July 5, 1973

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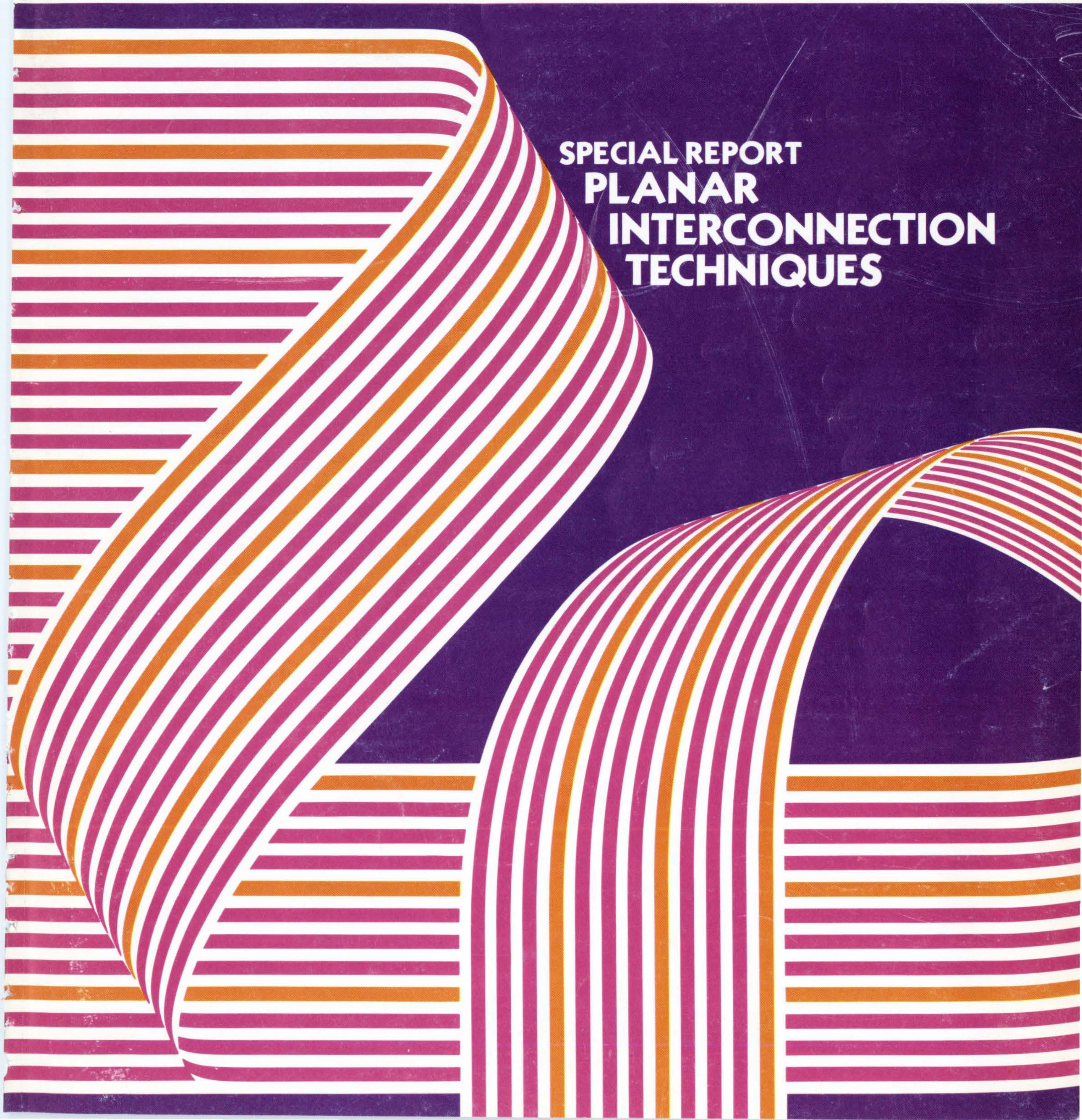
Electronics®

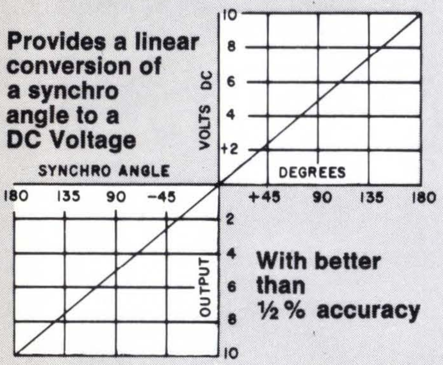


3 Wire Synchro to Linear D.C. Converter

ACCURACY ½ %

#MAC 1422-1

Provides a linear conversion of a synchro angle to a DC Voltage



With better than ½% accuracy

- Scaled for ±10V DC output
- Operates from ±15V supplies
- No external adjustments
- Hermetically sealed
- Output short circuit protected
- Units can be altered to operate with different L-L Voltages or frequency

Specifications

Accuracy: ±1% over temperature range
Input: 11.8V, 400HZ line to line 3 wire synchro voltage
Output impedance: less than 10 Ohms
Input impedance: 10K minimum line to line
Reference: 26V ±10% 400HZ (Unit can be altered to accommodate 115V if available at no extra cost)
Operating temperature range: −25°C to +85°C
Storage temperature range: −55°C to +100°C
DC power: ±15V ±1% @ 75ma (approx.)
Case material: High permeability Nickel Alloy
Weight: 6 Ozs.
Size: 3.6" x 2.5" x 0.6"

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- Linear DC to Synchro Converter
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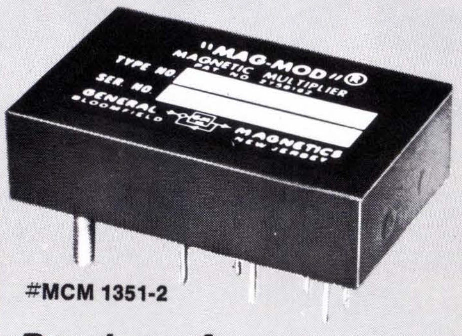
- 3 Wire to Linear DC Converter
- 3 Wire to Sine-Cosine Converter
- Sine-Cosine Generators
- Precision Modulators
- Precision Analog Multipliers
- Squaring/Square Root Modules
- Precision Analog Divider
- Precision A.C. Regulators
- Demodulators
- Transformers

Analog Computing Applications

- Trigonometric Manipulations
- Multiplying
- Dividing
- Squaring
- Modulating
- Automatic Gain Control
- Demodulation
- RMS Computation
- Phase Measurement
- AC Amplitude Regulation and Modulation
- Linearizing
- Square Rooting
- Power Measurement
- Ratio Measurement

4 Quadrant Magnetic Analog Multiplier

DC x AC = AC Output



#MCM 1351-2

Product Accuracy is ±1/2% of all readings Over Full Temperature Range of −55°C to +125°C

- Product accuracy is specified in % of reading for all output analog voltage product points over the full military temperature range instead of % of full scale error giving superior results for small values.
- Linearity, product accuracy, and zero point virtually unaffected by temperature changes.
- All units are hermetically sealed and completely shielded from external electric or magnetic fields.

Specifications Include:

Transfer equation: $E = XY/3$
X & Y input signal ranges: 0 to ±3V Peak
Maximum static and dynamic product error: ½ % of point or 2 MVRMS, whichever is greater, over entire temperature range
Input impedance: X = 10K; Y = 10K
Full scale output: 3 VRMS
Minimum load resistance for full scale output: 2000 ohms
Output impedance: Less than 50 ohms
X input bandwidth: ±0.5db, 0 to 200 hertz
Y input bandwidth: ±0.5db, 20 hertz to 1000 hertz
DC power: ±15V unless otherwise required @ 20 ma
Size: 1.8" x 1.1" x 0.5"

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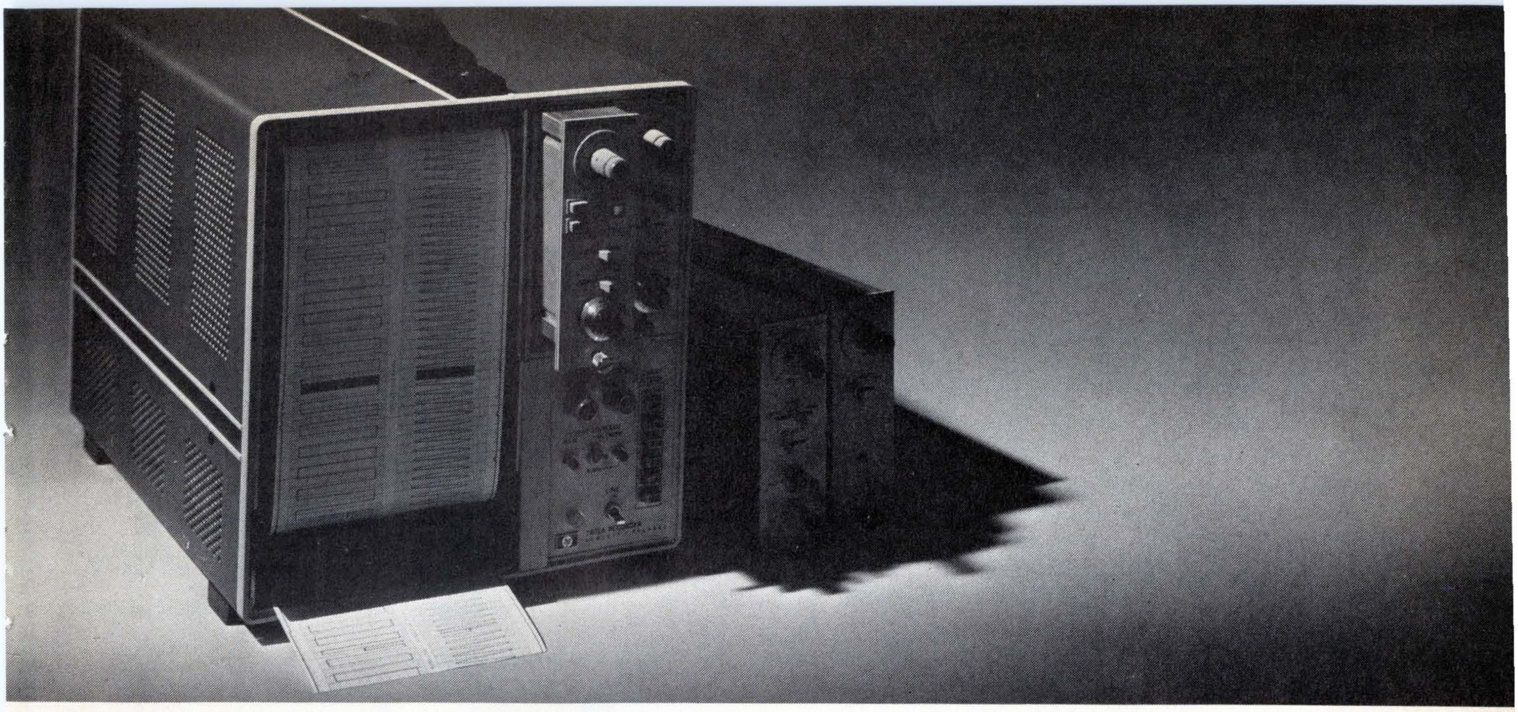
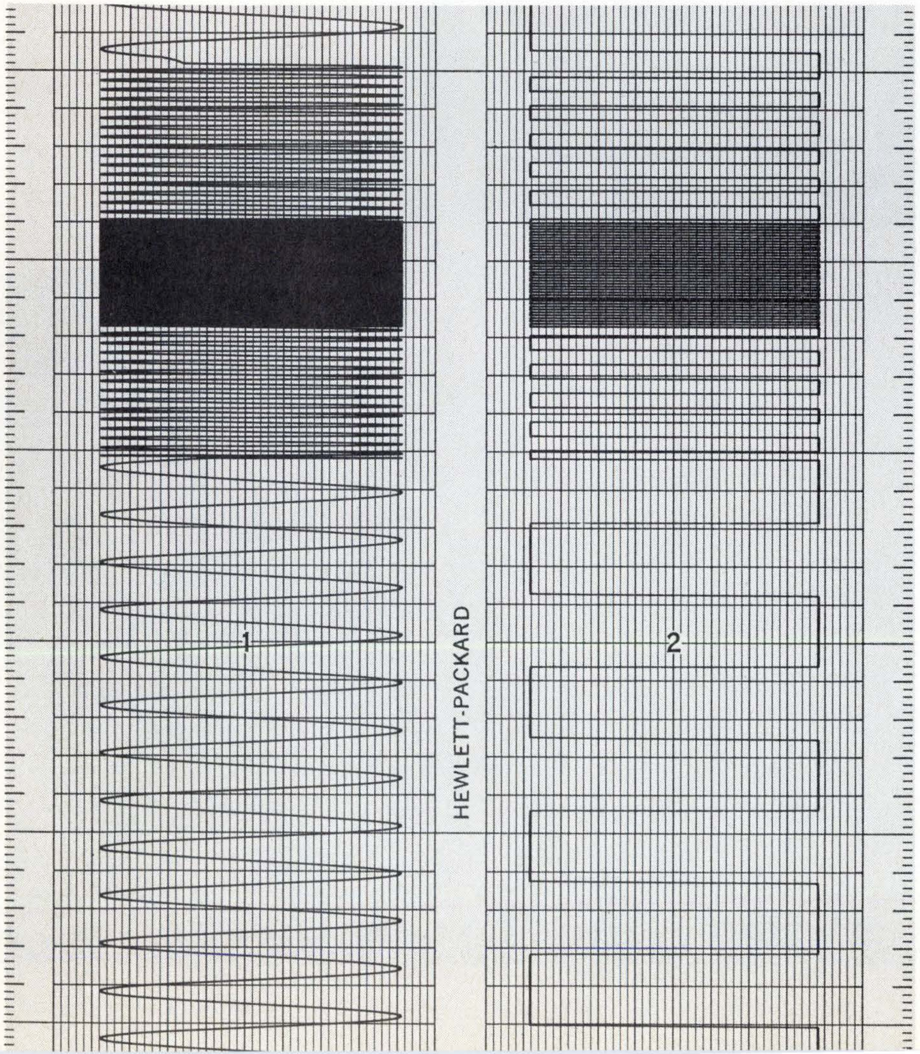


HP's new low cost, plug-in oscillographic recorder gives you more of everything.

(Make the trace-to-trace comparison)



First, check HP's bigger picture, a full 50 mm wide. Then there's smear-proof, skip-proof black ink that goes bone dry on contact (even at high speeds). Pulse or square wave recording won't produce overshoot problems. And non-fatiguing stainless steel pens help make the trace virtually fail-safe. You can even get remotely controlled event marker and timer options.

Trace-to-trace, HP's 7402 outperforms oscillographic recorders costing twice as much. Plus it's the only machine with ten combinations of plug-in signal conditioners. For low-gain recording, the basic 7402 comes complete with two 20MV/div plug-ins. Economical high or medium-gain modules are available as options.

Make your own trace-to-trace comparison. You'll sell yourself on the 7402's combination of big picture, fail-safe writing, versatility, high performance, HP reliability and low cost. Get complete details from your field representative, or write Hewlett-Packard, Palo Alto, California 94304; Europe: Box 85, Ch-1217 Meyrin 2, Geneva, Switzerland; Japan: Yokogawa-Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-Ku, Tokyo, 151.

113-04

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If you'd like complete technical and pricing information, please write or call Ken Collins at (408) 298-7080.

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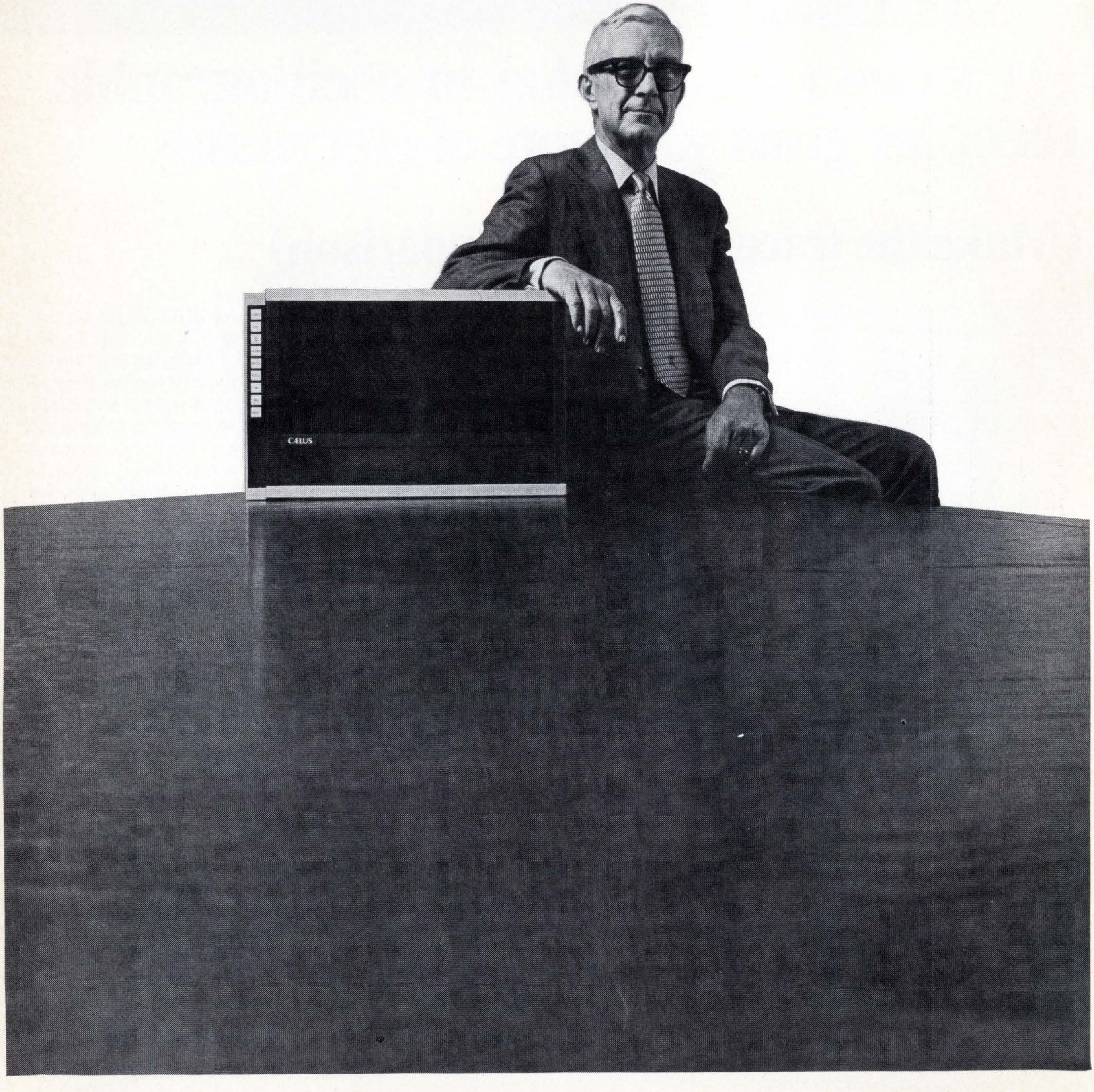


Electronics

The International Magazine of Electronics Technology

Vol. 46, No. 14 ■ July 5, 1973

Highlights

The cover: Plane facts about wiring, 84
Flat cable and flexible circuitry, originally military in purpose, have commercial advantages, too. In this special report, one author tells of the labor savings that result from designing a system around flat cable, another describes a dual-dielectric flat cable for high-speed data transmission, and the third analyzes the assembly economies possible with flexible circuits. Cover graphics are by Gabor Kiss.

Electronics enters the nation's newsrooms, 65
Attracted by large savings in labor costs, all sizes of newspaper all over the country are beginning to computerize their production processes. The larger papers need minicomputers, the smaller ones can manage on intelligent terminals.

Two-way CATV awaits low-cost frame-grabbers, 77
The FCC wants interactive TV, the cable-TV operators are strongly in favor, but the engineers have yet to come up with one of the essentials—a reliable video refresh memory or frame grabber costing about $100.

Minicomputer evaluates epi layer on ICs, 102
A bottleneck occurs in the production of ICs when the quality of newly deposited epitaxial layers has to be checked by hand. But, as the fifth "Minicomputers in action" article shows, linking a minicomputer to the test instrumentation speeds the process up and increases its accuracy, too.

And in the next issue. . .
Modern technology makes majority logic available to everyone. . .special report on industrial robots. . .minicomputers take over airplane testing (sixth article on "Minicomputers in action").

Electronics

Publisher's letter

As the Watergate saga unfolds, it goes to prove that the best stories out of Washington don't come from press releases but from the hard digging—"trudging around town with pencil and paper, talking to people," as Ray Connolly, our Washington bureau chief puts it. Aerospace Editor Bill Arnold, the No. 2 man in Washington, agrees.

Both Connolly and Arnold offer proof of the point with their respective stories assessing the prospects of trade with the Peoples Republic of China (p. 73) and the future needs of the U.S. space program in the shuttle era (p. 74). What both stories have in common is that they stemmed from internal documents that the sources were willing to discuss but unwilling to release.

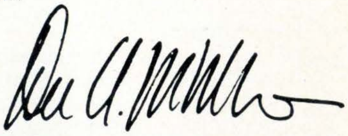
Arnold's story came out of a meeting of NASA's Space Program Advisory Committee, comprised of university and industry scientists. Though Arnold later was refused a copy of the NASA Office of Space Science budget outlook for 1975 and beyond, no one kept him out of an open meeting where he took extensive notes on its contents.

John Sodolski, vice president for communications and industrial electronics at the Electronic Industries Association, provided fuel for Connolly's pencil after the EIA vice president returned from Canton in search of a market for U.S. goods. Even though Sodolski held back an EIA staff report on China he talked about it freely, stressing how the Chinese "put great importance on the existence of 'American friends of the new China'."

Design engineers are accustomed to repeated encounters with a kind of technological *déjà vu*—what they design is used in the production of every-day items that they themselves use. But it's not often that an engineer can actually help to change the very nature of that item.

Something like that is happening with daily newspapers. Because of the adoption of electronic editing and printing systems, such as are described in the Probing the News on page 65, newspapers can print more-up-to-the-minute news. Those CRT terminals, optical character readers, and computers have broken a decades-old cycle in which news stories were typed, edited with a pencil, cast into lines of metal type, molded into stereotype plates that were locked on a press, and finally printed and delivered. So much time has been saved that some newspapers actually can make changes in "breaking" stories only five minutes before those stories are printed.

Planar wiring—a concept that includes flat cable and flexible circuits—has done a lot to ease the interconnection headaches in today's compact, sophisticated systems. Starting on page 84, y›u'll find a three-part special report on planar wiring that was put together by Packaging and Production Editor Steve Grossman. The report highlights how the planar approach to interconnection can bring significant economies to system design, how flat cable can now handle the computer's ultrafast pulses, and how flexible circuitry can save on assembly time.



July 5, 1973 Volume 46, Number 14
91,614 copies of this issue printed

Published every other Thursday by McGraw-Hill, Inc. Founder: James H. McGraw 1860-1948. Publication office 1221 Avenue of the Americas, N.Y., N.Y. 10020; second class postage paid at New York, N.Y. and additional mailing offices.

Executive, editorial, circulation and advertising addresses: Electronics, McGraw-Hill Building, 1221 Avenue of the Americas, New York, N.Y. 10020. Telephone (212) 997-1221. Teletype TWX N.Y. 710-581-5234. Cable address: M C G R A W H I L L N. Y.

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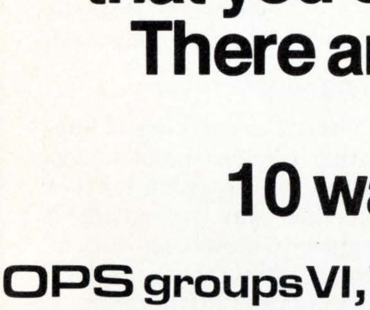

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Readers comment

On microprocessors

To the Editor: Four American manufacturers of microprocessors were listed in "East challenges West," [Electronics, June 7, p. 40]. As previously reported in *Electronics*, Rockwell International also has a microprocessor.

Scotty Maxwell
Rockwell Microelectronics division
Anaheim, Calif.

IC timer corrections

To the Editor: In my article, "Timer's duty cycle can stretch over 99%," in Engineer's notebook [*Electronics*, June 21, p. 129], the timing equations in the first figure (a) should have contained the constant 0.685, rather than 0.8. In the second figure (b), resistances R_A and R_B are each composed of a portion of the 10-kilohm potentiometer in series with a 1.2-kilohm resistor.

Michael S. Robbins
Los Angeles, Calif.

Calculating square roots

To the Editor: I am writing to suggest a rather obvious possible improvement in the algorithm for root extraction that was presented in your Engineer's notebook article, "More computation shortcuts with pocket calculators" [*Electronics*, March 29, p. 92].

For the square-root algorithm, I suggest that, having found the first approximation, rather than clearing the register, you should take the reciprocal and then multiply by N. It is still necessary, unless the calculator has a memory, to write down the first approximation result so that it can now be added as the next step. Where higher-power roots are to be extracted, the result of the first approximation calculation could be raised to the appropriate power (by squaring or higher-power algorithms, which are, I think, universally known, and which were mentioned in your article), and then you take the reciprocal and carry on as before.

W. Lyons
Managing Director
Lyons Instruments Ltd.,
Hoddesdon, Herts., England

40 years ago

From the pages of Electronics, July 1933

Radio production and the jobs of radio engineers depend on radio sales.

Radio engineers and radio technical men generally will therefore be deeply interested in the plans which the Radio Manufacturers Association has underway for a vigorous Radio Prosperity Campaign during September.

This month of active retail selling—coupled with rehabilitation of existing radio sets—will prepare the nation for a great series of special broadcast programs—Radio Progress Week, October 2 to 7.

Nearly seven million homes have obsolete radio sets which should be replaced. Thirteen million other homes have no radios at all. And among the millions of homes with workable sets, a large proportion need overhauling of installation, tubes or parts. Then there are opportunities to sell second or third "additional" sets, and automobile radios. And to put radios in offices, shops, stores and places of business.

The Radio Prosperity Campaign is a constructive, well-planned effort to stimulate radio sales and radio prosperity all along the line—among set manufacturers, parts makers, raw material suppliers, and broadcasters. It is a united drive to get, for radio, the dollars of the general public, for which the manufacturers of automobiles, refrigerators, clothes, and other personal commodities will be bidding.

The Radio Prosperity Campaign will put radio "back on the map," this Fall.

Industry's "New Deal" is under way.

With the signing of the National Industrial Recovery Act and the appointment of General Hugh S. Johnson as its administrator, President Roosevelt has put into action a revolutionary change in the industrial structure of America.

And now, like other businesses and industries, the radio industry is trying to find out just how it fits into the new industrial picture under the National Recovery Act, and what its responsibilities and benefits will be under the new plan.

SCRs		ON-STATE (RMS) CURRENT									
		0.25 AMP	0.8 AMP	4.0 AMP					8.0 AMP	12 AMP	16 AMP
		Case 28 Style 8	Case 29 TO-92 Style 10	Plastic Case 77-02 Style 2			Plastic Case 90-04 Style 1		Case 90-04 Style 1	Case 221-02 TO-220 AB Style 1	
V_{DRM} V_{RRM} BLOCKING VOLTAGE (DC OR PEAK) VOLTS	15 V	MCR051	MCR101	—	—	—	—	—	—	—	—
	25 V	—	—	—	—	—	—	—	MCR3000-1	—	—
	30 V	MCR052	MCR102 2N5060	2N6236	MCR106-1	MCR107-1	MCR406-1	MCR407-1	—	—	—
	50 V	—	—	2N6237	—	—	—	—	2N4441 MCR3000-2	2N6394	2N6400
	60 V	MCR053	MCR103 2N5061	—	MCR106-2	MCR107-2	MCR406-2	MCR407-2	—	—	—
	100 V	MCR054	MCR104 2N5062	2N6238	MCR106-3	MCR107-3	MCR406-3	MCR407-3	MCR3000-3	2N6395	2N6401
	150 V	—	MCR115 2N5063	—	—	—	—	—	—	—	—
	200 V	—	MCR120 2N5064	2N6239	MCR106-4	MCR107-4	MCR406-4	MCR407-4	2N4442 MCR3000-4	2N6396	2N6402
	250 V	—	—	—	—	—	—	—	—	—	—
	300 V	—	—	—	MCR106-5	MCR107-5	—	—	MCR3000-5	—	—
	400 V	—	—	2N6240	MCR106-6	MCR107-6	—	—	2N4443 MCR3000-6	2N6397	2N6403
	500 V	—	—	—	MCR106-7	MCR107-7	—	—	MCR3000-7	—	—
	600 V	—	—	2N6241	MCR106-8	—	—	—	2N4444 MCR3000-8	2N6398	2N6404
	800 V	—	—	—	—	—	—	—	—	2N6399	2N6405

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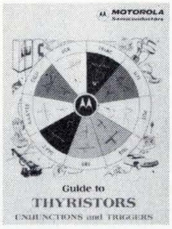
Now you can get control in solid state relays and light industrial applications from plastic triacs starting at 0.45 A current capability, 30 V blocking voltage, priced low as 50¢, 100-up. Or, in higher voltage designs use our latest triacs in the rugged, dependable Thermowatt TO-220AB case, the first 12 A plastic in the industry to provide 9600 W of full-wave control.

Now you can get control from SCRs beginning at 0.25 A at 15 V and offering a low, low 100-up 28¢ price. Try a 4-amp device for temperature control. Move up to 8-amps for battery charging applications. Then build up to the highest-current plastic SCRs in the industry — our new 16 A 2N6400 series.

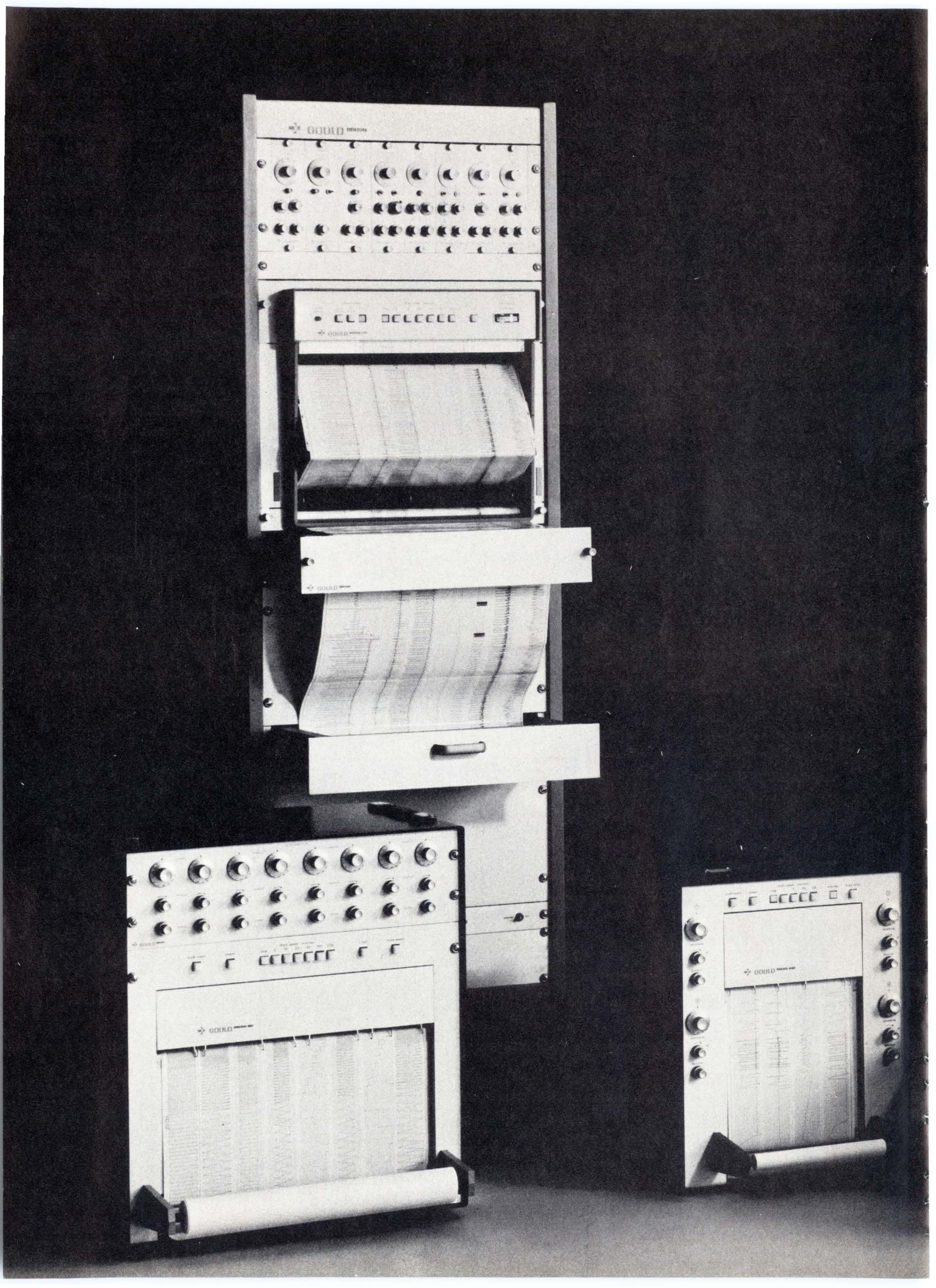
See your Motorola distributor or factory representative today. He'll help you pick the plastic thyristors you want, for the precise degree of full or half-wave stepless power control you need. They're up to it!

Use the reader service number to get your copy of our new "Guide To Thyristors." It contains selection and application guides, talks about definitions, symbols, technology and terminology, provides a complete cross reference and lists prices of all Motorola thyristors: SCR, triac, unijunction or trigger; plastic *or* metal.



From Motorola, the *plentiful plastic* thyristor producer.

TRIACs		ON-STATE (RMS) CURRENT												
		0.45 AMP	0.65 AMP	0.8 AMP	4.0 AMP			8.0 AMP		10 AMP		12 AMP		
		Case 29-02 TO-92 Style 12			Case 77 Style 5			Case 221-02 TO-220 AB Style 2		Case 90 Style 4		Case 221-02 TO-220 AB Style 2		
V_{DRM} V_{RRM} BLOCKING VOLTAGE (DC OR PEAK) VOLTS	25 V	—	—	—	2N6068	2N6068A	2N6068B	—	—	MAC11-1	MAC10-1	—	—
	30 V	MAC92-1 MAC92A-1*	MAC93-1 MAC93A-1*	MAC94-1 MAC94A-1*	—	—	—	—	—	—	—	—	—
	50 V	—	—	—	2N6069	2N6069A	2N6069B	—	—	MAC11-2	MAC10-2	—	—
	60 V	MAC92-2 MAC92A-2*	MAC93-2 MAC93A-2*	MAC94-2 MAC94A-2*	—	—	—	—	—	—	—	—	—
	100 V	MAC92-3 MAC92A-3*	MAC93-3 MAC93A-3*	MAC94-3 MAC94A-3*	2N6070	2N6070A	2N6070B	—	—	MAC11-3	MAC10-3	—	—
	200 V	MAC92-4 MAC92A-4*	MAC93-4 MAC93A-4*	MAC94-4 MAC94A-4*	2N6071	2N6071A	2N6071B	2N6342	2N6346	2N6154 MAC11-4	2N6151 MAC10-4	2N6342A	2N6346A
	300 V	MAC92-5 MAC92A-5*	—	—	2N6072	2N6072A	2N6072B	—	—	MAC11-5	MAC10-5	—	—
	400 V	MAC92-6 MAC92A-6*	—	—	2N6073	2N6073A	2N6073B	2N6343	2N6347	2N6155 MAC11-6	2N6152 MAC10-6	2N6343A	2N6347A
	500 V	—	—	—	2N6074	2N6074A	2N6074B	—	—	MAC11-7	MAC10-7	—	—
	600 V	—	—	—	2N6075	2N6075A	2N6075B	2N6344	2N6348	2N6156 MAC11-8	2N6153 MAC10-8	2N6344A	2N6348A
*Denotes A Version	800 V	—	—	—	—	—	—	2N6345	2N6349	—	—	2N6345A	2N6349A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People

Computer 'ombudsman' steps up from designing

Janet Norman, the newly appointed vice president of communications at Singer Corp.'s Business Machines division, New York, has two distinctions in her present position—the post was created especially for her, and she is the first woman vice president of the division.

"My function will be to act as an ombudsman," says the soft-spoken Miss Norman. Specifically, Miss Norman will have several functions including: organizing and presiding at point-of-sale industry shows, holding seminars, handling news releases, giving demonstrations of the POS system, working with financial analysts, arranging contracts, and working with various customers in all aspects of customer relations. The new vice president was instrumental in the design of the Singer POS unit, the MDTS or Modular Data Transaction System, and one of her aims is to educate the public about her electronic cash register system and the capability of computers. "No one has ever really explained to the public what computers are and what they can do, and as a result, there are many misconceptions, fears, and mixed emotions about them," she observes.

Innovation. About the creation of the point-of-sale systems and her role as a computer expert, she says: "Very rarely does one get involved in the innovation of design. Although I will miss designing, being part of market-support management is, of course, a great attainment." Miss Norman, an expert in terminal-based information systems, joined Singer in 1966 as manager of advanced systems for the Consumer Products division. She moved up to director of systems research in 1970, and then became director of retail systems support for the Business Machines division in 1972 before attaining her present post.

A native New Yorker, Miss Norman graduated *magna cum laude* from Hunter College in three years and won a Phi Beta Kappa key. Later, she studied mathematics at Cornell University. Before joining Singer, Miss Norman worked as a computer expert with Foster Wheeler Corp. and for the ITT Information Systems division. Before coming to Singer, she worked for the American Stock Exchange, designing a terminal system, and she was the first woman allowed fulltime on the floor of the exchange, overseeing the design and operation of the terminal system. In her spare time, the petite Miss Norman collects cash registers because "POS is a computerized cash register."

Phil Thomas sets a fast pace for himself

Twelve years ago, he recalls with a smile, he was explaining to customers why Fairchild's logic-product line wouldn't make it, and why Texas Instruments' logic would. Today, Philip R. Thomas, urbane, 38-year-old transplant from England's West Country—and U.S. citizen as of 1969—is the new general manager of the MOS Products division of Fairchild Camera & Instrument Corp., Mountain View, Calif. He succeeds Roy H. Pollack, who re-

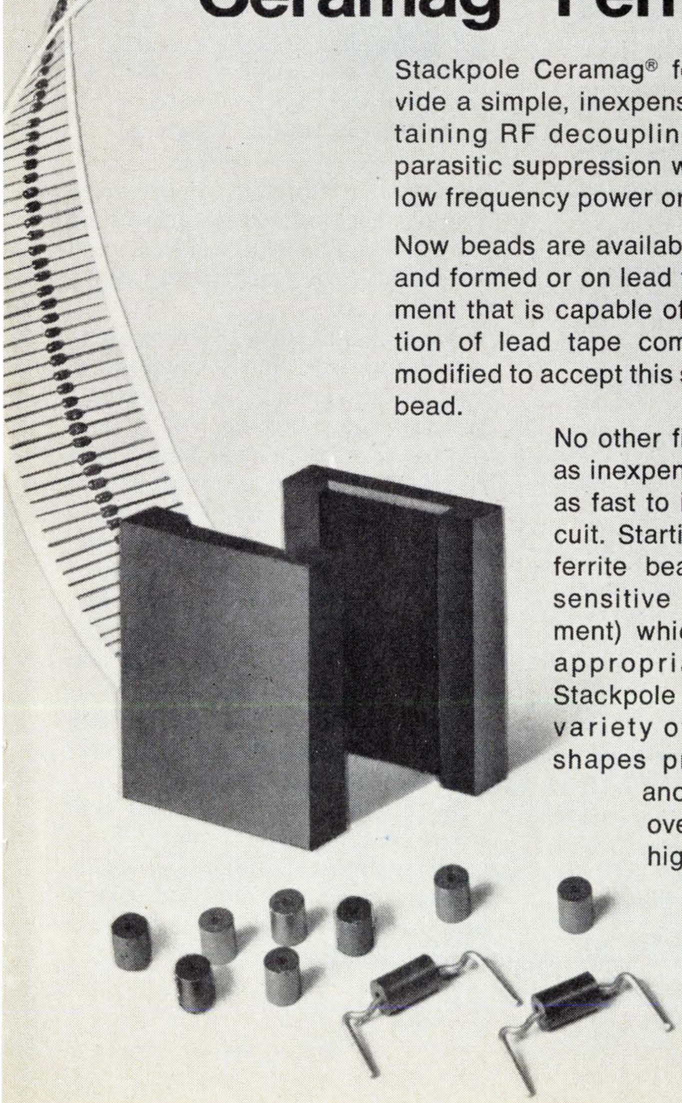
Distinction. Janet Norman's vice presidency is a job created especially for her.

NEW FAST ANSWER FOR ELECTRONIC NOISE PROBLEMS...

Ceramag® Ferrite Beads on Lead Tape

Stackpole Ceramag® ferrite beads provide a simple, inexpensive means of obtaining RF decoupling, shielding and parasitic suppression without sacrificing low frequency power or signal level.

Now beads are available with leads, cut and formed or on lead tape. Most equipment that is capable of automatic insertion of lead tape components can be modified to accept this special Stackpole bead.



No other filtering method is as inexpensive . . . and now as fast to insert in your circuit. Starting with a simple ferrite bead (a frequency-sensitive impedance element) which slips over the appropriate conductor, Stackpole has available a variety of materials and shapes providing impedances from 1 MHz to over 200 MHz. The higher the permeability, the lower the frequency at which the bead becomes effective.

CERAMAG® FERRITE BEAD CHARACTERISTICS

GRADE NUMBER	24	7D	5N	11
Initial Permeability	2500	850	500	125
Volume Resistivity @ 25°C	1.0×10^2	1.4×10^5	1.0×10^3	2.0×10^7
*Effective Suppression At:	1 MHz	20 MHz	50 MHz	100 MHz
Curie Temperature	205	140	200	385

*A tutorial guide on how these passive components behave with frequency and geometry is available from the Electronic Components Div.

Impedance varies directly with the bead length and log [O.D./I.D.]. Beads are available in sleeve form in a range of sizes starting at .020″ I.D., .038″ O.D., and .050″ long. The bead on lead tape is .138″ O.D. and .175″ long. Where quantities warrant, other beads on leads and/or lead tape are a design possibility. Tight mechanical tolerances are held in sizes and shapes as varied as the pair of giant, mating channels shown on the left which are used to eliminate the effect of transient noise in computers.

Sample quantities of beads are available for testing. Consult Stackpole Carbon Company, Electronic Components Div., St. Marys, Pa. 15857. Phone: 814-781-8521. TWX: 510-693-4511.

STACKPOLE®
ELECTRONIC COMPONENTS DIV.

Circle 15 on reader service card

signed to return to RCA Corp. Thomas says he came to the U.S. from TI's office in England 10 years ago because "the pace of U.S. business excited me more."

He began working for TI's Bedford, England, office in 1961, and he eventually became operations manager of the company's linear and custom digital bipolar operations in Dallas. In 1972, he went to General Instrument Corp., New York City, as vice president and general manager of the MOS LSI division. Since

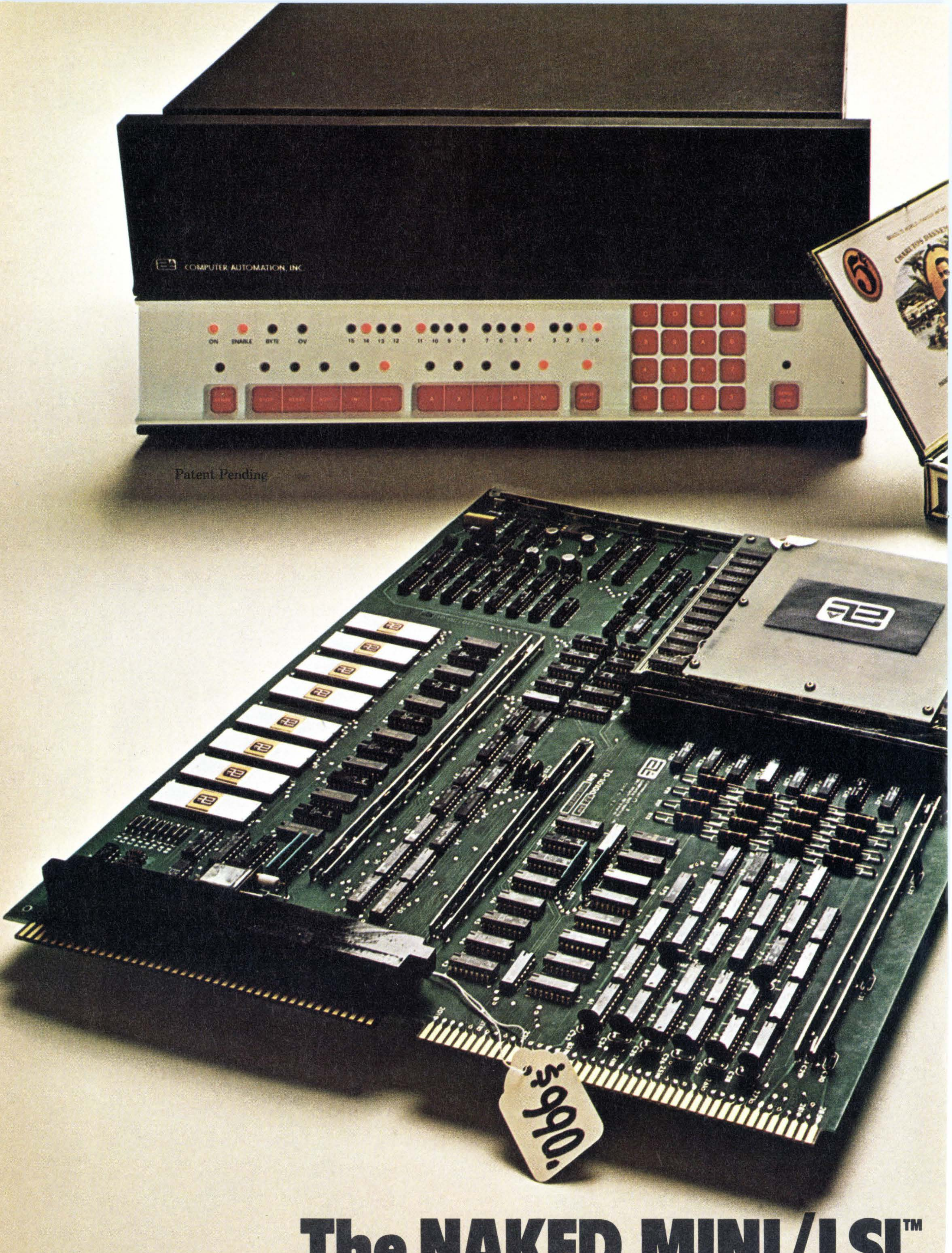
Transplant. Briton Philip Thomas runs Fairchild's MOS activities in U. S., overseas.

his arrival at Fairchild in mid-April, Thomas has outlined his answers to the challenge of U.S. business, and specifically, the excitement of the MOS business.

Most challenging to Thomas will be relating isoplanar technology to MOS, both p-channel and n-channel. He also plans to place more "emphasis on standard products versus custom." Thomas says, with a bare trace of British accent, that custom products will not be ignored, but "we need to be in both camps." Thomas received his B.A. in physics and M.A. in electronics from the University of London's extension program. He wrote his Ph.D. thesis and was a step away from getting his doctorate when he decided business was more important.

In his new post, Thomas will travel to Europe on visits to Fairchild's plant in Germany, where he is setting up a complete MOS operation, and to Fairchild's recently acquired plant in upstate New York.

Circle 17 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.™

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™), write Computer Automation Inc., 18651 Von Karman, Irvine, California 92664. Or call: (714) 833-8830. TWX 910-595-1767.

from Computer Automation.

Circle 19 on reader service card

Meetings

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.

Western Electronic Show & Convention (Wescon): Wema, Civic Auditorium and Brooks Hall, San Francisco, Sept. 11–14.

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

International Conference on Engineering in the Ocean Environment: IEEE, Washington Plaza, Seattle, Sept. 25–28.

International Exhibition of Industrial Electronics (Elettronica 2): Turin, Italy, Sept. 29–Oct. 8.

International Electron Devices Meeting: IEEE, Sheraton Park, Washington, D.C., Oct. 7–10.

Electronic and Aerospace Systems Convention (Eascon): IEEE, Sheraton, Washington, Oct. 8–10.

Optical Society of America Annual Meeting: OSA, Holiday Inn—Downtown, Rochester, N.Y., Oct. 9–12.

International Telemetering Conference/USA: ITC, Sheraton Northeast, Washington, D.C., Oct. 9–11.

Canadian Computer Show & Conference: CIPS, Exhibition Park, Toronto, Oct. 16–18.

American Society for Information Science Annual Meeting: ASIS, Hilton, Los Angeles, Oct. 21–25.

Connector Symposium: Connector Study Group, Cherry Hill Inn, Cherry Hill, N.J., Oct. 24–25.

Fluke problem solvers

Introducing the Fluke 8100B. At $595, you'll wonder how we did so much in a 4½ Digit Multimeter.

The new version of Fluke's most successful DMM, Model 8100B, gives you the most value for your money ever offered in a quality digital voltmeter.

With a basic dc accuracy of 0.02%, the Fluke 8100B measures ac and dc volts in four ranges from 100 microvolts to 1200 volts and resistance from 100 milliohms to 12 megohms. With an optional ac/dc current shunt accessory, it measures from 10 nanoamperes to 12 amps in six switched ranges.

Features include an active 2-pole switchable filter and automatic polarity indicator. All functions are push-button selectable.

For $100 extra, a rechargeable battery pack can be added to give the user complete portability with up to eight hours continuous operation. Other options include RF and high voltage probes, switched ac/dc current shunts, data output and a ruggedized case.

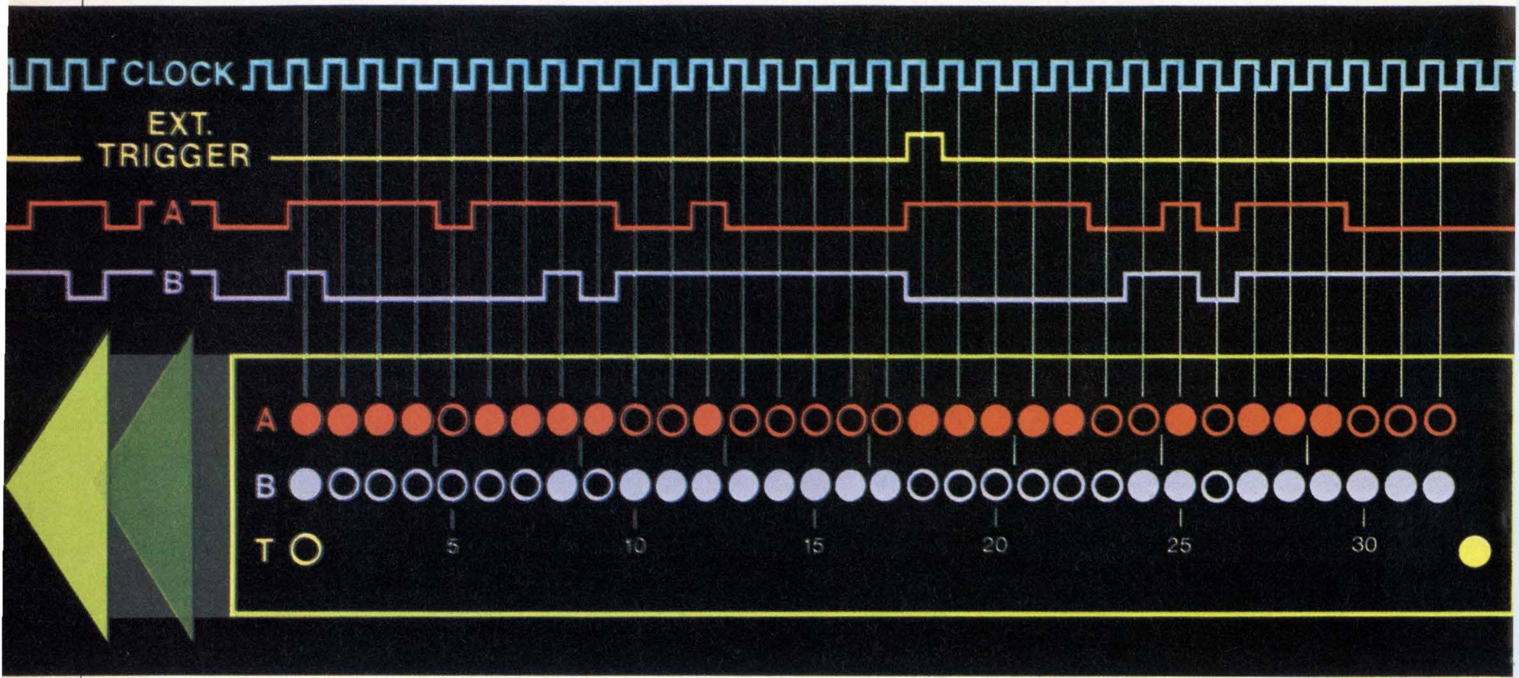
Demonstrated MTBF is over 10,000 hours, to make the instrument the most reliable available. The 8100B has tough environmental specs to ease your workload. Fully backed by Fluke's no-nonsense 12-month guarantee and service policy, here's an instrument that will meet your greatest expectations.

Call your local Fluke sales engineer for a demo and details. In the contiguous U.S., get his location by dialing our toll free number, 800-426-0361. Otherwise, address one of the locations listed below.

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, Nederland. 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

FLUKE®

Circle 21 on reader service card



The ordinary way of looking at digital

Introducing the HP 5000A Logic Analyzer. At last, a fast, simple, easy – and above all – accurate way to look at digital signal streams. Highs and lows are displayed by "on" and "off" states of LED's that make intuitive sense when you're working with truth-tables or timing diagrams.

For the first time ever you can look backwards as well as forwards in time from a trigger event. Plus, fast, easy-to-use waveform storage lets you conveniently capture single-shot or transient bit streams. Add to this straight-forward, almost self-explanatory controls and you have an ease of operation and display interpretation unmatched by any other method of monitoring digital bit streams.

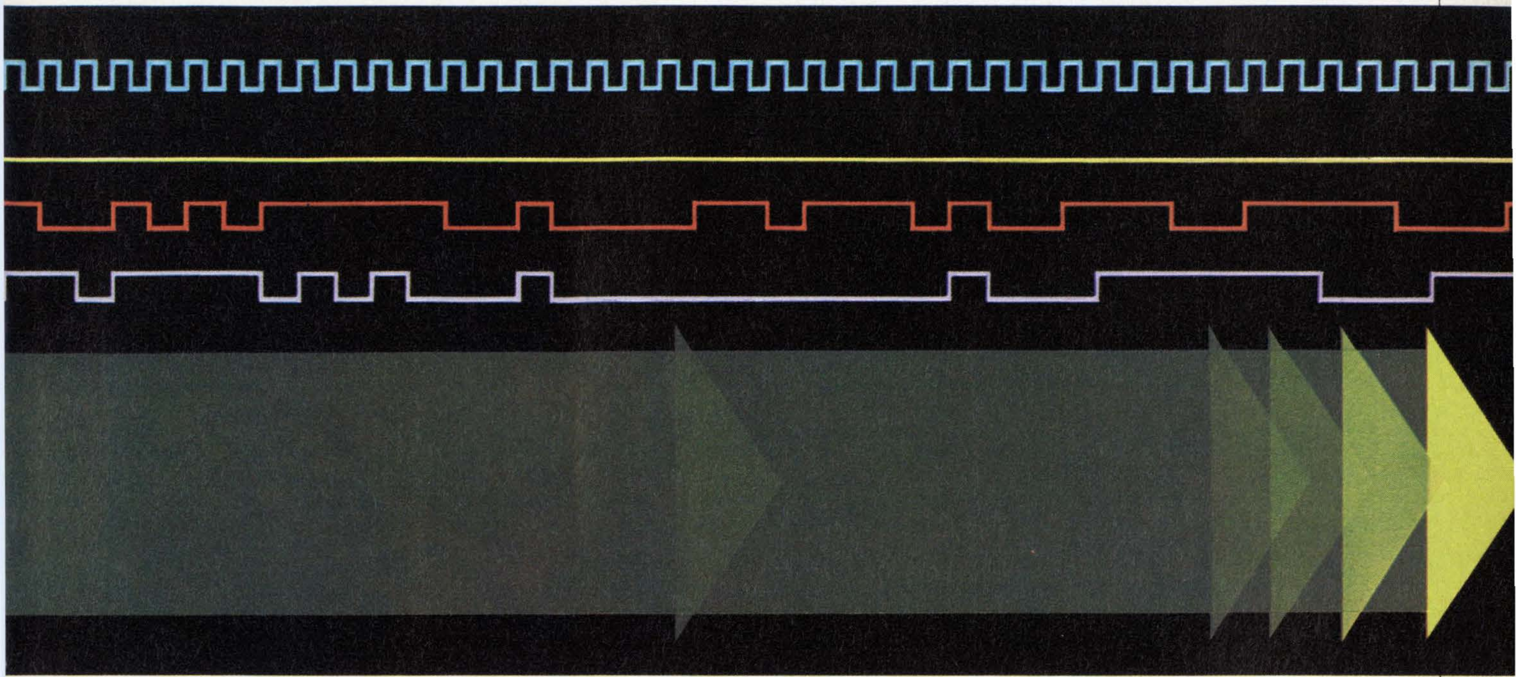
The HP 5000A can be effectively applied anywhere digital signals are used. A capture rate of up to 10 Megabits/sec., adjustable threshold, and 1 megohm impedance let you use it with any existing logic family. In addition, its unique digital triggering lets you select any AND combination of three inputs as the trigger word. This feature gives you wide latitude in defining the event or failure state to which you wish to key the display.

Precise digital delay makes algorithm-checking and accessing of particular data in long streams incredibly easy. Simply by dialing delay into the front panel thumbwheels, you can move the 32- or 64-bit display "window" forwards from your selected trigger up to 999,999 clock pulses – or backwards as many as 64 clock pulses. Because timing and display are keyed to your clock signal, absolute repeatability is assured. You're always certain exactly which pulses you're looking at in the data sequence.

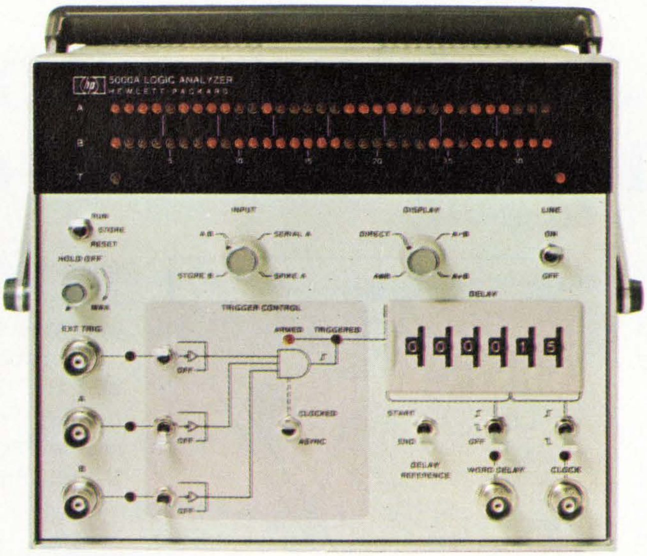
That's a lot of performance for $1900.* But the HP 5000A has still more features to make your work easier in the lab, on the production line, or in the field. The facing page tells more of the Logic Analyzer's revolutionary story and what it can do for you. To arrange for a demonstration, call your local HP field engineer today. Or, write us for complete specifications.

*Domestic USA prices only.

02304



bit streams has just become obsolete.



What led up to a failure? What resulted from it? The HP 5000A can be quickly set up to show data both immediately preceding and following your selected trigger.

Keep the display as long as you need it; store it indefinitely at full brilliance or just until the signal changes.

The LED display can show you *simultaneous* 32-bit segments of any two signal streams. Or, you can set it up to look at one 64-bit stream.

Another display mode allows you to hold a data pattern in one channel while continuously monitoring an on-going data stream in the other.

If you choose to use the HP 5000A for production or quality control instead of in the lab, yet another feature permits you to compare production units against a known good circuit *and have only the "bad" data bits show up on the display.*

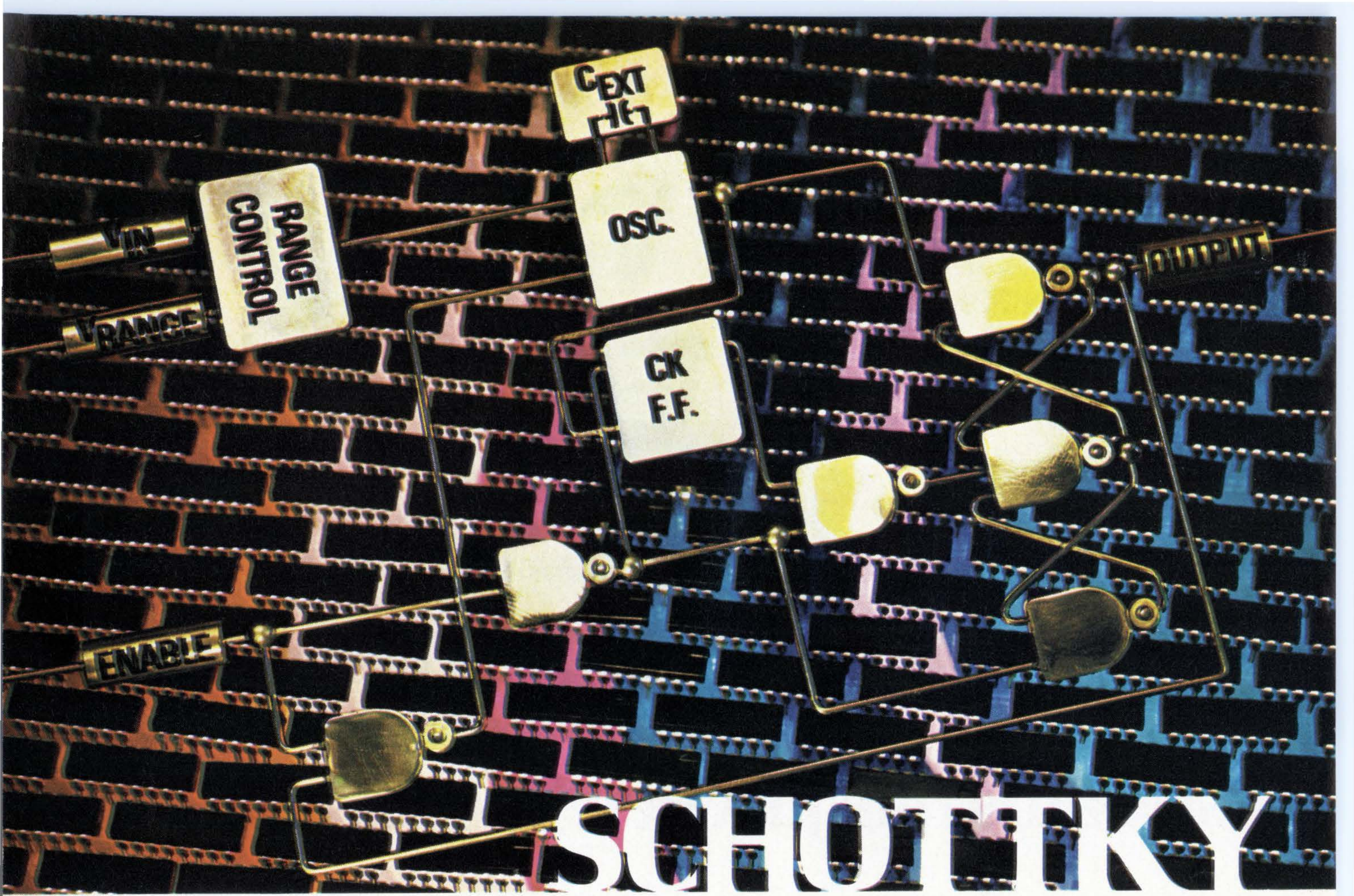
Short pulses due to noise or other causes are no problem for the 5000A. It not only detects these "spikes," it indicates where in the data stream they occur, and even tells you their polarity.

Portable, the 5000A is ideal for field service. With its negative delay and single-shot storage capabilities, you can perform "on site" analysis of the causes of intermittent errors — even those frustrating once-an-hour, or once-a-day events.

You get safeguards against wasted effort too. LED's light up at each input connector to show signal activity; two other LED's indicate arming and triggering. You never spend time looking for pulses that aren't there.

HEWLETT hp PACKARD

Sales, service and support in 172 centers in 65 countries.
Palo Alto, California 94304. Offices in principal cities throughout the U.S.



Versatile. Stable. Economical.
TI's new dual voltage controlled oscillator.

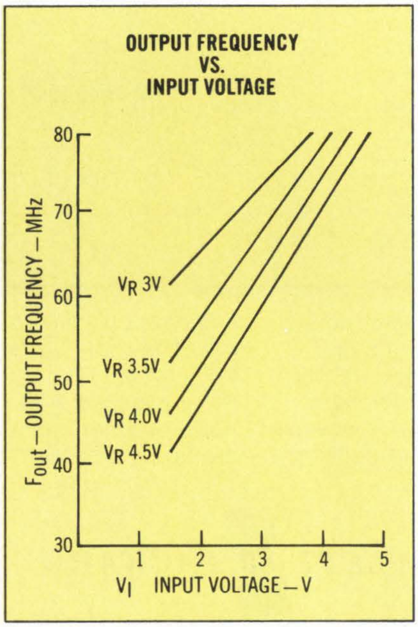
SN54S/74S124 VCO is here – an excellent match of cost and capability.

Made possible only through TI's broad Schottky TTL technology and experience.

The S124 is a self-starting, free-running dual symmetrical, square-wave generator, very useful as a clock generator in digital systems.

Center frequency is determined by an external component – either a crystal for a fixed frequency, or a capacitor for variable frequency operation. There are 2 voltage-sensitive inputs. One varies output frequency from the capacitor-set center. The other determines frequency range.

Set it to operate at any frequency between 0.12 Hz and 85 MHz. Use a capacitor and your control frequency range will be ± 1% to ± 100%. A single 5-volt supply operates it.



Operating at a center frequency of 1 Hz, the change in output frequency from −55° to 125°C is a stable ∓ 0.5% with V_r at 5 volts and V_i at 3 volts.

S124 is available in a plastic or ceramic 16-pin dual-in-line-package, or ceramic flat pack.

The 74S124N is priced at $2.61 in 100 piece quantities.

Order SN54S/74S124 from your local authorized TI distributor or directly from TI. For data sheets, specify by type number and write: Texas Instruments Incorporated, P. O. Box 5012, M/S 308, Dallas, Texas 75222.

TEXAS INSTRUMENTS
INCORPORATED

84089

Electronics newsletter

Big RAMs will clash this summer

The contenders in the battle of the 4,096-bit MOS random-access memories shape up as r-channel designs. **One of the big RAMs has a single transistor per cell, and the other has three transistors per cell.**

The single-transistor memory is made by Texas Instruments, which is now sampling its device; TI will be joined by Mostek in the fall. Microsystems International Ltd., presently the only supplier of 4,096-bit RAMs, uses the three-transistor design; MIL will be joined by Intel, probably this month.

Since both designs have practically identical specifications—single clock, standard power supplies, 300-nanosecond access, TTL-compatibility, 400- to 500-milliwatt operating power, and identical pinouts—**the outcome of the struggle will depend on availability. This, in turn, is closely tied to yield and determination of which design is best suited for mass production.**

Lockheed drops helicopter line

After losing the Army competition for the Advanced Attack Helicopter (AAH) [see p. 40] to replace the canceled AH-56 Cheyenne gunship, Lockheed-California Co., Burbank, is dropping out of the helicopter business, an official has confirmed. **Lockheed, which, for five years had been prime contractor for Cheyenne, is moving approximately 70 persons left on the AAH project to other assignments.** The company's earlier efforts to develop commercial models based on Cheyenne had also proved unsuccessful. **No other major military programs are in sight.**

H-P opens shop in Moscow

Hewlett-Packard is the first U.S. electronics company with a permanent accreditation in Moscow. The company is seeking office accommodations in the Soviet capital to establish what a company official described as a "technical-marketing-support base" for growing sales.

H-P will concentrate its sales efforts in the field of medical electronics and minicomputers, which already account for the largest chunk of its current sales volume in the Soviet Union of $3 million a year. Washington gave H-P approval to sell the Soviet Health Ministry a $300,000 time-sharing computer system, the first such unit to be cleared for sale to the USSR. The company, which considers the issuance of the previously denied export license a breakthrough, is hopeful that other similar opportunities will open up in the electronics field.

Military money dominates laser R&D

Military money continues to dominate Federal funding for lasers, despite efforts to broaden U.S. support in other areas [*Electronics,* June 21, p. 70]. Three new DOD efforts, typical of its preeminence in the field, include: $1.7 million to United Aircraft's Pratt & Whitney division in West Palm Beach, Fla., for a high-energy, gas dynamic laser for the Air Force Special Weapons Center's airborne laser laboratory; $2.5 million to Honeywell's Aerospace division, St. Petersburg, Fla., for a three-axis inertial-guidance system, containing helium-neon ring laser gyros, to be used by the Naval Weapons Center in the Advanced Tactical Inertial Guidance System (Atigs), plus a $74,000 Naval Air Systems Command award to Rockwell International's Autonetics division, Anaheim, Calif., to build a gas-laser accelerometer for use in another advanced inertial-guidance package. **"We can't begin to match DOD**

money," moans one Health, Education, and Welfare department laser specialist.

Singer and Hitachi hatch mutual deal

A 50-50 arrangement between the Singer Co., New York City, and Hitachi Ltd., of Japan has been formed to produce calculators, point-of-sale equipment, and accounting machines for both Japanese and export markets. **Besides developing POS systems through the joint venture each partner will manufacture products already made by the other.**

Industrial robot may star in the automotive scene

A prototype of a small-parts manipulator, the first to be designed with a programable controller for memory and control, is being used experimentally to load three punch presses. **The "robot" was designed by the Industrial Machinery group of USM Corp.,** whose DynaPert division, Beverly, Mass., manufactures component-insertion equipment for the electronics industries.

Little more than a pivoting arm with an attached hand for grasping parts, the robot has five-plus axes of motion, and it can lift a maximum of 5 pounds. It uses a PDP-16 controller from Digital Equipment Corp. with a read/write memory that can store as many as 50 program points. **USM is considering selling the manipulator for jobs in the automotive and electronics industries.** Eventually, the robot could be used in conjunction with USM's own insertion gear. Target price for the still-developmental robot is under $20,000.

Commuter system checks military communications net

The first ATEC (automatic technical control facility) in the U. S. Defense Communications System (DCS) has begun operation at Croughton Air Station in England. ATEC, being produced by Honeywell Information Systems under a contract from the Rome Air Development Center, Rome, N. Y., will eventually take over most of the routine monitoring, test, and control chores now being performed manually throughout the network, which has long been plagued by transmission-quality problems. **The ATEC system will eventually consist of approximately 17 regional centers, each with a control console and a central processor to coordinate data from outlying DCS sites.** At these sites, many computer-controlled test sets and telemetry units will continuously monitor links in the DCS long-haul communications network to indicate which need attention.

Addenda

IBM, which has been rumored to be entering the point-of-sale market for months, **may be ready to make the move,** observes Ken Ford, senior researcher at Creative Strategies Inc., Palo Alto, Calif. To avoid any antitrust difficulties, the company, Ford says, will enter the food or supermarket end of POS, rather than the retail sector, with a software-based mainframe system. **IBM, which has a POS research-and-development center in Raleigh, N.C., refuses comment on the matter . . .** Data General will have two new Nova computers, the 2/4 and 2/10, available in three months to OEMs and systems houses interested in purchasing at least five machines. **The company also has a new core-memory module that stores 16,384 16-bit words on a single printed circuit board** and uses a double herring-bone pattern to conserve space. Prices for the computers range from $3,850 to $10,150.

C-LINE SCRs

WE PUT 14 YEARS OF THYRISTOR EXPERIENCE INTO EVERY UNITRODE SCR.

And that means a better industrial product. Our performance record proves it. In industrial/commercial applications, the use of Unitrode SCRs doubled last year and has doubled again this year. For the military, Unitrode supplies more lead-mounted SCRs than everyone else combined. Unitrode is the only SCR supplier with Military Qualification Approval on all TO-5 and TO-18 mil. specs. Why this kind of acceptance? Our experience. It means a lot to people who've had experience with less.

Our broad line of SCRs including plastic and hermetically sealed metal types offers a wide range of choices for literally hundreds of applications. The Unitrode SCR product line ranges from our very popular, rugged 0.8 amp TO-92 plastic package and TO-18 hermetically sealed series to our 1.6 amp TO-5 and TO-39 series and 5 amp TO-59 stud series. Some series are available to 600 volts.

It's what you would expect from a company that makes thyristors a major part of its effort—not just a sideline.

For fast action, call Sales Engineering collect at (617) 926-0404 Unitrode Corporation, 580 Pleasant St., Watertown, Mass. 02172. For the name of your local Unitrode representative, dial (800) 654-9200 toll free or in New York State (516) 294-0990 collect. Check listing below for your nearest Unitrode distributor.

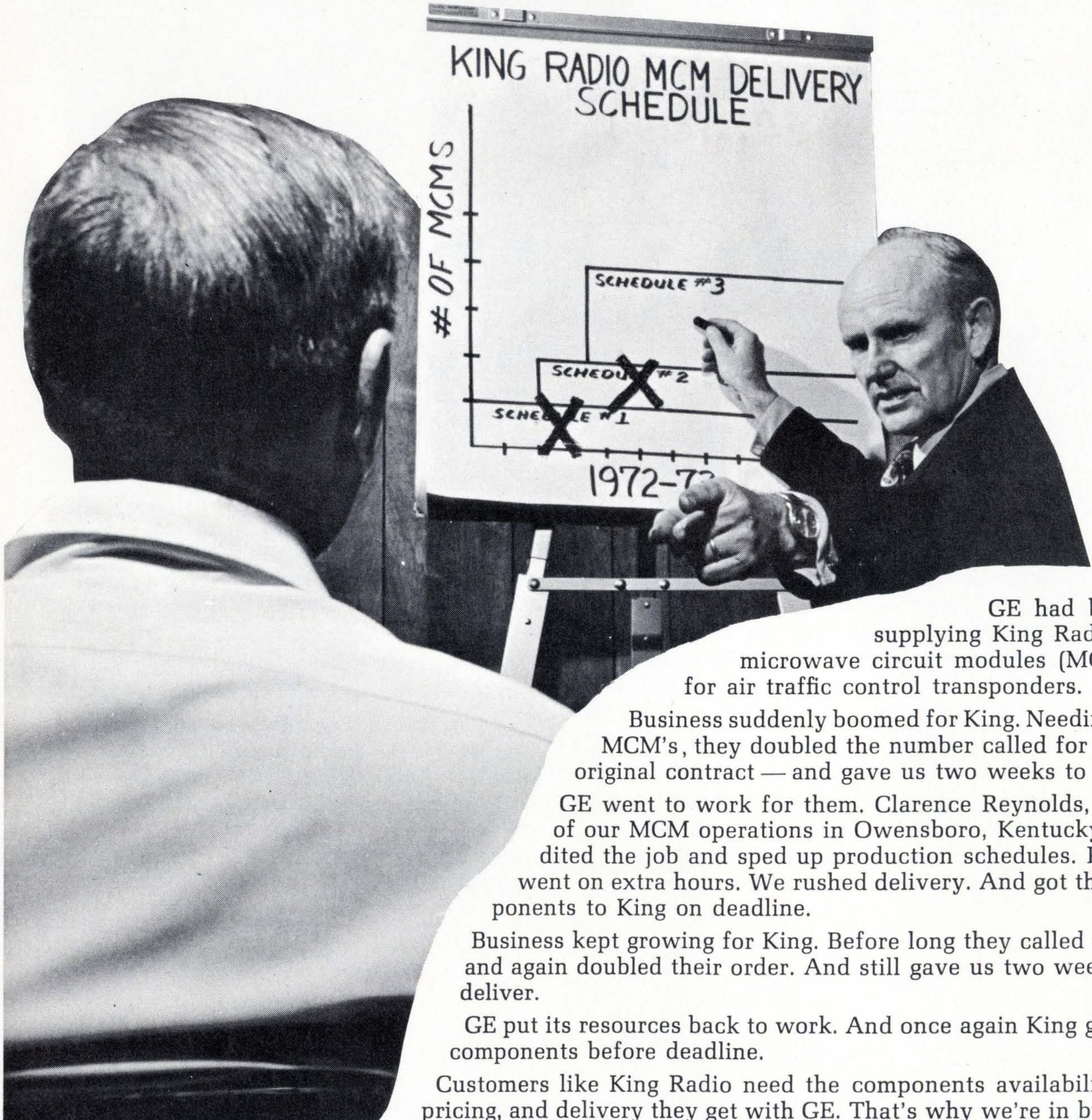
UNITRODE quality takes the worry out of paying less.

Unitrode Franchised Distributors: ARIZ., Kierulff, Phoenix (602) 273-7331; CAL., Kierulff, Los Angeles (213) 685-5511, Palo Alto (415) 968-6292, San Diego (714) 278-2112; CANADA, Schweber, Toronto (416) 925-2471; COLO., Kierulff, Denver (303) 343-7090; FLA., Schweber, Hollywood (305) 927-0511; GA., Schweber, Atlanta (404) 449-9170; ILL., Schweber, Elk Grove (312) 593-2740; MD., Schweber, Rockville (301) 881-2970, Technico, Baltimore (301) 828-6416; MASS., Schweber, Waltham (617) 890-8484; MICH., Schweber, Troy (313) 583-9242; N.J., Schweber, Somerset (201) 469-6008; N.M., Kierulff, Albuquerque (505) 272-1055; N.Y., Schweber, Rochester (716) 328-4180, Westbury (516) 334-7474; N.C., Schweber, Raleigh (919) 832-8881; OHIO, Schweber, Beachwood (216) 464-2790; TEX., Kierulff, Garland (214) 271-2471, Hamilton-Avnet, Dallas (214) 638-2850, Houston (713) 526-4661, Lenert, Houston (713) 225-1465; UTAH, Alta Electronics, Salt Lake City (801) 486-7227; WASH., Kierulff, Seattle (206) 763-1550.

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

Circle 27 on reader service card

When a customer doubled and then redoubled his MCM needs, GE met both deadlines.



GE had been supplying King Radio with microwave circuit modules (MCM's) for air traffic control transponders.

Business suddenly boomed for King. Needing more MCM's, they doubled the number called for in the original contract — and gave us two weeks to deliver.

GE went to work for them. Clarence Reynolds, head of our MCM operations in Owensboro, Kentucky, expedited the job and sped up production schedules. People went on extra hours. We rushed delivery. And got the components to King on deadline.

Business kept growing for King. Before long they called us back and again doubled their order. And still gave us two weeks to deliver.

GE put its resources back to work. And once again King got their components before deadline.

Customers like King Radio need the components availability, pricing, and delivery they get with GE. That's why we're in business.

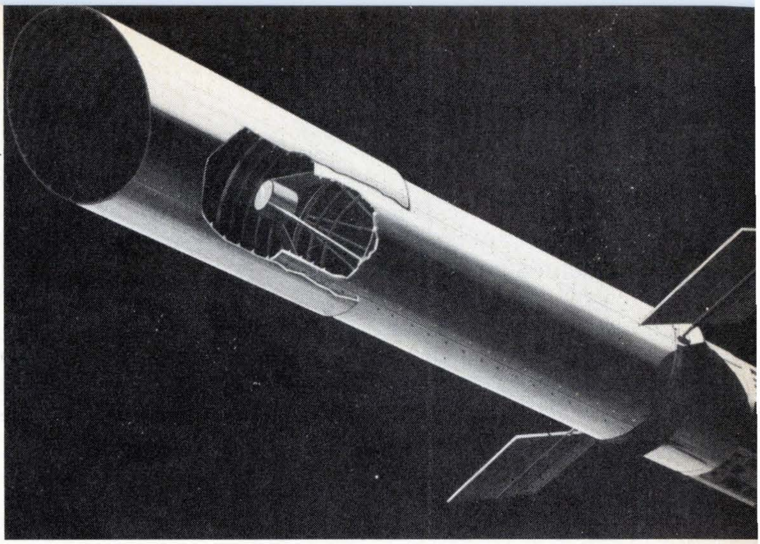
GE won't leave you alone.

690-16

OUR NO. 1 GOAL: TO MAKE GENERAL ELECTRIC YOUR BEST BUY

BEST BUY Our No.1 Goal QUALITY SERVICE VALUE

GENERAL ELECTRIC



NASA's dilemma: What else in 70s besides shuttle?

Vast space science program hinges on fiscal 1975, as agency fights for needed $3.4 billion a year

NASA's **Office of Space Science** plans a strong new program for the rest of the decade, beginning with the projected Pioneer-Venus mission to start in fiscal 1975 [see "The race to Venus," below]. The big "if" is whether the Office of Management and Budget and Congress will approve such plans.

The dilemma confronting the Office of Space Science is that the space shuttle proportionally is eating up more of the agency's dollars while the budget goes down. NASA will get a little over $3 billion in fiscal 1974, down from $3.2 billion in fiscal 1973. This amount is significantly less than the $3.4 billion (in 1971 dollars) that NASA Administrator James C. Fletcher tells the budget office and Congress that the agency needs to carry out healthy programs in space science and applications, as well as the shuttle. If the trend continues, big cuts will have to be made.

For the science office, the Pioneer probe may be the only bright spot in the fiscal 1975 budget. The OSS had informally requested about $489 million, down from $584 million in fiscal 1974. This funding was needed to complete the 1975 Viking-Mars missions, OSS chief John E. Naugle says. Barring further whacks during year-end budget go-arounds, his toughest battle could be to get funding levels up to a problematical but "respectable" level of $650 million a year in subsequent fiscal years. Naugle says the proposed programs are options, depending on how much money he has to work with, but they indicate his thinking.

Programs. For fiscal 1976, OSS would start the following programs:

- A $350 million lunar polar orbiter
- A spin-stabilized gamma- and X-ray detector using some Pioneer technology
- The solar maximum mission, a departure from the orbiting solar observatories, using a $30 million three-axis stabilized spacecraft and
- The $220 million inner-planets mission, a 1980 probe of Jupiter and Uranus.

For the big fiscal 1977 new start, OSS envisions beginning a $300 million Viking '79 program, a mission updating the results of the 1975 Mars probe and using existing Viking hardware with new scientific instrumentation. Other new starts for the decade include a $2.3 million Venus-Mercury extended mission, a Pioneer H prototype, a $5 million large-aperture infrared telescope, and a Pioneer-Saturn probe. During this period, Explorer satellite programs would run about $30 million a year, and the previously suspended High-Energy Astronomical Observatory program [*Electronics* Jan. 18, p. 119] will receive about $135 million.

NASA officials say that the agency has to get the 1975 budget "to see what makes sense" so that it can plan for later years. For fiscal 1975, Naugle says, he would like to "start the Pioneer-Venus program, if possible, and have the resources to keep open the other options." Obviously, if budgets remain low, "I'm not going to propose three major new starts in 1976," he told the agency's space program advisory council on June 14.

"With a constant, level budget of

Big view. Planned for final 1976, NASA's $350 million large space telescope will be serviced by the space shuttle in the 1980s.

The race to Venus

The two competitors for the $100 million portion of the projected Pioneer-Venus missions are Hughes Aircraft Co., El Segundo, Calif., teamed with General Electric's Space division, Philadelphia, Pa., and TRW Systems, Redondo Beach, Calif., teamed with Martin-Marietta Corp., Denver, Colo. Since the mission hasn't been officially approved, the winner will sign an advanced-design contract in February and be awarded the hardware portion in November 1974, when NASA gets the money from Congress.

Scheduled as a fiscal 1975 new start, the $157 million Pioneer-Venus program would launch, in May and August 1978, an orbiter and another craft containing three small probes equipped with such electronics as mass spectrometers and field-particle analyzers to explore the planet's atmosphere. NASA will try to complete the program below estimates by designing the orbiter around the probe pieces for commonality. The teams, which have each been under a $700,000 preliminary design effort, are the only two eligible to compete for the hardware contract, NASA says. They will answer requests for proposals by Aug. 15.

$3.4 billion [over the next several years] we can recoup," says NASA associate administrator Homer E. Newell. "If it stays down to $3 billion, we'll have to regroup." □

Space electronics

NASA's Mariner has digital controls

The Mariner spacecraft scheduled to fly by Venus and Mercury this winter is an indication of either the maturity or the poverty of the space program. The Mariner Venus/Mercury (MV/M) will contain only one major new subsystem, aside from experiments developed to investigate for the first time the planet nearest the sun.

The new subsystem will digitally control positioning of the experiments platform, high-gain dish antenna, and solar panels. Digital controls proved to be about $1 million cheaper than analog controls. Most other flight subsystems are copies or versions of equipment used on previous Mariner and lunar orbiter spacecraft, say Tord Dannevig and Ivan Hudgins, the engineers responsible for control and communications subsystems at Boeing Aerospace Company, Seattle, Wash.

Boeing built the MV/M for the Jet Propulsion Laboratory, Pasadena, Calif., which manages the Mariner program for NASA. Boeing recently completed construction of the MV/M and sent it to JPL for tests. JPL is scheduled to ship it to NASA's Goddard Space Flight Center, Greenbelt, Md., where it is to be equipped for the November launch.

Dannevig and Hudgins view the use of off-the-shelf subsystems as evidence that spacecraft design is settling down to the use of mature, proven equipment. Yet the MV/M has been nicknamed the "poor man's spacecraft" at Boeing because of its low cost. Boeing will receive only $42.5 to $48 million for the flight model sent to JPL, plus a test model being refurbished to serve as a flight backup. In contrast, the company was paid $240 million for six lunar orbiters—$40 million each—in NASA's heyday.

The first television pictures of Venus and Mercury will be made with two cameras mounted on the experiments platform. The antenna will point toward earth as the probe journeys around the sun to catch up with Mercury, and the panels will be rotated to lower the angle of incidence at which the intense sunlight hits the solar cells.

Rather than retain the individual analog control channels of the earlier spacecraft, JPL and Boeing decided to use digitally multiplexed controls. Digital signals from the ground or from the five-year old Mariner control computer on the spacecraft drive tiny stepping motors. The motors, which take only 13 watts of power, drive 9,000:1 gear boxes and provide a pointing resolution of 0.04°.

One other major design change is the way the spacecraft is thermally biased. The sun's heat won't warm up the craft until it approaches Venus. During the first part of the flight, resistance heaters will keep the equipment warm in thermal blankets. The heaters will be turned down during the flight, freeing power for the experiments. Then, as the sun's heat rises, louvers controlled by bimetal springs, will open up to cool the spacecraft. □

Consumer electronics

Computer terminal makes consumer bid

A computer terminal—with a price tag of less than $500—is aimed at the consumer market. The unit, to be on the market by year-end, is also expected to attract buyers in business and the professions. The terminal, developed by Cassette Sciences Corp., Los Angeles, uses a conventional television set for its display and acoustical coupling to a conventional telephone to help keep the price low. A companion unit for a similar price will show motion-picture films through a TV set, and the two can operate together.

The computer terminal, which has a conventional 50-key keyboard, displays a maximum of 16 64-character lines on the TV screen. The company hopes in the future to have numerous entertainment, educational, and business programs available through toll-free lines to interact with computers in major areas. The estimated cost of films is $1 per hour. Programs to be available include golf lessons, budget planning, information retrieval, and shopping, plus conventional Basic computer manipulation. The hardware in the system was developed by Special Purpose Technology Corp., Van Nuys, Calif.

The film player and computer terminal can be used independently of each other; both connect to the TV-set antenna terminals in the manner of an older uhf converter. The film player takes super 8-millimeter cartridges and reels up to 1,200 feet long. A 16-mm version will be ready next year. The system uses a flying-spot scanner operated at relatively low light level, contributing to long film life and permitting easy viewing of stills. Eastman Kodak Co. last year introduced a similar machine,

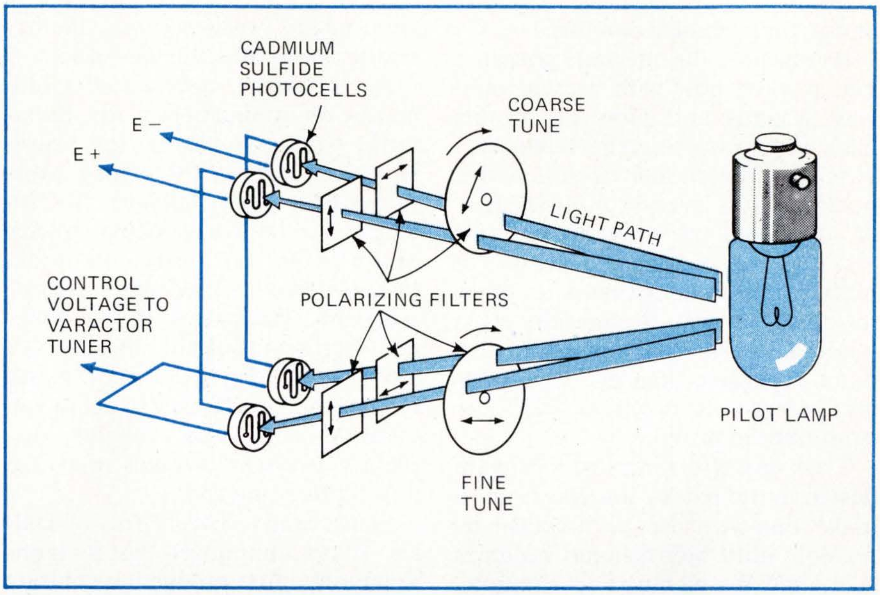
Teacher. Cassette Sciences' learning center will use TV and phone links.

but it is priced at $1,195 and is aimed at the commercial/educational market.

Cassette Sciences, a subsidiary of Allied Management Corp., picked film rather than videotape partly because of large existing libraries. The company has access to the Transamerica film library, including 2,400 feature and special-purpose films, which Allied expects to rent to subscribers for $2 to $10 each. □

Components

A uhf varactor tuner relies on light pots



Light dialer. Standard Component's Photomatic 82 varactor-tuning system uses two light-potentiometer systems, each consisting of a pair of photocells and 82 filter disks.

The multiple pre-set carbon potentiometers that vary the voltage applied to varactor diodes tend to drive up the price of a conventional varactor TV tuner. To replace them, Standard Components of Chicago has developed a light-controlled voltage divider that tunes its prototype 82-channel varactor tuner to frequency.

The "Photomatic 82" [*Electronics,* June 7, p. 36] has a single pair of concentric knobs for channel select and fine tuning of channels 2 to 83, plus a memory system to maintain the correct dial setting in subsequent returns to a channel position. The tuner, which is priced under $15, has a reset accuracy within 150 kilohertz; according to the company, this is well within the capability range of the automatic fine tuning circuitry.

Because of its two light potentiometer systems, each consisting of a matched pair of cadmium sulfide photocells and 82 polarizing filter disks, the tuner effectively incorporates 164 potentiometers. A standard pilot lamp is the light source for the filters and photocell pairs as well as for back-lighting the channel number display.

"Rotating the selector knob brings both a new channel number and a new pair of filters into positions," says William L. Fulton, the unit's inventor and chief advanced design engineer at Standard Components. The channel numbers and filter pairs are mounted on a continuous filmstrip—"the film is loaded on feed and takeup reels, and the channel select knob advances the film frame by frame, channel by channel," says Fulton. "Channel select is tuned at the factory; a push-to-tune concentric fine-tuning knob rotates the second polarizing filter disk for user fine tuning."

Not critical. The rotation of the disk causes a difference in light intensity between the cells in each pair, and therefore a difference in voltage output of the cells. This voltage difference is used to tune the channel to frequency. "Because the polarizing filter requires rotation to cross-polarize, mechanical tolerances aren't critical," Fulton explains, "and because cells and filters are arranged so that voltage changes are a result of the ratio of light to the cells, intensity of the lamp is not critical either."

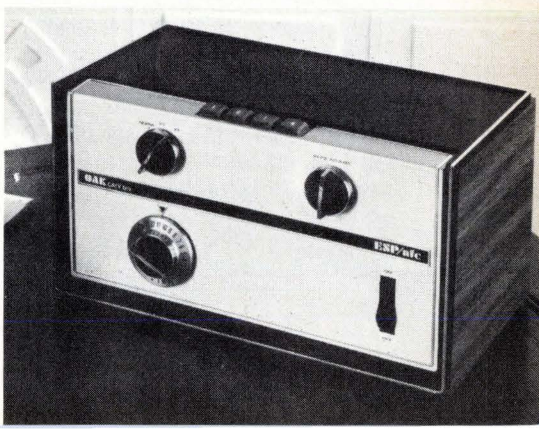
Although the tuner is designed for remote control, skip-channel programing for remote control is difficult on 70- and 82-detent tuners. And so Standard Components proposed a 36-detent version that, FCC permitting, it plans to offer. The vhf channels would be detented individually, and continued rotation of the knob would exhibit the numbers for three uhf channels at each detent—"any one of which can be selected and memory fine-tuned with the fine-tuning knob," Fulton says. □

Communications

The better way is two-way for CATV

The promise of rapid profits from selling premium television to CATV subscribers has pushed two-way cable out of the laboratory and at least part way into the sales room. Cable equipment manufacturers and systems operators gathered at the recent convention of the National Cable Television Association, Anaheim, Calif., were preoccupied with pay TV both on the show floor

Pay-TV expansion. Oak's converter will allow one-way, then two-way, pay CATV.



and in the technical sessions.

In essence, the message was: get into pay TV now with present one-way systems and plow the profits back into providing the better service of bidirectional or interactive hookups. On every count—security of scrambled transmission, customers' ease of ordering, accuracy of billing, ability to expand to other services—two-way is superior, cable manufacturers said, but it is also more expensive than one-way, costing perhaps as much as $250 per subscriber to install.

Thus, the effort in most hardware design in the pay TV line has been to make one-way use as practical as possible until bidirectional becomes economically viable. For example, the CATV division of Oak Industries Inc., Crystal Lake, Ill., has developed a system called ESP (for expandable scrambled programing) that walks a cable operator through the steps from installing a TV receiver converter to adding a one-way premium-program scrambler to the consummation of two-way pay TV. In the last two steps the operator has his original varactor converters retrofitted at the Oak plant, adding about $60 to $70 to the original investment for the one-way scrambler and another $50 for two-way service. This saves buying a completely new terminal with each changeover. For the one-way operation, subscribers would have to phone in orders; in the two-way mode, the operator's computer will take orders.

At the same convention, Goldmark Communications Corp., Stamford, Conn., revealed the availability of devices for polling cable subscribers over standard 50–220-megahertz one-way cable plants. Meanwhile, hardware manufacturers Jerrold Electronics Corp., Horsham, Pa., which is the dominant hardware supplier in the CATV industry, EIE division of RCA, North Hollywood, Calif., and Theta-Com of California, Los Angeles, displayed two-way systems that are now undergoing tests.

Significantly, Tocom Inc. of Dallas, Texas, announced that it claims to have the first production contract for installation of a two-way cable system by Rossmore Leisure World in Mesa, Ariz. The contract, worth about $3–5 million, calls for turnkey installation of 6,000 to 7,000 terminals initially, 11,000 by the time the project is completed. □

Production

Video camera with chip set gets smart

A smart video camera—one that inspects parts on a production line, controls parts sorting, prepares production records, and prints inventory lists—is nearing completion at Reticon Corp., Mountain View, Calif. It will be ready to go to work as soon as the programs for the camera's microcomputer control are debugged—probably within a month.

Reticon's president, John J. Rado, started planning the system last winter, when his company began producing the first solid-state industrial cameras [*Electronics*, Feb. 1, p. 121]. The next step was to develop a digital control that converted a camera into an inspection station. The addition of a microcomputer upgrades the camera to a general-purpose system. Operating routines will be varied with data entered into random-access-memory chips.

Fractions of a mil. The camera's sensor is a linear array of photodiodes. Inspection accuracy depends on the number of diodes in the array. With a 512-diode array, Rado says, the dimensions of a part can be checked to accuracies within a fraction of a mil.

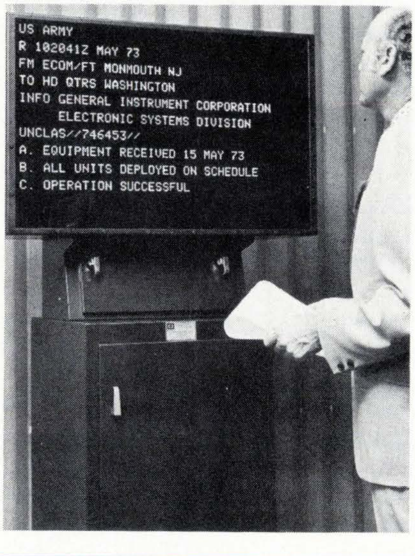
The general-purpose controller allows the camera to make go-no-go inspections, feed raw inspection data to a remote computer for processing, and actuate sorting mechanisms. "Signatures" of the parts to be inspected are set into the controller by means of thumbwheel switches.

Suppose, Rado explains, the camera is used to check the size of ring washers. The threshold of the diodes is set so that the sensor sees the washer as white and the conveyor as black. The next determination is how many high and low pulses the array will produce when it scans the diameter of a good washer. For example, the signature might be 50 high pulses produced by one side of the ring, 50 low pulses produced by the center hole, and 50 high pulses by the other side.

Other applications. Similar setups can be used to check sparkplug gaps, holes in punched parts, wire gauges, printing-press alignment marks, and knots in plywood, Rado points out. But to prepare production records and convert the pulse outputs to absolute measures, in

Now see this!

Some 16,800 discrete red light-emitting diodes spell it all out on this message display delivered to the U.S. Army Electronics Command. Five units, built by General Instrument Corp.'s Electronic Systems division, Hicksville, N.Y., will be installed in communication control centers where teletype messages will be electronically processed and displayed. The display screen measures 3 feet wide and 2 feet high and consists of 480 characters, each made up of a 5-by-7 diode matrix. There's enough light from the diodes for messages to be legible from up to 30 feet away.



production and process control applications, it would be necessary to connect the controller to a computer.

The microcomputer—an Intel MCS-4 chip set—will take over such chores, feeding processed data to a teletypewriter, a central computer, or both. A central computer would be needed to coordinate preprocessed data from several camera systems. The smart version will also be able to read and record inventory code marks on boxes, Rado says. □

Military electronics

On-board navigation sought for satellites

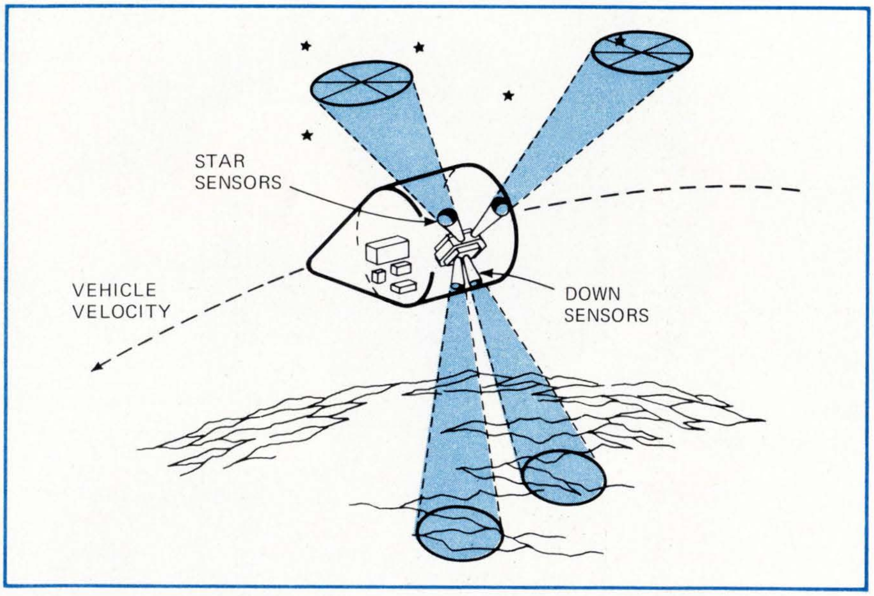
In its search for a self-contained navigation system that will make earth-orbiting satellites independent of ground stations, the Air Force is funding three industry design efforts for possible development of flight hardware. Contracts have been awarded by the Space and Missile Systems Organization to Honeywell Inc., IBM Corp., and TRW Inc.

Called ANT, for autonomous navigation technology, the program aims at enabling a satellite to determine its position—and correct it if needed—before completing one full orbit of the earth. This is especially useful for short-lived military satellites. The contracts, which run through mid-May of next year, include $820,000 to Honeywell's Aerospace division, St. Petersburg, Fla.; $901,289 to IBM's Federal Systems division, Owego, N.Y.; and $761,039 to TRW Systems, Redondo Beach, Calif.

Sensors. Honeywell is actively discussing its ANT efforts, which are directed by David C. Paulson. The company plans to develop a laboratory prototype of what it calls a down sensor assembly. Two DSA strapdown systems, containing semiconductor arrays in a focal plane, work in conjunction with an onboard computer, in which there is a gravitational model of the earth, and another strapdown device. Developed under an earlier Samso contract (see diagram), this device, the Space Precision Altitude Reference System, or Spars, is designed to stabilize the DSA measurement rate. (The Spars hardware has been tested and already flown on one Air Force program.)

The two DSAs, strapped to the satellite body, look vertically at the earth and receive radiated energy on their photodetectors. The time between the two DSA sightings of the same image is the basic measurement used to update the satellite's position and velocity, says Paulson. The two semiconductor matrix arrays convert signals sensing earth landmarks into digital form and then store them in the satellite computer, which performs a statistical algorithm to determine the shift of the satellite's position. Advantages of its strapdown hardware over gimbaled systems include both economy and performance, in Honeywell's view.

Whatever system the Air Force pushes to development later, the service has long sought a system like ANT, which promises to shorten response times in satellite navigation and at the same time permit economies of scale by reducing costs of building, manning and maintaining ground tracking stations. □



Honeywell's ANT. Satellite navigation set uses star sensors and "down" sensors.

Displays

Liquid crystals may aid CRT viewing

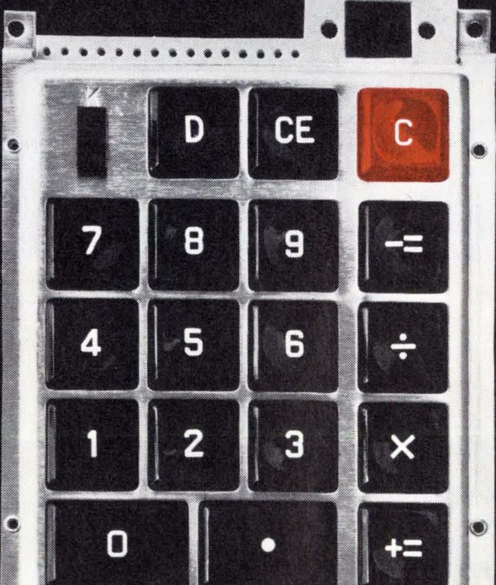
Finding an electronic display technique that doesn't wash out in high ambient light—for instance, in aircraft cockpits and air traffic control towers—has been a long-standing problem. The most common answer is the high-brightness storage cathode-ray tube. Now there is a new method on the horizon: a CRT with a faceplate containing liquid crystal squares, instead of a phosphor.

The advantage of the liquid crystal is that the contrast between data and background does not decrease with increasing ambient light, so that the display can always be read, no matter how bright the sunlight. The phosphor CRT, on the other hand, is difficult to read in brilliant sunlight.

Britain's Services Electronics Research Laboratory (SERL), therefore, has a research project aimed at making a storage CRT with a liquid-crystal faceplate. A small faceplate has already been built as a matrix of liquid-crystal squares 40 mils across, which has been operated successfully in a vacuum chamber standing in for a proper CRT.

As in a conventional storage tube,

The face you love to touch.



The face of the patented Klixon® keyboard from Texas Instruments. People love to touch it because they can hear it click. And they can feel it click. Which is why the Klixon keyboard is used by more pocket calculator manufacturers than any other type. There are countless other applications.

We've got a new brochure that tells you how reliable it is (gold-surfaced discs are sealed in Mylar™), how inexpensive it is, and about the company that stands behind it. For your copy, fill out the coupon on the reverse side.

TEXAS INSTRUMENTS
INCORPORATED

Circle 35 on reader service card

there are two guns—a write gun that switches on selected squares and a flood gun whose energy produces dynamic scattering and maintains that state in the liquid crystal. However, several years' work must be done before anything likely to be operationally acceptable can be built.

Obstacles. Colin Gooch, originator of the SERL work, explains that there are two main problems. The first, over which other researchers have stumbled, is to find a practical method of applying the beam energies to the liquid crystal and to combine that method with the use of alternating current to drive the liquid crystal. With direct-current driving, liquid-crystal life is unacceptably short. The experiments so far indicate that Gooch has solved this problem.

The second problem is to find a way of making the unit area of liquid crystal excited by the beam small enough to give the display acceptably high resolution. While Gooch can see how this resolution problem probably could be solved, he doesn't know whether it can be done at acceptable cost.

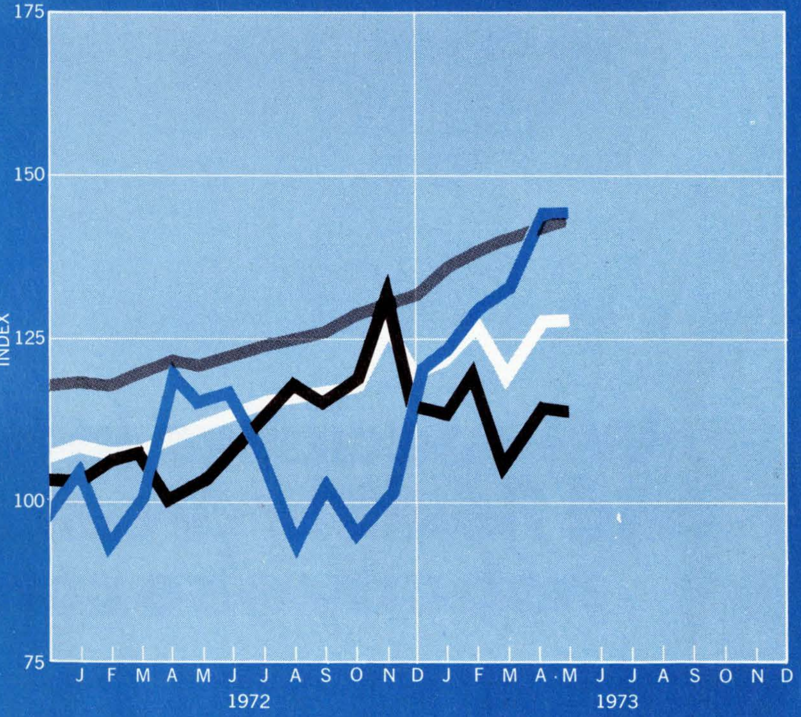
Gooch has built a second faceplate that goes some way toward providing adequate resolution. The thin liquid-crystal layer is sandwiched and sealed between the glass front plate of the tube and the target. The target is also a sheet of glass, with several thousand stainless steel wires running through it from front to back. The wires have 2-mil diameters, 10-mil pitch, and are theoretically on a true matrix. Each end is capped with metal so that the effective area on the end of each wire is more than 2 mils in diameter. In fact, the wire-packed glass is a proprietary material bought from American Optical Corp., Southbridge, Mass., and the caps are added by evaporating metal over both faces and photoetching it.

Transfer medium. The wire transfers energy from a rear cap to a front cap and so to a small area of liquid crystal on the front face. The charging process is started in selected caps by a pulse from the write gun, which changes the cap potential relative to the potential of the flood gun and a collector mounted behind the target. To erase the display, the collector potential is lowered.

The process works like this: initially the flood gun and target are at ground potential and the collector at about 150 volts. The write-gun pulse starts secondary electron emission from the cap, thus raising its potential. The pulse is sufficient to cause emission above a critical minimum level, from which the flood gun takes over and increases emission until cap potential stabilizes at collector potential. This voltage drives the liquid crystal. Reducing collector potential suppresses emission, and the cap returns to zero potential.

An ac drive to the liquid crystal is obtained by modulating the collector potential ±25 v at about 50 hertz, which similarly modulates the target potential. The dc level at the target is isolated from the liquid crystal by interposition of a thin dielectric layer (for instance, silicon

Electronics Index of Activity



Segment of Industry	May '73	April '73*	May '72
Consumer electronics	**145.2**	**145.1**	**113.6**
Defense electronics	**114.9**	**115.4**	**105.2**
Industrial-commercial electronics	**143.7**	**142.3**	**124.6**
Total industry	**128.9**	**128.6**	**112.5**

The index inched up 0.2% in May, but it remained a healthy 14.6% higher than last year. Consumer electronics was 27.8% above last May's level, while industrial-commercial electronics posted a 15.3% year-to-year increase. May's only loser was defense electronics, which fell 0.4% from April's level, but was still 9.2% higher than in May 1972.

Indexes chart pace of production volume for total industry and each segment. The base period, equal to 100, is the average of 1965 monthly output for each of the three parts of the industry. Index numbers are expressed as a percentage of the base period. Data is seasonally adjusted.
*Revised.

oxide) over the complete target surface in contact with the liquid crystal, which thus gets a true ac signal.

Gooch believes system resolution has to be improved. A 10-mil wire pitch gives 500-line resolution on a screen 5 inches high. This might be acceptable, except that the present minimum beam-spot diameter of 20 mils means that the write pulse activates too many wires. Ideally, says Gooch, the beam needs to have half that diameter, and the wire needs a pitch of less than 4 mils. □

Microwaves

Millimeter waves tamed by Bell's ICs

The use of millimeter waves, slow to be adapted for communications systems, may become more widespread with the development of millimeter-wave integrated circuits (MMICs). Bell Laboratories, Murray Hill, N.J., among others, has developed MMICs that are similar to hybrid microwave ICs, but they operate at frequencies as high as 240 gigahertz.

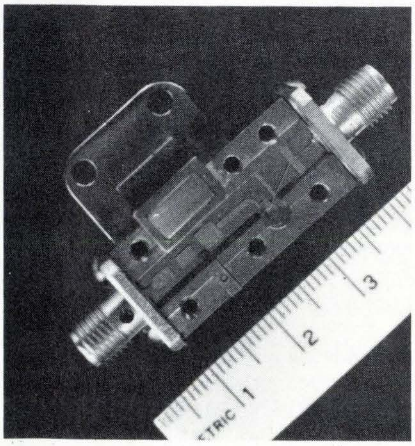
The circuits appear particularly applicable to wideband telecommunications using circular waveguides, but they should also be useful in high-resolution radar, radiometry, and radio astronomy. Automobile anticollision radar is also a possibility.

The present equipment in the millimeter-wave spectrum (10 millimeters to 1 mm or 30 to 300 gigahertz), uses waveguide technology. Most equipment must be considered experimental, and it remains in limited use at least in part because of the high cost of the precision subminiature waveguide structures necessary to operate in this range. For wider use, less expensive techniques appear necessary, and the Bell Labs MMICs appear to offer opportunities. A major telephone use would be line repeaters, and vast numbers would be required for this application.

The MMICs, built by microstrip techniques on silica substrates, include various receiver and transmitter components: among the more exotic are a 100-GHz Impatt oscillator with 30 milliwatts cw output, a 240-GHz detector, a 120-to-240-GHz doubler, and a 140-to-1.4 GHz converter that uses a gallium-arsenide Schottky barrier diode. In general, photo techniques, highly developed for the monolithic IC industry, are needed for constructing the thin-film circuits, but some of them have been cut with a scalpel under a microscope.

In the range of circuits that have more immediate use in the 30-GHz band, Bell Labs has developed an Impatt oscillator with 240-mW output and 5% efficiency, a 10-to-30-GHz frequency multiplier with 50-mW output and 29% efficiency, a 30-GHz-to-1.6-GHz down-converter with a total 5.5-dB single-sideband noise figure (see photo) and a 30-GHz ferrite circulator with 15% bandwidth for 20-dB isolation and only 0.55-dB loss, including transitions.

Unfortunately, design techniques at millimeter-wave frequencies are not as well developed as they are for microwave ICs because of the tiny size and losses in materials, as well as unfamiliarity. Bell Labs reports good results by designing lower-frequency circuits, then scaling their output to a higher frequency. This technique, though well known, has not been used widely because of the difficulty of scaling device parameters and finding suitable substrate materials for the large low-fre-



For millimeter waves. Down-converter developed by Bell Labs.

News briefs

House cuts off Aerosat

Following the lead of the Appropriations Committee, the House of Representatives passed the FAA budget without $2.7 million for the Aeronautical Services Satellite (Aerosat). The committee directed the agency to obtain the support of the airlines after it heard airline representatives' criticism this spring of the FAA's joint effort with Europe and Canada. The program also received similar treatment before the Senate Commerce Committee [*Electronics*, March 29, p. 41].

Telex-IBM battle almost over

A decision is expected shortly on the year-and-a-half-long antitrust battle between IBM and Telex. Jack Biddle, executive director of the Computer Industries Association, feels that Telex has proved its case. Says Biddle, "Whether the judge can write an opinion that will correct IBM's predatory practices is hard to say. The counterclaim against Telex— that Telex hired away IBM people to learn details of IBM's designs—should technically be ruled in IBM's favor, but the judge should dismiss the case because no harm has come to IBM on this account."

Univac computer pacts total $43 million

Sperry Rand's Univac division has won four Government awards for computer hardware with a combined value of $42.8 million and a potential for much more in follow-on business. The two largest awards are $30 million for 15 large-scale 1108 computers to be used in the Army's Military Personnel Center near Washington, and $11.9 million from the Air Force to produce weapons-system controllers for the Minuteman ICBM launch facility.

Smaller awards are $673,454 from the Naval Electronic Systems Command for models of a standard combat-system processor, and a $250,000 contract from the Department of Transportation for three 1616 computers.

Five years for liquid-crystal display

A clock radio with a liquid-crystal display that is expected to last five years is being built by a small one-year-old electronics firm in Stamford, Conn., called Abatronics. The unit, which will debut within three months and sell for about $80, is being marketed by Dalamal Electronics Corp., New York. A spokesman for Abatronics says that although the plug-in proprietary display will last five years, the company is actually guaranteeing the crystals for only one year, the current life expectancy of liquid crystals.

Helicopter prototypes awards go to Bell, Hughes

Bell Helicopter Co., Ft. Worth, Texas, and Hughes Tool Co., Culver City, Calif., recieved Army awards of $44.7 million and $70.3 million, respectively, to build prototypes of the advanced attack helicopter (AAH). Losers in the competition to build two each of the AAH prototypes for a competitive flyoff were Boeing Vertol Co., Lockheed California Co., and the Sikorsky Division of United Aircraft Co. The Army expects the flyoff to be completed by mid-1976, but a production go-ahead is not expected until the end of 1978.

Navy awards Trident design to RCA

RCA Corp. will design and build two prototypes of a new integrated radio room for the Naval Electronic System Command. For use on the Trident class of the next generation of ballistic-missile submarines, the radioroom's processors will handle vlf, lf, hf, and uhf equipment, data switching, an antenna interface, a teleprinter, and control, monitor, and test equipment.

Digital instrument standard is near

A standard for digital panel instruments that will allow interchangeability, provide common definitions for features, functions, and displays is expected soon from the National Electrical Manufacturing Association. The committee will also standardize electrical and mechanical test procedures for the instruments.

Microsystems International...

Big in Memories

It's an understatement! We're about the biggest semicon memory components manufacturer in the business—and we're getting big in memory systems too. (The board in the photo is Microsystems latest 8K X 12 memory module).

We're big in memory technology with p and n channel silicon gate MOS LSI for low cost, low power applications; and the complimentary Schottky clamped bipolar for high speed requirements. Our broad product line includes RAMs, ROMs, pROMs, Shift Registers, Special Purpose and Peripheral Circuits. The line features TTL compatibility, a range of bit capacities from 64 to 4096, access times from 20 ns to 1500 ns and a choice of static or dynamic operating modes. Deliveries are the best. Our high volume 3 inch wafer fab facility is running around the clock. And product of the highest quality is assured by a fully approved test lab, backed-up by our unique SEM failure analysis program.

We haven't overlooked new products either. Over 350 engineers and technicians are dedicated to the development of advanced circuits and processes. When it comes to service we're hard to beat, with our worldwide network of sales and applications engineering offices, stocking distributors and sales representatives.

When considering your next order for memory components and systems remember Microsystems International—we're about the biggest in the business.

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quency circuits.

Bell Labs gets around this obstacle by employing modified device packages at low frequencies and using inexpensive quartz plates for substrates. Careful attention must be paid to materials and components at the higher frequencies because of the relatively low Qs obtainable there. The company also builds the circuits in narrow channels below wave cutoff to eliminate undesired modes. □

Companies

Ampex turns around on losses

Ampex Corp. executives said last month that the firm is recuperating from "catastrophic" reverses in 1970, which left the firm operating at a $90 million loss, more than $250 million in debt, and on the verge of closing its doors. The optimism was occasioned by the fiscal 1973 report, showing an after-tax profit of $873,000 on sales of $256 million and net earnings of $3,654,000.

During the year, operating profits rose from 1.8% in the first quarter to 10.4% in the fourth quarter. With retrenchment to the company's more traditional lines—primarily professional audio and video equipment, computer memories, instrumentation recorders, and tapes—costs were reduced some $60 million and liabilities by nearly $40 million. Ampex, it was said, leads the industry in all but the tape line, and the others account for 70% of its sales.

The most significant development reported at the meeting was a software package that allows the firm's terabit tape memory to be used as a giant disk memory on IBM computers. The software is expected to open up commercial sales of the memory, which has a capacity equivalent to some 30,000 reels of tape. Two of the systems have been sold to Government agencies, the first without and the second with the software. □

the digital processing oscilloscope...

processing—a new dimension for the 7000-Series Oscilloscope family.

The Digital Processing Oscilloscope combines the waveform viewing power of the 200-MHz general-purpose oscilloscope with the processing power of the modern minicomputer. The P7001 Processor, housed between the Acquisition Unit and Display Unit, provides complete two-way computer communication.

Any waveform and its parameters which can be displayed on the CRT can be digitized, stored, and sent to the minicomputer for processing. The processed results returned by the minicomputer can be stored and/or displayed on the CRT.

The P7001 contains an I/O interface, A/D converters, D/A converters and 4,000 words of 10 bit core memory. It can store up to four digitized waveforms, associated parameters and messages. Sixteen User Definable Program Call buttons permit the operator to call prestored computer-measurement programs.

Processing means the user is no longer limited to 'scope waveforms for his information. The conventional display is usually of amplitude vs time (YT) format.

Suppose that the desired data is really of the dV/dt form. The derivative of a waveform can be calculated manually (providing that the waveform can be expressed as a math equation). *BUT* the Digital Processing Oscilloscope will perform the desired operation *AND* display the result at the press of a button. For this application and others see the illustrations at right.

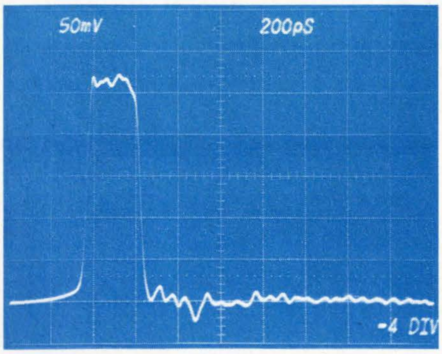
The Digital Processing Oscilloscope is available in packages complete with Oscilloscope, plug-ins, Processor, minicomputer and APD Basic Software. For complete information contact your local Tektronix field engineer or write Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005 for your copy of the "Digital Processing Oscilloscope" brochure.

 Circle 44 on reader service card

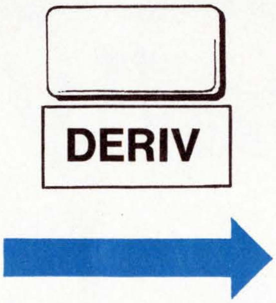
For a demonstration circle 45 on reader service card

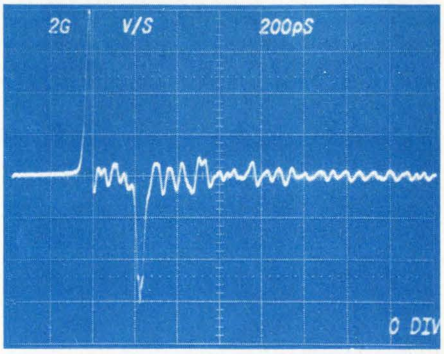
what it means to you...

...a few examples of the new measurement capabilities available at the press of a button.

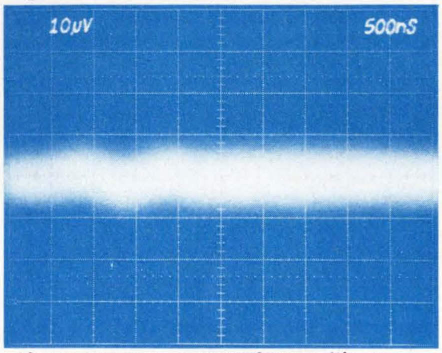


A very fast rise pulse is to be processed. The ground level is 4 divisions below the center line as indicated in the lower right corner.



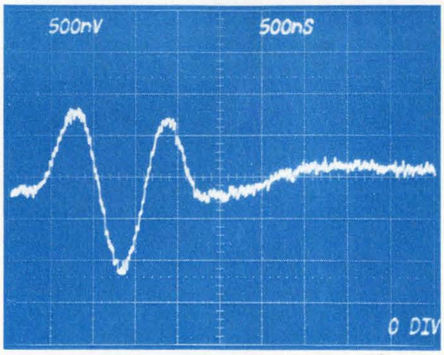


The result of pressing the Program Call button gives dV/dt for the waveform.

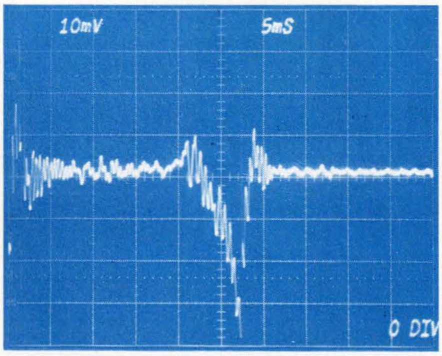


Above we see a waveform with so much noise present that no meaningful information is visible.

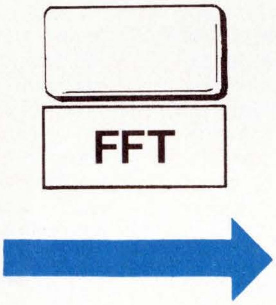
After pressing the SIG AVE (Signal Averaging) button the resultant waveform appears.

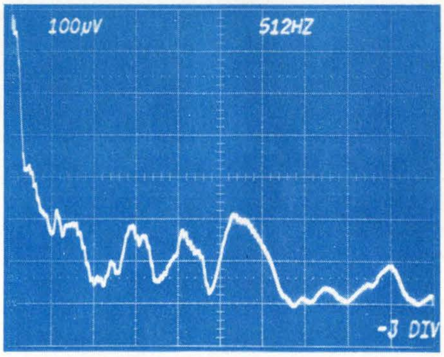


The signal was averaged 5,000 times and automatically rescaled for this display. Note the vertical sensitivity for this display is 500 nV/div.



The electrical signal caused by contact bounce in a switch is stored on a single shot sweep of the time base.

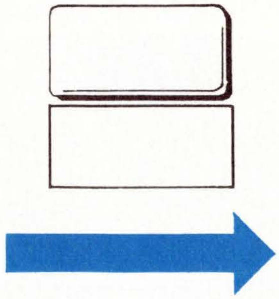




Pressing the FFT button shows the frequency distribution of the switch contact bounce with a frequency span of 512 Hz/div.

your waveform here

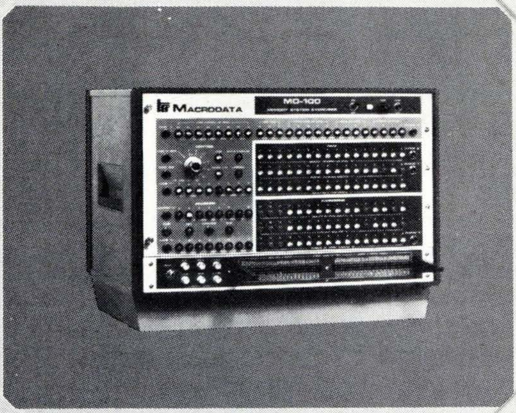
What is your measuring requirement?



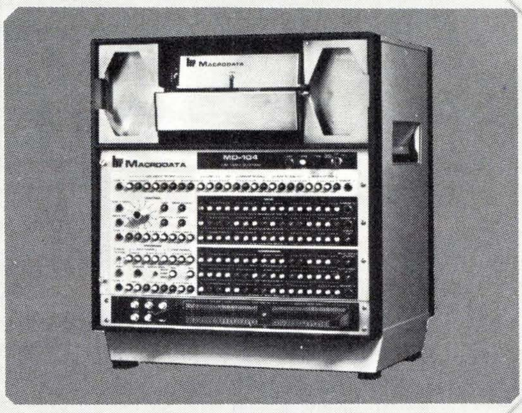
Press the button of your program which you wrote for your requirement.

your **processed** waveform here

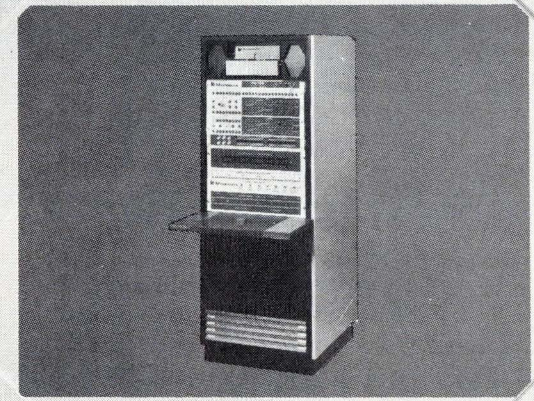
The answer will appear above.



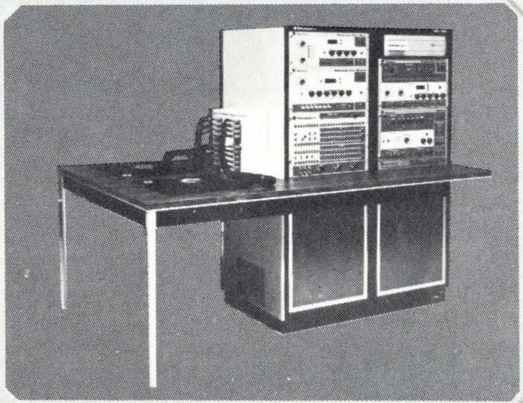
MD-100 A 5-MHz Functional Tester for RAM's, ROM's, and Shift Registers **Circle 240**



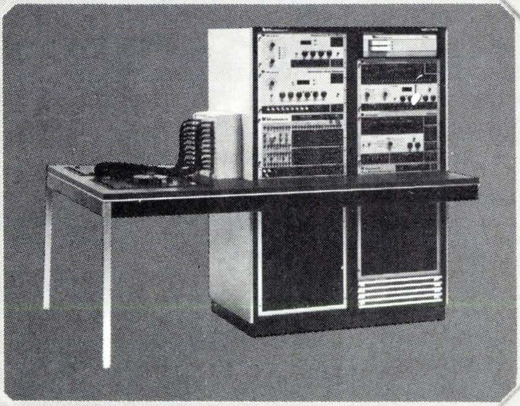
MD-104 A 10-MHz Functional Tester for RAM's, ROM's, Shift Registers, and Random Logics **Circle 241**



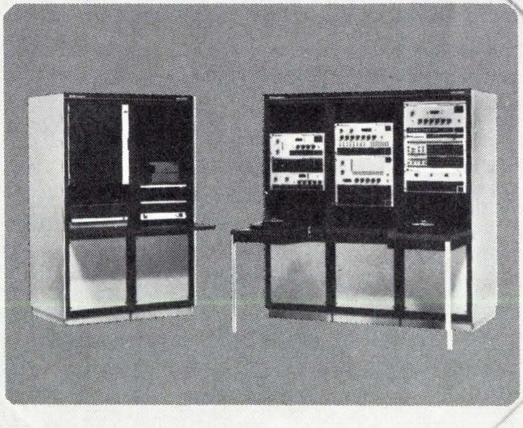
MD-110 A Functional/Parametric Tester for Calculator-Type Random Logics **Circle 242**



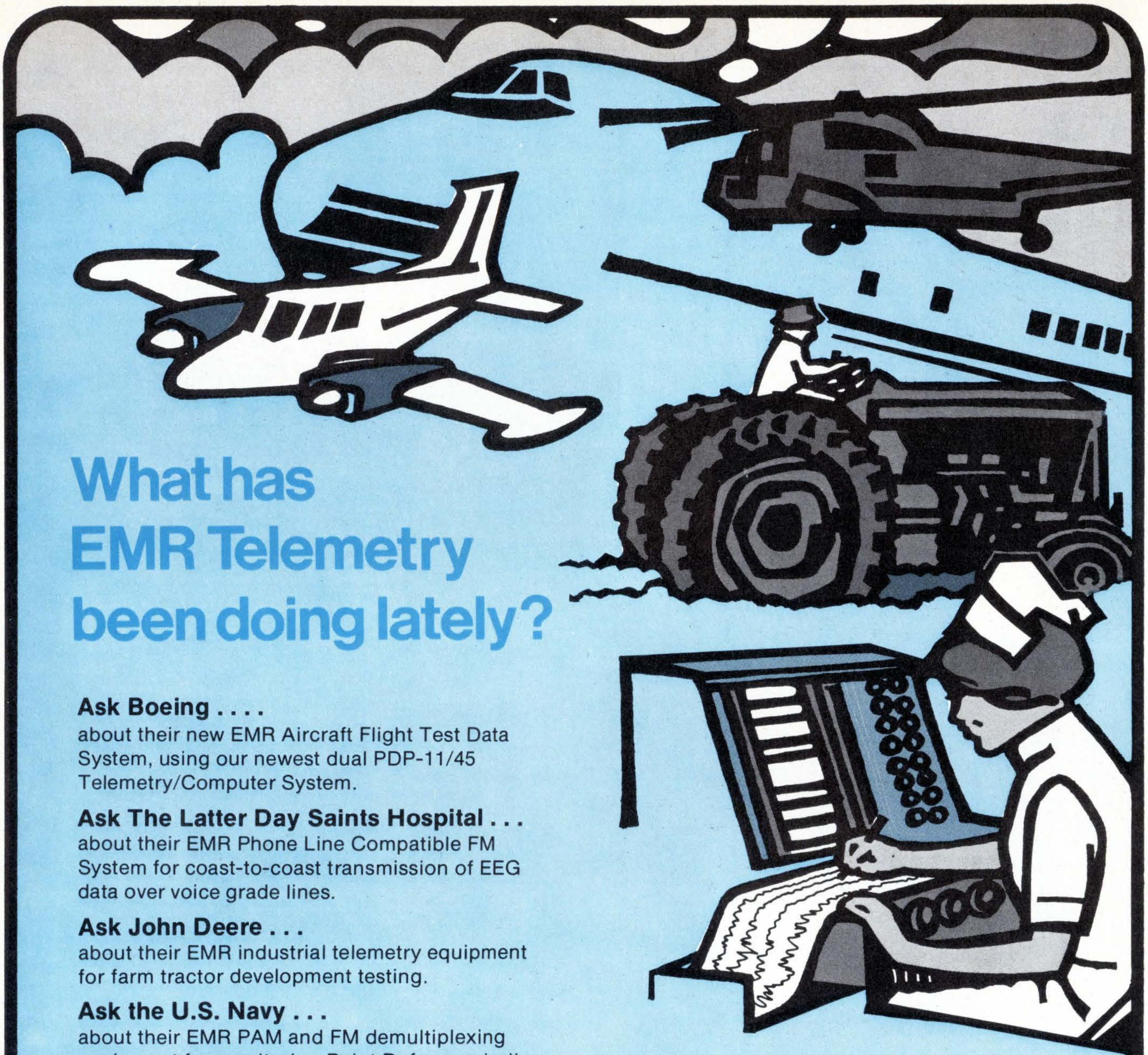
MD-150 A 5-MHz Computer-Controlled Functional/Parametric Tester with Universal Pin Electronics for All Devices **Circle 243**



MD-154 A 10-MHz Computer-Controlled Functional/Parametric Tester with Pin Electronics for All Devices **Circle 244**



MD-500 A 10-MHz, General-Purpose, Multi-Station, Functional/Parametric Tester for All Devices **Circle 245**



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Army's PEPE order could prompt major computer advance

Pentagon computer specialists foresee "a major step forward" in technology stemming from the Army's decision to proceed with **the development of PEPE—the parallel-element processing ensemble for intercontinental missile defense.** The first PEPE will be installed and tested over a 39-month period at the Advanced Ballistic Missile Defense Agency, Huntsville, Ala. Under a $9.5 million award to System Development Corp., "more than $5 million" was subcontracted to Burroughs Corp. for 36 small processors using medium-scale integration and designed to System Development's specifications.

"This should make the computer-utility concept more viable" in the competition with minicomputers for the expanding data-processing market, contends one Government source, "regardless of whether a SALT agreement with Russia" precludes deployment of an anti-missile system. **PEPE technology permits interconnection of up to 288 computers**—each able to handle up to 5 million instructions per second—**and links them with a Control Data Corp. 7600 control computer.** In the ABMDA application, the small modified commercial processors handle data from missile-defense sensors, and the large CDC machine is used for system command. The PEPE concept was proved in 1971 at Bell Laboratories, where a brassboard configuration of 16 small Bell-developed processors was run by an IBM 360/67 [*Electronics,* May 24, 1971, p. 32].

FAA plans more voice-switching systems for ATC

A $100–150 million program for electronic voice-switching units for larger airports and a later program for units for small airport towers are on the FAA's drawing boards to complete the agency's Switched Aviation Communications (Savcom) network. **The Satellite EVS System program for larger airports will place 150 units at hub airports and air-traffic-control towers with 10 to 100 ATC positions.** Present FAA plans call for requests for proposals to go out to industry in early 1975, following evaluation of Litton Industries' prototype system, which goes into operation at Dallas-Fort Worth in September. The smaller system, called the Electronic Key System and serving towers with five positions or less, is several years away.

Both of the switching systems would be added to the main EVS system now underway. The prototype contract for that EVS was won by Philco-Ford and included a production option to install units at 20 en-route ATC centers, for about $100 million total cost [*Electronics*, Jan. 18, p. 115].

Another fight looms over AT&T's tariffs for data-under-voice

Now that the Federal Communications Commission has given AT&T the go-ahead for its commercial data-under-voice service between five eastern cities, the special-service common carriers are expected to wage their next battle with Bell over the tariffs for the upcoming service. They want **to make sure that Bell doesn't try to subsidize the service by hiding costs in existing amortized facilities.** Following the commission's approval of the first $1 million data-under-voice segment, FCC staffers will have the thorny job of sorting out AT&T's cost allocations to ensure they are fair and competitive.

Washington commentary

Defense: what you buy and what you get

"What are we talking about here?" demanded the congressional staff investigator. "Are we talking about building a strong national defense? Or are we really talking about keeping a lot of companies alive?" Because those argumentative challenges were delivered in the cordial atmosphere of a corporate hospitality suite in the capital not long ago, they did not seem particularly threatening to the Pentagon R&D official who heard them. Thus was he able to respond with a smile and an evasion: "You Hill people are really feeling your oats with this Watergate business, aren't you?" The laughter that followed in that corner of the room was more nervous than hearty. And, as the Pentagon's man later observed, "I'm glad that came at a party instead of a hearing. I am also glad it is not my job to come up with the answer."

The men whose job it will be to answer are of course DOD's new secretary, James R. Schlesinger Jr., and his deputy, William P. Clements. Nevertheless, the questions are certain to be raised by a feisty Congress that has indeed been reinvigorated by Watergate.

Up the F-111

The Senate Armed Services Committee, for example, has guaranteed a confrontation with the Pentagon by following the lead of its House counterpart and adding an estimated $175 million in procurement money to the DOD budget for continued production of General Dynamics' F-111 interceptor. That Air Force program was recently cancelled by Clements in his role as acting secretary while Schlesinger awaited Senate confirmation [*Electronics*, June 21, p. 52]. Congressional sources report that the vote by both committees was "virtually unanimous" in overruling Clements' action, one reportedly taken to offset rising Air Force costs for development of the B-1 strategic bomber at Rockwell International.

Clements also faces problems with his proposal to buy more Navy F-14 fighters from Grumman Aerospace Corp., while obligating another $475 million to develop alternative follow-on programs. Congressional budget cutters, led by Wisconsin Democrats William Proxmire in the Senate and Les Aspin in the House, want the F-14 cancelled. Though both men "generate more sound than clout," as one F-14 subcontractor's man puts it, he concedes they are picking up some powerful allies in their drive. Among these are Sen. Stuart Symington (D., Mo.), acting Armed Services chairman, and Sen. Howard Cannon (D., Nev.), whose Tactical Air Power subcommittee is investigating the troubled F-14 program once more.

What should concern Government electronics prime and subcontractors is the question that is of concern to an increasing number of legislators who must vote the annual appropriations: are the military services getting the operational weapons—as opposed to airframes, ships, or other weapons platforms—they require? Marine Corps commandant Gen. Robert E. Cushman, for one, believes his is not. In recent congressional testimony, he played the good soldier by replying circuitously when asked if Clements had "shoved the F-14 down the throat" of his service by ordering it to substitute fewer Grumman planes for the larger number of uprated McDonnell Douglas F-4s it wanted. Afterwards, however, he was heard by congressional staffers to say angrily: "Just give me a plane, dammit. Any plane."

Needs and priorities

Such frustrations are heard increasingly among the military, who accuse Clements of inadvertently producing the same kind of environment that came to haunt Robert S. McNamara in his later Pentagon years, one in which a variety of weapons systems lingered in development without ever reaching large-scale production. Sen. Proxmire, who insists he favors a strong national defense instead of a series of "paper weapons," has dramatically observed that it will not be many years before the U.S. has fewer operational fighters than such potential minor adversaries as, say, North Korea, though several are in development.

Where Congress has fallen down, however, is in its ability to vote given programs up or down while still in R&D, before they move into production where cost and performance problems make them front-page news. Nevertheless, the Congress seems to be picking itself up at last and preparing to make some rough judgments on a number of languishing military development efforts. Among them are a variety of missiles, such as the Subsonic Cruise Armed Decoy and the SAM-D air defense system, as well as a number of aircraft like the Airborne Warning and Control System (Awacs) and others less advanced in the R&D cycle.

The fact these judgments seem to be coming at this point in time is only peripherally related to Watergate. It is more directly linked to the military's growing complaints about its diminished operational inventory. And contractors should be forewarned. It is they who are in the middle in this renewed confrontation of the Congress and the Pentagon. **—Ray Connolly**

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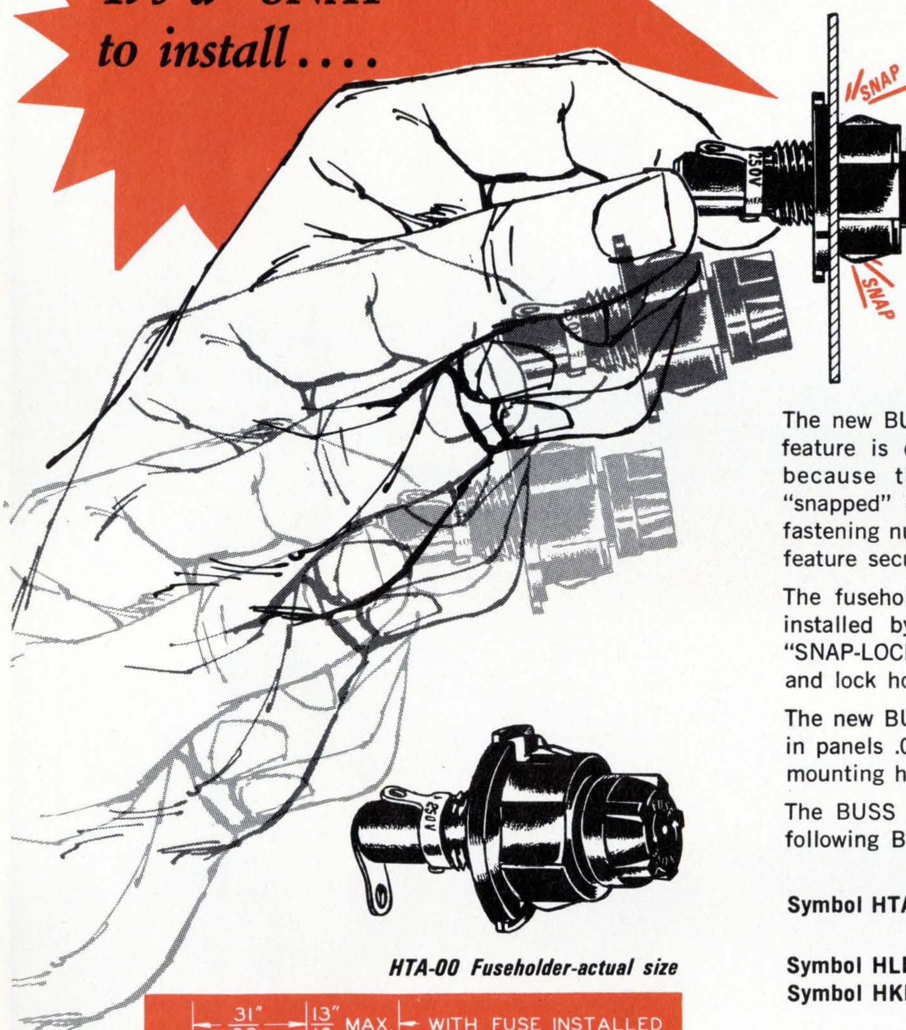

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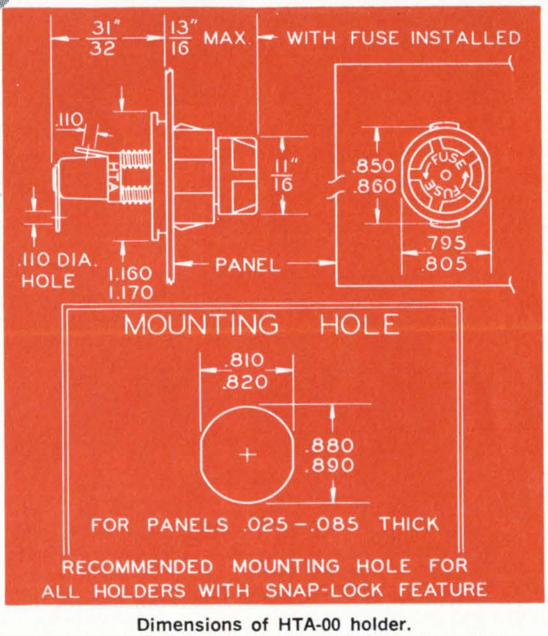

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Electronics international

Significant developments in technology and business

Ceramic device scatters light for large-screen display

Large-screen projection of alphanumeric and graphic data is the goal of a group developing a small ferroelectric ceramic display device. The device features high-speed, real-time, read-while-write operation and retains the memory capability of previous ceramic displays not capable of real-time operation.

Projection. The device, developed at Nippon Electric Co.'s Central Research Laboratory, is built on a transparent wafer on lead zirconate titanate that has been doped with lanthanum. In operation, the front surface of the wafer is illuminated through a hole in a parabolic mirror. This light passes through the wafer, is reflected at the rear surface of the ceramic by a mosaic of reflecting aluminum electrodes, and then is focused on the projection screen by the mirror. Scattering of the light depends on the orientation of domains within the ceramic overlying the reflecting electrode.

To enable addressing of individual picture elements, the device is fabricated in sandwich form, starting with a transparent ceramic wafer that measures 20 millimeters in diameter and 300 micrometers thick. An electrode, a semitransparent film of gold, is applied to the front surface, and reflecting electrodes—a mosaic of aluminum islands measuring 200 micrometers on a side and about 1 micrometer thick with a pitch of 250 micrometers—are applied on the back.

Barrier. The next layer on the reverse side consists of a high-resistivity light-barrier layer of a sulfide material. Then comes a layer of photoconductor, such as arsenic selenide, and another semitransparent gold electrode.

Writing to form a latent image requires a light pattern on the reverse side of the device and a voltage pulse. In initial experiments, the pattern source was a transparency in contact with the rear surface. Writing was performed by illuminating the transparency while applying a 250-volt pulse of about 0.1-second duration between semitransparent electrodes. At points under clear areas of the transparency, reduced photoconductor resistance causes the voltage to be applied, in effect, between the aluminum reflector electrode at that point and the front-surface electrode, and domains in the ceramic are realigned.

Erase is performed by a process similar to writing. The surface behind picture elements to be erased is illuminated, and a voltage pulse of opposite polarity is applied between semitransparent electrodes.

Once information is written into display it remains until erased, providing a no-power memory function. The light-barrier layer prevents the reading beam from interacting with the writing beam and thus disturbing the memory function of the device. Response of the ceramic is about 100 nanoseconds, but devices made so far operate at millisecond speeds because of the slow photoconductor response. □

Around the world

Two storage states, two colors emitted

In the summer of 1971, researchers at St. Andrews University in Scotland discovered that zinc selenide overlaid with an insulator and gold and operated as a diode had two distinct conductivity states at constant voltage. In the high-current state, it emitted yellow light [*Electronics,* Sept. 13, 1971, p. 169]. Now a researcher at the University of Manchester Institute of Science and Technology has discovered a similar effect in a similar structure in which the layers are gallium phosphide, an insulating oxide of gallium phosphide, and gold.

In this case, the light is green in the high-conductivity forward state, and a reverse pulse produces orange light. What's more, a silicon/silicon oxide/metal structure can also be made to operate in two conductivity states, although it does not emit visible light. Saeed Haeri, the institute researcher, thinks the similar effect in devices made from widely different materials indicates a semiconductor phenomenon that might be developed to make a new type of storage device. Light or the absence of light could be used as an indicator of the state of the store. Alternatively, display elements could be made with an integral, nonvolatile memory, so that constant rewriting to maintain the steady state is unnecessary.

X-band oscillator handles 60 mW

The designers were out for power when they developed the YIG-tuned swept Gunn-diode oscillators that RTC-La Radiotechnique-Compelec has readied for market. The oscillators develop 50–60 milliwatts in X-band (5.2–10.9 gigahertz) versions. The explanation for the higher power is simple, according to Vlad Pauker, the engineer in charge of the development. Usually, in YIG-tuned oscillators the power output is coupled through a YIG sphere. Since the sphere has to be very small to work at microwave frequencies—0.6 millimeters in diameter for X-band—there's an inherent power limit. RTC lifted this limitation by putting the load coupling at one end of a Gunn-diode chip and the reactive part of the oscillator at the other end. The coupling taper and the diode mount on a ceramic beam. The YIG sphere lies at the end of the beam opposite the taper, linked to the diode by a quarter-wave strap. The sphere, then, is out of the power circuit.

Other international developments in electronics

See page 73 for a Probing the News on China trade and page 34 for a story on a British display with a liquid-crystal faceplate.

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Circle 54 on reader service card

International newsletter

Philips begins making instant-on color-TV tube

Philips Gloeilampenfabrieken has started to move from pilot-plant to full-scale production on a "quick vision" 26-inch color-TV tube. On the new tube, **a viewable picture comes on about 5 seconds after switch-on if the set has the right solid-state circuitry.** Normal picture tubes take from 15 to 30 seconds to warm up.

Philips slashed the warmup time for its new tube without resorting to preheating. Instead, the tube has a smaller-than-usual cathode with a coil-shaped heater tucked inside it. The combination heats up to operating temperature some four times as fast as a conventional cathode having an M-shaped heater filament. Along with faster turn-on, the new cathode design cuts heater power by about 20%, Philips maintains.

Very few changes—sometimes none—are needed in receiver circuits to make possible the switch from conventional 110° tubes to the new types. **The main requirements: scanning circuits and the tuner voltage must stabilize within 5 seconds, and the impedance of the heater voltage source must suit the lower power requirements of the new heater.**

More British companies opt for touch controls

Several British companies are starting to promote equipment fitted with finger-tip-touch controls instead of push-buttons. As well as appearing on new TV sets [*Electronics*, June 7 1973, p. 65], a new frequency-analysis instrument from Solartron Electronic Group Ltd. has touch buttons for the entire front-panel controls. And the touch-wire display controller developed by Plessey Co. for air-traffic-control displays is being offered by Ferranti Ltd. for use with many other computer-controlled displays. **The advantage of touch control is elimination of mechanical movements, providing greater reliability and easier use.**

In the TV sets, the finger surface completes a circuit. Thorn and GEC use the current that flows to apply a voltage to the gate of an MOS transistor in a special-purpose IC made by Emihughes Microcomponents Ltd. That transistor triggers logic to latch in the chosen channel and positively latch out the other channels. Rank Bush Murphy uses discrete bipolar circuitry to achieve the same end and claims it's no more expensive. Philips has yet to decide on an approach: discrete bipolar, IC MOS, or bipolar IC made by Siemens. In all systems, the touch switches in a varicap diode tuner.

In the Solartron and Plessey-Ferranti systems, the finger connects the body's capacitance into a live circuit, and the change is detected to switch the system. Solartron uses metal films covering small rectangles that light up when touched, so that specifying frequencies using calculator-format touch panels is easier than using buttons. Ferranti uses printed wire sandwiched in transparent plastic, with the wire exposed and gold plated at touch points. A crt behind the plastic provides symbology. The technique is aimed mainly at retrieval-type computer operations such as reservation systems and stock control.

Memory-building process finds job in pc-board production

Thompson-CSF's Corbeville research laboratory now makes multilayer printed-circuit boards using its "copper insulation" technique. The company's researchers reported at the mid-June Brussels Internepcon meeting that they have **made both three- and four-layer boards including ground planes with 300-micrometer spacing for the conductors.**

Thomson-CSF originally developed the technique for integrated-core memories [*Electronics*, April 26, 1971, Electronics International]. Although the memory itself didn't pan out, the company's researchers realized that the technique pointed the way to low-cost printed circuits compatible with semiconductor-chip dimensions. With it, through-holes down to 10 micrometer diameter and conductor spacings to 25 micrometers can be had easily, as can "inverse beam lead" structures.

The Corbeville technique starts with a copper layer deposited onto a stainless steel sheet with the through-hole pattern engraved on it. **The resulting copper sheet is peeled off and serves as a temporary mechanical substrate.** Gold conductor patterns are electrodeposited onto the copper with no interface, obviously, at the holes. For multilayer circuits, added layers of copper and gold conductor patterns go on. Finally, the mechanical substrate is replaced by insulating material in two steps. Half the copper is etched away first, and the voids filled with insulation. Then the remaining copper is removed and replaced.

Swedish firm starts computer sales to Russia

Saab-Scania has received its first computer-system order from the Soviet Union, and according to the company, this opens a whole new market. The order went through Datasaab-Valmet of Finland, a jointly-owned firm of Saab-Scania of Sweden and the Finnish state-owned conglomerate, Valmet. The order includes a D5-/30 minicomputer—with a memory of 64,000 16 bits words—about 16 crt terminals made by StanSaab, which is owned jointly by Saab and Swedish government, two disc drives, two line printers and a card reader. Hardware will be supplied from Sweden, while Datasaab-Valmet will handle software. The order was from the MBS Bank, which serves as a central clearing agency for Comecon countries.

As the order was being signed, Datasaab—the computer division of Saab-Scania—put into operation its first computer-run bank-teller terminal system in the U.S., at a branch of the Central Savings Bank of New York. The order for this on-line installation—similar to a system Saab is delivering to all Scandinavian savings banks—was received in January, and the first units were in service in mid-June.

Spain seeks foreign help in computers

Spain, which lacks a home-grown computer industry, is about to enter the field with outside help. **Madrid officials are currently negotiating with three foreign computer groups about starting up an edp-equipment production center in which Spanish interests will amount to 31%.** The three contenders for setting up the facility are the computer combine composed of West Germany's Siemens AG and France's Compagnie Internationale pour l'Informatique—which Philips of the Netherlands is expected to join soon—Japan's Fijitsu, and West Germany's Nixdorf Computer AG and Britain's International Computers Ltd.—two companies which have been cooperating in data processing on a loose basis. A decision is due before the end of the year.

Significant by their absence are U.S. electronics groups. IBM and Univac, which jointly dominate computer sales in the Spanish market, have not entered bids in the contest thus far, according to well-placed sources. At stake is Spain's $30 million computer market, which also is one of the fastest-growing in Europe. Japan's Fujitsu is reported to hold the inside track with an offer to divide the interest in the venture evenly with the government's industry ministry.


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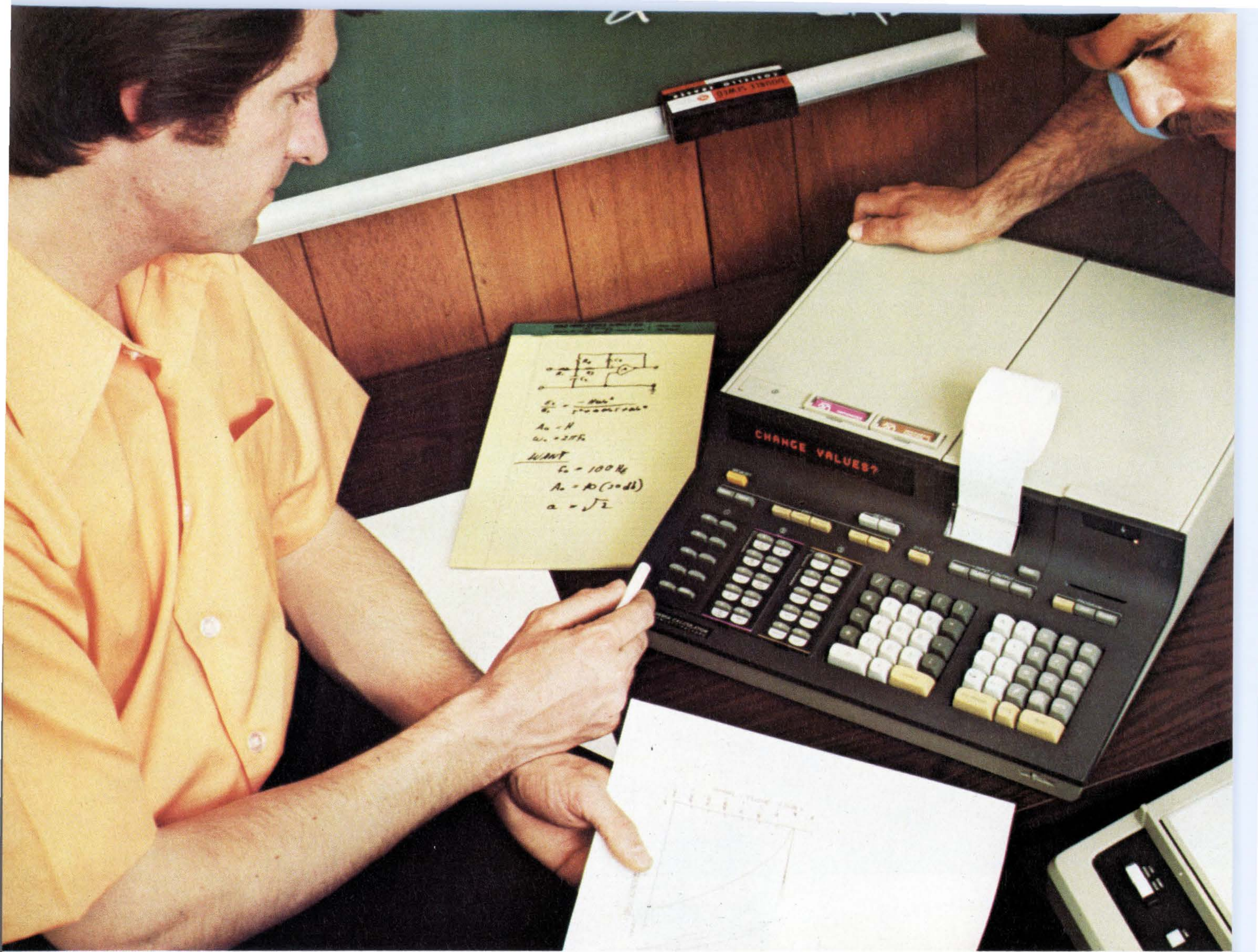

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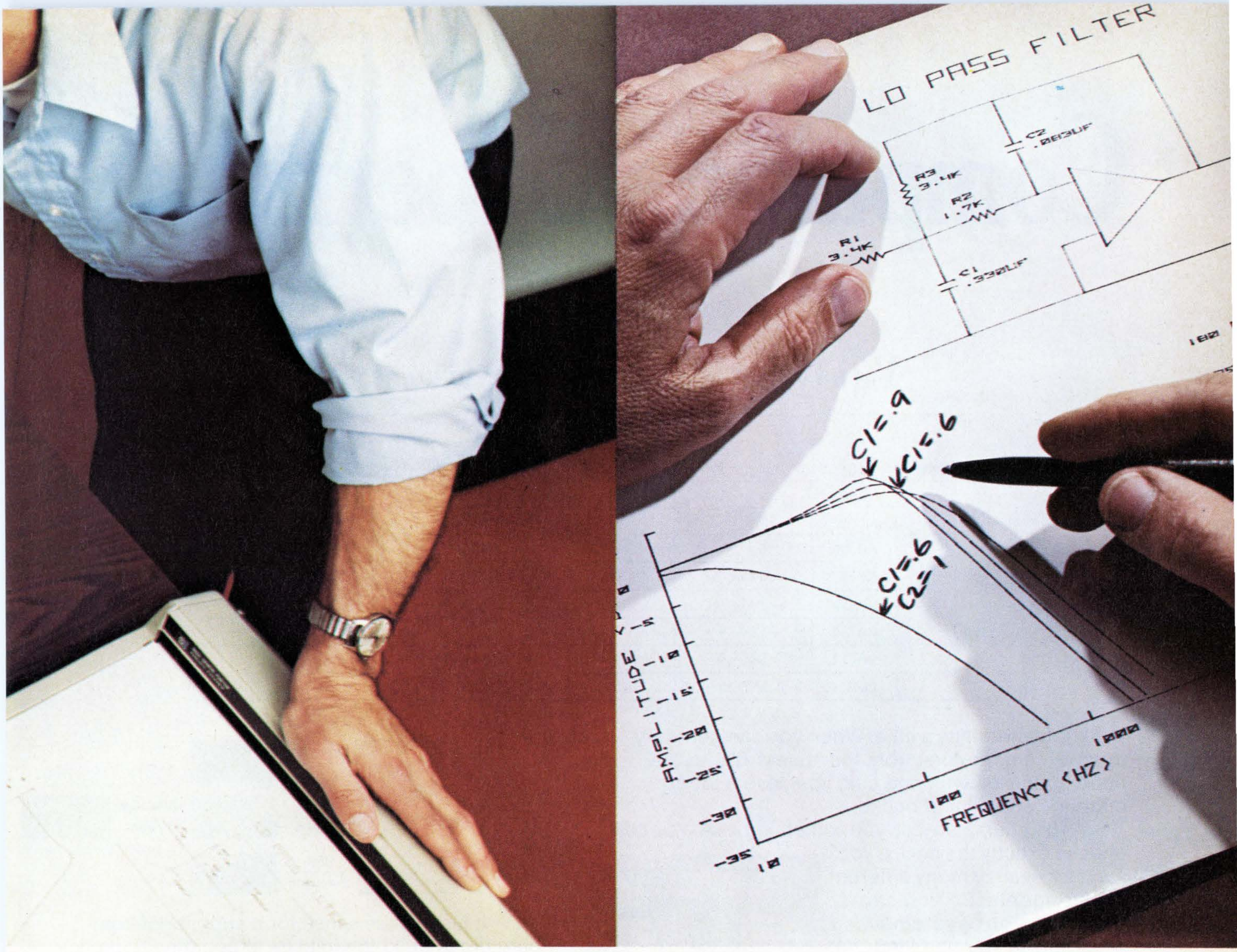

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	NE522	±5	10	5.0	20.0	7.5	10	15
	NE526	±5	10	5.0	35.0	5.0	40	48
	NE527	±5 to ±12	10	0.75	2.0	6.0	16	26
	NE529	±5 to ±12	10	5.0	20.0	6.0	12	22
	μA710	+12, −6	1	5.0	25.0	5.0	40	—
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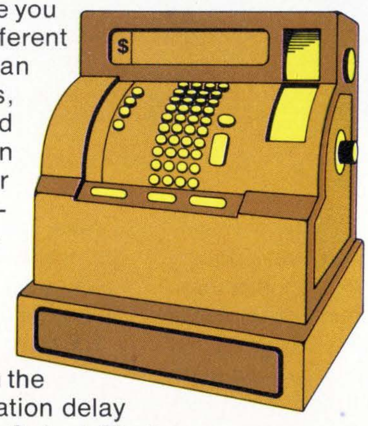

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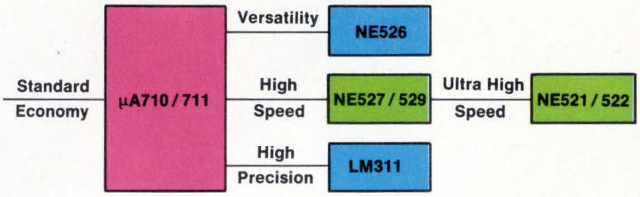

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Circle 64 on reader service card

Daily newspapers go electronic

Intelligent terminals linked to computers and OCRs that punch tape are replacing typewriters and pencils in nation's newsrooms

by Howard Wolff, Associate Editor

America's daily newspapers are edging into the electronic age. While most may not be equipped yet with editing terminals or use computerized typesetting, many of their executives are looking hard at the equipment that's responsible for the most radical changes in newspaper production since the invention of hot-metal linecasting machinery.

The motivation is money. As one newspaper professional puts it, "If they couldn't get it back in savings on labor, they wouldn't be interested." By "they" he means the publishers, and any time a newspaper publisher is told that he can make a dramatic dent in his overhead for the mechanical departments, he's going to listen carefully.

Profits swell. The experience of one small newspaper–circulation around 9,000–is typical. The publisher says that by investing $100,000 in electronic equipment he went from being unprofitable 80% of the time to being profitable 80% of the time. What he did was buy IBM Selectric typewriters, two Datatype bar-code readers, hard-wire them to two Hendrix cathode-ray-tube terminals for editing, and hard-wire the terminals to a pair of Compugraphic photocomposition machines. The result was reduction of the composing room force from a total of nine men to two.

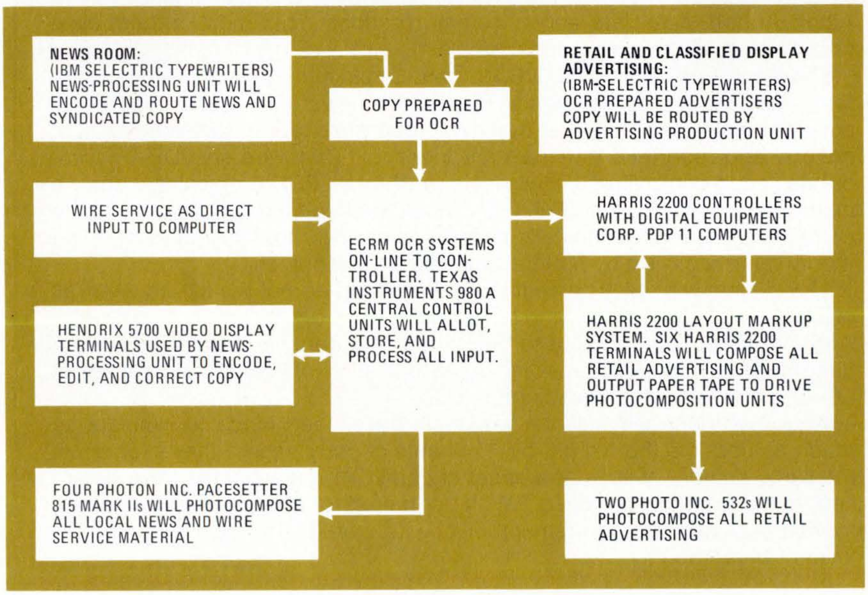
Of course, that newspaper is small enough so that it can get by without a central processor; the intelligent terminals contain enough memory to provide all the hyphenation and justification (making lines align at left and right margins) required. But a larger, big-city newspaper needs more capacity. The result is a burgeoning market in minicomputers, particularly the Digital Equipment Corp. PDP-8 series with its Typeset software as well as IBM 1130s and a scattering of almost every other minicomputer made.

There are, generally, three approaches to integrating the editorial and mechanical functions–and, in some, cases, the advertising operation–electronically. They are:

- The total video display system. Reporters write their stories directly on the intelligent CRT terminals, which are hard-wired to computers. Editors then call up stories, as they need them, on their terminals–also wired to the computers–for correction and length adjustment. Stories go from computer to phototypesetter, which turns out photocopy for pasting into forms. The *Detroit News* uses this arrangement (see "News at the *News*: call it input," p. 66).
- OCR scanner with paper tape. Stories are typed, the OCR converts them to punched paper tape, a computer hyphenates and justifies the copy, and the copy is then converted to photocopy or metal type. The *Providence Journal* and *Bulletin*, R.I., have taken this route.
- Video display for editing, OCR for input. This combination of the other two approaches is what most dailies will wind up with. With it, after the OCR has converted hard copy to punched tape, the terminal is used for editing. Richmond, Va., Newspapers Inc. will produce its two dailies and its weekly financial paper in this fashion.

The biggest problem most dailies have encountered in their efforts to go electronic is the interface with

Fit for all the news. This is the system that will be used for news and ads in Richmond, Va., to produce the morning *Times-Dispatch*, the evening *News-Leader*, and the *Financial Weekly*.



existing hot-metal linecasting machinery. The fastest such machine can chug along at 14 lines per minute, so that a good deal of the speed picked up in the editing process is lost when punched tape must be fed through those very slow Linotype machines.

The answer is the photosetting equipment now on the market that can handle 300 lines a minute in type sizes ranging from 5 point to 72 point—in other words, for everything from classified ads to page 1 headlines.

Program tailoring. Another obstacle is one commonly encountered when electronics is discovered by an industry. In the words of Joseph M. Ungaro, managing editor of the *Providence Bulletin*, "Manufacturers tend to think that one system can do the job for all newspapers. But there are almost as many different ways of moving news onto a page as there are newspapers. The result is that, while by and large the hardware is excellent, software has been a real problem. As a result, I have a feeling that most larger papers will eventually do their own programing."

Another thing most larger papers could eventually be doing is printing their newspaper, or regional editions of it, in plants that are miles away from the downtown news rooms. This would enable them to sell space in regionally circulated editions to local businesses without forcing those advertisers to "buy" readers in, say, another state; it would also do away with the truck-delivery straitjacket that forces newspapers to sell early editions to many suburban readers and late, up-to-the-minute papers to a relatively few subscribers in the downtown city area.

What will permit this vast physical separation of input and output is something America's national dailies have learned to handle—facsimile. Those national papers, *The Wall Street Journal* and *The Christian Science Monitor*, use regional printing plants. But wider use of fax has been blocked by the high cost of communications lines between the editorial offices and the remote plants—the combined requirements for high resolution and high speed have dictated the use of expensive broadband channels.

However, the *Monitor* has just bought a $500,000 fax system—as have the *Journal* and several European newspapers—that is changing the rules of the fax game. Called Dacom 300 Telepress, it uses a proprietary technique called by Dacom digital data compression. The system will transmit in six minutes a 14-by-21-inch page including text and halftone reproductions with a resolution of 600 lines per inch. Transmission is at 50,000 bits per second via AT&T lines. Combined with a new scanner and film recorder developed by Muirhead Ltd., Dacom 300 opens the way to fast, inexpensive, and interference-free transmission.

Perhaps the most sophisticated technology to be embraced by the Fourth Estate will be used starting next year by the Associated Press to transmit photos. The AP will use lasers for what it calls its Laserphoto service. The system, developed at MIT by William F. Schreiber, uses two lasers—one to scan the photo at a rate of 100 lines per inch at the transmission end, the other to trace out the information on dry silver paper. For transmission, photodetectors pick up the reflected laser beam.

Ink-jet printing. Finally, researchers and study committees aren't neglecting the actual printing of the paper. As pointed out by Peter P. Romano, director of the production department of the American Newspaper Publishers Association Research Institute, "Tons of iron are used to push ounces of ink into newsprint." So the ANPA/RI has a scientific advisory committee working on plateless printing. At the moment, says Romano, ink-jet techniques are favored, with a prototype system perhaps 10 years away. As Romano notes, printing a paper is a feasible compromise among time, economy, and quality—with quality running a poor third. Thus, it shouldn't be too difficult to put together an acceptable system. With a computer operating the jets, a story could be changed or replaced while the "presses" are running—and the whole process of hot metal, stereotype plates, and photoengraving, with pressmen in their square paper hats designed to keep hair from catching in the rollers of giant web presses, will join the reporter with press card tucked into his hatband as just another memory. □

News at the *News*: call it input

The Detroit News, which sells about 800,000 copies each afternoon, is America's most electronically advanced big-city daily newspaper. It has virtually eliminated the typewriter from its newsroom in downtown Detroit. "We keep a few in case a reporter wants to write a personal letter," says Albert Abbott, associate editor, communications, "but most of them even take notes over the phone on terminals."

The News has 72 Hendrix 5700 terminals split into three 24-machine systems. The keyboards have been tailored for newsroom use so that no reporter or editor needs special training to operate one. For the same reason, editors' and reporters' terminals are identical. There are six PDP-11 computers, each controlling 12 terminals, and three PDP-8 machines, each a central processor for two PDP-11s. Since punched tape is generated by the computers, the system has eliminated composing room keyboarding, even though type is still set by hot-metal linecasting machines.

The system will really come into its own at the end of the month when all of *The News'* production is moved 23 miles from downtown to a new plant. And the newspaper is about to hook the computers via a Datatype system directly to its eight bureaus, including one in Michigan's state capital at Lansing and another in Washington, D.C.

Abbott emphasizes that the terminals have been made to simulate as much as possible the old 8½-by-11 sheets of copy paper—they even show the same number of lines as a sheet of paper. Also, keyboards were simplified, and supershifts removed. "With our battery of 5700s, a man can go on four weeks' vacation and remember how to work the terminal when he returns," says Abbott.

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Smart traffic lights prevent errors

Intersections controlled by own microcomputers relieve drivers of need to make decisions and also cut dangers of high-speed travel

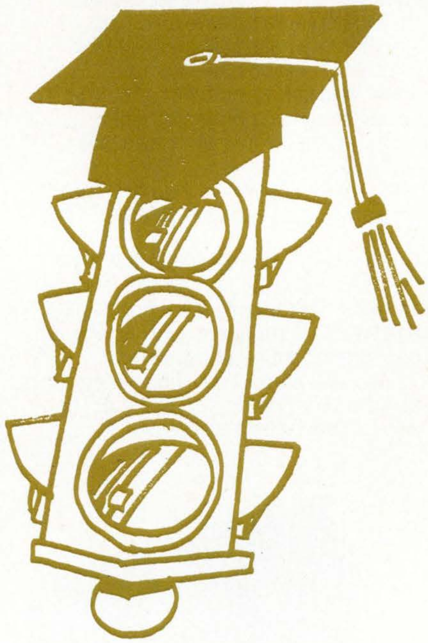
by George Sideris, San Francisco bureau manager

MOS microcomputers and California's mile-long traffic jams have given a needed push to the concept of using roadside computers to control traffic signals at isolated intersections. As a result, the "smart" light and "intelligent" intersection have become competitive with conventional hard-wired controllers—even though smart lights have, to date, won only a tiny share of the $100-million-a-year traffic-control market [*Electronics,* Feb. 1, p. 74].

Smart lights have had a gestation period longer than an elephant's. Though commercially available for three years, they've been the most expensive class of traffic-control automation. At a minimum cost of $20,000 or so per intersection, stand-alone computers were no economic match for either conventional controls or signal-control networks operated by remote computers.

This summer, however, at least two pioneers in smart-light technology will introduce systems governed by MOS microcomputers but priced in the conventional-controller range. Though not as versatile as the previous minicomputer models, these units are more flexible than conventional controllers, which must be custom-wired to cope with unusual traffic patterns. Smart lights are simply reprogramed, avoiding the expense, delay, and spare-parts inventories of custom equipment.

Tough sale. "It has been difficult to supply a dedicated minicomputer controller for under $20,000," says William J. Shiltz, traffic control sales manager at Eagle Signal division of Gulf and Western Industries Inc., Davenport, Iowa. His company started selling systems containing 8-bit Microdata 400 minis in 1971 and



now has some 25 at scattered installations across the country.

So, in August, Eagle will announce a new series of smart lights priced in the $6,135 to $12,500 range of complex hard-wired controllers. The systems will handle two to eight traffic phases, four fewer than the minicomputers but not many intersections have more than eight phases. Eagle chose an Intel 8008 MOS microcomputer as the central processor.

Another system with Intel's 8-bit microcomputer is being readied at Multi-Sonics Development Corp., Alamo, Calif. Multi-Sonics hasn't disclosed details, but Peter Josserand, director of sales, says it will be competitive with conventional controllers. Once a consulting firm, Multi-Sonics participated in Eagle's early smart-light development efforts. Since then, its principal business has been manufacturing systems controlled through centralized 16-bit minicomputers.

In 1971, Multi-Sonics supplied the California State Division of Highways laboratory with two minicomputers, which the division engineers converted into experimental smart-light controllers. That was the genesis of the first major smart-light project in the country—a project that has opened up a new and promising field for minicomputer controllers.

Speed in a crowd. Most smart lights have been used to relieve suburban traffic jams. However, California's highway engineers have focused most of their attention on the typical California driver, accustomed to freeway speeds, who goes full-bore down crowded highways. Their experiments indicated that smart lights could reduce accident rates by as much as 40%. They also projected a savings of 25% in controller costs if minicomputers rather than custom controllers were used at complicated intersections.

As a result, the division plans to equip more than 100 intersections a year for the next several years with smart lights. At present, the specifications call for 16-bit, general-purpose minicomputers to facilitate standardization while ensuring operational flexibility. However, the assistant state engineer coordinating the project, Gerald Bloodgood, says he has not ruled out future use of microcomputers. "It depends on which proves more cost-effective."

An order for 40 controllers in single and dual-minicomputer configurations and 10 backup computers was placed last November with Econolite division of Altec Corp., Anaheim, Calif.—a sale roughly equivalent to nationwide sales of smart lights in previous years. State engineers are checking out Econolite's first production models. Each controller is a Data General Nova 1210 minicomputer with four kilowords of core memory and sensor and signal interfaces.

Econolite bid less than $10,000 per controller in order to get in on the ground floor of a potentially lucrative market. Other firms bid $15,000 or more, and Rockne Lambert, Econolite's computer-systems manager, says a typical price for such systems would be about $18,000. However, the state is preparing its own operating programs, which will be modified at the street corner with portable tape readers.

Speed control. Bloodgood intends to use some of the initial installations to explore advanced methods of controlling high-speed traffic. Experiments will be conducted, on, for example, better methods of coordinating signal timing to traffic gaps. "You don't just turn the yellow light on those guys," he explains. "You can't force them to make the decision about whether to stop or not."

Since the data already gathered, and that to come, will have the imprimatur of civil engineers with long experience in highway traffic, the project has aroused high interest in other state highway departments. "We hope other jurisdictions will pick up what we have developed," Bloodgood comments.

One major contribution is the first generally recognized set of design standards and specifications. Most companies developing smart lights are working to the state's standards since national standards won't be ready until 1975, says A.J. Barry, advanced product planner for Automatic Signal division of LFE Inc. In fact, the Norwalk, Conn., firm decided to put his lab in Santa Clara, Calif., to make it handy to Golden State engineers.

Though unsuccessful in the November bidding, LFE built two models to state specifications. The state is trying them out at two intersections on El Camino Real in San Mateo county. The computers are packaged versions of Computer Automation Inc.'s Naked Mini. Barry hopes to cut the cost of the processor from about $5,000 to $1,500 or less in future models with Computer Automation's new MOS processor, the Alpha LSI.

Also, he thinks the time is ripe to eliminate the cost of air-conditioning controller cabinets—now necessary to protect core memories from thermal degradation—by substituting solid-state for core memories. He notes that air conditioning is not used in conventional controllers because they are cheaper and more reliable when made with miliatary-grade semiconductor devices.

But smart lights still have a long way to go to catch up in sales volume with the "half-smart" lights becoming popular in centralized computer networks. Automatic Electronic Systems Inc. of Montreal, for example, is supplying General Railway Signal Co., Rochester, N.Y., with 1,000 of its AES-80 TTL processors for the Baltimore, Md., control system. General Railway Signal Co. is supplying the street-corner equipment, including 964 microprocessors and 494 ultrasonic vehicle detectors, under a $3.8 million contract from TRW Inc.'s Transportation and Environmental Operations group in Redondo Beach, Calif. TRW will also be setting up the central office computer facility for Baltimore.

Located at the lights, the processors are programed to react to sensor inputs, actuate the signals, and communicate with the master computer.

Paul Mack, Automatic Electronic Systems' Eastern regional sales manager, says the company is bidding on a dozen traffic-control projects involving a total of some 20,000 processors. Each processor costs from $500 to $2,500. Even at the lower figure, the half-smart market today dwarfs the smart-light market.

The microprocessor, says Mack, is generally faster than minicomputers. The AES-80 can operate with a 240-nanosecond full-cycle time for executing an instruction when working with bipolar memory. He compares this with a cycle time of 1 μs for the average mini and 10 μs for Intel's 8080 chip.

Memory mix. The byte-oriented processor also has a serial input/output bus capable of transferring more than 100,000 eight-bit characters per second. It's also possible to intermix different types of data and instruction memories in the AES-80. Memory modules consist of 256 eight-bit data words or 12-bit instruction words; they may be bipolar or MOS read-only and random-access, core RAMs, capacitive ROMs, or special-purpose designs. In making its processor, Automatic Electronic has avoided specially designed circuits or chips because of their high cost, says Mack. □

Stop and go. This is a typical California intersection of the sort that would lend itself to control by "smart" lights. It's isolated and cars tend to move through it rather fast.

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Communications

The specialized carriers are setting up shop

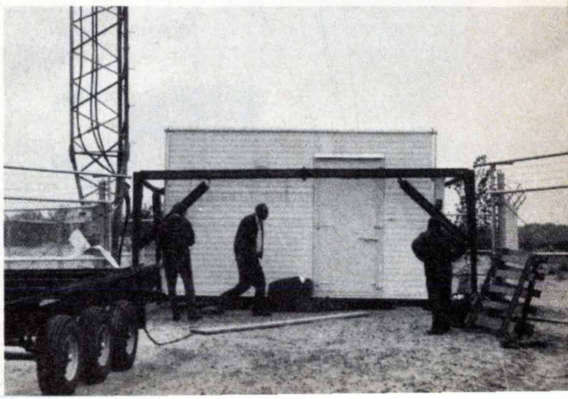
New companies prepare to open private-line channels, but find established carriers block $1 billion market

by Lyman Hardeman, Communications & Microwave Editor, and George Sideris, San Francisco bureau manager

Much water has passed over the regulatory dam since the FCC endorsed the concept of specialized communications common carriers in the 1960s. Now, as several carriers have opened segments of their microwave networks to the public, that concept is hardening into reality. With the progress has come a quickening of the competitive pace among the new carriers as well as between them and such established common carriers as AT&T and Western Union.

The new companies, some of them regional, are bidding for over $1 billion in annual business from those private-line users who need to transmit large volumes of data and voice and video signals. The contenders include:

- MCI Communications Corp., Washington, D.C., the company that first filed with the FCC 10 years ago and by now has operated a link between Chicago and St. Louis for over a year. MCI plans operation of a Los Angeles-New York link by December of this year.
- Data Transmission Corp., Vienna, Va., the financially beleaguered company that's the only one constructing an all-digital network. Datran expects to begin service to its first customers in December between Houston and St. Louis, and to provide nationwide service some time in 1975.
- United Video Corp., Tulsa, Okla., a cable-television company with some 1,300 route miles for carrying video in the Midwest, and plans to expand throughout the South. The company plans to use these routes to transmit both voice and data. A 700-mile Tulsa-Dallas link is to be completed late this year.
- Southern Pacific Communications Corp., a San Francisco-based subsidiary of Southern Pacific Railroad. Using railroad right-of-way, SPCC is constructing a network that will stretch from Seattle to Los Angeles and Dallas and then to St. Louis. A San Francisco-Los Angeles segment is set for August.
- Nebraska Consolidated Communications Corp., with headquarters in Lincoln, Neb., is already operating a link between Omaha and Chicago and is constructing links to expand its system to Oklahoma City, Houston, and Minneapolis by late summer and to Atlanta later this year.
- Western Telecommunications



Putting it up. MCI crew erects microwave relay tower. Company says it's building stations at rate of one a day, and adding 500 miles daily to its network.

Inc., Denver, Colo., the main business of which has been hauling television signals through the Rocky Mountains to 16 stations. WTC has a San Diego-Yuma, Ariz., link and plans for Los Angeles, Phoenix, and Tucson ties by Aug. 1.

■ Communications Properties Inc., Austin, Texas, which is also a CATV carrier with video systems in Texas and Ohio. The company is constructing a voice and data link for Dallas, Austin, San Antonio, Houston, Beaumont, and Corpus Christi by October. Plans are to extend the network into West Texas and Louisiana next year.

All of these applicants have received FCC construction permits and are actively building microwave relay links. Two other applicants–Hilderth Communications, with plans for a link between Boston and Portland, Maine, and Eastern Microwave Corp., planning a Washington, D.C.-Boston link–have not yet been granted the construction green light by the commission.

Uphill fight. Several obstacles still loom before the new specialized carriers. First, they must still solve the problem of connecting their terminals to customer locations in each city. Also, in order to sign new customers, each carrier must be able to provide a nationwide service, whether with its own facilities or by interconnection with other carriers.

Both of these requirements ultimately involve the Bell Telephone System, which is in direct competition with the specialized carriers. The reason is that, for most interconnections with customers within each metropolitan area, the specialized carriers will have to contract with telephone common carriers (usually operating companies within the Bell System) for existing local distribution loops. And the new carriers have received varying degrees of welcome from Bell.

Take John Albertson, vice president and general manager of SPCC. He's quite frank about what he describes as his troubles with Pacific Telephone, a Bell System company. He charges that Pacific Telephone has been stalling on agreements to interface local loops. But he adds that these problems are being resolved, and he hopes to sign an interconnect contract within 30 or 40 days.

Others are not as unhappy as Albertson. James McNabb, an MCI vice president, says that his company will have to depend on the Bell System for local distribution in the cities, particularly in New York, since it would be impossible to get a city's approval to dig up streets for private lines. He adds that so far he has found the telephone company cooperative. Most new carriers, however, seem to be accepting Bell terms in order to get business started, and hope to renegotiate.

Fighting AT&T. The need for specialized carriers to provide a nationwide service stems from the nature of private-line customers which, more often than not, are among the bigger companies and have offices across the country. Emphasizing the need to accommodate such customers, one industry insider admits, "The name of the game in private-line business is ubiquity, and that's where AT&T has the lead."

The more effectively to market their services, then, most of the new specialized carriers are scrambling to go nationwide, whether through expansion of their own systems, by interconnecting with other specialized carriers, or by interconnecting with AT&T. To date, however, AT&T has been unwilling to "piece out," or lease, portions of its intercity trunks to the specialized carriers. This would allow the specialized carriers to complete a link between two customer sites with the specialized carrier providing one segment, and AT&T the other.

On the other hand, AT&T charges the specialized carriers with "cream-skimming," or building only in high-density routes, and leaving AT&T with low-density routes where equipment overhead is higher. Reacting, AT&T has proposed its "high-low" pricing to the FCC [*Electronics*, March 15, p. 49].

Satellites. In time, the specialized carriers will make use of domestic satellites to expand and supplement their long-haul systems. According to Edward Taylor, president of United Video, "By 1977, no customer will pay more than $700 for a voice-grade private line." □

Electronics abroad

Tapping the Chinese market—slowly

EIA's Sodolski finds at the Canton Trade Fair that the People's Republic responds cautiously, but looks with favor on communications trade mission

by Ray Connolly, Washington bureau manager

Let a hundred flowers blossom.
Let a hundred schools of thought contend.
—Mao Tse-tung

It has been 16 years since chairman Mao explained in Peking that his "policy of letting a hundred flowers blossom and a hundred schools of thought contend is designed to promote the flourishing of the arts and the progress of science." While the time until the People's Republic of China begins importing American electronics technology to aid in that scientific advance is expected to be less than 16 years, the first impressions of U.S. executives is that the Chinese are playing it as inscrutably as ever.

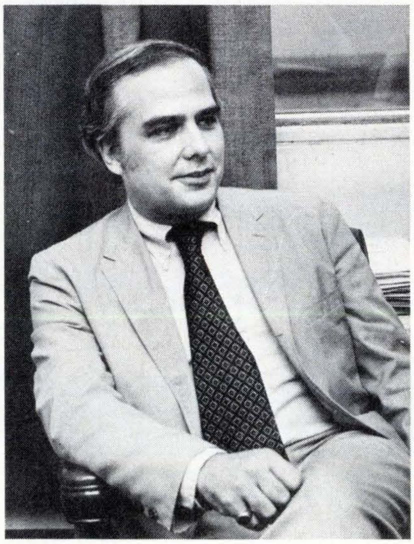
This is the view of John Sodolski, staff vice president of the Electronic Industries Association, after a week in Kwangchow at the annual Chinese Export Commodities Fair, commonly called the Canton Trade Fair. "The tone of all the meetings was good-natured, as well as friendly," recalls Sodolski, but "the Chinese gave very little information and rarely responded directly to questions." Others who have been to the fair confirmed that view, one man noting: "They don't even respond indirectly."

Mission. Sodolski, who heads EIA's Communications and Industrial Electronics division, says he had hoped to return from Kwangchow with a commitment for a U.S. communications equipment trade mission or trade delegation. While that hope was not realized, he does believe that "we will be hearing from the Chinese in the relatively near future" since, after a week at the trade fair, he was advised by Chinese officials that they regarded such a mission as "a good idea."

The technique of moving slowly from discussions of generalities to matters of substance is something Sodolski finds that the Chinese pursue artfully. On his arrival at the fair, he recalls, discussions dealt only with "trade and the growth of friendly relations between our two nations." Later, as the week progressed, Sodolski was apprised of the merit of a U.S. trade mission—but at a more appropriate time.

When will that be? The Chinese cited limitations on moving too swiftly. For example, the EIA official was told "relations between our two countries have just begun, and we must get to know each other."

Hardware. "Very little electronic equipment was on display at the fair, and what was there often was not labeled," Sodolski recalls. "There was one small, low-capacity computer, an rf direction finder, a laser cloud-height ceilometer, some unlabeled test and measurement instruments, and a variety of semiautomatic machine tools." There were no TV receivers, although there were some small consumer radios, presumably transistorized. Finding out the nature of the hardware was difficult, however. "No pictures of the exhibits were allowed," and permission was required to merely jot down what few details of the equipment were revealed on cards.



Softly. EIA's Sodolski warns that the hard sell won't work in dealing with Chinese.

What came through clearly to Sodolski and others who made the journey to Canton is what most Americans who track Chinese affairs have suspected for some time: technology is not highly developed in the People's Republic. And, if the Chinese want it, there is a potentially vast market for everything ranging from light bulbs to telephone and television systems.

But EIA's mission to Kwangchow proved to Sodolski that the Chinese, long known for patience, appear to be in no great hurry.

As a result, Sodolski says he is advising EIA member companies to carefully select the people who will represent them in dealings with China. Beyond being thoroughly knowledgeable in their field, "they should be familiar with the ideological basis on which current Chinese political thought is structured, have some knowledge of Chinese history, but—most important—they must possess almost unending patience and resilience."

"Attempts at hard-sell techniques simply don't work," Sodolski cautions. But, on the other hand, a lack of initiative may be viewed as a lack of sincerity. □

Space electronics

Scientists reserve shuttle space

Groups gather at Woods Hole to lay out plans and stake claims to footage aboard the space bus when it starts trips in 1980

by William F. Arnold, Aerospace Editor

If scientists have their way, the space shuttle will carry loads of new electronic experiments when the space bus begins flying between the earth and earth orbit in 1980. During a meeting July 2 to 14 sponsored by NASA and the National Academy of Sciences at Woods Hole, Mass., a group of astronomers, physicists, high-energy astrophysicists, and other scientists will discuss a topic significant for the future of space science: how to use the space shuttle.

What the scientists are doing is defining further what they'd like to see on board—and staking claims to a proportionate share of shuttle flights. Implicit in their deliberations are such questions as how many and what type of experiments should be flown after NASA's $5 billion shuttle program becomes operational.

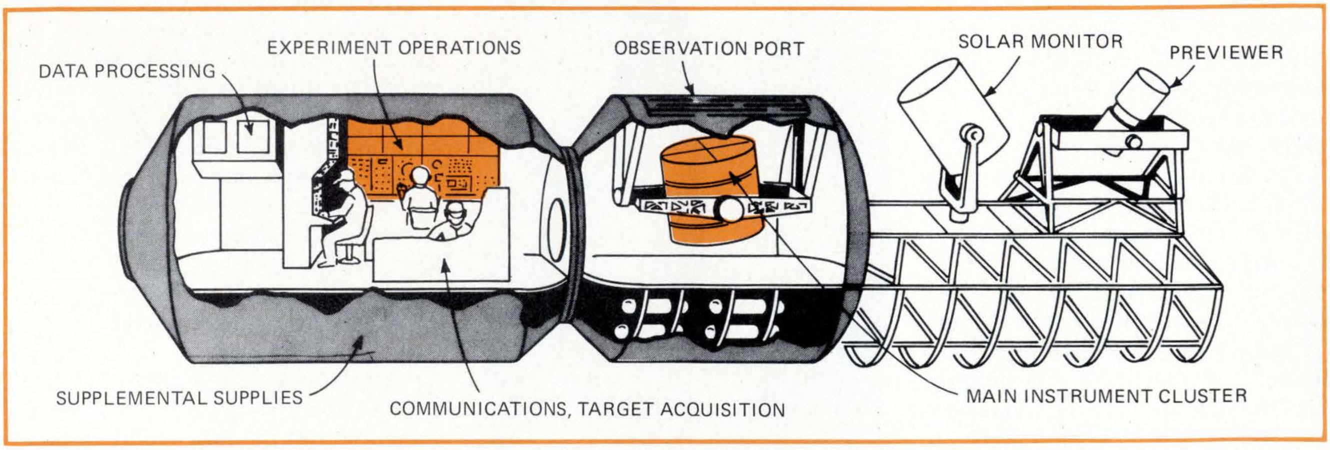
But, from all indications, the shuttle should advance the scientific application and development of a wide variety of instruments needed to detect and measure phenomena from extragalactic gamma radiation to ocean current temperatures. Communications, too, will receive attention.

The Woods Hole group will be using for their discussions the final reports of the NASA-run working groups on the space shuttle's payload planning, already well coordinated with the scientific community. Pointing toward what scientists want, the groups covered the fields of astronomy, atmospheric and space physics, high-energy astrophysics, life sciences, solar physics, communications and navigation, earth observations, earth and ocean physics, materials processing and space manufacturing, and space technology.

Evolution. The solar physics working group, for example, sees the shuttle as a step toward developing larger instruments for a free-flying large solar observatory in the 1980s. Strongly endorsing the need for a data relay spacecraft system, the group says that data transmission rates for a shuttle solar experiment would peak to 10^7 bits per second. For earth observations, the working group envisions the DC-9-sized shuttle orbiter as both a test-bed for calibrating sensitive instruments and an operational platform for high-resolution imaging.

See the sea. For remote ocean dynamics studies, the earth and ocean physics group wants to use microwave scatterometers, precision multifrequency coherent imaging radar, multifrequency dual-polarized microwave radiometers, and a host of laser instruments, including a laser scanning photometer. To monitor solid-earth dynamics, the list includes imaging radar for double-exposure holography, fm correlation radar, and multifrequency laser and microwave differential refraction equipment.

What makes scientists think of so many instruments is partly the large orbiter payload of 65,000 pounds, compared with "a few thousand pounds now" on a satellite, notes Alois W. Schardt, deputy director of NASA's space and astronomy pro-



Space scientists' office. This sortie lab of the Atmospheric Science Facility is one suggested type of payload for the shuttle. Martin Marietta has performed preliminary studies of the four-element design for the space agency. Shuttle trips are to start in 1980.

grams. Partly, too, scientists are intrigued by the shuttle's presumed versatility. For one thing, it can be used as a stage-2 rocket to launch outer space probes more cheaply.

As an orbital launch pad, the shuttle also could release and pick up earth-orbiting satellites, as well as automated free-flying experiments, such as the projected large space telescope. The proposed cost of the telescope has fallen from $1.5 billion to about $350 million, Schardt says, because with the shuttle "you can build it, take it up, use it for a while" and if it's not working right either retrieve it and fix it up there or "bring it down, change the instruments, and go back up again."

Also capturing scientists' imaginations is the sortie mode, either an automated flatbed of instruments or a combination of instruments and a manned laboratory where a few scientists could work in shirtsleeves for a week running their experiments, somewhat like Skylab.

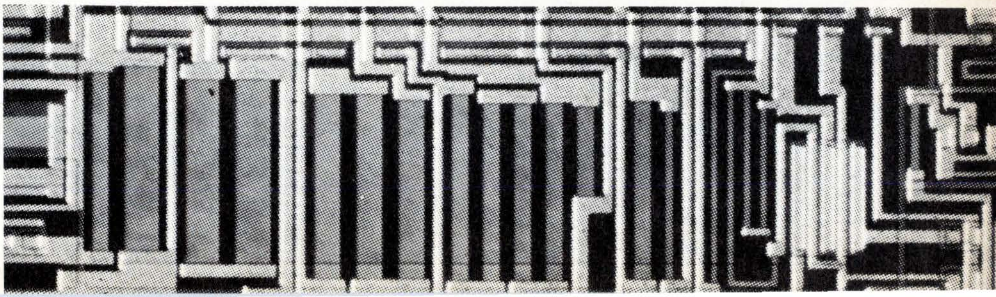
Sortie lab. An example of one kind of shuttle payload is the atmospheric science facility with a manned sortie lab (see illustration), for which Martin Marietta Aerospace, Denver division, has performed preliminary studies for NASA. Basically the design has four elements; the sortie lab, containing data processing and monitoring equipment: the basic module, containing the prime observation gear; the previewing and solar monitoring systems module; and a fourth element which could be secondary experiments or service units.

The shuttle's quick response, release and fetch capability, coupled with the large payload generates other benefits. According to an NAS staff member, "the relaxed size and weight constraints mean you don't have to go for so much subminiaturization nor long testing as with current launch vehicles."

Scientists are debating whether to use the shuttle as "a big truck and pack it with cheap experiments" or as a platform for big expensive instruments, the NAS staffer says. "Finding reasonable, low-cost ways of starting to do low-cost science on the shuttle" is a point of discussion.

Whether or not the shuttle means cheaper science remains to be seen, of course. Even though shuttle launch costs are estimated at $10 million per launch, what the scientific experiments cost—and how much money science is able to get—can't be determined now. The earth and ocean physics working group estimates that, with just two testbed flights a year during the 1980 decade, it would cost about $362 million for their experiments alone. NASA's Schardt cautions that the working group "figures haven't been endorsed by NASA top management, or OMB, or this Administration."

An unresolved question is "what degree of computer control we'll use," Schardt says. "Why train a man to turn dials if he can punch commands?" he asks, except that "a computer uses a lot of software," and, for last-minute changes, it's easier to put in a switch than reprogram a computer. The solution probably will be a combination of both human control and automation since, Schardt says, "we need the flexibility." □



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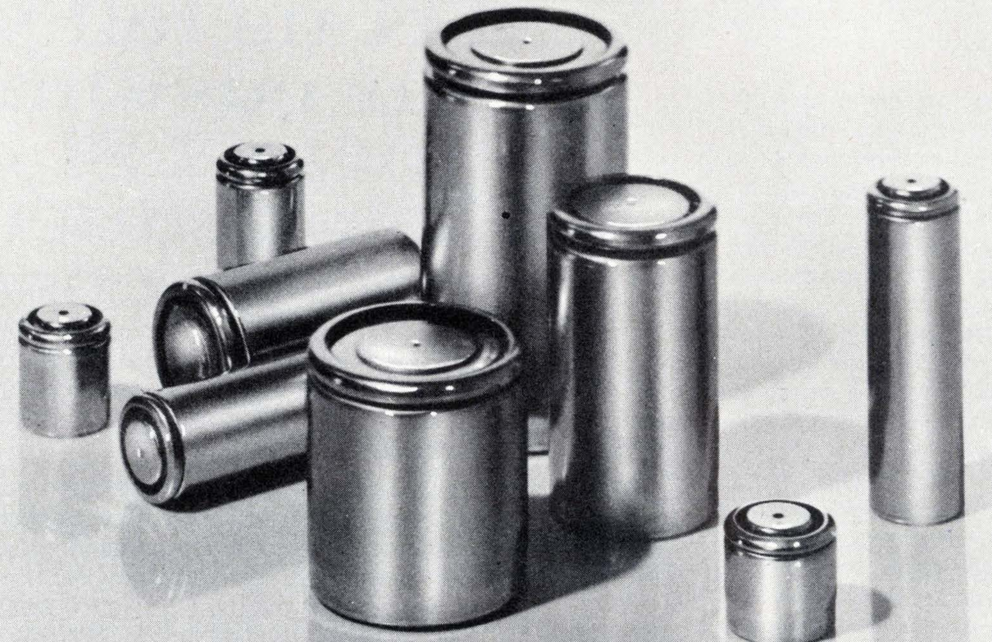

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Two-way CATV's future hinges on inexpensive frame grabbers

Until the cost of video refresh memories goes down, the entry of interactive cable television into consumers' homes will be stalled; but work in five memory technologies is beginning to show promise

by John L. Volk, *Mitre Corp., McLean, Va.*

☐ Two-way cable television is on its way to U.S. homes. It's coming in part because the Federal Communications Commission has mandated that all new CATV systems be capable of bidirectional transmission. What's more, cable-TV entrepreneurs see a profit-making opportunity in offering consumers more services than simply pumping network TV broadcasts into living rooms or picking up sports events from local arenas.

Many uses of the two-way capability have been proposed and tried experimentally—including automatic meter reading, burglar and fire protection, polling, and even shopping by TV. None is as exciting or as potentially profitable as the computer-based personal services that interactive TV can offer. Various hardware manufacturers and CATV operators have set up two-way trials around the country to find out the extent of demand for various services, many of which are interactive and built around a computer.

Based on these experiences, it appears that the only major technological impediment to the mass introduction of interactive TV is a reliable, low-cost video refresh memory (VRM). These memories, also called "frame grabbers," record a single TV field or frame and then play it back continuously. They have had limited applications in video-signal processors, TV special-effect equipment, airport display systems, motion detectors, graphic computer terminals, and scan converters.

If the cost of the video refresh unit can be brought down to $100, interactive TV may become the next significant new consumer electronics market. Even with a cost of $300 to $400 for a unit, interactive TV may find a market niche.

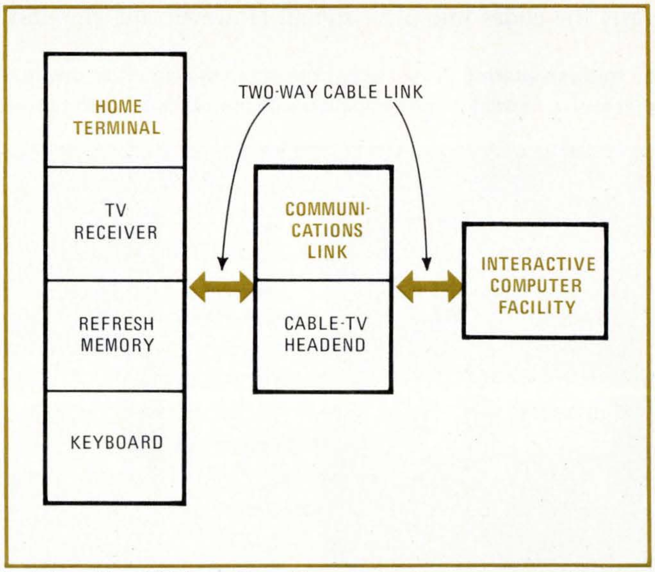
There are other technical difficulties in two-way systems—such as noise accumulation on the lines—and there are certainly marketing problems in determining what services will attract CATV subscribers and how much they would be willing to pay for them. But from a strictly engineering viewpoint, the video refresh memory poses the most difficult questions concerning type of machine, cost, and reliability.

What interactive TV can do

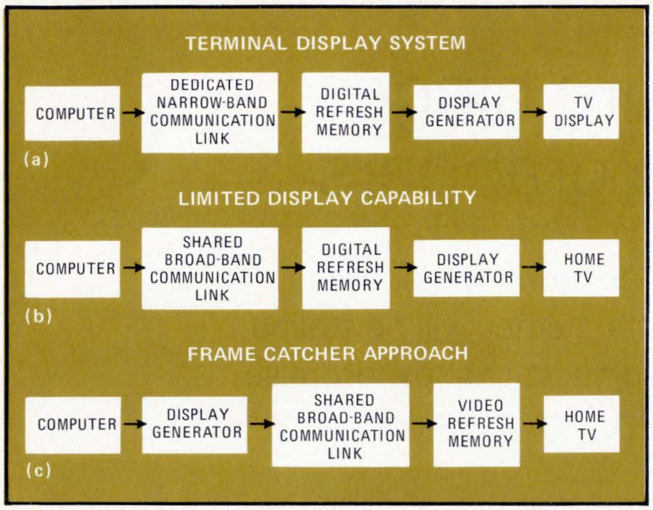
Interactive TV opens a whole new market for electronics. Two-way systems use the home TV receiver as a display terminal for computer-generated information, rather than solely an entertainment box. The viewer can order computer-based information using a small keyboard or can enter information into the computer's data base with a larger, alphanumeric keyboard. In other words, it is possible to transmit data via the cable "downstream" from the CATV "headend" and "upstream" from the individual subscriber. Thus a dual- or single-cable multiplex arrangement turns a CATV system into a kind of telephone party-line, only without switching stations.

Besides remote shopping and polling, other functions—such as computer-assisted instruction, banking by TV, computer-mediated games, access to directory listings, ticket reservations, gambling, and the like—are possible with interactive TV. In this system, the frame grabber plays an essential role at the home or receiving end, similar to the application of CRT displays in industrial and commercial computer time-sharing arrangements, but in many ways quite different.

In both terminals, computer-generated data is displayed at sites remote from the computer, and both use TV technology for the display. But in two-way CATV, the home receiver is connected to the computer via a broadband communications channel, while the time-sharing terminal uses a telephone line. The home viewer may



1. Interactive TV in action. Schematic of a two-way cable-television system shows all of the pieces that are required to link a computer facility to a home receiver. They include the all-important video refresh memory and the home keyboard.



2. Display types. Three possible approaches show where the frame grabber fits into the system: (a) with a time-sharing terminal, (b) with a limited display, and (c) with interactive TV.

only use an interactive-TV system for less than an hour each day; time-sharing terminals are in use several hours a day. The home unit has to be able to handle both graphic and photo display, capabilities not typically found in computer time-sharing terminals. Above all, the home TV terminal has to be much less expensive than the time-sharing version.

Setting up interactive TV

To appreciate the importance of video refresh memories to interactive TV, it is necessary to look at the overall system (Fig. 1). A typical time-sharing terminal is the simplest approach because it is designed to minimize the bandwidth required for the communications link over ordinary telephone lines.

The terminal's refresh memory captures computer-sent codes—perhaps 11 bits of data for each letter to be displayed—and repetitively (at least 60 times per second) passes them to the display generator, which converts the codes into a TV signal. However, the simplest approach prohibits use either of graphics or of photographic material.

A cable system could use this type of terminal for interactive services, but the limitation on display capability is a major disadvantage. For the display generator to be reasonably inexpensive, it must have only a small, fixed set of display characters; graphic display is expensive, and computer-retrieved photographic display is out of the question.

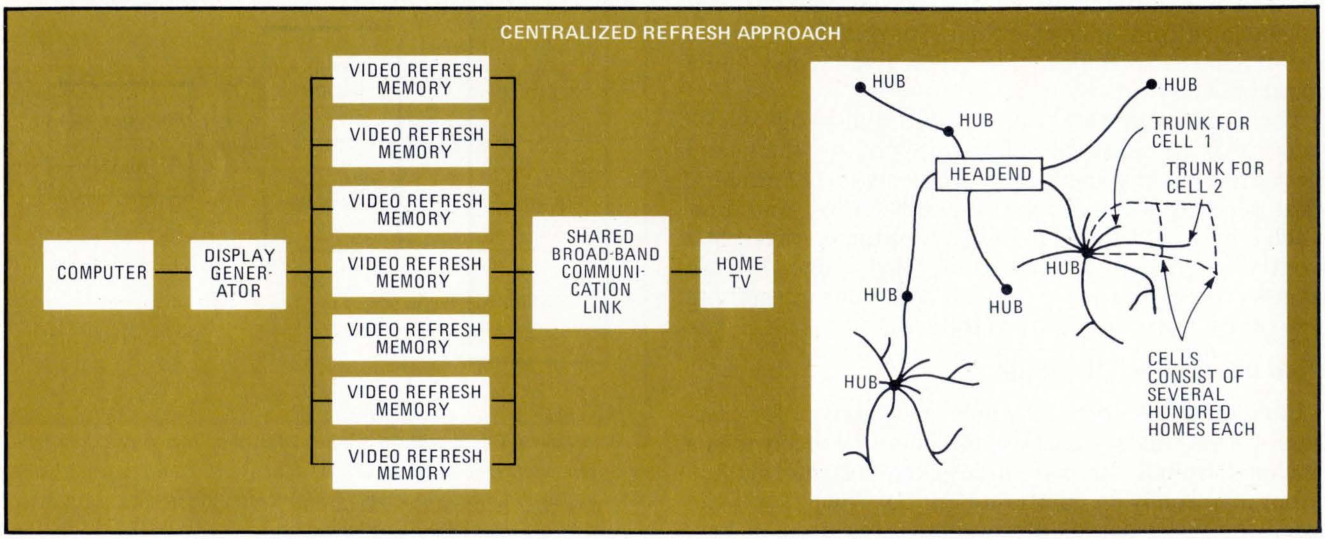
A more flexible display would be possible using a centralized display generator and the wideband capability of cable TV. Under the computer's control, the display generator creates a single-frame (or single-field) TV signal that represents the computer display. The signal passes over a regular TV channel on the cable in 1/30 (or 1/60) of a second. At the receiver, the VRM captures the signal and plays it back continuously on the screen. By adding a home "address" to each display generated, one display generator and one TV channel on the cable can serve many users simultaneously.

The expense of the display generator can be prorated over many users, so that increased display capabilities can be included without a significant boost in user cost. It's also possible to retrieve photographic images, convert them to TV signals, and transmit them as single fields or frames in the same manner as the computer-generated signals are handled. The viability of this approach, though, rides on the cost of VRMs and the extent to which home viewers value the computer services that the interactive-TV system delivers (Fig. 2).

There's another way of lowering the cost of VRMs—if home use of the interactive services will be limited to less than an hour a day. In this approach the refresh memories are located with the display generator and the computer. Each refresh memory is connected to a different TV channel. When the home viewer wishes to use the interactive system, he is assigned a channel tied to an unused memory.

The advantage of this approach is that the costs of both the display generator and the memory are prorated. The disadvantage is the need for what today is an

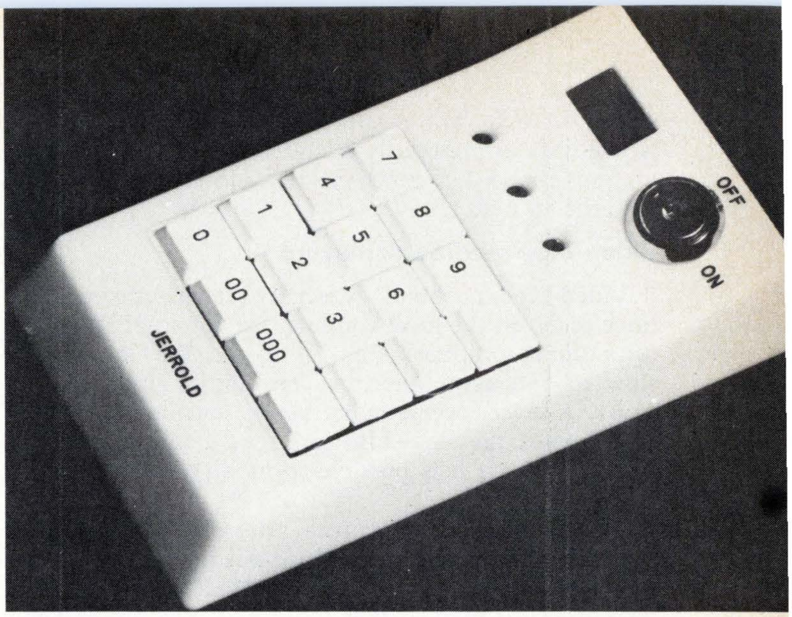
3. Refresh sharing. A centralized interactive system would permit sharing of video refresh memories and thus reduce costs. The problem is that such a network is not compatible with present practice in cable-television operation.



untraditional cable-TV network, one that uses many hubs to achieve through space-division multiplexing the equivalent of thousands of separate TV channels in a city (Fig. 3). Each hub would require several trunk lines, and each trunk would feed several hundred homes. What's more, while carrying broadcast-TV channels in common, each hub would have its own set of interactive-TV channels connected to VRM.

A recent Mitre study has shown that this system in an urban environment and providing 30 minutes a day of interactive computer services to each subscriber could be operated with a fee-per-home level comparable to a typical phone bill. A major weakness of this approach is that massive demand could cause long waits for the interactive channels.

Therefore, a combination of the two ideas might be ideal. The casual user could take the shared frame-grabber route, and the more serious user could have a VRM installed in his home. In either case, however, the VRM is a key element in the system.



4. Punchy. An interactive television keyboard would be used at home to request data from the computer. The prototype shown here is produced by Jerrold Electronics.

VRMs in assorted styles

It is possible now to build VRMs using magnetic disks with either digital or frequency-modulation recording, magnetic-tape players, electronic storage tubes, or MOS technology. Each of these technologies has certain operational or economic limitations.

The ideal VRM for an interactive system must be, first of all, reliable, and second, low in cost. A mean time between failure of 2,000 hours and a cost of about $100 would be acceptable. It should be able to record and play back TV images of color photographs without introducing noticeable noise or loss of resolution. And it should be possible to alter or edit part of a recorded image rapidly without having to retransmit the entire image. For instance, if a photograph were displayed by the computer in the upper half of the screen and text on the lower half described the photo, it should be possible for the computer to erase the text and continue with new text without retransmitting the picture.

Digital magnetic-disk recorders

An incoming monochrome TV image in a digital magnetic-disk recorder may contain from 100,000 to 300,000 bits for text and line graphics, depending on the resolution desired. Two to four tracks are required on the magnetic disk to hold this kind of image with the disk rotating at 1,800 rpm. Three or four times as many bits are needed to record a black-and-white photograph. Color photographs increase the number of bits by two or three times over that.

The digital magnetic disks produced today are not often used for storing photographic or color images (Fig. 5), because storing the large number of bits is costly. User cost is around 1/10 to ½ a cent per bit. In addition, to keep system costs down, separate disk memories for each display are replaced by a large disk with as many as 64 tracks. The large disk provides storage for several refresh-memory subsystems in one larger central display system.

A major advantage of the digital recording technique is the ease of editing. For instance, it's possible to replace a single character with another on a screen full of text without disturbing the rest of the text. On the other hand, it is handicapped as a VRM by the difficulty and expense of recording color photographic information and the difficulty of meeting the required mean time between failures.

Magnetic disk using fm recording

A more direct way of using magnetic recording technology is to record the TV image without digitizing it. As with the digital version, the disk rotates so that a signal for a black-and-white TV image is frequency-modulated and recorded on the disk. Equipment now on the market proves that this recording can be done with a low-cost machine. A unit from Hitachi, for example, which has a bandwidth of 5 megahertz, sells at $200 in small quantities.

Recording color-TV images with this technique is complicated by the NTSC color-encoding standard that calls for phase-encoded hue. The mechanical disk cannot rotate precisely at the TV field or frame rate, and these otherwise minor speed variations garble the phase-sensitive color information.

There are two straightforward solutions to this problem (Fig. 6). The first answer is to decode the incoming NTSC signal into its red, green, and blue components, recording them on separate disk tracks as if each were a black-and-white-signal. The individual signals can be combined at the output to produce an NTSC signal for the display.

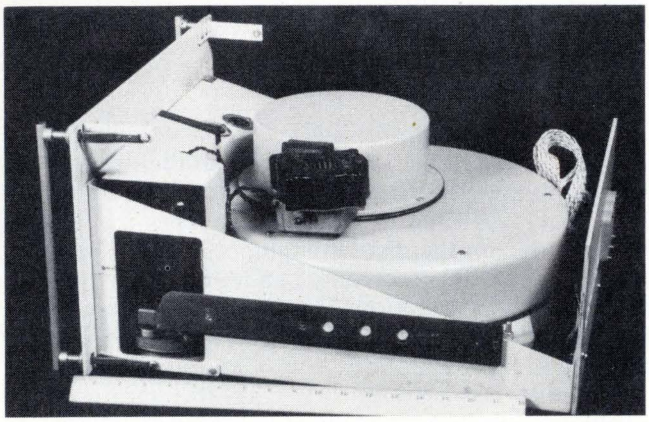
The second solution is to convert the incoming NTSC signal to an encoded signal that is not phase-sensitive, such as the French Secam technique, before recording. This Secam signal can then be recorded as if it were a black-and-white TV signal on a single disk track. However, the Secam signal must be converted to NTSC before being transmitted to the home receiver. This approach can be further simplified. The computer could send Secam-like signals instead of NTSC signals to the VRM in the first place.

The fm recording technique does complicate editing, however. There is no direct way to erase a single character from a frame of text or add a new character to a screen already fully occupied. It is possible to replace whole lines of previously recorded data with new information, if the disk mechanism is closely synchronized with the TV field rate.

Video-tape recorders/players

Video-tape machines, especially the cassette versions, have received the most comment as potential home-entertainment products (Fig. 7). So far, they have been slow to win acceptance by consumers. However, because in several years many people may have them in their homes, these machines are good candidates for the role of VRM—if it is possible to modify them inexpensively.

Video-tape recorders use slant-track, or helical, recording in which a single TV field is recorded as an fm signal on a track that is angled to the tape's axis. The tape moves around a drum containing a recording head (or, more usually, a pair) which spins at an angle with respect to the tape, completing a slanted track 1/60 of a second. Stopping the tape motion past the head would freeze a recorded image displayed on the receiver and convert the recorder/player into a frame grabber. The only modification required is to provide a means of stopping the tape and switching rapidly from record to playback.



5. Disk jockey. This digital disk refresh memory, which is produced by Data Disc Corp., has already been put to use in interactive television experiments carried out by Mitre Corp.

From an operational standpoint, the video tape machine has the same advantages and disadvantages as the magnetic disk. However, the head for the disk is stationary, simplifying the mechanics of the system, which means that the disk should generally be more reliable than the tape player.

Electronic storage tubes enter the picture

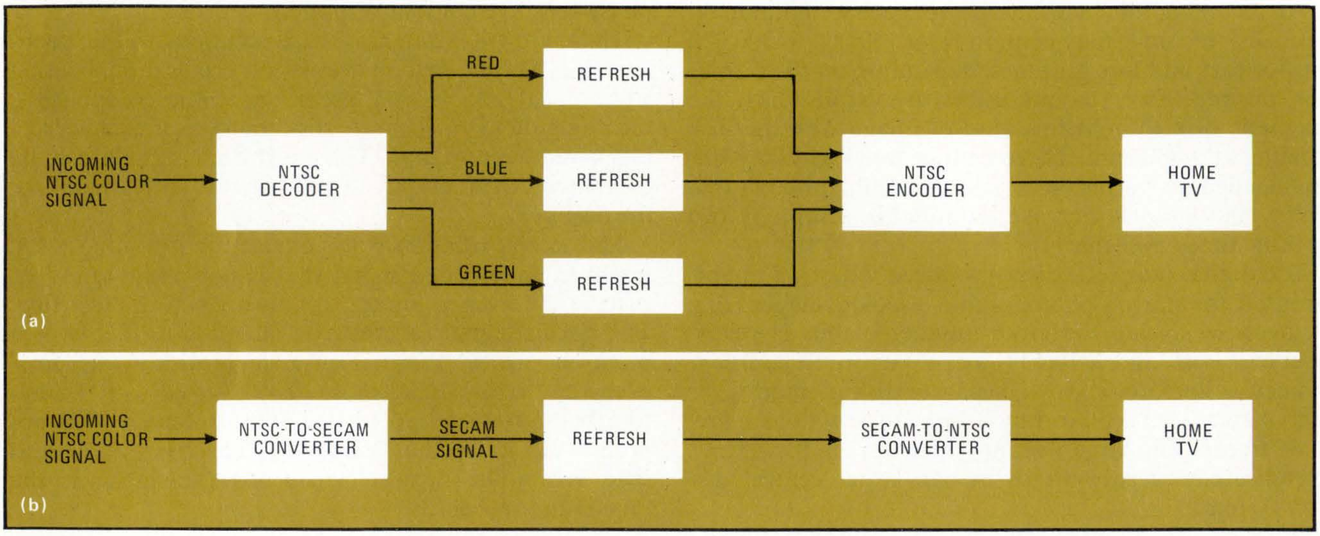
Direct-view storage tubes, like those in oscilloscopes, are not actually VRMs, but they are capable of performing that function as well as the display. However, their high cost, slow erase time, and absence of color capability make them poor candidates for use in an interactive-TV system.

The standard storage tube uses secondary emission to add or subtract charge to a target of nonconducting elements on the face of the tube. The charge-holding elements are on a conducting surface. To read, the electron-beam potential is lowered so that it cannot affect the charge on the nonconducting elements. Then, as a raster scans the target, the current reaching the conducting surface is a function of the charge on each charge-holding element the beam passes over.

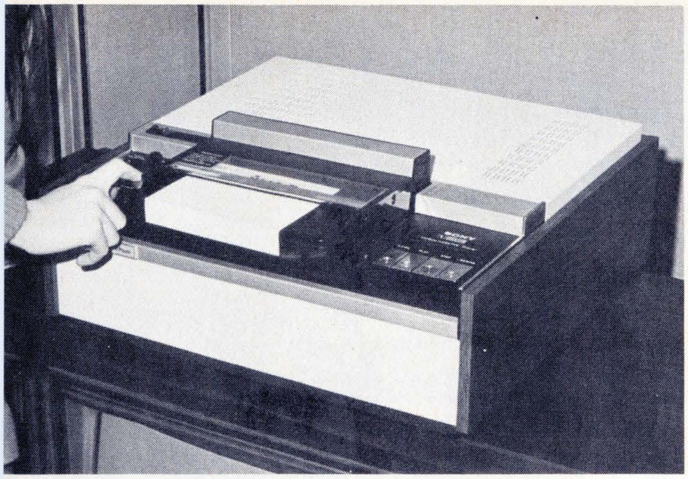
The picture quality recorded on the tube is directly related to the quality of the target—that is, the number of charge-holding elements, the number of imperfections, and the relation between scan pattern and the pattern of the charge-holding elements.

Storage tubes are relatively expensive as frame grabbers because they include not only the tube, but the electronics to direct the beam, which usually contains a fairly expensive magnetic deflection yoke. One manufacturer has experimented with a low-cost storage tube that uses electrostatic deflection, rather than the high-priced magnetic yoke.

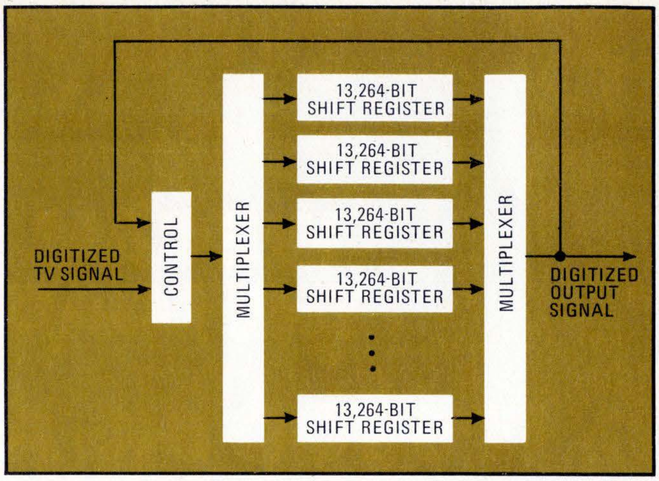
A major drawback with storage tubes is that they do not reproduce color. It has been suggested that if a storage tube had sufficient resolution, an NTSC signal could be recorded on the tube and the color information recovered along with the luminance information. Another



6. Fm that refreshes. There are two ways of using frequency-modulated disk tracks for color—by separating three color signals and recording them on separate tracks (top), or by recording a Secam signal on a single track (bottom).



7. **Tape holder.** This Sony video-cassette tape player could be used as a refresh memory for interactive television if the tape could be stopped at one frame and that frame then displayed on the receiver.



8. **Solid state.** An MOS IC digital refresh memory uses fewer data bits than a digital disk to display the same photo. The model shown was designed by Mitre and built by Intel Corp.

possibility being tried is the use of three storage tubes to hold the red, blue, and green components separately, but this has not been too successful.

It is quite easy to add new information to a display stored on an electron storage tube. However, it is difficult to erase information already recorded. It may take over ½ a second to erase an entire display, which is rather slow for an interactive-TV system.

Solid-state versions look good

It is now possible to build a solid-state VRM. MOS integrated circuits can be designed to hold a digital representation of a TV image in much the same way as is done with a digital magnetic-disk memory.

Mitre has developed a $700 solid-state refresh memory consisting of two subsystems—one for luminance and one for color refresh. Both use digital techniques—a shift register for luminance and random-access memory for color. The computer-generated display has the capability of being coded in seven different colors, including white. The display format is 17 rows of 43 characters each, with a character being a 10-by-12-bit matrix.

The MOS luminance register, which is manufactured by the Intel Corp., consists of 88 1,024-bit n-channel MOS shift-register ICs. As shown in Fig. 8, the refresh is organized as eight 13,264-bit registers operating in parallel. This allows operation of the register at a 10-MHz clock rate, although the individual registers are only being clocked at 1.25 MHz. The register operates in one of four modes—replace, selective erase, overstrike, and recirculate. The luminance refresh is contained on an 8-by-10-inch circuit card and requires power supply at only 5 volts. The color refresh memory is a 1,536-by-3-bit static MOS RAM, operating at a 1-MHz rate. Four color memories are contained on one 8-by-10-in. card.

With the digital disk refresh, bits are wasted during the TV-signal retrace interval and when the TV beam is hidden behind the tube's mask. With the MOS technique, though, the refresh clock may be stopped or slowed down significantly during these periods to cut this waste. Mitre's MOS design has 87,720 bits holding the desired image, the remaining bits are used to maintain the minimum shift-rate requirement during the vertical and horizontal blanking intervals.

By comparison, the same image stored at the same resolution on a disk would require 166,667 bits. Because the cost per bit of MOS shift registers approach the cost per bit of digital disk memory, this saving is significant. In addition, the cost per bit of MOS memory is not as sensitive to memory size as it is in the disk version, which approaches the cost of an MOS type only if many units share a single disk. Besides, the MOS memory doesn't suffer from mechanical reliability problems, it is adjustment-free, and it is easy to repair.

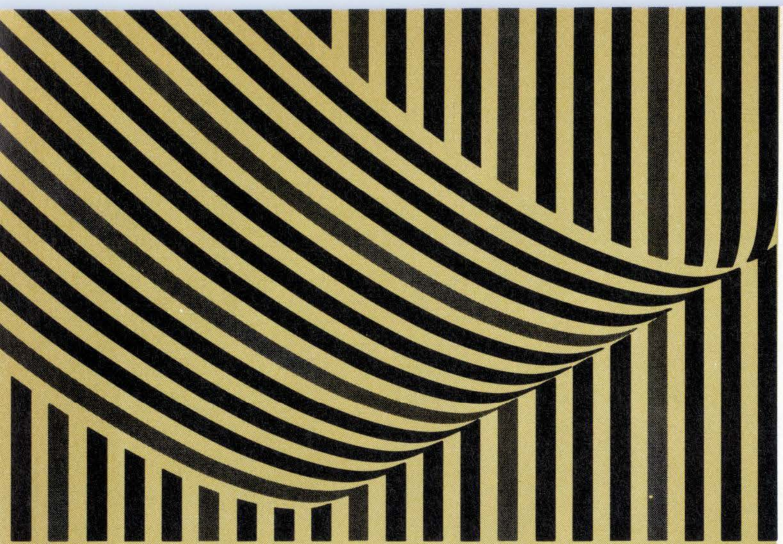
On the other hand, the MOS refresh memory has the same major weakness as the digital disk. It is not economical today to store either color or black-and-white photographic images. What's more, the cost per bit for MOS shift registers, while less than ½ a cent, is not low enough to cover the vast numbers of bits required for gray-scale material.

Combinations add up

Although all of the memories described here have significant disadvantages, these should not inhibit the development and use of interactive-TV systems. For example, Mitre's Time-Shared Interactive Computer-Controlled Information Television system being installed in Reston, Va., will use both MOS and fm magnetic-disk refresh. The MOS devices are to be used for displays with line graphics and text, while the fm disk is to be used for black-and-white photographic data. This system will begin delivering interactive services to several thousand homes this fall.

In the near future, low-cost fm disks capable of holding color photographs should be available. Further ahead, charge-coupled devices and other analog equivalents of the digital shift register may take the place of the refresh memories now in use. In the meantime, large-scale production may also bring down the cost of electronic storage tubes. The outlook for inexpensive, reliable video refresh memories is better than at any time. It remains for software developers to make their contribution toward getting interactive-TV systems off the ground. □

DATA GENERAL
Southboro, Massachusetts 01772



Although spawned out of military necessity to save weight and space and to augment equipment reliability, planar interconnection techniques have now developed to the point that their advantages should no longer be ignored by designers of consumer and commercial equipment. And indeed they are not, as a glance into modern computer and communications systems coming off the line will attest.

Planar wiring is attractive to system designers because it offers cost savings in many situations where traditional round-wire cable interconnections must be forced into small spaces, or where a lot of costly hand labor is required to form the harnesses needed in a particular design.

There are two major approaches to planar interconnections—flat cable and flexible circuit wiring. Flat cable, basically a planar version of a circular cable containing round wires, is usually fabricated from either flat rectangular or round conductors, made of bare or plated copper and laminated or molded in flexible plastic insulation. The cable is available in a wide range of wire sizes, conductor spacings, and configurations.

The other major category of planar wiring—flexible circuits—is a first cousin to the printed-circuit board, except that a flexible plastic, like polyester or polyimide, is substituted for the rigid materials of pc boards. Laminated to this plastic base is a thin layer of copper that is etched to form the required circuit configuration, just as with a pc board. A flexible circuit can be designed to fit exactly into a limited space and reliably make the required interconnections, thus eliminating the unwieldy harnesses, lacing terminal lugs, and other inconvenient and time-comsuming appurtenances of conventional round wiring.

In the following pages, three experts describe some of the new techniques being used to exploit the unique properties of flat and flexible cable interconnects. First, Westinghouse Electric Corp.'s Jim Henderson shows how he realized economy with flat cable by applying good design principles early in the design phase of an engineering project.

Then Joseph Marshall of Ansley Electronics Corp., a subsidiary of Thomas & Betts Inc., shows how flat cable can now handle the ultrafast pulses of modern computer systems.

And finally, Peter Maheux of Bell-Northern Research presents a use of flexible circuitry that produces extraordinary savings in assembly time. —Stephen E. Grossman

SPECIAL REPORT

Designer must plan early for flat cable

Matrix enables interconnections to be optimized in initial stages to achieve cuts in design and fabrication costs

by James A. Henderson, *Westinghouse Electric Co., Baltimore, Md.*

☐ Electrical interconnections are seldom given much thought in the initial design phase of a sophisticated electronic system. Often they are ignored until system partitioning and packaging designs are completed, and then the spaces available for the cables are sometimes so small and cramped that costly redesign may be required merely to incorporate the necessary signal and power conductors.

Flat cable changes all this, for it imposes a requirement for careful planning and system integration of electrical interconnections. Because of its planar construction, the address of each lead falls into a given position, which cannot be altered later as in a conventional round-wire harness. On the other hand, because the cable is designed in and not added on as an afterthought, much costly branching can be eliminated and significant labor savings achieved.

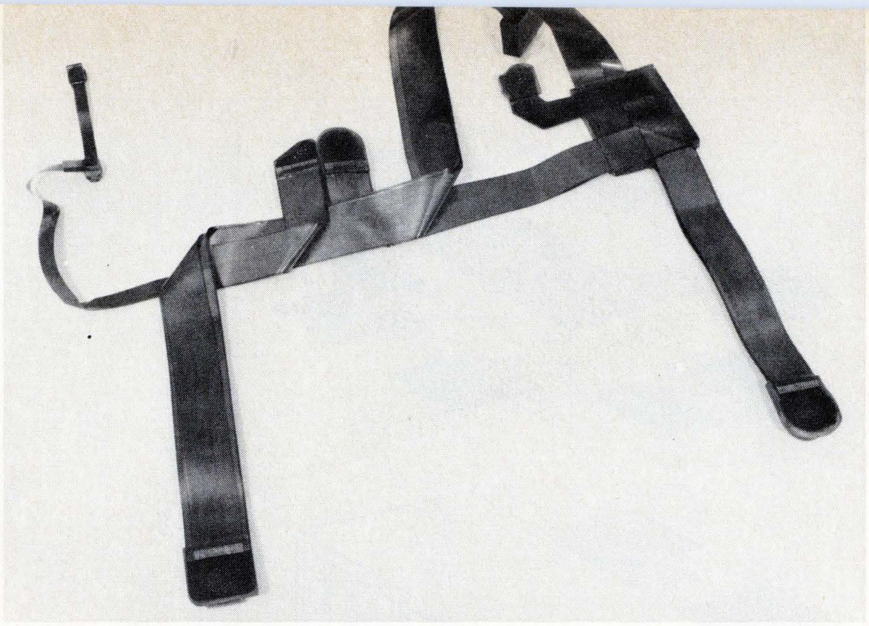
Figure 1 pictures a flat-cable assembly, and Fig. 2 indicates the labor savings possible. In quantities of 100, the 26-connector conventional round-wire bundled cable shown represents $680 worth of materials and 100 hours of labor. On a branch-for-branch, connector-for-connector basis (Fig. 2b), material costs for a comparable flat cable rose to $785, but labor dropped to 67.5 hours. With repartitioning, the system material costs fell to $720, and labor dropped markedly to 38 hours.

Thus, the extra cost of flat cabling materials is more than offset by the elimination of individual wire laying, shaping, and conductor-terminating techniques associated with round-cable assemblies. They are replaced with one set of design steps that determine the form and fit of the cable as an integral unit.

Interchanges

While conventional wiring employs break-outs and branch points to enable each wire to exit from the bundle and seek its termination, flat cable employs interchanges. These interchanges may consist of a single-sided printed-circuit wiring board with crossovers accomplished by judicious location of cable inputs on the board.

Alternatively, the connections may be automatically (or semiautomatically) wired matrices or multilayer printed-wiring matrices (Fig. 3a and 3b). In the latter,



1. Challenger. Typical wiring harnesses are being replaced by new flat-cable techniques, which eliminate expensive prototype and production pitfalls.

the cables are usually terminated at a junction box and interconnected within it by the same techniques. Finally, the interchanges may be a welded matrix (Fig. 3c), in which one layer of flat-conductor cable is laid on top of another, and conductors are welded together through the insulation as desired. This last technique lends itself best to thermoplastic insulations.

Interchanges are expensive, however, not only in dollars, but also in lowered reliability, increased requirements for quality control, and higher system weight. A good designer will eliminate them whenever possible by careful planning and partitioning.

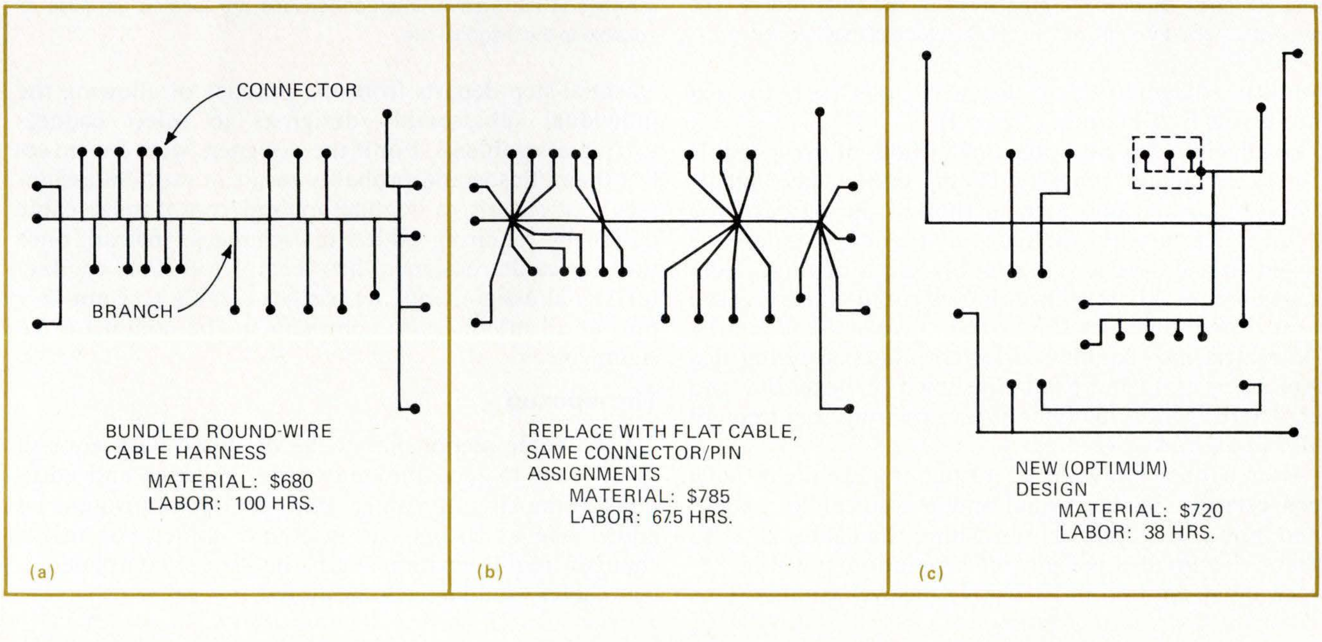
A case history

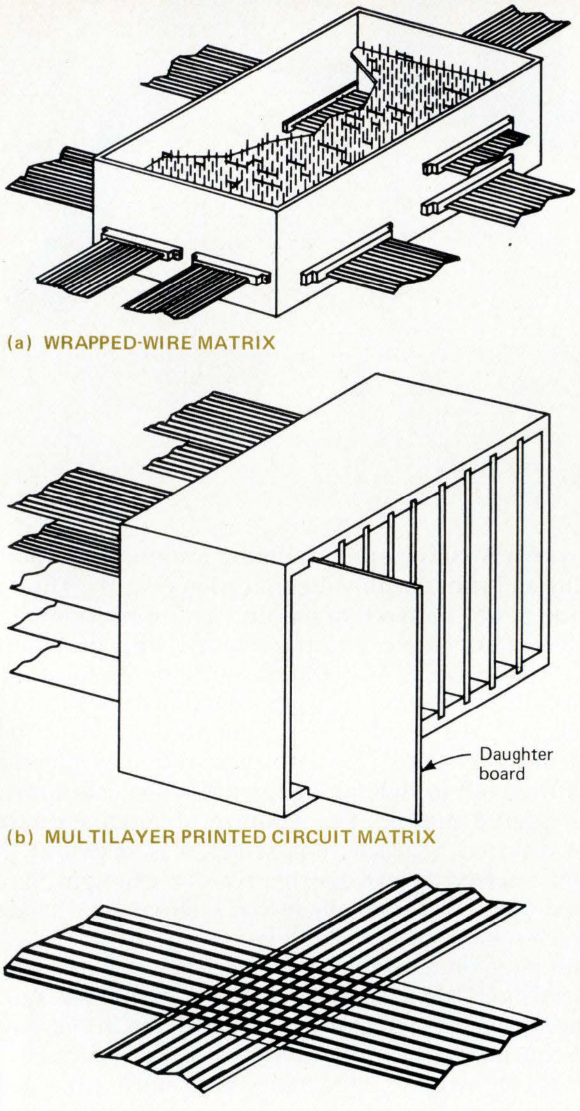
As an example of the design procedure, a weapons system was originally interconnected by hand-formed harnesses, but it was failure-prone because of wire breakage at the short lead-ins to the connectors from the main branches.

To optimize the design, a functional flow diagram of the system was prepared, outlining initial system partitioning and subassembly identification (Fig. 4). The signal and power-connection requirements were entered in an elementary interconnection matrix, with the matrix sequenced in order of planned subassembly location—that is, the subassemblies were listed on the left side of the chart in the order of their planned physical placement in the system. This list was repeated in identical order from left to right along the top of the chart, forming a square matrix. The number of interconnecting leads required between subassemblies is shown at the proper intersections in the matrix—for example, three twisted pairs and nine single conductors were needed between subassemblies D and E.

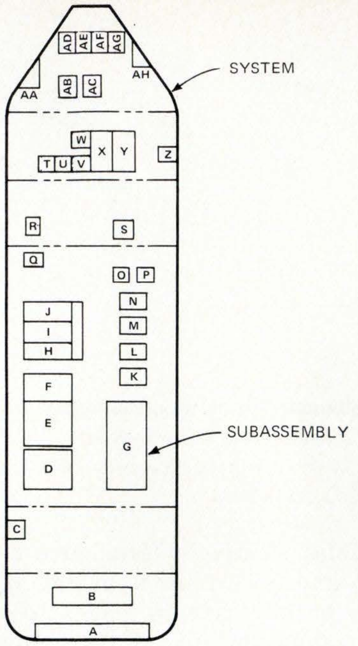
This interconnection matrix was developed as a practical offshoot of a shortest-path algorithm for interconnecting cables. With the matrix ordered in the physical sequence of the subassemblies in the system, it is easy to see where interconnections must take long paths, by virtue of their being relatively far removed

2. Evolution. Merely replacing a traditional harness (a), on a branch-for-branch, connector-for-connector basis as in (b), will yield significant savings in labor, with a slight increase in material cost. However, repartitioning the system can optimize labor and material costs (c).





3. Complex. The wrapped-wire matrix (a) is desirable when changes are anticipated. In large systems with complex wiring, a multilayer back panel (b) is programed by daughter boards. The compact welded-through matrix (c) is fine for a planar interface.



MATRIX

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
E				3TP 9S	X	3TP					1TP		1TP				
F					3TP	X	3TP			1TP	5TP		2TP				
G						3TP	X	1TPSJ		2TP							
H							1TPSJ	X									
I									X								
J						1TP	~~1TP~~ 2TP			X							
K					1TP	5TP					X		1TP		2TTSJ 1TPSJ	2TTSJ 1TPSJ	2TTSJ 1TPSJ
L												X					
M					1TP	2TP					1TP		X				
N														X			
O											2TTSJ 1TPSJ				X		

S = SINGLE CONDUCTOR
TP = TWISTED PAIR
TT = TWISTED TRIAD
SJ = SHIELDED AND JACKETED

4. Tool of the trade. Interconnection matrix is the key to optimizing a flat-cable design. Letters are assigned to the various subassemblies in the system. Interconnections are located as close as possible to the diagonal line.

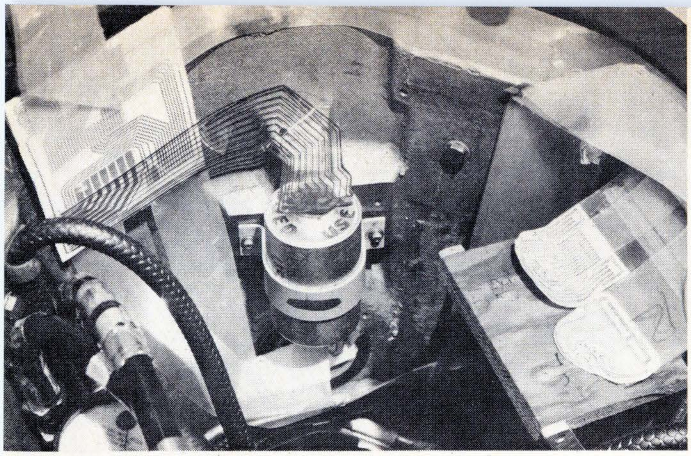
from the diagonal "zero-distance" axis (see, for example, row E, column M in Fig. 4).

To alleviate this situation, one or both of two possible courses of action may be taken: one of the subassemblies may be relocated to shorten the path, or the circuit function requiring the stray pair of wires may be moved to a different subassembly. Both of these techniques are used to optimize the system in an early stage in the design phase—a simple task, thanks to the matrix. The matrix also enables early resolution of wiring discrepancies, as in the example shown in boxes JG and GJ. There is little likelihood that a wiring requirement will be overlooked.

After subassembly input/output requirements have been establis'ed, the signal and power cables are defined, and conductors chosen within the cables so as to obtain the greatest degree of separation possible between noisy emitter and sensitive receiver circuits. This essential step departs from the practice of allowing the individual subassembly designers to select connector/pin assignments. For if the designers were free to select them, this would probably result in random assignments of signals to conductors and compromise cable design by requiring added interchanges. Instead, once the flat-cable designer has completed the conductor/signal assignments, he assigns signals to connector pins at all interfaces to complement the conductor assignments.

The mockup

Each cable section has to be designed with enough spare leads to accommodate minor changes and additions to the circuitry, since extra conductors cannot be added one at a time, as in round cable. For major changes, requiring more than the spares complement, new cables would have to be added.



5. Mockup. Mylar film serves as a model for flat-cable wiring in developing prototype of cable assembly. Note the model for the planar interchange on the wall. At the right are patterns for the flat-cable interface with the connectors.

The next step is to develop a cable mockup using clear Mylar film. For this purpose, an accurate mockup of the component layout of the actual system must be available as a basis for determining how and where the cables are to run, how they are to be mounted, and what their fold, bend, and retraction requirements are. The actual system enclosure can be used as the mockup, as shown in Fig. 5.

After the Mylar mockup is completed, the Mylar is removed from the mockup and is used to prepare the detail and assembly drawings, as well as the fixtures for the production cable assemblies. The time required to assemble such a flat-cable prototype is considerably less than that required to prototype a hand-formed round-wire harness.

These factors, coupled with the initial fit and form development using the Mylar mockup, result in cables that fit the first time. What's more, the need for documentation change to relieve poor-fit areas is virtually eliminated.

Table 1 demonstrates the power of prototyping with a Mylar mockup. It compares the labor costs for engineering a 300-wire cable system employing traditional cabling techniques with the costs of the new design techniques employing flat cable. Although both engineering and drafting costs are somewhat higher for flat cabling, the manufacturing time for the prototype is

TABLE 1: NONRECURRING LABOR COSTS FOR 300-WIRE ROUND AND FLAT CABLES

TRADITIONAL BUNDLED-ROUND-WIRE DESIGN				FLAT-CABLE DESIGN			
	HOURS				HOURS		
	ENG.	DRAFTING	MFG.		ENG.	DRAFTING	MFG.
Basic cable design: select connectors and wire and prepare wire	80	40 (Note 1)		Prepare interconnection matrix and resolve discrepancies	60		
				Define cable and connector-pin assignments and tabulate	80		
Develop cable, wire by wire			600	Verify cable run lengths, make Mylar layup, and prepare drawings	40	360	Note 2
Mount prototype in unit			32	Mount prototype in unit; no recycle necessary[2]			8
Rework, correct errors, and relieve tight areas	40	20					
TOTALS: Eng. / Drafting / Mfg.	120	60	632	TOTALS: Eng. / Drafting / Mfg.	180	360	8

Notes
1. Or Electronic Data Processing.
2. Large manufacturing and rework effort is eliminated by engineering design employing Mylar mockup.

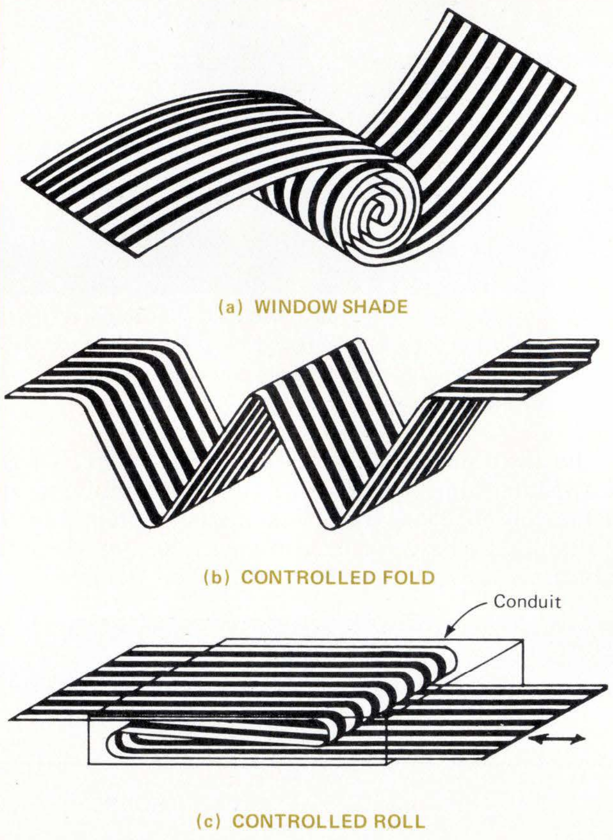
drastically reduced—down from 632 hours to only 8 hours.

Retraction techniques

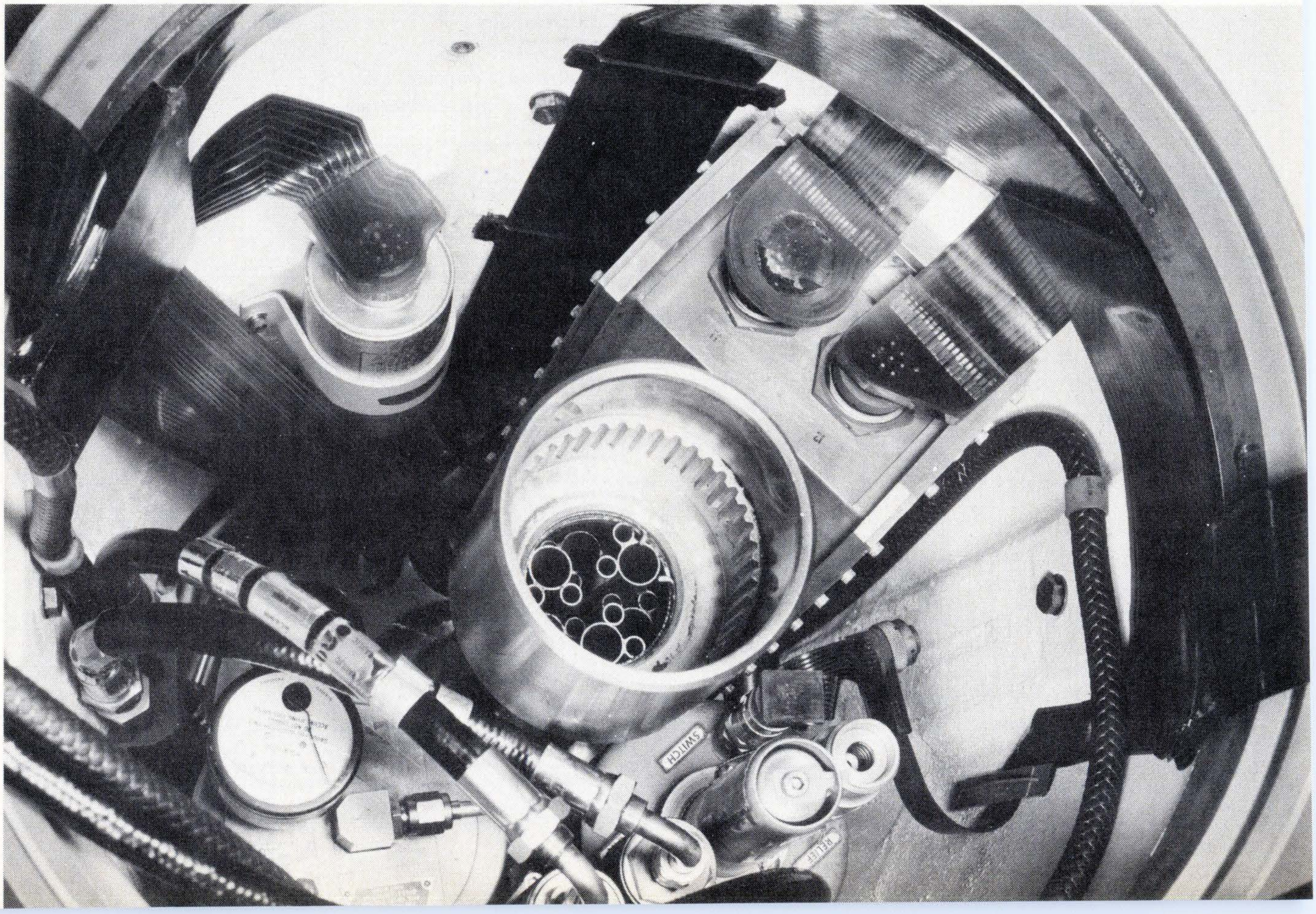
As part of over-all cable design, retraction and extension must be considered. Some of the common techniques are shown in Fig. 6. The one to be used depends primarily on the available space.

The window-shade form of flat cable may be either retractor-controlled (as with an automobile seat belt) or formed into the memory of some insulation systems. The controlled fold may be rigid at the bends and flexible at the straight sections, or flexible throughout. It is better not to allow flexing at the cable bends because the work-hardening encountered during bend formation may reduce the life of the copper significantly. Controlled-roll flat cable provides a slide-rolling action within a narrow enclosed conduit. The design includes selection of the conductor and insulation systems as required for the electrical and environmental conditions.

The last step is to produce a prototype of the cable to validate both mechanical and electrical design. The final cable assembly produced from preformed detail parts is the one illustrated in Fig. 1. This assembly is easily mounted into place, using adhesives and support brackets, as shown in Fig. 7. □



6. Retract. Flexible cable is usable with sliding drawers, doors, and hatches—window-shade (a) and controlled-fold (b) versions used where motion is straight pull-out and return. The controlled-roll type (c), confines the flexing cable to a shallow conduit.



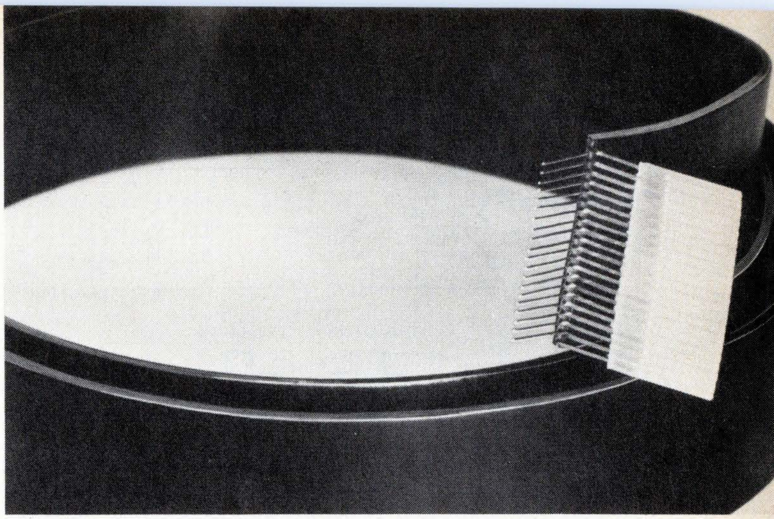
7. Installed. Jacketed cables, with potted connectors that are costly to assemble, are replaced by flat cabling, which eliminates expensive fabrication procedures. The flat-cable assembly is clean and compact and provides short thermal paths for all conductors.

SPECIAL REPORT

Flat cable aids transfer of data

Two dielectrics permit multisignal cable to operate well at nanosecond speeds with a minimum of crosstalk

by Joseph B. Marshall, *Ansley Electronics Corp., Doylestown, Pa.*



Boom to high-speed data. Twenty-channel flat cable handles 1-nanosecond data signals with negligible crosstalk. White polyethylene dielectric is folded back along with the 21 rectangular ground leads to expose the 20 signal lines.

☐ To transfer high-speed data from one point to another with minimal distortion, conventional cabling is not good enough. The system designer must think in terms of high-frequency transmission lines and their attendant parameters of impedance, attenuation, and particularly crosstalk. Such lines must often interface satisfactorily with printed-circuit boards, and their cost should be low.

Coaxial cable has been used for data transmission, and so have stripline techniques, but, besides requiring expensive connectors, and being expensive to fabricate, they are not really flexible enough. Nor, until recently, was flat cable able to perform where switching speeds were faster than 4 to 5 nanoseconds, because its far-end crosstalk was too high.

A recently developed dual-dielectric flat cable, however, provides the necessary transmission-line characteristics and, most significantly, has drastically reduced crosstalk at nanosecond switching speeds. Since its signal leads are spaced on 50-mil centers, it satisfies the density requirements and, compared with coax, it is also economical.

A flat-cable version of a transmission line is the culmination of a long-established trend (see "Planar transmission lines," p. 92). Cabling that interconnects pc boards should ideally be planar, like flat cable. Also, it should exhibit high wire density, as does flat cable, because the wide, rectangular body of insulation, covering a multitude of conductors, is physically strong, the conductors in such cable can be very thin—no thicker, in fact, than is necessary to fulfill attenuation requirements. Also, automated tooling is available to rapidly strip and terminate such cable, whereas twisted pairs or grouped coaxial cable cannot be terminated nearly as fast. However, conventional flat cable's serious shortcoming is its susceptibility to crosstalk at high switching speeds.

Crosstalk

Generally, when conventional flat cable is used to transfer data, it develops high crosstalk whenever the signal propagation delay along its length approaches the rise time of the pulse being propagated. The propagation delay is related to the length of the line and the square root of the effective dielectric constant of the insulating material. Some representative dielectic constant values for commonly used insulation materials are shown in Table 1.

A handy rule of thumb for adequate crosstalk control is that the principles of transmission lines should be applied when the delay time between connections exceeds 1/25 of the transmitted pulse's rise time (t_r). To get an idea of what this means dimensionally, these conditions are met by a 10-nanosecond pulse rise time on a polyethylene-insulated cable 3.2 inches long, or in air over a path only 4.8 in. long. Since data-processing equipment now commonly operates at two or three times this speed, and new designs employ subnanosecond rise-time devices, it's obvious that most system and device interconnections must be made by high-frequency transmission-line techniques. At the same time, mechanical compatibility with pc boards must be maintained.

A worst-case crosstalk condition occurs when, say, four out of five adjacent signal transmission lines are pulsed simultaneously, with the quiet line in the center. The interference level on the quiet line is expressed either in decibels of isolation between the active pulse-carrying signal lines and the quiet line, or as a percentage of the signal level on the active lines.

Relevant equations[1] are:

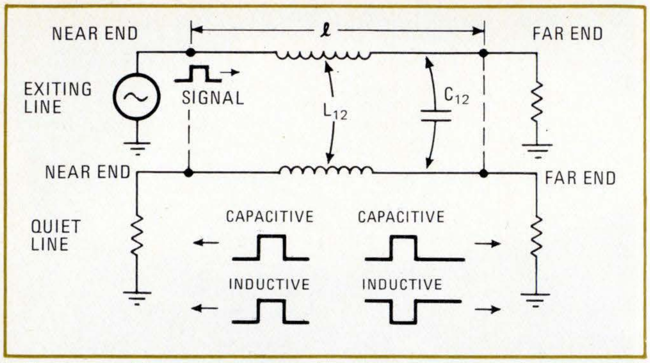
$$\text{Crosstalk (dB)} = 20 \log (V_a/V_q)$$

$$\text{Crosstalk (\%)} = (V_q/V_a) \times 100$$

Figure 1 represents two adjacent uniform signal lines, one of which carries a pulse-type signal. The coupling between the two lines is represented by mutual inductive and capacitive components, L_{12} and C_{12}, respec-

TABLE 1
SIGNAL PROPAGATION DELAY IN VARIOUS DIELECTRICS

Media	Propagation delay (ns/foot)
Air	1.016
FEP (Teflon)	1.47
Polyethylene	1.545
Polyvinyl chloride	1.8 – 1.9
Polyester	1.85
G–10 epoxy-glass-cloth printed-circuit board	2.0 – 2.2



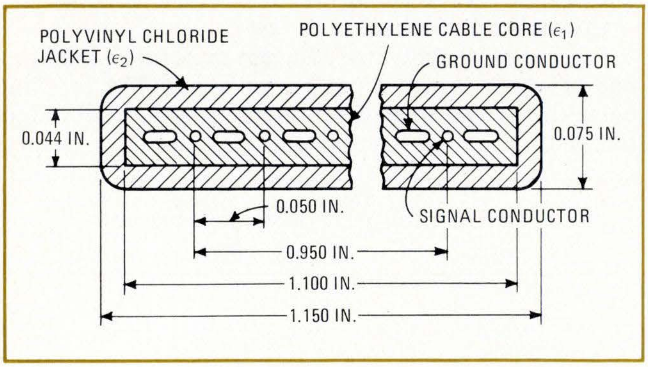
1. Crosstalk. Unshielded, signal lines that are adjacent and parallel are vulnerable to crosstalk. The distributed capacitive C_{12} and inductive components L_{12} couple the spurious crosstalk-signal components that propagate in the directions shown in the schematic.

tively. Signals introduced into the active line will be coupled into the quiet line by the electrostatic and electromagnetic fields that accompany the traveling signal.

The induced voltage and current propagate in both the forward and backward directions at the same speed as the exciting signal, but there are significant differences in the polarities of the components of the backward and forward crosstalk. The capacitively coupled component propagates in both directions with the same polarity as the signal in the exciting line. The inductively coupled component propagates backward with the same polarity, but forward with the opposite polarity.

The net effect of all these interactions comes to this. The near-end crosstalk will be the sum of both the capacitive and inductive effects; hence it will be an attenuated replica of the pulse on the active line. This pulse will reach a maximum amplitude when the effective propagation delay of the quiet line corresponds to $t_r/2$. (For example, a pulse with 1-nanosecond rise time will generate maximum backward crosstalk on a quiet air-dielectric line, 6 inches long or longer.) The far-end crosstalk component is the net difference between the inductively and capacitively coupled effects because they are opposite in polarity. Hence, if these components are equal, forward crosstalk is zero.

Coupling coefficients are expressed by the following formulas:



2. Two dielectrics. Inner polyethylene and 15-mil outer polyvinyl chloride dielectrics have differing dielectric constants (ϵ_1 and ϵ_2) that in combination minimize far-end crosstalk. Dense construction enables 20 signals to be carried in a cable a little over 1 inch wide.

$$k_L = L_{12}/(L_{11}L_{22})^{1/2}$$
$$k_C = C_{12}/[(C_{11}C_{22})^{1/2} + C_{12}]$$

where

k_L = inductive coupling coefficient

L_{11}, L_{22} = inductances of the independent signal lines

L_{12} = inductive coupling between adjacent signal lines

k_C = capacitive coupling coefficient

C_{11}, C_{22} = line capacitances of the two signal lines to the ground plane

C_{12} = capacitive coupling between two adjacent signal lines

The fact is that uniform matched impedance lines in a homogeneous dielectric medium exhibit $k_L = k_C$. The result is zero differential far-end crosstalk. But the dielectric medium of multiconductor cables, twisted pairs and conventional flat cables does not present a homogeneous cross-section to the propagating electrostatic and electromagnetic fields.

Portions of these fields extend beyond the solid dielectric into the surrounding air, altering the capacitive coupling coefficient considerably but not affecting the inductive coupling coefficient. The resulting differences in coupling coefficient polarities create far-end differential crosstalk. Far-end crosstalk increases by the length of cable and also by the faster pulse rise time; in the worst case could be as high as 40% of the transmitted signal.

A dual dielectric

The main reason for the development of high crosstalk in conventional flat cables is that their mutual capacitance, C_{12}, is much lower than the self-capacitances, C_{11} and C_{22}, compared to a transmission line where the fields are in a uniform dielectric. This deficiency can be compensated for, and crosstalk considerably reduced, by a dual-dielectric cable configuration in which conductors are surrounded by a core of low-dielectric constant material and that core in turn is clad by a material with higher dielectric constant, as shown in Fig. 2. This principle has been embodied in a line of flat cables designated Black Magic, manufactured by the Ansley Electronics Corp.

The concept was the side-effect of an attempt to produce a cable at reasonable cost that has an insulation with better electrical and self-extinguishing characteristics than was then available. The prototype cable with a polyethylene center core and vinyl jacket not only exhibited the desirable characteristics, but it unexpectedly appeared to virtually eliminate far-end crosstalk.

It turns out that the dual-dielectic cable corrects the imbalance between C_{12} and the self-capacitance because the higher dielectric constant of the vinyl jacket over the low dielectric constant of the polyethylene core equalizes the inductive and capacitive coupling coefficients. The configurations are shown graphically in Fig. 3.

Performance

Just how well does the dual-dielectric cable stack up against its competitors? Figure 4 illustrates the magnitude of the crosstalk on 20-foot lengths of both standard

TABLE 2: CROSSTALK IN TWISTED PAIR VS. DUAL-DIELECTRIC CABLE			
SINGLE CABLE LAYER	SIX TWISTED PAIRS BUNDLED	DUAL-DIELECTRIC CABLE	IMPROVEMENT RATIO
Length of cable	10 ft	10 ft	
Pulse rise time	1 ns.	1 ns.	
No. of Active lines	4	4	
Near-End crosstalk, peak	18.8%	3.5%	5.4
Far-End crosstalk, peak	14.0%	2.5%	5.6
Length of cable	30 ft	30 ft	
Pulse rise time	1 ns.	1 ns.	
No. of Active lines	4	4	
Near-End crosstalk, peak	22%	4.2%	5.2
Far-End crosstalk, peak	21%	2.5%	8.4
SINGLE CABLE LAYER	TEN PLANAR TWISTED PAIRS	DUAL-DIELECTRIC CABLE	IMPROVEMENT RATIO
Length of cable	30 ft	30 ft	
Pulse rise time	5 ns.	5 ns.	
No. of Active lines	4	4	
Near-End crosstalk, peak	25.8%	8.1%	3.2
Far-End crosstalk, peak	21.5%	3.3%	6.5
THREE LAYERS OF CABLES			
Length of cable	30 ft	30 ft	
Pulse rise time	5 ns.	5 ns.	
No. of Active lines	8	8	
Near-End crosstalk, peak	26.7%	8.0%	3.3
Far-End crosstalk, peak	24.6%	6.0%	4.0

and dual-dielectric flat cables. Pulse rise time in both cases is 0.18 nanosecond.

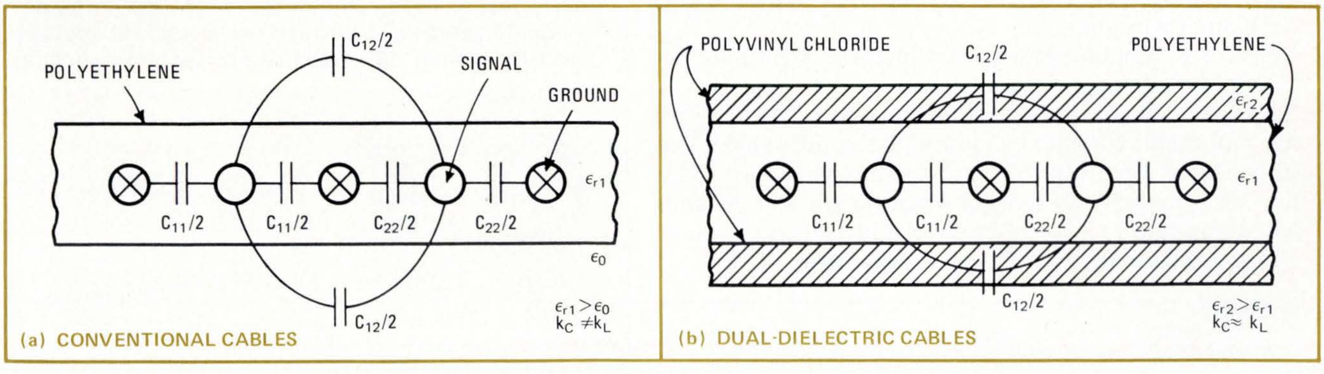
Tests employing two twisted-pair geometries yielded the results shown in Table 2. The six pairs in the cylindrical bundle exhibited a characteristic impedance ranging from 50 to 65 ohms, whereas the 10 pairs of wires arranged side by side in the single plane were 80-ohm pairs. The results, as shown in the table, indicate that dual-dielectric cable affords an improvement in both near-end and far-end crosstalk. The most dramatic improvement occurs for a 30-ft cable carrying 1-nanosecond rise-time signals. The improvement ratio is over 8:1.

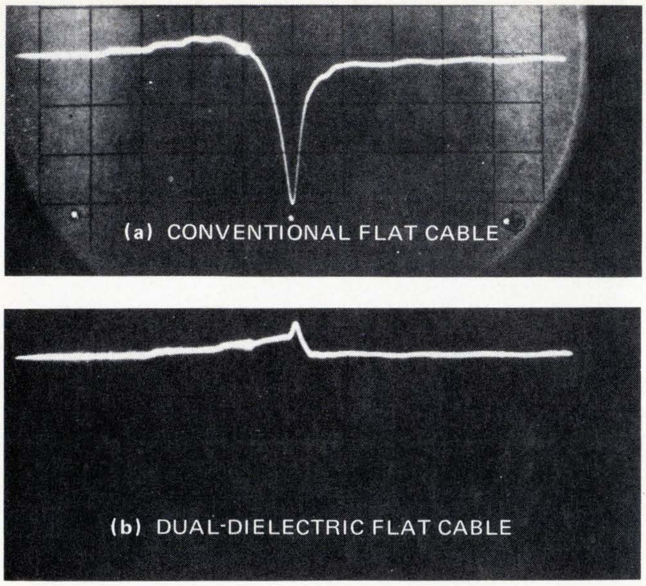
A dual-dielectric version of solid-logic-technique cable was also compared with conventional SLT cable. The far-end crosstalk improvement is five times for a 1-ns signal (Fig. 5). What is paramount, however, is that these tests show the dual-dielectric cable reduces crosstalk below a troublesome level for all the fast digital-logic families.

In summary, in regard to electrical performance, the polyethylene inner core determines the characteristic impedance, the propagation velocity, and the attenuation. The polyvinyl jacket, with its higher dielectric constant, limits the crosstalk.

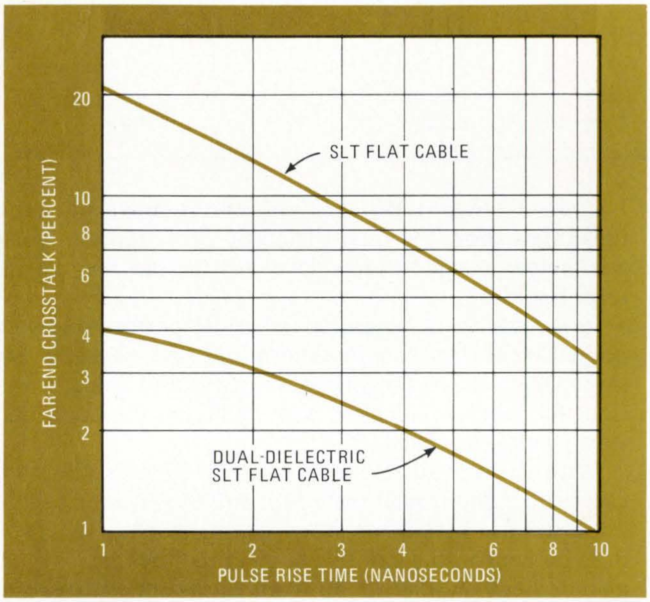
With an over-all thickness of 55 to 77 mils, the dual-dielectric cable is well suited for intra- and intercabinet applications. Flexibility is excellent, in that the cable may be bent into a radius equal to its thickness. It may also be bent over at 45° to form right-angle turns—and all with neither physical damage to the cable nor detriment to the electrical performance. What's more, the

3. Boost the epsilon. In (a), the dielectric region between signal lines is largely air. Adding the polyvinyl chloride outer cover (b) raises the dielectric constant of the region, which tends to equalize the coupling coefficients. The result: lower far-end crosstalk.





4. Performance. Dual-dielectric cable shows five-fold improvement in crosstalk over conventional flat cable when excited by 0.18-ns rise-time pulse. Cables are 20 feet long. Horizontal scale is 2 ns/division; vertical scale is 5% crosstalk/division.



5. Comparison. The graph depicts far-end crosstalk for both the dual-dielectric and conventional SLT cable. Each is 10 feet long, with the quiet line between four sets of active lines. At 1 nanosecond, the dual-dielectric cable exhibits a five-fold improvement.

cable fulfills Underwriters Laboratories' requirements for flame retardancy.

There is only one ground conductor to terminate between two adjacent signals (in conventional round-wire flat cables, two or more grounds have to be used). With flat and round conductors alternating in the cable, identification of signal and ground conductors is easy. This feature is particularly helpful when signals and grounds will terminate to two different conductor planes—such as a printed-circuit board used as microstrip. □

REFERENCE

1. N.C. Arvanitakis, J.T. Kolias, and W. Radzelovage, "Coupled Noise Prediction in Printed Circuit Boards for a High-Speed Computer System," IECP, 1966 Wescon.

Planar transmission lines

Planar transmission lines first appeared as stripline, which was introduced by R. M. Barrett for use in microwave components such as hybrid junctions, directional couplers, power-divider networks, and filters. This configuration evolved from coaxial geometry and made use of the etched printed-circuit board. As shown below, the cylindrical outer conductor of coaxial geometry is exchanged for two parallel ground planes. This promotes the propagation of a true transverse electromagnetic mode (TEM) along the line, just as in coaxial cable.

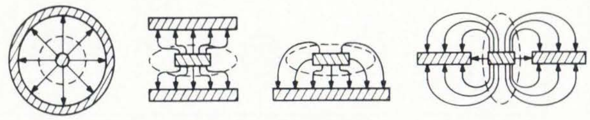
Microstrip is simpler in structure than stripline, having only one ground plane. It is characterized by an impure TEM-wave propagation, due to the air dielectric above the single strip. Still, with careful design, it will transmit high-speed data signals with fidelity. An even simpler geometry may be achieved by locating the ground and signal conductors in the same plane—a coplanar transmission-line configuration that achieves a performance comparable with that of microstrip.

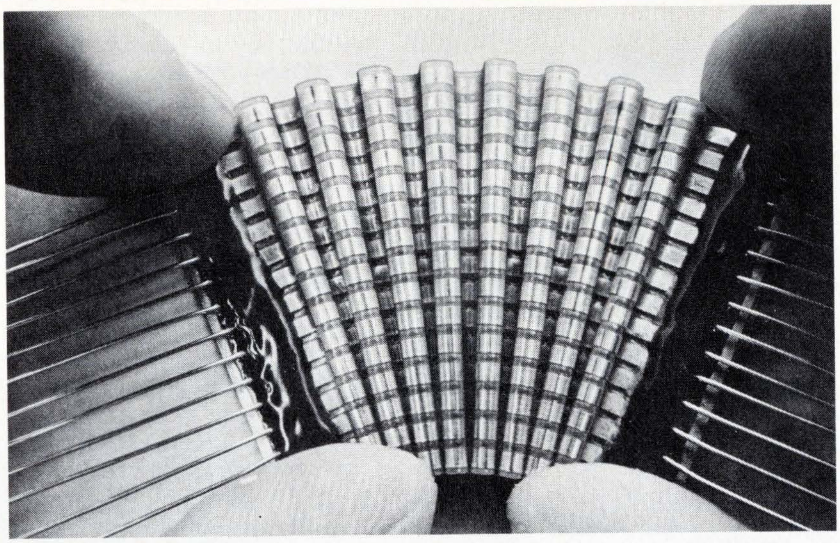
Each of these geometries can be applied either to pc boards or to flat cables. In practice, though, stripline and Microstrip are more often applied to pc boards, and the single conductor plane is usually favored in flat-cable design.

A 16-conductor flat cable was used by IBM in 1963 in the 1440 series SMS computers. Individual signal-transmission-line properties were not considered, so it was designed for optimum mechanical and fabrication qualities: flexibility, foldability, simple strain relief, small size, and ease of termination, including stripping and soldering.

The logic speed of IBM 360-series computers (pulse rise time in the neighborhood of 5 nanoseconds), however, required high-frequency transmission lines for interconnections. In 1964, IBM developed the solid-logic technique (SLT) cable. Sixty conductors carry 20 signals, since each signal conductor is centered between two ground conductors. The dielectric is self-extinguishing polyethylene, and the nominal characteristic impedance is 95 ohms. Signal-propagation time is 1.57 ns/foot, attenuation at 75 megahertz is 15 decibels per 100 ft maximum, and the worst-case cross-talk is 10% with a 2.6-ns rise-time pulse.

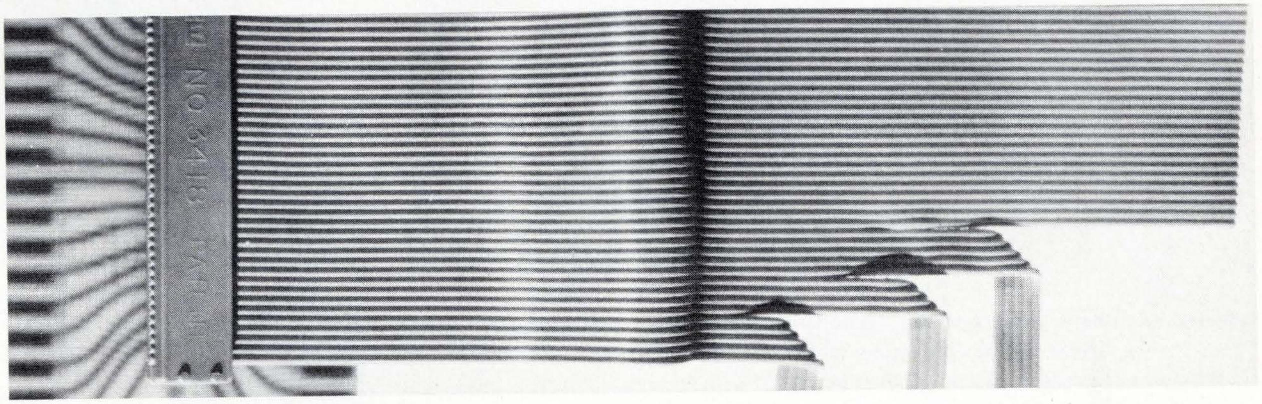
Because the geometry of the SLT design can be adapted to various impedance values, conductor sizes, and insulation materials, it is still a favorite today for conventional signal-transmission-line flat cables. But, as rise times approach 1 ns, there's a need for an even better cable. Such an improved flat cable is the multisignal dual-dielectric cable, described in the accompanying article, in which crosstalk can be kept below 10% even in the region of picosecond switching speeds.

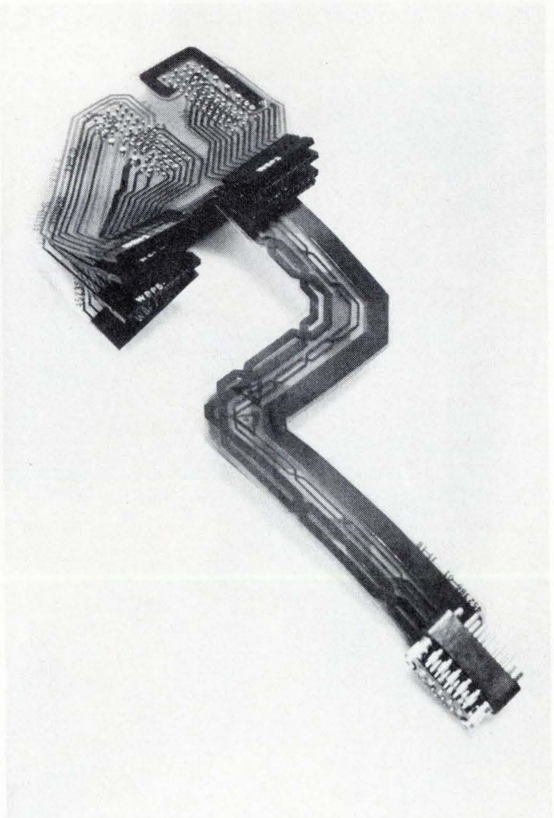




Accordian. Flexible circuit, such as one made by ITT-Cannon Electric (left), provides a dense yet flexible interconnection between two circuit assemblies. Pleat enhances flexability. Insulation is usually a polyimide, which is more stable over wide temperature ranges than competing Teflon and Mylar.

Zip. Flat cable (below) consists of parallel insulated conductors, which can be readily separated by hand or machine. Cable, such as this from 3M Co.'s Electro-Products division, which makes it in widths of up to 50 conductors, is fine for computer wiring, readouts, control panels, and electronic test equipment.

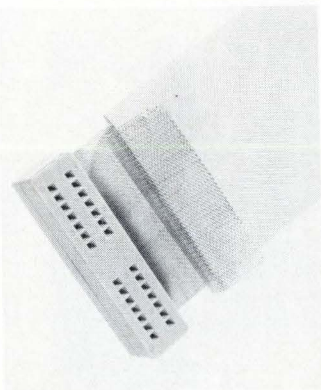


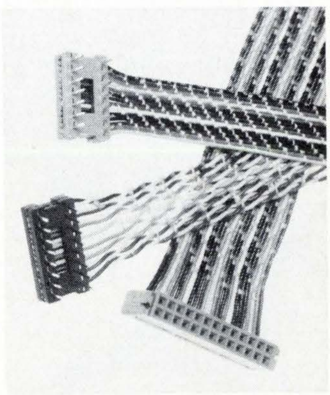


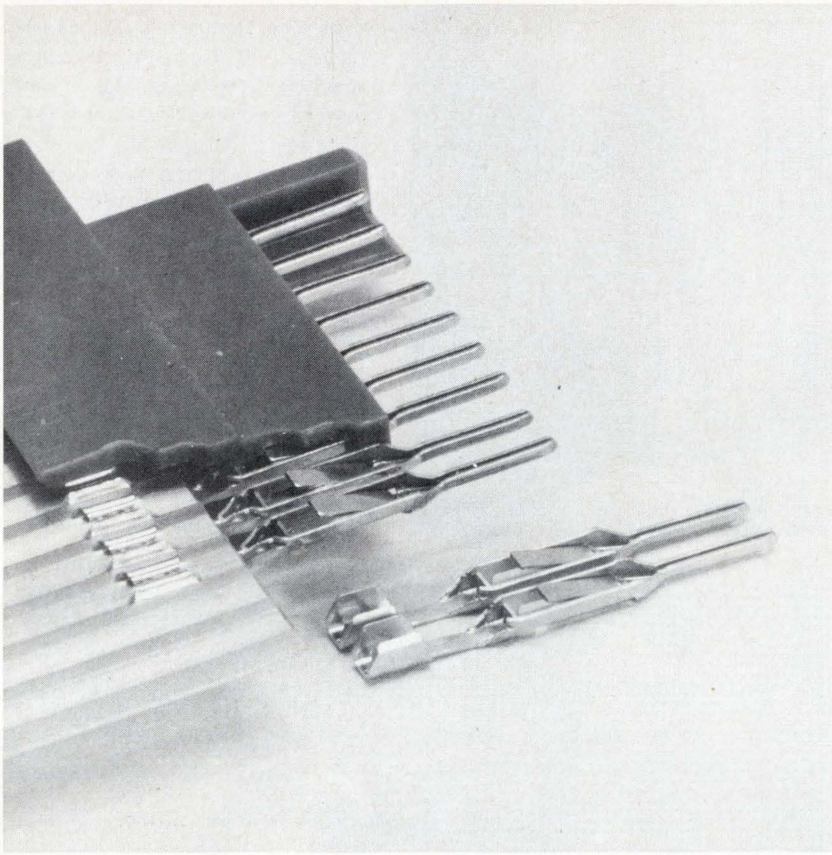
Multilayer. Flexible circuit (left) has a multilayer construction and mounts several connector types. This assembly was manufactured by the Parlex Corp. Note the simulated twisted-pair conductor pattern. Planar-wiring provides good thermal dissipation.

Shielded. Flat cable (below left) has 28-gage stranded conductors located on 50-mil centers and a mesh-shield ground plane. Made by 3M Electro-Products division for computer-mainframe and peripheral applications, it is available in 16-, 34-, 40-, and 50-conductor versions.

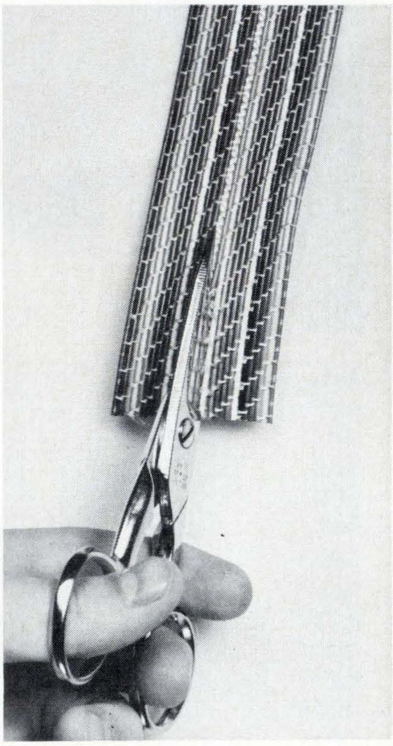
Woven. Planar cables (below right) can be custom woven with Teflon, Nylon, or other fibers to suit customer requirements. These cables, fabricated by Woven Electronics, illustrate both single-conductor and twisted-pair cables.





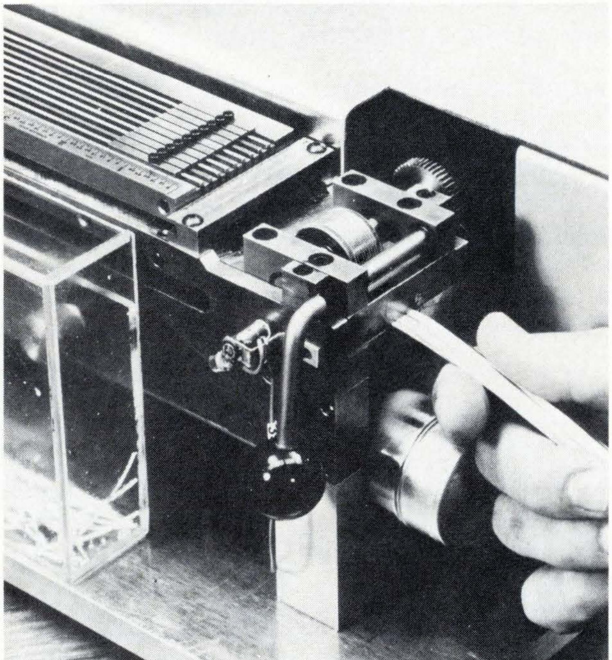


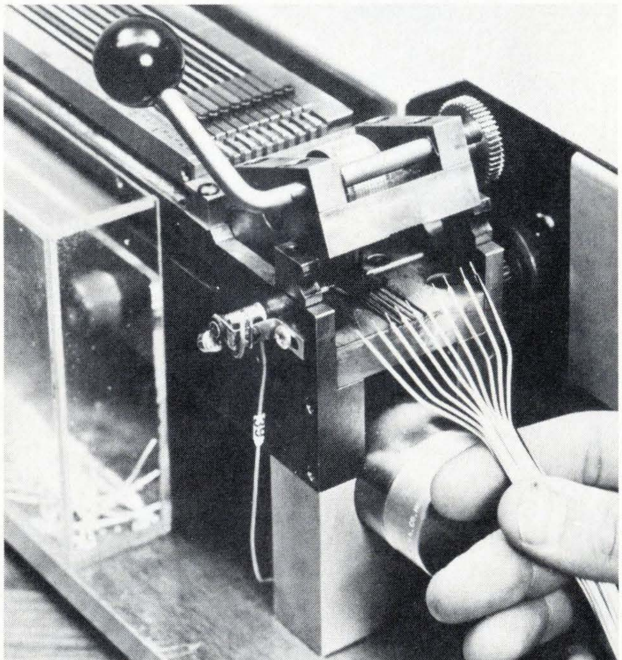
Tailored. Scissors makes fast work of separating wires of woven flat cable (below). Woven wiring employs textile techniques to combine wires into flat configurations required by a customer. This cable is made by Woven Electronics.



Pierce and crimp. These Amp Inc. flat-cable connector pins can be attached by automatic equipment at the rate of two per second. Designed for standard flat cable with 63-mil-wide conductors spaced 100 mils apart.

Quick Strip. In two-step automated stripping technique (below, left and right) tool, developed by the Spectra-Strip Corp. and Tektronix Inc., strips and separates end of the 10-conductor flat cable in 3 seconds.





SPECIAL REPORT

Flexible circuitry consolidates hardware for interconnections

Prefabricated wiring, which eliminates several conventional parts, allows simplification of assembly process, as well as the design of other components; it is especially suitable for solid-state displays

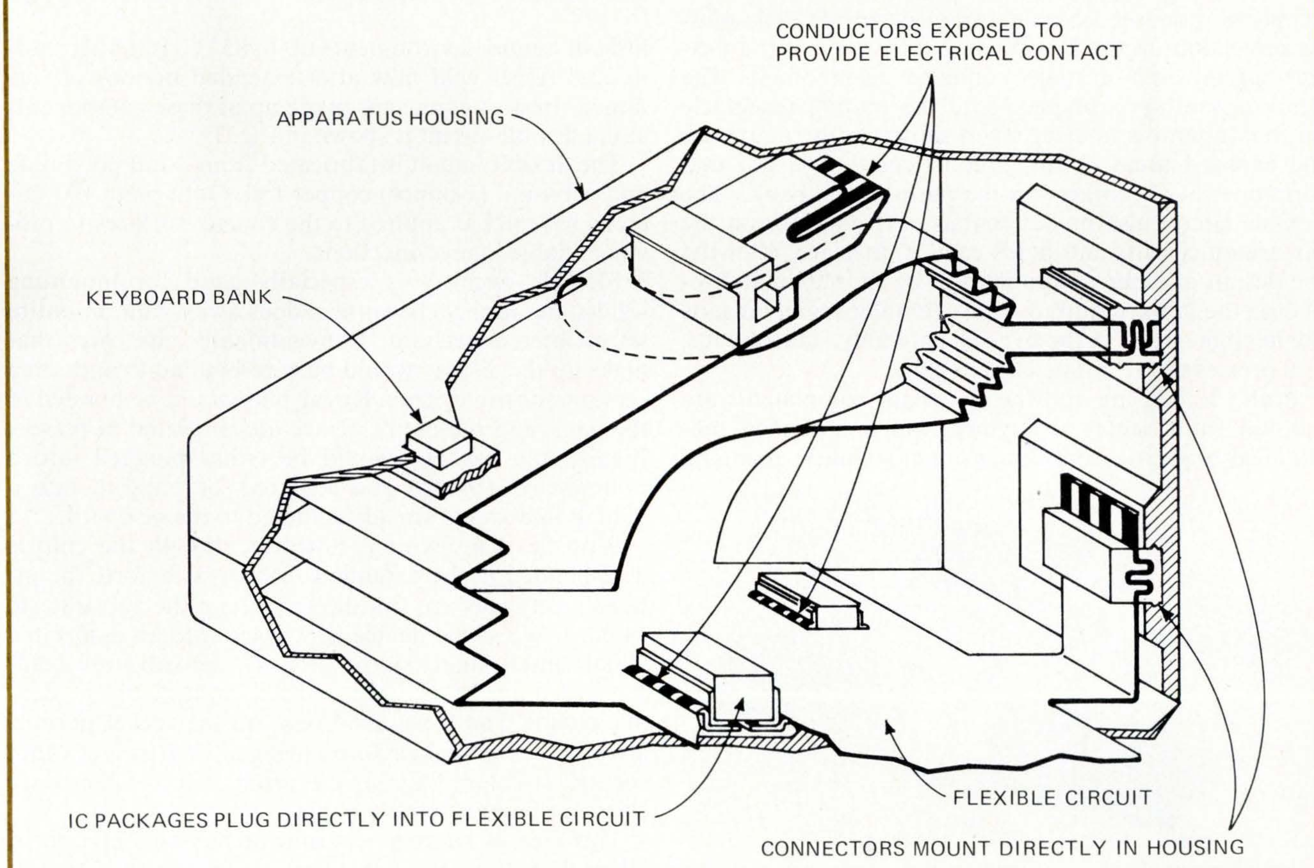
by Peter Maheux, *Bell-Northern Research, Ottawa, Canada*

□ One of the greatest attractions of flexible circuitry is that it can entirely replace the individual rigid printed-circuit boards, hard wiring, and the piecemeal, cumbrous, and expensive interconnection techniques that boards and wire require.

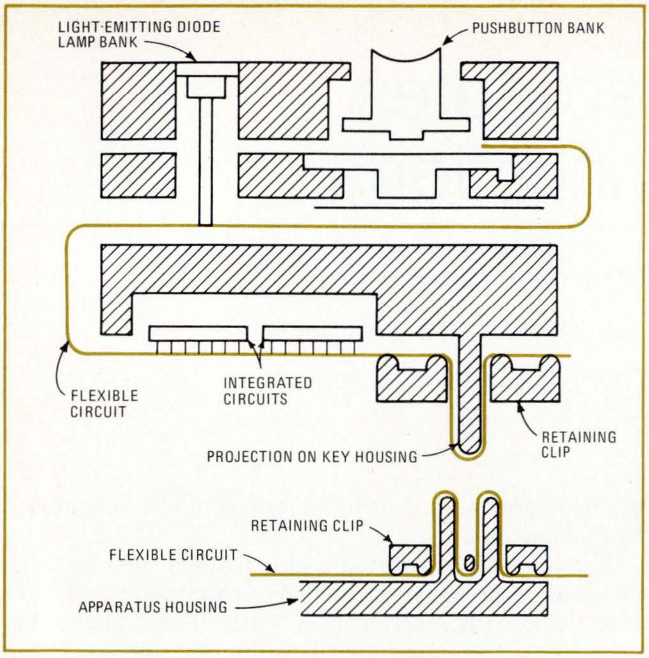
A system that best illustrates these advantages is a telephone set. Figure 1 illustrates how the traditional arrangement in a telephone set can be reduced to three basic elements: flexible circuitry, connectors, and a housing. The key and the circuit contacts are portions of the foil exposed in the circuit's plastic covering. This does away with a set of contacts and the conventional multicomponent connector—often complex assemblies by themselves.

The circuit is fabricated and assembled before being installed in the housing, much as a ship model is assembled before it is inserted in a bottle. The housing, besides providing mechanical stiffening and a shield against the environment, also has cavities molded into its wall to mount connectors. The flexible circuit is then formed about the lips of the connector interfaces; retaining clips hold the flexible circuit securely in place about the male and female mating parts.

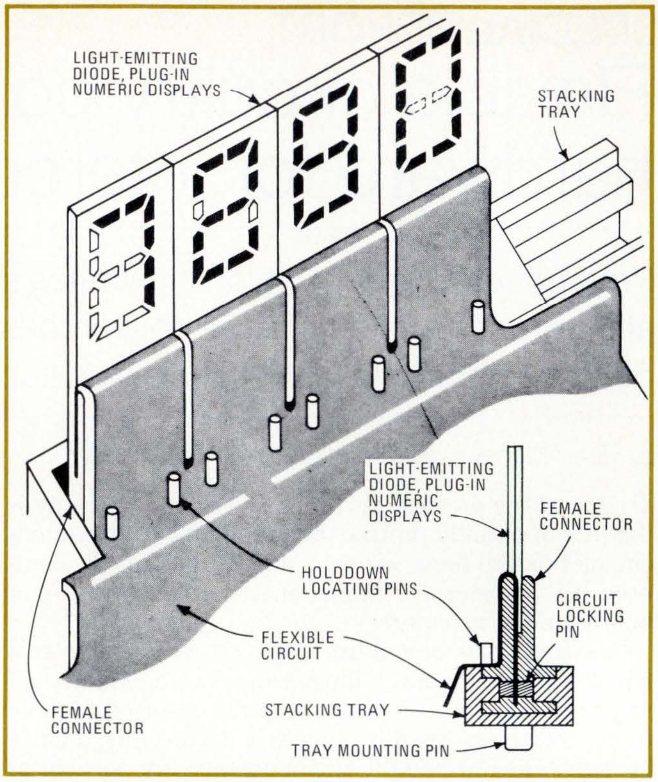
Figure 2 demonstrates how the conjunction of circuit



1. Package revolution. Flexible circuit banishes traditional discrete-component mounting methods and laborious point-to-point wiring, offering instead pressure interconnections that are quickly assembled. Terminals, soldering, and conventional connector hardware are gone.



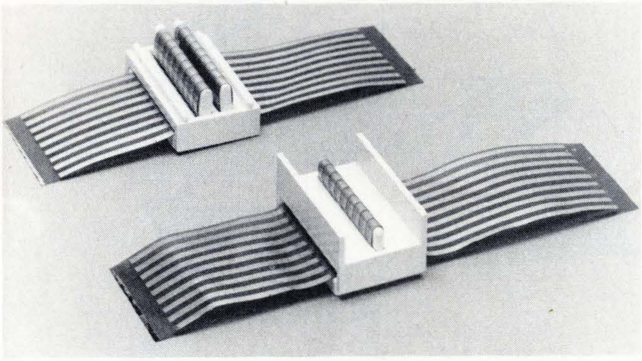
2. All wrapped up. Flexible circuit starting at the push-buttons of telephone-handset subassembly is connected to the light-emitting-diode lamps, secures and is connected to several ICs, and finally is wrapped round a projection to form a connector.



4. Ideal for LED displays. Flexible circuit teams with tee-shaped plastic connectors to form a versatile socket system for digital displays. Any number of connectors may be slid into stacking tray to mount the number of displays desired.

and components can provide electrical interconnection and mechanical placement. Here a light-emitting-diode bank and a push-button bank, like the one used in a telephone handset, become a single structure. The plastic projection on the key housing turns part of the flexible circuit into a male connector component. The whole assembly is plugged into the mating receptacle on the apparatus housing. (Not shown in the figure are the exposed areas of the circuit's conductive foil that form one set of contacts for the push-button bank.) The flexible circuit also makes contact with the pins on the integrated circuits and holds each IC in place, allowing the design of other components to be simplified and reducing the labor required—the assembler merely inserts the flexible circuit in the over-all assembly, adds the ICs, and presses the retaining clips in place.

Both the housing and the connector components are molded from acetal copolymer, which has good mechanical properties and dimensional stability, changing



3. How it mates. The flexible circuit is wrapped about the male and female portions of the plastic shapes to form the contact interfaces. With this configuration, no separate connection step is required because the flexible circuit is both wiring and connector contact.

little in humid environments up to 85° C. It molds readily and resists cold flow after extended periods of sustained stress. A connector made up of these components and a flexible circuit is shown in Fig. 3.

The flexible circuit is fabricated from 3-mil polyimide and a 1.4-mil (1-ounce) copper foil. Gold plate 100 microinches thick is applied to the contact surfaces to provide reliable interconnections.

Flexible circuitry is especially good for mounting solid-state displays because it does away with an entire set of interconnections. Conventionally, the chips that make up the display would be wire-bonded to pads on a ceramic substrate. Then Kovar pins would be bonded to the pads, and the entire device encapsulated in plastic. Finally, the package would be either plugged into a printed-circuit board and soldered, or plugged into a dual in-line socket already soldered to the pc board.

With flexible circuitry, however, though the chip is wire-bonded to the ceramic substrate as before, the interconnect leads are run directly along the substrate to its edge. When the device is plugged into an associated female interconnect shape (Fig. 4), the substrate leads are forced against the exposed foil contacts on the flexible circuit. The tee-shaped base on the socket permits any number of sockets to be arrayed in a tray or other support structure. Again, the result is lower hardware costs and fewer assembly hours.

This kind of interconnect scheme has no metal parts, other than the conductive foil in the flexible circuit. Also, the connectors have but one interface, while many conventional connectors on the market today may have from three to five interfaces. □

TTL interface circuit synchronizes computer clock

by Jim Crapuchettes
Stanford University Medical Center, Stanford, Calif.

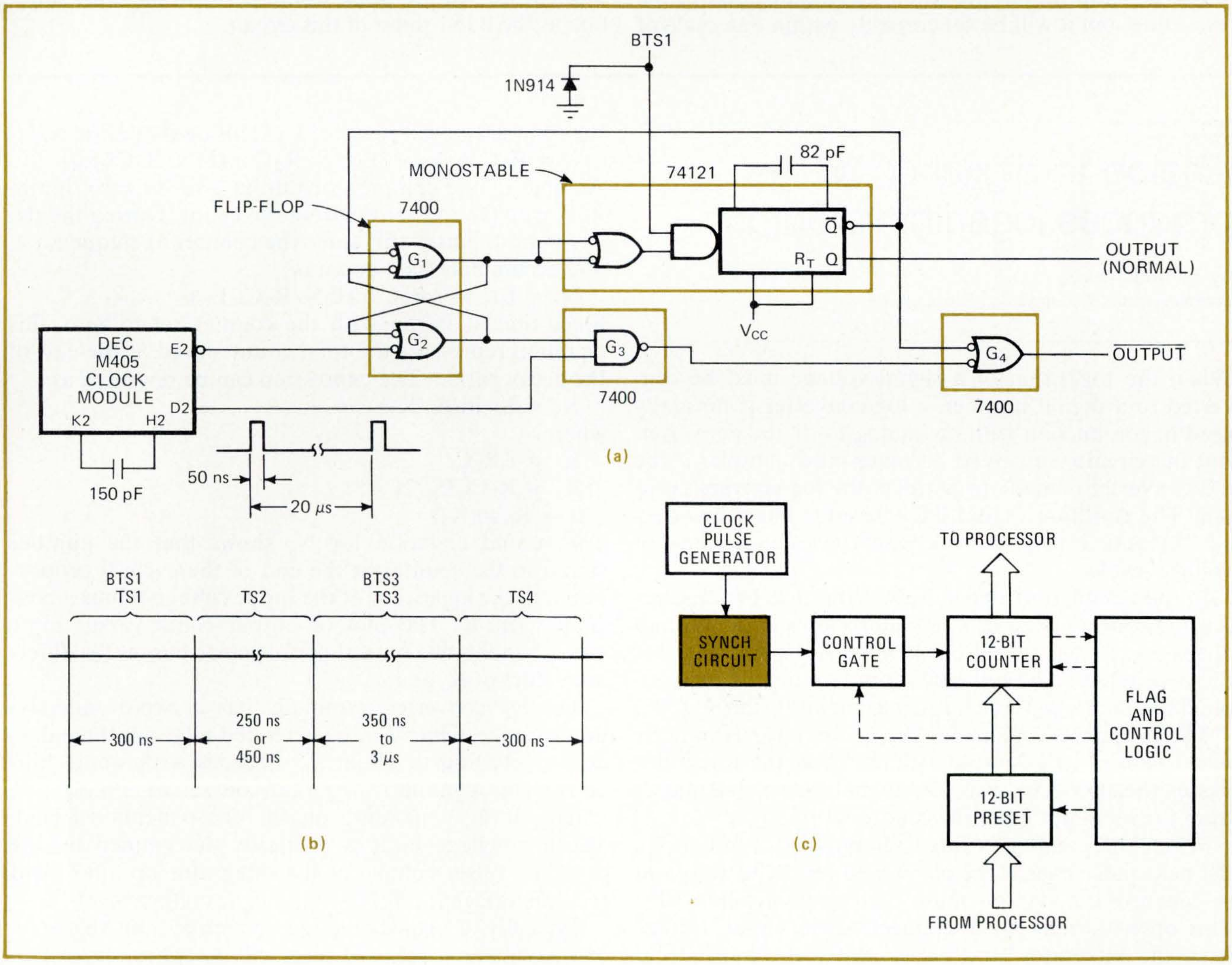
A clock-synchronization circuit for computer interfacing allows the counter of a continuously running real-time clock to be read by the computer when the counter is not changing. The circuit requires only two TTL IC packages. The normal approach is to use complicated circuits requiring a latch or flip-flop for each bit of the clock counter.

There are only two restrictions on the two-IC clock-synchronization circuit: the computer processor must have time states available for the circuit, and the longest cycle time for the processor must be shorter than the period between two successive pulses from the system's clock-pulse generator.

Essentially, this simple circuit (a) forces the clock into synchronization with the processor, rather than trying to synchronize the processor with the clock. This is done by letting the contents of the clock counter be changed only during that portion of the processor cycle in which the counter cannot possibly be read by the processor.

This particular synchronization circuit is designed for the PDP-8/E minicomputer with an external I/O bus option, which is made by Digital Equipment Corp. of Maynard, Mass. The circuit can also work directly from DEC's Omnibus bus design, and it can be applied directly to DEC's PDP-8/I, PDP-8/L, and PDP-12 minicomputers.

The processor cycle, which is drawn in (b), is split into four time states, TS1 through TS4. Two of these time states, TS1 and TS3, are brought out from the processor



Reading out data. Synchronization circuit (a) forces real-time counter clock to be in step with computer processor so that data is read only when the counter is not changing. The delay, time state TS2, in the processor's timing cycle (b) between counter changes (TS1) and the execution of I/O instructions (TS3) is used. Block diagram (c) of real-time clock indicates where sync circuit goes.

on the I/O bus as buffered time states, BTS1 and BTS3. All I/O instructions are actually executed during TS3, and there is a minimum delay of 250 nanoseconds between TS1 and TS3. Therefore, as long as the contents of the clock counter changes only during TS1 and all carries across the counter are finished in less than 250 ns, the counter changes and the computer readouts cannot overlap. The diagram (c) of the system's real-time clock shows the circuit's location.

A pulse from the clock-pulse generator sets the R-S flip-flop formed by gates G_1 and G_2. The next occurrence of time state TS1 (it may be occurring when the flip-flop is set) will trigger the monostable multivibrator. (The 74121 is used here because it produces a fixed-length pulse or none at all, contains part of the necessary gating, and has complementary outputs.) The diode, which is between the monostable and ground, prevents undershoot from the BTS1 line of the I/O bus.

The $\bar{Q}$pulse output from the monostable resets the flip-flop. To be sure that the flip-flop will always be reset, the duration of this $\bar{Q}$pulse must be longer than the duration of the pulse from the clock pulse generator. Since this clock pulse is 50 ns, an 82-picofarad capacitor is added to stretch the monostable pulse to about 100 ns.

The flip-flop has no provision for initialization to the reset state, but it will be set correctly within one cycle of the processor. Initialization is necessary only if the clock control gating is between the clock-pulse generator and the synchronization circuit.

Gates G_3 and G_4 are needed if the clock must continue to run even when the processor is in the halt (pause) state and if the processor does not halt in the time state used for clock counting. In the case of the PDP-8/E, the processor halts in TS1, so these gates are not needed.

When used, they cause the pulses from the clock generator to be gated directly to the circuit's output if the flip-flop is set. As soon as the processor returns to the run state, the flip-flop releases the pulse it has been holding, triggering the monostable and allowing the normal sequence to continue.

The correct number of pulses, therefore, always passes through the circuit, whether the processor is running or not. The only difference will be a long pulse period when the processor is halted and a short pulse period when it continues.

It should be noted that the same synchronization technique could be used with a computer that has only one time state brought out to peripherals. The trailing edge of that time state could be used to trigger a monostable whose output pulse would perform the same function as the BTS1 pulse of this circuit. □

Analog-to-digital converter produces logarithmic output

by Ronald Ferrie
Communications & Controls Co., Pittsburgh, Pa.

When the logarithm of a signal voltage must be converted to a digital number, a log converter is normally used in conjunction with an analog-to-digital converter. But the circuitry involved becomes much simpler if the a-d converter is made to perform the log conversion itself. The resulting digital log converter has a two-decade dynamic range that can be set over a wide range of voltage levels.

In the circuit, a START pulse sets flip-flop FF_1 and resets the counter to zero. This action closes switch S_1 and opens switch S_2. (Field-effect transistors are used for these switches.) The unknown input voltage is now applied to the integrator, charging capacitor C through R_1.

The reference voltage for the comparator is initially set at zero. As the output voltage from the integrator passes through zero, gate G_1 is enabled so that pulses from the oscillator enter the counter at frequency f_o.

When the counter is filled (N pulses accumulated), the next pulse causes the counter to return to zero and to generate a carry-out pulse that resets flip-flop FF_1. This opens switch S_1, disconnecting the input voltage from the integrator, and closes switch S_2, causing capacitor C to discharge through resistor R_2. Also, the comparator reference voltage becomes E_R.

The integrator's output voltage decays until it reaches the comparator reference of E_R. This decay period is:

$$t_x = R_2C \ln(E_{o(pk)}/E_R) = R_2C \ln(E_iN/R_1Cf_oE_R)$$

At time t_x, the comparator output goes to zero, inhibiting gate G_1 and terminating the count. During the decay period, pulses still enter the counter at frequency f_o and accumulate for a count of:

$$N_x = f_ot_x = f_oR_2C \ln(E_iN/R_1Cf_oE_R)$$

Since time t_x began with the counter set to zero, this equation represents the total count stored at the end of the decay period. The expression can be rewritten as:

$$N_x = K_0 \ln(E_i/K_1) - \alpha$$

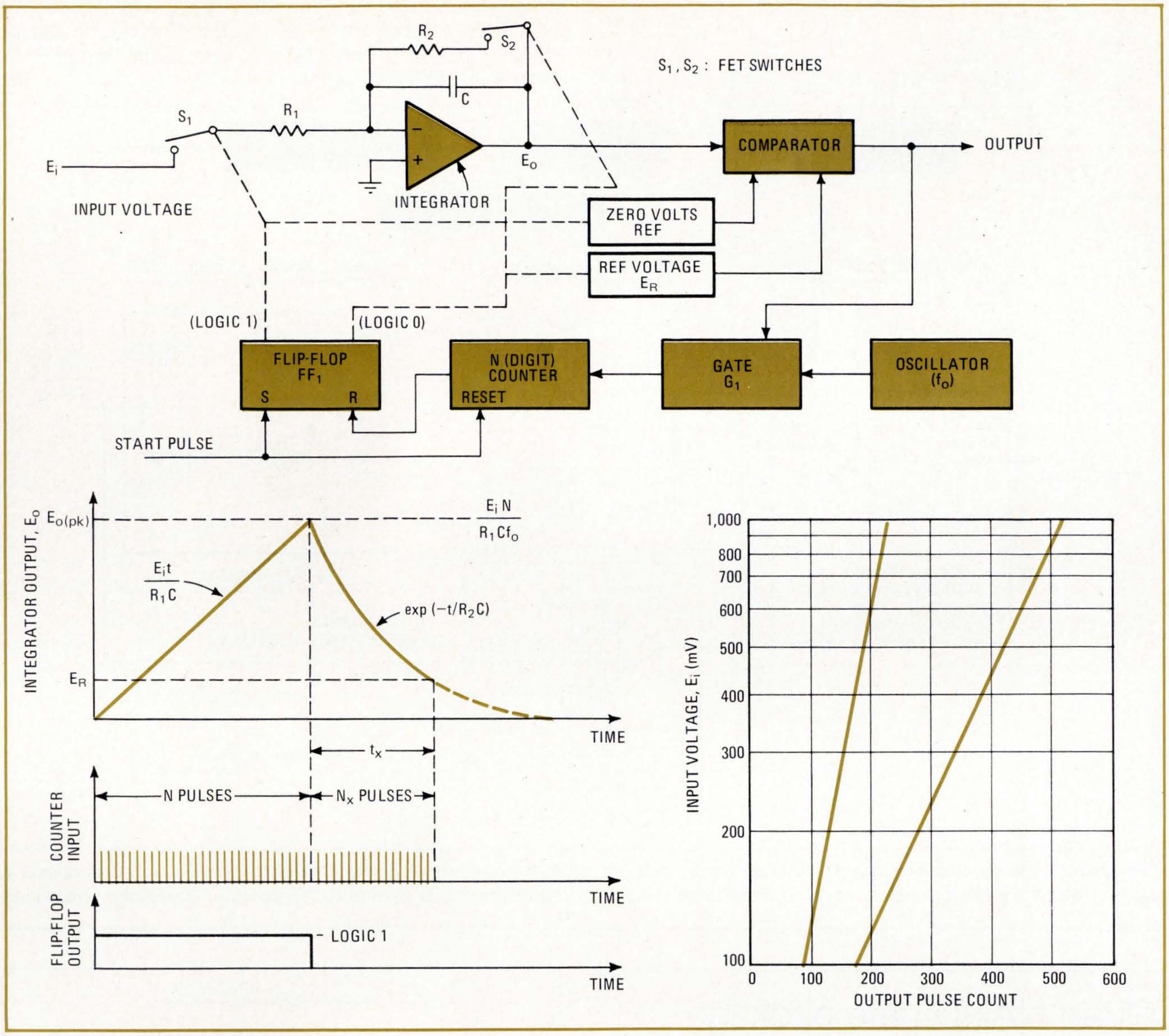
where:

$$K_0 = f_oR_2C$$
$$K_1 = R_1Cf_oE_R/N$$
$$\alpha = K_0 \ln(K_1)$$

The second equation for N_x shows that the number stored in the counter at the end of the cycle is proportional to the logarithm of the input voltage minus a constant term, α. The plot of output count versus input voltage shows two typical performance curves for different values of K_0 and α.

The log converter nominally has a two-decade dynamic range, which can be extended to about three decades easily and to about 3.5 decades with some difficulty. This dynamic range can be set at almost any voltage level, depending on the components selected. The low-voltage limit is primarily determined by the drift and offset voltage of the integrator op amp. And resistor voltage ratings limit the high-voltage level.

Typically, a two-decade log converter built this way, and having an α value of zero, will accept inputs of 1 to 100 volts, producing an output pulse count of 0 to 460. For such a converter, N = 1,000, f_o = 50 kilohertz, R_1 = 100 kilohms, and C = 2 microfarads. □



Digital log converter. Modified a-d converter provides logarithmic output over two-decade dynamic range. Integrator capacitor C charges from input voltage until counter accumulates N pulses. When counter resets and begins to count again, the capacitor discharges until integrator output reaches comparator reference E_R. Converter's output for this decay time, t_x, is proportional to the log of the input.

Analog multiplier/divider simplifies frequency locking

by Moise Hamaoui
Fairchild Semiconductor, Mountain View, Calif.

In phase-locked loops, servo systems, and TV receivers, it is often necessary to lock two different frequencies together. The conventional method is quite cumbersome. First the higher of the two frequencies is divided down to a value close to that of the lower frequency. Then a signal that is proportional to the difference between the stepped-down frequency and the low frequency is generated. Lastly, this signal is used to adjust the high frequency so that it is locked to the low frequency.

The analog multipler/divider shown, however, locks the two frequencies in one step. The block diagram illustrates how the circuit accepts pulses of frequency f_{in} and generates pulses at frequency $f_{out} = Mf_{in}$, where M is a constant determined by the designer.

Dc voltages V_1 and V_2 are proportional to the two frequencies to be locked together:

$V_1 = K_1 f_{in}$

$V_2 = K_2 f_{out}$

The output voltage is the difference between these two:

$V_{out} = A(V_1 - V_2) = A(K_1 f_{in} - K_2 f_{out})$

where A is the gain of the differential amplifier. The output frequency is given by:

$f_{out} = KV_{out} = KA(K_1 f_{in} - K_2 f_{out})$

which can be rewritten as:

$(K_1 f_{in} - K_2 f_{out})/f_{out} = 1/KA$

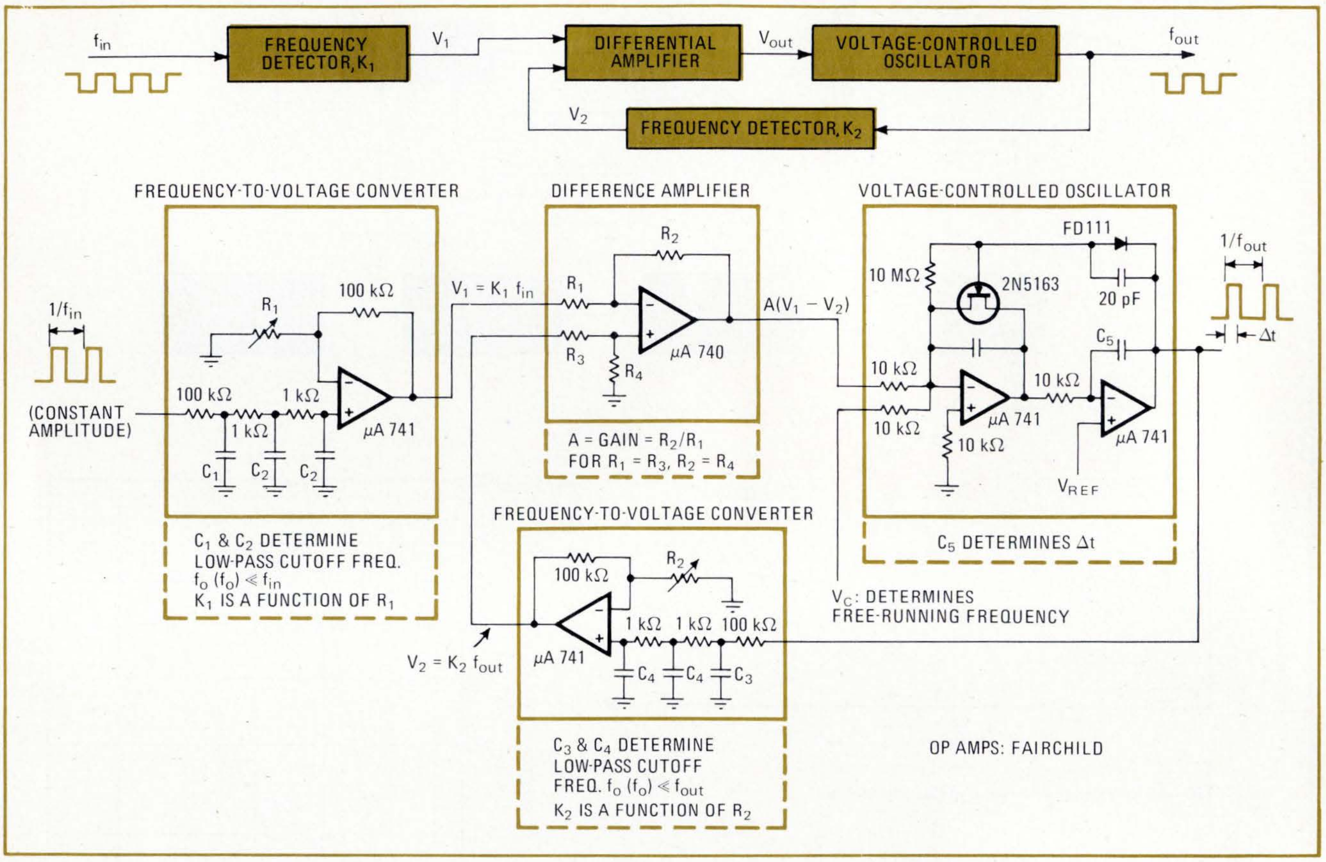
As amplifier gain A becomes very large:

$K_1 f_{in} - K_2 f_{out} \approx 0$

Solving for f_{out} yields:

$f_{out} = (K_1/K_2) f_{in} = M f_{in}$

By varying K_1 and K_2, then, the input frequency can be multiplied or divided by any factor. For the hardware implementation shown, either f_{in} or f_{out} may range from 30 hertz to 10 kilohertz. □



Step saver. In single operation, analog multiplier/divider locks two different frequencies together. Differential amplifier accepts voltages V_1 and V_2, which are proportional to the frequencies to be locked. Varying the constants, K_1 and K_2, multiplies or divides the frequencies.

Quad NAND gate package yields two-frequency clock

by Howard L. Nurse

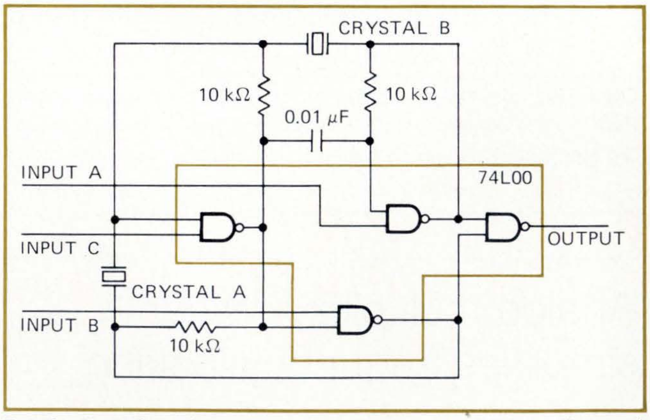
Applied Technology Division, Itek Corp., Palo Alto, Calif.

Crystal-controlled clock oscillators generally require three logic gates to produce a single output frequency. This means that the fourth gate in the common quad-type gate package is not used. But, with just a couple of extra parts, that fourth gate can be put to work.

The two-frequency crystal clock in the diagram takes maximum advantage of a quad TTL NAND gate package with a minimum of external components. And this economical circuit can be remotely programed by grounding one of its three input lines.

With input A grounded, the circuit oscillates at the frequency of crystal A. With input B grounded, it oscillates at the frequency of crystal B. If input C is grounded, the circuit is inhibited.

The TTL-compatible output of this two-channel clock is a 40% square wave when either input A or input B is grounded. With the low-power TTL NAND-gate package used here, operating frequencies in excess of several megahertz can be achieved. □



Two for the price of one. Dual-frequency crystal-clock oscillator utilizes all four gates in a quad package, whereas conventional single-frequency oscillators make use of only three. This inexpensive circuit can be remotely programed by grounding input A to operate at the frequency of crystal A or by grounding input B to oscillate at crystal B's frequency. Grounding input C inhibits the circuit.

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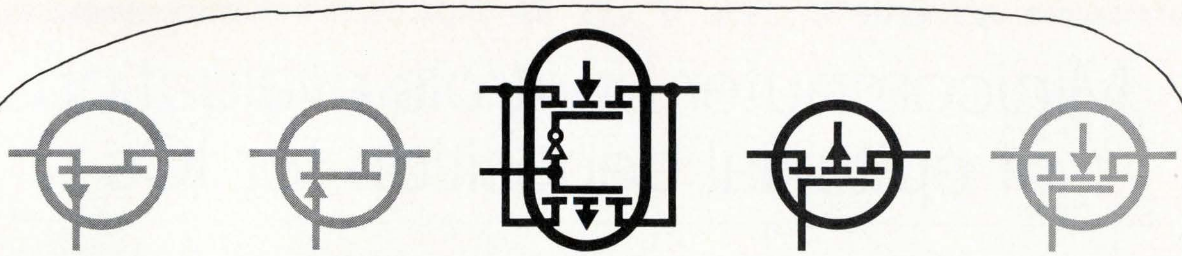

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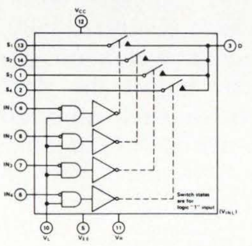

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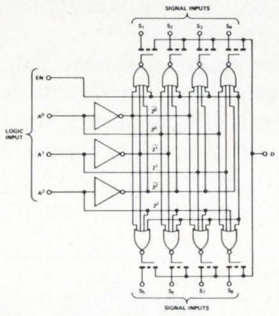

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Part V of a series

Minicomputer controls evaluation of epitaxial deposition for ICs

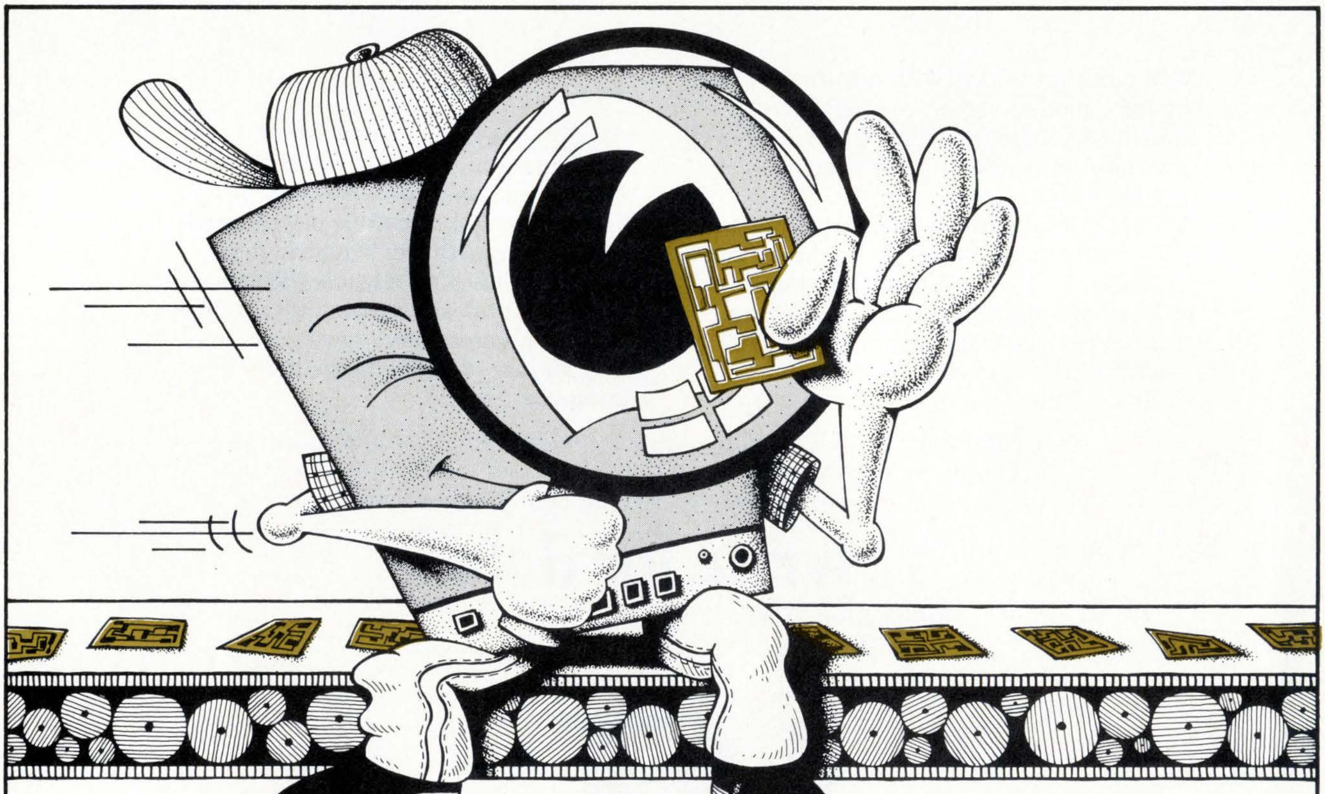
Automated process speeds semiconductor wafer fabrication with less personnel, providing increased accuracy at critical measurement point; the system now accommodates more than half of a plant's production

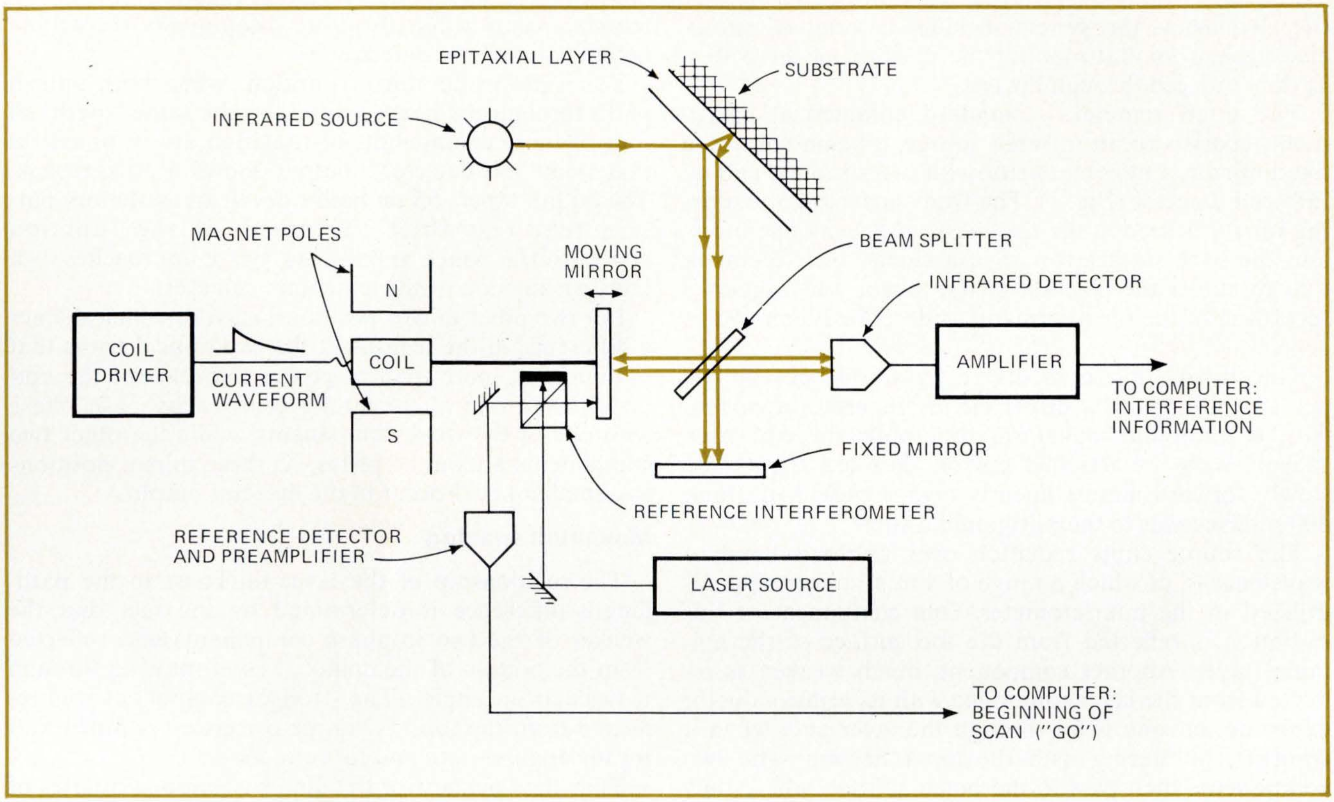
by C. A. Germano, M. R. Ellett, and M. J. Russ, *Motorola Semiconductor Products Division, Phoenix, Ariz.*

☐ A key step in the production of integrated circuits of all sizes is the epitaxial deposition of a layer of semiconductor material on a substrate of crystallographically similar material that differs substantially in the nature or concentration of its controlled impurities. ("Epitaxial" means having the same crystalline orientation.) In this layer, by a series of etchings and further depositions controlled by masks, the individual components of the integrated circuit are created.

Since the quality of the epitaxial layer is fundamental to the quality of the finished IC, its evaluation immediately after the deposition is critical. Some highly sophisticated techniques have been developed for making this evaluation, which involves primarily checking the thickness and the electrical resistivity of the layer. But since the evaluation is usually done manually, this step is a bottleneck in the entire production process because it is slow and tends to be somewhat inaccurate. Motorola found that, in order to maintain the flow of wafers to subsequent steps in production, more people were required for evaluation than for deposition.

To clear this bottleneck, the conventional evaluation equipment was combined with a minicomputer. The automatic system is substantially faster and more accurate than manual evaluation, and results of each evaluation directly adjust the deposition process. As a bonus, the system is self-calibrating, although it is more reliable than manual evaluation and lower in operating cost. Furthermore, the system can handle a variety of wafer sizes, epitaxial-layer specifications, and depo-





1. Interferometer. Two instruments are combined in one, to measure interference caused by the double reflection from the epitaxial layer and to trigger the monitoring computer. Infrared radiation is used in the thickness measurement, while the auxiliary contains a laser.

sition processes. Moreover, output data can be presented in any of several formats.

Although the system cannot yet handle all the wafers that Motorola produces at Phoenix, it can evaluate a significant proportion of those produced during normal operations. Its capacity is about 7,000 wafers a day.

Interferometer measurement

For the thickness measurement, the first of the two steps in the evaluation, infrared interferometry is best. It requires no physical contact with the wafers and can provide reproducible measurements, especially when used in conjunction with laser position monitoring and digital computation. Furthermore, the digital computer, which is indispensable in making the interferometer measurement, can also easily supervise wafer transport, combine thickness and resistivity calculations, and store test specifications.

For the second step, measuring resistivity, the most reliable, production-proven technique uses a colinear array of four equally spaced probes that contact the surface of the test specimen. A constant current passes from one of the outer probes to the other outer probe, and the voltage drop is measured between the two inner probes. The ratio of voltage to current is, of course, the resistance, in ohms. This value can be translated into sheet resistance in ohms per square by a relatively simple formula, and sheet resistance multiplied by thickness gives resistivity.

An alternative method uses a probe with only two points. A constant voltage is applied to the probes, and the current flowing between them, through the specimen, is measured. This measurement, called the "spreading resistance," in some ways resembles the use of a simple volt-ohmmeter.

Both these methods of measuring resistivity have several disadvantages: they require contact with the wafers, with attendant risk of contamination and damage; they must be frequently calibrated; and preventive maintenance requires much attention. However, all other measurement techniques that would not be subject to these disadvantages—for example, microwave conductivity—are of limited accuracy when applied to epitaxial layers. Therefore the four-point probe was chosen, and means were provided for automatic calibration and switching to a redundant probe head if the main head drifts too much or fails.

Jet-propelled wafers

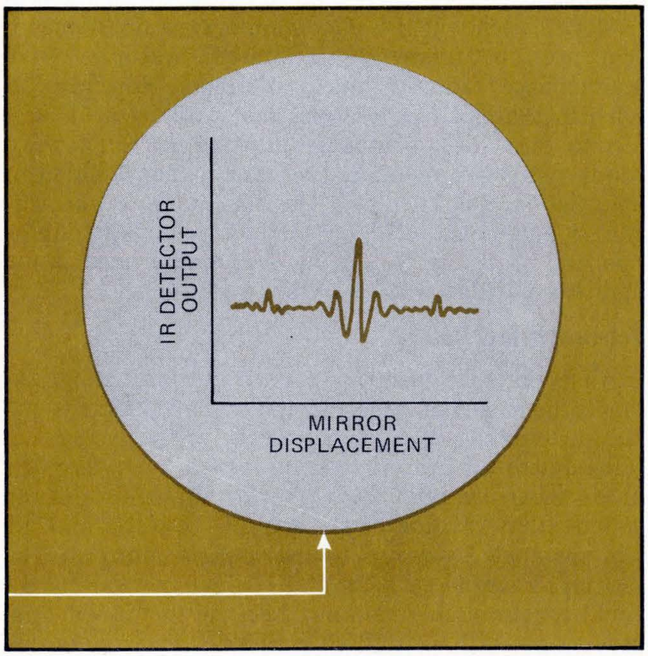
An important subsidiary part of the evaluation system is the means of transporting the semiconductor wafers through the evaluation process. In the system described here, air bearings transport the wafers. Tiny jets of air under the guide track blow air upward to lift the wafers a tiny fraction of an inch off the track, and the jets are angled forward to move them along it. The bearings have no surfaces that contact the wafers and could contaminate them, and, because they involve no moving parts, they are highly reliable. Their main disadvantage is that keeping track of where the wafer is at any point in time is more difficult with air bearings than with, say, a conveyor belt of some kind; to overcome this deficiency, the system includes a series of photoelectric sensors that monitor the position of the wafers as they proceed through the test.

The interferometer, a standard commercial instrument, consists of an infrared source, a beam splitter, a fixed mirror, a moving mirror with two surfaces, and an infrared detector (Fig. 1). The front surface of the moving mirror is used in the thickness-measuring operation, and the back surface is part of a second interferometer that monitors the position of the mirror and triggers a recording of the measurement, as described later in this article.

The moving mirror is driven by a coil between the poles of a magnet; a driver circuit generates a current with a triangular waveform that pulls the coil back sharply with the attached mirror, then lets them slide slowly forward almost linearly over a period of about 400 milliseconds to their original position.

The source emits radiation over a broad band of wavelengths, of which a range of 4 to 40 micrometers is utilized in the interferometer. One component of this radiation is reflected from the top surface of the epitaxial layer. Another component, much weaker, is reflected from the layer's interface with its semiconductor substrate, passing twice through the layer and, when it emerges, interfering with the top reflection. The two components then pass to the beam splitter, where they are further divided into four components, two strong and two weak.

Two of these four components of radiation pass through the beam splitter, to the fixed mirror, back to the beam splitter, and then to the infrared detector. The other two are reflected by the beam splitter to the front side of the moving mirror, then back through the beam splitter to the detector. An additional degree of interference occurs when the four components recombine before entering the detector.



2. Three peaks. Optical properties of the beam splitter and of the epitaxial layer being measured create a complex three-maximum output. Spacing between outer two peaks measures layer thickness.

For a particular mirror position, when both optical paths through the beam splitter are the same length, all four of these components of radiation are in phase; at that point the detector's output shows a strong peak. The output tapers off on both sides in an oscillatory pattern that resembles the graph of the function $y = (\sin x)/x$, which approaches 1 as x approaches 0—a familiar function from elementary calculus.

For two other mirror positions, each of which defines a difference in the lengths of the two optical paths that is somewhat more than twice the thickness of the epitaxial layer, one of the strong components is in phase with one of the weak components, while the other two components are out of phase. At these mirror positions two smaller peaks occur in the detector output.

Maximum spacing

The relationship of the layer thickness to the path-length difference is determined by the fact that the weaker of the two in-phase components was reflected from the bottom of the epitaxial layer, passing through it twice at an angle. (The stronger component was reflected from the top.) A simple correction compensates for the angular path and for refraction.

Thus the thickness of the film is about one quarter of the distance between the two positions of the moving mirror at the moments the two smaller maximums occur at the detector. This distance is measured by a second interferometer, which is illuminated by a laser and uses the back of the moving mirror. The laser light's path encounters no double reflections, as in an epitaxial layer. Hence, the second detector produces only one pulse, where the difference in the distances from the secondary beam splitter to its own fixed mirror and the moving mirror is a multiple of the laser light's wavelength. Normally, the moving mirror makes a series of cycles, producing a series of interferogram scans that are averaged.

Up to this point, operation of the interferometer in the computerized system is identical with that of the one used in manual measurements. When one is used manually, the pulse from the auxiliary interferometer triggers a signal averager; the averager's display shows the main detector's output, which can be measured directly or photographed (Fig. 2).

But in the automatic system, the pulse triggers data-collection operation in the computer, which processes digitized versions of the information from both the main and auxiliary interferometers and computes the average of several scans.

For each type of epitaxial film, a reference signal, generated by inserting a front-surface reflector in place of the wafer, is kept in the computer's memory. The computer subtracts this reference signal, which contains only the strong central peak, from each digitized interferogram pattern, thus emphasizing the peaks of the two side bursts in the interferogram. Otherwise, in very thin layers, these side peaks would sometimes be lost in the clutter surrounding the central peak. From the spacing between these peaks, the computer determines the thickness of the layer then being measured and sends the result to a printer and to a display unit. The whole process, using 15 scans of the moving mirror, takes 6 seconds.

Some kinds of wafers, such as those with buried layers, may tend to absorb more of the infrared radiation than others and therefore require more scans. The number of scans required, along with the appropriate reference signal, is kept in a disk storage unit, identified by the wafer's code number, and brought into the main memory at the start of a series of measurements on a particular wafer type.

The system's precision depends on how well-defined the side bursts are, a condition that establishes how well their separation can be determined. Their definition depends in part on the properties of the materials of the epitaxial layer and the substrate and in part on the components of the interferometer. The latter place an inherent limit of ±0.05 micrometer on the system's precision; this precision is approached by those wafer materials and configurations that produce the strongest infrared reflections.

Resistivity

Because further processing often depends on the resistivity of the epitaxial layer on the semiconductor wafer, resistivity is a fundamental parameter. As mentioned previously, the standard method for measuring resistivity uses a four-point probe.

This measurement can be affected by a host of variables, including the material of the probes, the radius of their tips, their spacing, the pressure with which they are applied to the sample, the temperature of the sample, its mechanical stability (how easily it bends or cracks), and the current applied. Because of these variables, measurements by different people in different places are likely to vary somewhat, particularly when the measurements are made manually.

Ordinary manual production measurements may be precise only within ±5%, whereas a procedure defined by the American Society for Testing Materials reduces this tolerance to ±2% for measurements in different laboratories. On the other hand, a semiautomated measurement can be accurate within ±1%. Thus, the advantages of automation are clear.

The automated system does not depend on the operator's placement of the sample being measured, and it can control the environment closely. It can readily optimize the sample current on the basis of a quick survey reading, followed by a second measurement for a precise determination. The system can measure the resistivity in several different sample positions and compute a statistical average while the next sample is being evaluated for thickness in the interferometer.

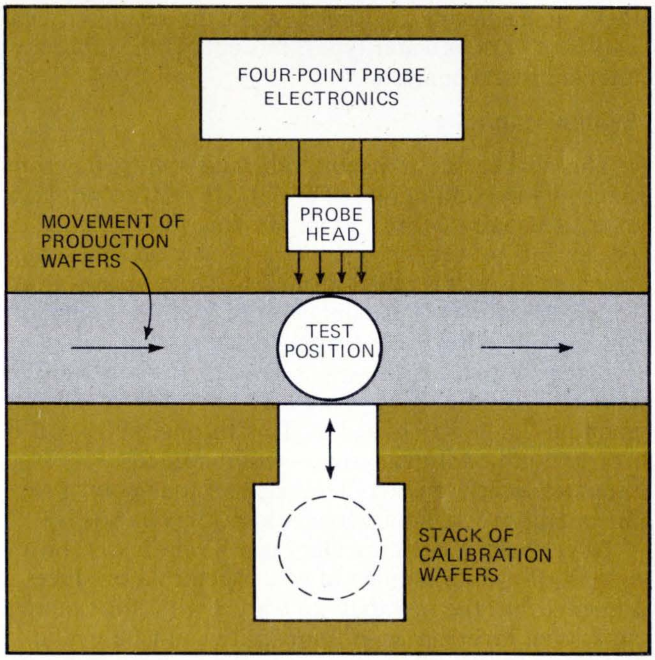
One of the most important advantages of the automated system is that it can calibrate its own resistivity measurements under computer control, instead of at arbitrary intervals, as is the case with manual measurements. At intervals that can be determined by the computer program—either at fixed time intervals or whenever the computer detects a trend in the measurements that may not reflect the true state of the wafers—the system can stop work on the production wafers and substitute a wafer drawn from a calibration stack (Fig. 3). If the measurement is within the proper limits, the calibration wafer is returned to its place and the work of evaluation resumed. If the measurement does not meet the proper specifications, the whole stack of calibration wafers may be measured to determine a new calibration function, and production evaluation is resumed. Or, if the calibration is too far "out of spec," a redundant probe head can be brought into position, and the need for repair or readjustment of the original head is signaled to the system operator.

Computer control

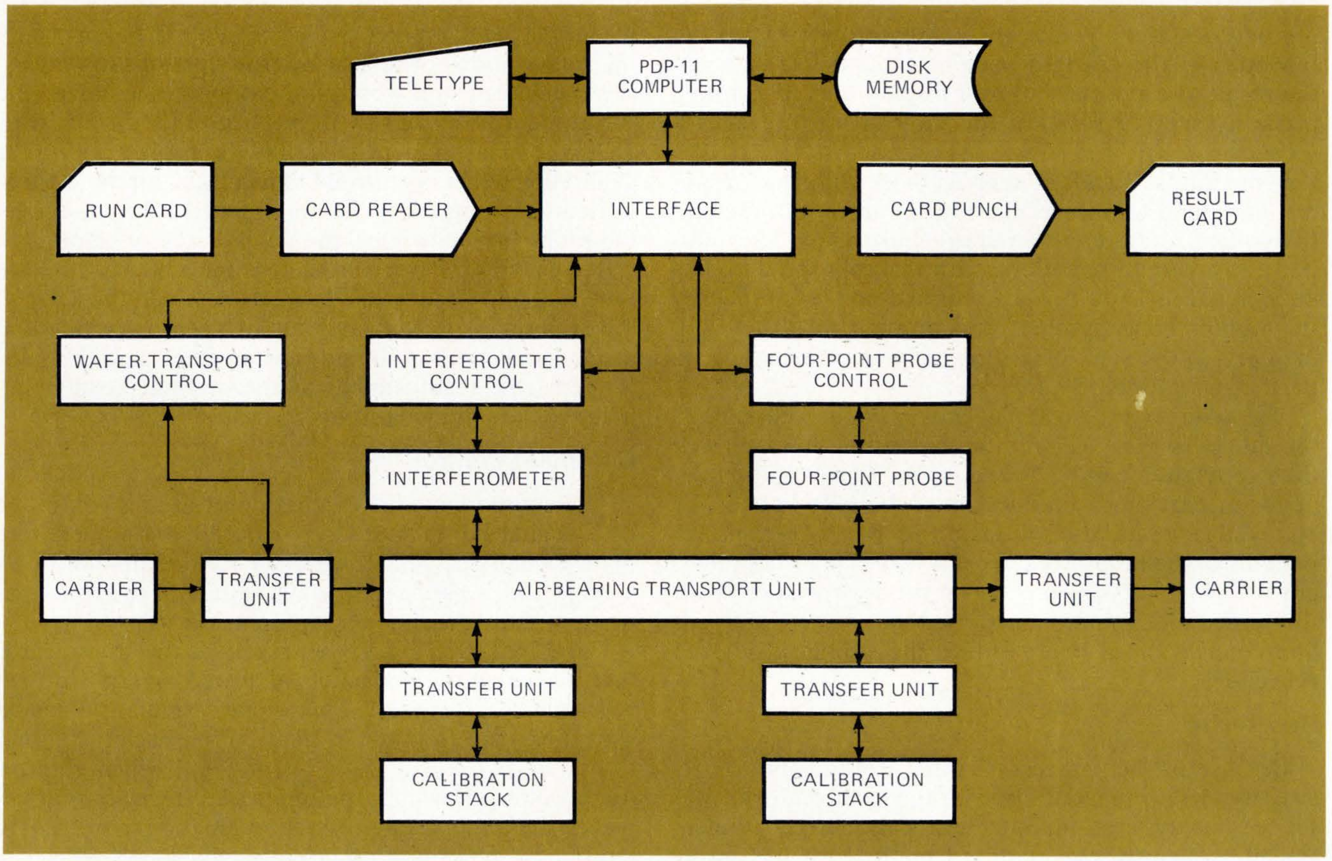
The entire automatic evaluation process is controlled by a Digital Equipment Corp. PDP-11 computer with a main memory of 12,288 words, a 1.2-million-word disk storage unit, a card-read/punch unit, and the usual paper-tape and teleprinter equipment (Fig. 4).

Data from each evaluation run is punched into cards that accompany each batch of tested wafers through subsequent processing operations. Similar punched cards feed data from the evaluation run back to another computer, a Control Data Corp. 1700, which controls the reactor in which the epitaxial deposition takes place; thus, the results of the evaluation are used to modify the deposition process directly. This feedback is planned eventually to take place through a direct interface between the PDP-11 and the 1700, so that the process is controlled on line.

As mentioned previously, the disk storage unit stores procedures and specifications for evaluating several hundred different types of wafers, corresponding to dif-



3. Calibration. Computer stops work on production wafers when conditions demand it, turning instead to a stack of calibration wafers with which it readjusts the automatic system.



4. Computer system. A PDP-11 controls the evaluation, punching results into cards that control subsequent processing, and, if required, modify the deposition process in the following wafer run. Eventually an on-line feedback path to the reactor will be added.

ferent crystal structures, different deposition techniques, and so on. It also stores a Fortran compiler, which is used when the system is reprogramed for new or improved evaluation procedures. And, in addition to these, it has room to store data on the results of evaluation of various wafer types; this data is the input for a later statistical analysis.

System capacity

The air-bearing transport can send wafers down the track at a maximum rate of about one per second. However, it usually doesn't maintain this rate because the evaluation procedure is limited by the thickness measurement, which requires from 6 to 13 seconds for each wafer. Resistivity is usually finished in a few tenths of a second, including the averaging process.

Under these conditions, assuming the system runs about 80% of the time during a 24-hour day, its capacity is about 7,000 wafers a day. This throughput could be nearly doubled if the system were modified to incorporate two interferometers feeding one four-point probe; this modification, however, would be very expensive.

Nevertheless, not all wafers can be measured on the system. It evaluates most of what Motorola produces in Phoenix; but the resistivity of wafers with, for example, an n-type layer on an n^+ substrate can't be evaluated directly with the four-point probe because the resistivity of the layer can't be distinguished from that of the substrate.

Furthermore, if the layer and the substrate have nearly the same refractive index, practically no radiation is reflected from their interface. Reflection occurs primarily when the refractive indexes are different. In most cases, the reflection is substantial; but even so, the layer itself absorbs a great deal of the radiation, so that the signal emerging from the layer may be 50 to 100 times smaller than the radiation reflected directly from the front surface of the wafer.

Where n-on-n wafers must be evaluated, a special n-on-p check wafer can be included with each batch of production wafers. These check wafers are evaluated and the results assumed to apply to the entire batch. Although using these check wafers reduces the output of the reactor by about 10%, it tightens the specifications and increases the yield by more than enough to compensate for their use.

At the present time, the system can evaluate about 60% of the wafer types produced during normal operations. This fraction is expected to increase when alternative measurement techniques are added to the system. These techniques will include a radial resistivity profile, obtained by making more detailed probe measurements; checking for spreading resistance and photoluminescence; optimizing the evaluation procedure more so than at present for different categories of wafers; classifying and sorting the wafers before evaluation; and statistically analyzing the results of successive runs to determine long-term yields. □

Curve-fitting program matches measured data

by Glen Miranker

Yale University, New Haven, Conn.

A Fortran computer program called FIT can do your curve fitting for you. The program, which utilizes a least-squares method of approximation, takes a set of n data points and fits a polynomial (up to degree n − 1) to these points.

FIT determines the coefficients of the polynomial by solving a system of normal equations, which are derived by considering some quantity, y, as a polynomial function of another quantity, x. Then, for the ith data point:

$$\Delta + y_i = a_0x_i^0 + a_1x_i^1 + a_2x_i^2 + ... + a_nx_i^n$$

where Δ is the difference between the "correct" data value and the observed or measured data value. If the coefficients provide a good fit, Δ can be neglected. Summing over the data points yields:

$$\Sigma(a_0x_i^0 + a_1x_i^1 + a_2x_i^2 + ... + a_nx_i^n \nu y_i)^2 = \Delta^2$$

which is the form of a least-squares fitted curve. FIT computes the coefficients to minimize Δ.

To find the best-fitting curve for a given set of data, all FIT needs to know is the values of the observed data points and the desired degree of the polynomial approximation. The first part of the program (statement numbers greater than 999) accepts the data, stores it, and organizes it for use in the rest of the program.

At this point in FIT's program list, a subroutine (like the one called FUNCTION at the end of FIT's program list) can be used to redefine the x variable so that approximations can be made to curves that are not strictly polynomials in x. For example, if $y = \sin^2(x)$, a polynomial fit can be made by letting $F = \sin(x)$ since y is a polynomial in sin(x).

The second part of the program, statement numbers from 99 to 999, set up the normal equations. Statements 20 through 90 then solve this normal equation system, avoiding cumulative errors through judicious use of single- and double-precision variables. In the final part of the program (statement numbers less than 20), the residuals (differences between the fitted and the measured

Getting a good fit. Fortran instruction list for curve-fitting program named FIT generates a polynomial, of up to degree n − 1, to fit a set of n measured data points. By writing a subroutine, like the one called FUNCTION at the bottom of this list, approximations can be made to curves that are not strictly polynomials. The program makes use of a least-squares approximation method to do the curve fitting.

```
*  THIS IS THE FIRST LINE OF FIT
        DOUBLE PRECISION D(51,52)
        REAL X(100),Y(100),W(0/100),Z(0/100),A(51),B(51,52),C(51,52)
        TYPE 1001
1001    FORMAT(' ARE YOU USING STORED DATA?  ',$)
        ACCEPT 1002,COMMEN
1002    FORMAT(A1)
        IF(COMMEN.EQ.'Y')GO TO 6000
        TYPE 1000
1000    FORMAT(' PLEASE ENTER THE NUMBER OF SAMPLES - MAXIMUM 100',/)
        ACCEPT 2000,NP
        WRITE(10,2000)NP
2000    FORMAT(I2)
        TYPE 3000
3000    FORMAT(' ENTER THE DATA TABBING ONCE AFTER ENTERING',
     *  ' THE X DATA')

        TYPE 4000
4000    FORMAT(' TYPE IN THE DATA POINTS.',/,/,' SAMPLE NUMBER
     *    XDATA          YDATA',/)
          DO 5001 I=1,NP
        TYPE 4500,I
4500    FORMAT(1H+,T7,1I2,T21,$)
        ACCEPT 5000,X(I),Y(I)
5000    FORMAT(2G)
        WRITE (10,5000)X(I),Y(I)
5001    CONTINUE
        END FILE 10
        REWIND 10
6000    READ (10,2000)NP
          DO 100 I=1,NP
        READ (10,5000)X(I),Y(I)
        X(I)=F(X(I))
100     CONTINUE
        TYPE 200
200     FORMAT(' ENTER THE ORDER OF THE DESIRED POLYNOMIAL',/,
     *  ' (MAXIMUM = THE NUMBER OF POINTS-1)',/)
        ACCEPT 300,M
300     FORMAT(I2)
        W(0)=NP
          DO 401 I=1,NP
          DO 400 J=1,2*M
        W(J)=W(J)+X(I)**J
        Z(J)=Z(J)+Y(I)*X(I)**J
400     CONTINUE
        Z(0)=Z(0)+Y(I)
401     CONTINUE
          DO 500 I=1,M+1
          DO 500 J=1,M+1
        B(I,J)=W(J-2+I)
        B(I,M+2)=Z(I-1)
500     CONTINUE
*
*       THE FOLLOWING SERIES OF NESTED DO LOOPS DO THE FOLLOWING:
*       THE FIRST STEPS THE DO SYSTEM SOLVING FOR EACH COEFFICIENT
*       SUCCESIVELY.
*       THE SECOND CLOCKS THE DO LOOP SYSTEM DECREASING THE MATRIX
*       SIZE BY ONE ROW AND ONE COLUMN EACH ITERATION.
*       THE THIRD AND THE FOURTH TAKE THE ITH ROW AND DIVIDE IT BY
*       ITS NTH COEFFICIENT. THEN MULTIPLIES THE ITH ROW BY THE NTH
*       COEFFICIENT OF THE (I+1)TH ROW. FINALLY IT SUBTRACTS THE
*       I+1TH ROW FROM THE ITH.
*       THE LAST TWO DO LOOPS RESTRUCTURE MATRIX D SO THAT IT
*       CONTAINS THE C MATRIX MINUS THE NTH COLUMN AND THE LAST ROW.
*
         DO 50 N=1,M+1
         DO 20 I1=1,M+1
         DO 20 J1=1,M+2
20      D(I1,J1)=B(I1,J1)
         DO 40 K=1,M
        IF(N-K)25,25,23
23      L=1
        GO TO 27
25      L=2
27       DO 30 I=1,M+1-K
         DO 30 J=1,M+3-K
        C(I,J)=(D(I,J)/D(I,L))*D(I+1,L)-D(I+1,J)
30      CONTINUE
         DO 40 I=1,M+1-K
         DO 40 J=1,M+2-K
        IF(J.GE.L)GOTO 35
        D(I,J)=C(I,J)
        GO TO 40
35      D(I,J)=C(I,J+1)
40      CONTINUE
        A(N)=D(1,2)/D(1,1)
50      CONTINUE
         DO 90 I=1,M+1
        TYPE 70,I,A(I)
70      FORMAT(' COEFFICIENT NUMBER',I3,'= ',1PE15.5)
        WRITE (11,70)I,A(I)
90      CONTINUE
        TYPE 10
10      FORMAT(' DO YOU WANT A LIST OF RESIDUALS?',$)
        ACCEPT 1002,ANS
        IF(ANS.NE.'Y')GO TO 1
        DO 5 K=1,NP
        THEORY=0.
        DO 7 I=1,M+1
7       THEORY=A(I)*X(K)**(I-1)+THEORY
        RESID=Y(K)-THEORY
        TYPE 3,K,RESID
5       WRITE(12,3)K,RESID
3       FORMAT(' DATA POINT',I3,'  ',1PE15.5)
1       STOP
        END
*****************************************************************************
******   THIS FUNCTION ALLOWS APPROXIMATIONS TO BE MADE TO  CURVES THAT  *****
******    ARE NOT STRICTLY POLYNOMIALS BY REDEFINING THE "X" VARIABLE.   *****
*****************************************************************************
        FUNCTION F(X)
        F=1./X**2
        RETURN
        END
```

curves) are calculated, providing some indication of how good the fit is and allowing convenient comparison of fits of different degree for a given data set.

The sample program list shown for FIT, with the FUNCTION subroutine, could be used to check the pass characteristics of a nonlinear amplifier, which should have a pass characteristic of $1/x^2$. The size of the residuals computed by FIT could indicate how much of the amplifier's distortion can be analyzed as a second-order effect. □

Power hybrid circuit controls tape-recorder speed

by W.D. Harrington
University of Florida, Gainsville, Fla.

A hybrid power amplifier, the HC1000 from RCA, makes it possible to build, for only about $50, a speed control for line-operated tape recorders with ratings of up to 35 watts. The circuit is essentially a power converter, consisting of the hybrid amplifier and a power transformer. The amplifier is a multi-purpose plastic-packaged device that provides a 7-ampere peak output current at up to 100 W root-mean-square.

Most line-operated tape recorders employ synchronous drive motors, permitting the tape speed to be controlled by a change in the effective line frequency. Since the power converter's frequency is determined by the function generator, the line frequency effectively applied to the recorder can be varied by changing the frequency of the function generator.

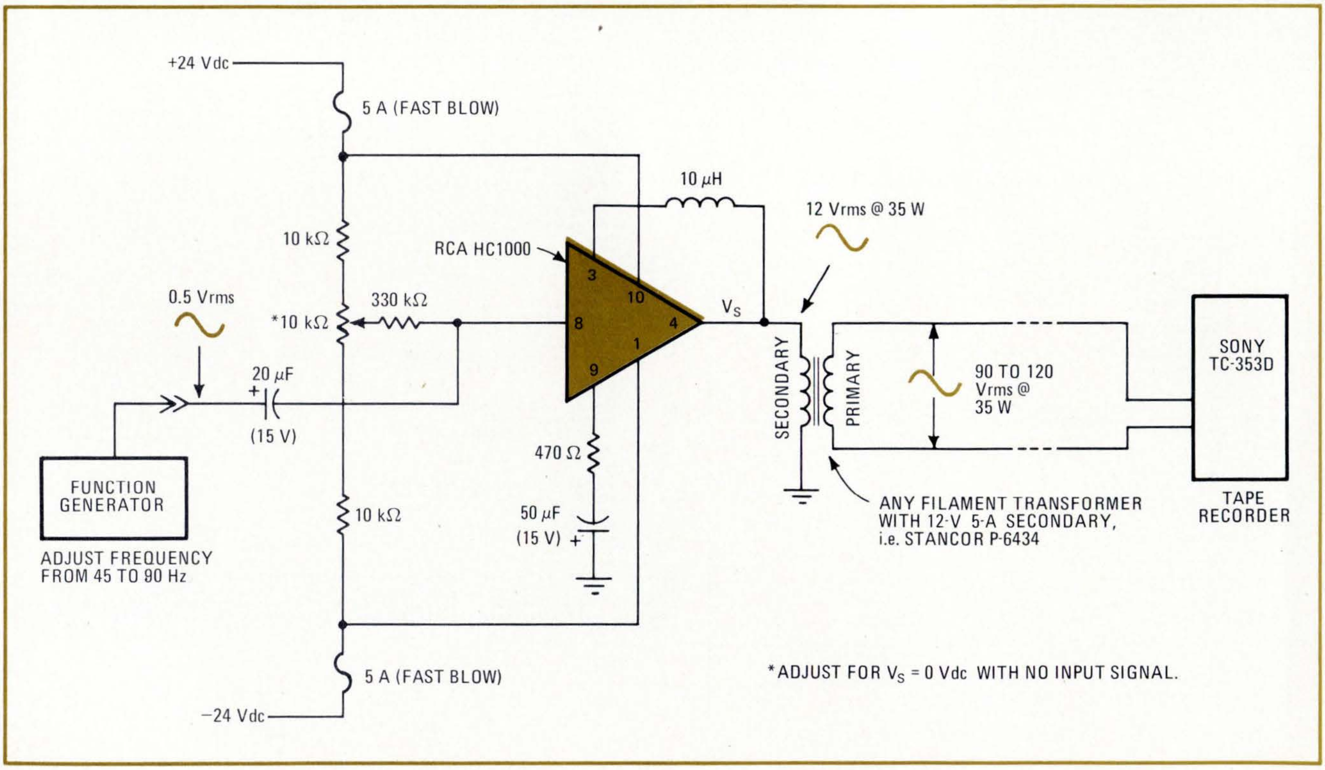
The transformer may be any filament- or power-type unit having a 12-volt secondary rated for at least 5 A. (The secondary windings of several transformers can be paralleled to obtain this current rating.) The transformer is connected in reverse—that is, its secondary faces the amplifier and must be driven at close to 4 A peak at 12 V to deliver 35 W at 120 V to the primary.

The bias network for the hybrid amplifier cancels its dc offset voltage, which is typically 200 to 300 millivolts. This prevents the offset voltage from working into the fractional dc resistance of the secondary transformer winding and causing unneccessary power dissipation in the amplifier's internal output transistors.

When output power is at maximum—35 W at 120 V—and the effective line frequency is less than 60 hertz, some transformers become inductive and may activate the current protection circuitry of the HC1000 amplifier. This situation can be avoided by lowering the input level of the function generator's so that the circuit operates at an effective line voltage of less than 120 V. Voltages as low as 95 V may be used.

The dual ±24-V dc supply voltage can be provided by an array of motorcycle batteries, making the power converter attractive for field use. □

Tape control. This power converter varies tape speed by changing the frequency applied to a recorder's synchronous motor. The circuit's input function generator determines motor driving frequency and voltage. The heart of the converter is a hybrid amplifier that develops a 35-watt output at 5 amperes. The transformer secondary faces the amplifier so that the motor receives the correct drive voltage.

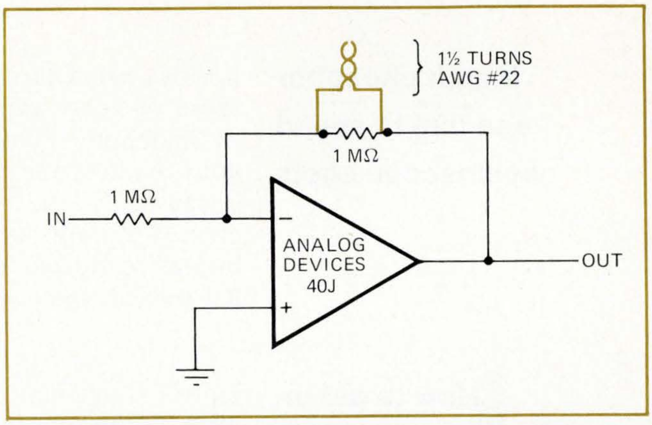


Capacitance of twisted wire trims fast FET op amps

by Victor D. Roberts
General Electric Co., Large Lamp Dept., Cleveland, Ohio

High-speed FET-input operational amplifiers that have a large feedback resistor sometimes need a low-capacitance trimmer that can be adjusted to prevent oscillation without appreciably decreasing the op amp's frequency response. Try twisting together two short pieces of insulated wire to make a cheap and readily available trimmer capacitor. It's a technique that has been used for quite some time by builders of amateur radio equipment for neutralizing rf amplifiers.

Here is a typical application for this handy trimmer capacitor. A FET-input op amp is connected as a simple unity-gain inverter with a 1-megohm input impedance, as noted in the figure. Without a feedback capacitor, the circuit produces damped 200-kilohertz oscillations when driven by a fast-rise-time square wave. Employing 1½ turns of AWG #22 vinyl-insulated wire (0.4-millimeter wall) eliminates these oscillations without degrading the circuit's rise time. The twisted wire provides a capacitance of approximately 2 picofarads. □



Twisting away oscillations. Short insulated wires make handy trimmer capacitor when twisted together. One or two turns can provide enough capacitance to stop fast FET op amps from oscillating.

Oscillator converts counter to capacitance meter

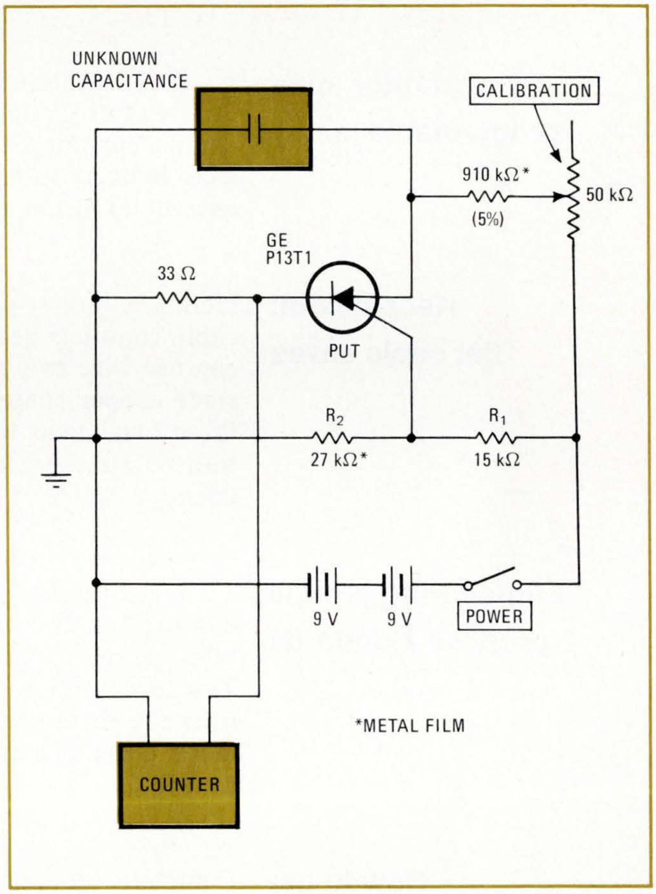
by M.J. Salvati
Sony Corp. of America, Long Island City, N.Y.

A relaxation oscillator will convert any counter that measures time periods into a direct-reading capacitance meter. The battery-operated circuit can be assembled in a small minibox and plugged directly into the counter. For the capacitance measurement, seconds indicate microfarads, milliseconds indicate nanofarads, and microseconds indicate picofarads.

The conversion circuit uses a programable unijunction transistor (PUT) in a standard relaxation oscillator that is simpler, more stable, and more accurate than previous capacitance-measuring schemes. Since the two biasing resistors, R_1 and R_2, determine the PUT's firing characteristics, the oscillator period is substantially independent of PUT device characteristics.

The oscillator period—and, therefore, the indicated capacitance—changes only +0.5% when the supply voltage is reduced from 18 to 14 volts. By using high-stability resistors and a precision (±0.1%) capacitance standard for initial calibration, an accuracy of better than 1% can be achieved over the capacitance range of 5,000 pF to more than 10 μF. Below 5,000 pF, a constant error of about +40 pF degrades the accuracy of an absolute-value measurement, but the relaxation-oscillator circuit can still be used to match capacitors having values as low as 100 pF.

Because battery drain for the circuit is only 0.5 milliampere, the two standard 9-V radio batteries that are used to power the circuit will last a long time. □



Capacitance meter. Period-measuring counter determines value of unknown capacitance. The test capacitor sets the timing of PUT relaxation oscillator. Microfarads are displayed as seconds.

Engineer's notebook is a regular feature in Electronics. We invite readers to submit original design shortcuts, calculation aids, measurement and test techniques, and other ideas for saving engineering time or cost. We'll pay $50 for each item published.

Engineer's newsletter

Match phosphor and film to speed oscilloscope shots

Besides using large shutter openings and fast film for recording very rapid one-shot events, you can increase oscilloscope recording speeds by matching the sensitivity of the film with the peak color output of your oscilloscope phosphor. For example, the popular P-11 phosphor, because it is the best match for Polaroid type 107 and 410 films, increases writing rate by 50% faster than CRTs with P-31 phosphors. **And by leaving the camera shutter open for at least 5 seconds after the sweep has passed, you can take advantage of the phosphor's afterglow.**

How to get on the microcomputer bandwagon

Here's your chance to profit from the microcomputer explosion. Software Technique Inc., 8811 Colesville Rd., Silver Spring, Md., will **conduct in your office hands-on workshops devoted to the capabilities and programing techniques of all available microcomputers.** Included is a selection seminar in which all the known microcomputers are discussed, documented, and compared. Prices for the service start at $1,000.

Comparator joins programable family

Joining the operational amplifier and voltage regulator in the growing family of programable ICs is the comparator—the device widely used to control current loads in industrial systems. **In one new programable device, built by RCA, a separate terminal permits programing the output current up to 150 mA by means of a bias current.**

Keep it cool: flat cable saves

Here's a money-saving production tip: Use flat cable. Because flat cable conducts heat better than wire bundles, it keeps cooler, and you can use wire two or three sizes smaller than other methods allow. **And since copper content determines wire costs, you can often save two or three times your normal cabling costs** in complex data-processing and transmission systems. Caution: Smaller gauges mean higher voltage drops.

Engineering groups propose standards

To deal with the growing problems of professional engineers, 13 major engineering and scientific societies have drawn up a document called "Guidelines to Professional Employment of Engineers and Scientists." The guidelines, which can be obtained from the IEEE in New York, defines the **recommended employment practices in such areas as recruitment, terms of employment, professional development, termination, and transfer.**

How to get the right time

Complete, up-to-date information on the many services provided by National Bureau of Standard's radio stations WWV, WWVH, and WWVB is available from True Time Instrument Company, 2255 Melbrook Way, Santa Rosa, Calif. 95405. Request Bulletin #373-1. The NBS transmissions provide engineers throughout the world with **extremely precise audio and radio frequency standards, as well as accurate time signals and radio-frequency propagation forecasts.**

BROWN PROPOSES CANNON® ZERO FORCE RECTANGULAR CONNECTORS. POINTS OUT LOWEST WEAR, LOWEST COST.

VP NEW PRODUCTS STARTLED.

)ISC MEMORIES CAN'T FLY; ;O WHY DO WE NEED CANNON?" ıe retorts.

Brown took off: "Don't knock Cannon's ıerospace background. That's how they :ame up with their DL rack and panel con- ıector with a 10,000-cycle life, instead of he 500 or less we've had to live with."

The VP blinked at the order of magni- ude difference. But Brown had the ımmunition: "It's simple. There's no wear ›ecause the contacts don't touch during nsertion. A quarter turn of the actuator cams them together and cleans the surfaces at the same time. No jackscrews, no problems."

As usual, someone brought up cost. Brown levelled him: "Cannon's zero-force DL's cost less than any other rectangular connector. And they've got an automatic strip-and-crimp machine, too.

We just cut the wires to length; it strips the end and crimps on a contact. Takes jacketed cable, and you know how much trouble we're having with that... come to think of it, since our present sources can't hack it, maybe it's time now to look at Cannon."

Now maybe your forte isn't startling VP's, like Brown, but maybe if you shook them up just a tiny bit, it might help them. And you.

Write for our free catalog today. ITT Cannon Electric, International Telephone and Telegraph Corporation, 666 E. Dyer Road, Santa Ana, CA 92702. Phone (714) 557-4700.

uropean facilities in: Brussels, Belgium; Basingstoke, Hants, England; Toulouse, France; 7056 Beutelsbach/i.R., Germany; Milano, Italy.

CANNON ITT

ICs blow the whistle on faults

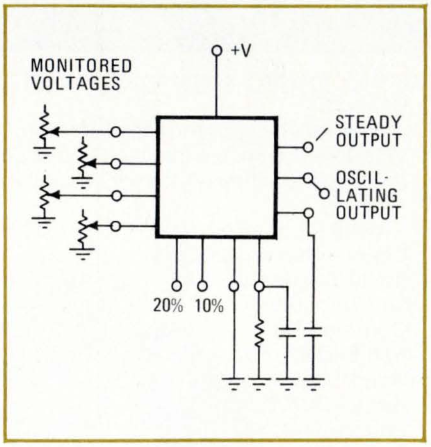
Monitoring circuits for instruments and other equipment sound alarm for calibration errors, power failures, overheating, signal-level changes

by George Sideris, San Francisco bureau manager

A quad monitoring circuit that blows the whistle when an instrument needs calibration is one of five unusual supervisory control circuits from Intech Corp. The Intech 3040 calibration monitor also detects excessive ripple on supply lines and generates a precision voltage reference.

Others in the Intech 3000 series of monolithic circuits look for power supply failures, equipment overheating, missing pulses and other equipment operating problems, or for changes in signal levels. When something happens in the system, they flash lamps, sound alarms, or switch shutdown logic.

Hans Camenzind, whose company developed the circuits for distribution by Intech, expects the 3040 to change the way component testers and other industrial instruments are "kept honest." Camenzind, who originated the monolithic phase-locked loop and several other integrated circuits as a designer at Signetics Corp., is president of Interdesign Inc., of Sunnyvale, Calif.



Calibration monitor. If voltage changes by selected percentage, alarm is actuated.

Traditionally, he points out, testers are periodically shut down for calibration, a procedure that does not ensure accuracy between calibrations. Besides, he says, the cost of routine calibrations often adds up to more than the original cost of the instrument. "With our calibration monitor," he says, "the instrument can stay on line until an indicator tells the operator that measurements can no longer be made within normal production tolerances."

Drift. The 3040 monitors four inputs for drift or ripple. With standardized pin connections, the user can set input tolerance ranges of 5%, 10%, or 20%. Alternatively, different tolerances can be set for each input line by connecting the inputs through potentiometers.

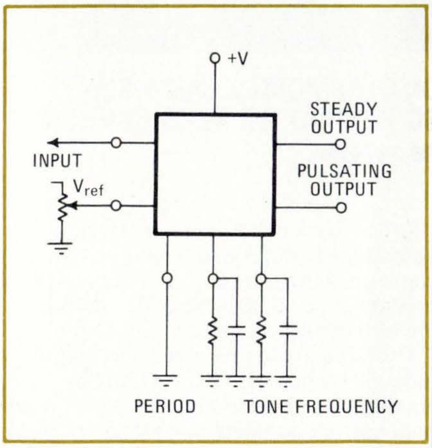
The circuit compares the inputs against a reference voltage generated on the chip, actuating two alarm outputs if any input changes more than the set tolerance. One output will switch from a high-impedance state to a low state suitable for driving a lamp, a light-emitting diode or a TTL input. The other oscillates between high and low, to flash a lamp or produce a pulsating tone in a loudspeaker. The steady output ranges from 10 milliamperes at a voltage drop of 0.3 volt to 100 mA at a 1-V drop. The oscillating output delivers 100 mA at 1-V drop. Both have a leakage of 0.1 microampere at 15 V.

External resistors and capacitors may be used to control the oscillator. The oscillator has a frequency range of 0.1 Hz to 10 kHz and a duty cycle range of 30 to 70%. A third output pin makes the reference voltage available for other uses. It is 2.4 ±0.1 V at 25°C, with a stability of 50 parts per million/°C.

Another device, the 3010 tone alarm, also has steady and pulsating outputs, but compares two inputs, such as a signal and a reference voltage. For supply voltages from 5 to 15 V, the reference voltage range is 1 to 14 V. If the signal input goes higher or lower than the reference, the alarm outputs are actuated. Input switch-point uncertainty is a maximum of 20 millivolts and typically 5 mV.

The 3010's output specs are similar to 3040's. However, the steady output's current at a 1-V drop is 50 mA, and the oscillating output has a minimum frequency of 50 Hz. Also, the circuit's hysteresis is externally adjustable. Camenzind recommends this circuit for checking digital voltmeter reference levels and transducer output limits.

The three independent outputs of the 3020 triple flasher can produce either a steady output to drive a warning lamp or LED, or a pulsating



Signal watcher. If input deviates from reference, IC generates a tone or a light.

output to make the light flash when operating conditions become intolerable. Two of its uses are monitoring supply lines and logic loops.

Each flasher has two inputs. The output is steady if the first input goes to the TTL low level and pulsating if the second input goes low or if both inputs go low. Several packages will operate in parallel with common oscillator timing components. Pulse duty cycle and period ranges are 5 to 90% and 0.1 to 10 seconds.

The 3030 temperature alarm trips when its temperature rises beyond a limit preset with resistors. Designed primarily to detect cooling-fan failures, it operates to 100°C and is accurate within ±5°C.

Several 3030s may be paralleled in a supply-shutdown, loudspeaker or flasher control circuit. The steady output is compatible with open-collector TTL logic and the pulsating output sinks only 0.5 mA. Oscillation range is 0.1-millisecond to 10-second periods and 30% to 70% duty cycle.

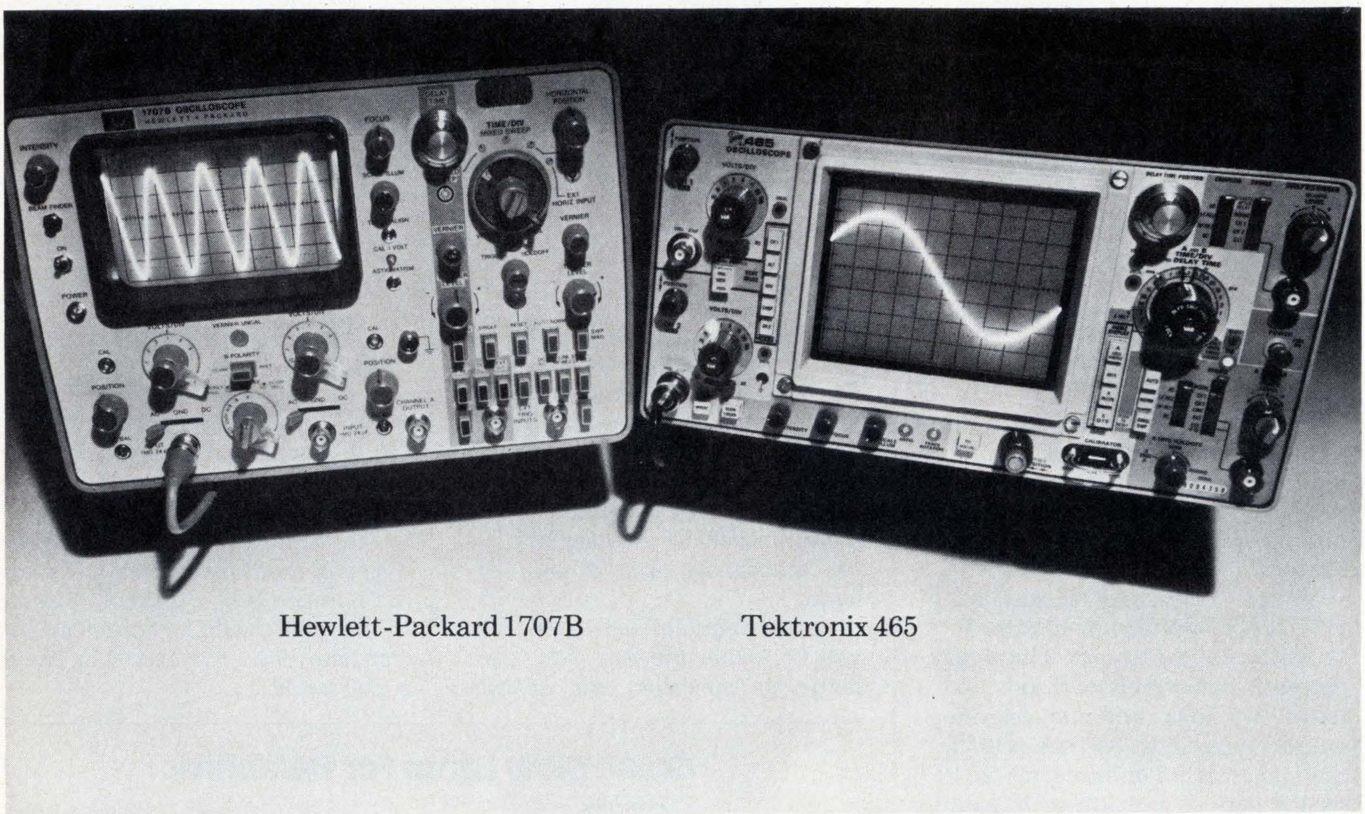
Timer. Besides detecting sinusoidal signals or pulse trains, the 3050 can monitor high-voltage lines (common-mode range is several kilovolts), detect missing pulses or amplifier oscillations, and act as a timing element or latch.

There are three inputs, one an optional high-impedance input (100 kilohms) and two that are normally coupled through capacitors to the signal lines. One of the two outputs normally sources current while the other sinks. If the input waveform peaks exceed a set level, the outputs reverse state. The circuit can also be set to trip if the input falls.

All five circuits operate on single supplies from 5 to 15 volts, with quiescent current drains around 1 milliampere. Operating temperatures are -25 to +85°C, except for the temperature alarm. The packages are 16-pin ceramic DIPs. Prices in 100-up quantities are: 3010, $4.90; 3020, $6; 3030, $5.30; 3040, $6.35; and 3050, $5. Single-unit prices are, respectively, $8.70, $10.80, $9.50, $11.20, and $8.95.

Intech Inc., 1220 Coleman Ave., Santa Clara, Calif. 95050 [338]

Here are two of the world's best oscilloscopes.



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Rental Electronics, Inc.

A PEPSICO leasing company.

Components

Breadboarding made easier

Terminal blocks in variety of sizes provide solderless contact with ICs, discretes

Simplifying the often tedious chore of breadboarding circuits, a block of terminals makes easy contact with ICs, transistors, or passive components: the components' leads are just pushed into holes in the blocks.

Developed by Vector Electronics, Klip-Bloks are multiple versions of the company's earlier Klip-Strips. The new blocks provide four connected contacts across in lengths of eight or 24 sets. All contacts are on standard 100-mil centers used for ICs. Two eight-contact units, for example, can be spaced 300 mils apart and parallel to receive a 14- or 16-pin IC, plus up to three additional connections per pin. Two of the larger 24-by-4 units can be used for three 16-pin ICs or a large IC of up to 48 pins, sufficient for dual in-line packages.

Floyd Hill, vice president of marketing at Vector, says that the company first introduced the basic contacts as strips of four and longer buses of 32 and 48, but many users wanted larger blocks of contacts to eliminate the need for handling individual strips.

The blocks are inserted into a Vector-perforated circuit board in the desired configuration (integral pins hold them in place), then components and wires are pushed into the holes. Low insertion pressure is required, and the contacts are virtually damage-free, yet contact resistance is less than 0.001 milliohm per wire. The contacts take leads of any shape, 12 to 35 mils in diameter or to 50 mils with adapter clips. The nylon shell provides a stop to avoid damage, and oversize leads cannot fit through the holes in the shell.

The leads can be inserted from the top or bottom, making a neat assembly with wires on the bottom and ICs and other components on the top. The assembly can be mounted on a plug-in board. The Klip-Bloks can be combined with the long Klip-Strips, which make buses for ground or power connections. The parts are reusable.

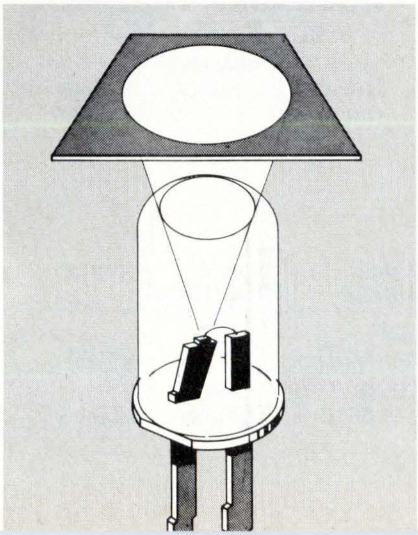
The blocks can also be used vertically, and for this application, they are available without mounting pins. The contacts are beryllium copper with fused tin-lead coating, and insulation resistance between the strips is 1,000 megohms minimum, with a safe voltage rating of 300 volts. The contacts are rated at 5 amperes, and strip-to-strip capacitance is approximately 1.7 picofarads. The blocks are 0.47 inch wide, 0.30 in. high, and either 2.45 or 0.85 in. long. Other sizes are available from the company as custom products.

The blocks cost about 2 cents per point or 8 cents per quad.

Vector Electronics Co., 12460 Gladstone Ave., Sylmar, Calif. 91342 [341]

At 10 mA, LED lamp emits 9 millicandela

As top of the line of a series of gallium-phosphide units, a red light-emitting diode is said to be three times brighter than gallium-arsenide-phosphide backlights now available. The XC554-9 indicator lamp emits 9 millicandela at 10 milliamperes. The developer, Xciton Corp., says this is a minimum luminous intensity and that it compares with 3–4 mcd for GaAsP lamps in similar applications.



Other backlit LEDs in the XC554 series are units with ratings of 6 and 3 mcd. All provide a concentrated 24° viewing angle that illuminates a ¼-inch diameter circle (see below, left). Each is packaged in a two-pin red-epoxy lens housing and is a direct replacement for GaAsP backlit illuminators. The XC554-9 can also replace incandescent and neon lamps in lighted push buttons and behind indicators with colored glass and plastic lenses.

The new lights offer direct-drive compatibility with single-gate TTL and MOS logic. They may be mounted on printed-circuit boards or on front panels with snap-in clips. For 1 to 99 units, price of the XC554-9 is $1.75 each.

Xciton Corp., 5 Hemlock St., Latham, N.Y. 12110 [342]

Liquid-crystal display offers four digits, 1-inch height

For clocks and instruments that need to be read from a distance, a four-digit liquid-crystal display has characters that are 1 inch high.

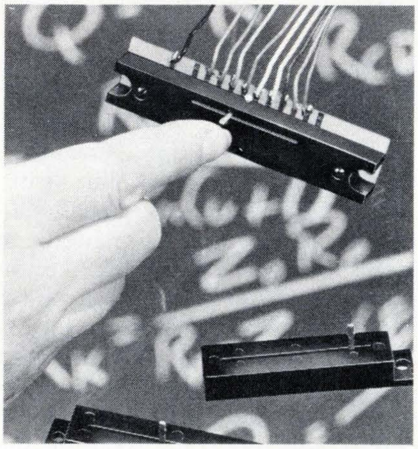
The seven-segment readout operates directly from a metal-oxide-semiconductor driver and requires 24 volts peak to peak with a symmetrical waveform. Transmissive and reflective versions are offered. Power requirement is only 10 microwatts per segment.

Life of the display is rated at 10,000 hours. It measures 5.1 by 2.5 in., is ⅛ in. thick, and plugs into a solderless, pressfit connector that has contacts on 100-mil centers. The unit includes four decimal points and a colon in addition to the four digits. Price is about $5 per digit.

Industrial Electronic Engineers, 7740 Lemona Ave., Van Nuys, Calif. 91405 [343]

Slide switch handles from 9 to 13 detent positions

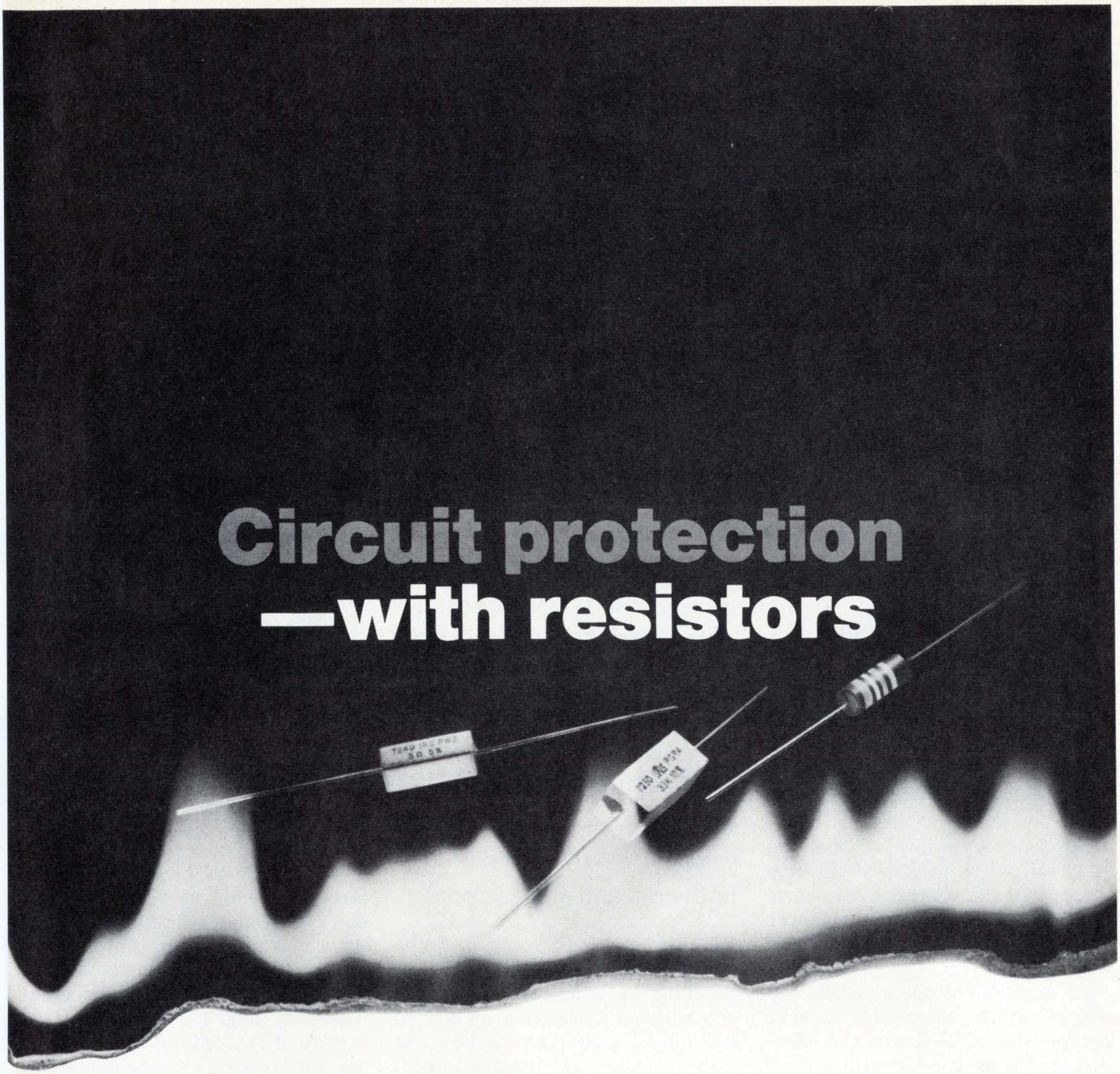
A miniature, binary-coded linear slide switch is designed for use in computers, business machines, instrumentation, and home entertainment products. The series MCS-100 is capable of handling from nine to 13 switch positions. Detent force can be varied from a 10 ounce minimum. There is no visual readout on the switch housing, but the units can replace rotary and thumbwheel switches because of their size advantage—type A with pc-terminal mounting is ⅜ by ¾ by 3⅛ inch, type B is ⅜ by ½ by 2-13/16 inch. The unit handles 20 v dc maximum and 1 to 10 milliamperes, and has 60 picofarads capacitance between



the common and any other switching circuit. The series MCS-100 is designed to customers' requirements, and price is under $2 in quantities of 10,000.
Standard Grigsby Co., 920 Rathbone Ave., Aurora, Ill. 60507 [344]

Wideband current probe won't affect circuit

The miniature size and low impedance of the model 711 current probe allows its insertion in the current path of high-speed circuits without affecting the circuit operation. Wideband response (80 kilohertz to 100 megahertz) and rise time (less than 3.5 nanoseconds), combined with a sensitivity of 1 volt per ampere ±1%, makes the unit suitable for measuring high-speed current pulses such as those found in GaAs laser systems. Price is $30.
American Laser Systems Inc., 106 James Fowler Rd., Santa Barbara Airport, Goleta, Calif. [345]



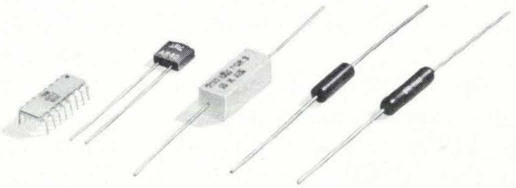
Where your circuits require resistors with built-in fault protection, TRW may have a solution. Specifically:

IRC Type PW. Wirewound power resistor, 2-50 watts. Inorganically constructed. Use as a standard power resistor. Or use as a *fusible* resistor. Highly effective where you need a versatile, low-cost power resistor, or specific fusing characteristics.

IRC Type BWF. Economical 2-watt wirewound resistor in the familiar 1-watt size molded jacket. For years an industry standard for high-volume, automated assembly application. Now available with fusible flameproof feature for hazard applications up to 1000 X overload or 1000 V.

IRC Type PGR. Ceramic-insulated, semi-precision film resistor, 1-5 watts. Famous Metal Glaze™ construction—rugged and stable. A low-cost, universally applicable flameproof resistor in ranges up to 100K ohms—far beyond wirewound resistor capability.

Complete resistor choice. Remember, TRW/IRC offers a total resistor capability—wirewound, carbon comp., metal film, functions.



For technical data, flameproof specifications or specific application needs, contact your local TRW sales representative. Or write TRW/IRC Resistors, an Electronic Components Division of TRW, Inc., Greenway Rd., Boone, N.C. 28607. (704) 264-8861.

TRW® IRC RESISTORS

Circle 117 on reader service card

Instruments

Panel meter is system-oriented

3½-digit unit costs under $90 in OEM quantities; uses Sperry readouts

Progress can proceed in various directions, including backwards, as Weston's latest digital panel meter demonstrates. Unlike its predecessors, which were designed around a single MOS chip, the new model

1230 consists mainly of standard 7400 series TTL packages. The reason is that the company wanted to provide parallel BCD outputs at TTL levels, and this was the cheapest way to do it.

In addition to the parallel BCD output, which is available as a $5 option, the 1230 features a maximum input bias current of 2 nanoamperes, a 3½-digit Sperry display, and an automatic zeroing circuit. The low input bias current and high-quality C-MOS transmission gates in the autozero circuit prevent detectable zero shifts even when measuring voltages from source impedances as high as 10 to 20 kilohms.

But the biggest difference between the 1230 and earlier models is pricing. List price is $135, dropping to less than $90 for quantities of 100, as compared with $285 for earlier meters.

The new meter is particularly well suited to systems applications. Its standard sampling rate of 7.5 samples per second can be changed to 15 or 30 times a second by merely moving a solder jumper. Further, if a system uses a master voltage reference, the DPM can be slaved to it, instead of working on its own. A "hold" feature allows the user to freeze the display at any time by switching a terminal on the input connector. And finally, an option is available which allows synchronizing of the start of the integration period with the application of a 1-microsecond TTL-level pulse.

Full-scale ranges from 100 milivolts to 1,000 V and 10 microamperes to 100 milliamperes are available, with 100% overranging provided on all but the 1,000-V scale. Maximum error—over the full 2,000-count range—is ±(0.1% of reading + 1 digit). Temperature coefficient is ±0.125 digit per ±C, max.

Common-mode rejection at 60 Hz is 80 dB, with a source imbalance of 1,000 ohms. Prime power requirements are less than 5 watts at 117 V ac ± 10%. Weight is 13 ounces.

Weston Instruments Inc., 614 Frelinghuysen Avenue, Newark, N. J. 07114 [351]

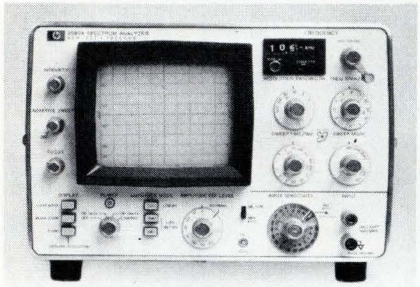
Audio spectrum analyzer cuts both cost and analysis time

Rf engineers have come to know and love the spectrum analyzer—for tweaking up a microwave filter or checking out a frequency multiplier, it's a hard instrument to beat. At lower frequencies, however, spectrum analysis has met with less enthusiasm. Probably the long sweep times required to obtain the very narrow bandwidths typically desired in audio work are responsible for this cool reception.

Things may change now that Hewlett-Packard has come out with a new spectrum analyzer that can cut the time of many analyses and eliminate much of the trouble associated with long sweep times.

To actually speed the analysis of a spectrum, H-P has come up with an innovation called adaptive sweep. With this feature, signals below a variable baseline, set by the user, are swept automatically at speeds up to 20 times faster than the speed set by the instrument's controls. When the signal rises above the threshold level, the sweep slows to produce a full-resolution display of the spectrum. Substantial reductions in analysis time can be achieved with this technique.

The new analyzer uses a digital memory as the storage medium and an ordinary CRT for the display. This combination has several advantages: the intensity and focus



controls, once set, need no readjustment when the sweep speed is changed; even the slowest (2,000-second) sweeps are clear and steady with no flicker or fading; if a trace is needed for future reference, it can be stored in memory at the touch of a button, and then recalled and superimposed on a later trace.

In addition to these special features, the 3580A spectrum analyzer has a minimum i-f bandwidth of 1 Hz, a maximum input sensitivity of 30 nanovolts, and an instantaneous dynamic range of 80 dB. Its input frequency range is 5 Hz to 50 kHz.

Price of the 3580A is $3,800.

Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif. 94304 [352]

Flatbed plotter has speed of 60 in./s

An automated flatbed plotter offers a maximum diagonal speed of 60 inches per second and maximum acceleration is 2 g, reached linearly. Accuracy is to within ±0.005 inch, and repeatability is ±0.001 in. A feature of the plotter is a motor, which produces linear motion directly through the controlled interaction of magnetic forces. Where conventional motors convert rotary motion to linear, and require lead-screw

gear trains or other mechanical linkages, these problems are eliminated in this system. Price ranges from $40,000 to $100,000, depending on model and specifications.

Xynetics Inc., 6710 Variel Ave., Canoga Park, Calif. 91303 [353]

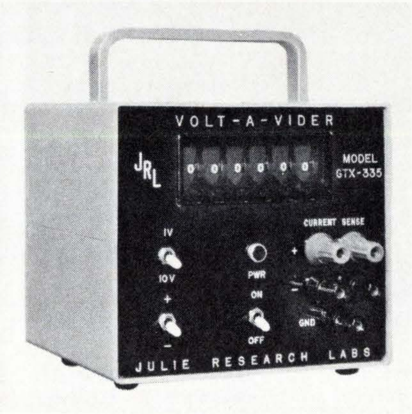
Generator produces nonlinear functions

For use in controlling a variety of testing, quality control, and processing operations, a function generator produces nonlinear functions. The military-quality unit can also be customized for specific applications. It delivers an infinite variety of mathematical and empirical functions, including those with multiple-slope reversals. The functions are set up and modified easily by inexperienced operators. Price is $745 plus an interpolating potentiometer for $262.50. Industrial-quality units sell for $300 without interpolator.

Perkin-Elmer Corp., Industrial Products Division, Main Ave., Norwalk, Conn. [355]

Voltage reference standard delivers 0–25-mA load

A bipolar solid-state prime-voltage reference standard with 1-ppm settability is capable of delivering a 0–25-mA load current from a less than 50 x 10^{-6} ohms source. A front-panel switch selects either a



The FET set! Everything you need in FET op amps

The Burr-Brown family of TO-99 FET op amps offers you a one-stop source for the exact FET units you need, regardless of your requirements. The three units highlighted below are representative of the performance and price advantages available from Burr-Brown's new 14 unit series. They are pin compatible with 741 types and are 100% tested to all min/max specifications.

Hybrid/thin-film techniques and a monolithic FET input stage provide excellent drift characteristics for source impedances to 1 MΩ. Active laser trimming of proprietary Burr-Brown high-stability, thin-film resistors contributes to outstanding performance at reasonable prices. Both output short circuit and input-to-supply-voltage protection are provided. Units are also available with MIL temperature ratings and MIL-883 screening.

MODEL NO.	3521L	3522L	3542J
Input Offset Voltage			
vs Temperature, Max.	±1μV/°C	±25μV/°C	±50μV/°C
Initial Offset, 25°C, Max.	250μV	±500μV	±20mV
Input Bias Current, Max.	−10pA	±1pA	−25pA
Price, 100 up	$28.00	$12.50	$4.50

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Burr-Brown amplifiers deliver what they promise!

Circle 120 on reader service card

New products

1-V or 10-V full-scale output, which can be subdivided into 1 million parts through the use of six front-panel lever-wheel switches. A number of models are available that have errors from ±0.005% of setting +5 microvolts to ±0.001% of setting +5 μV. Price ranges from $855 to $1,000.

Julie Research Laboratories Inc., 211 W. 61st St., New York, N.Y. 10023 [354]

Signal generator ranges from 4.5 to 520 megahertz

A signal generator with a 4.5–520-megahertz range offers a-m, fm, and pulse modulation. The model 750A provides an accuracy from within ±0.0001% to within 0.005% of frequency, which is said to be two orders of magnitude better than most

instruments of this type. The instrument is continuously tunable without band switching, thus eliminating problems associated with band-end measurements. The fm can be used independently or with a-m or pulse modulation. The 750A has a 5-digit LED display. Price is $3,100.

Logimetrics Inc., 100 Forest Dr., Greenvale, N.Y. 11548 [356]

Tape-tension gage inserts onto stationary, moving tape

A handheld tape-tension gage measures stationary or moving magnetic tape. Two models are available, and they accommodate ⅛-inch to 2-in. tape widths. Ranges offered are 3-, 12-, and 20-ounce full-scale configurations, and logarithmic scales provide readability for low tensions. Applications include service, quality control, engineering-data compilation, and preventive maintenance of

tape transports in audio, video, and computer industries.

Tentel, 1210 Camden Ave., Campbell, Calif. 95008 [357]

Digital thermometer is accurate to within ±0.2%

The model 921 PL digital thermometer, suitable for a variety of industrial processing and research and development applications allows continuous or intermittent operation over the range from −85° to +200°C with an accuracy and stability to within ±0.2% of reading ±0.15° over the full temperature range. A front-panel switch converts the display to Fahrenheit or Celsius, with the proper sign and decimal point automatically displayed. Price is $595.

Stow Laboratories Inc., Kane Industrial Dr., Hudson, Mass. 01749 [358]

Digital IC tester operates at 200 kHz

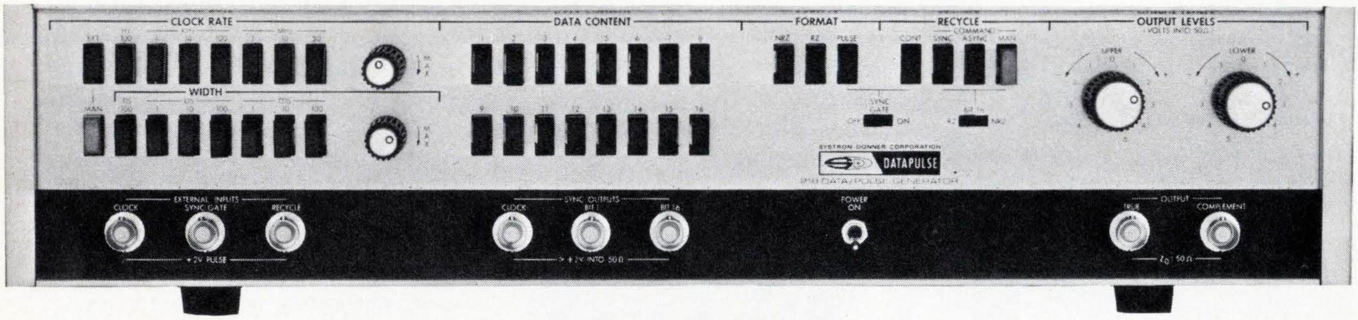
A test frequency of 200 kilohertz gives the model 3200 tester the ability to check complex digital ICs more thoroughly than before in the same amount of time. The instru-

ment performs parametric and functional tests and accepts devices with up to 24 pins, expandable to 34 pins. Tests performed include power consumption, fan in, fan out, function, and threshold. The model 3200 also has a built-in diagnostic capability. Price is $4,250.

Sitek Inc., 1078 W. Evelyn Ave., Sunnyvale, Calif. 94086 [359]

Now there's a generat~~ion~~ *or* gap

Here's the 50 MHz data generator you've needed all along—the one you've been stacking pulse generators to simulate. And it's a high speed pulse generator, too.



Check out the front panel. You have pushbutton control of the data content of 16-bit words in either NRZ or RZ format. You can recycle words continuously (synchronously or asynchronously), manually or by external command. You can vary pulse width continuously when using the 218 as a pulse or RZ data generator. Output is upper/lower level controlled.

Of course, there's a remote programming option. And two or more 218's in parallel provide multi-channel outputs, if you need them. In series, they permit longer word lengths.

You can't buy or build a more complete, more versatile data and pulse generator.

Get the full story on the low-cost ($925) Model 218 Data/Pulse Generator from your nearest Scientific Devices Office, or contact Datapulse Division, 10150 West Jefferson Boulevard, Culver City, California 90230. Telephone (213) 836-6100; TWX 910/340-6766; Telex 67-3219. In Europe: Systron-Donner GmbH, Munich W-Germany; Systron-Donner Ltd., Leamington Spa U.K.

DATAPULSE
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Semiconductors

Fast counters are variable

Dividers operate to 300 MHz; large, fixed-ratio prescalers drain only 50 milliwatts

An in-house program to develop a high-speed front end of a digital synthesizer has blossomed at Plessey Semiconductors into a family of high-speed counters, dividers, and prescalers that are being marketed—in addition to synthesizer applications—for frequency meters, pulse-counting equipment, and timing instruments.

Latest products in the British company's line are counters with a division ratio that is electronically variable. These include a divide-by-10-or-11 and a divide-by-15-or-18 prescaler working at up to 300 megahertz, and a divide-by-10 with binary-coded decimal and carry outputs, clock inhibit, and reset.

Prescalers now cover a range up to 1 gigahertz with division ratios of 2, 4, 5, 10, 16, 20, and 32. For frequencies up to 300 MHz, the larger division-ratio types consume only 50 milliwatts.

Using the same process, Plessey engineers are planning units that have acceptable performance above 1.3 GHz. Most of the units are made by the Plessey Bipolar III process, a buried-n^+ planar technique with reduced epitaxial layer and diffusion depths. These smaller diffusion depths have reduced the clearances necessary between the various diffusions and hence the parasitic capacitances. Geometries of the active components are much smaller, so packing density is higher, than with earlier processes.

Among the most recent additions to the series are six uhf dividers, designated the SP640, 641, 642, 643, 646, and 647, which are prescalers that may be programed to divide by 10 or 11, using pulse-enable inputs. All inputs have internal pull-down resistors and may be directly coupled with emitter-coupled logic. Interfacing with transistor-transistor logic is accomplished by use of two external resistors.

On the 640, 641, 642, and 643, both true and inverse outputs are provided at ECL lev ls. These outputs are capable of driving into a 50-ohm load (to +3 volts). The 646 and 647 have an additional TTL output that will drive up to three TTL gates at a maximum frequency of 250 MHz, using common supply rails. An external pull-up resistor to the positive supply is required, and for best performance this should have a value of about 2,000 ohms.

In quantities of one to 24, prices for the high-speed dividers range from $18.40 to $80.

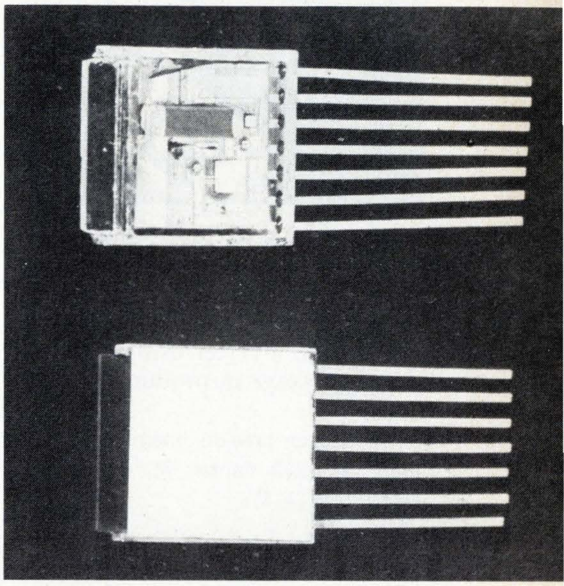
Plessey Semiconductors, 170 Finn Ct., Farmingdale, N.Y. 11735 [411]

Injection lasers combined with drivers, charging circuits

To improve on discrete combinations of injection lasers with separate pulser modules, Meret Inc., of Santa Monica, Calif., has developed a series of hybrid pulser-and-injection-laser combinations packaged in ⅜-inch flat packs. According to the company, the unit prices of these devices are less than half the cost of other laser-pulser combinations offered commercially. A complete transmitter, rated at 6 watts peak power for example, is available in 1 to 4 lots for $230 and for $198 for 5 to 9 quantities.

The hybridization of the GaAs laser die with SCR-driver electronics, says Meret, minimizes series resistance and inductance, and reduces stray capacitance. Rise times of less than 10 nanoseconds and pulse widths of less than 30 ns are achieved at radiant power outputs (at 905 nm) greater than 20 watts. Units delivering more than 150 W peak power are also available.

In addition, the company says, shorter rise times and pulse widths result in increased power efficiency and in improved performance in systems using threshold-detection



principles. Pulse-repetition rates to 25 kilohertz are said to be greater than those previously achieved. The increase in power efficiency and narrowing of the pulse width also make it possible to operate units at low current drains from a small 67½-volt battery.

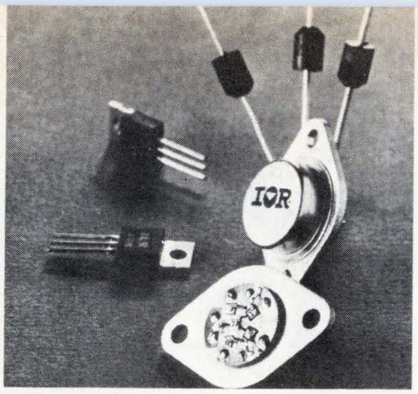
Applications of the units, designated the FIP series, include laboratory investigations requiring short-pulse visible and IR transmitters, high-precision ranging and surveying using threshold-detection techniques, intrusion alarms where battery-operated devices are essential—as in airport perimeter surveillance—and smog, fog, and haze detection in a variety of modes.

Options offered by the company include FIP series integrated with local oscillators, the laser emitter in center of flat pack or on a DIP, thermoelectrically cooled modules, and higher powers to 300 watts on custom orders.

Meret Inc., 1815 24th St., Santa Monica, Calif. 90404 [412]

Hybrid modules come in versions rated to 10 A

Power-level hybrid modules, called PACE/pack, are housed in TO-3 cans and are available with ratings up to 10 amperes average, operating from either 110- or 240-volt ac lines. Models available are a full SCR



bridge, two SCRs for center-tapped full-wave control, two SCRs and three power diodes in a semiconverter, a half-wave inverter bridge, and a full-wave inverter bridge. Price is in the $5 range in production quantities.

Semiconductor Division, International Rectifier Corp., 233 Kansas St., El Segundo, Calif. 90245 [414]

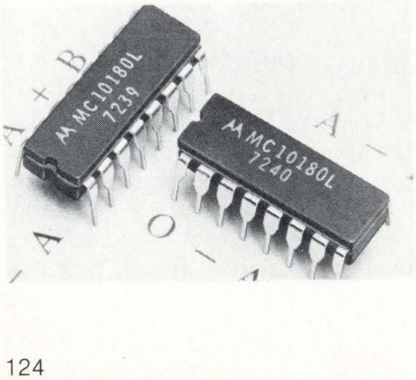
12-MHz op amp sells for $1.95

A wideband 12-megahertz operational amplifier called the AD518 combines a slew rate of 70 volts per microsecond with internal compensation and is priced at $1.95 in quantities of 100. Unity-gain slew rate and bandwidth can each be doubled in inverting applications by adding feed-forward compensation. The settling time to within 0.1% can be reduced to 800 nanoseconds with an external capacitor. Offset voltages are below 2 millivolts, and offset drift is 10 μV/°C maximum.

Analog Devices Inc., Rte. 1 Industrial Park, Box 280, Norwood, Mass. 02062 [413]

Adder-subtractor operates four ways

An expansion of the MECL 10,000 logic function family, an MSI circuit called the MC-10180, is a dual high-speed adder/subtractor that operates four ways. Each circuit has



three binary data inputs. Outputs are the sum, its complement, and carry-out. Two select inputs determine the function performed. Price is from $22.50 to $18. Delivery is from stock.

Motorola Inc., Semiconductor Products Division, Box 20924, Phoenix, Ariz. 85036 [417]

C-MOS circuits generate time base from 60-Hz line

Three standard C-MOS dividers each generate a different time base: 10 pulses per second, 1 pulse per second, or 1 pulse per minute, with a 50% duty cycle when operated from a 60-hertz line. The dividers are typically used where line-frequency accuracy is adequate for generating pulses for use in time-keeping circuits, or where timing pulses are required for controlling instruments, time-delay circuits, counters, and general-purpose industrial controls. Price is $4.75 in 100-lots.

LSI Computer Systems Inc., 55 Central Ave., Farmingdale, N.Y. 11735 [415]

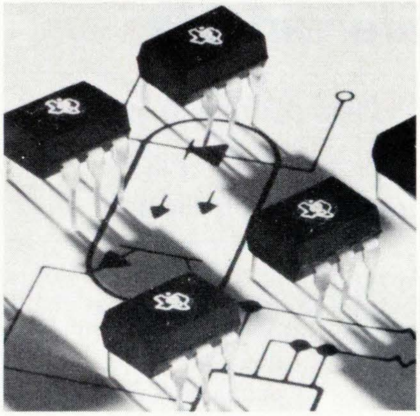
Transistor delivers 80 W of rf output power

A 28-volt transistor with internal matching provides 80 watts of rf power output. Designated the 2N6369, the unit is specifically designed for broadband high-power vhf operation over the range of 70–220 megahertz. The unit's internal matching eliminates problems caused by low input impedance and high input Q, problems commonly found in conventional power devices. Price is $70 each in quantities of 100 to 499 and $90 for 1 to 99.

Communications Transistor Corp., 301 Industrial Way, San Carlos, Calif., 94070 [418]

DIP couplers offer high direct-current transfer ratio

Six optically coupled isolators in six-pin plastic dual in-line packages are designated the TIL114 through 119. Each coupler features a high transfer ratio. The TIL117, for example, has a minimum 50% current-transfer ratio at a forward current of 10

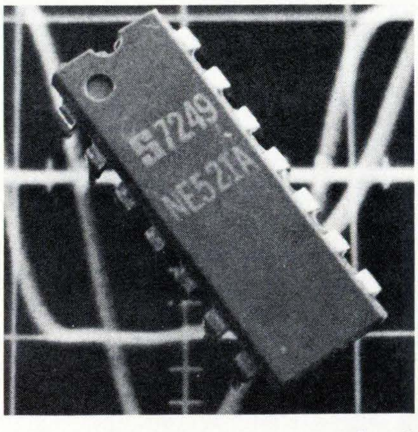


milliamperes. Price ranges from $1 to $1.95 in quantities of 100 to 999.

Texas Instruments Incorporated, Box 5012, M/S 308, Dallas Texas 75222 [416]

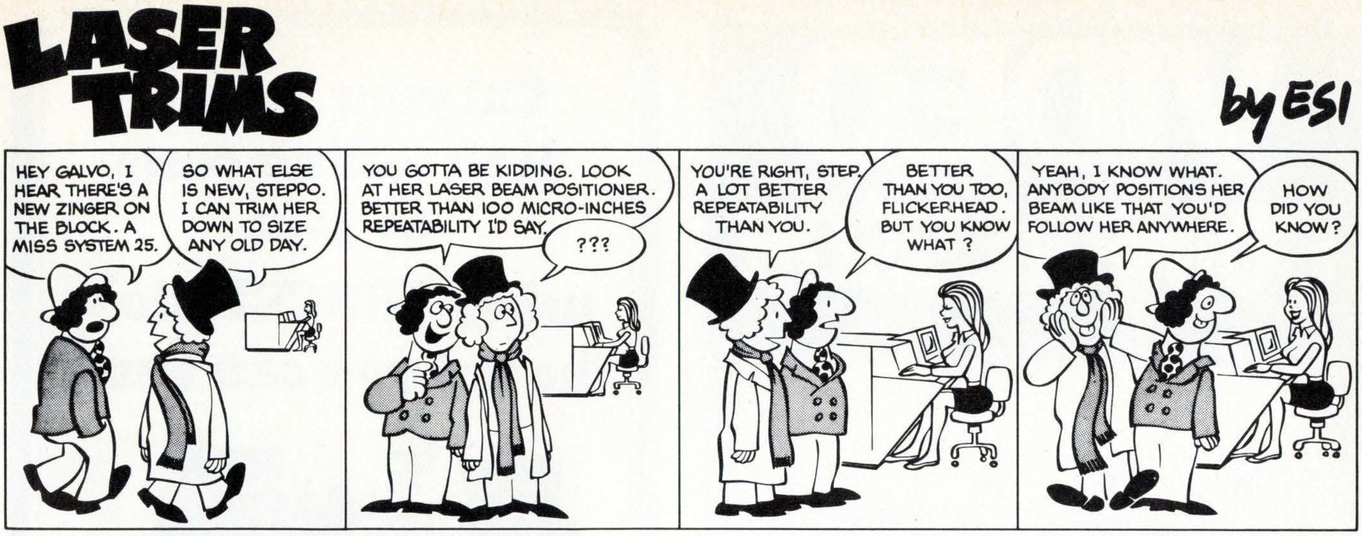
TTL comparator has propagation delay of 6 ns

Two dual voltage-comparator integrated circuits, called the 521 and 522, feature typical propagation delays of 6 and 10 nanoseconds, respectively. The units maintain a ±3-volt common-mode range, a 7.5-mil-



livolt input offset voltage, and a 5-microampere offset current. The 521 has TTL-compatible output levels that can source or sink up to 10 Schottky-gate loads. The 522 features open-collector output structures that permit wired-OR applications.

Signetics, 811 East Arques Ave., Sunnyvale, Calif. 94086



Any resemblance to actual persons or to galvanometer or stepping motor laser trimming systems, alive or dead, is purely coincidental.

The System 25 laser beam positioning system is sui generis*

For the System 25 Laser Trimmer Electro Scientific Industries developed a sui generis method of positioning the laser beam, and in so doing achieved a breakthrough in repeatable positional accuracy and absence of hysteresis.

Linear motors of the type used to position recording heads in computer disc memories are used to move an X-Y laser optics carrier of very low mass. Not only is a positional repeatability of better than 100 microinches attained, but the laser beam can typically be moved from one resistor to the next resistor to be trimmed in less than 30 milliseconds. Translation: Highest possible throughput for each circuit type being trimmed.

This new positioning system also allowed the elements in the laser's optical train to be designed to assure a uniform depth and kerf of laser cut over the entire 3″ x 3″ substrate area.

You will want to know more than Galvo and Steppo will ever be able to tell you about the System 25. Write for the details.

Sui Generis: They ain't nothing like it.

Electro Scientific Industries
13900 N.W. Science Park Dr.
Portland, Oregon 97229
Telephone: (503) 646-4141
Telex: 36-0273

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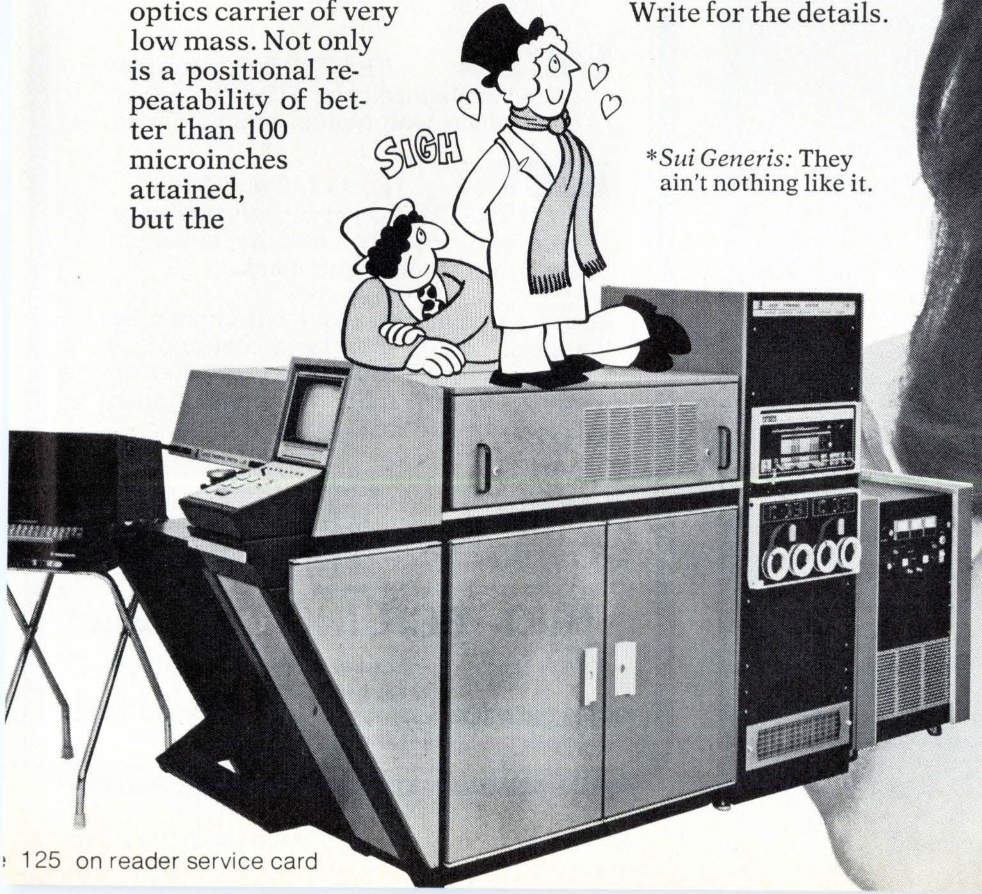
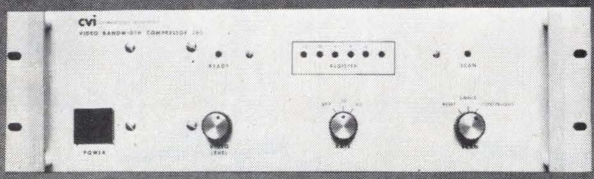


125 on reader service card

VIDEO COMPRESSOR



FOR LAB AND COMMUNICATION SYSTEMS

The CVI Model 260 Video Compressor samples conventional "real time" television signals to achieve a large reduction in bandwidth. The compressor also digitizes the signals for computer input and image analysis. A special 260 feature incorporates a "real time" video output which allows users to monitor the sampling process.

TYPICAL APPLICATIONS INCLUDE:

- **Computer data input, linear or semi-random scanning**
- **Communications: transmission of TV images over voice grade circuits for conference or data distribution purposes**
- **Environmental monitoring: transmission of TV signals for remote observation and computer analysis**
- **Data recording: utilization of conventional audio cassette or reel-to-reel tape recorders for image storage**
- **Biomedical image analysis**
- **Industrial control**
- **Computer image enhancement**

Video instruments for data acquisition, processing, transmission, and display.

Colorado Video, Inc. **cvi**

P.O. Box 928 Boulder, Colorado 80302 (303) 444-3972

Cut your helium leak testing costs by 50% using TRACER-flo® - the test you can trust.

FACT 1 TRACER-flo performs **both** gross and fine non-destructive hermeticity testing on MOS, LSI, hybrids and semiconductors using non-toxic, inert Krypton 85 tracer gas. Helium won't work for gross leak testing.

FACT 2 TRACER-flo performs gross production testing to 1 X 10^{-6} atm. cc/sec. and fine testing to 1 X 10^{-11}. Helium can't come near this sensitivity. We've found that an average of 38% of the helium rejects we retested on TRACER-flo are good!

FACT 3 TRACER-flo's new low priced system sells for $10,950. That's competitive with helium equipment.

FACT 4 Facts 1, 2 and 3 add up to TRACER-flo production testing at an overall cost that's **half** that of helium even in moderate quantities.

Give us a chance to prove our claims. Get the facts. Call or write for a cost analysis comparison of TRACER-flo and helium testing. Or, call for a demonstration at either of our two facilities.

TRIO-TECH, INC. OF CALIFORNIA

2435 North Naomi Street, Burbank, Ca. 91504
(213) 846-9200
1954-M Old Middlefield Way, Mountain View, Ca. 94040
(415) 969-9600

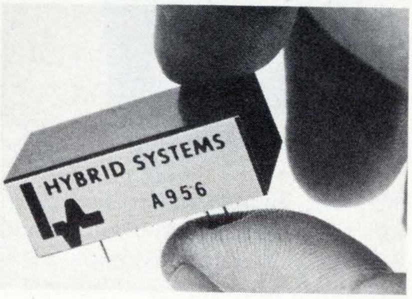
New products

Subassemblies

FET op amp stresses speed

Aimed at data conversion, unit settles to within 0.1% in under 1.5 microseconds.

The speed required of operational amplifiers in data-conversion systems calls for the use of discrete devices because integrated-circuit types are usually too slow. But discrete op amps are bulky, and the ad-



dition of a field-effect transistor makes the package even larger. By designing its new A956 discrete FET-input op amp specifically for data conversion, Hybrid Systems Corp. says it has been able to eliminate extraneous components, bringing size down to 1.4 by 0.6 by 0.5 inches—small enough to plug directly into a single 16-pin IC socket—and concentrate on speed. This approach has also kept the price to $24, compared to the $30 and up generally charged for FET op amps.

Sales manager Carl M. Kramer says Hybrid chose a special-purpose unit for its entry into the op amp market because "data conversion is one of the fastest growing, most dynamic fields," The A956 trades off some of the performance characteristics of general-purpose amps for speed and size. Instead of optimizing a typical discrete op amp for high speed and then adding a FET input, Hybrid says it re-examined conventional design techniques and optimized the design as a whole for its particular purpose.

For instance, the unit settles to within 0.1% in under 1.5 microseconds, a speed Hybrid claims is unmatched in the unit's size and price range. The remaining settling time is slower, since to settle faster would require extra steps and therefore extra space-consuming components. And Kramer says, "We don't care if it gets past 0.1% because, when looking at a CRT screen, the eye can't make that judgment."

Over-all slew rate is 40 volts per μs, and unity bandwidth is 5 megahertz. Output current of 20 microamperes means the unit's speed can be realized in data-conversion systems. Output voltage range is ±10 V.

The A956 is a complete amplifier package; it is internally compensated, requiring no external resistors or capacitors. There are two models—the A956 has initial bias current of 50 picoamperes and voltage offset drift of 40 microvolts/°C, and the A956B has initial bias current of 20 pA and voltage offset drift of 20 μV/°C. Operating temperature for both is from 0 to 70°C.

Price of the A956 is $24 for one to nine, and $29 for the A956B. Delivery time is from stock to two weeks.

Hybrid Systems Corp., 87 Second Ave. Northwest Park, Burlington, Mass. [381]

Log ratio module accepts current or voltage inputs

Since they don't have internal summing nodes required for voltage inputs, most log modules can only operate for two current source inputs. However, the model 756 log ratio module accepts voltage as well as current inputs. Unit price is $75, and this drops to $42 for OEM quantities of 100. The unit is a temperature-compensated log ratio module with two channels, one containing a FET op amp and the other intended

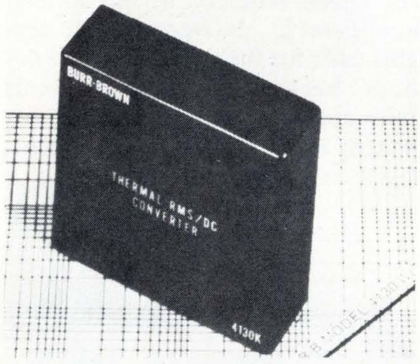
Circle 128 on reader service card

primarily for use as a reference but capable also of signal processing.

Analog Devices Inc., Rte. 1 Industrial Park, Box 280, Norwood, Mass. 02062 [382]

Thermal converter offers accuracy to within 0.05%

The model 4130 true-rms-to-dc converter is a modular device that uses a thermal-conversion technique.

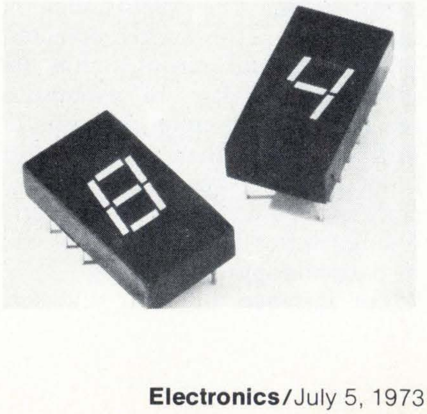


The unit incorporates the company's thermal converter and is said to provides higher conversion accuracies for a wider range of input signal levels, frequencies and waveforms than is possible with the computer techniques used by other types of modules. Accuracy is to within 0.05%. Price ranges from $80 to $150.

Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. [384]

LED indicators cost $2.95 in quantities of 1,000

Numeric LED indicators, suitable for commercial applications, are priced at $2.95 in quantities of 1,000. With uniformly illuminated, diffused segments, the units come in DIP hous-

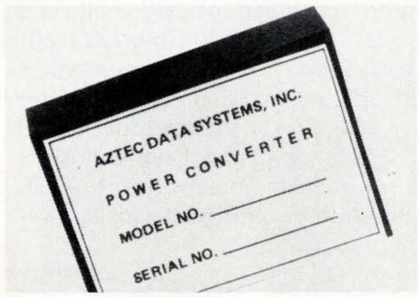


ings, and individual digits can be packed on 400-mil centers. Electrically, the displays are IC-compatible, and forward voltage per segment or decimal point is 1.6 volts. Luminous intensity is typically 250 microcandelas per segment. Typical operating current is 10 milliamperes per segment when strobed. Price is $3.95 each for 1 to 99 units and $3.25 for 100 to 999.

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [385]

Dc-dc converter offers up to three output voltages

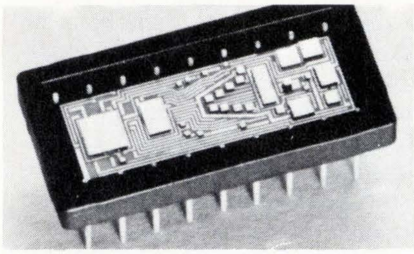
For point-of-load and portable applications when power requirements are less than 1 watt, an ultraminiature dc-to-dc converter has provisions for up to three output voltages. Input voltage can be varied from 3 volts to 9 volts. In single-output-voltage configuration, the power connector is available in OEM quantities of 10,000 pieces for as low as $5 each.



Aztec Data Systems Inc., 17805 Sky Park Circle, Irvine, Calif. 92707 [386]

A-d converter guarantees full MIL temperatures

Eight-bit analog-to-digital converters are designated the models MN502H and MN503H. The DIP converters guarantee operation over the full military range of $-55°$ to $+125°C$. The units are factory-trimmed for zero gain adjustment, and linearity of $\pm\frac{1}{2}$ least significant bit is guaranteed over the full operating range. Price is $225 each for 1 to 24, and the industrial versions of



the units are priced at $150 in the same quantities.

Micro Networks Corp., 5 Barbara Lane, Worcester, Mass. 01604 [389]

Op amp settles to 0.1% in 0.7 microsecond

The mono OP-01 is an operational amplifier that settles to within 0.1% in 0.7 microsecond and has a slew rate of 18 volts per microsecond. These specifications are achieved through the use of an internal feed-forward frequency-compensation network; no external capacitors are required. Power bandwidth is 250 kilohertz, small-signal bandwidth is 2.5 megahertz, bias current is 20 nanoamperes, and power consumption is 50 mW.

Precision Monolithics Inc., 1500 Space Park Dr., Santa Clara, Calif. 95050 [383]

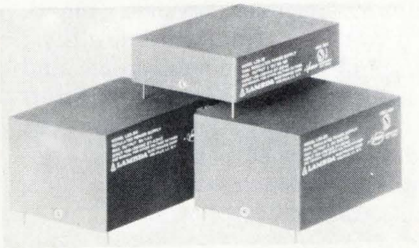
D-a converter provides a resolution of 16 bits

A digital-to-analog converter has a resolution to 16 bits and a temperature coefficient to ±0.00015%/°C. In addition, linearity is ±0.00015% and accuracy is to within ±0.0015% of full scale. Designated the model DAC-HR16B, the unit uses a precision thin-film ladder network that tracks to within ±0.5 ppm/°C and is current-controlled within a high-gain servo loop plus four IC quad

switches. Price is $495 for the unit.
Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021 [388]

Field-repairable power supply is pc-mountable

For the designer who needs a pc-mountable power supply, the LZ series is available. They are field-repairable and offer continuously ad-



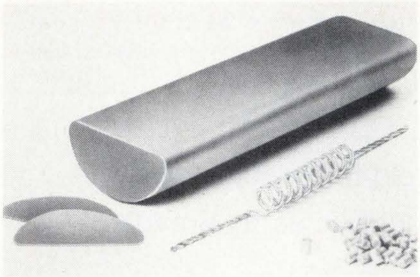
justable voltage. The units are also multivoltage-rated. They have an input-voltage range of 105–132 v ac, are shortcircuit proof and have a vacuum-impregnated transformer. Prices start at $35.
Lambda Electronics Corp., 515 Broad Hollow Rd., Melville, N.Y. 11746 [387]

Generator provides secure data communications

The model 213 generator provides an economical means of data coding for secure communications and computer data storage. The unit provides both transmitting and re-

ceiving modes of operation. It is programed to various codes whether manually, by means of thumbwheel switches, or electronically by 35 TTL inputs. Price is $525.
Crypto Industries, Box 23162, San Diego, Calif. 92123 [390]

New products/materials



Materials for use in the production of light-emitting diodes and other semiconductor components include gallium arsenide crystals, ingots, and wafers; binary gold alloys; aluminum for metalization; and nickel-chromium alloys for resistors and gold evaporation charges. The materials are nearly pure.
Materials Research Corp., Rte. 303, Orangeburg, N.Y. 10962 [476]

A resistor-paste system, designed for soda-lime glass substrates, is called the composition 2800 C series. The material exhibits narrow resistance distributions and low current noise. It fires at 575° to 625°C. The system is available in sheet-resistivity values of 10 ohms/square to 1 megohm/square. Voltage gradient capability is said to be high.
Electro-Science Laboratories Inc., 1601 Sherman Ave., Pennsauken, N.J. [478]

Pyro-Tape 546 is a glass-plastic tape that can withstand continuous temperatures of 500°F and flash temperatures up to 4,000°F. Designed for applications including masking surfaces for plasma- or flame-spray work and attaching thermocouple leads, the tape comes in 0.006-inch-thick rolls with an adhesive backing. An 18-yard roll of ½-in. tape costs $19.50; 1-in. tape is $39.
Aremco Products Inc., Box 145, Briarcliff Manor, N.Y. 10510 [479]

A material called Siloxide Etchant is used in the photolithographic process of manufacturing electronic devices and circuits. The material is ready to use, operates at room temperature with an etch rate of 40 angstroms per minute, and is compatible with negative and positive photoresists. Price is $15 per gallon.
Transene Co. Inc., Rte. 1, Rowley, Mass. 01969 [480]

New literature

Removal tool. Product bulletin No. 266 from Switchcraft Inc., 5555 N. Elston Ave., Chicago, Ill. 60630, describes a lamp-removal tool for use with subminiature lamps, pilot lights, and other components using T-1¾ lamps. Circle 421 on reader service card.

Capacitors. The Elmag Corp., 54 Clark St., Newark, N.J. 07104. A six-page brochure describes a line of standard high-voltage capacitors and filters. An applications section is included. [422]

Product catalog. The 1973 product catalog from Optical Electronics Inc., Box 11140, Tucson, Ariz. 85734, is a 36-page guide to products, including operational amplifiers, converters, comparators, voltage references, memories, and filters. [423]

Modem. A six-page brochure describing the model 2012 synchronous modem, and providing general information, is available from Intertel Inc., 6 Vine Brook Park, Burlington, Mass. 01803 [424]

Capacitors. Cornell-Dubilier Electronics, 150 Ave. L, Newark, N.J. 07101, has issued an eight-page technical data sheet describing the company's Class 201.17 type HNLH capacitors. [425]

Spectroradiometer. EG&G Inc., Electro-Optics Division, 35 Congress St., Salem, Mass. 01970, has issued an eight-page application note on measuring light-emitting diodes with the model 580/585 spectroradiometer. [427]

Filters. Catalog 12F describes a range of custom-built precision L-C filters available from Allen Avionics Inc., 224 E. 2nd St., Mineola, N.Y. 11501. The 12-page catalog includes specifications, graphs, and has a glossary of terms. [428]

Switches. Control Switch Inc., 1420 Delmar Dr., Folcroft, Pa. 19032. Six-page bulletin 73B describes a line of illuminated push-button switches and indicators. [429]

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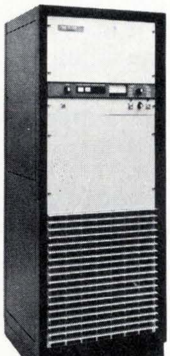

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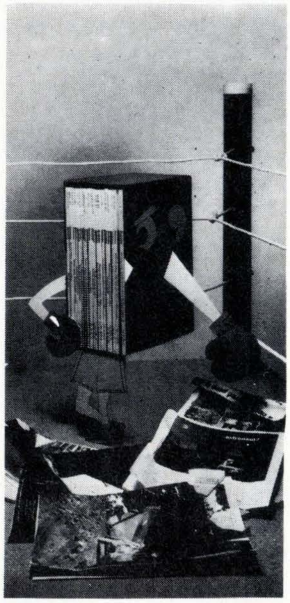

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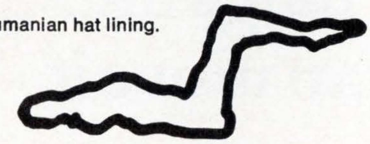
Petroleum and You (A History of the Former)

Chapter Three: A Giant Awakens

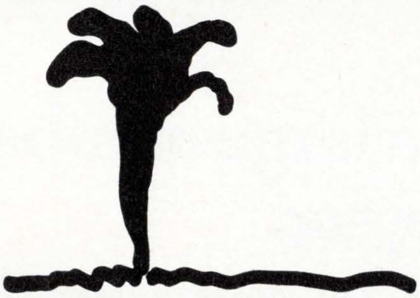
In 1852 a Canadian chemist named Abraham Gesner succeeded in distilling a new fuel from petroleum which, by a clever rearrangement of the letters of his name, he dubbed kerosene. This created an important new demand for petroleum, thus setting the stage for the emergence of a burgeoning industry. (See forthcoming Chapter titled "Stage Settings of the 1850s.")

Many historians of note credit Rumania with the establishment of the first oil industry, citing the fact that in 1857 the country produced 2000 barrels of oil. Of course in later years this output came to be looked upon as laughably small, and any Rumanian who contended otherwise was likely to be in for a round of good-natured kidding in which his face would be mocked, his beard tweaked, and the lining ripped out of his hat.

Rumanian hat lining.



Also in 1857 James Miller Williams discovered oil at Oil Springs, Ontario and set up a small refinery. However, his endeavor brought him only a limited amount of recognition since many people felt—some resentfully so—that to find oil in a place named Oil Springs was something almost anyone could have managed.

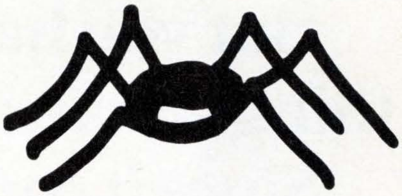


Oil Springs, Ontario, circa 1857.

Consequently the majority of informed historians prefer to trace the beginning of the oil industry to the well drilled in 1859 at Titusville, Pennsylvania by Edwin L. Drake. Drake, who was hired to drill the well by a consortium of businessmen, was a retired railroad conductor, and therein lies an exciting tale. Early on, there was a bold move afoot among the businessmen to hire a retired optician for the job, while, on the other hand, an opposing faction plumped strongly for a retired piano tuner. Hence, the happy compromise.

In any case, on August 27, 1859, Drake struck oil after drilling to a depth of 69½ feet, and from this well it is reported that he was able to produce 10 to 35 barrels a day.

Also it is interesting to note that a neighbor of this same Edwin L. Drake was the inventor of the rubber spider.



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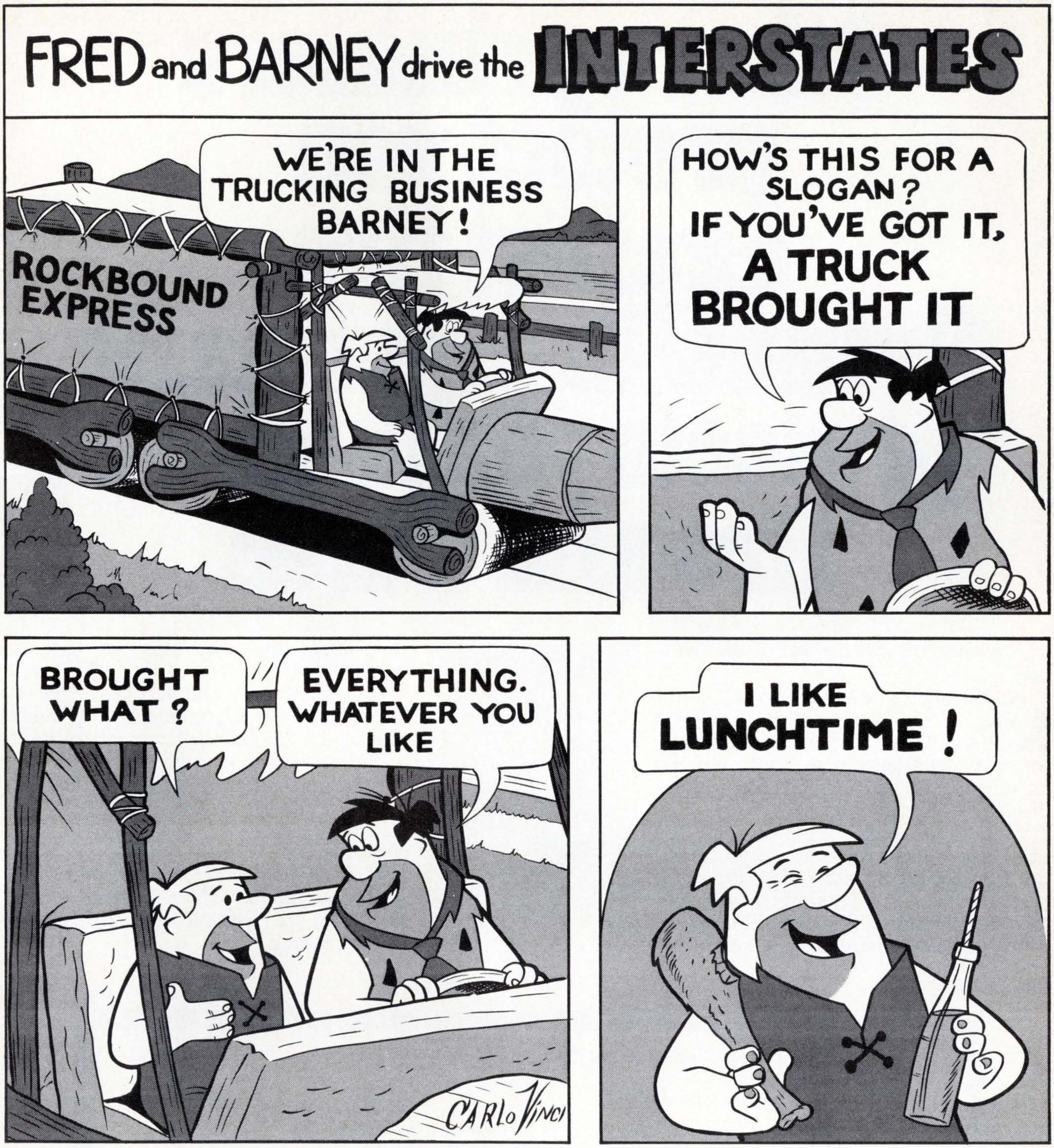

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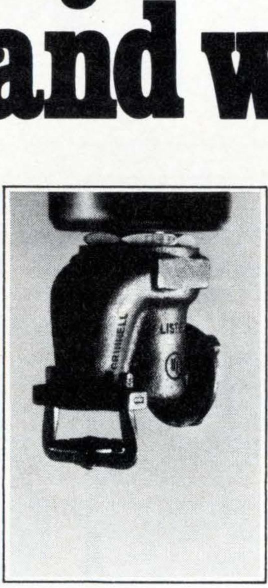

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