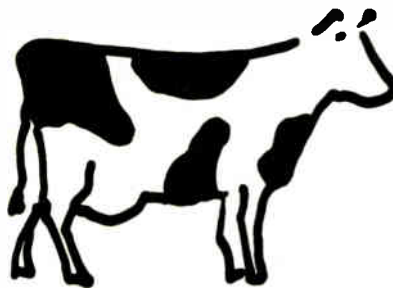
Civilizations began to flourish, and petroleum, at first little more than a bit player venturing timidly out from the wings, began to develop into the accomplished performer which would one day, amid well-deserved plaudits, take its rightful place at center stage nightly plus matinees on Wednesdays and Saturdays. For example, asphalt, a petroleum residue, was used around 600 B.C. by King Nebuchadnezzar in constructing the Hanging Gardens of Babylon, considered one of the seven wonders of the world until he fell behind in his watering.

In like manner, the Assyrians used asphalt in the building of their cities and received many nice compliments. One of the most treasured of these was the remark of Darius the First, King of Persia, which has been translated from ancient scrolls of the period as, "I really like your use of asphalt in the building of this city." He reportedly said this of Nineveh just before demolishing it.

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City of Nineveh after visit  
by Darius the First.

Meanwhile the ancient Chinese while drilling for salt inadvertently struck oil. Early documents indicate it tasted terrible on eggs but was found to work well as a fuel. Although this appeared at the outset to be a significant advance, it led them to the erroneous conclusion that anything which tasted terrible on eggs would make a good fuel. Several years were wasted pursuing this false line of reasoning—time that might have been better spent in coming up with the eraser, the black and white cow, and other important inventions.



The black and white cow,  
unknown in China to this day.

As for the western hemisphere, there is evidence that the American Indians were acquainted with petroleum hundreds of years before the arrival of the white man. They were, in fact, among the first to recognize the medicinal value of petroleum, and were it not for their research and dedication the petroleum bandage would today be only a half-realized dream.



The petroleum bandage as it might have been—a half-realized dream, and also coming unstuck at one end.

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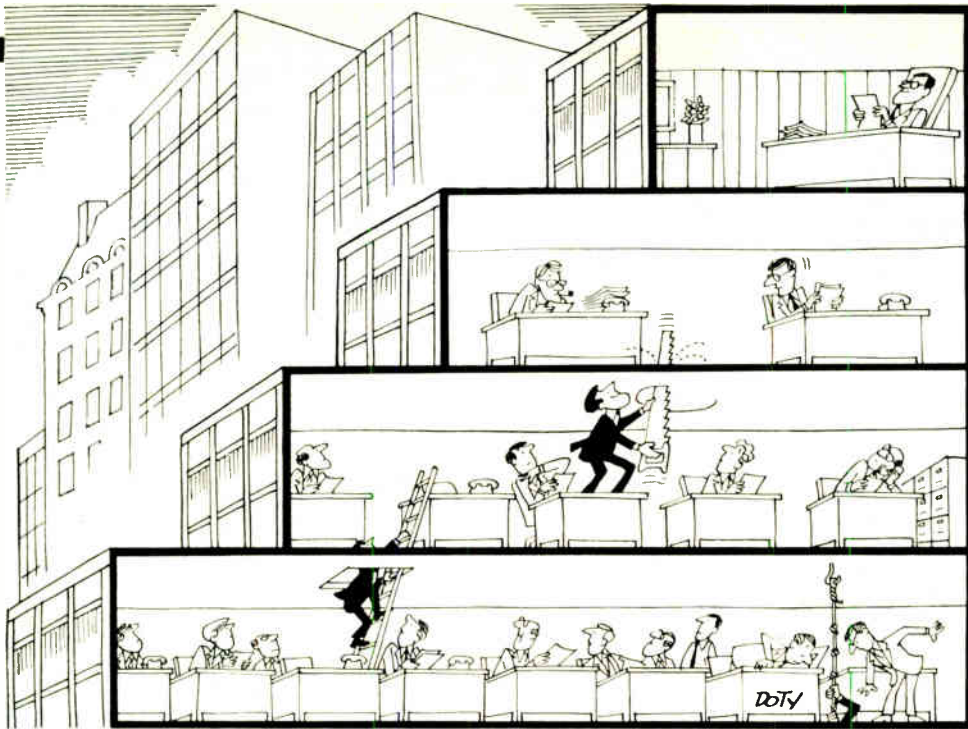
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Roy Doty



ALSO IN THIS SECTION:

EDUCATION

Handling the college misfit

TRAVEL COMMENTARY

Guide to the guidebooks

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World Radio History

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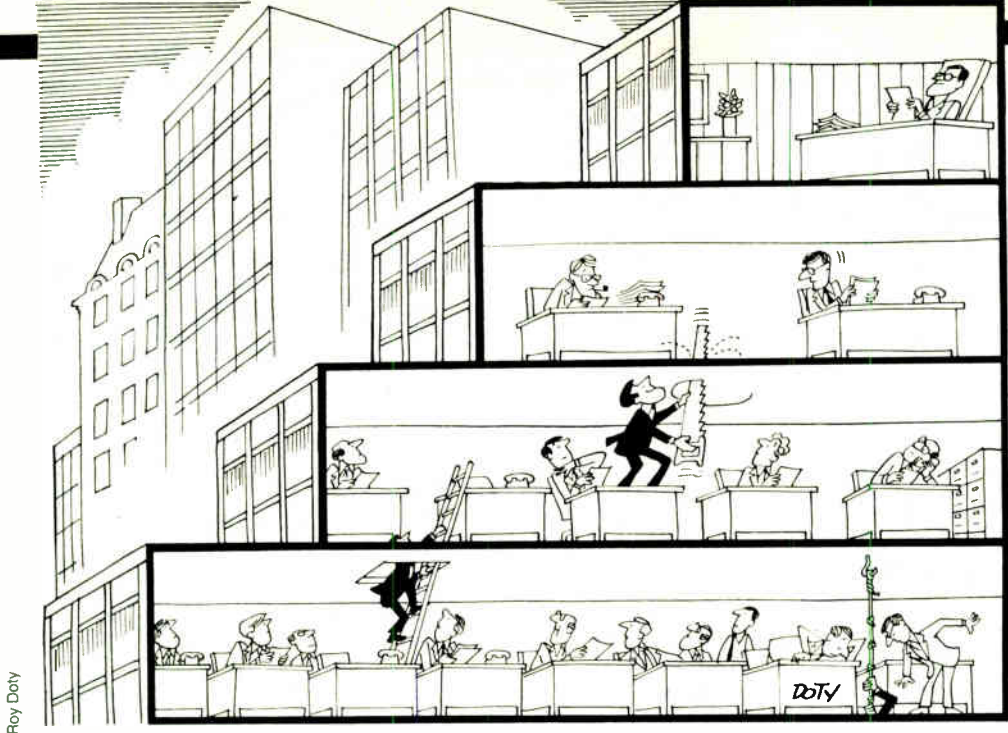
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son, "and is more pertinent today than ever before." If the basic decision to aim at management comes hard, the young man is wise to do some practical testing. One way is simply to turn away entirely from business for a year or two. Then, if corporate life still holds a strong enough attraction, he can return, this time perhaps with a greater energy and desire to forge ahead.

Another way—more consistent with the common need to earn a living—is to work in a small company for a year or two. The purpose is to try as varied a range of duties and responsibilities as the boss will allow.

Once an executive prospect has made his career decision, another point is given weight these days: He should think in terms of broad business experience, not merely job continuity. Now, in the early 1970s, the bigger, well-managed companies aren't nearly so leery of a job changer as they were even 10 years ago. Almost the opposite prevails. Many companies are, in fact, seeking smart, qualified younger men who have made some wise company-to-company moves. Often they are looked on as the best prospects for key jobs, assuming their company-changing has been thoughtful and not capricious.

"This is important for a young man to understand today," says Chicago consultant John Struggles, whose executive search efforts on behalf of major corporations keep him in close touch with current attitudes.

Another caveat for a younger executive is to avoid, if he can, the company that is overly paternalistic—or, at least, to be well aware of any excessive, smothering paternalism.

Further, he should think twice about getting himself on a big company's fast-transfer list that will have him periodically moving around the country to do the same work, even if the pay gets a little greener with each move. "The transfer list," says Struggles, "can bury a younger man, instead of being a road-way to high promotion."

What the young executive should do, say the pros, is study the career moves of the company's top men—and follow their leads. "If a younger guy in business isn't really aware of this," says McKinsey's George Foote, "he hasn't a good handle on what's going on."

Stepping up a notch, the middle manager in his 30s or 40s would be smart to keep in mind another trend of the day: going back to college. The reasoning is, of course, that by this age, one's formal education may have grown stale by corporate standards. Generally, the pros

agree that for key middle managers and top brass, back-to-study will gain momentum throughout the 1970s.

The biggest blunder, they say, is to stay complacent on this score, relying on seniority, illusive "status," and the oft-cherished ability to "handle people."

But balance, as in all elements of career planning, is needed. The quest for education can be naive for the businessman who goes overboard and becomes a "professional student." Too much seminar psychology, caution the experts, has been the undoing of many an otherwise sensible executive.

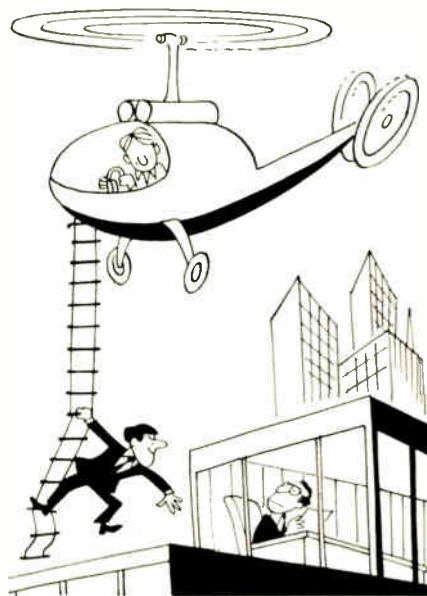
The manager who is just a step or so beneath top management obviously must follow a demanding strategy if he's to be in line for the ranking position above him. The danger is that he will push too hard, and antagonize, or conversely, *ignore* the right moves out of an unconscious fear that he may not really fit the top job.

What are obvious moves for the man steering a steady upward course? Some lesser items suggest themselves. For instance, getting to know the board members well, and making no secret whatsoever of one's quest for the top position. But the *prime* move is this: getting to know the flavor and spirit and technique of the whole business, not just one part of it.

This is where the prudent lateral move in a large business comes in. It can be most fruitful, the pros agree, to accept or even seek a horizontal shift (maybe for little or no more money) that involves entirely new and different job responsibilities; for potential top brass, varied experience is what shines.

But wise hands sound a clear caution. Says George Foote: "An upward move at the ranking executive level is not a game—it's a thoughtful strategy, based on true human motivations."

If it's phony, it probably won't work. ■



personal *Life*

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## The college misfit: What's the best course for parents?

The college malcontent and dropout are so prevalent as to be almost as much in evidence as the smiling June graduate. Examples can be culled from somebody's family experience on nearly every block in suburbia, and rare is the patio party that features no tale of the young guy or gal who can't make a go of it on campus.

In affluent Westchester County outside New York, an Ivy League dropout is defiantly selling shoes in a small retail shop in Yonkers. His banking-executive father bitterly complains to friends, "Paul is off the track—ruining his life." From a Thailand monastery, a former Columbia University anthropology major

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### EDUCATION

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writes to his professors that he has finally found "relevance." Two of the three children of the mayor of an upper-class bedroom town near Cleveland in the solid Midwest have suddenly dropped out—and the third wants to. Disillusionment on campus today permeates major universities and even disrupts the calm of once-tranquil small colleges coast to coast.

One man who has probed the rejection by youth of parental values, tracking the progress of 1,500 Harvard students for 10 years after they withdrew, is Dr. Armand Nicoli, a Harvard Medical School psychiatrist who specializes in social relations. He found that 90% of the drop-outs eventually returned to school. But many dropped out again, and only half of the returnees ever earned a degree.

A new pattern is emerging on campuses. Increasingly students are taking a year or more away from campus life, reassessing their goals, and returning to college. Certainly withdrawal is losing much of the stigma it once carried, as changes of the 1960s and 1970s have transmogrified the campus into a baffling, alien land to pre-1955 alumni. Even when they plug on to a degree, disenchanted students can become what one psychologist calls "technical drop-outs," aimlessly going through the motions of education.

But some experts assert that dropping out can be a potentially healthy move, if parents are supportive. Dean Ruth E.



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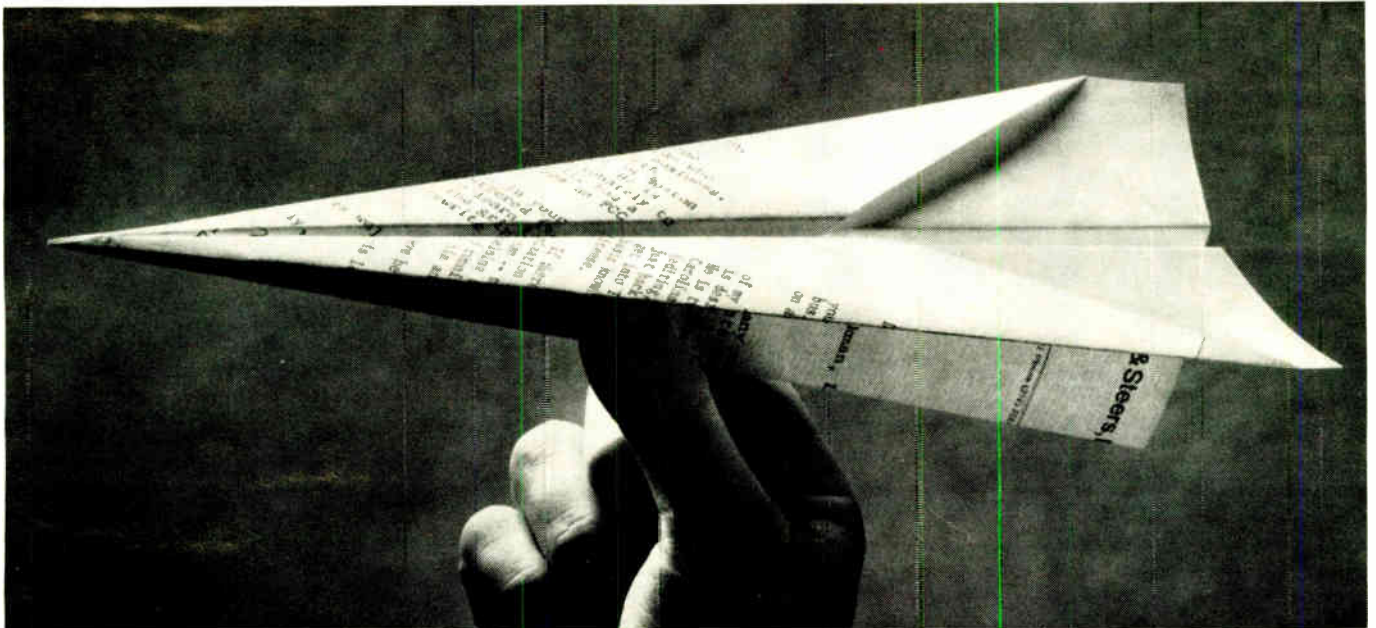
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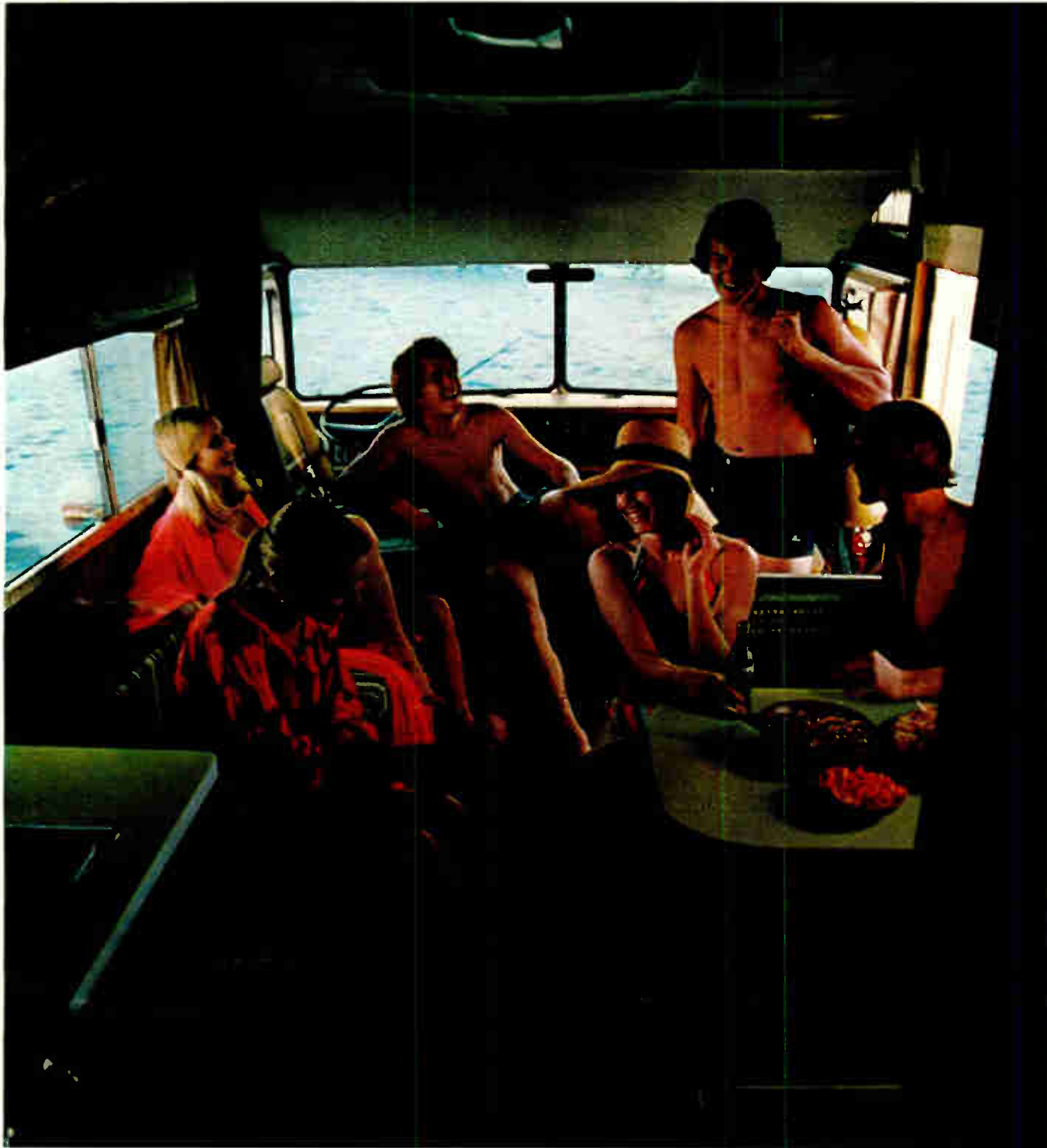
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But Grinnell's new Aquamatic On-Off sprinkler does more. It shuts itself off when the fire's out. It puts the water only where it's needed—on the fire, and not outside the fire area. So it keeps water discharge to a minimum.

Aquamatic is ideal for places where you have high value inventories, materials extremely sensitive to water, flash fire exposures, or expensive equipment and machinery. Because of its efficient use of water, it helps eliminate excessive down



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## personal business

### Venturing afield with Fielding, Fodor and friends

Snobbishly seasoned European travelers used to say that travel guidebooks were a great help—they singled out hotels and restaurants for the "tourists," so that the elite few knew what places to avoid until the season ended. The guidebooks may no longer be so reliable. There are so many, aimed at so many audiences, that there's hardly a watering hole from Shannon to Ankara that doesn't rate mention in somebody's handbook.

This year, as the new editions spread beyond the seas in a million and more

#### TRAVEL COMMENTARY

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First, all the guides this year—including *Fielding's Travel Guide to Europe 1973* (Fielding Publications, with William Morrow & Co., \$8.95), the favorite of a generation of U. S. tourists—were caught in awkward disarray by dollar devaluation and fluctuating currencies. Quoted rates and prices, therefore, are hardly more than ballpark figures this year in anybody's guide. More frank about it than most, Temple Fielding needed in a "Top Urgent!!!" warning to readers, pleading, "So don't shackle us to the doghouse if that Spanish mantilla is \$8.57 or \$8.69 instead of \$8.25 by the time you drop anchor."

Even in this era of the 747, Fielding's people still "drop anchor." Indeed, the *Fielding Guides* evoke the indulgent mood of shipboard yesteryears. The clubby, inside-y prose is solely concerned with creature comforts. The high priest of hospitality, Fielding focuses on the hotels, inns, restaurants and bistros of some 30 countries and regions. For historical or cultural points of interest, readers must look elsewhere. Politics, particularly angry, party-pooing politics, is also anathema. On Greece, Fielding takes the view that its controversial regime is none of the *Guide's* business.

Single-minded devotion to bed-and-board makes Fielding's *Guide* comprehensive, but some familiarity with Fielding's taste is necessary; nearly all the judgments are his own. Quickest way to master Fielding is to pick a place with which you're familiar, and compare what he says with what you know. Judging the



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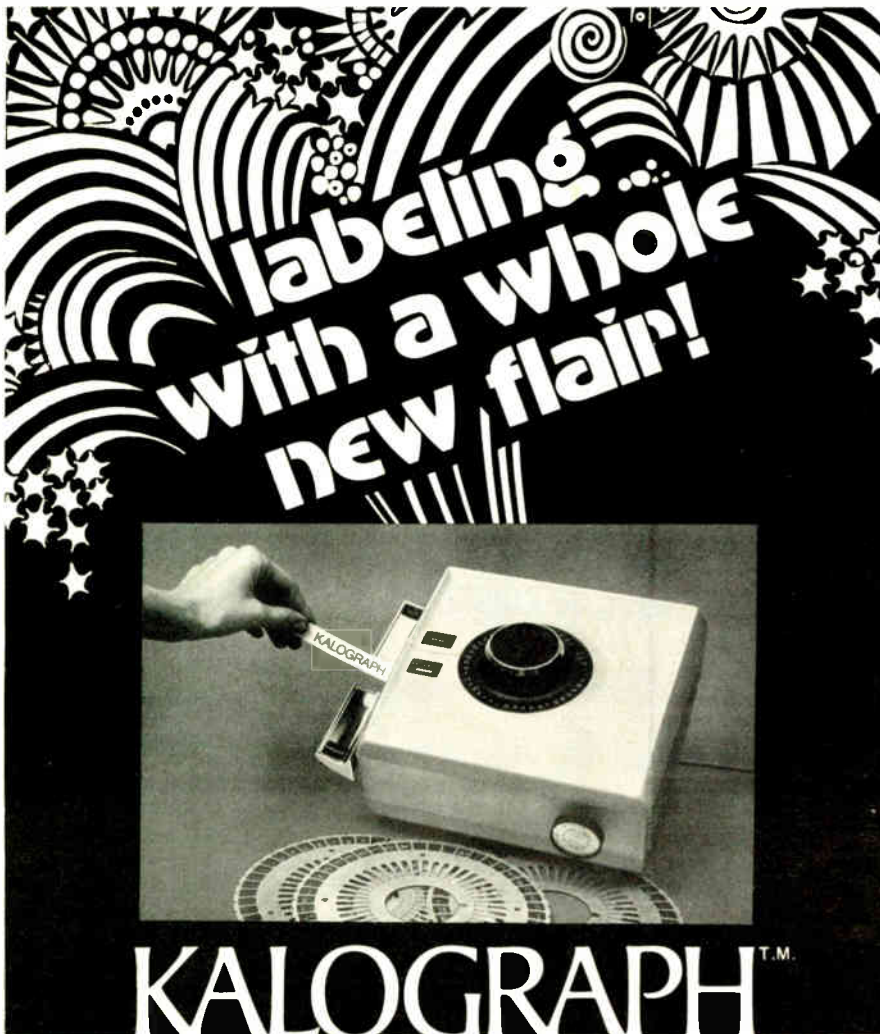
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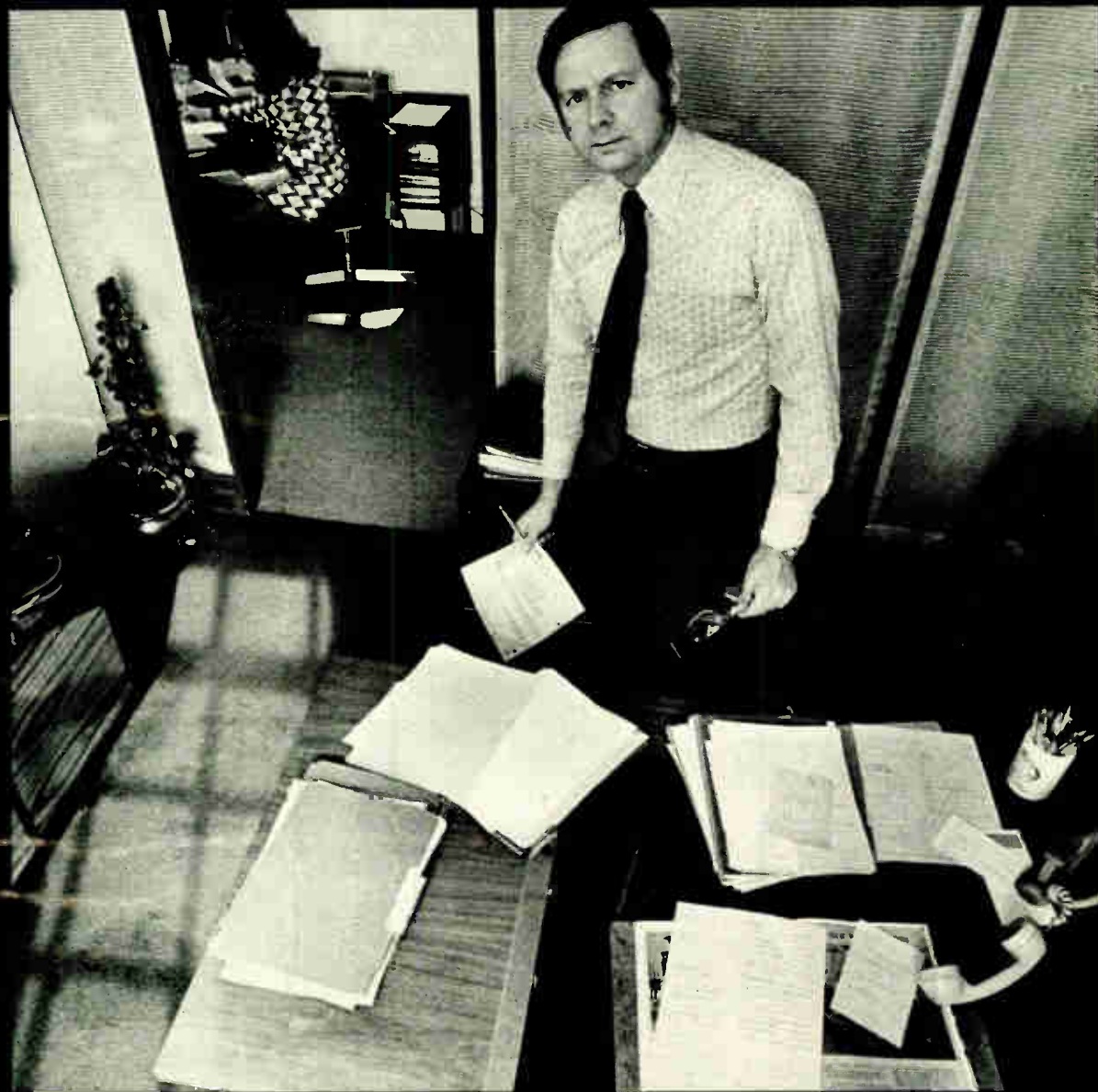
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rest of the book is easy.

Another full-scale guide is *Fodor's Europe 1973* (David McKay Co., \$9.95). Eugene Fodor's books are neatly arranged, fact-packed, and occasionally dull—as, some travelers will insist, guide-books ought to be. *Fodor's Europe* is a tightly edited compilation of reports from a corps of native correspondents. There are more countries (35) but fewer places listed, since, judging from the bland commentary, Fodor doesn't list those he might have to condemn. Also, he devotes some space to a historical sketch of each country, sights to see, street maps, and other non-housekeeping matters Fielding ignores.

One wonders whether a 1,168-page volume (Fodor) or a 1,403-pager (Fielding) is an ideal traveling companion. Fielding stabs at the problem by publishing his *Guide* in a "Fieldingflex" binding, which can be sliced up the spine, so that only those parts pertinent to one's trip need be hauled along.

The airlines, particularly Pan American, offer some of the most portable guides. Pan Am's so-called *Insider's* series and what might be called its *Real* series are prime examples. Pan Am's *The Real Europe and the Mediterranean* (Bantam, \$2.95), *The Real Restaurant Guide to Europe*, and *The Real Economy Guide to Europe* (both \$1.95) are pocketbooks. For the money, they are panoramic in view, if occasionally skimpy on detail. *Real Europe*, for instance, cites only seven restaurants in London. The *Real Restaurant Guide* does better, but still cites only 26.

Pan Am's *Insider's* series—there's one for New York, London, Paris, Amsterdam and Rome (Random House, \$4.95 each)—strives for convenience by being published as a series of pocket-sized folding cards. Each card lists a category of restaurant, activity, entertainment or the like. The reverse side is a street map, keyed for finding the places listed. Chief problem is the advance planning it requires to use the cards efficiently, without carting the whole packet around.

None of the new breed tops the familiar city-by-city *Michelin Guides* (U. S. distributor: French & European Publications, Inc., 610 Fifth Ave., New York, N. Y. 10020, English editions, \$3.50) for portability and authority. Still, the titles proliferate. There are walking guides, shopping guides, and even fleamarket guides—*Street Markets* by Carol L. Cohen (Grosset & Dunlap, \$2.95), for instance—for deserving audiences.

But, then, there are also guides to travel on mini-budgets that only the knapsack set would believe, and some sexily titled guides to the fleshpots that only the socially obtuse might need. The message: Besides Fielding, Fodor and friends, strangers have crept into the travel bookshelf who bear more watching than reading.

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4. If someone is trying to reach you while you're talking on the phone, a tone signal will tell you a call is waiting. (It will also tell you whether the call is from outside or inside the company.)

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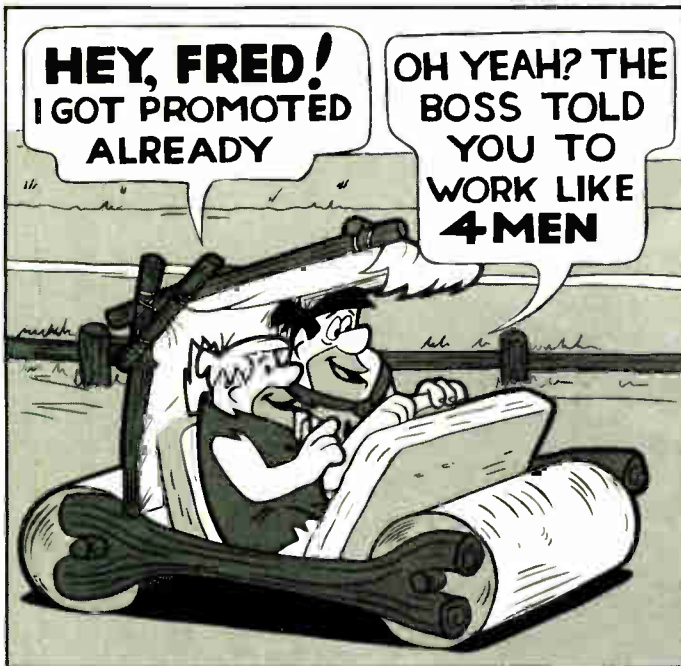
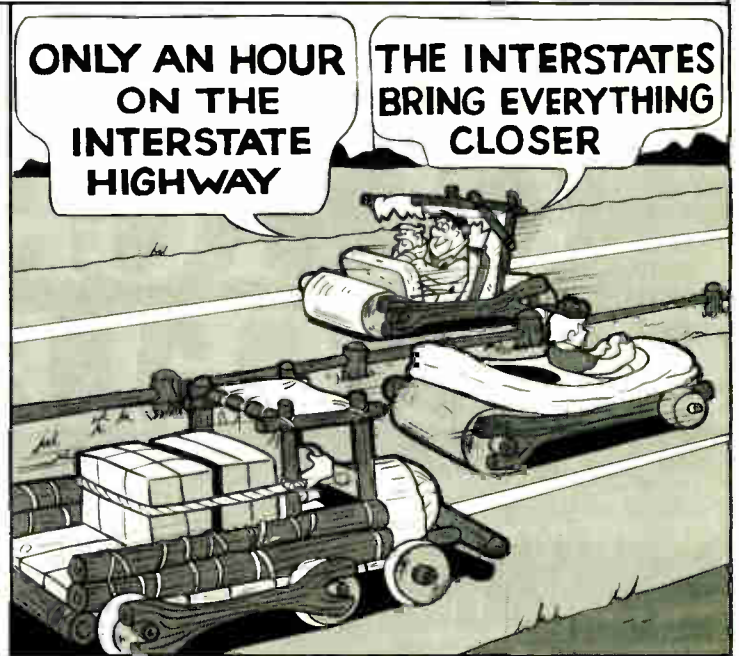
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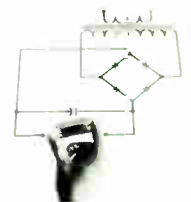
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